Developing Professionals for the Lifting Equipment Industry

# Lifting Machines Manual



# Advanced Programme

# Training Course Step Notes

INSTRUCTOR LED TRAINING

# LEEA Learning and Development Agreement

In the interests of all parties and to ensure the successful achievement of the LEEA Lifting Machines Manual Advanced Programme, the following arrangements are to be confirmed:

**Student:**

I agree to:

- Follow the instructions of my LEEA training facilitator at all times
- Follow all rules and procedures regarding health and safety matters whilst on site
- Respect the tidiness and cleanliness of training areas and rest area facilities
- Notify my LEEA training facilitator immediately if I have any concerns
- Inform my LEEA training facilitator of any learning difficulties at the soonest opportunity (this may be done privately between you and your LEEA training facilitator)
- Keep to agreed session times and return from rest breaks and lunchtime periods in a timely fashion
- Keep my mobile phone on 'silent' for the duration of all training sessions and to leave the class if I have to make or receive an urgent call, for the benefit of my fellow students
- Provide feedback to the LEEA facilitator regarding the training I have received
- Respect the opinions of my fellow students and to actively engage in group discussion
- Strictly adhere to the rules regarding LEEA Assessments



Signed ________________________________________ Date __________________________

**LEEA Training Facilitator**

I agree to:

- Safeguard the health, safety and welfare of my students throughout the training programme
- Provide my students with quality training, maintaining the highest of professional standards throughout
- Maintain confidentiality for all students at all times
- Provide regular feedback to students on their progress, identifying areas which may need additional study
- Keep appropriate records of any assessments conducted
- Ensure that all students are able to discuss any issues or concerns which may arise during the training course

Signed ________________________________________ Date __________________________




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# Disclaimer

These Step Notes are a useful and authoritative source of information for the LEEA Lifting Machines Manual Advanced Programme student.

Whilst every effort has been made to achieve the highest degree of accuracy in the generation of the data and information supplied, ultimate responsibility remains with the student and their employer to ensure that current legal requirements are followed.

**First Edition.........................December 2016**



**Operative training for all the equipment covered in these step notes should always take the manufacturer's information and instructions for use into account.**

# CONTENTS





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# 1. LEGISLATION

## Moral, Legal and Financial Reasons for Health and Safety Legislation

- Employers have a moral responsibility to ensure appropriate working conditions are provided
    - This is known as a common law duty of care

- Unsafe working conditions are likely to have an impact on production
    - Loss of output leading to lowering of morale and motivation
    - Loss of sales turnover and profitability

- Society and customer expectations of a company's approach to managing safety - health and safety culture
    - Negative public relations would have a damaging effect on any business

- Financial cost from loss of output
    - Fines, damages, legal costs, insurance etc.


## The Legislative Framework

**Health and Safety at Work etc. Act 1974 (UK)**

- The Act is general in nature
- There is no reference to specific articles or substances
- The Act applies to all sectors



Specific duties of care for:

- Manufacturers/suppliers of articles or substances
- Employers
- Employees

The **Health and Safety at Work Act (HSWA)** is an enabling Act for specific regulations.

**Status in UK**: legal requirement.
**International**: adopted as best practice and requested by LEEA member companies.

## The Main Purposes of the HSWA

The Health and Safety at Work Act covers nearly all occupations. It is designed to protect people at work including staff, visitors, contractors and members of the public. The HSWA supersedes nearly all previous health and safety laws in the UK.

The main purposes of the Act are set out in section 1 as follows:

- To secure the health, safety and welfare of persons at work
- To protect other people from hazards arising from work
- To control the keeping and use of dangerous substances and materials, including explosives and highly flammable materials
- To control the emission of noxious substances from certain premises

It sets out a framework of general duties, primarily on employers, but also on employees and the controllers of premises, and on designers, manufacturers, importers and suppliers in relation to articles and substances used at work.

## Regulations from the HSWA

Regulations are one form of delegated legislation made possible by Section 15 of HSWA which gives powers to the Secretary of State (UK) to make regulations for matters concerned with health and safety at work.

Regulations are not Acts of Parliament but do have the support of the law and therefore must be complied with.

Regulations are increasingly drafted by reference to European Directives (these will be discussed at a later stage in this module).

There are many sets of regulations applying to health and safety. Some apply to all places of work and others are specific to particular industries, operations, substances, materials or premises.

Here are some examples of such Regulations:

- The Manual Handling Operations Regulations 1992
- The Control of Substances Hazardous to Health Regulations 2002

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## Health and Safety at Work Act Section 2

**Duties of the Employer**

**"Duty to ensure so far as is reasonably practicable, the health, safety and welfare at work of all his/her employees"**

- Safe plant and systems of work
- Safe use, handling, storage and transportation of articles and substances
- Information, instruction, training and adequate supervision
- Safe place of work and a safe means of access and egress
- Safe working environment and adequate welfare facilities

## Health and Safety at Work Act Section 6

**Duties of Designers, Manufacturers, Importers and Suppliers**

- To ensure, so far as is reasonably practicable, that articles they design, construct, make, import, supply etc. are safe and without risk to health at all times e.g. when it is being set up, cleaned, used or maintained by someone at work
- To carry out or arrange such testing and examination necessary to perform the duties above
- To ensure that those supplying the item have adequate information about its designed and tested use. This includes essential conditions for dismantling and disposal
- Take steps to ensure, so far as is reasonably practicable, that those supplied are given updated information where it becomes known that the item gives rise to serious risk to health and safety

## Health and Safety at Work Act Section 7

**Duty of Employees**

- States that employees must not endanger themselves, or others, by their acts or omissions
- Also, they must co-operate with their employers; as long as this does not lead to an increased risk to health and safety, or is an illegal act; so that employers can comply with their statutory duties

**This makes responsibility for safety a joint employer/employee effort**

## Management of Health and Safety at Work Regulations 1992 (Revised 1999)

In addition to Section 2 (2) c of the HSWA, The Management of Health and Safety at Work Regulations 1999 require employers to ensure the effective planning, organisation, control, monitoring and review of preventive and protective measures. All these arrangements must be recorded and made known to employees. This is usually accomplished by the design of a company health and safety policy.

- MHSWR underlines the requirements for employers to provide instruction and training
- Employers must ensure that their personnel are properly trained to use any equipment necessary in the course of their work, but the regulations also place an obligation on employees to undergo such training and follow the instructions given by their employer
- Operatives are required to only use equipment for which they are trained and to use it in the manner and for the purpose for which they have been trained

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## LEEA Definition of a 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, skill and ability to perform the specific duty to which the requirement refers. There can therefore be several 'competent persons', each with their own duties and responsibilities, i.e. competent for the purpose.

The term has never been fully defined in law but, for the purpose of thoroughly examining lifting equipment, the LEEA definition of a competent person is a person having such practical and theoretical knowledge and experience of the equipment which is to be thoroughly examined that will enable him/her to detect defects or weaknesses which it is the purpose of the examination to discover and assess their importance to the safety of the equipment.

The competent person should have the maturity to seek such specialist advice and assistance as may be required to enable him/her to make necessary judgements and be a sound judge of the extent to which he/she can accept the supporting opinions of other specialists. He/she must be able to certify with confidence whether it is free from patent defect and suitable in every way for the duty for which the equipment is required. It is the view of LEEA that competency can be a corporate responsibility.

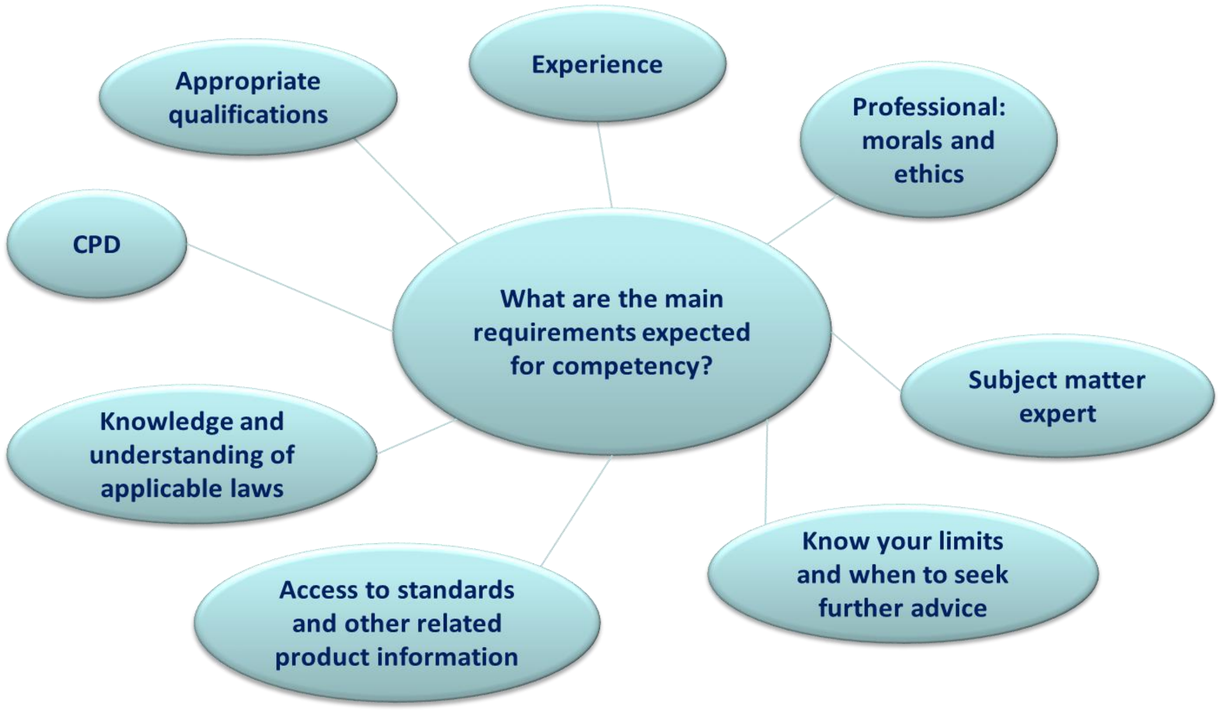
## Primary Elements of Competency

**I**nformation
**I**nstruction
**T**raining
**S**upervision



**Note:** LEEA training course certificates and Advanced Programme qualifications are not evidence, declaration or proof of competency.

## What are the Required Elements of Competency?



## Risk Assessment

**What is "Risk Assessment"?**
Put simply, it is a careful examination of what, in your work, could cause harm to people, so that you can weigh up whether you have taken enough precautions or should do more to prevent harm.

What are the 3 main reasons to assess and manage risk?

- Human Harm
  - Injury and illness

- Legal Effects
  - Duty of care and consequences of unsuitable or insufficient risk management

- Economic Effects
  - Substantial financial costs are related to accidents at work

Although there are no fixed rules about how a risk assessment should be undertaken, it is important to take a structured approach which will allow all relevant risks or hazards to be addressed.

Firstly, we have to consider the factors that contribute to accidents/ill-health in the workplace:

**HAZARD | DANGER | LIKELIHOOD | SEVERITY | RISK**

**Hazard**
A hazard is something (object or situation) that has the potential to cause harm.

**Danger**
A liability or exposure to harm; something that causes peril.

**Likelihood**
How likely is it that someone could be harmed by the hazard?

**Severity**
If the potential for harm was to occur, how severe would the accident be?

**Risk (a Combination of Likelihood and Severity)**
Risk is the likelihood that the harm from the hazard is realised.

**Definitions**

Net Result (Risk) = Likelihood x Severity

**i.e. how likely x how severe the consequence**

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**5 Steps to Risk Assessment...**

1. Identify the hazards
2. Decide who might be harmed and how
3. Evaluate the risks and decide on control measures
4. Record your findings and implement them

Review your assessment and update if necessary

## Control Measures

**Hierarchy of Control Measures (ERIC-PD)**

**E**liminate
**R**educe
**I**solate
**C**ontrol
**P**PE
**D**iscipline

## Monitor and Review

Ensure control measure compliance (discipline)



Be vigilant - note changes:

- Additional hazards presented?
    - e.g. traffic, pedestrians etc., changes in production activity

Record your findings and change the risk assessment as necessary.

This may result in the requirement for additional control measures.

## Are you Following a 'Safe System of Work'?

✓ You have evaluated the hazards

✓ You have identified who may be harmed

✓ You have decided upon and implemented control measures

✓ You have recorded your findings

✓ You will review and monitor the situation

**If you have completed the above checklist, you are now following a "Safe System of Work"**

## The European Machinery Directive

A European Directive is a Directive to the member states of the European Community, which has been adopted by the Council of Ministers, to introduce legislation with common requirements throughout the Community. The Directives are used to remove barriers to trade and introduce common safety requirements.

The Machinery Directive is largely based on Risk Assessment and use of European Standards for critical features such as guards and emergency stops. Machinery Directive provides the harmonisation of the Essential Health and Safety Requirements (EHSRs) for machinery.

It applies only to products that are intended to be placed on or put into service in the market for the first time.

## What is a 'Machine' by Definition?

**Machinery**:

> "an assembly, fitted with or intended to be fitted with a drive system other than directly applied human or animal effort, consisting of linked parts or components, at least one of which moves, and which are joined together for a specific application".

Manufacturers are responsible for verifying whether a particular product falls within the scope of the machinery directive.

Note: The definition here is for 'machinery' within the scope of the directive in the 'strict' sense, but the directive also has other definitions covering machinery in the 'broader' sense. The strict sense definition excludes Lifting Machines Manual, accessories, ropes, chains and webbing. All of which are covered by the broader sense definitions.



## Supply of Machinery (Safety) Regulations 2008 – SM(S)R

Machinery Directive is implemented in the United Kingdom under the Supply of Machinery (Safety) Regulations.

The Supply of Machinery (Safety) Regulations 2008, SI No 1597 implement the Machinery Directive and contain essential safety requirements which the machinery, including lifting machines and lifting accessories, must meet.

Manufacturers, importers (into the European Union) and suppliers placing such equipment on the market for service in the community have a duty to:

- Design, build and supply equipment that is safe and meets the Essential Safety Requirements
- To carry out such tests as may be necessary to ensure the requirements of above are met
- To maintain records of all calculations, tests and other relevant information that go to make up a **Technical File** which may be called upon by the enforcing authorities and which must demonstrate that the Essential Safety Requirements have been met
- Issue with each item of equipment information on the installation, maintenance, care and safe use, and:

- Issue a Declaration of Conformity and affix the CE mark, or issue a Declaration of Incorporation depending on its nature and intended use. In this context, if you manufacture or import (from outside the European Union) an item for your own use, you assume the full responsibilities of the manufacturer and must therefore meet all of the requirements of the regulations

To support the Machinery Directive, the Joint European Standards Organisation, CEN/CENELEC, has been producing Harmonised European Standards.

Most of these standards have been published but there are still some left in the pipeline. As and when they are published, they will supersede any existing British Standards or other European national standards covering the same products.

These Harmonised Standards have a special status in that products made to the standard are deemed to meet the essential health and safety requirements of the Relevant Directives, and therefore the UK Regulations, in so far as the standard addresses such essential requirements.

They therefore provide a relatively easy way for manufacturers to know that their products meet the legal requirements and equally a convenient way for purchasers to specify their needs.

Following the publication of the new Machinery Directive 2006/42/EC in 2006, all the relevant Harmonised Standards have been amended to make reference to it.

## The Technical File

The Essential Health and Safety Requirements that apply to the lifting equipment:



- A description of the methods used to eliminate these hazards or reduce risks
- The standards used in the design; information from the user
- Design information (calculations, drawings, procedures, etc.)
- Material traceability; tests reports and instructions for use

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## Supply of Machinery (Safety) Regulations 2008

Aligned to the requirements of the Machinery Directive, the Supply of Machinery (Safety) Regulations state that lifting equipment must be designed and built to sustain a static overload of:

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| Manually operated machines | 1.5 | x WLL |
| Other machines | 1.25 | x WLL |
| Lifting accessories | 1.5 | x WLL |

Machinery must be capable of sustaining a dynamic overload of: -

1.1 x WLL

Previous standards and directives have used different values therefore it is important to always consult manufacturers documentation for specific requirements.

Lifting machines must also be supplied with instructions for:

- Care and safe use
- Installation, commissioning and testing
- Maintenance and adjustments
- Limitations of use and possible misuse
- Noise and vibration emissions
- Training



Notes:

## PUWER and LOLER Regulations

**PUWER**: Provision and Use of Work Equipment Regulations 1998
Applies to all work equipment

**LOLER**: Lifting Operations and Lifting Equipment Regulations 1998
Applies to lifting equipment in addition to PUWER

Both LOLER and PUWER apply to all sectors of industry

**Status of PUWER and LOLER**

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|---|---|
| United Kingdom: | Legal requirement |
| International: | Good practice demanded by customers and local authorities, integral to the LEEA Code of Practice |

## The Essentials of PUWER

PUWER places duties on the employer to ensure that:

- It is the duty that the employer to ensure that work equipment coming into his undertaking meets with any EHSRs and in the case of lifting equipment this would be of directive 2006/42/EC.
- Work equipment is suitable for the purpose for which it is to be used
- The working conditions and risk to health and safety of personnel in which the work equipment is used is to be considered
- Equipment is suitably maintained and a log kept up to date
- Equipment is inspected on a regular basis (ref. LOLER)
- All inspection and maintenance records are kept and recorded
- All persons using work equipment have sufficient information pertaining to its use, e.g. operating manuals and guides to safe use

PUWER requires employer to address risks or hazards of equipment from all dates of manufacture and supply.

Equipment first provided for use after 31st December 1992 must comply with any ‘essential requirements’

Equipment may still present a hazard or risk if:

- Application different from that originally envisaged
- Safety depends upon the way it is installed
- Technical mismatch between the supply side and user side legislation

Employers can ensure compliance by checking:
- CE Marking
- EC Declaration of Conformity

PUWER requires that, when providing equipment for use at work:
**The purchaser obtains equipment complying with the relevant European Directives**. E.g. In the case of grade 8 mechanically assembled chain slings, specifying BS EN 818-4 and requesting the EC Declaration of Conformity will ensure that the slings meet this requirement.

## Provision and Use of Work Equipment Regulations (PUWER)

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| Regulation 4 | Suitability of Work Equipment |
| Regulation 5 | Maintenance |
| Regulation 6 | Inspection |
| Regulation 7 | Specific Risks |
| Regulation 8 | Information and Instructions |
| Regulation 9 | Training |

## Summary of the Key Requirements of PUWER

PUWER requires employer to address risks or hazards of equipment from all dates of manufacture and supply.

Equipment first provided for use after 31st December 1992 must comply with any 'essential requirements'.



Equipment may still present a hazard or risk if:
- Application is different from that originally envisaged
- Safety depends upon the way it is installed
- Technical mismatch between the supply side and user side legislation

How does an employer check that equipment he has purchased complies with the requirements of PUWER?
- Locate the CE marking
- Obtain the EC declaration of conformity from the supplier

Notes:

## Lifting Operations and Lifting Equipment (LOLER)

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|---|---|
| Regulation 4 | Strength and Stability |
| Regulation 5 | Lifting Equipment for Lifting Persons |
| Regulation 6 | Positioning and Installation |
| Regulation 7 | Marking of Lifting Equipment |
| Regulation 8 | Organisation of Lifting Operations |
| Regulation 9 | Thorough Examination and Inspection |
| Regulation 10 | Reports and Defects |
| Regulation 11 | Keeping of Information |

**Regulation 4: Strength and Stability**

Requires the employer to ensure that the load they are planning to lift does not exceed the limits for strength and stability of the lifting equipment.

**Regulation 5: Lifting Equipment for Lifting Persons**

Details the additional safeguards that must be considered when using lifting equipment to lift people.

**Regulation 6: Positioning and Installation**



Details the considerations on where lifting equipment, both fixed and mobile equipment, should be sited.

**Regulation 7: Marking of Lifting Equipment**

Requires all lifting equipment to be marked with its SWL and information that gives the items characteristics, e.g. grade, angle of use etc.

**Regulation 8: Organisation of Lifting Operations**

Clarifies that each lifting operation needs to be planned, supervised and carried out safely.

**Regulation 9: Thorough Examination and Inspection**

Before lifting equipment is put into service for the first time it is thoroughly examined for any defect unless the lifting equipment:

- Is less than 12 months old
- Owner holds the original DOC
- Equipment that has not been used before will require thorough examination when entering service if the DOC is older than 12 months. Equipment can be damaged during long periods within the supply chain

Maximum fixed periods for thorough examinations and inspection of lifting equipment as stated in regulation 9 of LOLER are: -

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| Lifting Accessories | 6 months |
| Lifting Equipment | 12 months |
| People Carrying Equipment | 6 months |

- Or in accordance with a written scheme of examination
- Or each time that exceptional circumstances which are liable to jeopardise the safety of the lifting equipment have occurred

The information to be contained in the report of thorough examination is given in **schedule 1 of LOLER.**

Notes:



## Minimum Requirements for a Report of Thorough Examination – Schedule 1 of LOLER

- The name and address of the employer for whom the thorough examination was made
- The address of the premises at which the thorough examination was made
- Particulars sufficient to identify the equipment including where known its date of manufacture
- The date of the last thorough examination
- The safe working load of the lifting equipment or (where its safe working load depends on the configuration of the lifting equipment) its safe working load for the last configuration in which it was thoroughly examined
- In relation to the first thorough examination of lifting equipment after installation or after assembly at a new site or in a new location:
  - That it is such thorough examination;
  - (If such be the case) that it has been installed correctly and would be safe to operate

In relation to a thorough examination of lifting equipment other than a thorough examination to which paragraph 6 relates –

- Whether it is a thorough examination:
    - Within an interval of 6 months under regulation 9(3)(a)(i)
    - Within an interval of 12 months under regulation 9(3)(a)(ii)
    - In accordance with an examination scheme under regulation 9(3)(a)(iii)
    - After the occurrence of exceptional circumstances under regulation 9(3)(a)(iv)

- (If such be the case) that the lifting equipment would be safe to operate

- In relation to every thorough examination of lifting equipment:
    - Identification of any part found to have a defect which is or could become a danger to persons, and a description of the defect
    - Particulars of any repair, renewal or alteration required to remedy a defect found to be a danger to persons

- In the case of a defect which is not yet but could become a danger to persons -
    - The time by which it could become such a danger
    - Particulars of any repair, renewal or alteration required to remedy it

- The name, address and qualifications of the person making the report; that he/she is self-employed or, if employed, the name and address of his employer



- The name and address of a person signing or authenticating the report on behalf of its author

- The date of the report

**Model report of thorough examinations is available for LEEA members on the LEEA website.**

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## Written Schemes of Examination

The Lifting Operations and Lifting Equipment Regulations 1998 permits a scheme of examination, drawn up by a Competent Person, as an alternative to the fixed maximum periods.

The benefit of an examination scheme is that, by focusing on the most safety critical areas, the examinations can be carried out the most cost effective way. This may provide a means of reducing examination costs, however it may also provide a means of enhancing safety without increasing costs.

## Information for Written Schemes of Examination

- The written scheme of examination should contain at least the following information:
- The name and address of the owner of the lifting equipment
- The name and contact details of the person responsible for the equipment. If responsibility is divided, e.g. between maintenance and operations, there may be more than one name, however it should be clear who should be notified in the event of a dangerous or potentially dangerous defect and to whom reports should be sent
- The name, qualifications and address of the person drawing up the scheme. If the Competent Person is not working on their own account, the name of their employing organisation and their position in that organisation should be given
- The identity of the equipment, i.e. a description including the make, model and unique identity number
- The location of the equipment if it is a fixed installation or the location where it is based for portable and mobile equipment
- Details of any information or references used in drawing up the scheme. For example, the manufacturer's manual, expected component life, or specific information on the design life of the crane structure and mechanisms as detailed in clause 7 of ISO 12482-1
- The basis for the scheme. For example, is it based on hours of service, duty monitoring, examining certain parts or components at different intervals to other parts?
- Details of any data logging system fitted, including a list of the parameters monitored and the means of data retrieval, monitoring and storage
- What determines when the thorough examination shall take place and who is responsible for monitoring that and instigating the examination?
- Identification of the safety critical parts requiring thorough examination
- A risk assessment should take account of:
    - The condition of the equipment
    - The environment in which it is to be used

- The number and nature of lifting operations and the loads lifted
  - The details of any assumptions about usage, expected component life
  - Etc.

