Foundation Certificate (Global)

Workbook

Lifting Equipment Engineers Association | Lifting Standards Worldwide

www.leeaint.com

Welcome to the Foundation Certificate

The Foundation Certificate training course provides the essential underpinning knowledge required for those wishing to continue their study for Diploma qualifications. There is a mandatory requirement to have successfully completed this Foundation Certificate before accessing LEEA's Diploma qualifications.
The core areas covered in this course are:

- Legislation, regulations, standards and best practice relating to lifting equipment
- Definitions
- Controlling risks
- Materials science
- Units of measure
- Basic machines
- Manufacturers verification
- Rating of lifting equipment
- Types of lifting equipment

Learning Outcomes

On successful completion of this course, students will be able to outline the legislative requirements of the lifting equipment industry and choose appropriate standards and bestpractices for specific lifting equipment use. Students will be able to identify different lifting equipment and describe the materials andmethods of manufacture, including how manufacturers verify the equipment and all patentdefects which may become evident in service.

Legislation and Regulations

In this section, we will explore the purpose of legislation and regulations in the lifting equipment industry.
Legal frameworks establish a broad system of rules that governs and regulates decision making,agreements, laws etc.

NOTE:

Health and Safety

The responsibility for health and safety at work rests primarily on the shoulders of the employer, yet employees also have responsibilities under health and safety law. Employers have a moral responsibility to ensure appropriate working conditions are provided and this is generally known as a ‘moral duty of care’.
The consequences for employers failing to adequately manage the health and safety of their employees can have serious implications:

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Common elements of legislation pertaining to lifting equipment, worldwide

Previous versions of the LEEA Foundation Certificate training course focused on the UK legislative framework. All LEEA courses now build on these requirements to provide globally applicable and accepted industry-specific, best practice training.

Throughout the world, there are numerous national legislative requirements concerning liftingequipment.

For example, the legislative framework for health and safety in the UK is the Health and Safety at Work Act, which is the primary piece of legislation and is responsible for enforcing the act and a number of other acts relevant to the working environment. It also states that all staff should take reasonable care of themselves and others around them and for their safety.

Other examples are Australia, where the model WHS Act forms the basis of the WHS Acts thathave been implemented in most jurisdictions across Australia. In the USA, the Occupational Safety and Health Act of 1970 is the primary health and safety legislation.

> **Regional Health and Safety Frameworks**
>
> It is therefore important to note that all countries have a similar form of health and safety framework. They may be names differently, and many constructed differently, but they all have the same purpose; to protect the health and safety of everyone in the workplace.

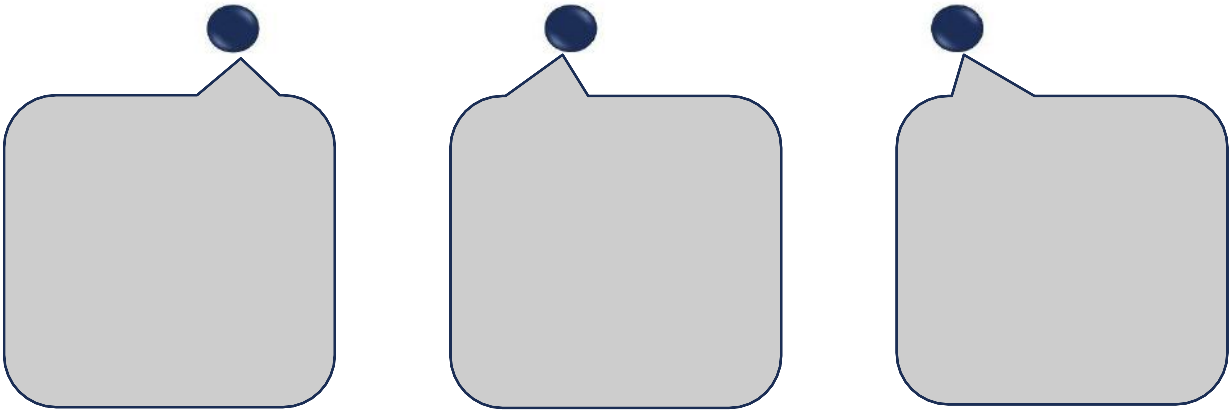
- Legislation:

- Regulations:

Standards

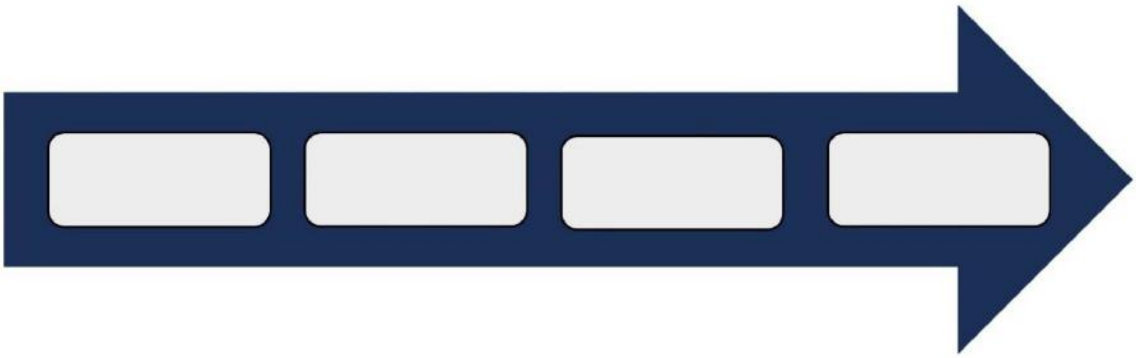
Standards are a published specification that sets a common language and contains a technicalspecification or other precise criteria and is designed to be used consistently, as a rule, a guideline, or a definition. Standards are applied to many materials, products, methods, and services helping to make life simpler and increase the reliability and effectiveness of goods andservices.

Standards are designed for voluntary use and do not impose any regulations, but many havesuch recognition that compliance with them gives a presumption of conformity and as such aquasi-legal status.



Creating Standards

Standards are usually created by a collective of subject matter experts, who function togetheras a committee. Details of proposed standards are agreed upon, and a draft of the standard isreleased for anyone who has an interest in the standard to make comments about the contents. When the reviews have finished, the standard is published.
The four stages of creating any standard are, therefore:



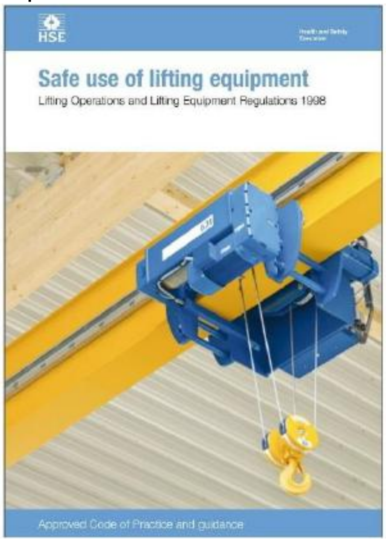
NOTE:

Codes of Practice, LEEA COPSULE and Best Practice

A Code of Practice is a set of written rules which explain how people working in a particular profession should behave, or a set of standards agreed on by a group of professionals who doa particular job. There are various types of Codes of Practice:

- ACoP (Approved Code of Practice)
- RCoP (Recommended Code of Practice)
- A trade or professional Code of Practice
- Technical publications
- Safety information sheets

The Regulations which provide the detailed requirements in respect of the general duties set out in 'Acts' do not specify how employers and others should meet those requirements. This is therole of the Approved Codes of Practice (ACoPs). These detail how to comply with the legal requirements.



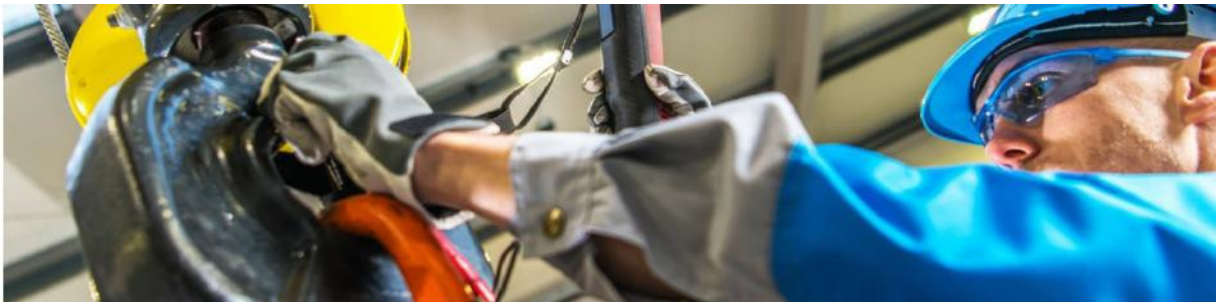
Who issues ACoPs?

ACoPs are issued by relevant authorities with the consent of a government minister and followingconsultation with stakeholders, such as trade associations. There are ACoPs accompanying some of the health and safety regulations and they have a particular significance beyond providing guidance on complying with regulations. Contravention of the advice in a code of practice is admissible in evidence to prove a breach of the statutory provisions as set out in statute law and its associated regulations.

ACoPs often contain statements that clarify their status, usually in the form of a disclaimer similar to the following:

> “Although failure to comply with any provision of the code is not actually an offence, such a failure may be used in criminal proceedings as evidence that a person has contravened a regulation to which the provision relates. In such a case, however, it will be open to that person to satisfy the court that he has complied with the regulation in some other way.

A common example of an ACoP in the lifting equipment industry is the guide to the application of the Machinery Directive 2006/42/EC.



Working in a safe environment and with equipment that has been maintained and tested is vitalin this industry.

NOTE:

Industry Relevant Definitions

Duty Holder

This is a broad concept used to capture all types of modern working arrangements.

The duty holder is the person responsible for the lifting equipment that they own and use. Usually, this is the employer or self-employed person.

> It is important to note that the duty holder is not necessarily always the employer; it may be a building owner, the person in charge of the equipment, or a hire company.

The obligations imposed by legislation apply to the duty holder.

However, in many cases, the duty holder will not possess the necessary skills required to fulfilthese obligations. It is therefore acceptable for them to delegate some or all of their obligationsto suitably qualified personnel or organisations. If they do so, then it is important to note that this does not absolve them of responsibility, it simply changes the nature of their accountability.

A duty holder who delegates or sub-contracts their legal obligations becomes culpable for ensuring that those undertaking the tasks are suitably qualified, experienced, trained, equipped, etc. In short, they are competent for their task. This means that they must ensure that employees are assessed and properly trained and provided with the necessary equipment for their role. Interms of external organisations, the duty holder must have procedures in place for vetting theircompetency.

An example of national terminology used for duty holders would be that of Australia where the ___________ places the primary duty of care and various other duties and obligations on a 'person conducting a business or undertaking' (PCBU). 'Officers' and 'workers' have duties aligned to the director and management and that of the employee.

Modern legislation places responsibilities on users and those in the supply chain. In terms of useultimate responsibility lies with the duty holder (employer of persons using the equipment), butemployees also have obligations, typically to use only use equipment for which they have beentrained and in accordance with that training. In terms of supply, ultimate responsibility tends to lie with the manufacturer. However, importers and distributors also have legal obligations. Thereason for placing such responsibilities on suppliers and users is to protect the health and safetyof everyone exposed to lifting equipment and lifting operations by ensuring that they are properly designed, constructed, maintained, and used correctly.

If we consider what factors legislation may be required of the manufacturers to establish suchlevels of safety, we will need to include:

-
-
-
-
-

What about the employers' responsibilities?

Of course, employers (persons responsible for controlling work equipment) also have animportant part to play in ensuring the health and safety of their employees.

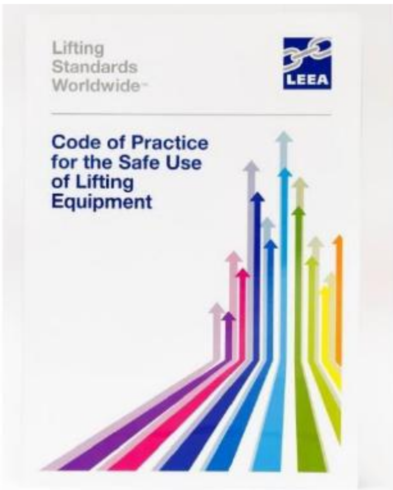
Their duties include:

- Ensuring equipment complies with any essential health and safety requirements
- Ensuring equipment is maintained and regularly examined
- Providing equipment and systems that are safe and without risk to health
- Provide employees with the necessary information, instruction, training, and supervision
- Ensure equipment is correctly selected for the task

What are the equipment manufacturers responsibilities?

Equipment manufacturers must comply with all national supply legislation applicable. This legislation varies between countries worldwide, but their fundamental principles generally alignto EN ISO 12100 – Safety of machinery. General principles for design. Risk assessment and risk reduction.

The standard identifies the essential safety requirements that need to be considered by all manufacturers to overcome hazards in lifting equipment.



The LEEA Code of Practice (COPSULE) is designed and established upon the general principlesof the requirements of the duty holder and work equipment legislation.
We will look at COPSULE in further detail later in this course.

NOTE:

Competent Person

The term 'Competent Person' has long been used in legislation.

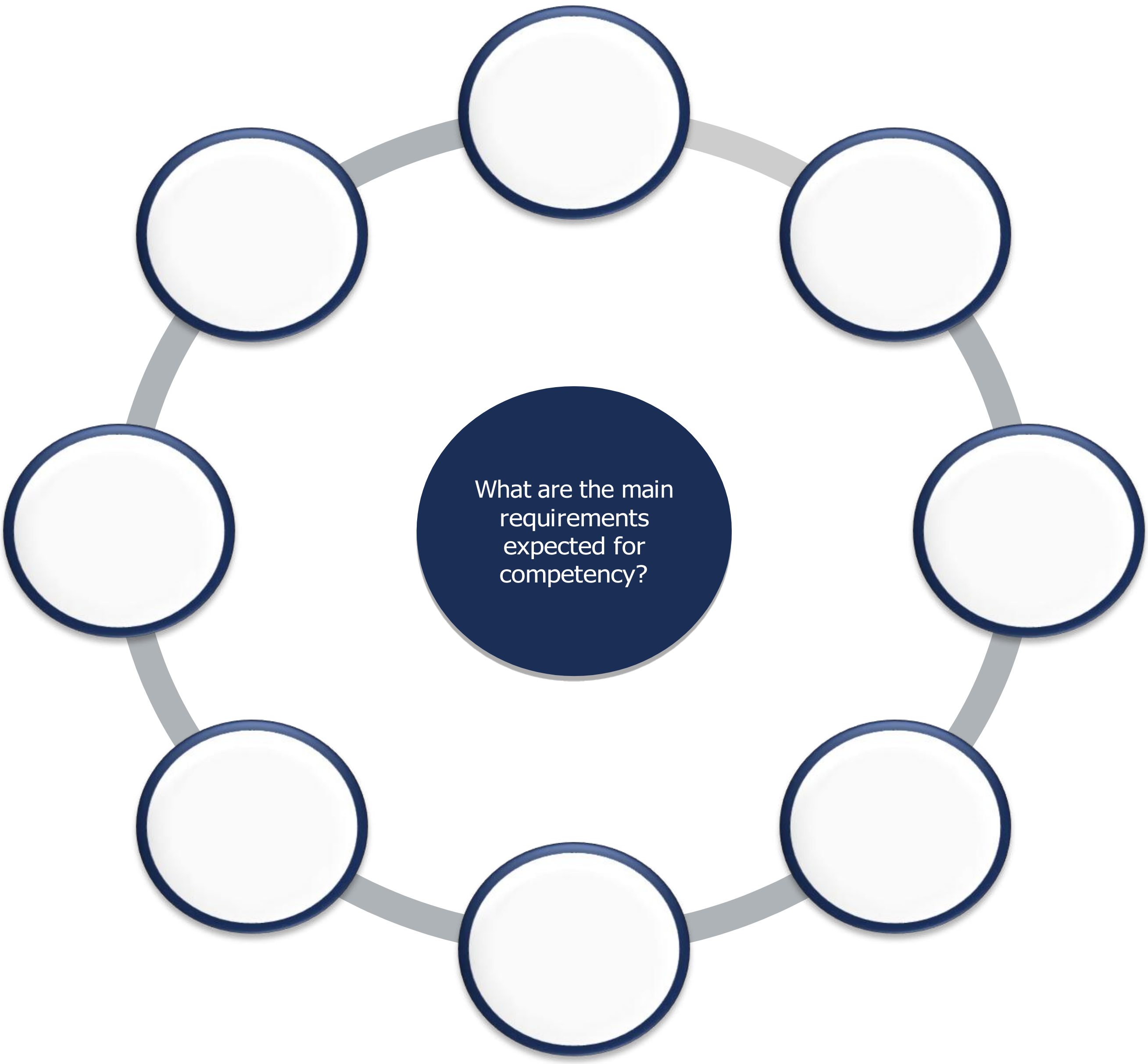
Current legislation uses it for a variety of duties to describe a person with the necessary knowledge, experience, training, skills and ability to perform the specific duty to which the requirement refers. There can therefore be several 'Competent Persons', each with their ownduties and responsibilities, i.e. competent for the purpose.

The Competent Person should have the maturity to seek such specialist advice and assistanceas may be required to enable him/her to make necessary judgements and be a sound judge ofthe extent to which he/she can accept the supporting opinions of other specialists.
For example, the competent person inspecting, maintaining, or examining lifting equipment mustbe able to certify with confidence whether it is free from defect and suitable in every way for theduty the equipment is required.

NOTE:

Competency

What can be considered as the most important elements of competency?



NOTE:

Factor of Safety, Inspection and Lifting Equipment

Factor of Safety
(FOS)

The Factor of Safety (FOS) is known as a working coefficient and is an additional redundancy of strength built into the component that makesallowance for such things as accidental overload and deterioration over time.

For example, if there was no redundancy there would be no tolerance for loss of material and strength due to wear.

Inspection

We will consider 3 levels of inspection during this course:

1)

2)

3)

NOTE:

Pre-use Inspection:

Interim Inspection:

Thorough Examination:

Question:

Why is regularly inspecting the equipment important? (Select all that you feel apply)

- ☐ Ensure that the equipment is safe to continue in service for another period
- ☐ To ensure you are competent to use the equipment
- ☐ To note any repairs that need to be made
- ☐ Ensure the equipment is working correctly
- ☐ Ensure that the equipment is safe to use
- ☐ To familiarise yourself with the equipment

NOTE:

Lifting Equipment

Lifting Equipment: This is a generic term used to describe all types of lifting accessories and appliances.

Lifting Accessory: Sometimes referred to as lifting gear, lifting tackle or rigging equipment, anaccessory is defined as a piece of lifting equipment that is used to connect a load to the liftingappliance.

In 'supply' legislation, the lifting accessory may be included as an integral part of the load andindependently placed on the market.

In some national user legislation, accessories that are incorporated into the load are deemed tobe part of the load and therefore not subject to the national lifting equipment inspection legislation. However, they must still be considered in the lift planning, be of adequate strengthand be found to be free from defects. In which case it is recommended that there is an inspectionregime that is as robust as that required by the national lifting equipment legislation.

Examples of lifting accessories would include:

- Shackles
- Spreader beams
- Chain slings

Lifting Appliance: Sometimes referred to as a lifting device or machine. An appliance is a machine that can raise, lower, or suspend a load.
This excludes 'guided loads' such as lifts and continuous mechanical handling devices such as
conveyors.
Examples of lifting appliances would include:

- Cranes
- Hoists
- Jacks

NOTE:

Manufacturers

This in any natural or legal person who designs and/or manufactures lifting equipment or partly completed lifting equipment and is responsible for the conformity of the equipment with the applicable legal requirements with a view to its being placed on the market, under his own nameor trademark or for his own use.
In the absence of a manufacturer as defined above, any natural or legal person who places theequipment on the market or puts it into service shall be considered a manufacturer.

Manufacturer's Certificate, Record of Test or Statement of Conformity

Depending on the standard being used, the manufacturer will usually issue a manufacturer'scertificate, a record of test, or a statement of conformity confirming the verification of the equipment. This document serves as the manufacturer's confirmation that any necessary manufacturing test or other product verification required by the standard has been carried outand states the working load limit.
Unless a specific document is required by the national supply legislation, then this document isalso known as the 'birth certificate' for the product and it should be retained as part of the liftingequipment records.


MANUFACTURER'S CERTIFICATE & EC DECLARATION OF CONFORMITY LIFTING ACCESSORIES
REFERENCE NO: CMF16863

MANUFACTURED BY:
ATLAS LIFTING EQUIPMENT LTD.
TITAN WORKS
PROMETHEUS STREET
LINCOLN
LN1 2NS

SUPPLIED TO:
SAMSON CASTINGS
PROVIDENCE WORKS
LOWER GORNAL
WEST MIDLANDS

SPECIMEN

QTY	DESCRIPTION	CERTIFICATION NUMBER	WLL
1	KUPLEX GRADE 8 10MM TWO LEG CHAIN SLING FITTED WITH SHORTENING CLUTCHES AND TERMINATING IN KHX10C SAFETY HOOKS REACH 3 MTR COMPONENTS PARTS 1 x KM-C - P2Y246 2 x KSC10N - P5Y246 2 x KHX10C - P1Y213 2 x 2.6 MTRS 10MM KUPLEX 10030RPC GRADE 8 CHAIN - 242967 HARMONISED STANDARD BS EN 818-4	KC58184	4.25 TONNES 0-45°

ON BEHALF OF THE ABOVE FIRM
SIGNED
DATE

DECLARATION OF CONFORMITY

NOTE:

Industry Relevant Definitions

It is important to have clarity on key industry relevant definitions.

Minimum Breaking (or Failure) Load	The minimum breaking or failure load is the specified load (mass orforce) below which the item of equipment does not fail either by fracture or distorting to such an extent that the load is released.
Multipurpos eEquipment	Multipurpose equipment is any equipment designed to a standard specification to lift a variety of loads up to the marked SWL, i.e., used for general (multi) purposes, and not designed for one specific liftingapplication.
Operative	An Operative is a trained person using the equipment.
Rated Capacity	This is defined as the maximum gross load that the lifting appliance can lift in any given configuration; generally used for lifting appliances in the same way as Working Load Limit is used for lifting accessories.
Proof or Test Load	A proof or test load is a load (mass or force) applied by the Competent Person for the purpose of a test. This load appears on reports of thorough examination if a proof test has been made by the Competent Person in support of their examination and on test certificates. Note: Proof load tests are also done as part of the verification of newlifting equipment or following installation.
Single Purpose Equipment	Single purpose equipment is any equipment designed for and dedicated to lifting a specific load in a specified manner or working ina particular environment, i.e., used for a single purpose.
Report of Test	Report of test, previously known as 'test certificate', is a report issuedby the competent person who did the test and details the specifics of the test. Test reports are not legal documents allowing the equipment to be used, except when used in support of legal documents such as the EC Declaration of Conformity, Manufacturers Certificate or Report of Thorough Inspection/Examination. Note: new equipment for European or British markets this will be an EC or UK declaration of conformity respectively, or for products placed on other markets a 'manufacturers certificate'. For older equipment test certificates and certificates of test and thorough examination were used. Previously these were known as a ' birth certificate'. However, all lifting equipment is verified in some way and manufacturers may append the verification details to the declaration of conformity / manufacturers certificate or combine them in a singledocument.
Verification	Verification is the generic term used to describe the procedures adopted by the manufacturer or Competent Person to ensure that lifting equipment is to the required standard or specification, meets legal requirements and is safe to operate. This includes proof load tests, sample break tests, non-destructive tests, calculation, measurement and thorough examination.

Verification – New Equipment

For new equipment, the verification methods used by the manufacturer will depend on the standard being worked to. Some equipment is unsuitable for proof load testing due to the nature of the materials used, e.g. textile slings. Some items are assembled from components verified to their own standards so no further tests are required, e.g. grade 8 mechanically assembled chain slings. Once in service, the verification methods used will be those deemed necessary by the Competent Person in reaching their conclusions about fitness for purpose.

NOTE:

Report of a Thorough Examination

A report of a thorough examination (also known as a report of thorough inspection or report ofperiodic inspection) is a report issued by the Competent Person giving the results of the thorough examination, which will detail the defects found or include a statement that the item is fit for continued use. Where the Competent Person has carried out a test as part of the inspection/examination, the report will also contain details of the test.

Key Note 1: The report of thorough examination must be retained as part of the liftingequipment records.

Key Note 2: In some cases, a reference to the test report appears as an appendix to thethorough examination.

Question:
Would a proof load test be used as part of a 'thorough examination' for lifting accessories? (Select one answer)

□ Yes
□ No

NOTE:

Safe (Specific application) Working Load (SWL)

The safe working load or specific application load (SWL) is the maximum load (mass) as assessedby a Competent Person which an item of lifting equipment may raise, lower or suspend underthe particular service conditions. The SWL is marked on the equipment and appears in statutoryrecords.
In some geographical regions, the word 'safe' is not used in the description but the requirement is the same, so instead of safe the phrase 'specific application' is used instead and the acronymSWL will be used throughout this handbook.

Did you know?

The SWL will normally be the same value as the working load limit, maximum safe working load or rated capacity where the term is used in a particular section of the code; but may be less.

Working Load Limit (WLL)

The working load limit is the maximum load (mass) that an item of lifting equipment is designed to raise, lower or suspend. In some standards and documents WLL is referred to as 'maximumSWL.' This term is more generally used for lifting accessories, but lifting appliances are now commonly marked with a rated capacity.

NOTE:

WLL vs SWL	Much confusion exists between the terms 'SWL', 'working load limit' and 'rated capacity'. By way of explanation, working load limit or rated capacity is the loadvalue assigned to the 'maximum' SWL under ideal conditions (by calculation)and in most cases, the working load limit or rated capacity and the SWL will bethe same. However, depending upon the conditions of use, it may be necessaryfor the Competent Person to reduce this to a lower SWL, and it is in these casesthat the working load limit or rated capacity and SWL will differ.
Risk Assessment	If the risk assessment of the application indicate that such reduction may berequired, it is essential that the user declares this information at the time ofordering so that the correct SWL may be attributed to the equipment and documentation. In the absence of such a declaration, the manufacturer or supplier will assume that the application is suitable for equipment rated withthe SWL equal to the working load limit. If the equipment is in service or theuser has not declared this information to the manufacturer, then it is the user's responsibility to determine and mark the appropriate SWL.
Hazardous Duties	The conditions where it may be necessary to reduce the working load limit toa lower SWL are HAZARDOUS DUTIES. Hazardous duties could, for example, be environmental conditions such as extremes of temperature, high windspeeds or lifting procedures such as a likelihood of shock loading or inaccuracy of weight. When such circumstances arise, it is essential that systems should be instituted to prevent normally rated equipment from beingused to its full capacity.
Key Considerations	Whilst it is the responsibility of the user to take such steps, the following adviceshould be considered: ▪ For specific installations where the equipment is fixed permanently inposition, the equipment may be marked with the reduced SWL for that specific duty ▪ For specific installations where the equipment is portable, the user should provide written instructions to the operative which include aninstruction to use a normally rated piece of equipment (i.e., SWL = WLL) but of appropriately higher capacity thus achieving the same effectivereduction ▪ For an industry or a definable section of an industry where the majority of tasks require equipment having a reduced working load, then all the equipment should have a reduced working load i.e., that corresponding to the most hazardous duty

NOTE:

Controlling Risks

Risks

The 3 primary reasons for assessing and managing risk are:

-
-
-

Before we delve into more detail, first we have to consider the factors that contribute to accidents / ill-health in the workplace.

NET RESULT (Risk) = Likelihood x Severity

Risk Assessment

Many workplace activities are inherently dangerous, or they may be given a combination of circumstances. However, no one expects to risk life and limb, or their physical or psychologicalhealth, as a consequence of going to work. There is, therefore, a moral duty on employers to take appropriate steps to ensure the safety and health of their employees, and others. Risk assessment is the main means by which this can be effectively planned.

Commonly referred to as Job Safety Analysis, Job/Task or Job Safety Review, simply put, this isa careful examination of all potential hazards that could cause harm to people so that a decisioncan be made as to whether enough precautions are in place, or if further control (precaution)measures need to be established. It is therefore a requirement that the totality of the risks in theworkplace have been identified and that a plan is in place to control these.
Although slightly different from nation to nation, a common approach to managing risk features a 5-step approach.

Step 1: Identify the Hazards

This is the process of identifying all the hazards that exist in the workplace. You need to beaware of all the possible hazards, but it is the significant ones that are important.

Step 2: Decide Who Might Be Harmed and How

This is the process determining who may be at risk from the hazards – the groups of staff and others likely to be affected in the case of an incident involving the hazard.

Step 3: Evaluate the Risks and Decide on Precautions

This is the process of assessing the significance of the risks and what needs to be done to protect people.

Step 4: Record Your Findings and Implement Them

The significant findings of the assessment must be recorded and kept. There should, then, be a record of all hazards, the risks that they present and what precautions are in place to protect people from harm.

Step 5: Evaluate the Risks and Decide on Precautions

The way we work is constantly changing – as a result of new or modifications of existing equipment, building alterations, new procedures, new or modified products, etc. Sometimes systems and procedures get changed by the staff themselves. These all bring their own hazards, but new hazards can also arise in existing methods of work – the effects of stress are a recent example. It is important to continue to be vigilant about hazards and risks and to review workplace conditions regularly. How often is 'regularly' will depend on the extent of the risks and the degree of change.

Question:
When considering people at risk, you only include those carrying out particular activities. (Select one answer)

- ▢ True
- ▢ False

Identifying People at Risk

When considering people at risk, it is important to think not only of those carrying out particular activities but also of all those who may be affected by those activities. This may include other workers who may be in the vicinity, both during working hours (such as maintenance staff, contractors and other staff who just happen to be passing) as well as those who may be present at other times, such as cleaners and security guards. In addition, the position of visitors and other members of the public who may be affected must be assessed

Identifying the precautions (control measures) necessary

The first priority for controlling any significant risk to health is to try to avoid or eliminate it completely, i.e. no further risk present. However, this is impossible in many situations, so a hierarchy of control measures is used. Following on from step 3 of our risk assessment process the hierarchy will determine the most effective approach to controlling the risks and the followingguide is generally used for this purpose:

1 –
2 –
3 –
4 –
5 –
6 –

Examples of control measures may include:

- Preventing access to the hazards
- Organising your work to reduce exposure to the hazard
- Issuing protective equipment
- Providing welfare facilities such as first-aid and washing facilities
- Involving and consulting with workers

Monitor and review

The safe systems (risk assessment, JSA, JSR etc) need to be regularly monitored to ensure thatthey are effective. It is often the case that more can be done to further reduce the level of riskas identified through effective monitoring.

Just because a system is effective, it does not mean it is having maximum effect. It must also be noted that whilst all personnel involved in work under any specific risk assessment must havereceived suitable and sufficient information, instruction, training and supervision, this also applies to the supervisory role of those personnel carrying out the monitoring of the safe systemsof work in place.

Manufacturing of Lifting Equipment

The materials used in the manufacturer of lifting equipment will need to be strong and capable of resisting shock loads, but depending on application other properties will be required:

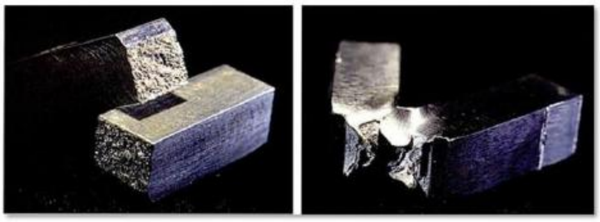
- Resistant to wear
- Resistant to chemicals
- Resistant to extreme temperatures
- Resistant to corrosion

Sometimes the material has to be capable of being welded.

Material Properties

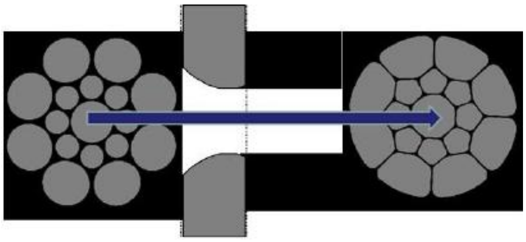
Lifting equipment requires a balance of physical and chemical properties to make it suitable for its purpose.

- Strength: Strength is a measure of how well a material can resist being deformed fromits original shape. Typically, metals are specified for their tensile strength or resistanceto being pulled apart, but compressive strength is also a legitimate material property describing resistance to being squeezed



- Ductility: Ductility is a mechanical property that describes the extent to which solid materials can be plastically deformed under tensile stress without fracture

- Malleability: Malleability is similar to ductility, but it is a material's ability to deform under compressive stress. A good example of this is the manufacture of wire for wire ropes

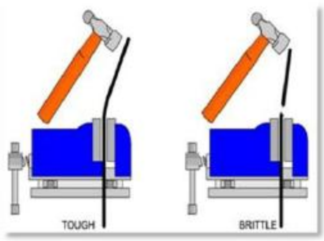


- Brittleness: Brittleness is the tendency of a material to fracture or fail upon the application of a relatively small amount of force, impact, or shock
  - Brittleness is the opposite of toughness

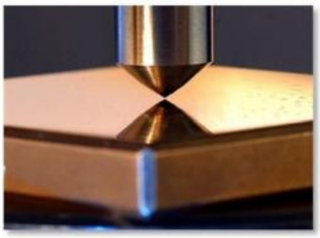
- Elasticity: The ability of a material to return to its original dimensions after the removal ofstress. A good example of this is a spring

Plasticity: The ability of a material to retain its new dimensions once the stress is removed. Agood example of this is a stretched chain link

Toughness: Toughness is the ability of a material to absorb energy and plastically deform without fracturing



Hardness: Hardness is a measure of how resistant solid matter is to various kinds of permanent shape change when a compressive force is applied



Corrosion: This is the electrochemical oxidation of metals in reaction with an oxidant such as oxygen. Rusting, the formation of iron oxides is a well-known example of electrochemical corrosion. This type of damage typically produces oxide(s) or salt(s) of the original metal

Materials commonly used in the manufacture of lifting equipment

- Materials used for the manufacture of lifting equipment are typically grouped into 3 categories:

NOTE:

Metals

Metals are the primary group of materials used for lifting equipment manufacture. Metal is made from metal ores, which have to be mined and processed to transform them into usable materials. Pure metals are usually blended with other metals to change their basic properties. A mixture ofmetals is known as an alloy.

- Ferrous:

- Non – ferrous:

Iron and Steel

Pure iron is soft and easily shaped. Pure iron is too soft for many lifting equipment uses. Ironfrom the blast furnace is an alloy of about 96% iron with carbon and some other impurities. It is hard but too brittle for most applications, therefore most iron from the blast furnace is convertedinto steel by removing some of the carbon within it. This is done by blowing oxygen into the molten metal which reacts with the carbon, in turn producing both carbon monoxide and carbon dioxide which escape from the molten metal. The amount of oxygen used depends on the amount of carbon content required in the finished steel.

Carbon steels are produced in several types:

- Low carbon steel (MILD STEEL)
- Medium carbon steel (HIGHER TENSILE STEEL)
- High carbon steel (HIGH TENSILE STEEL)

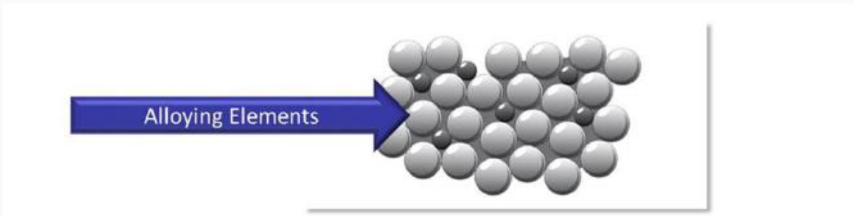
The quantity of carbon present will affect the tensile strength, with the form and distribution ofthe carbon affecting the mechanical properties. Typical amounts are 0.25% -0.33% for HigherTensile Steel.

- Mild steel is considered of limited use in the manufacture of lifting gear, i.e. chains andfittings. It is however used to fabricated items, such as grabs, trolleys, spreaders etc.

- Higher tensile steel is used to manufacture chain and fittings, resulting in a product one-third stronger than mild steel and recognised by grade marks 4, 04 or M.

High tensile steel has limited use in lifting equipment. The hard-wearing properties do howevermake it suitable for use in components such as wheel axles and gearboxes.

Other metals (alloys) are often added, such as vanadium and chromium which change thephysical properties of the steel, such as toughness, ductility, and hardness.

Alloy Steel	Alloy steel is a mixture of two or more elements, one of which is ametal (e.g. nickel, copper, titanium, chromium, vanadium etc.) whichare added to improve the properties such as increased strength, ductility and toughness. The disadvantage of alloy steels comparedwith carbon steels is that they are usually more difficult to weld, formand machine. Alloys contain atoms of different sizes. These different sizes distortthe regular arrangements of atoms. This makes it more difficult for the layers to slide over each other, so alloys are harder than the puremetal. 
Copper and its Alloys	An alloy used in lifting equipment such as wire rope sling securing ferrules. It is also a good conductor of electricity, used in cables. It is also non-magnetic and corrosion-resistant.
Brass	An alloy of copper and zinc. It has limited applications in lifting equipment.
Bronze	An alloy of copper and tin. The range of alloys can contain anything up to 18% tin to give the desired properties. It is tough and ductile and has good resistance to corrosion.
Monel Metal	An alloy containing nickel and copper with small percentages of manganese and iron. Good mechanical properties and excellent corrosion resistance. Monel metal is easily welded (although this isvery expensive) and therefore tends to be considered where steelgear cannot be used under any circumstances, such as acidic conditions.
Aluminium	Aluminium is very light (one third that of steel) and has good corrosion resistance. It has many uses in lifting equipment and its typical uses are jacks, jaw winch casings, hand chain hoist covers, and most notably, for ferrules for wire rope eyes. Mobile Lifting Frames and profiled runway beams are also manufactured from lightweight aluminium extrusions, e.g. light crane systems produced by many manufacturers.
Stainless Steel	This steel has a minimum of 12% chromium added to improve its corrosion resistance.

Strain Age Embrittlement

Alloy steel may contain impurities or additional elements to produce the required properties. Oxides in the finished steel can produce a form of brittleness known as strain age embrittlement. If the steel is over-strained, followed by resting in warm conditions, the steel may become very brittle.

The addition of elements such as manganese, silicon or aluminium which attract oxygen, will de-oxidise the steel and produce a steel known as 'killed steel'. This eliminates strain age embrittlement.