- The frequency of thorough examination of those parts identified as safety critical taking into account the degree of risk associated with each part. This may include time or loading or duty cycle limits and vary for different parts of the equipment. Where the scheme is based on such criteria, we recommend that a maximum period between thorough examinations is always specified as equipment can deteriorate whether used or not

- The method of examination of those safety critical parts, which may include the degree of dismantling required and the techniques employed e.g. visual examination, measurement, NDT, operational test, load test

- The rejection criteria or a reference to where this information may be found

- An indication of the resources required to prepare the equipment and carry out the thorough examination. This may include qualified personnel, workshop facilities, specialist NDT and metallurgical facilities

- Any changes to equipment condition, operational or environmental parameters that will require a review of the scheme by the Competent Person. These may include damage to the equipment, change of use from general duty to heavy duty or moving from an inland location to a marine environment



- A requirement for the person responsible for the equipment to monitor its circumstances of use and inform the Competent Person who drafted the scheme of any changes

- The date of drawing up the scheme and the date at which any routine review is required

**Further information on written schemes of examination can be found in the LEEA COPSULE Edition 8 Appendix 1.8.**

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# Lifting Operations and Lifting Equipment Regulations (LOLER)

**Regulation 10: Reports and Defects**

A person making a thorough examination for an employer under regulation 9 shall:

- Notify the employer forthwith of any defect in the lifting equipment which in his opinion is or could become a danger to persons
- As soon as is practicable make a report of the thorough examination in writing authenticated by him/her or on his/her behalf by signature or equally secure means and containing the information specified in schedule 1 to the employer; and where there is in his opinion a defect in the lifting equipment involving an existing or imminent risk of serious personal injury, send a copy of the report as soon as is practicable to the relevant enforcing authority

Where there is in his opinion a defect in the lifting equipment involving an existing or imminent risk of serious personal injury, the Competent Person will send a copy of the report as soon as is possible to the relevant enforcing authority. In this case, an employer who has been notified of an imminent risk shall ensure that the lifting equipment is not used before the defect is rectified.

**Regulation 11: Keeping of Information**

An employer obtaining lifting equipment shall:

- Keep the EC Declaration of Conformity for so long as they operate the lifting equipment
- Ensure that the information contained in every report is kept available for inspection

In the case of a thorough examination for lifting equipment:

- Until he ceases to use the lifting equipment



In the case of a thorough examination for lifting accessories:

- For two years after the report is made

## LOLER and the Tester/Examiner

LOLER refers to 'Thorough Examination and Inspection' of which a test may be part.

A report of thorough examination to include details of any tests carried out.

The duties of the Competent Person include ensuring that:

- Lifting equipment has been thoroughly examined before it enters service
- Second-hand, hired or borrowed equipment has a current examination report before it is used
- And, where safety of equipment depends upon installation:
    - That it has a thorough examination after it has been installed
    - That it has a thorough Examination after it has been assembled

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## Manual Handling Operations Regulations

- Refers directly to lifting operations and adds to the employer's duties in section 2 of the HSWA

- Requires an assessment to be made of any operation where loads are handled manually, or where manual effort is necessary, with a view to reducing the number of injuries that result from such operations:
    - Task
    - Individual
    - Load
    - Environment

- Requires the introduction of lifting appliances where the risks are high or if the operation can be made safer by their introduction

## Working at Height

The danger of people and materials falling affects not only those working at height, but also sometimes to a greater degree, those underneath.

Working at height is one of the biggest causes of fatalities and major injuries. Commonly, accidents are caused from falls from ladders and through fragile surfaces. Work at height means work in any place where, if there were no precautions in place, a person could fall a distance that could cause personal injury (for example a fall through a fragile roof).



Employers and those in control of work at height must first assess the risks.

**Before working at height, you must follow these simple steps:**

- **Avoid** work at height where it is reasonably practicable to do so

- Where work at height cannot be easily avoided, **prevent** falls using either an existing place of work that is already safe or the right type of equipment

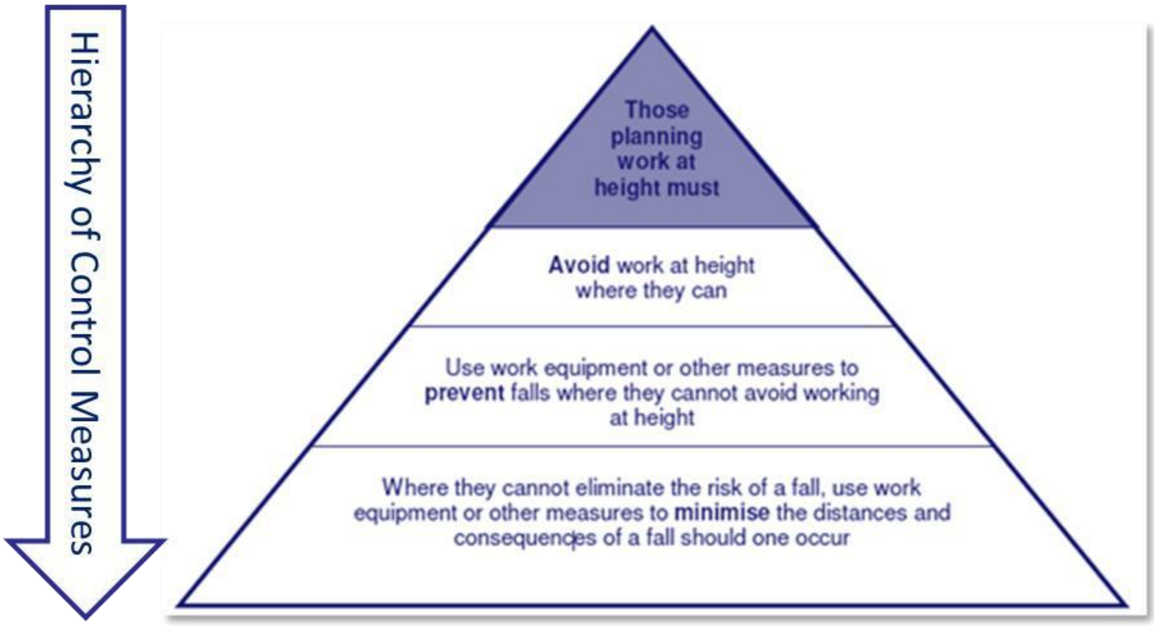
- **Minimise** the distance and consequences of a fall, by using the right type of equipment where the risk cannot be eliminated

## Working at Height Regulations (UK)

The Work at Height Regulations 2005 have an influence on lifting practice.

They emphasise the need to avoid working at height if possible but, where it is necessary, they require the most suitable means of reducing and controlling the risk.

Consequently, this has affected the choice of equipment for some lifting operations.




**Do:**

- As much work as possible from the ground
- Ensure workers can get safely to and from where they work at height
- Ensure equipment is suitable, stable and strong enough for the job, maintained and checked regularly
- Take precautions when working on or near fragile surfaces
- Provide protection from falling objects
- Consider emergency evacuation and rescue procedures



**Do not:**

- Overload ladders; consider the equipment or materials workers are carrying before working at height. Check the pictogram or label on the ladder for information
- Overreach on ladders or stepladders
- Rest a ladder against weak upper surfaces, e.g. glazing or plastic gutters
- Use ladders or stepladders for strenuous or heavy tasks, only use them for light work of short duration (a maximum of 30 minutes at a time)
- Let anyone who is not competent (who doesn't have the skills, knowledge and experience to do the job) to work at height

**Working at Height – A Brief Guide**

Please read the HSE document: "Working at Height – A Brief Guide", available at www.hse.gov.uk

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## Revoked, Repealed and Amended Legislation

Prior to 5 December 1998, the Factories Act 1961 was the main legislation concerned with the use of lifting equipment and it was augmented several sets of industry specific regulations. The Provision and Use of Work Equipment Regulations 1998 and the Lifting Operations and Lifting Equipment Regulations 1998 together repeal, revoke or amend and replace the requirements for lifting equipment given in the following:

- The Factories Act 1961
- The Construction (Lifting Operations) Regulations 1961
- The Shipbuilding and Ship-repairing Regulations 1960
- The Docks Regulations 1988
- The Mines and Quarries Act 1954
- The Offshore Installations (Operational Safety, Health and Welfare) Regulations 1976
- The Lifting Plant and Equipment (Records of Test and Examination Etc.) Regulations 1992

Notes:

# 2. MECHANICS OF MACHINES

In their most basic of form, machines are a combination of parts we use to overcome a resistance by transferring or transforming energy. In the case of Lifting Machines Manual, this force is exerted by a human being.

Usually, the forces we need to overcome are referred to as the 'resistance'. The forces we apply in order to overcome the resistance is referred to as the 'effort'. We must do work to overcome the force due to gravity and move loads upward.

The simple machine is designed to multiply force or change direction of a force; simple machines are devices that help us do work. When we do work, we use energy; energy transfers or transforms, but it does not disappear. When we do work we also use a force to overcome inertia, friction or gravity. We can measure work.

Although not strictly true, we will consider weight and force to be equal and expressed in the same units throughout this module.

## Work and Energy

**Work**

- Forces act on objects
- When a force causes an object to move, it is the force that does the work
- The distance moved by the force is the same as the distance moved by the object
- The work done by a force (F) moving through a distance (d) is given by:

$$W = F \times d$$

If the force is overcoming frictional forces, all or some of the work done by the force is converted to heat energy.

**Energy**

The work done by the force may also be converted to kinetic energy or potential energy of the object.

**Kinetic Energy**

Moving objects have kinetic energy. The heavier the object is and the faster it moves, the more kinetic energy it has. All moving objects have kinetic energy, even very large objects, such as overhead cranes, jacks and very small ones.

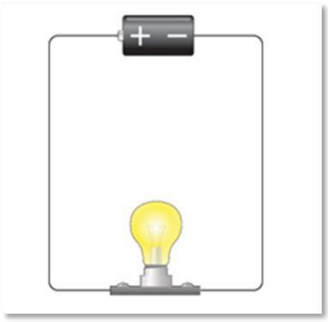
**Potential Energy**

This is the stored energy of a position possessed by an object.

It is an energy that is stored within an object, not in motion, but capable of becoming active. When at rest, every object has rest mass potential energy; if the object can be affected by gravity and can fall, it has gravitational potential energy. Once an object is in motion, potential energy is converted to kinetic energy, which is the energy of motion.

When work is converted to different forms of energy you can use the work done relationship to calculate energy gained or lost, and energy relationships to calculate work done.

It is important to remember that energy cannot be destroyed. It is always converted into other forms of energy.




As an example of energy transfer, the battery shown below transfers its electrical energy to the lamp, and the lamp emits light energy to the surrounding area.



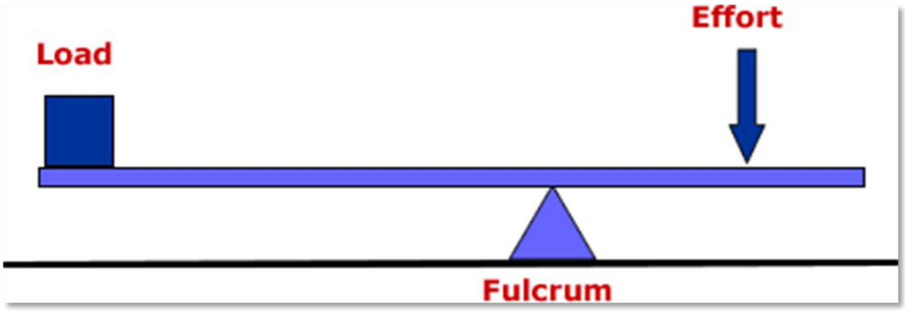
Notes:

## Levers

Levers are probably the most common simple machine.

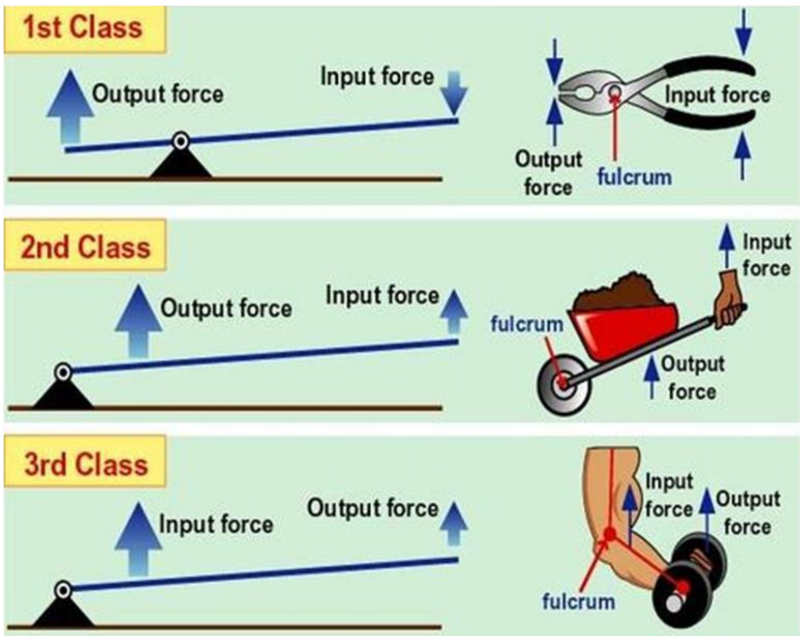
Nearly everything that has a handle on it has a lever attached.

The point on which the lever moves is called the fulcrum. By changing the position of the fulcrum, you can gain extra power with less effort.



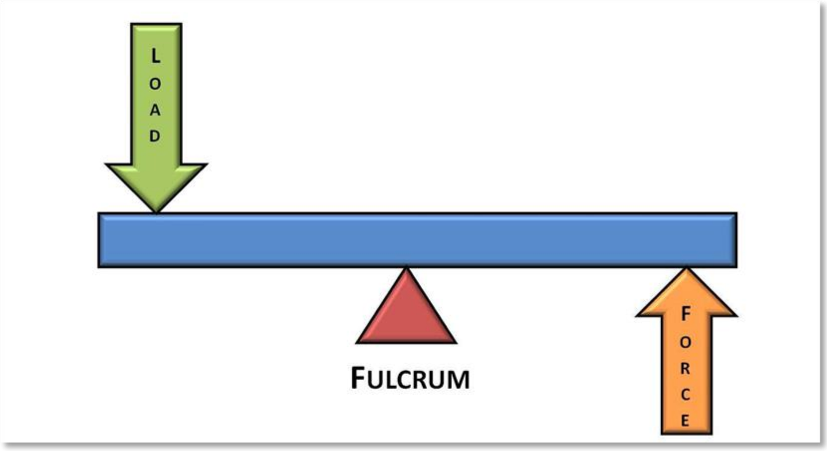

**3 Classes of Lever**

Levers are all around us, and within our bodies, as the basic physical principles of the lever are what allow our tendons and muscles to move our limbs with bones acting as the beams and joints acting as the fulcrums. The following illustration shows three principal types of lever:



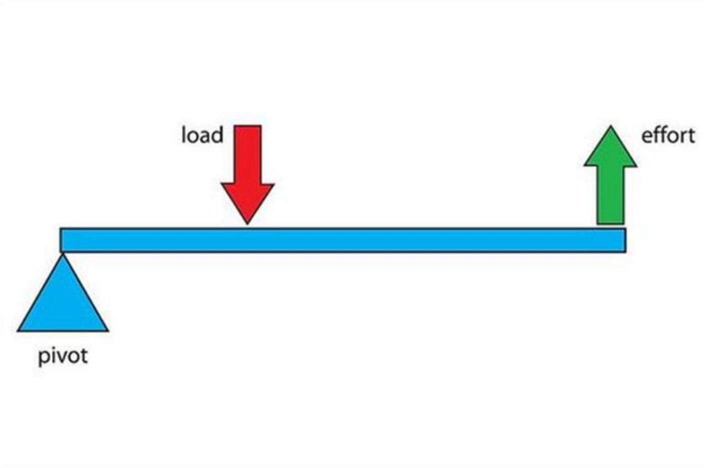
**Class 1 Levers**

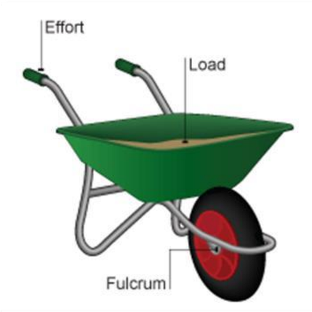
A class 1 lever has the load and the effort (force) on opposite sides of the fulcrum, like a seesaw. Other examples of a class-one lever are a pair of pliers and a crowbar.




**Class 2 Levers**

A class 2 lever has the load and the effort (force) on the same sides of the fulcrum, like a wheelbarrow.



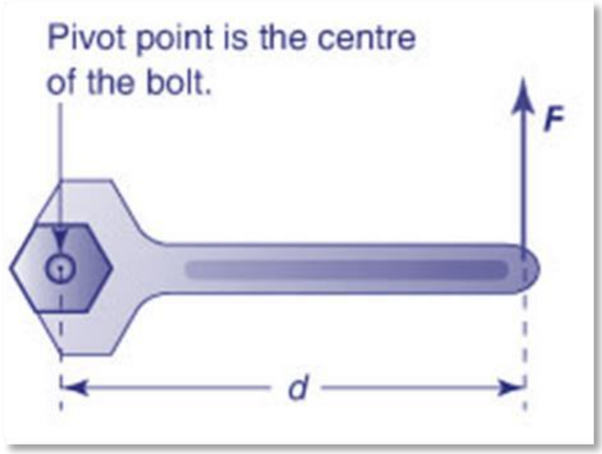

Notes:

## Moments of Force

There are many examples of the lever in our everyday life, some are obvious, others are not so obvious, e.g. a spanner is an obvious example but a less obvious example is a jib crane.

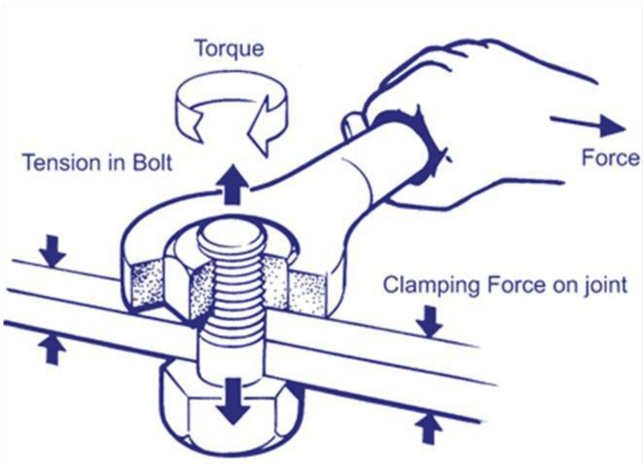
When a force is applied to a lever it gives it a turning effect, which is known as the **moment of force** or **turning moment**.

The **moment of force = force (F) x shortest distance (d)** to the line of action of the force. This turning moment is called **torque**.




### Torque

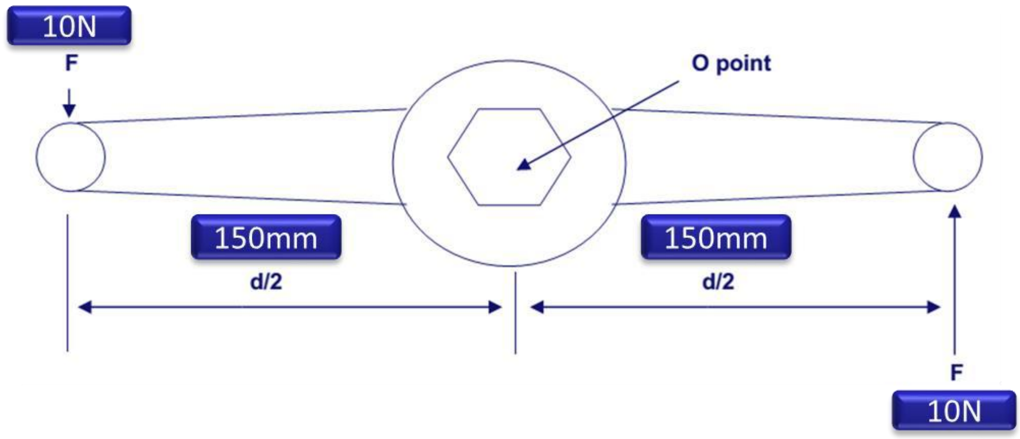
Torque is important to the examiner and tester. For example, the nuts of wire rope grips must be set to the correct **torque,** as must the foundation bolts of crane structures. These are set using a **torque wrench,** which allows the nuts to be tightened to a known **torque.** In the course of our duties it is often necessary to check that nuts have been correctly tightened to the required **torque.**



**Couples**

A couple is a pair of forces, equal in magnitude, oppositely directed, and displaced by perpendicular distance or moment.

The principle of moments states that when in equilibrium, the sum of the anti-clockwise moment is equal to the sum of the clockwise moment. The illustration below shows a moment of equilibrium:




Anti-clockwise moment is: 10 x 150 = 1500
Clockwise moment is: 10 x 150 = 1500

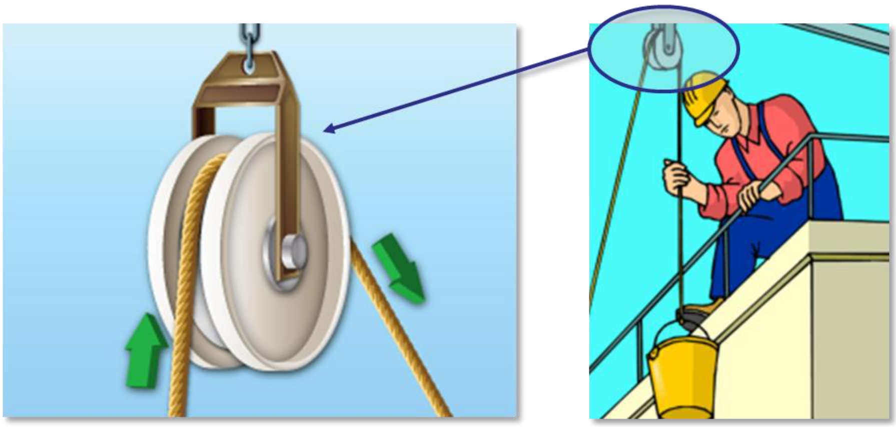
Therefore, we have a state of equilibrium.

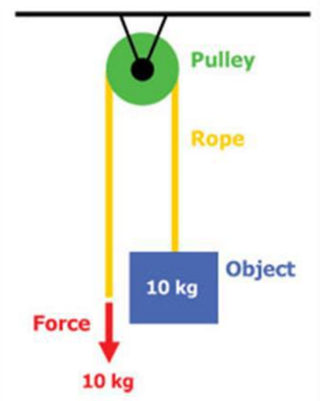


Notes:

# Pulleys

A pulley is a wheel with a groove along its edge, where a rope or cable can be placed. It uses the principle of applying force over a longer distance, and also the tension in the rope or cable, to reduce the magnitude of the necessary force. Complex systems of pulleys can be used to greatly reduce the force that must be applied initially to move an object.