Steel Grades Used in Lifting Equipment

Grade 4 –

Grade 6 –

Grade 8 –

Grade 10 –

Grade 12 -

The history of material grades is rather complex. They are not in fact material grades but rather product grades. The origin is chain and the grade is the breaking strength of the chain expressedas 'grade x chain diameter squared.
It only works in imperial units so a 1" grade 40 chain broke at 40 x 1^2 = 40 tons. A ½ "grade 80 breaks at 80 x $½^2$ = 20 tons.

When chain went metric some companies started using letter grades to make the distinction.Others used an abbreviated number e.g. 4 instead of 40.

Coincidentally the mean stress at failure when expressed in N/mm^2 is almost 10 x the breakingstrength in tons derived from the above formula. So imperial grade 80 has a mean stress at failure of approximately 800 N/mm^2. The mean stress is now used to define the grade. So grade 40 became M or 4, 60 became S or 6 and 80 became T or 8. This has continued with grade 100being V or 10.

There were a few variations along the way. The original BS grade 40 was used at a factor ofsafety of 5:1 and because of that, it could either be in the normalised condition or hardened and tempered. To make the distinction the mark 04 was used for normalised and 40 for hardenedand tempered. Later the factor of safety was reduced to 4:1 so it had to be hardened and tempered and again to make the distinction, grade M was used. So all three have the same breaking strength but the heat treatment and rating varied.

Once all grades of chain were hardened and tempered, the letters and numbers became interchangeable and expressed as M(4), S(6) and T(8). However, when we started the European standards programme in the late 1980s, we agreed to use the number grades for medium tolerance chain for chain slings and the letter grades for fine tolerance chain for hoists. At the same time, we started using the terms medium tolerance and fine tolerance. Previously chain forhoists was termed calibrated to make the distinction but in practice, all machine-made chain iscalibrated as part of the manufacturing process, the distinction is one of accuracy.

Did you know?

The European separation of number and letter grades were then adopted in ISO.
We also have a few other variations. Chain for use in hand-operated hoists is through-hardened but for power operation, it is surface hardened to improve the wear hence we have grade T (Types T, DAT and DT) with types of DAT and DT being surface hardened. Also in ISO, we have grades TH and VH these being through-hardened grades T and V for hand-operated hoists.

When applied to components other than chain, the grades are not defined strictly by stress levels, rather by being compatible with the same grade of chain so whilst the maximum stresslevels may be of a similar order, it is the manufacturer who decides on most of the dimensions(within the confines of the dimensional envelope) and therefore the stress level. Hence 'Kuplex'can use the same components for grades 8 and 10.

NOTE:

Basic Machines

What is a machine?

A machine is a mechanism that uses an applied force at one part of the machine to transmit to another part, in order to gain a mechanical advantage for a specific purpose.

Types of Machines

There are two categories when it comes to machines, these are:

- Simple machines
- Compound machines

Simple machines	A lever is an object that acts as a pivot point that multiplies the forcethat can be applied to another object. The wheel and axle is a rodattached to a wheel that can multiply an applied force. A pulley consists of a wheel on an axle with a rope running over the wheel. Pulleys are used to change the direction of an applied force. The inclined plane is a flat surface with ends at different heights. Inclinedplanes reduce the amount of force required to move an object. Wedges are triangular-shaped and used to separate, hold or lift anobject. Screws are cylindrical shafts with grooves that pass throughor move other objects through rotational force.
Compound machines	A collection of simple machines working together. Compound machines are the most common type of machine and do more complex work than individual simple machines. They perform morework and therefore offer a greater advantage than simple machinesalone. Compound machines may consist of various and innumerable combinations of simple machines. For example, a mobile crane's mechanisms would include levers (the jib/mast), pulleys (sheaves), screw (limit switch), wheel and axle (drive train wheels) etc.

Lifting equipment is manufactured using multiple combinations of basic machines in order to carry out a particular task.

NOTE:

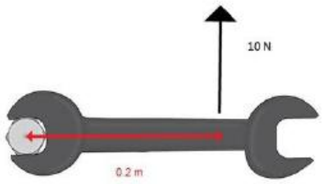
Weight and Force (F)

Although not strictly true, we will consider weight and force to be equal and expressed in thesame units. In a lifting machine, a small weight or force is used to lift a larger weight or force. Wecall the force required to do the lifting, the effort. We call the force being lifted, the load.

Simple machines provide mechanical advantages. They make our work easier by increasing theamount of work done with a certain amount of effort, or by decreasing the amount of effort required to do the same work.

Work, be definition, equals force x distance.

When a force (effort) is applied to a lever it gives it a turning effect, which is known as the Moment of Force or Turning Moment.
When we apply a force (F) on the spanner at a distance (d) from the centre of the bolt, the turning moment on the bolt is F x d.



Question:

Using the image above, calculate the turning point. (Select one answer)

□ 0.5Nm

□ 10.2Nm

□ 2Nm

□ 9.08Nm

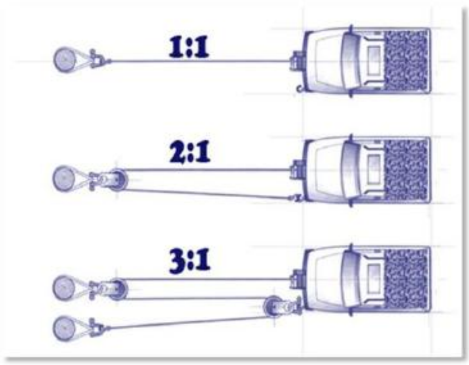
NOTE:

Mechanical Advantage (MA)

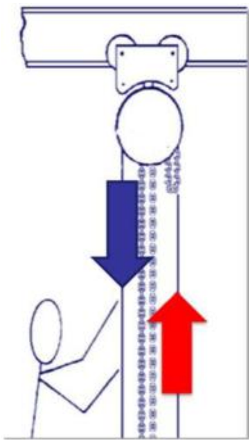
When the force and effort in a machine are equal, a state of equilibrium exists. Any subsequent increase in effort will move the load. In more complicated machines, e.g. a hand chain hoist, the effort required to move a load is usually much smaller than the load. Their relationship is known as the Mechanical Advantage. The mechanical advantage allows the device to perform the taskfor which it was designed.

Consider...

Consider the Mechanical Advantage of a simple winch. By increasing the lines of cable betweenthe winch and the vehicle being pulled, we can pull more than the working load limit of the winch.

Example...	▪ 1t WLL winch and 1 line of cable = 1t Max. tow weight ▪ 1t WLL winch and 2 lines of cable = 2t Max. tow weight ▪ 1t WLL winch and 3 lines of cable = 3t Max. tow weight  NOTE: this illustration does not consider friction.

A chain hoist is operated by hand. An operator will pull down on one of the chain loops on oneside of the chain. This will turn a pulley mechanism inside the chain hoist housing. When thispulley turns, it lifts up the end of the other chain, which usually has a hook on the end. By pullingdown on one chain, the manual hoist is actually able to increase the mechanical work that isbeing done. This is caused by the gear ratio inside the manual chain hoist. Typically, the forceexerted on the hand chain can be multiplied by the gearbox as much as 30 times.



Having established that the relationship between of the load (W) to the effort (P) is the mechanical advantage, this is represented by a simple formula:

Mechanical Advantage = Load ÷ Effort

So if we know the load that is to be lifted and the amount of effort that has to be applied to themachine in order to do so, we can calculate the mechanical advantage.

Note: we do not use any particular units of measure for a mechanical advantage as this is a simple mathematical ratio.

Question:

Select from the options below which one is the correct Mechanical Advantage calculationif the load is 300kg and the Effort is 50kg. (Select one answer)

- ☐ 4
- ☐ 6
- ☐ 3

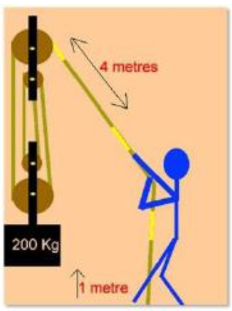
NOTE:

Velocity Ratio (VR)

Are machines can move large loads by applying small amounts of force.

Unfortunately, as we all know, you never get something for nothing and in order to move theload a short distance, it is necessary for the effort to travel a greater distance. Having establishedthat the relationship between these movements is called the Velocity Ratio, this can be represented by the following formula:

Velocity Ratio = Distance moved by effort ÷ Distance moved by load (or DME ÷ DML)



Question:

Select from the options below which one is the correct Velocity Ratio calculation if thedistance moved by effort is 75m and the distance by load is 3m (Select one answer)

☐ 25

☐ 30

☐ 10

NOTE:

Efficiency (EFF)

Are machines are designed to waste as little energy as possible. This means that as much of the input energy as possible should be transferred into useful energy stores. Efficiency indicates how good a machine is in transferring energy input to useful energy output. A very inefficientdevice will waste most of its input energy. A very efficient device will waste very little of its inputenergy. The following formula can be used to establish the relationship between the Mechanical Advantage and Velocity Ratio to establish the Efficiency of a machine:

Efficiency = MA ÷ VR x 100%

Question:

Using your answers above, what is the Efficiency calculation? (Select one answer)

☐ 16

☐ 24

☐ 12

NOTE:

EXAMPLE

A machine has a mechanical advantage of:
- Load (300kg) ÷ Effort (30kg) = 10

Velocity ratio can then be calculated as:
- Distance moved by effort (50m) ÷ Distance moved by load (2m) = 25

Efficiency is:
- Mechanical Advantage (10) ÷ Velocity Ratio (25) x 100 = 40% efficiency

Polymers and Natural Fibres

Polymers

There are two types of polymers:

Natural Polymers: Such as shellac, wool, silk and natural rubber have been used for centuries. A variety of other natural polymers exist, such as cellulose, which is the main constituent of woodand paper.

Synthetic Polymers: Are materials such as synthetic rubber, resin, nylon, polyvinyl chloride (PVC or vinyl), polypropylene, polyamide, polyester, high modulus polyethylene (HMPE) and others.

NOTE:

Polymer products are lightweight which makes them ideal for moving around from job to job. Theproperties of polymers can be altered by introducing additives such as plasticisers and stabilisers.

In the lifting equipment industry, polymers are commonly used for roundslings and flat webbing slings, ropes, gears, bushes and sheaves. Nylon compounds, often in association with latex andrubber, are also used to manufacture wear seals, pressure seals and oil seals.

Natural Fibres

Fibre rope slings are the traditional form of textile sling whose origins are recorded in the earliesthistory of lifting equipment.

Although their use has declined in recent years in favour of the newer forms of textile slings, i.e. flat woven webbing slings and roundslings, they may still be found ingeneral use throughout the industry.

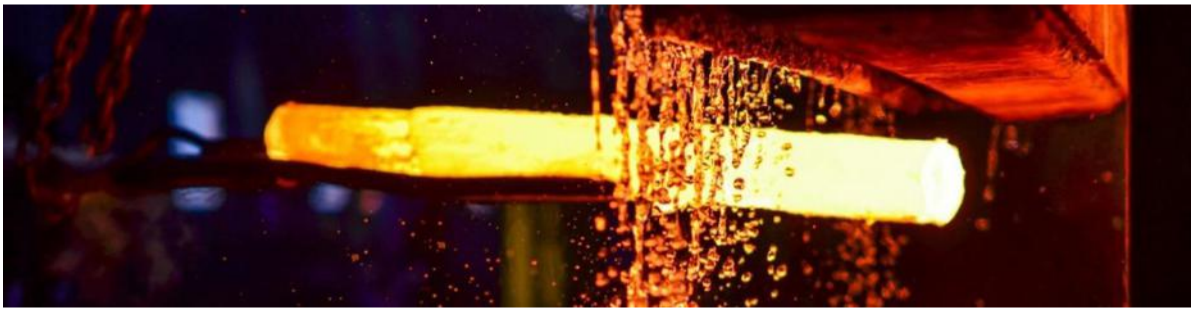
Natural fibres are produced from grasses and other leaves that are spun to form ropes. Fibre rope slings are produced from cut lengths of rope which are then hand spliced. Common natural fibres for rope slings include manila, hemp and sisal.

Heat Treatment

There are various reasons for carrying out heat treatment.

Heat treatment is the process of heating and cooling metals to change their microstructure and to create the physical and mechanical characteristics that make metals desirable for specific applications. The temperatures metals are heated to, and the rate of cooling after heat treatment, attribute to a metal's final properties and can:

- Increase the strength (hardening a material)
- Decrease the strength (soften a material)
- Complete or surface hardening of a material
- Toughen a material by tempering
- Relieve stresses in a material
- Anneal a material after cold working to soften it, or to refine its grain structure

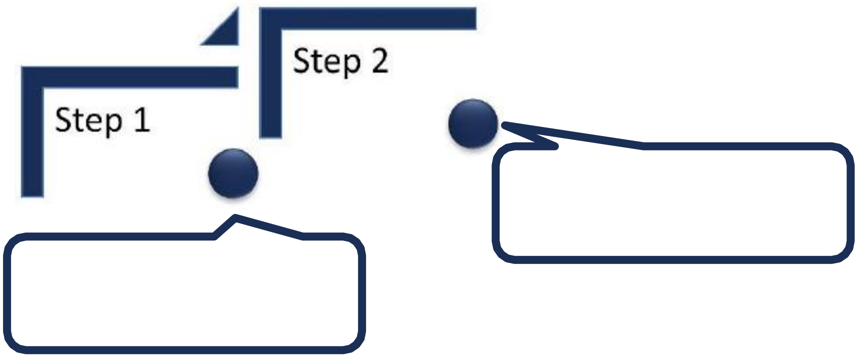


Although each of these processes bring about different results in metal, all of them involve threebasic stages: heating, soaking, and cooling.

These 3 stages are used accordingly by the manufacturers to gain their desired

properties.Hardening and Tempering as being the most common form of Heat Treatment.

Heat treatment of steel is normally a two-step process.



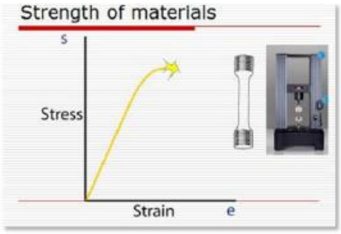
Heat treatment can therefore change properties of materials, such as

- Toughness
- Brittleness
- Ductility
- Hardness

NOTE:

Stress and Strain

“ It is unlikely that you will need to carry out stress calculations as a lifting equipment examiner. However, it is important to understand their effects on equipment being examined and tested. **- LEEA ”**



Stress

There are forces acting on lifting equipment when it is under loaded conditions. Strength is therefore an important mechanical property of any lifting equipment. It is related to how muchforce can be applied to the equipment before it eventually breaks. The load (force) applied tothe equipment and its cross-sectional area is the resultant stress in the material. It is the stresswhich controls whether a material will fail. The stress is found by dividing the (load) force by the cross-sectional area.

In simple terms, when calculating stress, a force is usually spread over a given area resulting ina pressure of magnitude force unit ÷ area unit.

Calculating Stress

When calculating stress, the material section is usually measured in mm giving an answer in N/mm². This is easy to convert as 1 N/mm² = 1MN/m². Strictly speakng the SI unit of stress has its own name – Pascal, which is abbreviated to Pa. 1Pa = 1N/m².

Some national standards use foot/lbs for measuring pressure and stress.

Strain

When a load (force) is applied to lifting equipment it will respond by changing its shape. This isknown as strain.

Take an elastic band for example. If you hold it at its ends in a relaxed state, it will show no signsof extension, but as you apply an opposing force to the elastic band between your hands, it willbegin to stretch. This extension of the elastic band is known as strain.

Stress =

Strain =

The Tensile Test

The tensile test, also known as the tension test, is probably the most fundamental type of mechanical test you can perform on material.

- The Tensile Test

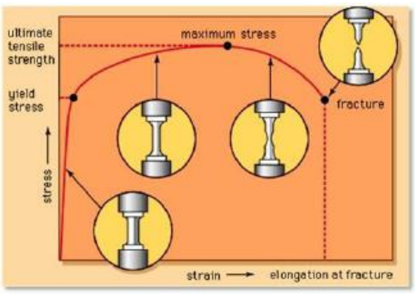
This tensile test reveals a great amount of information about the material and quantifies the important properties of the material.

- Why is this test important?

Lifting equipment examiners need to know these properties and how they are determined in order tounderstand various material specifications and relate these to their suitability for making lifting equipment.
A standard size specimen of the material to be tested is machined to a predetermined size. The
cross-section of the specimen is usually round, square or rectangular. For metals, a piece of sufficient thickness can be obtained so that it can be easily machined - a round specimen iscommonly used. For sheet and plate stock, a flat specimen is usually used.

From the tensile test, we can use the results to determine how a material will react under tensileloading. Typical properties revealed include the elastic limit, yield point, ultimate tensile strength and elongation/reduction in the cross-sectional area of the material under test.

A tensile load is applied to the specimen until it fractures. During the test, the load required tomake a certain elongation on the material is recorded. A load/elongation curve is plotted by arecorder so that the tensile behaviour of the material can be obtained.



NOTE:

From a tensile test, a stress/strain, or sometimes known as a load/extension curve can beproduced. Five definite points can be seen as the line of the graph below:

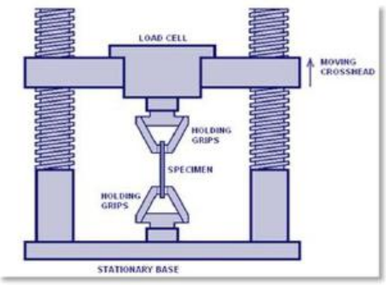
A. Limit of Proportionality

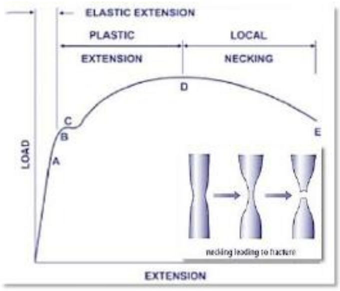
B. Elastic Limit

C. Yield Point

D. Tensile Strength

E. Ultimate Breaking Stress





Question:
What is meant by the term, 'local necking'? (Select one answer)

□ a. When a material under tensile load exceeds its maximum tensile strength, a reduction inmaterial cross-sectional occurs which is known as local necking.

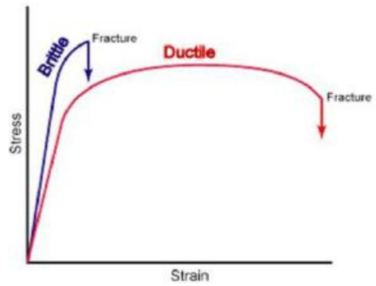
□ b. When a material reaches its elastic limit, the measured reduction in cross-sectional area iscalled the local necking yield.

NOTE:

Tensile Test Definitions:

There are some key phrases/terms used regarding tensile test – see below:

Limit of Proportionality	Initially as the force is applied the stress and strain are proportional until point A is reached. This is the point at which the graph is no longer a straight line. This point is known as the Limit of Proportionality.
The Elastic Limit	This is the point up to which the material remains elastic. Within theelastic limit, the test piece will return to its original dimensions if the load is removed. (With mild steel this point practically corresponds with the Limit of Proportionality. This is not generally true of other materials or for materials that have been overstrained). When this point has been exceeded the extension is permanent and is referred to as Plastic Deformation.
Yield Point	Slightly above the elastic limit, the Yield Point is reached when a sudden permanent extension, B to C, occurs without any increase inload. (Sometimes there is a slight drop in the load, due to the extension, giving an upper and lower yield point).
Tensile Strength	The Tensile Strength is reached at this point. When this is passed thecross-sectional area becomes noticeably smaller and 'necking' occurs. This is the point of maximum load.
Ultimate Breaking Stress	This is the actual breaking load where an increase in stress is obtainedwith a reduction in load. Although the value is smaller than the tensilestrength this gives a false impression of what occurred. From points D to E the section of the test piece considerably reduces as it 'necks' - thereby effectively increasing the stress. However, as the graph records the stress as load over the original cross-sectional area, it appears to decrease.



There is a clear difference between a ductile material and a brittle material under the same tensile test. A brittle test piece withstands deformation until the stress applied is at a relatively highlevel. It then yields, deforms and fractures.

A ductile test piece withstands deformation but yields at a lower level of stress than the brittletest piece. This is because the ductile material is not as strong as the brittle material. The ductilematerial then continues to elongate, reaching its maximum tensile stress and eventually fracturing.

NOTE:

Shear, Tension and Compression

Loading conditions: lifting equipment may be subjected to single or multiple types of stress:

- Single shear – forces acting across a material
    - Example: A lifting lug on a waste skip being lifted

- Double shear – forces acting across a material in two areas
    - Example: A shackle pin under load

- Compression – a pushing force
    - Example: A jack body under load

- Tension – a pulling force
    - Example: A chain sling under load

- Torsion – a twisting force
  - Example: A rotating gearbox shaft driving a hoisting appliance

Throughout your studies with LEEA at Diploma level you will gain further understanding of these forces in different applications and why it is important for the lifting equipment examiner to be able to recognise deformation in equipment during periodic inspections.

NOTE:

Units of Measure

A unit of measure can be described as a standardised quantity of a physical property, used todetermine multiple quantities of a given property.

For example:

- Weight
- Length
- Mass
- Force

Different systems of units are based on different choices of a set of fundamental units. The mostwidely used system of units is the International System of Units, or 'SI'. There are seven SI base units. All other SI units can be derived from these base units.

Under the SI system when marking lifting equipment only one decimal point is used for fractions of a tonne e.g. 2.1t, apart from when marking 0.25 which is always to two decimal places, e.g.2.1t, 2.2t, 2.25t, 2.3t, 2.4t, 2.5t, 2.6t, 2.7t, 2.8t, 2.9t

Did you know?

Some manufacturer use 2.75t although this does not align with the sequence above.
Example: a 4.75tn Shackle

NOTE:

Question:
Let's check your understanding of symbols relating to units of measure. From the listbelow, select which one you think matches the symbol of 'cwt'. (Select one answer)

- ☐ Pound
- ☐ Hundredweight
- ☐ Imperial or US Ton
- ☐ Metric tonne
- ☐ Kilogrames

NOTE:

Question:
From the list below, select which one you think matches the symbol of 'T'. (Select oneanswer)

- ☐ Imperial or US Ton
- ☐ Hundredweight
- ☐ Kilogammes
- ☐ Metric tonne
- ☐ Pound

NOTE:

Symbols and Conversions

Ton (US)	T = Imperial or US Ton 1 Ton (US) = 2000lbs = 907.185kg = 0.907t (metric) (commonly referred to as the 'short Ton')
1 tonne (Metric)	t = Metric tonne 1 tonne (metric) = 1000kg = 2204.62lbs (rounded to 2204lbs)
1 Ton (Imperial)	kg = Kilogrammes 1 Ton (imperial) = 1016kg = 2239.9lbs (rounded to 2240lbs) ('long Ton' in the USA)
1 cwt	cwt= Hundredweight1 cwt = 50kg The hundredweight was established in the imperial measurement system inwhich 1 Ton is divided into 20 subdivisions, each being a hundredweight. Occasionally, lifting accessories may be found in service today with a marked safe working load or working load limit of 'cwt'. 1 hundredweight(cwt) = 50 kg, therefore, a marked load limit of 2 Ton 1 cwt = 2050kg, rounded down to 2t.

1 Ton (US) =

- 2000 lbs (pounds)
- 907.185 kg (kilogrammes)
- 0.907 tonne (metric tonnes)

1 Ton (Imperial) =

- 2239.9 lbs (pounds) *Rounded to 2240 lbs
- 1016 kg (kilogrammes)

1 tonne (metric) =

- 2204.62 lbs (pounds) *Rounded to 2204 lbs
- 1000 kg (kilogrammes)

1 cwt (hundred weight) =

- 50 kg (kilogrammes)

Other useful conversions:

- 1kg = 2.2lbs
- 1 inch = 25.4mm
- 1 foot = 12 inches
- 10kN = 1000kg (approximately)

The SWL of new equipment will normally be in the metric units of tonnes (t) or kilograms (kg) orimperial units of Tons (T) and Pounds (lb). The generally accepted rule is that a SWL of less thanone tonne or Ton are marked in kilograms or pounds, respectively.

NOTE:

All lifting equipment should be of adequate strength, sound material, of good construction and suitable for the duty which it must perform.

Types of Verification

New equipment should comply with the essential health and safety requirements stipulated inany applicable legislation, product standard where available, and issued with the required conformity documentation. This documentation is often combined with the results of the verification and together they form the 'birth certificate' which is an important legal document.

What is verification?

Verification is the generic term used to describe the procedures adopted by the manufacturer or Competent Person to ensure that lifting equipment is to the required standard or specification, meets legal requirements and is safe to operate. This includes proof load tests, sample break tests, non-destructive tests, calculation, measurement and thorough examination.

New Equipment

For new equipment, the verification methods used by the manufacturer will depend on the standard being worked to. Some equipment is unsuitable for proof load testing due to the nature of the materials used, e.g., textile slings. Some items are assembled from components verifiedto their own standards so no further tests are required, e.g., grade 8 mechanically assembledchain slings. Once in service, the verification methods used will be those deemed necessary bythe Competent Person in reaching their conclusions about fitness for purpose.

Types of Verification

There are many types of verification and test available to the examiner, including:

-
-
-
-
-
-
-
-

Test Machines and Force/Load Measuring Equipment

Many of the product standards and codes of practice that require the application of a load, orforce, lay down the accuracy to which the test load or force must comply.

For example, BS EN 818-1 for chain requires accuracy of ±1%.

The LEEA Technical Requirements for Members and Guidance document (reference LEEA-042) is available to download on our website – https://leeaint.com/documents

It requires that test machines and load cells be calibrated and verified by a competent person orauthority, in accordance with ISO 7500-1 at intervals not exceeding 12 months. It also requiresthat the accuracy of the applied load/force must be within that required by the standard beingworked to and, in all cases, within ±2% of the nominal load/force.

ISO 7500- 1 has various classes or grades of machines:

- 0.5
- 1.0
- 2.0

This relates directly to the accuracy.

Grade 0.5 = ±0.5%, 1.0 = ±1% and 2.0 = ±2%.

This information will be given on the certificate of calibration and verification. In some cases, dependent on the design and construction of a test machine, or load measuring device, two grades may be shown.

For example, grade 1.0 for one range of readings, grade 2.0 for a further range of readings.

The certificate will also give the Lower Limit of Calibration. This will be expressed as a load or force, depending on the units in which the machine or device is calibrated. This is the minimumload/force that can be read from the display within the required accuracy. Test loads below this cannot be measured with this equipment. In some cases, there may also be a similar restriction on the upper limit.

The person performing any form of load test must be aware of the limitations for use imposed on the test machine, or load/force measuring equipment, and ensure that the accuracy of the applied load meets the requirements of the standard being worked to.

Dimensional Measuring equipment

Only the most basic of dimensional measuring equipment, such as a tape or rule, is usually called for in the verification of lifting equipment. This should be graduated to national standards in increments of 1 mm. For certain items, a Vernier gauge may be necessary. In this case graduation of 0.1 mm is usually enough when examining general lifting equipment.

LEEA Technical Requirements

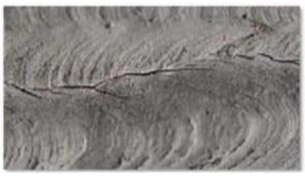
LEEA Technical Requirements requires that a procedure be in place for checking and verifyingmeasuring devices at appropriate periods. For tapes and rules, it will probably only be necessaryto regularly check them to ensure that they are undamaged. However, precision measuring equipment will require periodic verification.

NOTE:

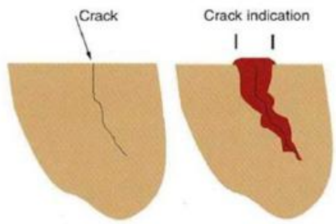
Crack Detection

When dealing with general lifting equipment, usually only basic crack detection (such as dye penetrate or magnetic particle) is performed to examine welds. Trained operatives are requiredto perform the tests and interpret the results. The tests are relatively inexpensive, both in termsof the equipment and the labour necessary to perform the tests.

For more detailed crack detection examinations, particularly on high-value items or where additional safety requirements require a higher degree of examination, other methods used are eddy current, radiography and ultrasonic. These are more expensive to perform and call for ahigh degree of training and skill to interpret the results.



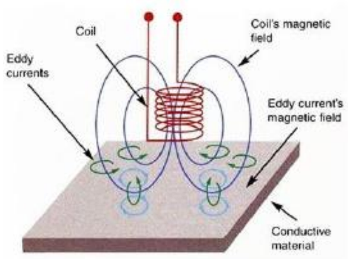

Dye Penetrant: Dye penetrant crack detection is used to locate cracks, porosity, and other defects that break the surface of a material and have enough volume to trap and hold the penetrant material. Liquid penetrant testing is used to inspect large areas very efficiently andwill work on most nonporous materials.



Magnetic Particle (MPI): common and easy to use method for the detection of surface cracks and laminations in ferrous/magnetic materials and is primarily used for crack detection.

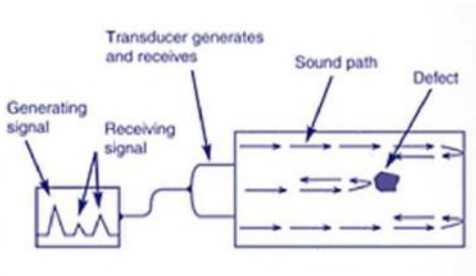
The specimen material is magnetized and if the material is sound, the magnetic flux is predominantly inside the material. If there is a surface-breaking flaw, the magnetic field is distorted, causing local magnetic flux leakage around the flaw. This leakage flux is displayed by covering the surface with very fine iron particles applied either dry or suspended in a liquid. MPIis considered much more accurate, effective, and efficient than inspections that use dye penetrants. MPI is excellent at detecting flaws on the surface of objects.

Eddy Current: this test can accurately find tiny flaws (cracks, corrosion, erosion, material degradation and loss of thickness in a material) in materials using hi-tec software and detection equipment. Operators can identify anomalies on both the surface and sub-surface of a materialwith good levels of accuracy. It cannot however be used on materials that are non-conductive.It requires minimal set-up time and there is no requirement to use chemicals or radiation in theprocess.

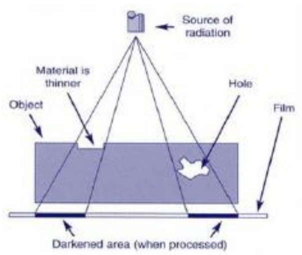


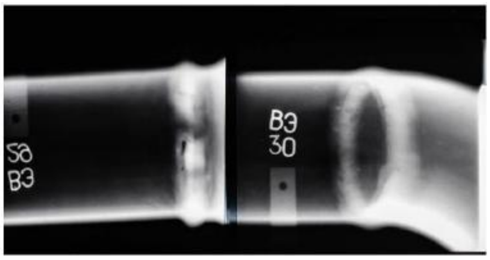
NOTE:

Ultrasonic: a transducer is moved over a material by the operator. This subjects the material to high-frequency sound waves; tiny cracks, hairline fissures, microscopic pockets will create anecho that is shown visually on the test machine. The benefits of UT include speed, reliability and versatility for use in the field. In addition, the results of particular tests can usually be recorded, allowing for comparisons to be made over a length of time (identifying signs of deterioration). It is now one of the most commonly used methods of NDT.



Radiography: a hazardous form of NDT that is not so common now as it has been in the past.Operators can be exposed to dangerous doses of radiation and there are extremely specialist skills are required to use this equipment. The test monitors the varying transmission of ionisingradiation through a material with the aid of photographic film or fluorescent screens to detectchanges in density and thickness. It will locate internal and surface-breaking defects.

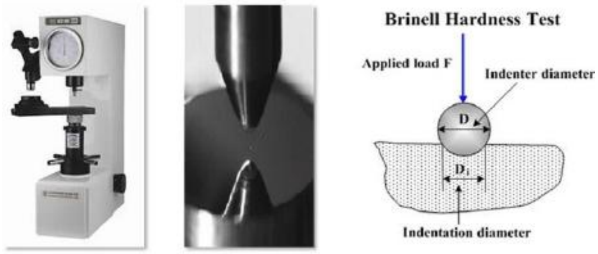




Electromagnetic Wire Rope Examination: This is a fast method of detecting defects in long lengths of wire rope. The rope is passed through a magnetic field. Breaks and disturbances inthe magnetic field are detected and a printout of the field is given. The test involves using aninstrument to examine ferromagnetic wire rope products in which the magnetic flux and magnetic flux leakage methods are used. If properly applied, the magnetic flux method is capable of detecting the presence, location, and magnitude of metal loss from wear, broken wires, andcorrosion, and the magnetic flux leakage method is capable of detecting the presence and location of flaws such as broken wires and corrosion pitting.

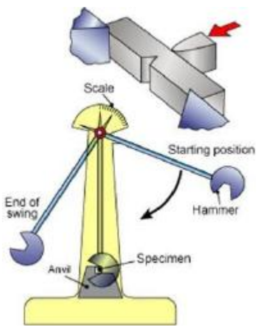
NOTE:

Hardness: indentations are used to verify the hardness of lifting equipment following heat treatment, or where equipment is used in conditions that might affect the heat treatment. There are three basic methods: Vickers, Brinell and Rockwell. Brinell is the most common method used in the lifting equipment industry by manufacturers.

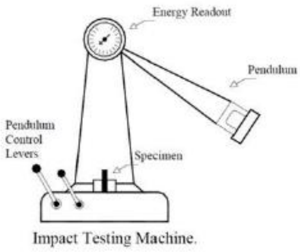


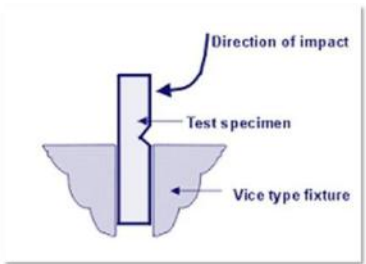
The Brinell Test

Impact: the impact test is normally carried out by manufacturers using one of two methods, Charpy, or Izod. The Charpy impact test, also known as the Charpy V-notch test, is a test thatdetermines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's notch toughness and identifies the properties that material willexhibit when it experiences a shock loading that causes the specimen to immediately deform,fracture or rupture completely. A specimen of material is supported at its two ends on an anvilthen struck on the opposite face to the notch of the swinging pendulum and broken as the pendulum swings through it. The height of the pendulum swing measures the amount of energy absorbed during fracture. Three specimens are tested at any one temperature.



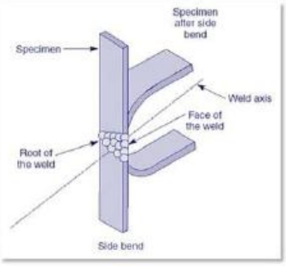
The Izod Impact test is similar to the Charpy test but in this test, the material is held vertically ina vice type jaw and is in a cantilever. Izod impact is defined as the kinetic energy needed to initiate fracture and continue the fracture until the specimen is broken. Izod specimens are notched to prevent deformation of the specimen upon impact. This test can be used as a quickand easy quality control check to determine if a material meets specific impact properties or tocompare materials for general toughness.





Bend: this is a simple and inexpensive qualitative test that deforms the test material at the midpoint causing a bend to form without actually breaking the specimen. The test can determinethe ductility or resistance to fracture of a material. Generally, a bending test is performed onmetals or metallic materials but can also be applied to any substance that can experience plasticdeformation, such as polymers and plastics.

The bend test is usually used for the testing of welds. The purpose of bend testing welds is tomake sure that the weld has properly fused to the parent metal and that the weld itself does notcontain any defects that may cause it to fail when it is subjected to bending.



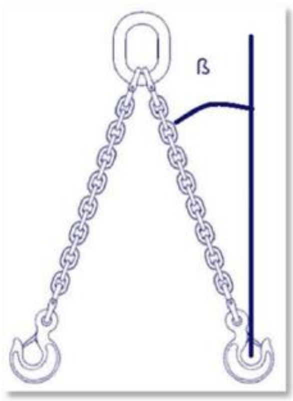
Marking Lifting Equipment: marking should be by suitable means, i.e. plate, metal tab, textile label, etc, permanently attached or by stamping directly into the equipment, preferably in a non- load bearing or low-stress area. Stamping into a stressed area may also be permissible provided that the mechanical properties of the component are not significantly impaired. Where applicable, the position and size of stamping should be as indicated in the relevant standard.When the means of marking can be lost, additional information should be used to convey thisinformation. It is therefore recommended that the identification mark should also be put directly onto the equipment so that in the event of the original means of marking becoming detached,the identity is not lost, and the other information can be recovered from the related documentation. It may occasionally be necessary to re-mark lifting equipment, but care must be taken in doing so as stress raisers may be induced. Marking should therefore only be made on selected areas where detrimental effects are minimised, and the stamping should not be too sharp or excessively deep.

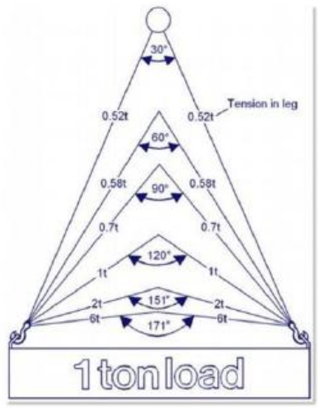
NOTE:

Trigonometry of slinging and the effects of angles in sling legs

Uniform and trigonometric load methods

When multi-leg slings are used at angles, the load in the individual sling legs will increase as theangle of each leg to the vertical (included angle between the sling legs) becomes greater.





There are currently many multi-leg slings in service which are marked with the rating expressedat the 'included angle' or range of angles, e.g. 0-90°. This is the angle between the legs of thesling, and it should be noted that the LEEA COPSULE no longer recommends this method, statingthat best practice is to use the angle between the sling leg and the vertical.

As many geographical regions will not yet have adopted this approach, we will reference boththe 'included angle' and 'angle to the vertical' in this training course. It must however be notedthat in some regions, the angle of the sling leg to the horizontal is also used (e.g. USA) and atspecifically included angles of 60°, 90° and 120° (e.g. Australia). These will be visited in the regional versions of the Lifting Accessories Diploma (Australia) / (USA) training courses.

NOTE:

If a sling is to be used safely, allowance must be made for this angle and this is achieved by rating the sling in one of two ways. The two methods of rating are often known as the 'uniformload method' and the 'trigonometric method'.