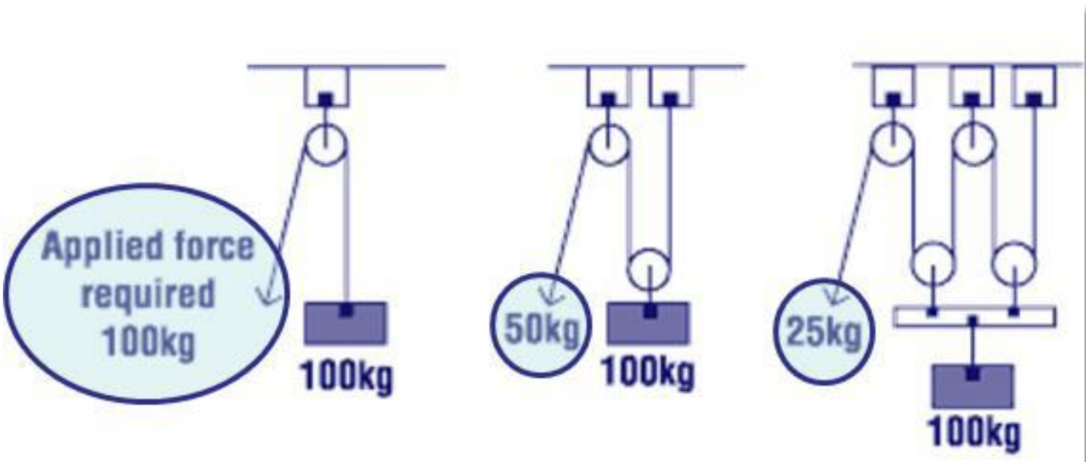





As shown in this illustration, a single wheel pulley and a rope helps you reverse the direction of your lifting force. If the bucket weighs 10kg then you would have to apply 10kg to lift the bucket, although you would have to exert more force to overcome friction in the pulley.

Pulleys can be used to multiply force:






If you add more pulleys, and loop the rope around them, you can reduce the force (effort) that you will need to lift the weight.

| Notes: |
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## Mechanical Advantage

The theoretical mechanical advantage of a system is the ratio of the force that performs the useful work to the force applied, assuming there is no friction in the system.

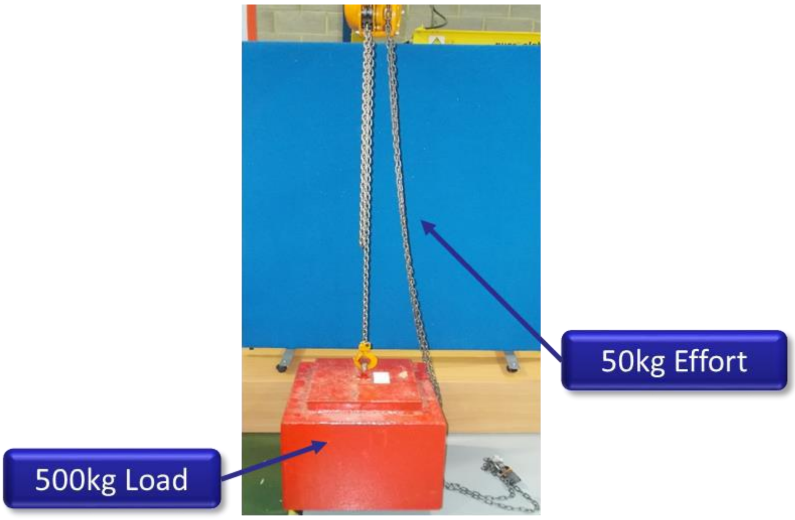
In more complicated machines, the relationship of load (W) to effort (P) is known as the **mechanical advantage (MA)**. The units of load and effort are the same, MA has no units and is a simple ratio.

**Mechanical Advantage = Load ÷ Effort**

In the example shown, MA = L ÷ E

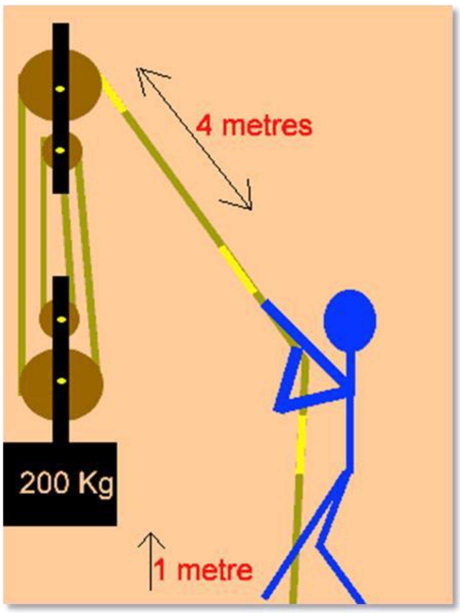
= 500 ÷ 50 = 10

**Mechanical Advantage is 10**






## Velocity Ratio



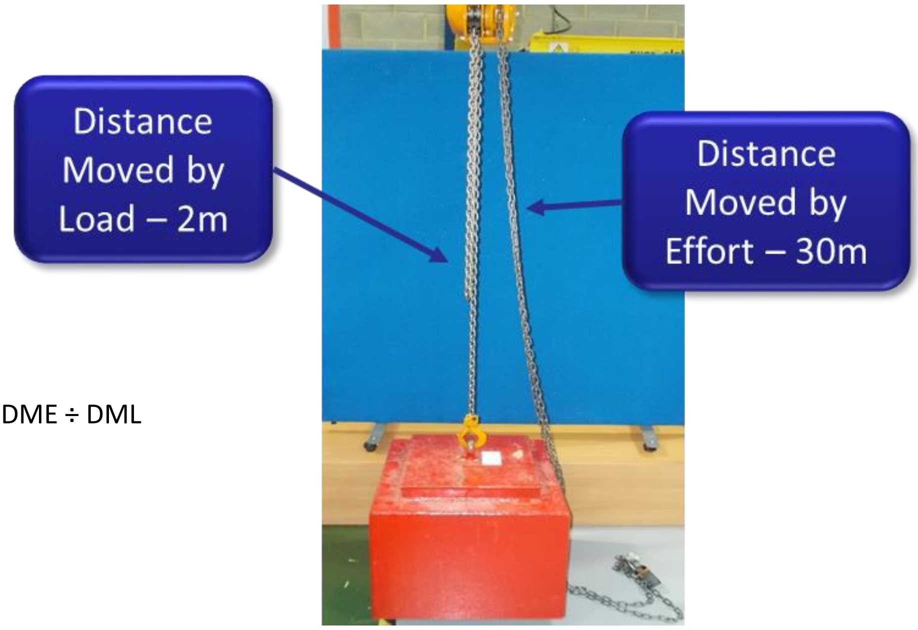

Machines are a great tool, as they enable us to move very large forces by applying only small ones.

Unfortunately, as we all know, you never get something for nothing and in order to move the load a short distance it is necessary for the effort to travel a greater distance.

The relationship between these movements is called the **velocity ratio** (VR).

In order to move the load a short distance it is necessary for the effort to travel a greater distance. The relationship between these movements is called the velocity ratio (VR). As the units of distance are the same, VR has no units and is a ratio.

**Velocity Ratio = Distance Moved by Effort ÷ Distance Moved by Load**




In the example shown, VR = DME ÷ DML

= 30 ÷ 2 = 15

**Velocity Ratio = 15**

Notes:



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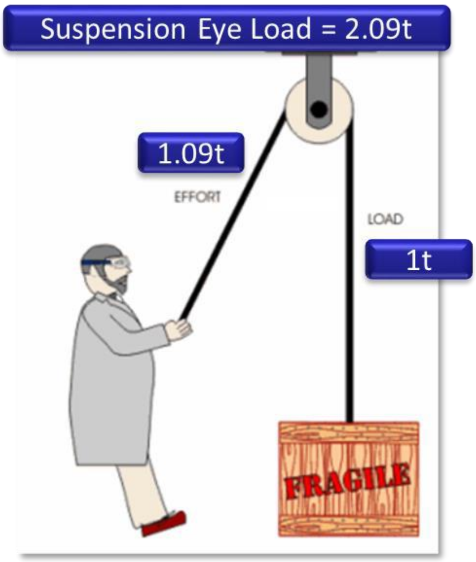
## The Effects of Friction

No matter how well a machine is designed we can never get out more in total than we put in, in fact we get out far less. This is due in the main to **friction**, which is the enemy of movement.

For example, **in a simple pulley a loss of between 4% and 9% of the force is accounted for by friction in the sheave**, therefore the more sheaves the greater the loss and the lower the **efficiency** as the friction is cumulative.

Efficiency is then expressed as a percentage of the 'work done', i.e. **MA ÷ VR x 100%**



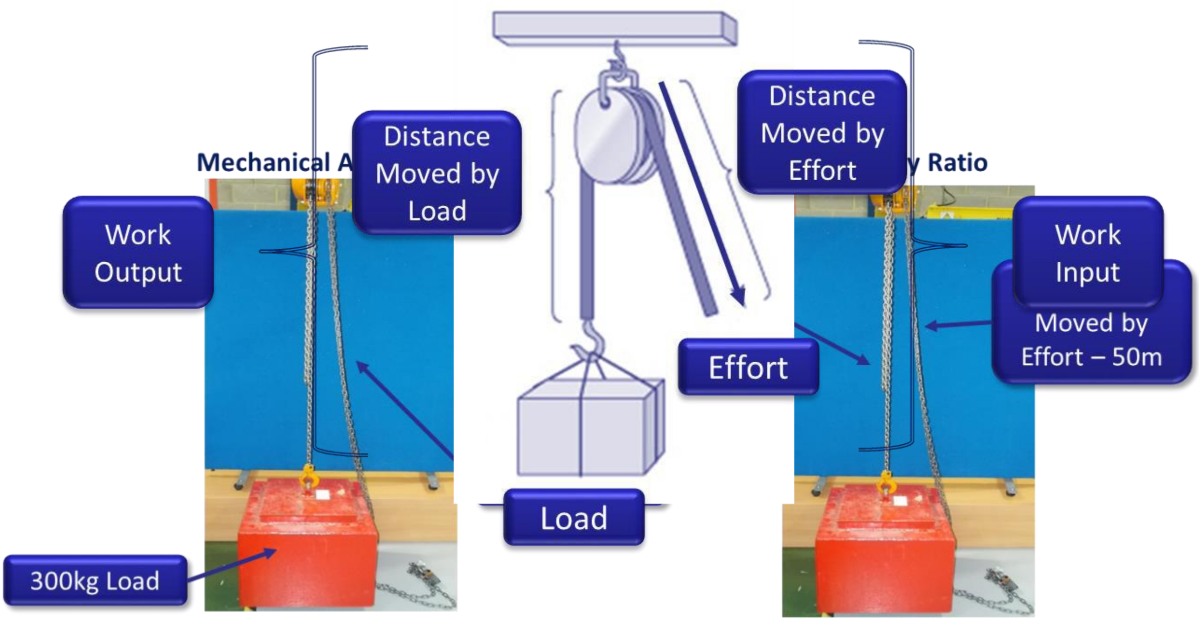

If the load is 1t, then the effort required to lift the load will need to be greater than 1t + 9% i.e. 1.09t.

As both the load and the effort act on the sheave the total load on the suspension eye will be 2.09t, i.e. the sum of the effort, the load lifted and friction.



## Efficiency

Efficiency can be determined by comparing the total input with the total output and this is known as **work done**.



From looking at the above, the **mechanical advantage can be calculated as:**

Load (300kg) ÷ Effort (30kg) = **10**

**Velocity ratio can be calculated as:**

Distance moved by effort (50m) ÷ Distance moved by load (2m) = **25**

**EFFICIENCY is Mechanical Advantage ÷ Velocity Ratio x 100, it can be calculated as:**

10 25 (x100) = **40% efficiency**

| Notes: |
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# 3. VERIFICATION


Verification is the generic term used to describe the procedures adopted by the manufacturer or competent person to ensure that lifting equipment is of the required standard or specification, that it meets legal requirements and is safe to operate. This may include proof load testing, sample break testing, non-destructive testing, calculation, measurement and thorough examinations.

**Note:** 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 and some items are assembled from components verified to their own standards, therefore no further tests are required. Once in service, the verification methods used will be those deemed necessary by the competent person in reaching his conclusions about fitness for purpose.

All lifting equipment must be verified:



- To ensure it is safe before first use
- Periodically once it is in service to ensure it remains safe to use

## Extract from LOLER

Every employer shall ensure that before lifting equipment is put into service for the first time by him/her self it is thoroughly examined for any defect unless either:

- The lifting equipment has not been used before

- In the case of lifting equipment for which an EC declaration of conformity could or (in the case of a declaration under the lifts regulations 1997) should have been drawn up, the employer has received such declaration made not more than 12 months before the lifting equipment is put into service

- If obtained from the undertaking of another person, it is accompanied by physical evidence

For in-service equipment, LOLER places the duty for deciding if, and what, tests are necessary on the 'competent person' making a thorough examination.

It requires the details of any tests made to be included on the examination report.
Note the words: 'any test'.

The report needs to include any test, not just a proof load test. This could include functional, light load, non-destructive tests etc. LOLER does not use the word 'test' but instead refers to a 'thorough examination'.

The purpose of the examination is to determine if the item being examined is safe to use or otherwise. The majority of general lifting equipment will require as a minimum a basic functional test with no load to ensure the equipment functions correctly.

## 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, skill and ability to perform the specific duty to which the requirement refers.

There can therefore be several 'competent persons', each with their own duties and responsibilities, i.e. competent for the purpose.

The term, 'competent person' has never been fully defined in law but, for the purpose of thoroughly examining lifting equipment, the LEEA definition of a competent person is a person having such practical and theoretical knowledge and experience of the equipment which is to be thoroughly examined that will enable him/her to detect defects or weaknesses which it is the purpose of the examination to discover and assess their importance to the safety of the equipment.

The competent person should have the maturity to seek such specialist advice and assistance as may be required to enable him/her to make necessary judgements and be a sound judge of the extent to which he/she can accept the supporting opinions of other specialists. He/she must be able to certify with confidence whether it is free from patent defect and suitable in every way for the duty for which the equipment is required.



It is the view of LEEA that competency can be a corporate responsibility.

## LOLER ACoP Minimum Requirements for a Competent Person

You should ensure that the person carrying out a thorough examination has such appropriate practical and theoretical knowledge and experience of the lifting equipment to be thoroughly examined as will enable them to detect defects or weaknesses and to assess their importance in relation to the safety and continued use of the lifting equipment.

Thorough examination is required at several points during the life of lifting equipment:

- On initial use or following installation
- Periodically during its life to ensure it remains fit for use
- Following certain exceptional circumstances, e.g. if it is damaged.

| Notes: |
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**The Thorough Examination**

The thorough examination can be broken down into 3 distinct areas:

i. Preparing for the thorough examination

ii. Conducting the thorough examination

iii. Actions following the thorough examination

During the remainder of this module, we will break down each area and look at them in depth.

## Preparing for a Thorough Examination

A judgement has to be made as to whether an item is fit for a continued period of service.

In simple terms, will the equipment be safe to operate until the next examination is due, given its current condition and the prevailing service conditions?




**Scope of the Examination:**

What items are required to be examined? (See reference documents)

Does the owner require the items to be marked or color coded after examination?

Is all the equipment to be examined available?

If you are to use test weights, are the floor areas where the test weights will pass over of adequate strength?

Is the equipment to be examined in accordance with a written scheme of examination?

Has the equipment been modified?

What repairs have been carried out to the equipment?

**Note:** If a chain sling is to be repaired it is advised that the manufacturer's certificate is consulted and damaged components are replaced with only those that are identified in the list. The use of equivalent components from other system manufacturers may result in the original declaration of conformity becoming void. In this case LEEA recommend that following the work the details of the repair are recorded in the sling maintenance log and the equipment is thoroughly examined by a competent person and also recorded in the report of thorough examination.

**Well Lit, Clean and Safe Area**

- Is there sufficient lighting (natural or artificial) in the area where the examination is to take place?
- Is the area clear from contaminants that can harm the equipment under examination or the examiner themselves?
- Is the examination area safe from hazards, moving traffic, ongoing lifting operations etc.?

**If you are concerned for your own safety, you will be distracted and unable to give 100% concentration to the examination task at hand.**

**Cleaning Materials**

- Does the equipment require cleaning before the examination is carried out? (Dirty equipment can hide faults)
- Always ensure that the method of cleaning will not cause damage to the owner's equipment. (Follow manufacturer's guidance for cleaning)



**Reference Documents**

- Do you have access to the manufacturer's certification and previous examination reports?
- Do you have the correct standards for the equipment you are examining?
- Do you have manufacturers' technical brochures or catalogues to give specific dimensions etc.?

**Suitable Suspension Point**

- Will the suspension point be strong enough to withstand any load testing that you need to carry out?
- Is the suspension point at a height that enables the examiner to carry out a thorough examination? (Using all of the inspection period in an uncomfortable work position causes the examiner to become less observant and can lead to back problems over time)

**Test Equipment**

- Is your test equipment and test weights (if used) calibrated?
  - Certificates of calibration should be made available to the owner of the equipment
- Do you have the correct test equipment?

**Assistant / Site Representative**



- Is there an assistant / site representative available for locating equipment to be examined?
- Does the assistant / site representative know of the quarantine procedures for defective equipment?
- Do you need items of equipment to be dismantled to enable a thorough examination to take place?

**Tools**

**Note:** This list only covers basic requirements - other specific tools may be required.
Do you have?

- A basic tool kit that will enable you to remove covers, split pins, nuts, bolts and circlips during the thorough examination of the equipment?
- A camera to highlight defects?
- A calculator to calculate wear, elongation etc.?
- Calibrated fine measuring tools?
- The recommended size marking stamps or other methods of marking the equipment?

| Notes: |
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## Conducting the Examination

The examination shall be carried out by a competent person in accordance with the schedule of requirements.

The examination must be carried out in a logical sequence to minimise the chances of missing a part of the equipment under examination.

The identification number and rated load shall be checked and cross referenced with the manufacturer's declaration of conformity of the accessory. Where markings have become illegible, these shall be re-stamped or marked.

Where appropriate, the standard procedures of examination, checking of hooks, chain sizes, pitch and diameter of wires etc. shall be those recommended by the manufacturer. Further criteria may also be given in standards.

Parts shall be exposed and examined sufficiently to enable a proper conclusion as to their condition to be reached and reported on and where necessary parts must be dismantled and cleaned to achieve this.

The assembly of parts and anchorages must be checked for correctness and proper operation and all locking and securing devices must be checked as being sound and in place.

The procedures given in conducting the examination shall be carried out in full, with a view to establishing the condition and suitability of the article for test before any testing is commenced.



### Testing as Part of the Thorough Examination

The competent person should decide whether or not a load test is necessary, and the nature of the test, as part of the thorough examination.

The design of certain lifting equipment is such that damage may be caused by conventional overload tests. The competent person carrying out the thorough examination or testing should take account of the instructions and other relevant information, e.g. regularity of such testing, provided by the manufacturer.

Other testing may be carried out as part of the thorough examination where the competent person considers they are required to properly assess the safety of the equipment, e.g. non-destructive tests.

### Test Machines and Force Measuring Equipment

Test machines and load cells must be calibrated and verified in accordance with BS EN ISO 7500 – 1 at intervals not exceeding 12 months.

Requires that the accuracy of the applied load/force must be within that required by the standard being worked to and, in all cases, within ±2% of the nominal load/force.

Various classes or grades of machines:

- Class 0.5
- Class 1.0
- Class 2.0

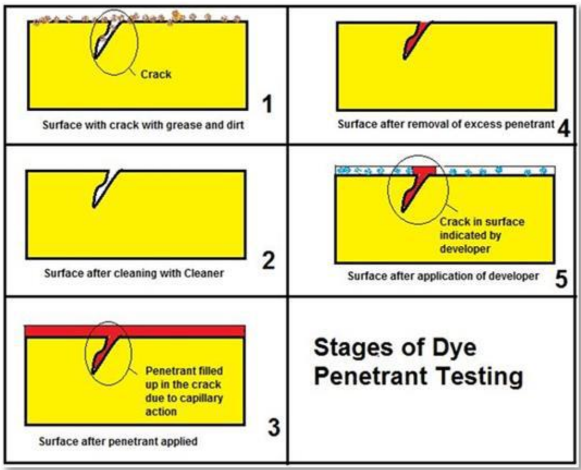
The information will be on the certificate of calibration and verification.

In some cases two grades may be shown e.g. grade 1.0 for one range of readings, grade 2.0 for a further range of readings.

## Types of Test

### Liquid / Dye Penetrant Testing (PT)

Penetrant testing locates surface-breaking discontinuities by covering the item with a penetrating liquid drawn into the discontinuity by capillary action. After removal of excess penetrant the indication is made visible by application of a developer (colour contrast or fluorescent).

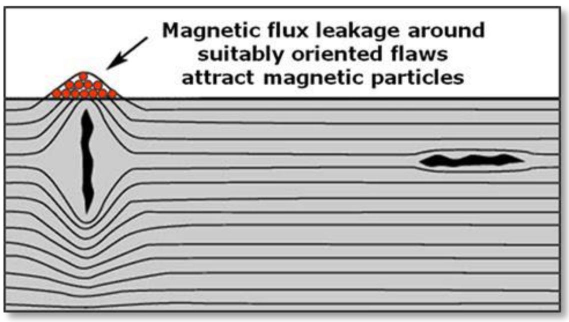





### Magnetic Particle Inspection

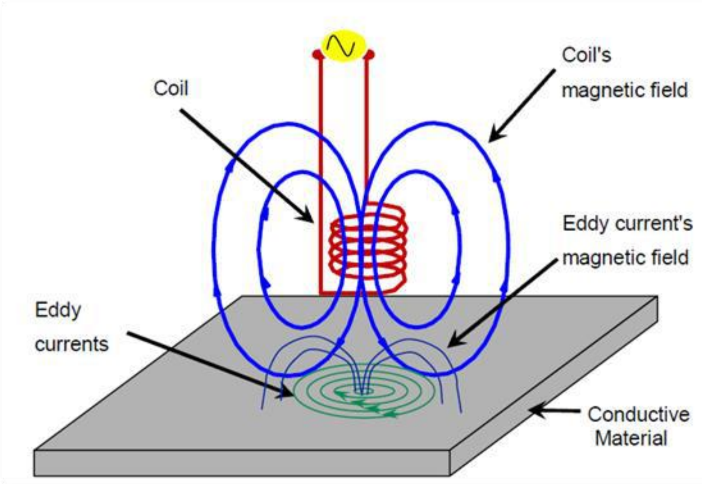
Magnetic particle inspection (MPI) is used to locate surface and slightly sub-surface discontinuities in ferromagnetic materials by introducing a magnetic flux into the material.

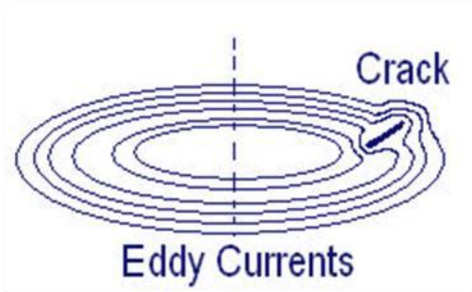
- White background lacquer is applied to the area to be inspected
- Items are magnetized and then sprayed with a solution of suspended iron filings
- Cracks or imperfections near the surface will distort the magnetic field
- Will attract the iron filings revealing the flaw by an accumulation of particles along the line of the crack
- Sub-surface defects by an accumulation in the area over the fault



## Eddy Current Inspection

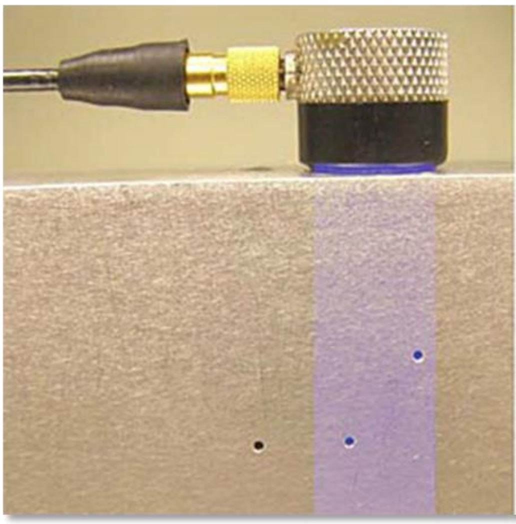
Eddy current inspection is based on inducing electrical currents in the material being inspected and observing the interaction between those currents and the material. Eddy currents generated by coils in the test probe are monitored by measuring the coils electrical impedance. As it is an electromagnetic induction process, direct electrical contact with the sample is not required but the material must be an electrical conductor.



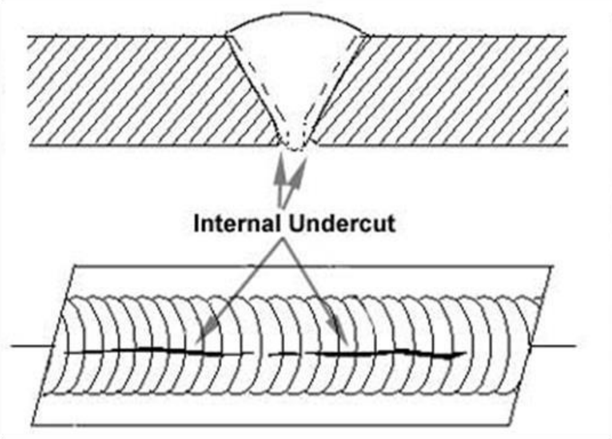

## Ultrasonic Testing

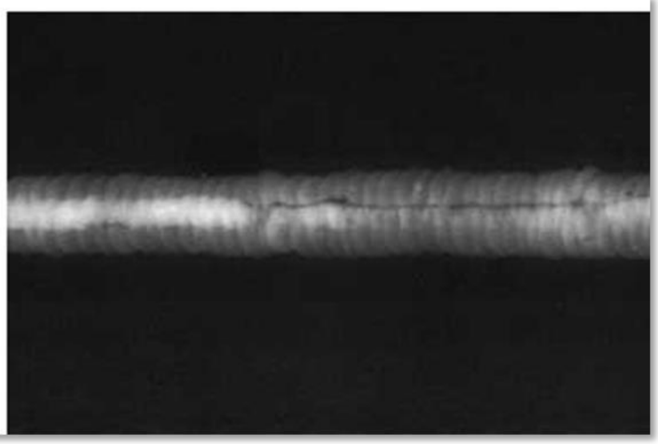
Ultrasonic testing (UT) measures the time for high frequency (0.5-50MHz) pulses of ultrasound to travel through the inspection material. If a discontinuity is present the ultrasound returns to the probe in a period other than would be expected of a fault free specimen.



**Radiography Testing**

Radiography testing (RT) monitors the varying transmission of ionising radiation (X rays) through a material with the aid of photographic film or fluorescent screens to detect changes in density and thickness. It will locate internal and surface-breaking defects. As shown on the weld defect below, this would have been impossible to detect with a surface only method of non-destructive testing.



Notes:

## Proof Loads/Forces

Where proof testing is appropriate, the load or force applied should be that given in the relevant standard or specification to which it was manufactured.

In the absence of such information the following International Labour Organisation table gives accepted proof load/force factors:

| ILO Table for Proof Load/Force Factors | | | | | |
|---|---|---|---|---|---|
| SWL (tonnes) | Lifting Appliances | Single Sheave Pulley Blocks | Multi-Sheave Pulley Blocks | Lifting Frames, Beams and Spreaders | Other Lifting Gear |
| 0 – 10 | SWL x 1.25 | SWL x 4 | SWL x 2 | SWL x 2 | SWL x 2 |
| 11 – 20 | SWL x 1.25 | SWL x 4 | SWL x 2 | SWL x 1.04 + 9.6 | SWL x 2 |
| 21 – 25 | SWL + 5 | SWL x 4 | SWL x 2 | SWL x 1.04 + 9.6 | SWL x 2 |
| 26 – 50 | SWL + 5 | SWL x 4 | SWL x 0.933 + 27 | SWL x 1.04 + 9.6 | SWL x 1.22 + 20 |
| 51 – 160 | SWL x 1.1 | SWL x 4 | SWL x 0.933 + 27 | SWL x 1.04 + 9.6 | SWL x 1.22 + 20 |
| 161 and over | SWL x 1.1 | SWL x 4 | SWL x 1.1 | SWL x 1.1 | SWL x 1.22 + 20 |

Notes:

## Actions Following an Examination

Following an examination the tester and examiner must prepare a report regardless of whether or not the item has passed the examination.

Where the competent person identifies defects which must be made good within a specified timescale, they should submit the report promptly to allow the employer to take the necessary action within the required period.

**CERTIFICATE OF THOROUGH EXAMINATION**

This report complies with the Lifting Equipment Engineers Association Technical requirements

| Date of Through Examination: | Date of Report: | Report number: |
|---|---|---|

| Name and Address of employer for whom the thorough examination was made: | Address of premises at which the examination was made: | | |
|---|---|---|---|
| Description and identification of the equipment: | Safe Working Load(s): | Date of manufacture if known: | Date of last thorough examination: |



The competent person should make a report of the state of the equipment at the time of the thorough examination. Defects should be notified even if there is no intention to use the equipment again (such as when it is immediately scrapped) or not immediately to do so (e.g. equipment taken out of use until repairs can be carried out). The duty applies even where repairs are carried out immediately. In all cases the competent person should make a report on the condition of the equipment which necessitates the repairs.

Competent persons' reports are a vital diagnostic aid in the safe management of lifting equipment. If defects are habitually not detected or rectified until the competent person's thorough examination this indicates inadequacies in management systems. Where a competent person repairs a defect on the spot, or immediately prior to thorough examination, it should be included in their report. Failing to report such a defect is disguising a potentially dangerous situation.

For in-service equipment, if the examination reveals one or more defects which present an immediate or imminent risk of serious or personal injury, a copy of the report must be sent to the relevant enforcing authority.

In this regulation "relevant enforcing authority" means:

a) Where the defective equipment has been hired or leased by the employer: the Health and Safety Executive, and
b) Otherwise, the enforcing authority for the premises in which the defective equipment was thoroughly examined

This is a duty placed on the person making the examination.

Although your company may have a procedure for doing this, **it is your legal responsibility** to ensure it has been done.

| Notes: |
| --- |
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# 4. LOAD CHAIN

Chain is the most basic of lifting media. Although capacity for capacity it is five or six times heavier than rope it has a far longer life being far more robust. It can better withstand rough usage, is less likely to damage, is almost perfectly flexible and can be stored for long periods without serious deterioration. In use it tends to show evidence of damage better than wire rope or textiles, consequently examination is more reliable. Therefore it remains the principle component of much lifting equipment.

In this module we will consider the various grades of chain and consider their suitability for use as load chain in manually operated machines.

## Older Standards – BS 4942:1981

BS 4942:1981 was produced as a metric standard for the various grades of chain. As the relationship of grade numbers was related to imperial units a new system of grading was required and so as to avoid confusion a lettering system was adopted.

- **Grade M** = the metric equivalent of grade 40
- **Grade S** = the metric grade almost equivalent to grade 60 (actually 63)
- **Grade T** = the metric equivalent to grade 80



In preparing this standard it was possible to take into consideration the further advances made both in technology and in quality control. Material specifications can now be maintained more consistently and chain of uniform size and performance readily produced. These improvements, together with increased knowledge and understanding, enabled the factor of safety to be reduced to 4:1 allowing for higher loads chain size for chain size.

It was also necessary to establish a relationship between size (in millimetres) and load (in tonnes). BS 4942 gave the following mean stresses for each type of chain as shown in the following table:

| Grade of Chain | Mean Stress at WLL ($N/mm^2$) | Mean Stress at Proof Force ($N/mm^2$) | Mean Stress at Minimum Breaking Force ($N/mm^2$) |
|---|---|---|---|
| M(4) | 100 | 200 | 400 |
| S(6) | 157.5 | 315 | 630 |
| T(8) | 200 | 400 | 800 |

**BS 4942**
**Chain Grade/Stress Relationship**

## Development of BS EN 818

In early 1997 the first parts of a new standard, BS EN 818, started to appear and the final part was issued in 2002, at which time BS 4942 was completely withdrawn.

BS EN 818 is the harmonised European standard for chain and chain slings.

The standard was prepared to enable manufacturers to demonstrate that they are meeting the essential safety requirements (ESRs) of the **European Machinery Directive**.

BS EN 818 is the only standard for chain with which all new chains for lifting purposes must comply.

To identify chain a grading system is used:

- Chain intended for use in chain sling assembly is graded using numbers
- Chain intended as load chain for lifting appliances is letter graded

**Note:** This now means that the grade of chain intended for sling manufacture formerly known as grade T is now grade marked 8.

BS EN 818 makes changes to the way we define chain.

In the past it was common to refer to calibrated and non-calibrated chain. In fact all chain is calibrated to some degree and so, in strict terms, these terms are incorrect.

BS EN 818 therefore uses the terms 'medium tolerance' and 'fine tolerance'.



**BS EN 818-7 covers grade T 'fine tolerance' chain of three types, T, DAT and DT:**

- This is chain has been manufactured to precise dimensions for use as load chain in lifting appliances
- The pitch of the chain is important as it has to mate with other, moving, components
- Fine tolerance chains are less ductile than medium tolerance chain and have a harder surface skin in order to resist wear

## Composition and Heat Treatment of Fine Tolerance Chain

BS EN 818-7 lays down the minimum percentage of nickel, chromium and molybdenum in the steel used for each type of chain.

- Type T chain is hardened and tempered, whilst types DAT and DT are case hardened
- The comparative WLL of each type of chain differs size for size

For example: a 6mm diameter type T chain has a WLL 1.1t, type DAT 0.9t and type DT 0.56t. This is also due to the different characteristics of the chains and the duties for which they are intended.

**Type T**

For manually operated blocks, or slow speed power hoists, in environments where there are no abrasive conditions. Used no lower than -40˚C

**Type DAT**

For power hoists with high speeds and working capacity giving good wear resistance for a longer working life. Used no lower than -20˚C

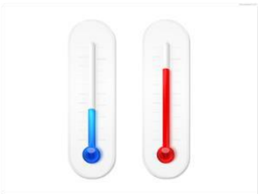
**Type DT**

For power hoists in abrasive conditions. Used no lower than -10˚C

**Note:** Case hardened chains type DAT and DT are not suitable for use in hand chain blocks.



## Effects of Exposure to Temperature



Hoist chain types T, DAT and DT can be used up to temperatures of + 200˚C. If the hoist chain reaches a higher temperature it should be withdrawn from service.

In low temperature conditions, the following limitations apply:

| Hoist Chain Type | Lower Temperature Limit ⁰C |
|---|---|
| T | -40 |
| DAT | -20 |
| DT | -10 |

## Exposure to Acidic/Alkaline Conditions

Hoist chain types T, DAT and DT should not be immersed in acid solutions or exposed to acid fumes.

In your 'Resources' tab, there is a document called **PM39 – Hydrogen Cracking of Grade T and Grade 8 Chain and Components.** You are advised to refer to this document, the latest version of which was published in 2014.


This **guidance note** gives advice to users of grade T and grade 8 chain and components on their susceptibility to hydrogen cracking.

Incidents reported to the **health and safety executive** indicate that grade T and grade 8 chain and components are still being used in corrosive environments, despite advice from manufacturers.

## Calibration

When chain is produced by machine the links are marginally misshapen, the sides having 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 extends by a marginal amount.

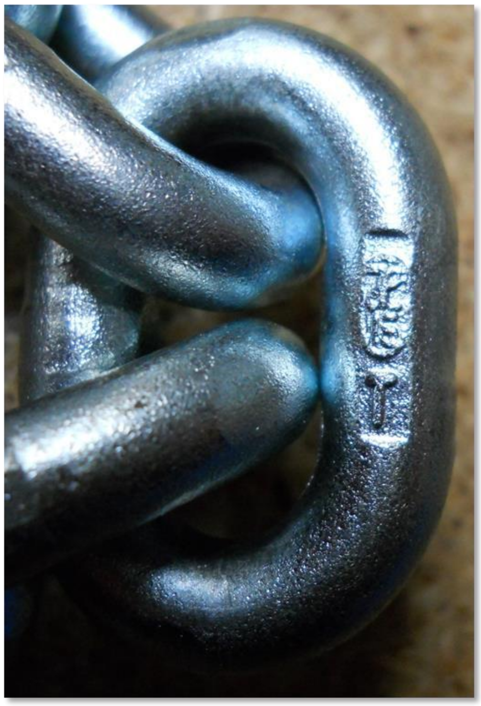
In the case of load chains it is vital that the links are of precise size and form so that they engage correctly in the pocketed load wheels of the appliance.

This is achieved by manufacturing the chain to a calculated undersize.



The finished chain is then subjected to an increased force, which pulls it to the required even shape, size and pitch.

## Identification



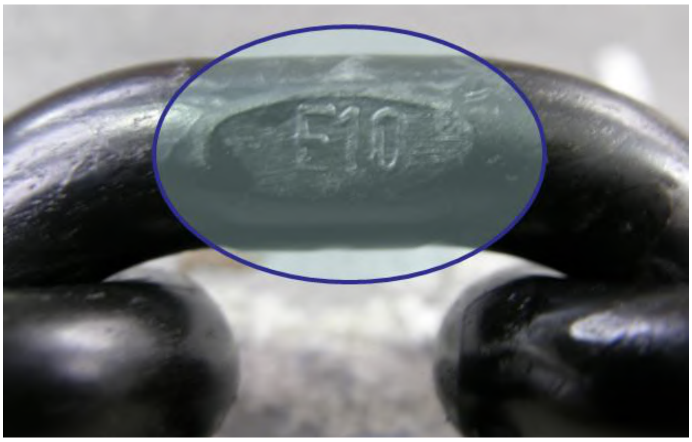
It can be seen then that correct identification of these chain types forms a vital part of any thorough examination.

However, there is a slight problem here, which may apply to some older manually operated machines that can still be found in use.

Slings made in the UK between 1981 and 1997 may show the letter 'T' as a grade mark whilst load chain may be marked 8 or have no mark at all.

You should make yourself familiar in the recognition of fine tolerance and medium tolerance chains by looking at as many examples as possible.

## Grade 10/V Chain



Since the publication of BS EN 818, further advances have been made in material development and chains of much higher breaking loads have entered the market place.

Manufacturers have followed the spirit of the standard with regard to marking and grade '10' load chains marked V are becoming common.

**This grade of chain is not currently covered by standards.**

## Finishing Treatments

Various finishing treatments are then given to fine tolerance chain to increase its wear resistance.

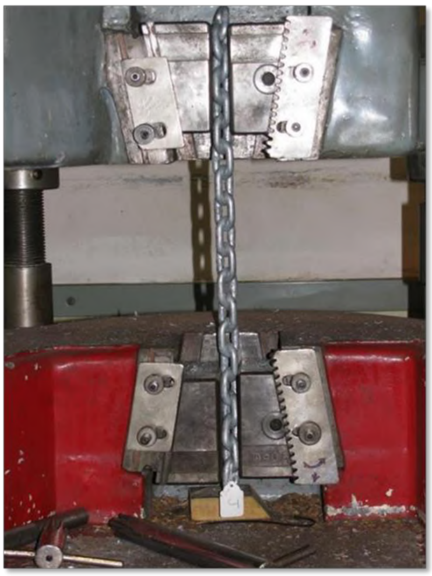
The loss of some ductility due to the manufacturing and finishing processes is relatively unimportant for load chains, which do not suffer the same shock loading conditions that a sling experiences in normal use.

Fine tolerance chain may be recognised in two ways:



- The calibrating process has the effect of removing all of the residual scale from the heat treatment process and many of the finish treatments include corrosion resistant finishes
- As a result it has a bright finish and of course there is also the grade mark

## Manufacturers' Test Requirements



Each of the British standards specified the proof load/force that had to be applied by the chain manufacturer.

In the case of chain manufactured to BS EN 818 the manufacturer's test force is higher than the customary 2 x WLL being set at 2.5 x WLL.

It is intended that this is the initial test, which is not intended to be repeated.

Random tests are carried out to destruction, by tensile loading, bend test and by fatigue testing to ensure the properties and qualities of the finished chain have been achieved and remain consistent.

Following the completion of all of the manufacturing processes, chain manufacturers test the chain and issue a master test certificate, which also gives the traceability back to the production, heat treatment and finishing batch.

## Grade Marks

- Grade marks tell us much about a piece of chain (or other forged items of gear) and these matters are important to the tester and examiner of Lifting Machines Manual
- Over the years, the various standards have called for the grade mark to appear regularly throughout the length of chain. The exception to this is grade 80 load chain to BS 3114 which was unmarked
- The grade mark should appear every 20th link or at intervals of 1 metre (3ft in the case of the imperial standards) whichever is the lesser distance
- The links must be stamped or embossed on the least stressed part of the chain, i.e. on the side of the link opposite the weld
- If stamps are used to mark the chain they must have a concave surface and the indentation should be such that it does not impair the mechanical properties of the chain link
- The vast majority of students will only ever see load chains grade 8 or grade 10, however some lifting machines fitted with chain to older standards, and therefore grades, still remain in service. It is therefore necessary for the tester and examiner to be able to recognise them



| Grade | Breaking Load (tons) | WLL (tons) | Material | British Standard | Grade Marking |
|---|---|---|---|---|---|
| N/A | $30d^2$ | $6d^2$ | Mild Steel | N/A | N/A |
| 40 | $40d^2$ | $8d^2$ | Higher Tensile Steel | BS 1663 | (04) |
| 80 | $80d^2$ | $14d^2$ | Alloy Steel | BS 3114 | N/A |
| M | $40d^2$ | $10d^2$ | Higher Tensile Steel | BS 4942 Pt.3 | 4 |
| T | $80d^2$ | $20d^2$ | Alloy Steel | BS 4942 Pt.6 | T or 8 |
| 8 | $80d^2$ | $20d^2$ | Alloy Steel | BSEN 818-7 | T |
| 10 | $100d^2$ | $25d^2$ | Alloy Steel | N/A | V |

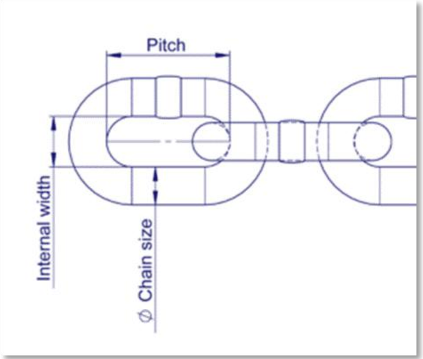
**Grade marks – ISO 3077 Load Chain**

ISO 3077 states that the markings on the chain shall be in accordance with ISO1834 (originally BS4992) which is a placement at every 20th link or 1 metre, whichever is the lesser.

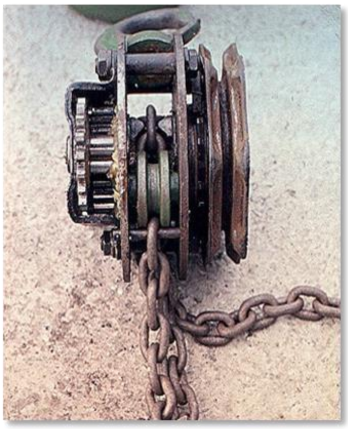
This will also include a marking to show the material grade (T, DT or DAT) and the manufacturer's traceability code.

For serial type hoists, please note that ISO 3077 also refers to the following standard: FEM 9.671[3] section IX, serial hoists – chain grades, criteria for selection requirements.

## Examination of Chain




- Measure wear: 8% reduction in material diameter for the chain, components and fittings
- Check documentation and ID plates
- Hang the item from a suitable suspension point
- Markings - grade mark T
- Measure elongation:
  - Maximum 3% increase in pitch for hand operated appliances
  - Measured over an 11 link length against the **original equipment manufacturer's** data
- Deformed or twisted links
- Weld structure/integrity
- Heat:
  - Direct or indirect
  - Weld splash or bluing
- Lubrication
- Chemical damage
- Heavy corrosion
- Nicks/cuts/cracks/gouges
- Duty cycle
- End terminal fittings to be examined as required for the item concerned



Notes:

# 5. LOAD ROPE

**Wire Ropes for Lifting Appliances**

Wire ropes are generally regarded as an expendable component.

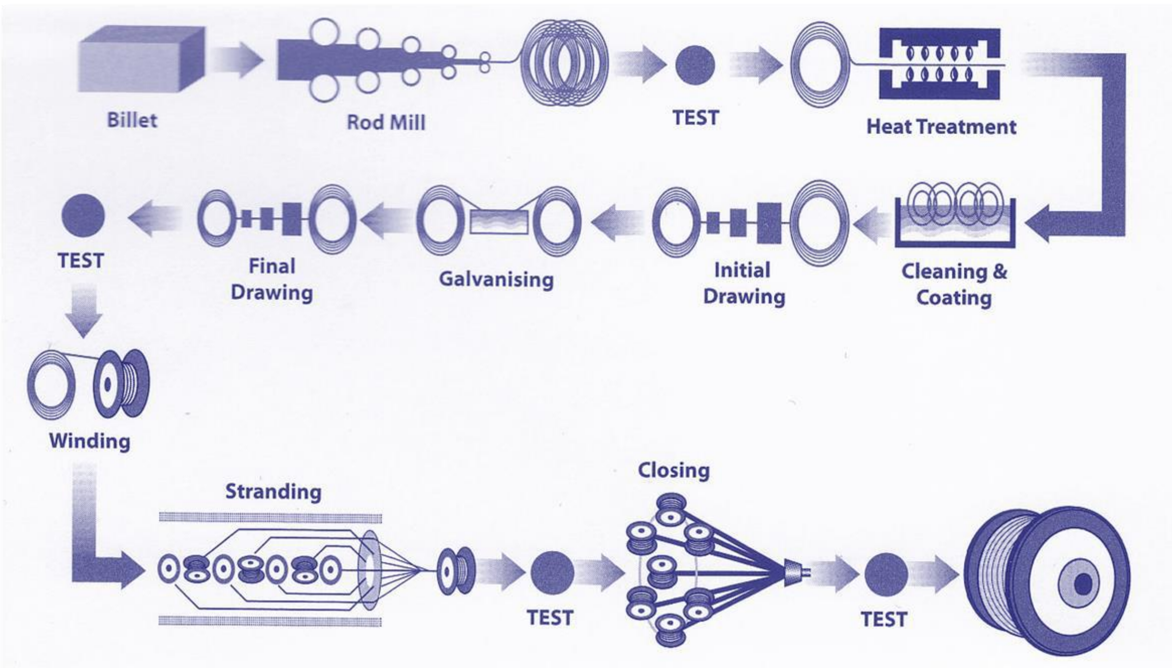
The load rope requires replacement when inspection shows that its condition has deteriorated and further use would not be suitable for safety reasons.

By following well-established principles, such as those detailed in various standards, LEEA COPSULE, and any additional specific instructions provided by the original equipment manufacturer of the crane or hoist and/or by the manufacturer of the rope, this criteria should never be exceeded.

When correctly applied, the discard criteria given in full in BS ISO 4309 are aimed at retaining an adequate safety margin.

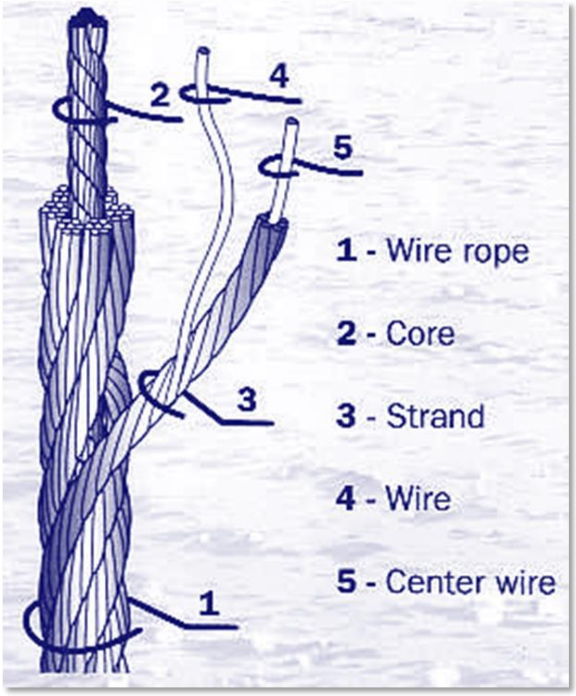
Failure to recognize them can be extremely harmful, dangerous and damaging.