<table>
<tr><td>The Uniform Load Method</td><td>This is a simpler option. It has built-in safety advantages which allow only one working load limit up to an angle of 45° to the vertical (90° included angle) and a reduced working load limit at angles between 45° and 60° to the vertical (90° and 120° included angle). This is the recommended method that should be used for all multipurpose slings. The working load limits are obtained from the following:

• Single leg sling = 1.0 x WLL of a single leg
• Two leg sling 0-45° (included angle 0-90°) = 1.4 x WLL of a single leg
• Two leg sling 45°-60° (included angle 90° -120°) = 1.0 x WLL of a single leg
• Three and four-leg sling 0-45° (included angle 0-90°) = 2.1x WLL of a single leg
• Three and four-leg sling 45°-60° (included angle 90° -120°) = 1.5 x WLL of a single leg

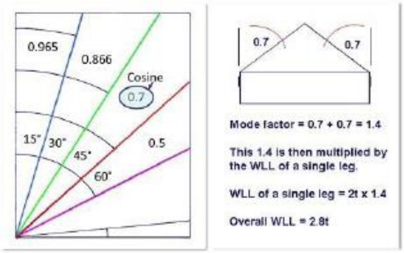
Standards where the uniform load method has been used, rate a multipurpose four-leg sling at the same working load limit as a three-leg sling of the same size and grade. This is on the assumption that the load might be taken by only three of the four legs. However, some national standards have now been amended such that they work on the assumption that the load may be carried by two of the legs.

Note: Some standards do not recommend the rating of three leg slings at included angles greater than 90°. This is due to the danger of a user assuming that the 'included angle' referred to the angle between the legs of the sling instead of twice the angle of a leg to the vertical. Where slings are rated and marked on the basis of the angle to the vertical this danger does not exist.

In Australia, the WLL of multi-leg slings comprising of more than two legs is limited to the same WLL as a two-leg sling. This is rated at an included angle of 60° between sling legs.</td></tr>
<tr><td>Mode Factor</td><td>The mode factor is a numerical value that is applied to the marked working load limit of the sling to determine the maximum load which the sling may lift, according to the mode of use and assembly, e.g. angle of sling legs to the vertical in use.</td></tr>
</table>

Calculating the Mode Factor

The mode factor for various sling angles is derived from the cosine of the angle to the vertical.



Question:

The WLL of a single leg sling is 2t. If two of these identical slings are used together atan included angle of 0-45° to lift a load, what is the maximum load that the sling assemblymay lift? (Select one answer)

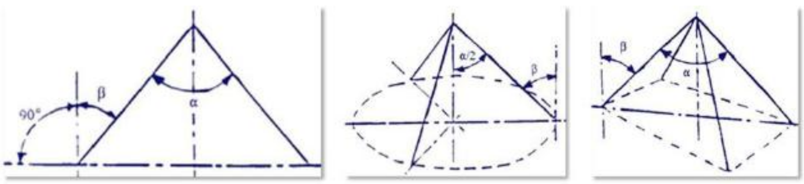
□ a. 4t
□ b. 2.8t
□ c. 1.4t
□ d. 5.4t

NOTE:

The Uniform Load Method Design Factors

The following design factors should be applied to the WLL of a single leg to establish the WLL ofmulti-leg sling assemblies or where a number of single slings are being used in combination:

- 2 leg sling 0°- 45° to the vertical (or 0° - 90° included) 1.4
- 2 leg sling 45°- 60° to the vertical (or 90°-120° included) 1.0
- 3 and 4 leg sling 0° - 45° to the vertical (or 0° - 90° included) 2.1
- 3 and 4 leg sling 45° - 60° to the vertical (or 90°- 120° included) 1.5



	0-45° (0-90°)	45° - 60° (90° -120°)
2 leg sling	1.4	1.0
3 and 4-leg sling	2.1	1.5

The Trigonometric Method

The trigonometric method provides for a variation in the working load limit as the angle to thevertical (or the angle between the sling legs) varies.

This method is the one that was previously used in many standards, but in order to use it formultipurpose applications, the operative must calculate the SWLs at various angles for each sizeof the chain, rope, etc. It also requires the operative to be trained in judging a range of anglesand has the inherent danger that if he should misjudge these, the sling may well be overloaded.

Although the uniform load method was introduced to some standard practices, some manufacturers continue to rate and mark multipurpose slings by the trigonometric method. Slings intended for multipurpose use marked this way will not comply with those standards that haveadopted the uniform load method and it is strongly recommended that this method should beused only for slings designed for a single purpose or in accordance with the applicable nationalstandards that permit it. Working load limits are obtained from the following:

Single leg sling	
Tow leg sling	
Three leg sling	
Four leg sling	

β is the angle to the sling leg from the vertical

Rating of Slings

The uniform load method simplifies matters by removing the need for tables and reducing theneed for the operative to estimate angles. Whilst the uniform load method of rating is most easily applied to equipment such as multi-leg slings, it may, with advantage, also be applied to suchitems as eyebolts when used in pairs.

Many national and international standards are now in favour of the uniform load method, largely on the grounds of safety and simplicity. However, this does not exclude the trigonometric method when working to national standards that allow it within their scope or with a justifiablereason to deviate from the uniform load method.

LEEA COPSULE

LEEA COPSULE recommends that the uniform load method is used for all multipurpose applications and that the trigonometric method should be restricted to slings designed and used for a single purpose. It should be clearly understood however that whilst equipment designed to be used under the trigonometric method may be re-rated and marked according to the uniform load method, the reverse is NOT always possible and my be dangerous. It is therefore recommended that to avoid confusion, all items of a given type (e.g. all chain slings) at the location should be rated and marked by the same method.

Other forms of rating for lifting equipment

Multi-Leg Slings (User Information): If a multi-leg sling is used with less than its actual numberof legs attached to the load, then obviously the safe working load of the sling must be reduced.The amount by which it should be reduced can be calculated exactly but it is rather complex, asnumerous factors need to be considered, including the method of rating. An easy way of ensuringthat the sling is never overloaded is to reduce the safe working load from that marked on thesling according to the number of legs in use. The following ratings apply:

- A 4 leg sling with only 2 of the legs being used:
- A 3 leg sling with only 2 of the legs being used:

Rating of Lifting Accessories

Endless slings have fewer variations of use, but it should be remembered that the slinging factor for endless chain and wire rope slings assumes choke hitch, whereas the standard rating for textile slings assumes a straight pull.

In all cases, it is also assumed that, at the points of attachment to both the lifting appliance and the load, the radius around which the sling passes are large enough to avoid damage to the sling. In the case of chain and wire rope endless slings, the rating takes account of the chain and wire rope being bent around itself on the bight.

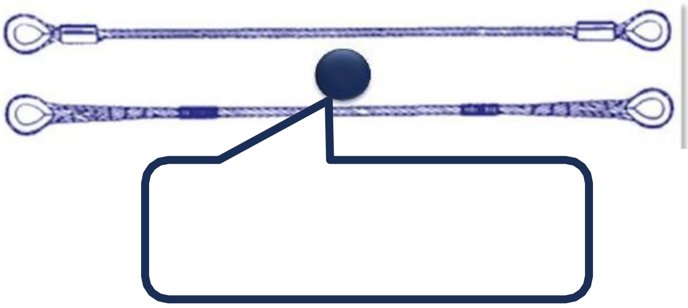
Rating of other types of lifting accessories will be detailed in the relevant modules within this, and further Diploma level LEEA courses.

Wire Rope Slings

Wire rope slings are very popular for general lifting duties. Due to their rigidity, they can be easily passed under loads when slinging. However, they are more susceptible to damage than chainslings.

The construction of the rope from which the sling is made is within reason unimportant provided that the rope has adequate flexibility and an adequate minimum breaking load (from which theSWL of the sling is calculated). The rope should be ordinary lay and maybe six or eight strandshaving a fibre or a wire core.

As with any lifting media, slings of all configurations can be assembled from wire rope and willbe found in service. Those working in the offshore industry will be familiar with the 'five leg' slings attached to offshore containers. These are actually four-legged wire rope slings with a pendantsling attached to the master link. In general industry, the most common type of wire rope slingin service is the single leg.



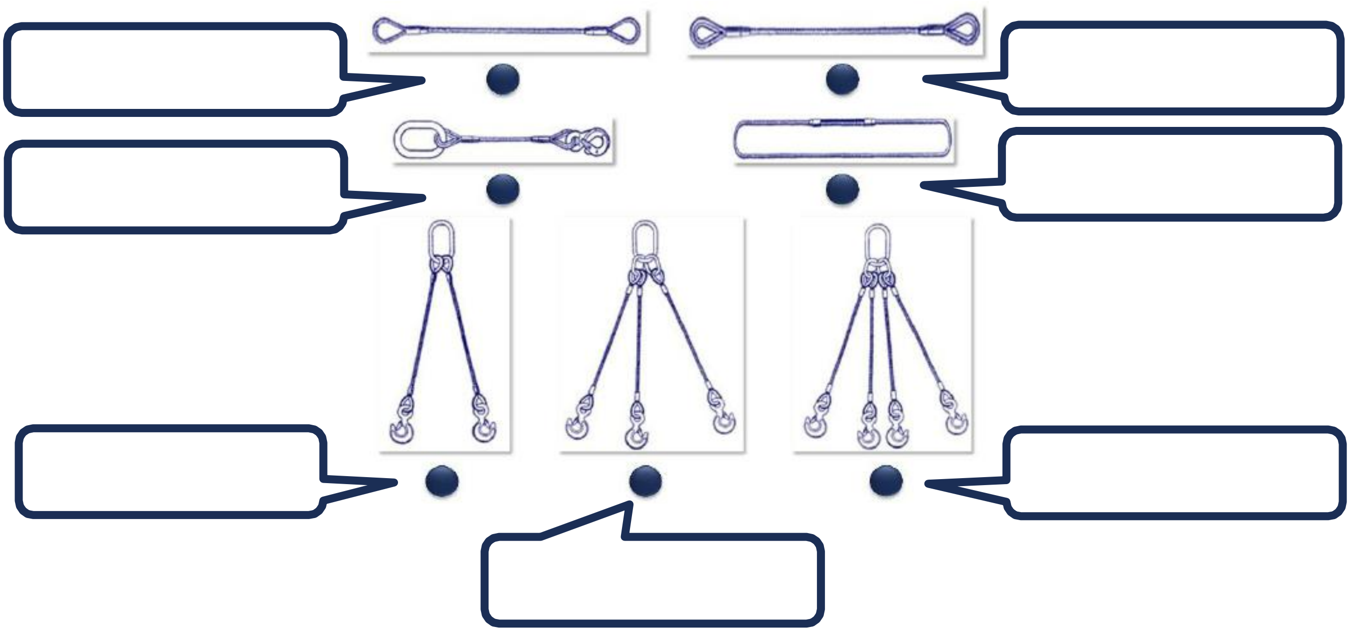
Thimbles: these are a protective insert that is fitted to the eye of a sling leg at the time of manufacture. Thimbles are fitted where it is desirable to protect the eye from the worst effectsof abrasion and point loading.

Two common types of thimble are used in the construction of slings. The teardrop-shaped thimble, which is used where sling legs are to attach to other fittings, and the reeving thimble, isdesigned to permit the passage of one eye through the other so that the sling may be used inchoke hitch. A similar protective inset, known as the stirrup or half thimble, is designed to protectthe wire rope of a soft eye when the sling is used in choke hitch.

Hand Spliced Eye: the hand spliced eye is an eye formed at the end of a sling by the traditionalmethod of threading the individual strands of the rope back along the main body of the rope ina prescribed pattern. This type of eye is now less popular than the more modern ferrule securedeye, but it is still available and preferred by some users.

Common Sling Assemblies: in addition to 2, 3 and 4 leg wire rope slings, the most commonlyused wire rope sling assemblies are:

Single leg with soft eye or thimble eye at each end. They can also be fitted with a link at one endand a hook at the other.



⚙ Endless wire rope slings are also commonly found in use

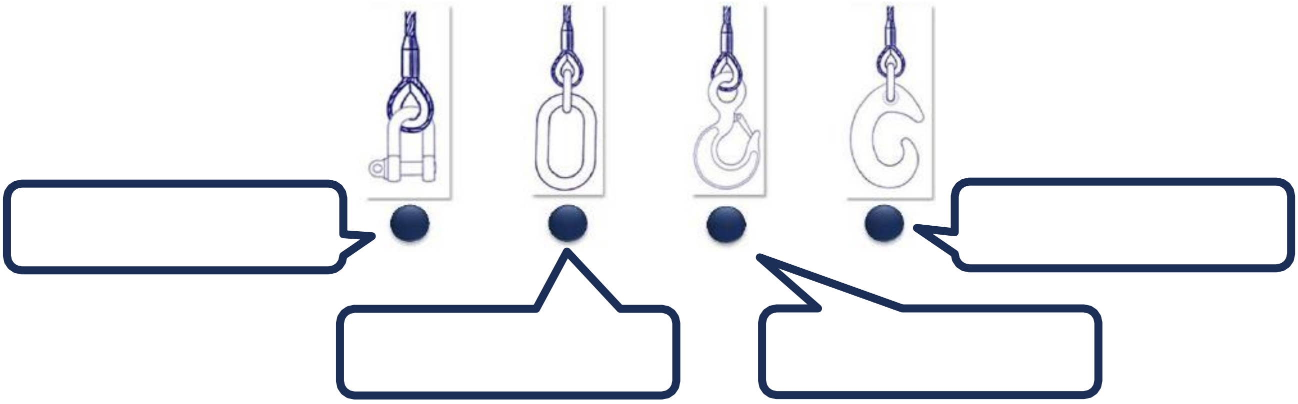
Other special assemblies may be devised for lifting specific unusually shaped loads. Sling legs may be a single part or double part with hand spliced or ferrule secured eyes.

NOTE:

Terminal Fittings

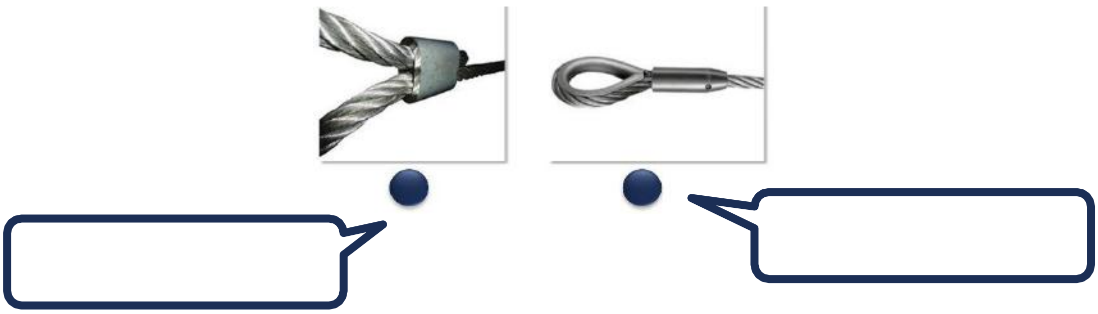
A range of terminal fittings are available for wire rope slings.

Terminal Fittings



Eye Terminations

There are two ways that eyes can be made, ferrule secured (sometimes incorrectly referred toas a mechanical splice) and hand spliced.

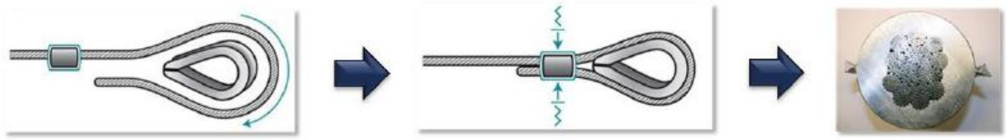


NOTE:

Turn Back Loop

The turn back loop is the cheaper option to manufacture and therefore is perhaps used morecommonly for general purpose slings. With this method, an aluminium ferrule is used to securethe eye made in the end of the rope

The eye is simply formed by passing the ferrule over the rope, bending the rope back on itselfto form the eye, pulling the ferrule back over the returning tail end of the rope and then pressingthe ferrule. Under pressure the aluminium flows into the rope formation, making a homogeneousjoint



- Ferrule Secured Eyes

When square-cut ferrules are used, it is necessary for a small amount of the tail to protrude through the ferrule to ensure that the rope is fully engaged within the ferrule. The standard saysthat the length of this should be no more than one half of the rope diameter. However, if the rope has been cut by a heat process, a portion of the rope will have become annealed (softened) inthe heat-affected area. The protruding tail in this case should be no more than an amount equal to one diameter of the rope and positioned so that none of the annealed section is within theferrule

- Tapered Ferrules

Tapered ferrules are also available from some manufacturers. In this case, the tail end remainswithin the ferrule and it is essential that the ferrule manufacturer’s instructions for fitting arefollowed. Often, the manufacturer of the ferrule will provide a small view hole in the ferrule toenable the tail end to be seen

What is a Soft Eye?

A soft eye is an eye formed at the end of a sling leg comprising a loop made in the wire rope which is then secured by either a ferrule or by hand splicing, having no protective attachments, i.e. thimbles.

Flemish Eye

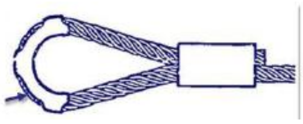
A tapered steel ferrule is passed over the rope. The standing part of the rope is then taken, andthree strands are unravelled and opened so that a ‘Y’ formation is made. Care must be taken toensure that the strands still lay together as they had in the rope

The leg of the 'Y' that includes the core is bent to form an eye so that the ends of the strands sitagainst the undisturbed part of the rope at the bottom of the 'Y'. The remaining three strands arethen re-laid into the rope in the opposite direction, taking up the position they originally had inthe rope so that the lay of the strands is not disturbed

The ends of the strands are then evenly distributed around the intact standing part of the ropeto complete the eye. The ferrule is then slid back over the distributed wires without displacingthe strands and then pressed. The ferrule compresses and grips the rope

- Stirrups

The minimum peripheral length of a soft eye should be four times the rope lay length. This is so as to ensure that the lay of the rope is not disturbed. It is extremely difficult to fit thimbles whenmaking Flemish eyes. If the sling is to be used in a choked situation then a protective attachment, known as a stirrup thimble, is commonly used to protect the rope from damage



- Hand Spliced Eyes

A hand-spliced eye is an eye formed at the end of a sling by the traditional method of threadingthe individual strands of the rope back along the main body of the rope in a prescribed pattern

Whilst this type of eye is now less popular than the more modern ferrule secured eye, it is stillavailable and preferred by some users

In the case of hand splices, these should be made with five tucks against the lay of the rope. Thetype of splice where the tucks are made with the lay of rope, should not be used as this tendsto undo if the rope rotates in use and is effectively banned from splicing wire ropes for liftingpurposes

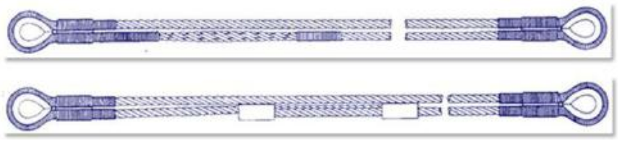
NOTE:

Wire Rope Grips

For many years it has been common practice to make temporary eyes in wire rope, particularly winch wires, by using clamp-type grips, commonly known as 'bulldog' grips.

The use of such gripping devices which clamp the wire to form temporary eyes is not recommended for the manufacture of slings. The reason for this is that tests have showedthat these grips do not give an acceptable or consistent level of safety.