## How Wire Rope is made




Notes:

## Elements of a Wire Rope




## Definitions

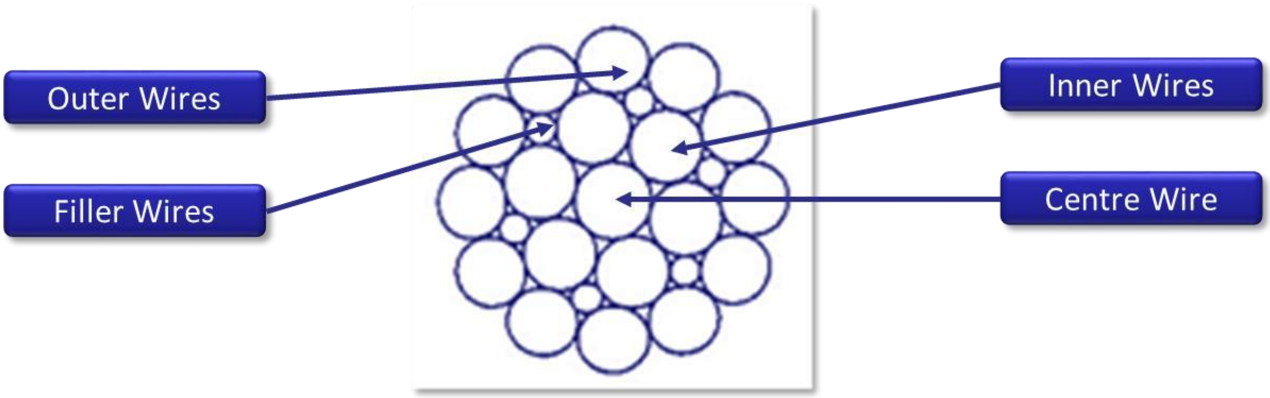


**Outer wires:** all wires positioned in the outer layer of a spiral rope or in the outer layer of wires in the outer strands of a stranded rope.

**Inner wires:** all wires of intermediate layers positioned between the centre wire and outer layer of wires in a spiral rope or all other wires except centre, filler and outer wires in a stranded rope.

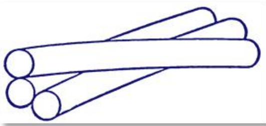
**Filler wires:** wires used in filler construction to fill up the gaps in between the layers.

**Centre wires:** wires positioned at the centre of a spiral rope or the centres of strands of a stranded rope.

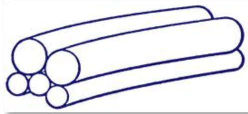


## Strand Construction

A single wire, known as a king wire (centre wire), is taken and then the remainder of the required number of wires are twisted around this to form a strand.



Cross Lay Rope



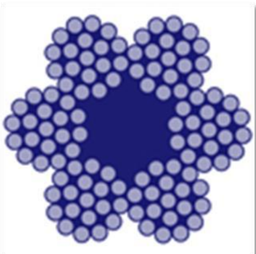
Equal Lay Rope (Parallel)

Wire sizes and the manner in which they are laid up can be adjusted to give varying performance characteristics to the rope for different service duties.

Most common for wire rope for sling manufacture is 6 x 19. However, 6 x 36 is also widely used and other constructions can be employed.

6 x 19 means that there are 6 strands each of 19 wires and 6 x 36 means that there are 6 strands each of 36 wires. Both of these are equal lay ropes.

This illustration shows a wire rope construction made of 6 outer strands with each outer strand made up of 19 wires.

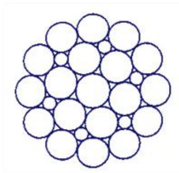


6 x 19 Construction

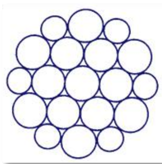
The three basic methods of laying up a strand:-

Seale Construction

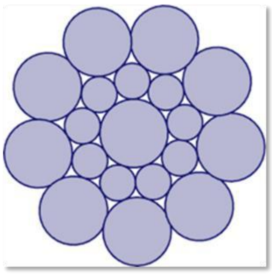
Filler Construction



Warrington Construction



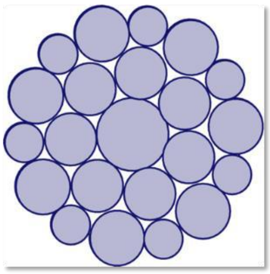
**Seale Construction**



This is a parallel lay strand with the same number of wires in both layers.

In the example shown opposite, the construction consists of:
1 x centre wire, 9 x inner wires and 9 x outer wires.

**Warrington Construction**

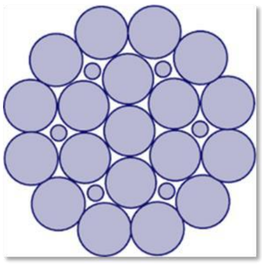


A parallel lay strand having an outer layer containing alternately large and small wires.

In the example shown opposite, the construction consists of:
1 x centre wire, 7 x inner wires and 14 (7 large and 7 small) x outer wires.

You may have noted that previous images of Warrington construction rope in this module show a 1/6/12 (6 large and 6 small outer wires) however, as long as the geometry of the outer wires remains the same, there may be alternative numbers of wires in a particular rope construction.

**Filler Construction**

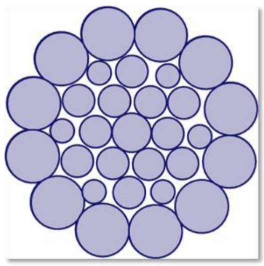




A parallel lay strand having an outer layer containing twice the number of wires than the inner layers with filler wires in the valleys between the layers.

In the example shown opposite, the construction consists of:
1 x centre wire, 6 x inner wires, 6 x filler wires and 12 x outer wires.

**Combined Construction**



A parallel lay strand having three or more layers laid in one operation and formed from a combination of the previous strand types.

In the example shown below, the Warrington Seale construction consists of:
1 x centre wire,  6 x inner wires, 12 Warrington wires and 12 x outer wires:

| Notes: |
| --- |
| |

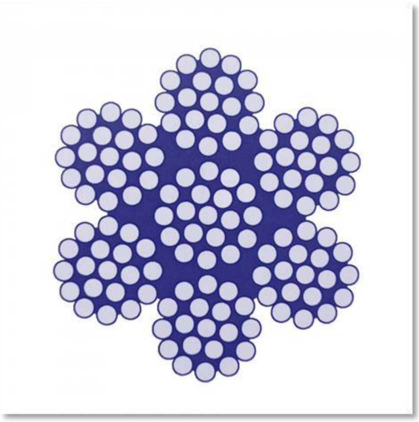
## Types of Wire Rope Core

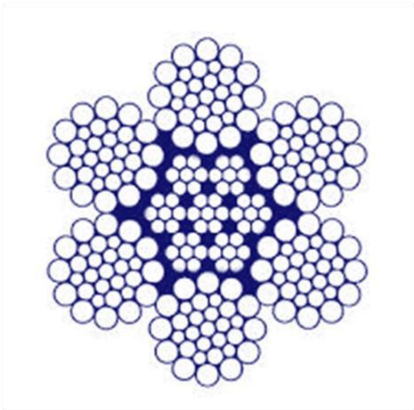
**Fibre core (FC)**
This type of core is made from either natural fibres or synthetic fibres.


**Wire Stranded Core (WSC)**
This type of core can be either one single wire as the core or more typically the core construction the same as the outer strands.

**Independent Wire Rope Core (IWRC)**
This type of core is actually made up of a core and strands so is actually a rope that is utilised as the core. (Ropes over 12mm diameter shall have IWRC)







Notes:

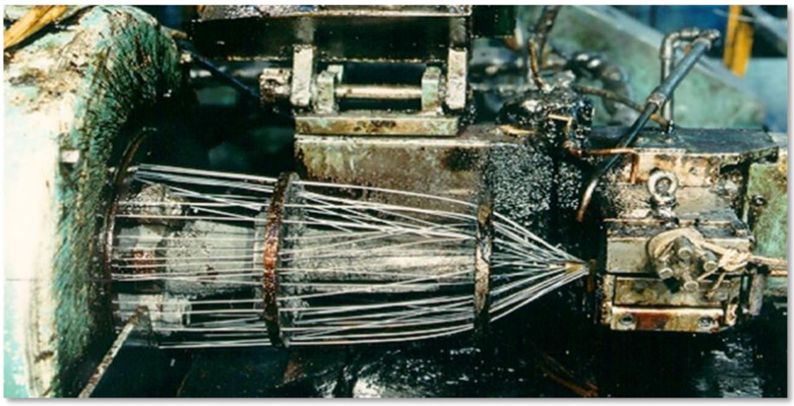
## Grades of Wire Rope - Wire Tensile Strength/Grade

The grade of the wire rope based upon the tensile strength of the wires in N/mm².

| Rope Grade | Wire Tensile Strength Grade | |
|---|---|---|
| | Minimum | Maximum |
| 1770 | 1570 | 1960 |
| 1960 | 1770 | 2160 |
| 2160 | 1960 | 2160 |

## Stranding

The stranding operation takes place when all the wires are brought together at the forming point. Note that the wires during this and the closing operation are spun in to the correct helical shape, this process is called preforming. This reduces the internal stresses in the strands and the rope meaning that if the wires and strands are cut they do not spring out of the rope formation.



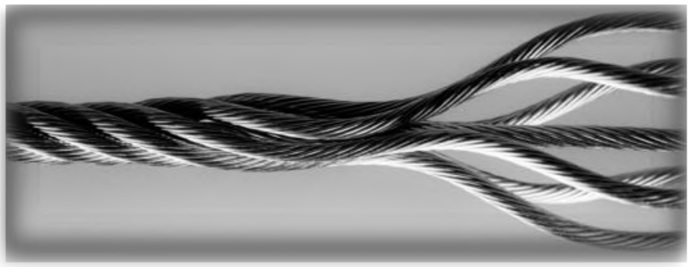


## Pre-Forming

During this operation, the strands are now brought together at the forming point around the specified core to make the rope.

The individual wires in the strand are bent into the correct helix before being wound into position. The strands are then wound into the correct helix, generally the opposite direction.

- Results in a relatively inert (dead) rope
- Resistant to kinking
  - Easy to handle so when such a rope is cut:
  - Wires will stay in position
  - Broken wires do not stick out
  - Less dangerous to the user
- Rope is more flexible



## Rope Lay

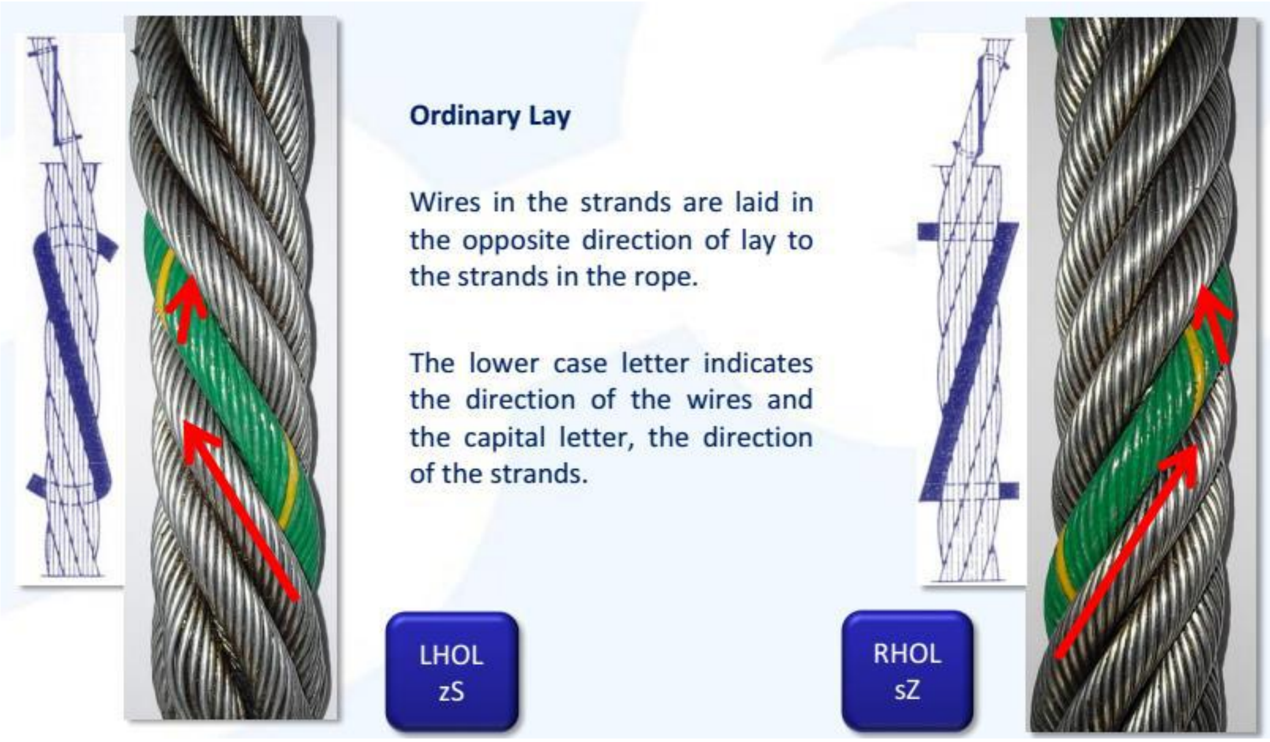
Rope lay refers to the way in which the wires are laid when forming the strands and the way in which the strands are laid when forming the rope.

There are 2 types of lay, ordinary lay and Lang's lay:

**Ordinary lay:** the wires that make up the strand and the strands that make up the rope are laid in opposite directions. When formed, this gives the impression that the wires are running the length of the wire rope.

**Lang's lay:** the wires that make up the strand are laid in the same direction as the strands in the rope. When formed the wires quite clearly run across the diameter of the rope. Due to the tendency of the rope to unwind, Lang's lay ropes are not suitable for wire rope slings.

**Rope Lay**







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**Lang's Lay**

- The advantage of Lang's lay is that this construction offers a much better wearing surface than ordinary lay
- Lang's lay rope is more flexible than one of ordinary lay
- Its disadvantage is that it can only be used in applications where both ends of the rope are secured, such as a lift or multi-fall hoist. If suspended under load with one end free to turn, such as on a single fall powered hoist rope, it will un-lay itself
- Both ordinary lay and Lang's lay ropes are usually supplied right-hand lay, but left-hand lay is available for special applications

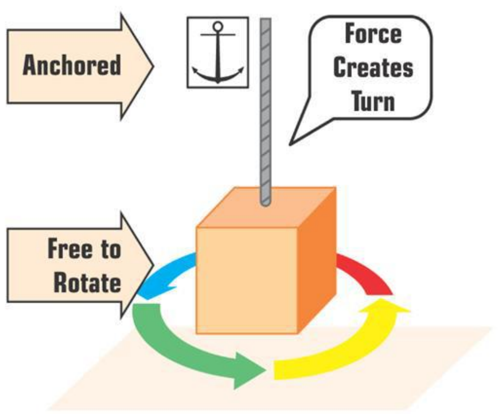
## Low-Rotating Rope

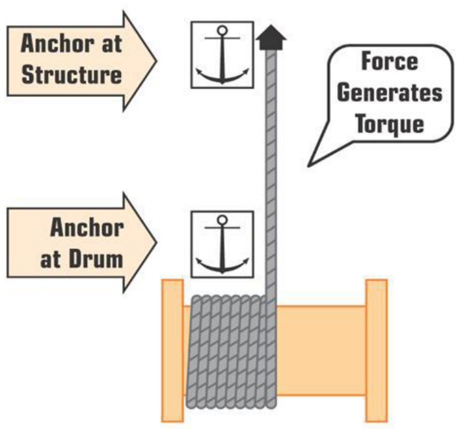
Although the six strand rope is the most common, there are many exceptions, and the exception is most likely to be the low-rotating type usually used on cranes or on larger capacity hoists.

All six strand ropes tend to untwist when load is applied to them:

- An undesirable characteristic especially on long multi-fall hoist blocks where it can cause the bottom block to twist
- It may be overcome by using what is known as a multi-strand rope, which has low-rotating qualities by having two or three layers of 7 wire 1-6 strand laid in opposite directions






Notes:

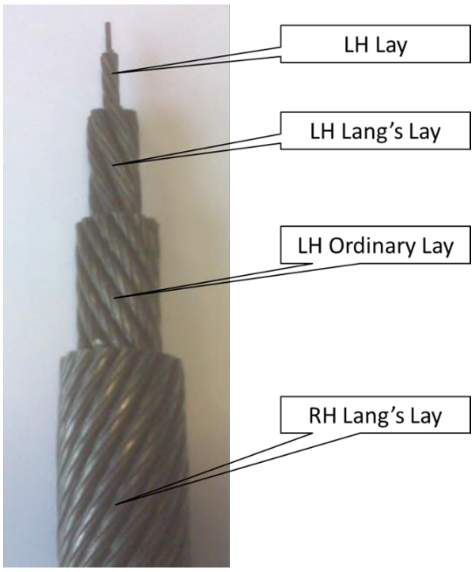
**Effects of Rope Rotation**

The most common type is the 17 x 7 (1-6), which has an outer layer of 11 strands laid over an inner layer of 6 strands, which in turn is laid over a core strand.

The construction is 11 strands/6 strands/1 strand all 7 wire 1-6.

The layers of strands are laid in opposing directions to prevent the rope from spinning under load.



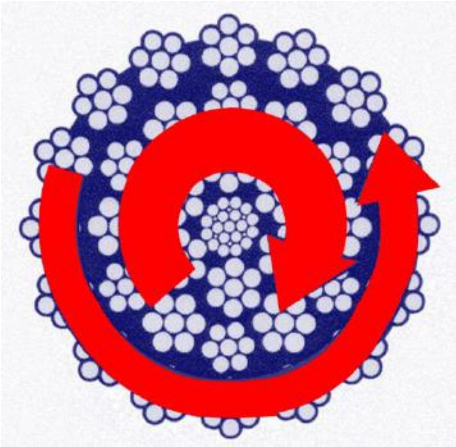



A more flexible version is the 34 x 7 (1-6), which is simply a 17 x 7 with an additional layer of seventeen strands laid around it.

The construction is 17 strands/11 strands/6 strands/1 strand all 7 wire 1-6.

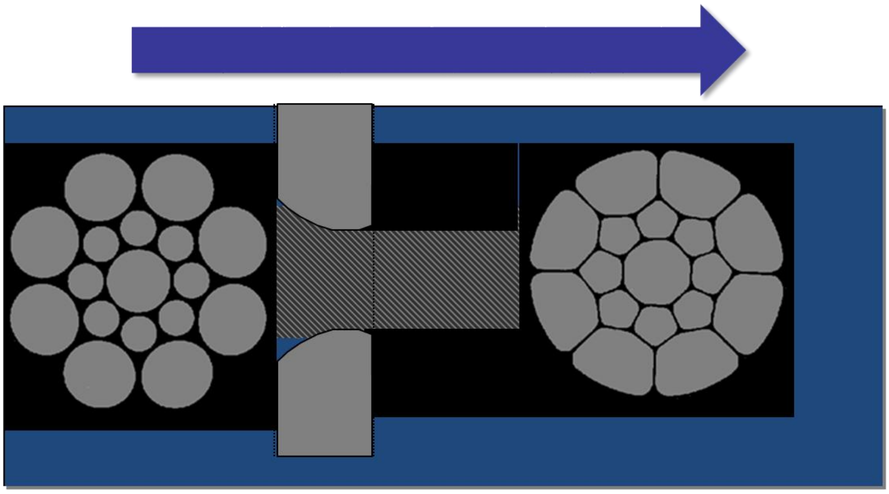
The layers of strands are laid in opposing directions to prevent the rope from spinning under load.

Notes:



**Rotation-Resistant Rope (Illustration is 35LS – Low-Rotating Rope)**

## Compacted Rope (K Designation)



**Benefits of Compacted Rope**

**Increased steel area:**

- Increase in strength
- Crush resistance
- Diameter stability
- Reduced stretch

**Smooth surface:**

- Increased fatigue life
- Lower contact pressures

**Accurate diameter:**

- Improved spooling
- Twin rope systems

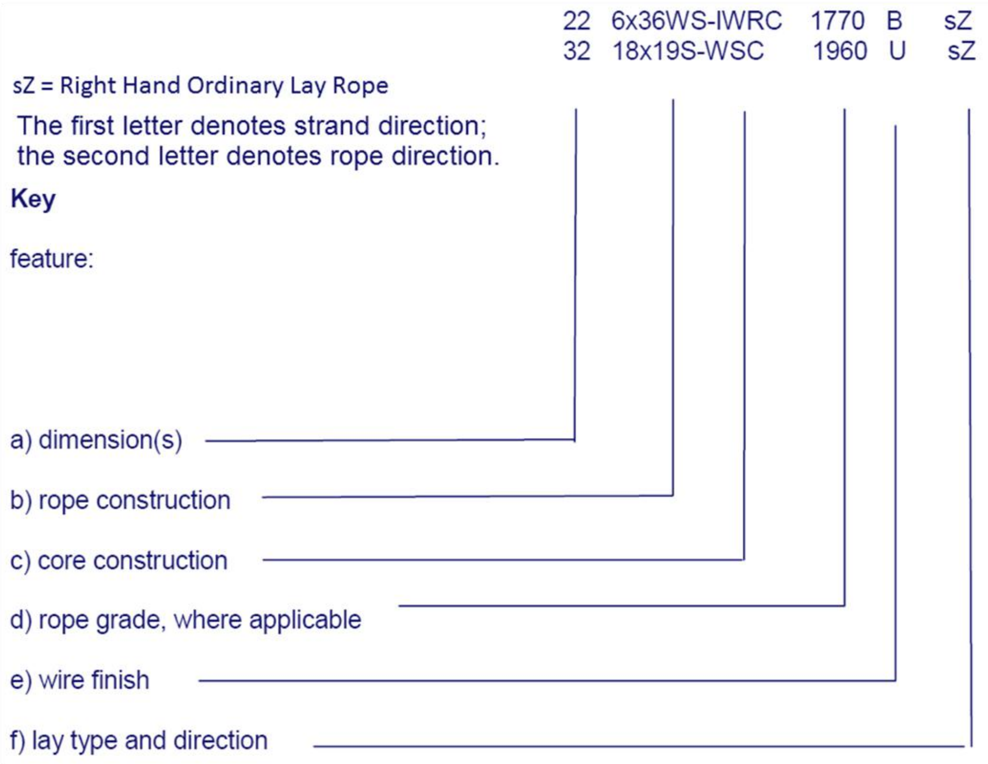
## Rope Finish

BS EN 12385 uses the symbol '**U**' to denote uncoated or bright finish.

For zinc finishes the symbol will depend on the class of the coated finish, e.g.