Sockets and Fork Ends	Sometimes used fitted to the rope by a compression process orby a white-metal or resin bonding process. The manufacturer's/supplier's advice should always be sought and followed where their use is intended.
Single and 2-Part Wire Rope Slings	This is not a common way of producing sling legs but is used forvery large capacity slings, so the examiner needs to be awareof them. An endless sling is produced and then a thimble is bound at each end.



The thimbles that are used must be two or three sizes larger than would normally be used forthe rope diameter. The looped sling leg will take a greater load than a single part sling made from the same size rope and a thimble for the actual rope diameter would collapse under the increased load it has to take. In order to make the thimble fit the rope it is necessary to servethe rope with wire or spun yarn.

A sling leg produced by this method is not capable of twice the WLL of a single part of the rope,as one might expect, but is in the order of 25% less than this. This is due to the increased stressdue to the rope being bent around such a tight radius.

Rating of Wire Rope Slings

The working load limit of a wire rope sling depends upon the following factors:

The size and tensile strength of the rope	It will be noted that different but similar constructions of rope ofequal tensile strength have the same minimum breaking loads.
The core of the rope	A rope with a steel core will have a marginally higher breakingload than a similar rope with a fibre core. It will at the same time be slightly less flexible and more resistant to crushing.
The number of parts of wire rope (single or double) persling leg	For some applications, double part legs are preferable as theygive more flexibility than the equivalent capacity single part leg. They are however more costly and therefore normally only usedfor large capacities in order to utilize smaller diameter wire rope whilst offering a greater bearing area to the load.
The geometry of the sling	For example, the number of legs and, in the case of multi-leg slings, the angles between the legs and the vertical and theirarrangement in plan.
The method of rating	This may be either the uniform load method or the trigonometricmethod, dependent on the application. Whilst slings may be found in service rated by either method, the uniform loadmethod is the preferred method for rating multipurpose slings.

The maximum angle of inclination at which the sling may be rated is 60° (120° included angle) but it may only be rated for use at 45° (90° included angle).

The SWL to be marked on the sling should be assessed by a Competent Person and will be thesame as the WLL in normal conditions or less than the WLL under special conditions.

The maximum load that can be lifted by a sling may also vary from the marked SWL dependingupon the method of use.

NOTE:

Chain Slings

Steel chain is a very common product that is generally 5 to 6times heavier than wire rope.

Chain also tends to have a longer working life than that of wirerope as it is very robust and is less susceptible to damage in use.

How is a Chain made?

Chain is made by passing lengths of steel bar into a machine that uses a series of automatedprocesses to shape, form and weld each link into the finished chain.

Following welding of the links, the chain will undergo a process of heat treatment to achieve thedesired material properties such as strength, ductility and toughness.

Chain slings are versatile and provide a safe method of lifting loads, but it is important that theyare used correctly to avoid damage and potentially serious incidents.

Material	Chain slings manufactured from wrought iron are obsolete and no longer available. Similarly, mild steel chain slings have been obsolete since theearly 1980's following the publication of newer standards which specifically exclude the use of this grade of chain for lifting applications. However, it is possible that examples of wrought iron and mild steel chainslings may occasionally be found in service, but their continued use is not recommended by LEEA. Most modern chain sings are constructed from grade 8, and although not yet covered by standards in certain regions, grade 10 chain is becoming increasingly popular. Medium tolerance chain intended for sling manufacture needs to be more ductile to withstand shock loading. However, in use it is not subject to wear and can therefore have a softer skin. As it does not mate with othermoving parts, it does not need to have such a precise pitch.
Calibration	When chain is produced by machine the links are not all exactly the same exact shape; the sides have a slight curve. When the manufacturer 'calibrates' it by the application of a force, the links bed down on each other and the sides of the link straighten. As a result, the chain extendsby a very small amount. With load chains for lifting appliances (e.g. hand chain hoist), it is vital that the links are of precise size and form so that they engage correctly in the pocketed load wheels of the machine. This is achieved by manufacturing the chain to a calculated undersize. The finished chain isthen subjected to an increased force, which pulls it to the required evenshape, size and pitch.

Finish	Various finishing treatments are then given to fine tolerance chain to increase its wear resistance (e.g. case hardening). The loss of some ductility due to the manufacturing and finishing processes is relatively unimportant for load chains. However, these features are undesirable ina sling chain where it is less likely to wear. Sling chain is more liable to be shock loaded, so good ductility is essential. Fine tolerance chain may be recognised in two ways. The calibrating process has the effect of removing all of the residual scale from the heattreatment process and many of the finish treatments include corrosion resistant finishes. As a result, it has a bright finish and of course there isalso the grade mark.
Assembly	Older chain slings, and currently a few for special applications, were assembled by a blacksmith and had welded joining links. These are veryrarely found in service nowadays. Modern chain slings are assembled from components that have mechanical fixings, such as spiral roll pins, to retain them. They are therefore assembled and repaired very easily using standardised rangesof fittings. • A full range of fittings is available with the clevis form of chain connection, such as hooks, shackles and egg links • This system of assembly minimises the number of components necessary to assemble a sling, as the terminal fittings locate directly onto the chain • With clevis attachment, the end link of the chain is passed into the jaw of the clevis • A load pin is passed through the clevis and chain, on which the chain seats • Spiral roll pins or circlip type fixings are used to lock the load pinin position

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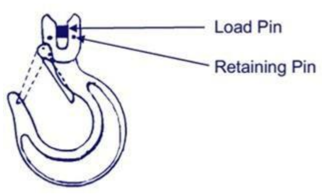
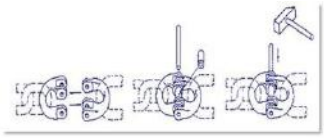
- This system of assembly minimises the number of components necessary to assemble asling, as the terminal fittings locate directly onto the chain
- With clevis attachment, the end link of the chain is passed into the jaw of the clevis
- A load pin is passed through the clevis and chain, on which the chain seats
- Spiral roll pins or circlip type fixings are used to lock the load pin in position
- For the connection of the chain to master links a simple shackle like ‘coupler’ is available in some systems:





Rating of Chain Slings

The factors to be considered fall into three main groups

1. How the sling is attached to the load
2. The geometry of the sling, i.e. the angle of the legs to the vertical and the arrangementof the legs in plan
3. The number of legs in use

The amount of load that will be carried by an individual leg will depend on the angle betweeneach of the legs and the vertical, the arrangement of the legs in plain view and the total loadbeing lifted.

The reduced ratings for slings when used in choke hitch take account of higher stresses at thepoint where the choking hook or link bears upon the chain.

The maximum angle of inclination at which the sling may be rated is 60° (120° included angle)but it may only be rated for use at 45° (90° included angle).

The SWL to be marked on the sling should be assessed by a Competent Person and will be thesame as the WLL in normal conditions or less than the WLL under special conditions.

The maximum load that can be lifted by a sling may also vary from the marked SWL dependingupon the method of use.

NOTE:

Textile Slings

> Fibre rope slings can be produced from man-made fibres and a limitedrange of natural fibres.

Textile slings are manufactured from man-made fibres such as:

- Polyamide (nylon)
- Polyester
- Polypropylene

Additionally, fibre rope slings may also be produced from natural fibres such as:

- Manila
- Sisal
- Hemp

Although these will very rarely be found in service nowadays.

New, specialist man-made fibres, such as HMPE (High Modulus Polyethylene) are now being produced to manufacture specialised lifting slings. These feature high cut and abrasion resistance; Although the various fibres have many common features, they react differently totemperature, chemical contact and environment.

We will consider these matters in the Lifting Accessories Diploma training course.

Types of textile slings

Textiles slings can be found in various forms:

Flat woven webbing slings
Are also commonly known as belt slings, are used for a variety of lifting purposes. They are atextile sling which is soft and easy to handle whilst offering rigidity across their width. Theyare ideal for handling loads which require some support when being lifted as the load is spreadacross the full width of the webbing, avoiding point contact as is the case with chains or ropes.They are therefore less likely to cause damage to the load's surface than rope, wire rope or chain slings. However, they are less robust and more easily damaged than equivalent capacitywire rope and chain slings.

Roundsling

Roundslings comprise of a core enclosed in a protective cover. The core is the load-bearing partof the roundsling and is in the form of a hank of yarn made up from one or more strands of theparent fibre material wound together continuously and joined to form an endless sling. The protective cover is a woven tubular outer sleeve of the same parent material as the core, whichis designed to be non-load bearing as it is intended only for protection and containment of thecore.

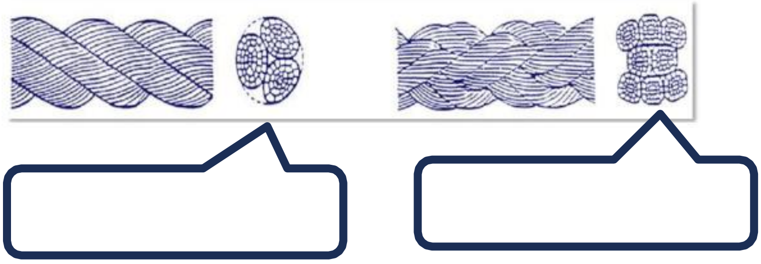
Man-made fibre roundslings are an endless textile sling that is soft and pliable to use, easy tohandle and especially useful on delicate surfaces. They are less robust and more liable to damage than equivalent capacity wire rope and chain slings.

Fire Rope Slings
Fibre rope slings are the traditional form of textile sling whose origins are recorded in the earliest history of lifting equipment. Their use has declined in recent years in favour of the newer forms of textile slings, i.e., flat woven webbing slings and roundslings but they may still be found in general use throughout the industry. Fibre rope slings are produced from cut lengths of rope which are then hand spliced.

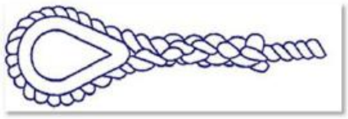
NOTE:

In the case of three-strand rope, this is an easily learned skill and as a result, many fibre rope slings are produced by the user. The intention is not to condemn or condone this practice, but to acknowledge that it occurs. It must however be remembered that the manufacturer of the sling is the responsible person (legal) under the applicable national legislation, who must comply fully with that legislation. LEEA therefore, strongly recommends that slings are obtained from a lifting equipment supplier who is able to guarantee compliance with the appropriate legislation and applicable standards.

Fibre rope slings are less pliable than other forms of textile sling and are bulky to handle. Unlikeflat woven webbing slings and roundslings they present a hard, point contact to the load although this is less severe than with chain or wire rope.



Single leg, multi-leg or endless fibre rope slings can be produced. They are made by hand splicing eyes at each end of a piece of rope or by splicing one cut end of a rope to the other end,forming an endless loop. With multi-leg slings, the eye one end of each sling leg is made througha master link. Where this is done, the use of thimbles is advised to protect the eyes.



Eyes are produced by bending the rope to form a loop. The strands at the end of the rope areseparated and then tucked back into the standing part of the rope against the lay to form theeye, in a similar way as with wire rope. This is done in such a way that they lock and do not slipwhen a load is applied. There are differences in the splicing requirements, depending on the typeof rope used. This is due to differing coefficients of friction.

Identification

visually, the various fibres appear much the same. This makes identification extremely difficult.An international system of colour-coded labels, which carry the information necessary to be marked on a sling (see marking), has therefore been adopted in standards as follows:

Natural Fibres	Polyester	Polyamide	Polypropylene	Aramid Polyamide (where used regionally)

Shackles

Shackles are probably the most common and universal lifting accessory. Their uses are extensive. They may be used to connect a load directly to a lifting appliance, to connect slingsto the load and/or lifting appliance, as the suspension for lifting appliances or as the head fittingin certain types of pulley blocks. There are three main types of shackles used for lifting today:

1. Bow
2. Dee
3. Grab types

Shackles are normally forged from various grades of steel. Higher quality alloy steels give a higher safe working load than those made in higher tensile steels, while higher tensile steel shackles have a higher safe working load than those made in mild steel.

Some manufacturers continue to make shackles to old now withdrawn standards, whereas manyhave now adopted the current standards.

The older, now withdrawn shackle standards fully specified all dimensions of the shackle. In contrast, the current standards tend to specify only some dimensions fully, the rest being specified as a maximum or minimum value. Shackles to the older standards are sized by the diameter of the material in the shackle body and not the diameter of the pin. Shackles to laterstandards are usually sized by their WLL.

Dee Shackle	All shackle standards specify dee shackles, with some specifying both alarge dee and a small dee shackle. A large dee shackle is a shackle that has ample internal clearances in the body and jaw, and which is appropriate for general engineering purposes. A small dee shackle is a shackle that has moderate internal clearances in the body and jaw but, size for size has a SWL higher than that of the large dee. It is suitable for use with hook eyes, eyebolts, egg links, wire rope thimbles, etc. and for the head fittings of ships' blocks.
Bow Shackle	Similarly, all shackle standards specify bow shackles, with some specifying both a large bow and a small bow shackle. A large bow shackle is a shacklewhich has ample internal clearances in the body and jaw, and which is appropriate for general engineering purposes. A small bow shackle is a shackle which has moderate internal clearances in the body and jaw but,size for size, has a SWL higher than that of the large bow. It is suitable foruse with the eyes and bodies of hooks, eyebolts, egg links, wire rope thimbles, etc. and for the head fittings of ships' blocks.
Grab Shackle	A grab shackle is a dee shackle having a screwed countersunk pin, designedfor use with grabs where the shackle must pass through a circular apertureof minimum diameter.

Application	The selection of the shape of the shackle body will depend on the intended use. It is desirable to use a shackle with as small a jaw opening as is consistent with an adequate articulation of the connection. Dee shackles are, in general, used to join two pieces of lifting equipment. Bow shacklesare, in general, used where more than one attachment is to be made to the body or to allow freedom of movement in the plane of the bow.
Pins	There are two types of shackle pin in common use, the screw pin, and thebolt, nut and cotter pin (commonly referred to as the safety pin or 4-pieceshackle). Screwed pins with eye and collar are the most common type of pin and aresuitable for a wide range of uses. However, if they are subject to movementand vibration (e.g. by a sling moving over the pin), they can loosen and unscrew. The bolt with hexagon head, hexagon nut and split cotter pin is used where a positive connection is required as it cannot unscrew unintentionally. Theyare also ideal where a permanent connection is required, (e.g. connectingthe top slings to a spreader beam).

NOTE:

Eyebolts

Eyebolts

Eyebolts are one of the most widely used items of lifting accessories, but they do have severe limitations in usage and multiple accidents occur as the result of misuse.

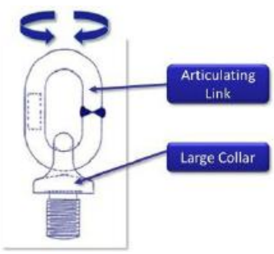
Types other than those to recognised standards are commonly used, such as 'eyenuts' and 'bownuts' and further information can be found from LEEA COPSULE Appendix 20.1 (reference is made to this in 'Recommended further reading' at the end of this course handbook).

We will consider the main three types on eyebolt:

1.
2.
3.

Eyebolt with Link

This eyebolt has advantages over the other patterns of eyebolt when the loading needs to beapplied at an angle to the axis and/or the plane of the eyes. Provided that the angle of the loadto the axis of the screw thread does not exceed 15° they may be loaded in any direction to thefull SWL rating. Thread sizes range from 20mm to 48mm in the metric coarse pitch series or ¾" to 1¾" in the imperial BSW or UNC threads.



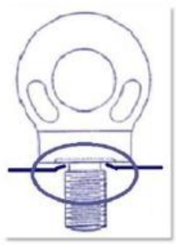
They have a small, squat, eye that is blended into the collar in all directions and a link is fitted to allow articulation and connection with other lifting components. The link is designed to accepta hook of the same capacity. Compared to size for size with Collar Eyebolts, the SWL for axialload is lower. In all other arrangements, the SWLs are relatively greater than those of Collar Eyebolts when used in the same conditions. Unlike the Collar Eyebolt, the load can be appliedaway from the plane of the eye, as the link will articulate to align and the collar has equal strength in all directions, making correct fitting easier.

Eyebolts of 8 and 10mm are available, but LEEA does not recommend their use as they can be easily overtightened and subsequently overloaded.

Collared Eyebolt

Designed for both axial and angular loading. The eye is blended to the collar in one plane. However, the eye is not large enough for direct connection to a hook and it is necessary to usea shackle for connection to other components.

They are generally available in a range of capacities of 0.4t to 25t SWL with corresponding threadsizes of 12mm to 72mm in the metric coarse pitch series, and capacities of 0.25t to 30t with corresponding thread sizes of 3/8” to 3” BSW or UNC. The SWL range of the imperial threadedcollar eyebolt differs from that of the metric threaded collar eyebolt because they are intended as replacements for eyebolts to older now withdrawn standards.

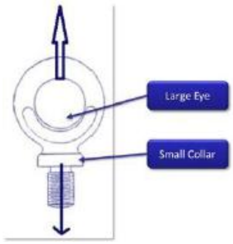



When used in pairs of the same capacity, the plane of the eye of each eyebolt must not be inclined to the plane containing the axis of the two eyebolts by more than 5°. In order not tooverstress the shank, this alignment may be achieved by use of shims up to a maximum of halfof one thread in thickness.

A reduction in the maximum load that may be lifted is necessary due to the angular loading. Thisis far more drastic than is required with the Eyebolt with Link. Although in axial loading, size forsize, Collar Eyebolts have a higher SWL, their capacity when subject to angular loads is far lower.

Dynamo Eyebolt

The Dynamo Eyebolt is the most basic in design and the most limited in use because it only suitable for axial (directly vertical) lifting only.



Essentially it is a ring sitting on top of the shank and has only a small collar. Although it is limitedto axial loads, the eye is large enough to accept a hook of the same capacity. Dynamo Eyebolts get their name from their historical use by electric motor manufacturers, who would fit them tothe tapped hole over the balanced lifting point of the motor.

They are generally available in capacities of 0.32t to 10t with corresponding thread sizes of 12mm to 52mm in the metric coarse pitch series. Imperial threaded dynamo eyebolts are alsoavailable in a range of capacities of 0.25t to 10t with corresponding thread sizes of 3/8” to 2”BSW or UNC.

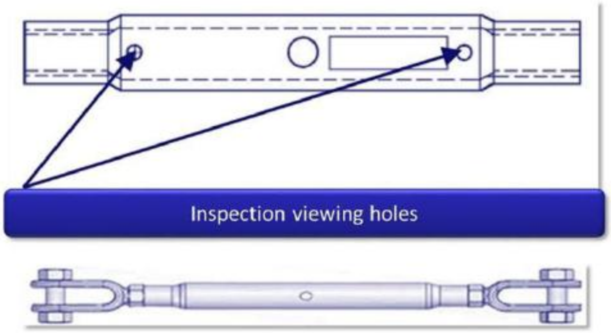
NOTES FROM THE VIDEO:

Rigging Screws and Turnbuckles

Rigging screws and turnbuckles are used for the tensioning and fine adjustment of length in lifting assemblies and stays where chain, wire rope or textile element form the main component of the assembly. They can also be used on their own for some applications. Further uses include cargo restraint, suspension, etc.