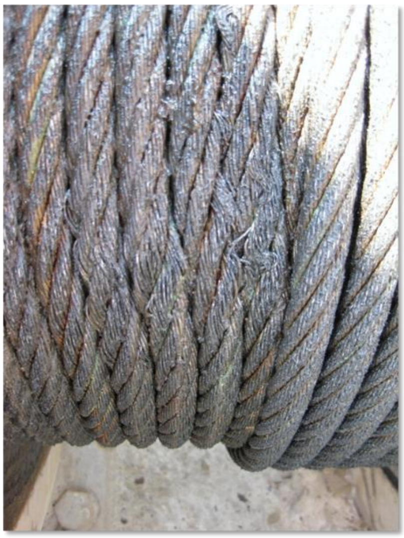
- **Class A zinc finish is designated 'A'**
- **Class B Zinc is designated 'B'**

## Rope Details and Designation




Notes:

## Wire Rope Examination



Safe operation of Lifting Machines Manual incorporating wire rope as the lifting medium depends, to a large extent, upon the level of detailed examination that is applied by the competent person during the thorough examination, notwithstanding that daily operator checks by the user also have a significant bearing on safety of the machine in use.

The competent person should firstly refer to instructions provided by the original equipment manufacturer. Local or application specific regulations should always be followed.

Rope should always be clean; if this is not possible, consider electromagnetic wire rope inspection method, where appropriate.

In the absence of **original equipment manufacturer's** criteria, BS ISO 4309 (to which BS EN 13157 refers) criteria may be used to determine the serviceability of the load rope fitted to a manual appliance.

BS EN 13411 series of standards should be referred to for terminations in steel wire ropes.

**BS ISO 4309:2010 - Modes of Deterioration and Assessment Methods**

| Mode of Deterioration | Assessment Method |
|---|---|
| Number of visible broken wires (randomly distributed, localised groups, valley breaks and those that are in the vicinity of a termination point) | By counting |
| Decrease in rope diameter (resulting from external wear/abrasion, internal wear and core deterioration) | By measurement |
| Fracture of strand(s) | Visual |
| Corrosion (external, internal and fretting) | Visual |
| Deformation | Visual and by measurement (wave only) |
| Mechanical damage | Visual |
| Heat damage (including electric arcing) | Visual |



Notes:

## BS ISO 4309 – Wire Rope Discard

### Discard Criteria (General)

The safe use of wire rope is qualified by the following criteria:

- The nature and number of broken wires
- Broken wires at the termination
- Localised grouping of wire breaks
- The rate of increase of wire breaks
- The fracture of strands
- Reduction of rope diameter, including that resulting from core deterioration
- Decreased elasticity
- External and internal wear
- External and internal corrosion
- Deformation
- Damage due to heat or electric arcing
- Rate of increase of permanent elongation

The examination of wire ropes should be systematic and follow a logical order so that no part of the rope, or the accessories and attachments to which it connects are missed. In manual machines, particular attention is to be taken at the following locations:

- Rope drum anchorage
- Rope within the area of a termination point
- Sections of rope travelling through sheaves
- Sections of rope travelling through the hook block
- Sections of rope that spool onto the rope drum, especially in areas where the rope crosses over itself in multi-layer drums
- Any section of the rope that can be damaged by abrasion in contact with an external fixture such as a hatch opening
- Any part of the rope that is exposed to heat

### Spooling/Crossover Damage

Notes:

## Broken Wires

It is usually the number of broken wires developing in a wire rope, which causes its removal from service.

It is essential that the entire length of a wire rope be inspected frequently for broken wire(s), excessive wear, and lack of lubrication, with particular attention being paid to those areas adjacent to terminal fittings and where an accelerated rate of wear or corrosion is to be expected, e.g. where a rope passes around sheaves or pulleys, or is particularly exposed to the elements.

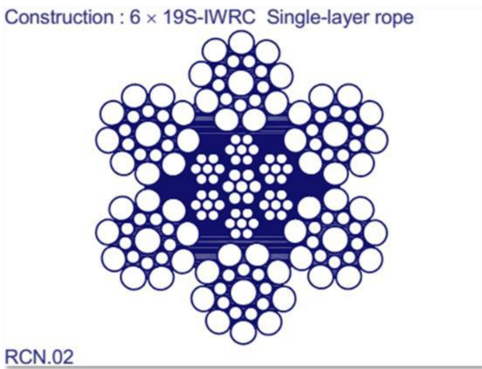
All examinations shall take into account these individual factors, recognising the particular criteria.

**BS ISO 4309 details the discard criteria for the allowable amount of broken wires, depending upon the rope category number of the rope (RCN).**

**Example of BS ISO 4309 Rope Category Number:**

Before determining the discard criteria for load ropes under BS ISO 4309, it is necessary to identify the RCN of the rope.

By way of example, we are going to look at an RCN 02:




| Rope category number RCN (see Annex G) | Total number of load-bearing wires in the outer layer of strands in the rope[a] $n$ | Number of visible broken outer wires[b] | | | | | |
|---|---|---|---|---|---|---|---|
| | | Sections of rope working in steel sheaves and/or spooling on a single-layer drum (wire breaks randomly distributed) | | | | Sections of rope spooling on a multi-layer drum[c] | |
| | | Classes M1 to M4 or class unknown[d] | | | | All classes | |
| | | Ordinary lay | | Lang lay | | Ordinary and Lang lay | |
| | | Over a length of $6d$[e] | Over a length of $30d$[e] | Over a length of $6d$[e] | Over a length of $30d$[e] | Over a length of $6d$[e] | Over a length of $30d$[e] |
| 01 | $n \leqslant 50$ | 2 | 4 | 1 | 2 | 4 | 8 |
| 02 | $51 \leqslant n \leqslant 75$ | 3 | 6 | 2 | 3 | 6 | 12 |

Viewing the example from BS ISO 4309 above, we can see that an ordinary-lay rope, categorised as an RCN 02 (single-layer or parallel-closed rope) may have a maximum of **6 broken wires over a length of 6 x its diameter**, or **12 broken wires over a length of 30 x its diameter**, in a machine such as a hand operated winch, utilising a multi-layer drum.

**RCN Number**

**What if you do not know the RCN number?**

If the RCN number of the load rope cannot be found in annex G of BS ISO 4309, the following method should be used for calculating the number of allowable broken wires:

- Determine the total number of load-bearing wires in the rope;
  - Simply add together all of the wires in the outer layer of strands except for any filler wires and read off the discard values for broken wires over a length of 6d and 30d for the appropriate conditions, in the tables provided.

| Rope category number RCN (see Annex G) | Total number of load-bearing wires in the outer layer of strands in the rope[a] $n$ | Number of visible broken outer wires[b] | | | | | |
|---|---|---|---|---|---|---|---|
| | | Sections of rope working in steel sheaves and/or spooling on a single-layer drum (wire breaks randomly distributed) | | | | Sections of rope spooling on a multi-layer drum[c] | |
| | | Classes M1 to M4 or class unknown[d] | | | | All classes | |
| | | Ordinary lay | | Lang lay | | Ordinary and Lang lay | |
| | | Over a length of $6d$[e] | Over a length of $30d$[e] | Over a length of $6d$[e] | Over a length of $30d$[e] | Over a length of $6d$[e] | Over a length of $30d$[e] |
| 01 | $n \leqslant 50$ | 2 | 4 | 1 | 2 | 4 | 8 |
| 02 | $51 \leqslant n \leqslant 75$ | 3 | 6 | 2 | 3 | 6 | 12 |



**Deterioration**

In the case of 6 and 8-strand ropes, broken wires usually occur at the external surface.

In the case of rotation-resistant ropes, there is a probability that the majority of broken wires will occur internally and are “non-visible” fractures.

**Note:** Students are reminded that access to relevant standards, such as BS ISO 4309, is necessary in order to carry out thorough examinations correctly.

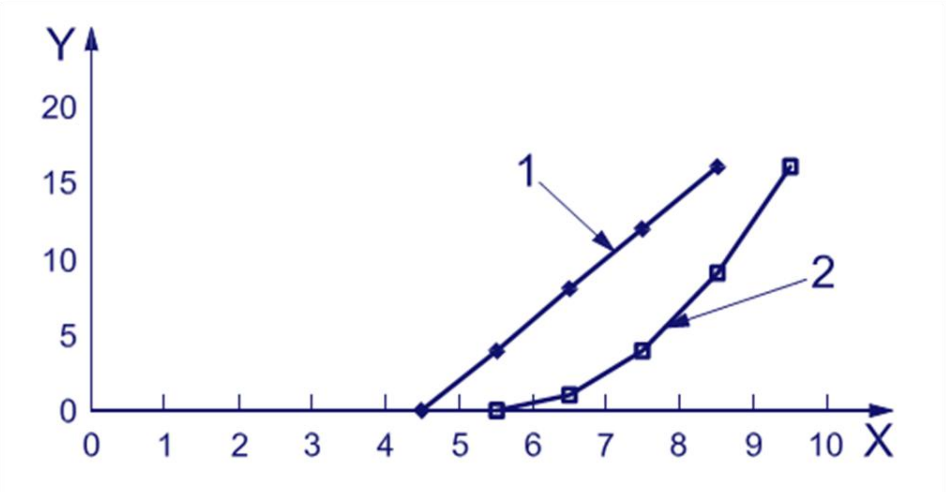
The competent person can find it prudent to initiate or recommend more frequent periodic inspections than those required by legislation.

This decision can be influenced by the type and frequency of operation.

Also, depending on the condition of the rope at any time and/or whether there is any change in circumstances, such as an incident or change in operating conditions, the competent person can deem it necessary to reduce or recommend the reduction of the interval between periodic inspections.

**Examples of Rate of Increase for Broken Wires in 2 Different Ropes:**

Generally, ropes develop broken wires at a greater rate later on in the life of a rope than in the early stages. Have a look at the following graph which shows two examples of this.



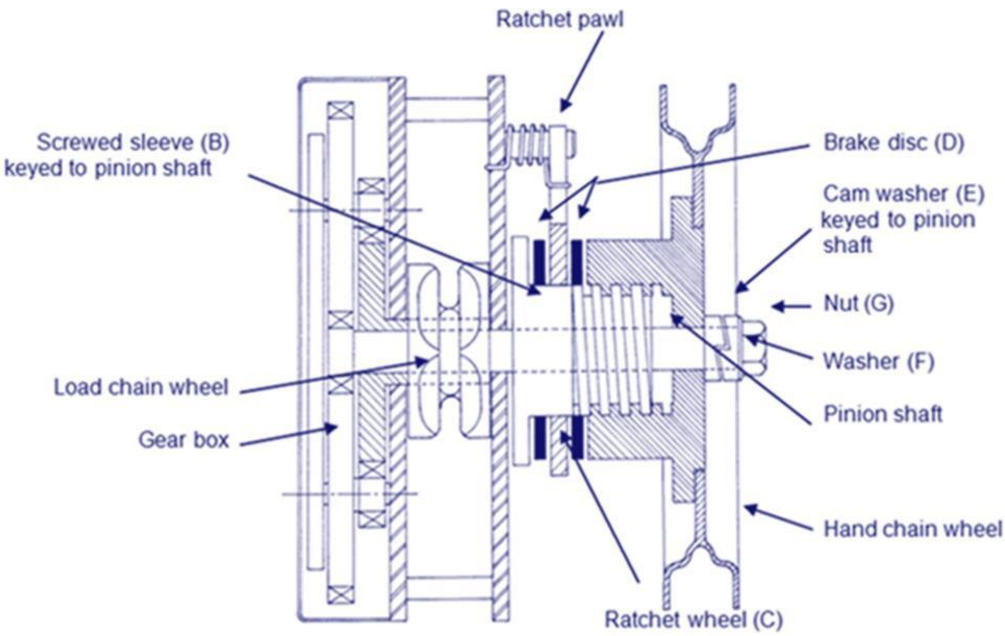

**Key:**
X = time, in cycles
Y = number of randomly distributed broken wires per unit length



Notes:

# 6. SCREW BRAKE MECHANISMS

Brake mechanisms are central to the design of hand chain blocks and lever hoists and are crucial to their safe operation.

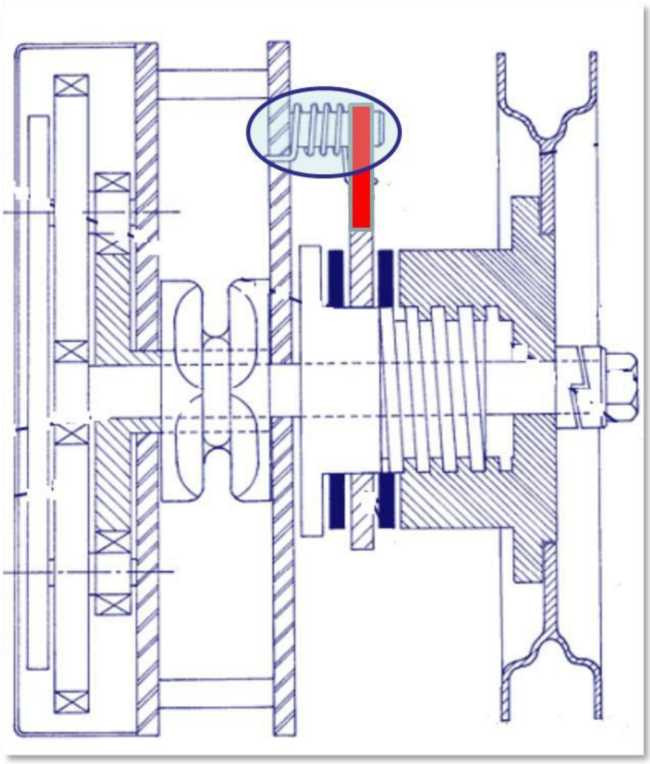


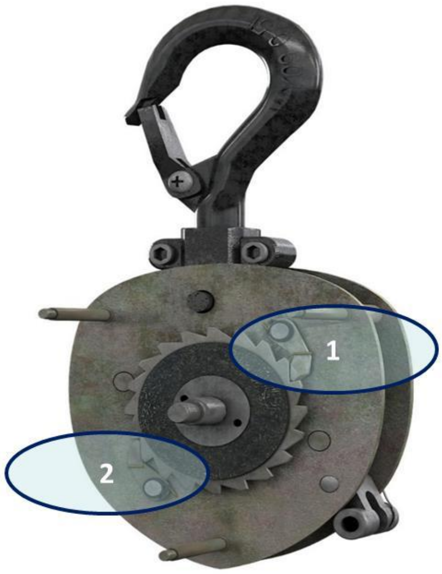



Although manufacturing design variations exist, lifting machine screw brakes all work on the same principle and the brakes described in this unit are typical examples.

The illustration here shows a section through a typical chain block but omits the drive side cover for clarity. This is of the older type which only has a single pawl positioned so that it will engage with the ratchet wheel by gravity. A spring assists the engagement of the pawl with the ratchet wheel, however, should the spring fail the pawl will still engage under gravity alone.

Modern chain blocks incorporate 2x spring loaded pawls, the upper having a gravitational and spring mode of operation, the lower, by spring operation only.






**2 Pawl Chain Block Brake**

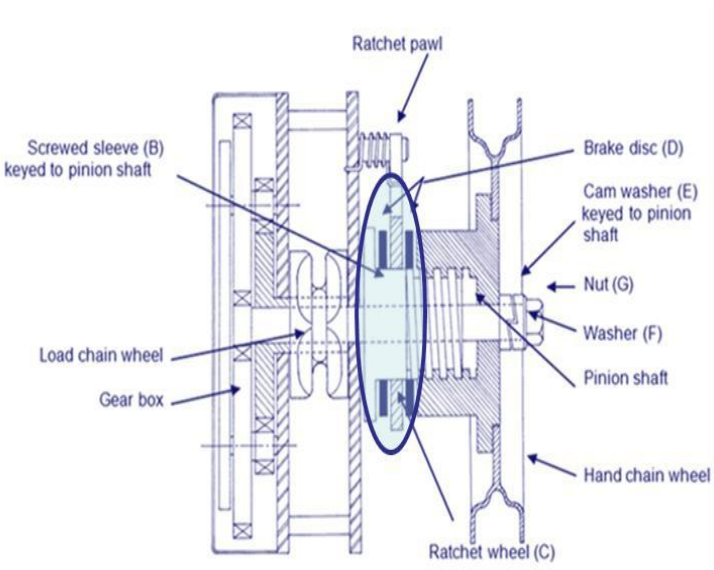
## Raising the Load

When effort is applied to the hand chain wheel in a clockwise direction it tightens onto the thread on the screwed sleeve (B) locking the ratchet wheel (C) between the brake discs (D).

The brake is now a solid unit and continued effort turns the screwed sleeve (B) which is keyed onto the pinion shaft (E).

The drive is then transmitted via pinion shaft and gear box to load chain wheel.

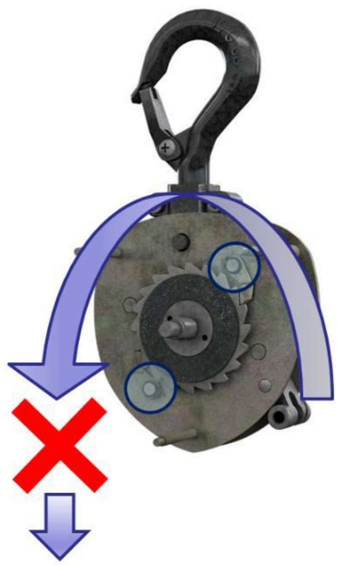
The ratchet wheel, which is locked to the screwed sleeve also turns and the ratchet pawl rides over the ratchet wheel making the familiar 'clicking' noise as it raises the load.




## Holding the Suspended Load

When drive to the hand chain wheel ceases, the suspended load tries to fall down and in so doing exerts a reverse force which tends to drive the brake assembly anti-clockwise.

This reverse motion is resisted by the pawls which engage positively with the ratchet wheel, keeping the brake locked as a solid unit.

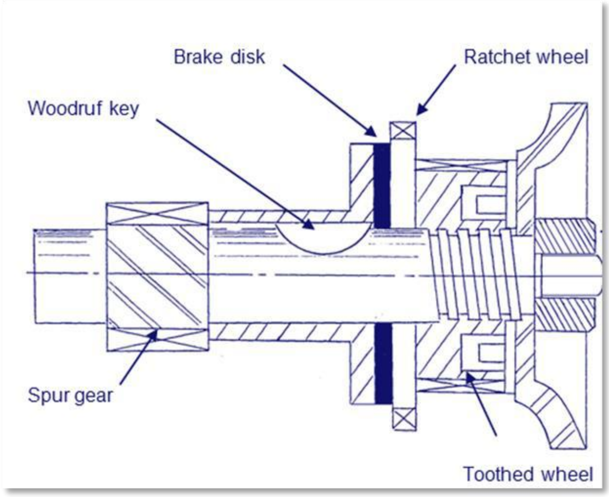


## Lowering the Load

When effort is applied in an anti-clockwise direction to the hand chain wheel, it unscrews the hand chain wheel releasing the brake discs, freeing up the ratchet wheel to turn.
The load falls under gravity until this downward action tightens the brake discs against the ratchet wheel.
Load is lowered by a 'slipping and gripping' action in a controlled manner.
The brake mechanism relies on the weight of the load being sufficient to overcome the weight of the slack chain, which is working against it, to close the brake.
If the load was too light the brake would remain open and load would free fall.

Notes:

## Lever Hoist Brakes




The principle of operation is exactly the same as that of the chain block, the lifting and lowering motions being made by a lever instead of a hand chain wheel.

The effort is applied by the lever via the toothed wheel, to a spur gear and then the load chain pocket wheel. In the raising position, the brake locks and the drive is transmitted to the pocketed wheel. When the operation is reversed the load is lowered by the same type of slipping and gripping action.

Lever hoists are designed to operate in any position, the ratchet pawl is therefore spring loaded so as to engage with the ratchet wheel, without the assistance of gravity, at all times.

Most modern lever hoist designs have followed the development of chain block brakes having two spring loaded pawls, so that there is little, or no difference, between modern lever hoist brakes and those used in hand chain blocks.



## Brake Adjustment

Modern chain blocks no longer have the cam washer feature, alternatively the brake is usually adjusted by tightening up the nut at the end of the pinion shaft and then releasing it between half a turn and a full turn, then a split pin is fitted to keep the nut in position and allow the correct operating gap for the brake 'slipping and gripping function'.

Adjustment of the brake should be done in accordance with particular manufacturer's instructions, which must be referred to before any adjustment is attempted by a competent person.

## Examination of Screw Brake Mechanisms

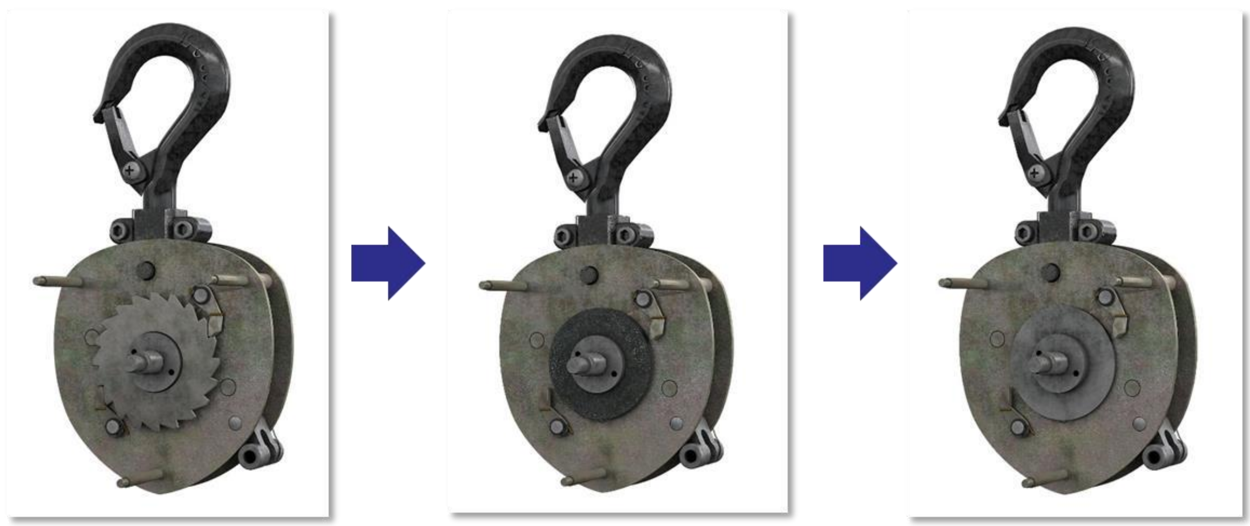
The brake mechanism is a most safety critical part of any chain block or lever hoist and hence its efficiency and integrity must be maintained at all times. Although it is not the tester and examiner's duty to undertake the repair of the mechanisms he must fully understand how dismantle them in order to make a full examination.

To dismantle and examine the brake:

1) Unscrew the hand chain wheel retaining nut locking nut and remove hand chain wheel from the screwed sleeve



2) Lift off brake discs and ratchet wheel



3) Examine the brake discs. The thickness should be even with no scoring or cuts on the faces of the washers. Fit new brake discs when any wear cannot be taken up by brake adjustment. Ensure that there is no impregnation of foreign matter, particularly lubricants

4) Examine the brake surfaces of the ratchet wheel for wear, scoring and cuts

5) Examine the ratchet wheel for tooth wear and damage

6) Examine the ratchet pawl for tooth wear and deformation, check the spring for fracture and the stud for freedom of movement

7) Examine the screwed sleeve, paying particular attention to the brake surface, for wear, scoring and cuts

**Reassemble the brake**. This is a reverse of the dismantling procedure although it calls for particular attention to the engagement of the pawls.

Notes:

# 7. HAND CHAIN HOISTS

The use of hand chain blocks can be labour intensive, particularly when moving very heavy loads, but despite this, there are many of these machines in service around the world.