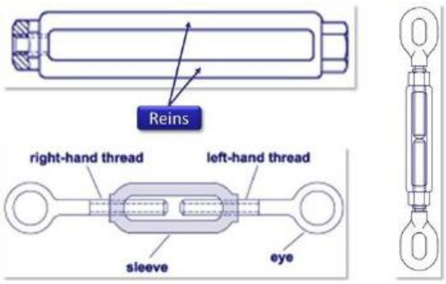
Rigging Screw

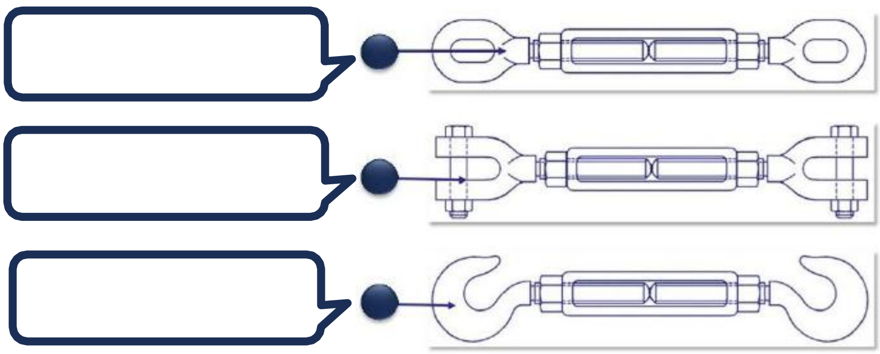
These have a tubular body, internally threaded at each end, with one right hand and one left-hand thread connecting to terminal fittings of various forms, e.g., screwed eyes, hooks or forks. They are also known in some industries as bottle screws



Turnbuckle

This has an open body consisting of reins, with internally threaded bosses at each end, with one right and one left-hand thread connecting to terminal fittings of various forms, e.g., screwed eyes, hooks or forks. A drilled inspection hole across each end of the body of a riggingscrew facilitates checking that the threaded portion of the terminal fitting has adequately engaged with the body.





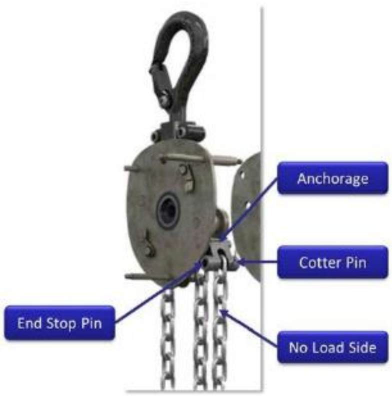
Hand Operated Chain Hoists

> Hand Operated Chain Hoists
>
> Manual chain hoists are very popular and are found in wide use throughout the world. Thisis because they can be used very effectively in the following applications where:
>
> - A permanent installation for infrequent use is required
> - A temporary installation for erection or maintenance purposes is required
> - Precise location of the load is required
> - A suitable power supply is not available

The advances in material and manufacturing technologies have enabled much, smaller, lighterand more efficient chain hoists to be produced.

Chain hoists use a pocketed wheel into which the load chain must fit, but freely enter and leave.The drive to the pocketed wheel is via a hand chain and screw brake mechanism.

The free end of the load chain shall be fitted with a chain end stop to prevent it from passingthrough completely.



All modern hand-operated hoists are fitted with an automatic brake which, when functioningcorrectly, is capable of arresting and sustaining the load at any position. Students will visit thissubject in further detail in the LEEA Manual Lifting Machines Diploma.

Attachment

The hoist may be of ʻsuspendedʻ or ʻcombinedʻ unit, many manufacturersproducing both options. Suspended types have a top hook, shackle, eyebolt or other fittings by which the hoist is hung, and which allows a degree of articulation between the hoist and the supporting structure.

Combined types are usually combined with a purpose-made travelling trolley, although a direct connection to the supporting structure may also be possible. The connection between the hoistand the trolley or structure is usually rigid.

Lower Capacity Hoists	The lower capacity hoists (e.g. 500kg, 1t) lift the load on a singlefall of load chain.
Higher Capacity Hoists	Higher capacity hoists may either be of similar design but with alarger frame or may utilise two or more falls of load chain. The very high capacity hoists may utilise a combination of a larger frame and multiple falls of load chain and may even have two or more frames linked by a yoke.

NOTE:

Hand Operated Lever Hoists

Hand-operated lever hoists are widely used since they can perform both lifting and pulling applications. The ability of the lever hoist to operate in any attitude makes the lever hoist a versatile tool, particularly for rigging. It can be used as an adjustable sling leg to enable a load tobe balanced or for line adjustment when positioning - to give just two examples. Two basic types are available: one using fine tolerance (calibrated) short link steel chain, the other usingroller chain.

Advances in material and manufacturing technologies have enabled much, smaller, lighter andmore efficient lever hoists to be produced.

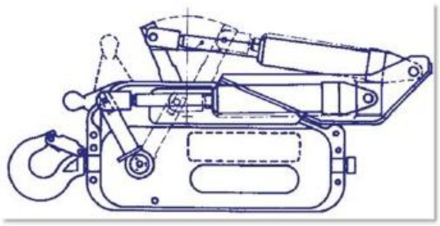
Lever hoists use a pocketed wheel into which the load chain must fit, but freely enter and leave.The drive to the pocketed wheel is via a hand chain and screw brake mechanism. The lever hoistwill also have a change-over lever with a neutral position which allows the user to set the chainto the correct length (free-wheel facility). The free end of the load chain shall be fitted with achain end stop to prevent it from passing through completely.

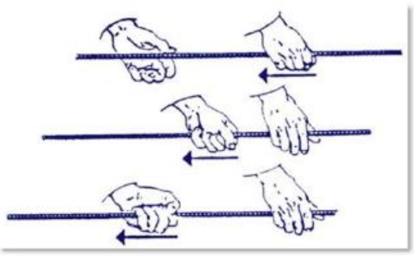
NOTE:

Lifting and Pulling Machines - using a gripping action on the wire rope

Commonly referred to as 'jaw' or 'creeper' winches in different regions, these winches are widely used throughout the industry for both permanent applications and temporary or rigging applications. They are used as pulling machines as well as lifting, which may permit a lower factor of safety and giving a higher working load limit when the winch is used for pulling.

Jaw winches are most common as a manually operated lifting machine but are available as a hydraulically operated machine. This would then be linked to a hydraulic pump unit specifically for the jaw winch being used.

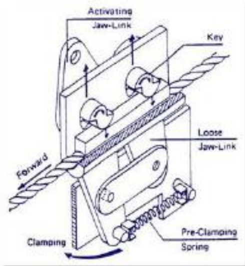




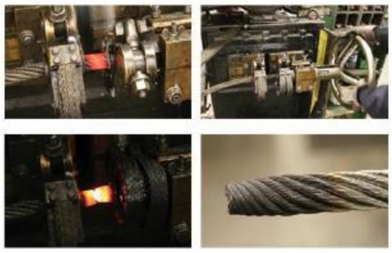
All jaw winches operate by the same general principle. Effort to the rope in a jaw winch is provided by two levers, which act via a lever and cam system on keys. Each set of jaws is madeup of a top and bottom jaw which are brought together (clamped), or separated (unclamped), byhalf-moon-shaped keys actuated by levers known as jaw links.

The wire rope supplied for use with a jaw winch should be considered as integral a part of themechanism as a load chain of a chain hoist. Some ropes, which appear to be of the correct size, and which are accepted by the winch, may not be suitable. The efficiency and safety of thefriction grip of the winch's jaws depend entirely on the rope being the right diameter and constructed to withstand the crushing force of the jaws.

With a rope diameter that is too small, the jaws will not grip the rope sufficiently. With a ropediameter that is too large, the rope may become stuck in the winch, putting the winch out of operation. It is therefore essential that only ropes approved by the manufacturer are used with the specified jaw winch.



One end of the load rope is plain tapered and fused to allow entry into the machine. The otherend has a terminal fitting for attachment to the load.



NOTE:

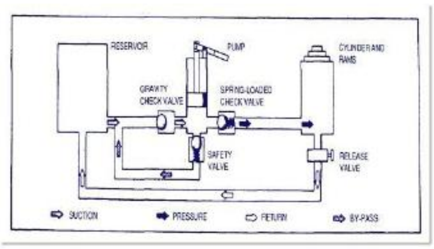
Jacks

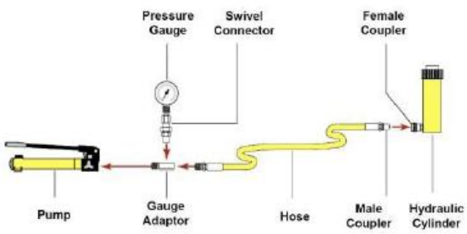
Jacks are widely used for lifting purposes where loads need to be raised or lowered a limited distance. Jacks are hydraulically or mechanically motivated by manual or power systems. There are several modern standards throughout the world covering a wide range of mobileor movable jacks for various applications. The range includes hydraulically operated, pneumatically operated, electrically-operated and manually operated jacks and jacks for road vehicles.

Hydraulic Jacks

Hydraulic jack bodies are commonly manufactured from aluminium, steel or cast iron. The material used affects the design, size, self-weight and capacity of the jack. Hydraulic jacks useoil and the body of the jack acts as a reservoir for the oil. When the jack is operated, the oil is passed through a system of non-return valves to the underneath of the lifting ram.

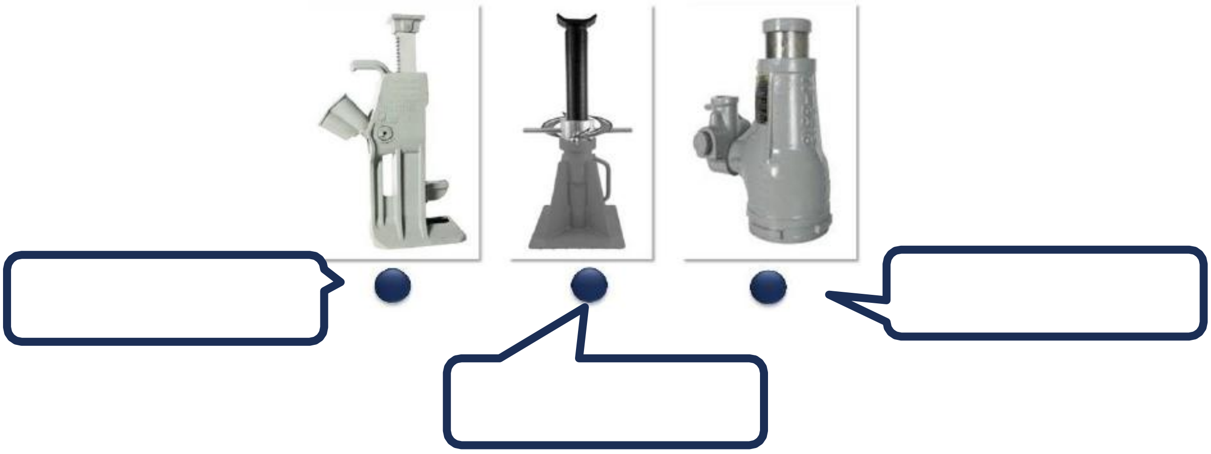
When more oil is delivered through each stroke of the handle, the lifting ram is forced out ofthe chamber lifting the load. The load is lowered by opening a valve which allows the





Mechanical Jacks

There are several types of mechanical jack available. The 'ratchet', 'screw' and 'journal' jack most commonly found in service:



Ratchet jacks	The body of the jack contains a pair of pawls that engage in a rack.Operation of the jack causes the pawls to raise or lower the rack,which is fitted with a lifting head and toe, providing alternative positions for supporting the load. The full rated load may be supported on the head or toe. During the jacking operation, the operative effectively carries the load via the operating lever. At theend of each stroke, the load is sustained by a pawl.
Screw jacks	Consist of a single hollow casting with a square form female threadinto which fits a male screwed shank. A swivel head is fitted to theshank to support the load. Directly turning the screwed shank causes it to raise or lower.
Journal jacks	Consists of a cast body that houses a bevel gear and screw mechanism. The operation of a ratchet lever turns the gears that drive a screwed shank. This in turn drives a running nut that is captive in the lifting journal and therefore causes the journal to raiseor lower.

NOTE:

Crane Forks and 'C' Hooks

Crane forks and C-hooks are suspended from crane hooks but lift loads directly without the needfor other lifting accessories.

Whilst C-hooks are usually designed to lift a specific load, crane forks are of a more general nature and are usually supplied as a standard product. Although very different in design, craneforks and C-hooks have much in common, which enables them to be considered together. Differences will be noted where relevant.

- Crank forks: These are used to lift palletised or similar loads suspended from a cranehook.
- C – Hooks: These are used to lift hollow loads such as pipes, paper rolls or coils of steel.Fabricated from a profiled plate or rolled beam sections.

Powered Lifting Machines (Appliances)

Powered lifting machines are widely used in industry, often as part of a larger lifting installation, e.g. with an overhead runway, jib crane or overhead travelling crane, or where a permanent lifting facility is required. They may also be used for fixed position lifting applications or where a temporary powered lifting facility is required.

Powered lifting machines are available with electric or pneumatic operation, but the mostcommon in general use at the present time are electrically operated.

Powered lifting machines are ideal for heavier or repetitive lifting applications as they offer thefollowing advantages over manually operated chain hoists:

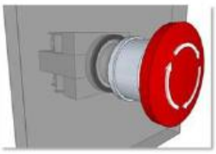
- Speed of operation
- Less fatigue for operatives, particularly on long lifts
- Operatives may be remote/away from the load

Electric Chain and Wire Rope Hoists	Modern electric power-operated hoists are normally fitted with low voltage control which is derived internally within the unit by a transformer. This is usually in the range of 24to 50 volts AC or DC and is often known as 'Extra Low Voltage'. Older hoists and specialpurpose hoists may not have LV control. It should also be noted that it is common in many European countries to use mains voltage control. The two principal lifting media used with all power-operated hoists are: • Short link round steel chain • Steel wire rope • HMPE and textile belt materials In hoists that use chain, the chain passes overa pocketed wheel with the slack side of the chain hanging loose. A collecting box may beused to house the slack chain, but as this sitsbelow the body of the hoist it restricts the height that certain loads may be lifted. In hoists that use wire rope, the wire rope passes on and off a drum upon which it is stored. The range of lift is limited by the amount of wire rope that the drum canaccommodate.
Pneumatic Hoists	Pneumatic power-operated hoists tend to bemore limited in use than electric power-operated hoists, mainly due to the problemsassociated with the provision of a suitable air supply. However, they offer many advantages over electrically operated equipment and as aresult are widely used in industries where the air is provided for other purposes or where the safety aspects associated with air- operated equipment are a majorconsideration.

Hydraulic Hoist	The hydraulic hoist provides smooth and accurate lifting and lowering operations and is very quiet in operation. An electric motor is used to run a hydraulic motor. The hydraulic motor is a mechanical actuator that converts hydraulic pressure and flows into torque, or rotation, which in turn moves the hoist. The advantages of this form of the machine are that the electric motor does not have to be physically near the fluid drive, so the system is virtually noiseless. They are regularly used in intrinsically safe areas, as is the pneumatic hoist.
Electrical Controls	Other control options, such as radio or infra-red controls, enable remote or central control. They are useful in areas where direct access may not be possible. Multi-point controls, usually wall-mounted, enable hoists to be controlled from several positions, which is useful in applications such as raising loads through several floor levels. Such arrangements must be suitably interlocked to prevent more than one control from operating at a time. A further essential requirement with this arrangement is the provision of emergency stop buttons to override all control positions until manually reset.

Various examples of Electrical Controls



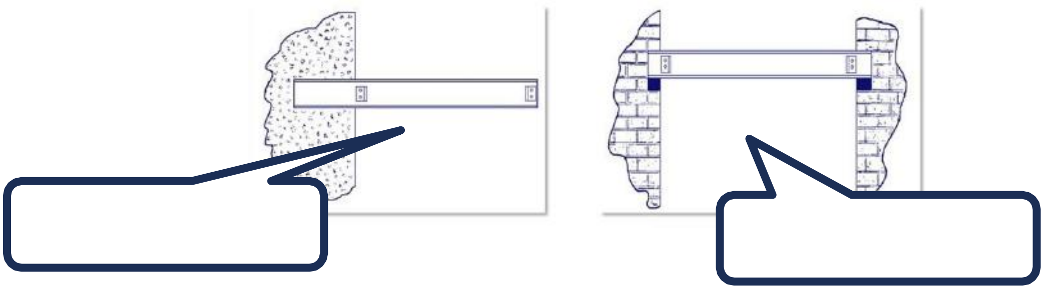
Supporting Structures for Hoists and Light Crane Systems

Runways

Runways are widely used in industry to provide a track that has a lifting appliance fitted to allow loads to be raised, lowered and travelled along the path of the runway. Runways can be manufactured from standard rolled steel sections or from special track sections and may be supported from building structures, dedicated free-standing structures or a combination of both. Runways offer a cost-effective alternative to overhead travelling cranes. Their design can range from a simple beam to more complex systems which may include switches, turntables and bends allowing the movement of the load along alternative routes.

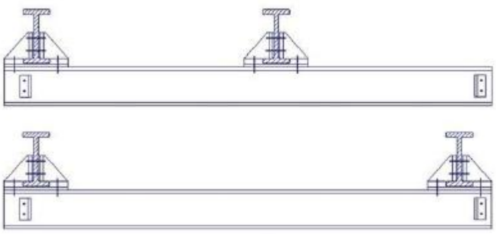
Built-in Runways

These are usually runway beams supported by existing building structures. The 'simply supported' and 'encastred' type runways are most common.



Suspended Runways

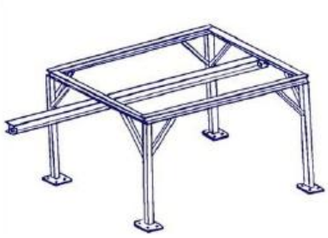
These runways can also be suspended from suitable roof members or beams built into the building structure.

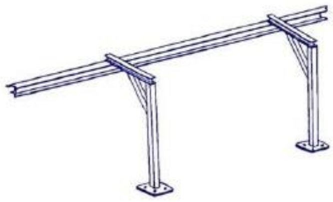


NOTE:

Free Standing Runways

Where no existing suitable supports are available, then free-standing runway structures are common.





Special track systems (Light Crane Profiles)

Special track sections are quite versatile and are often supplied in kits, sometimes referred to as light crane systems, that can be assembled in various configurations, such as simple runways, runways with switches, turntables, etc, and even low capacity bridge cranes.

Switches and Turntables

The use of runway switches and turntables allow the lifting appliance to be transferred from one runway system to another.

NOTE:

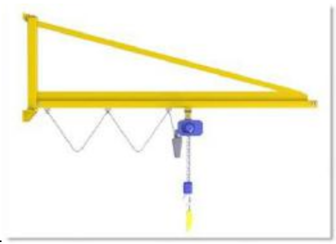
Crane Systems

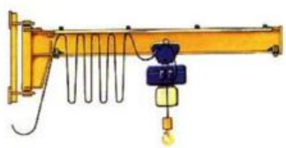
Slewing Jib Cranes

Slewing jib cranes are widely used in industry in conjunction with manual or power operated lifting appliances where a permanent facility is required to perform both lifting and limited moving operations. Typical examples of their use being over workbenches, in fitting and maintenance shops, over machine tools and in loading and unloading bays. They offer a wide area of floor coverage within the slewing radius of the jib arm and are ideal where full overhead travelling crane coverage may be either impracticable or uneconomic. They are often used to supplement overhead travelling cranes.