In certain application, they are more suitable for use than powered hoists, for example:

- Where a permanent installation for infrequent use is required
- Where a temporary installation for erection or maintenance purposes is required
- Where precision location of the load is necessary
- Where there is no means of a suitable power supply to a powered hoist

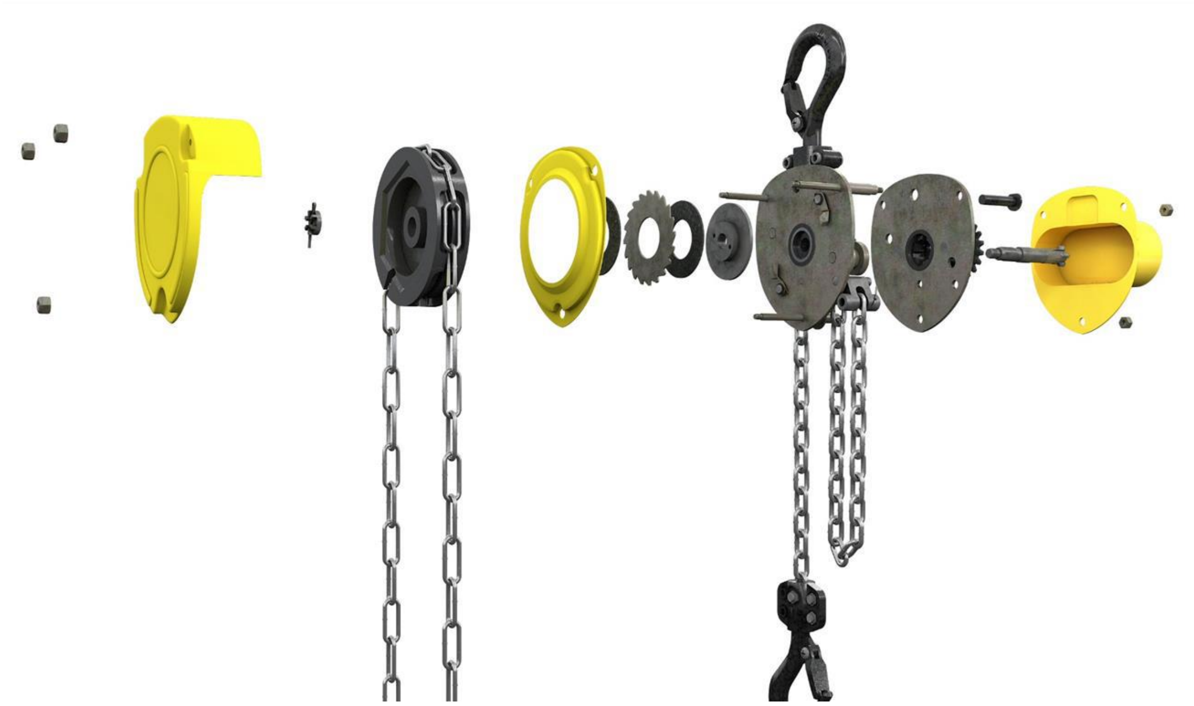
Typically, there is an emphasis on applications involving either long intervals between use or frequent changes of use, both of which require particular vigilance in the in-service inspection procedures to ensure that no significant deterioration or damage has occurred since last used.

All modern hoists are fitted with an automatic brake, which when functioning correctly is capable of arresting and sustaining the load at any position.

You may occasionally still come across older equipment not fitted with a brake. If so the competent person should remind the owner of their obligations under the health and safety at work etc. act 1974 to provide safe systems of work and also the requirements of PUWER and LOLER. Such equipment will not meet these requirements.

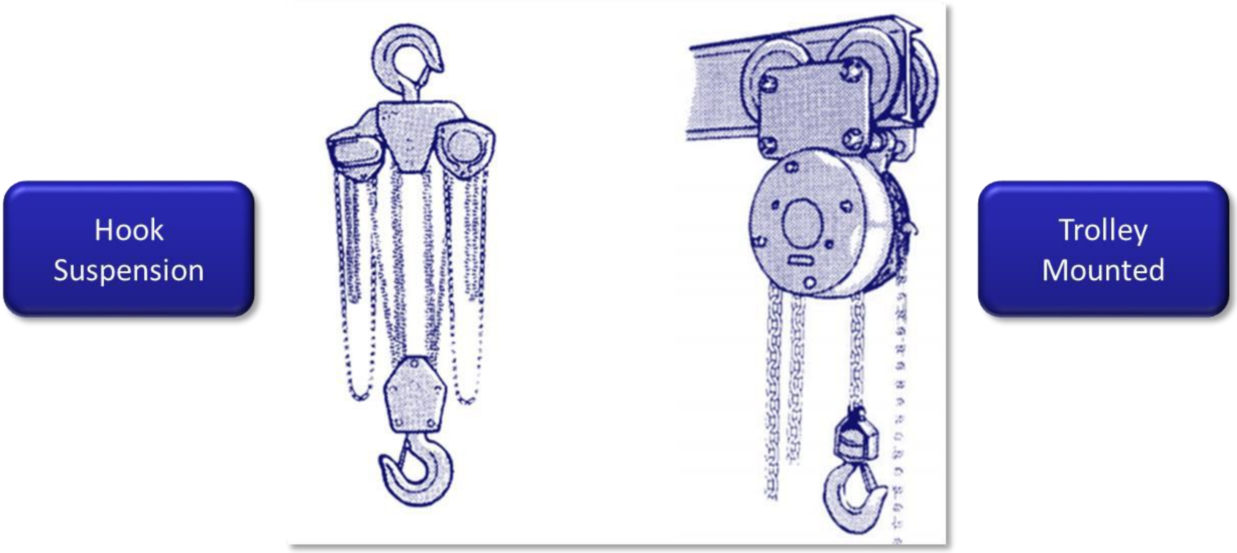
 BS EN 13157: 2004 cranes – safety – hand powered lifting equipment, superseded BS 3243: 1990 – hand operated chain blocks. A large number of blocks to other standards remain in use, but users should be encouraged to consider the advantages of these newer specifications.

## Components of a Hand Chain Hoist



## Types of Suspension

The block may be of a 'suspended' or 'built in' pattern, many manufacturers produce both options. Suspended types have a top hook, shackle, eyebolt or other fitting by which the block is hung and which allows a degree of articulation between the block and the supporting structure. Built in 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 block and the trolley or structure is usually rigid.




## Load Chain Falls

The lower capacity blocks (e.g. 500kg, 1t) lift the load on a single fall of load chain.

Higher capacity blocks may either be of similar design but with a larger frame or may utilise two or more falls of load chain. The very high capacity blocks 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.

Notes:

## Safety Requirements of BS EN 13157

### Mechanical Strength

BS EN 13157 requires chain blocks to have a factor of safety of at least 4:1. They must be designed to withstand 1500 continuous cycles with a load of 110% of the WLL without failure or the need for maintenance or replacement parts, other than lubrication.

### Brakes

The braking function must be automatic when the operating force ceases in any motion.

Brake discs must not contain asbestos.

The fracture of a pawl spring must not lead to a failure of the braking system. Where the system utilises several springs, if any one fails the design must be such that the remaining springs will ensure the correct engagement of the pawl.

The brake must only be able to be altered, maintained or interfered with by the use of tools, i.e. cannot be interfered with either intentionally or accidentally.

### Operation



The maximum effort exerted by each person to operate the block at full capacity must not exceed 55daN and if the operating effort is below 20daN the block must be fitted with an overload protection device.

The operation of an overload device must be independent of the brake and must ensure that the lowering function is maintained and that the load remains under control. If the overload device triggers it must not lead to a release of the hand chain.

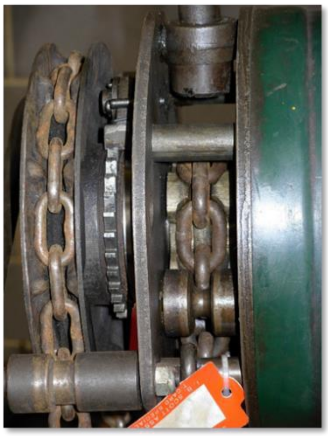
Chain blocks and their components must be capable of operation within the temperature range of -10°C to +50°C.

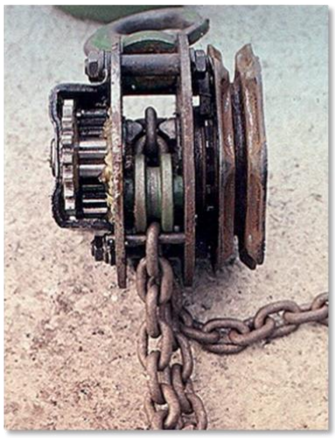
Chains and Chain Wheels
Load chains must comply with BS EN 818-7, fine tolerance short link grade T. Hand chains must have no sharp areas around the welds and the connecting link must not deform at a force of 120daN or less.

BS EN 13157 requires the free end of the chain to be fitted with a chain end stop to prevent the chain passing completely through. This stop must be able to withstand 2.5 times the tension in the chain when the WLL is being lifted. The load chain wheel must be made as a single piece. Chain anchorages (i.e. attached to the hoist body) should be capable of withstanding 4 x the rated capacity of the chain.


Chain guides must be provided for both the hand chain and load chain to prevent them jumping off of the chain wheels.

## Guarding Covers





Accessible parts of the hand chain block shall have no sharp edges, no sharp angles, and no rough surfaces likely to cause injury.

Gearing shall be guarded to prevent accidental ingress of parts of the body.

## Testing of Hand Operated Lifting Machines

New hand operated lifting machines are within the scope of the machinery directive 2006/42/EC and BS EN 13157 cranes – safety – hand powered cranes.

Section 4 of annex 1 of the directive contains the essential health and safety requirements (EHSRs) specific to lifting operations. Clause 4.1.1 defines two tests: static test and dynamic test.

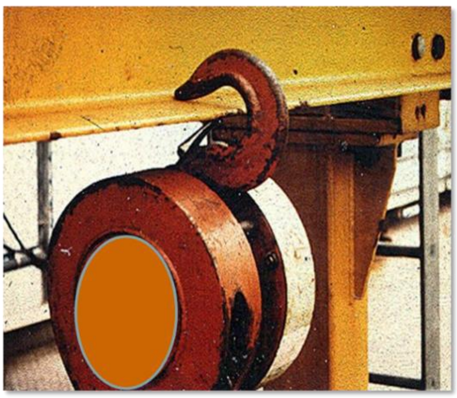
The static test is defined in a way that permits the force to be applied by external means. That is appropriate for lifting accessories but not for lifting machines as it will not test all the teeth of each gear or ratchet wheel nor will it test the ability of the brake to arrest a descending load. Therefore for lifting machines the load should be applied through the machine's own mechanism. The static test for hand operated lifting machines is 1.5 x WLL.

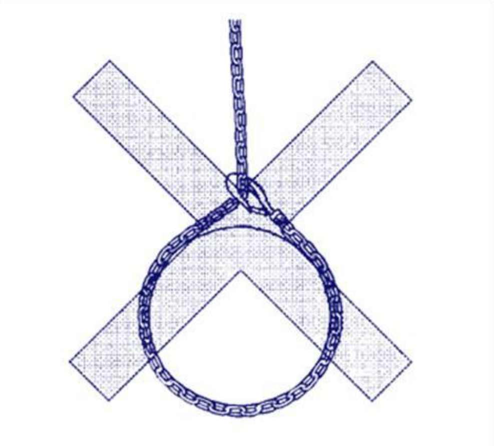


The dynamic test requires the lifting machine to be operated in all possible configurations and this is explained further in EHSR 4.1.2.3. The test should be made at the nominal speeds and combine all movements which the control system allows to be operated simultaneously. For a complex lifting machine such as a mobile crane, that could mean operating the hoist, slewing, derricking and telescoping motions simultaneously. The dynamic test is 1.1 x WLL.

## Safe Use of Hand Chain Blocks

Defects and damage that can occur due to misuse. Full details of the safe use of hand chain blocks are provided in the LEEA code of practice for the safe use of lifting equipment, which you should also study during this course.





Never hook back a load chain like this

The load chain should not be used to form a sling around a load and back hooked. This would remove the swivel action of the bottom hook, possibly leading to the chain becoming twisted and additional forces would be imposed on the chain links at the point of choke which can bend and distort the links and, at worst, crack the weld.

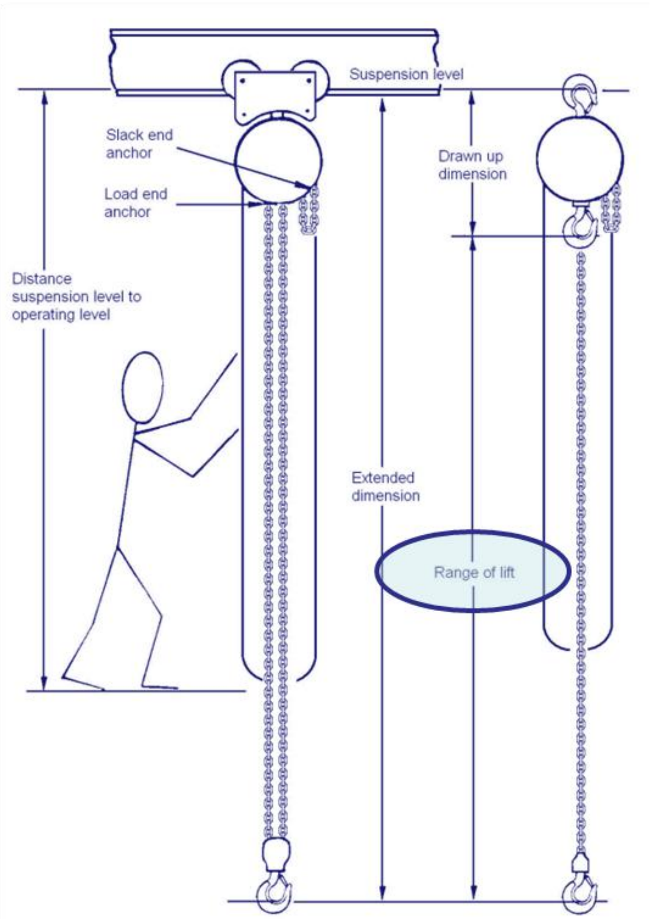
No part of the load or slings should be in contact with the point of the hook as this can distort and open the hook. The hook should not be overcrowded as this will damage the slings and can also distort and open the hook.

The majority of blocks are designed to be operated by a single person. If it is found necessary for more than one person to operate the block to lift the load, the load may exceed the WLL of the block or maintenance may be needed. In either case continued use will lead to damage and possible failure of the gears or other mechanism.

The block should not be subjected to shock loading. This will lead to all types of damage, e.g. stretched chain, opening of hooks, damage to gears or brakes.

Care should be taken not to drop the block, e.g. when handling, dismantling or erecting. This can cause damage to the casing which will press on the gears or other mechanisms or cause distortion of the blocks alignment.

85 **Range of Lift**



**Documents to be supplied by the Manufacturer**

In accordance with relevant legislation and standards, the following documents are to be supplied by the manufacturer for all hand operated chain hoists:

- EC declaration of conformity (guidance LEEA 030.1e)
- Manufacturer's instructions for use (guidance LEEA SI.12.3)

**Information to be exchanged between the User and Designer/Supplier**

As hand chain hoists are frequently used for miscellaneous lifting purposes, precise details of the load to be lifted are not always available. In these circumstances, only a general specification can be given and this should include the following information:

- The safe working load or maximum load to be lifted
- The maximum extended dimension
- The maximum acceptable drawn up dimension (if headroom is important)
- The range of lift
- The distance from the suspension level to the operating level (this caters for the situation where the hand chain required is shorter than the load chain)
- Whether the block is to be used at an angle to the vertical
- The conditions of service and in particular any conditions which the user suspects might be hazardous, e.g. extremes of temperature, high probability of shock loading, uncertainty of weight of load
- The type of suspension, i.e. hook suspended or trolley mounted



**Marking**

The following information should be permanently and legibly marked on a suitable part of the hoist:

- CE mark
- Business name and address of the manufacturer
- Identification mark; if any
- Safe working load
- The series or type designation
- Size and grade of the load chain
- Year of manufacture

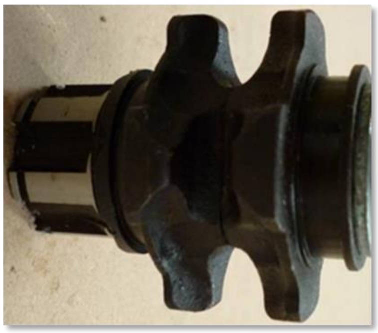
**Note:** If manufacturer does not provide a unique identification mark, then the owner of the equipment will be responsible for ensuring that the equipment is marked with one.

## Thorough Examination

### General Appearance and Operational Checks

- Check all markings are present and correct, clear and legible
- Carry out a functional check to ensure smooth operation of the hoist
  - Is the hoist noisy in operation or does it have an erratic movement?
  - Does the load chain jump in the load wheel?

Chain Stripper

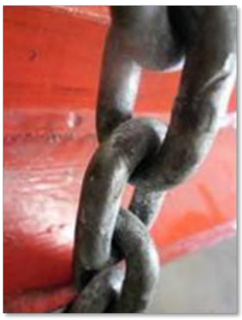


Load Wheel

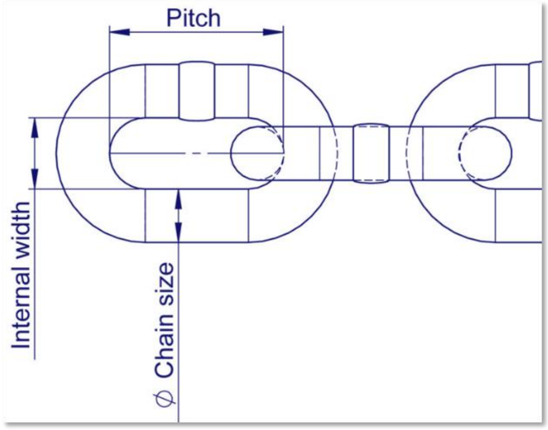
- Check that the chain stripper present and undamaged
- Check for any damage to the chain hoist casing that could cause malfunction of the machine
- Ensure that the chain is not twisted, especially at the anchorage
  - In the case of multi-fall hoists, the bottom block may have twisted the chain by turning over



- Check the load chain for damaged links, including indentations, cuts and cracks
- Ensure that the individual links are not distorted (twisted)
- Check for heat damage, weld splatter, exposure to chemicals (pitting and discolouration)
- Ensure the load chain is marked correctly and is of the correct grade and size

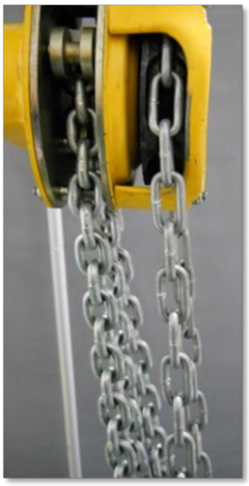


Check chain load chain for pitch elongation and link reduction in material diameter (wear) and refer to the manufacturer's discard criteria:




- Diameter
- Pitch
- Width

- **Maximum reduction in material diameter Is 8%**
- **Maximum elongation (due to wear) is 3%**



The hand chain and hand chain wheel should be examined. Whilst this is not load bearing similar attention should be given as with the load chain. A badly fitting hand chain can jump during operation, making the operation dangerous for the operator, and a twisted hand chain can jam.



Notes:

**Hand Chain Wheel Examination**

Examination of the Hand Chain Wheel

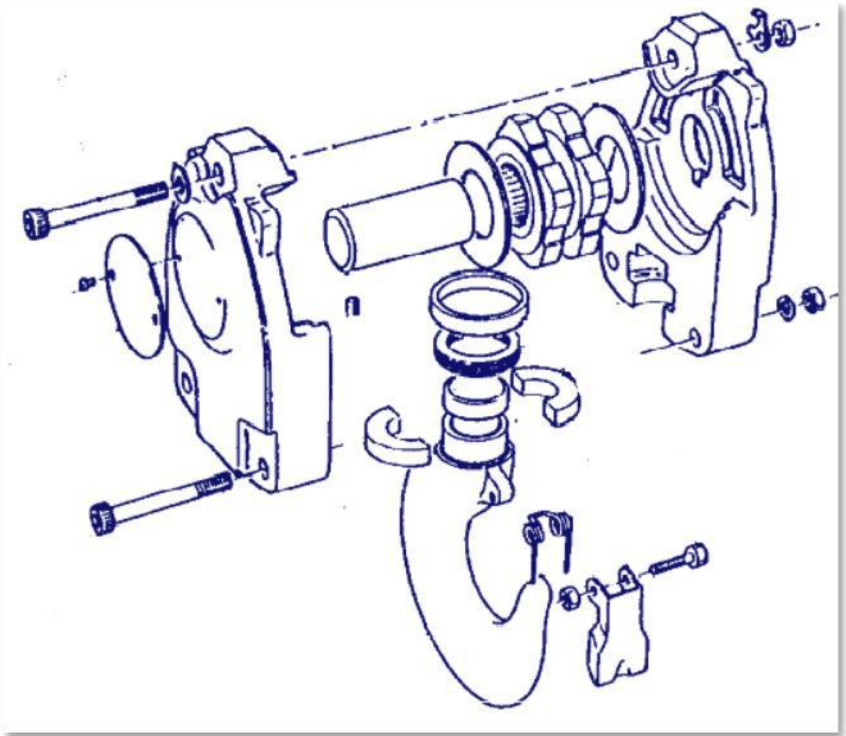
- Check the top and bottom hooks for the following faults:
- Distortion, e.g. twisting, deformation and stretching of the hook opening
- Check for cuts, indentations and cracks
- Ensure that the hooks can articulate and rotate freely
- Ensure that safety catches are fitted (see BS EN 13157 section 5.1.8)
- Maximum wear in the cross sectional area of the hook is 8%




- Free rotation and movement of hooks.

- If there is excessive movement or float of the hook in the cross head it will be necessary to remove the hook from its housing in order to examine the seating and bearing surfaces.

- Well-designed housings are bolted together to allow this but in many cases they are riveted, in which case the rivets must be drilled out and subsequently replaced with bolts and nuts.



**Examination**

Where necessary the block should be stripped down, degreased and cleaned to enable a full examination of all or any of the following:



- Gears for wear, fracture and alignment, paying particular attention to the load wheel gear and axis
- Side plates are in proper alignment and free from wear
- Load wheel for wear on splines
- Brake discs for contamination, wear and damage (it is preferable to replace the discs rather than attempt to clean them)

**Testing**

Functional testing at the WLL and a light load test to ensure the integrity of the brake may also form a part of the examination.

A **light load test** should be made to ensure the correct and safe operation of the brake. This is the most important test that can be made and is necessary if the tester and examiner is to certify that the block is 'safe to operate' on the report of thorough examination.

A load between **2% and 10%** of the WLL should be raised a height of at least 500mm and then lowered. To be acceptable, when the hand chain is released at any point during the test, the brake must hold the load. In the case of blocks with extended heights of lift particular care is needed and the raised height of the load during the test should be increased. This is due to a condition which can arise where the weight of the slack chain is sufficient to hold the brake open allowing the load to descend.

Notes:

# 8. LEVER HOISTS

Chain lever hoists are in wide use throughout industry for both lifting and pulling applications.

They provide a comparatively lightweight method of moving loads over a short distance and the lever operation allows them to be used in any operating position.

This ability to operate in any attitude makes the chain lever hoist a very versatile tool particularly in rigging applications where it may be used as an adjustable sling leg to enable a load to be balanced or for line adjustment when positioning a load or as a means of restraint to quote just three examples.

BS EN 13157: 2004 Cranes – Safety – Hand Powered Lifting Equipment, superseded BS 4898: 1973. Chain lever hoists made in compliance with these standards have a 'free wheel' facility, which allows the operative to rapidly extend or take up slack chain under no load conditions.

Two basic types are available, one employing fine tolerance (calibrated) steel short link chain, the other employing roller chain. Some manufacturers offer both types and in addition there may also be a choice between a lightweight aluminium alloy model and a ferrous model.

Hand operated chain lever hoists are suitable for a variety of purposes and the braking mechanism is designed for use at any attitude, making them suitable for both lifting and pulling applications, unlike the hand chain hoist.