Slewing jib cranes are often designed, supplied and tested without lifting appliances and it must be realised that a slewing jib arm becomes an effective crane only when fitted with a hoist, hoist and trolley or similar lifting appliance.

Wall or Column Mounted:
The jib arm, king post and bracing are assembled as a single unit. They may be either over-braced or underbraced in design dependent on the intended use and the location of the installation. Top and bottom bearing brackets fit onto the king post and these, in turn, are fixed to the supporting structure.

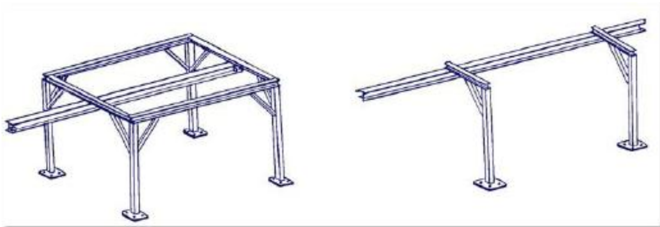




Free Standing:
The jib arm and supporting column are assembled as a single unit which includes all mountings and bracing. They may be either over-braced or underbraced in design dependent on the intended use and the location of the installation. The supporting column is usually manufactured from a square box section, fabricated sections or tube dependent on the required angle of slew. The angle of slew and intended use will also affect the design of the king post and mounting structure. Free standing jibs are available with a wide variety of slewing angles. They may have a full 360° angle of slew, allowing for continuous rotation if a tubular column is used, or be limited to 270° angle of slew if a square box or similar section column is used.

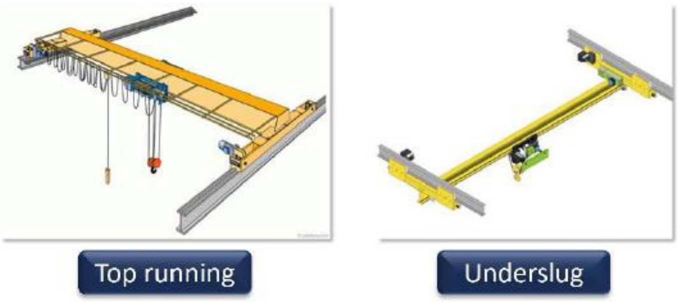
Mobile Gantries: a mobile gantry is normally used in areas where it is not cost-effective to have a permanent installation. A mobile gantry is a free-standing structure comprising a runway beam and two supports or A-frames assembled in a goalpost-like configuration. The supports are usually mounted on wheels or castors to enable the structure to be relocated by man-power only; they may however be mounted on free-standing feet requiring the structure to be dismantled for transportation.

Goalpost Gantry: This consists of a runway beam, often in the form of a manufacturer's branded track section, with single column supports. Lateral stability is provided by a base member on which the column is mounted. This design is limited to light loads, usually up to 500kg, and light-duty applications.



'A' Frame Gantry: this is the most common type of mobile gantry. It consists of a runway beam, usually of standard rolled steel section, with supports in the form of an 'A'. Lateral stability is given to the structure by the shape of the supports. This design is available in all capacities, usually up to 5 tonnes.

Adjustable Height Gantry	To provide limited variations to the erected height of the runway, an adjustable height gantry has telescopic supports enabling the runway to be raised or lowered to suit differing site conditions. This facility is not intended for use under load but is to allow for varying lifting height requirements only. This design is available in all capacities, usually up to 5 tonnes.



Foldaway Gantry	Designed for easy dismantling and storage. They are intended for applications where regular dismantling and transportation is necessary or where the usage is such that long periods of storage occur. This design is usually limited to loads of up to 2 tonnes.
Self-Erecting Gantry	Designed with the provision of hand winching mechanisms that allow the structure to be assembled horizontally on the floor. Operation of the winches pulls the side members of the 'A-frame supports together until the gantry is in its operating position. Additional locking structural components are then inserted making the structure rigid. This design is usually available in higher capacities from 2 tonnes upward.
Crane Supporting Structures Tracks (Gantries)	Tracks will generally be constructed as 'top running' or 'under-slung'. Top running gantries are supported in various ways.

Free Standing Crane Supporting Structures

If a building has not been designed to support the crane tracks, then tracks can be supported on dedicated columns and carrier beams, in the case of underslung cranes, to form a free-standing support structure. There are several types of track support structures in service.

Crane Tracks: Generally manufactured from standard constructional sections. For top running cranes a rail section is usually welded to the top flange of the track beam. For underslung cranes, the crane will run on the bottom flanges of the beam. Dependant on the crane type the track will either be suspending from a cross beam known as a carrier beam or fitted directly to the tops of the supporting columns.

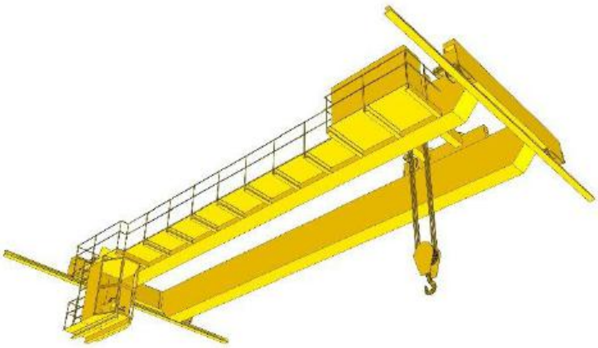
Crane or Track Rails: Depending on the duty, the rail will have a profile similar to one of those shown below, but more often than not for light duties, this will be a square bar. These rails are normally fixed by intermittent welding and if not welded with the rail securely clamped to the beam weld, cracking will occur in service.

Bridge and Gantry Cranes: Bridge and gantry cranes provide a means of lifting and transporting loads over the area covered by the crane. Some bridge and gantry cranes may use manual effort to lift, lower and move the load. However, it is more usual for some, or more typically all, of the crane's motions to be electrically powered. There are four main types:

- Top running bridge crane
- Under-slung bridge crane
- Semi-portal gantry crane
- Portal gantry crane

Top Running Bridge Crane

Distinguished by running on the top of rails which are part of the crane supporting structure.



Under-Slung Bridge Crane

Distinguished by running on the bottom flanges of the cranes tracks. Because of the under-slung arrangement, the bridge of this type of crane can have a cantilever at one or both ends. Two or more such cranes running on parallel sets of tracks can be fitted with latching mechanisms to facilitate the transfer of loads from one crane to another.

Portal Bridge Crane: Distinguished by running on a low-level track, usually at ground level, with the bridge girder or girders supported on legs. The bridge of this type of crane can have a cantilever at one or both ends.

Semi-Portal Bridge Crane: A combination of a top running bridge crane and a portal bridge crane. The bridge of this type of crane can have a cantilever at the end of the span supported by the legs.

Portal

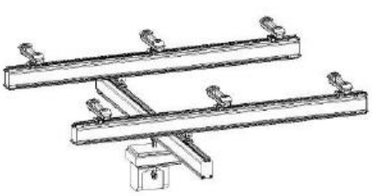
Semi-Portal

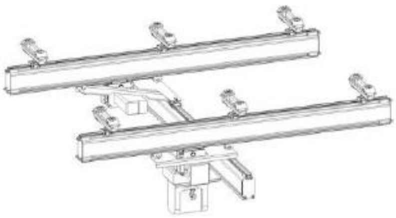
Light Crane Systems (Parallel Track, Bridge and Hoist)

Defined as an assembly of lifting devices, bridges, trolleys and tracks with their suspensions for lifting operations and usually manufactured from proprietary sections of steel. There are many different manufacturers of these systems and modular in design. There are several advantages to be gained in using a light crane system:

- Smooth travelling movements
- Silent running of the trolleys
- Less wear and less pollution (nylon wheels)
- Modular system
- Pendulum construction (less stress on the support structure)
- Easy installation
- Easy ,modifications if required at a later date
- Reduced maintenance

The general configuration would be two parallel tracks suspended from the ceiling or building structure with a single or dual-bridge bridge crane running between the tracks. The single bridge version would normally be of manual push/pull type long travel fitted with a manual or electric chain hoist suspended from a trolley running inside the bridge profile section, and the dual-bridge would be fitted with a trolley that is suspended between the two bridge sections. This would normally accommodate an electric chain hoist. Installations may be altered and extended with relative ease to meet changing needs of the end user.





Power to the hoist and travel/traverse motions can be supplied by festoon cables suspended from trolleys that run inside the track profile, or it can be fed through internal conductor bars mounted inside the top of the track profile. The motor assembly has a collector arm inside the track which picks up the power supply.

NOTE:

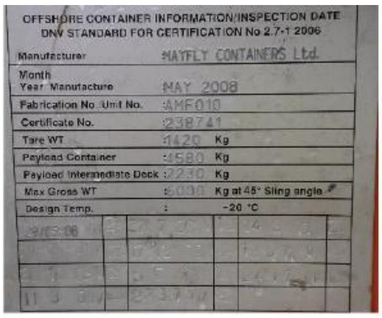
Offshore Containers

An offshore container is a freight or service container with a maximum gross mass not exceeding 25000kg, intended for repeated use to, from and in between offshore installations and ships.

The conditions that offshore containers are transported and handled in mean that the rate of wear and tear is high. An offshore container built to a recognised standard is designed, manufactured and tested to be able to withstand this wear and tear.

An offshore container is also designed with pad eyes to enable a suitably designed lifting set to be the recognised method of lifting offshore. There are various types of offshore container in service, including waste skips, baskets and skids for machinery/plant assemblies.

Specific marking requirements are prescribed by the standard that the container is designed to conform to.


OFFSHORE CONTAINER INFORMATION/INSPECTION DATE
DNV STANDARD FOR CERTIFICATION No 2.7-1 2006

Manufacturer	MAYFLY CONTAINERS Ltd
Month Year Manufacture	MAY 2008
Fabrication No. Unit No.	:AMF010
Certificate No.	:238741
Tare WT	:1420 Kg
Payload Container	:4580 Kg
Payload Intermediate Deck	:2230 Kg
Max Gross WT	:6000 Kg at 45° Sling angle
Design Temp.	: -20 °C

The lifting set which is used for lifting the offshore container must be specifically designed for the maximum gross mass of the container to be lifted.

There are enhancement factors that must be considered when designing these lifting sets, due to the dynamic motions that an offshore container will experience when being lifted offshore.

There must also be a top leg (forerunner) fitted if the lifting set does not hang over the long side of a container to a specific height. This will ensure the rigger does not have to put themselves in danger by standing on top of a container.

NOTE:

Mobile Cranes

Mobile Cranes can be manufactured in many forms. The most common types of mobile crane are:

Yard crane	Used in factories and plants where small loads can be carried on the crane's platform.
Truck-mounted crane	Has a multi-use crane with fast relocation from job to job.
Rough terrain crane	Ideal for use on construction sites on uneven ground. Easily able to relocate over rough ground and can pick up a load and carry it whilst moving.
City crane	Designed to work in often confined spaces of urban areas.
All terrain crane	A very common and popular type of crane. It is designed to travel over different types of terrain and is also able to relocate at speed on highways between sites.
Loader crane	A truck loader crane, truck-mounted crane, HIAB or 'crane truck' is a crane that is mounted to a truck, either just behind the cab or just behind the deck. It is designed to lift goods on and off the truck and means that a driver can deliver goods exactly where is required without the need for a forklift, telehandler or separate crane.

NOTE:

Tower Cranes

Tower cranes are widely used for lifting operations in the construction industry.

Tower Crane

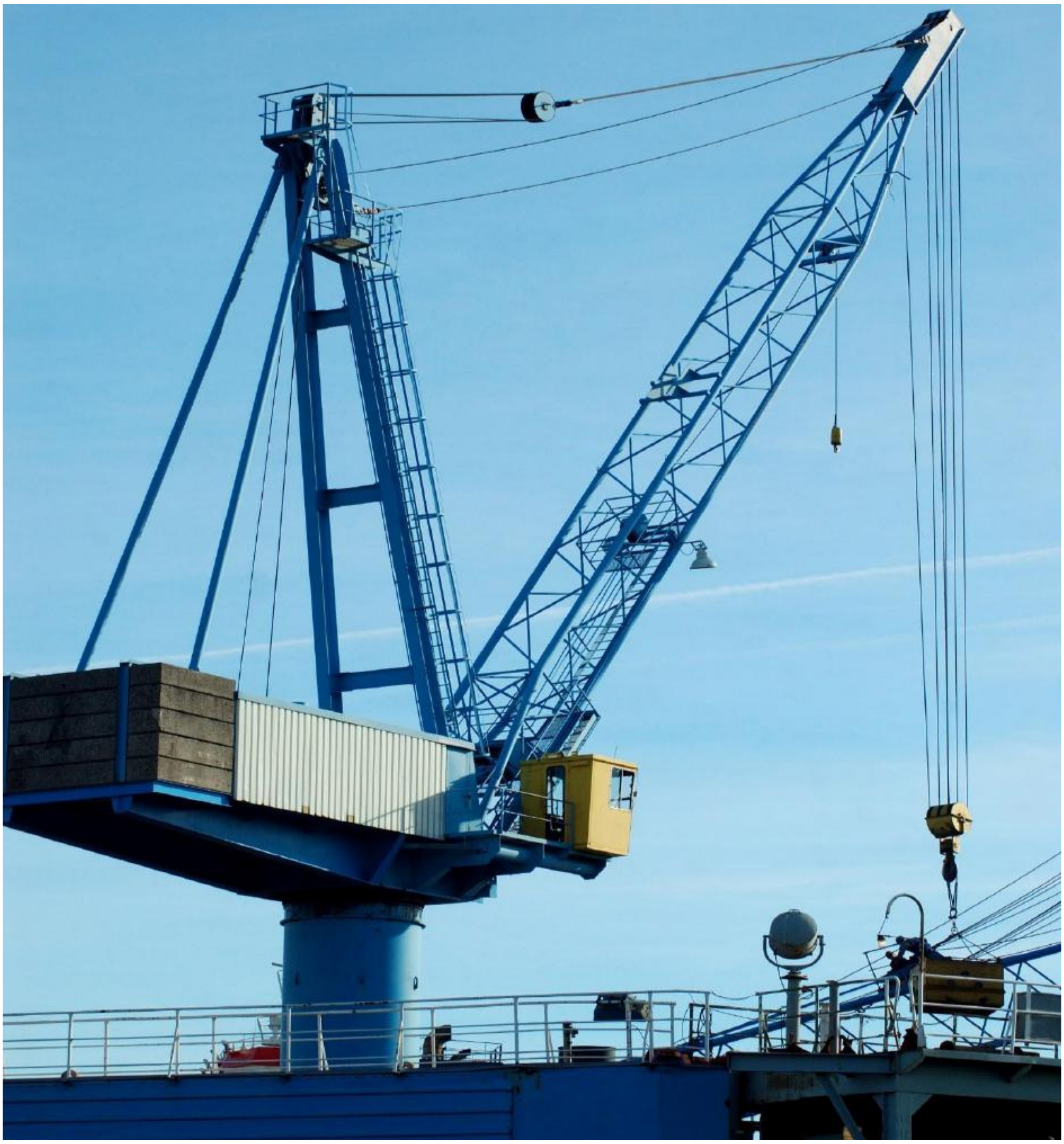
Tower cranes are extremely common at major construction sites. Often rising hundreds of feet into the air with a sizeable radius (outreach).

The construction crews use tower cranes to lift steel, concrete, waste skips, generators and a wide variety of other building materials.

NOTE:

Offshore Pedestal Crane

Defined as a pedestal-mounted, elevating and rotating lifting device used to transfer materials and personnel to or from marine vessels, barges, and structures, a standard used to design and manufacture offshore cranes.



Offshore Pedestal Cranes

Offshore Pedestal Cranes can be used for various tasks including unloading of supply vessels, offshore installation work, pipe transfer, deck handling, and subsea installation.

All main equipment – winches, electrical cabinets and/or hydraulic power units – is located inside the crane house to protect it from the harsh marine environment, to increase reliability and to reduce required maintenance. The boom hoist runs from the top of the crane house to the boom tip and controls the radius of the lower blocks.

NOTE:

- Whats next? – Having successfully passed the Foundation Certificate assessment, you will be able to study any of LEEA's diploma level training courses, in any order you choose.

you will be able to study any of LEEA's diploma level training courses, in any order you choose.

- What is your specialism? - There are no levels or tiers of qualification; each diploma is a LEEA qualification in its own right and carries equal value to that of any other LEEA diploma. So if your specialism is overhead cranes, you may now wish to move directly to the Bridge & Gantry Cranes Diploma (BGC) course. This is perfectly acceptable. If you specialise in manual chain hoists and lever hoists, you may consider moving directly to our Manual Lifting Machines Diploma (MLM).

- So…? - The choice is yours!

On gaining any LEEA diploma(s), you will automatically be issued with LEEA's TEAM Card. This will list your qualification(s) and validate their currency, which lasts for 3 years from the initial awarding date. Thereafter, every 3 years, you will be invited to update your qualification by taking a short on-line refresher course in the LEEA eLearning Academy. This will provide new information in support of your specific qualification(s) and test your essential underpinning knowledge. On completion of the refresher course(s) your TEAM Card will be revalidated and sent to you automatically.

> “ We do hope that you have enjoyed your Foundation Certificate training course and we look forward to supporting you throughout yourcontinuing studies at diploma level.
>
> \- LEEA

Summary

During the course of your study at LEEA Foundation Certificate level, you will have gained essential underpinning knowledge of relevant legislative requirements, standards and best practices, in addition to specific technical information regarding common types of lifting equipment, the materials and the science behind their development and verification.

Knowledge Check

The questions covered below do not form part of any formal qualification scoring. The intention is to just check and help embed the content we have covered so far.

There are 5 questions which are all multiple choice.

Question 1:
What does ACoP stand for? (Select one answer)

- ☐ Approved Certified Operating Procedures
- ☐ Accreditation of Certified Operating Procedures
- ☐ Applied Codes of Practice
- ☐ Approved Codes of Practice

NOTE:

Question 2:
From the list below, select which ones would fall into the category of Lifting Accessory. (Select all that apply)

- ☐ Chain sling
- ☐ Crane
- ☐ Hoist
- ☐ Eyebolt
- ☐ Jack
- ☐ Shackles

NOTE:

Question 3:

From the list below, please select all that would fit into the criteria of 'Types of Verification'. (Select all that apply)

- ◻ Hardness test
- ◻ Electromagnetic wire rope examination
- ◻ Pre and Post Inspection
- ◻ Proof load test
- ◻ Shear test

NOTE:

Question 4:

Velocity Ratio = Distance moved by effort ÷ Distance moved by load (or DME ÷ DML)

- ◻ True
- ◻ False

NOTE:

Question 5:

Who is responsible for the disposal of lifting equipment? (Select one answer)

- ◻ A. Employer
- ◻ B. Owner / End user
- ◻ C. Competent Person

NOTE:

We would be grateful for your feedback regarding this Workbook, after completing this training course. Please make your comments known to your LEEA Facilitator – you can use the note box below to list anything you would like to bring to our attention.

We value your views and will use your comments to help our continual improvement of our learning and development materials.
Thank you for in advance for your participation.

Andrew Wright
LEEA Deputy CEO

Step Notes – verbal feedback to LEEA:

Lifting Equipment Engineers Association | Lifting Standards Worldwide

www.leeaint.com