## Brake Mechanism



The hoist should be fitted with an automatic brake capable of arresting and sustaining the load. If it is intended to lift a load which is very light, i.e. 10% or less, in relation to the lever hoist's working load limit, the manufacturer's or supplier's advice should be sought with regard to the performance of the brake. This is because the brake relies upon the hoisting effort for its operation and with a very light load the effort available may be inadequate to operate the brake fully.

## Type of Chain

For the majority of applications, there is little to choose between the link chain and roller chain models.

**Note:** Roller chain will only articulate in one plane otherwise such factors as price, weight or drawn up dimension may influence choice of one over the other.

Notes:

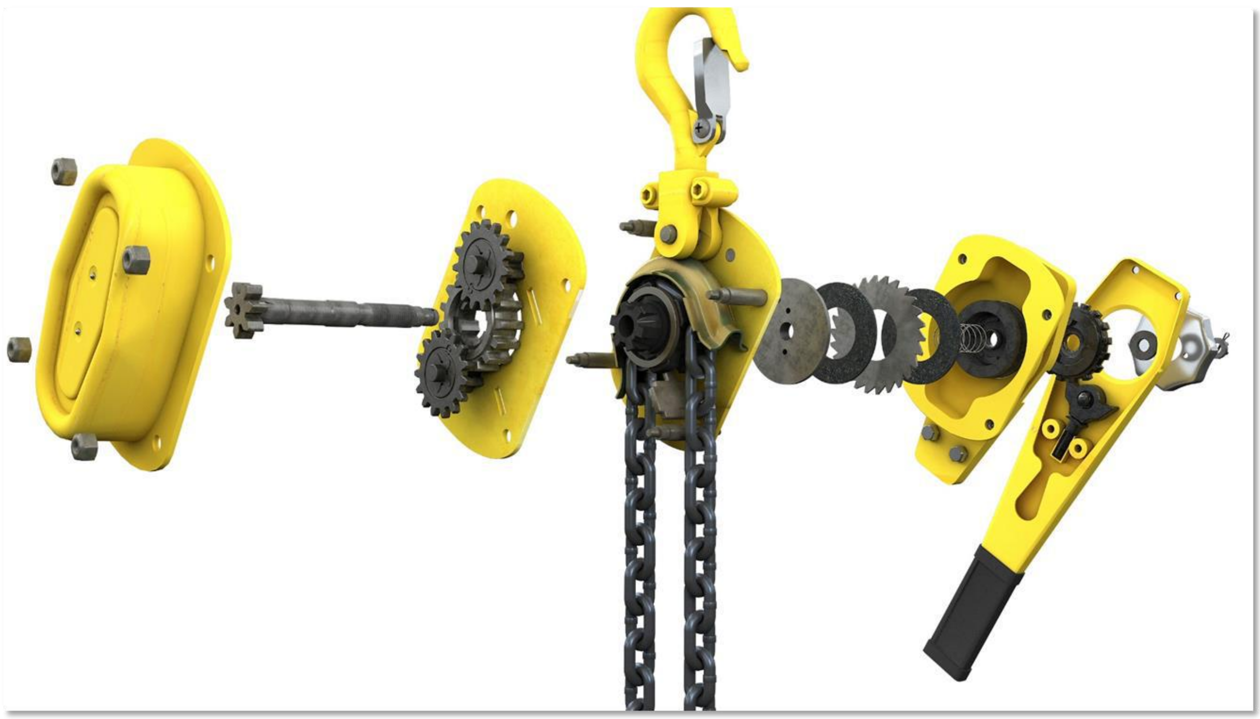
## Link and Roller Chain Variants

Link Chain

Roller Chain

93

## Components of a Lever Hoist



## Load Chain Falls

In general, there is no choice available to the user in this respect.

The lower capacity models lift the load on a single fall of load chain, the higher capacity models utilising two or more falls.

## Safety Requirements of BS EN 13157

### Mechanical Strength

BS EN 13157 requires lever hoists to have a factor of safety of at least 4:1.

The lever hoist shall be designed to withstand 1,500 cycles with 110% of the rated capacity with no failure, no replacement of parts, no resting time, except for lubrication, a lifting path of the lifting medium of at least 300mm per cycle in order to get at least a complete revolution of the load chain wheel or drum.

### Brake Mechanism

The hoist should be fitted with an automatic brake capable of arresting and sustaining the load.

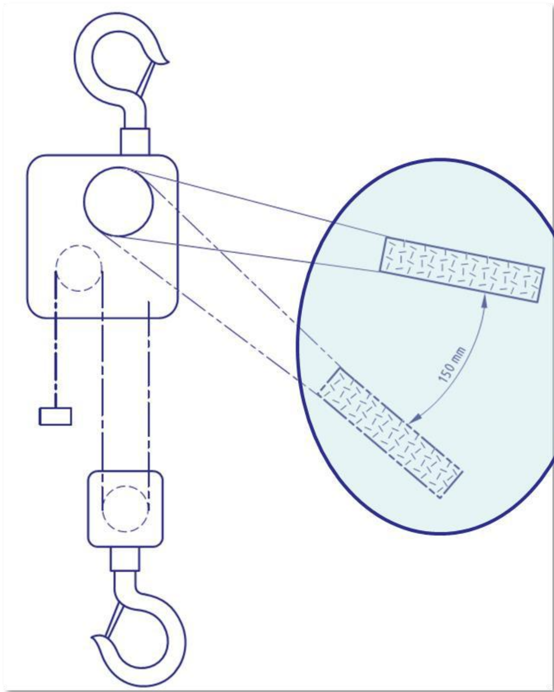
If it is intended to lift a load which is very light, i.e. 10% or less, in relation to the lever hoist's working load limit, the manufacturer's or supplier's advice should be sought with regard to the performance of the brake. This is because the brake relies upon the hoisting effort for its operation and with a very light load the effort available may be inadequate to operate the brake fully.

### Operation

Removable levers shall be capable of being secured against unintentional slippage/stripping and disconnection from the drive shaft.

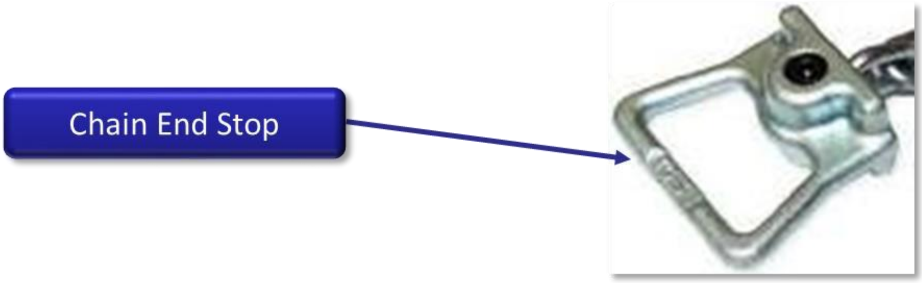
Levers shall have a return travel distance not exceeding 150mm (see illustration opposite).

After a movement of not more than 150mm, a pawl or other load retaining device shall be engaged.



BS EN 13157 requires the free end of the chain to be fitted with a chain end stop to prevent the chain passing completely through. This stop must be able to withstand 2.5 times the tension in the chain when the WLL is being lifted.

This requirement is an important safety feature and should be considered as the minimum for hoists of all ages. If the user inadvertently runs the chain fully out and the slack end anchorage is not adequate, the chain will easily continue through the hoist and drop the load.




**Free Spooling of the Lifting Medium**


For free-spooling of the lifting medium it may be possible to open the brake system only under the condition of low loading.

The brake system shall automatically apply when the load on the lifting medium is greater than 30kg for capacities up to 1,000kg, and greater than 3% of the rated load above 1,000kg.

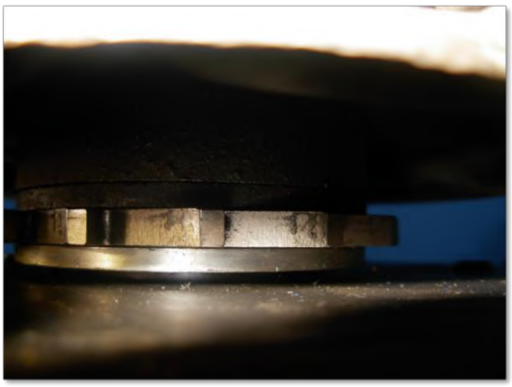
In this respect, the load shall not be allowed to descend more than 300mm, before the brake acts to stop the load falling.

It must not be possible to declutch or disengage the chain wheel.

**Guarding Covers**

Accessible parts of the lever hoist shall have no sharp edges, no sharp angles, and no rough surfaces likely to cause injury.

Gearing shall be guarded to prevent accidental ingress of parts of the body.



## Testing of Hand Operated Lifting Machines

New hand operated lifting machines are within the scope of the Machinery Directive 2006/42/EC and BS EN 13157 Cranes – Safety – Hand Powered Cranes.

Section 4 of annex 1 of the directive contains the essential health and safety requirements (EHSRs) specific to lifting operations. Clause 4.1.1 defines two tests: static test and dynamic test.

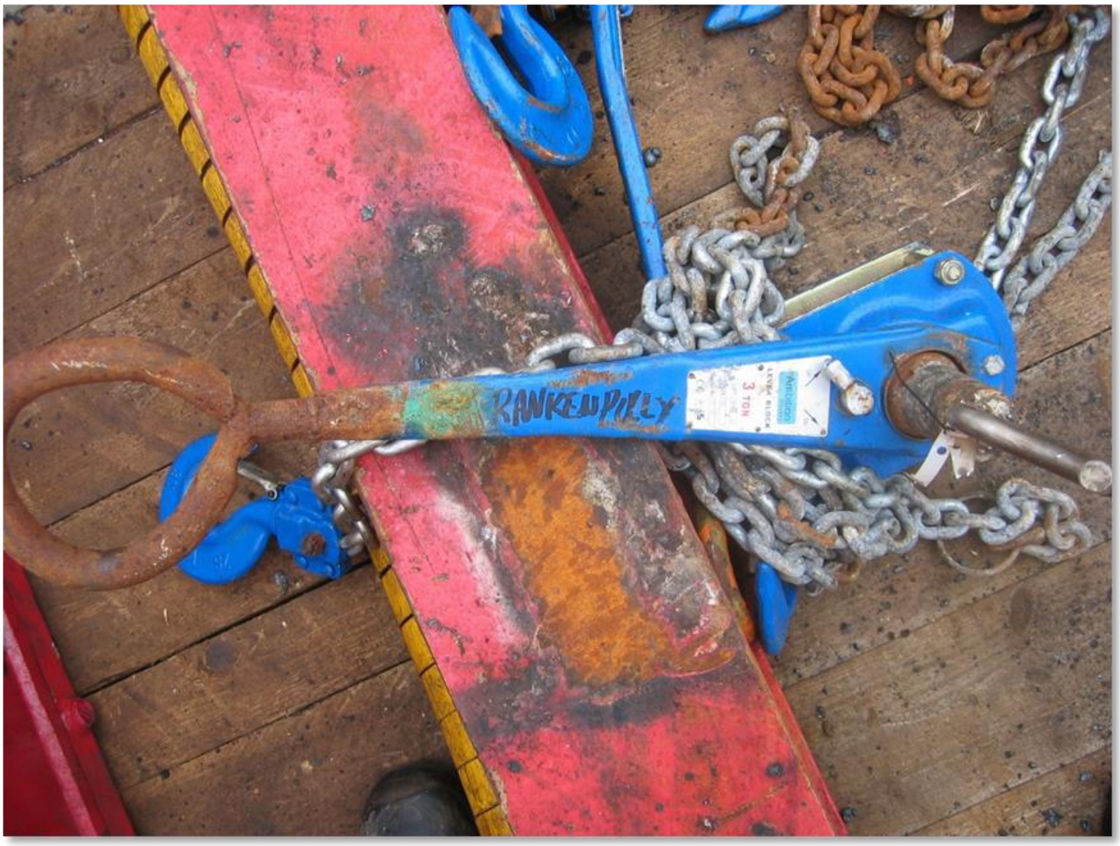
The static test is defined in a way that permits the force to be applied by external means. That is appropriate for lifting accessories but not for lifting machines as it will not test all the teeth of each gear or ratchet wheel nor will it test the ability of the brake to arrest a descending load. Therefore for lifting machines the load should be applied through the machine's own mechanism. The static test for hand operated lifting machines is 1.5 x WLL.

The dynamic test requires the lifting machine to be operated in all possible configurations and this is explained further in EHSR 4.1.2.3. The test should be made at the nominal speeds and combine all movements which the control system allows to be operated simultaneously. For a complex lifting machine such as a mobile crane, that could mean operating the hoist, slewing, derricking and telescoping motions simultaneously. The dynamic test is 1.1 x WLL.

## Safe Use of Lever Hoists

Defects and damage can occur due to misuse. Full details of the safe use of hand chain blocks are provided in the LEEA code of practice for the safe use of lifting equipment, which you should also study during this course.





The hoist must not be used to raise, lower or suspend a load that is in excess of the safe working load marked upon the hoist body. It should be noted that the majority of hoists, and especially the lower capacity models, are designed for operation by one person only. If it is found that more than one person is required, it is probable that either:

- The load exceeds the safe working load of the appliance

or

- The appliance is in need of maintenance

or

- A combination of the two

Whichever the case, unduly high operating effort requires investigation before the lift proceeds. This is not intended to preclude the use of two persons to operate the block which may in certain applications be found advantageous but is to indicate the degree of operating effort normally required. For larger capacity appliances, the manufacturer will advise on the number of persons normally required to lift maximum capacity.

**Operating Effort**

To lift the rated capacity the operating effort shall not exceed 55 daN at the end of the lever.
To avoid overloading, the operating effort at the end of the lever to lift the rated capacity shall be between the following values:

- Rated capacity ≤ 1000 kg: 20 daN up to 55 daN on the lever
- 1 000 kg < rated capacity< 5000 kg: 40 daN up to 55 daN on the lever
- 5 000 kg ≤ rated capacity: 45 daN up to 55 daN on the lever

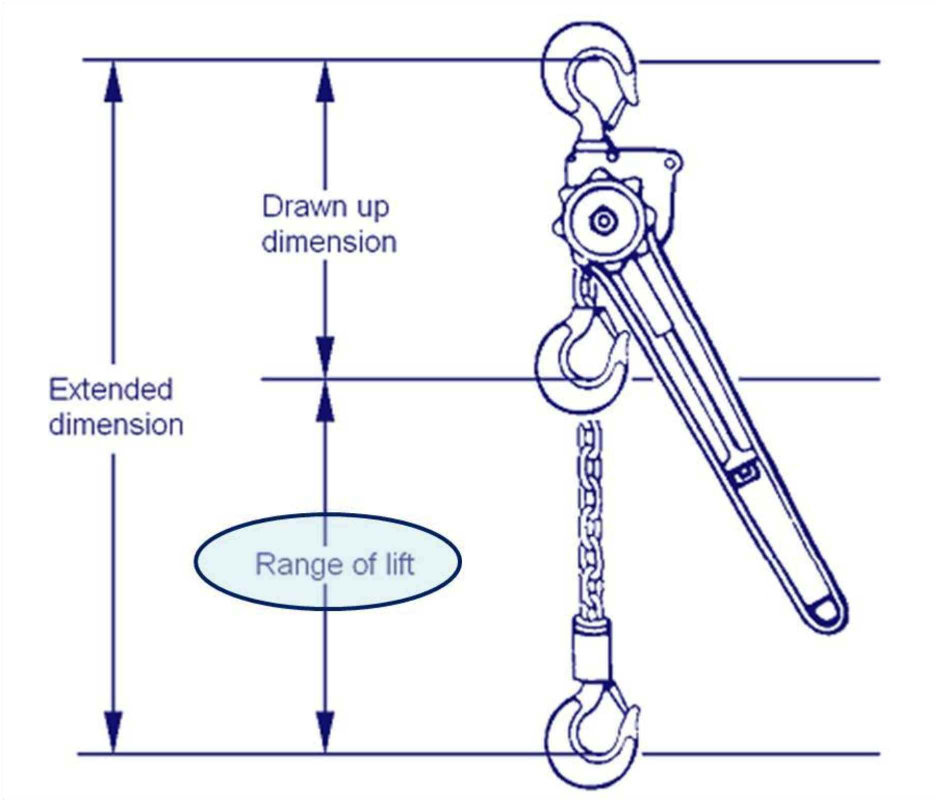


If the operating effort is beneath 20 daN at rated capacity the lever hoist shall be equipped with an overload protection system, against overloading caused by excessive operating effort on the levers. The overload system shall be independent from the braking device and shall operate in a way that the lowering function is maintained and that the load remains under control.

The triggering shall not lead to sudden release of the lever.

Lever hoists should not be subjected to shock loading. This will lead to all types of damage, e.g. stretched chain, opening of hooks, damage to gears or brakes.

Care should be taken not to drop the hoist, e.g. when handling, dismantling or erecting. This can cause damage to the casing which will press on the gears, direction selector and other mechanisms, or cause distortion of the hoist body and/or operating lever alignment.


**Range of Lift**



**Documents to be supplied by the Manufacturer**

In accordance with relevant legislation and standards, the following documents are to be supplied by the manufacturer for all hand operated chain hoists:

- EC Declaration of Conformity (guidance LEEA 030.1e)
- Manufacturer's instructions for use (guidance LEEA SI.12.3)

**Information to be exchanged between the User and Designer/Supplier**

As chain lever hoists are frequently used for miscellaneous lifting purposes, precise details of the load to be lifted are not always available. In these circumstances, only a general specification can be given and this should include the following information:

- Intended application e.g. lifting, tensioning or pulling
- The safe working load
- The maximum extended dimension
- The maximum acceptable drawn up dimension if headroom is important
- The range of lift
- The type of chain required
- The conditions of service and in particular any conditions which the user suspects might be hazardous, e.g. extremes of temperature, high probability of shock loading, uncertainty of weight of load

## Marking

The following information should be permanently and legibly marked on a suitable part of the hoist:

- CE mark
- Business name and address of the manufacturer
- Identification mark, if any
- Safe working load
- The series or type designation.
- Size and grade of the load chain
- The direction of movement.
- Year of manufacture


**Note:** If manufacturer does not provide a unique identification mark, then the owner of the equipment will be responsible for ensuring that the equipment is marked with one.

Notes:

## Thorough Examination

### General Appearance and Operational Checks

- Check all markings are present and correct, clear and legible
- Carry out a functional check to ensure smooth operation of the hoist
    - Is the hoist noisy in operation or does it have an erratic movement?
    - Does the load chain jump in the load wheel?


- Check that the chain stripper and chain guide are present and undamaged

- Check for any damage to the hoist casing that could cause malfunction of the machine



- Ensure that the chain is not twisted, especially at the anchorage
    - In the case of multi-fall hoists, the bottom block may have twisted the chain by turning over

- Link chain load chains must comply with BS EN 818-7, fine tolerance short link chain grade T

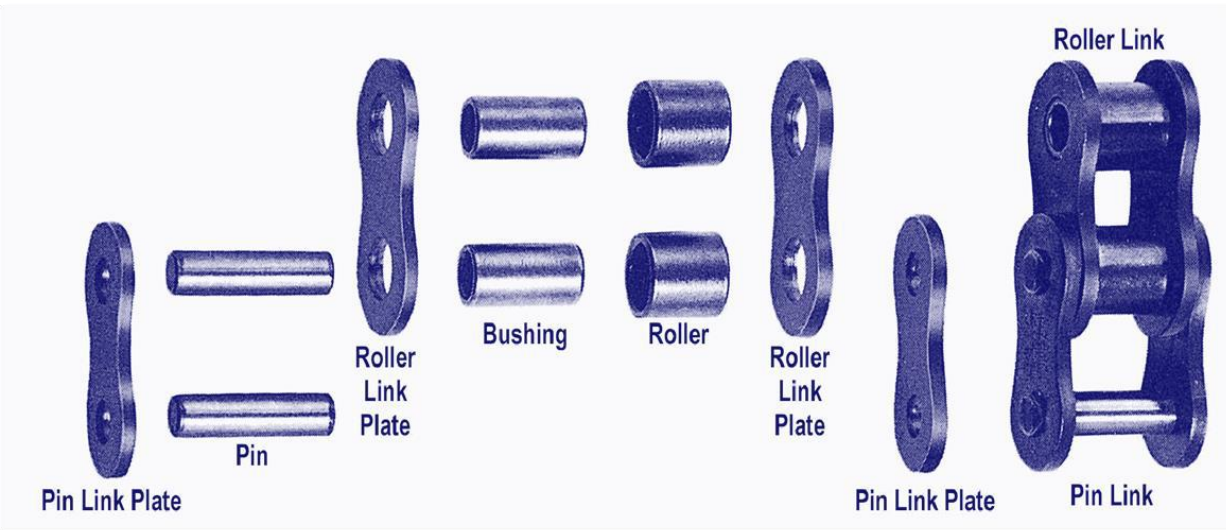
- Roller chain load chains must comply with ISO 606, short pitch transmission precision roller chains

- Check the load chain for damaged links, including indentations, cuts and cracks

- Ensure that the individual links are not distorted (twisted)
- Check for heat damage, weld splatter, exposure to chemicals (pitting and discolouration)
- Ensure the load chain is marked correctly and is of the correct grade and size



**Components of a Roller Chain (ISO 606)**

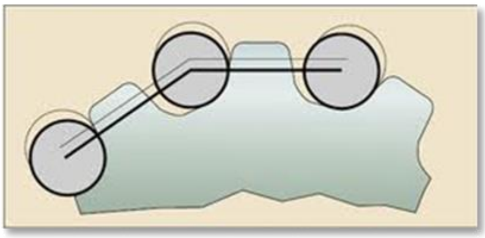


**Examination of a Roller Chain**

Unlike link chain, which has flexibility in all directions, roller chain only has flexibility in one plane – along the line of the plane of the link plates. It is constructed from individual plates which are riveted together with case hardened pins and rollers are fitted at each joint. These both space the internal width of the link and give flexibility to the joint.

With roller chain, most of the wear takes place on the rivet pins, about which the plates swivel. The wear in the chain can therefore be determined by measuring the elongation over a number of links. A maximum increase in length of 2% is permitted, as this is the point at which the case hardened skin of the pins will have just worn through. Beyond this point rapid wear and failure would occur.

To check the length, the chain should be laid on a flat surface and pulled tight.
Rivet pins are usually centre punched as a result of the riveting process. These punch marks give a convenient marker from which to measure.





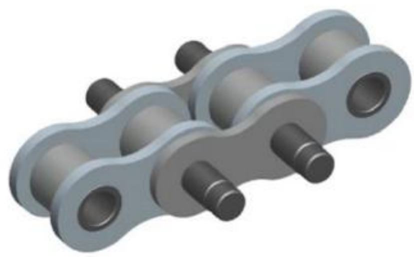

The measurement over a number of links, usually 12, can then be compared to the original and the elongation calculated.

When original length is unknown the wear can be determined using the 'shunt' method.

Original, or mean, length will be equal to the closed length plus half of the difference between the two measurements. If the difference is 4% then the actual elongation will be 2% and the chain should be discarded.

In addition to the general wear that will occur with use, lack of lubrication will cause this to be more rapid.

Lack of lubrication and corrosion will cause some of the links to 'lock' and therefore jump or jam during operation. Overloading will also cause the links to become stiff and lock due to the pins having become bent.



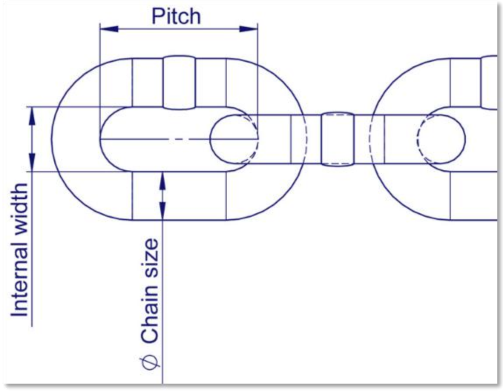
These points require special attention during the examination.

**Examination of Link Chain**

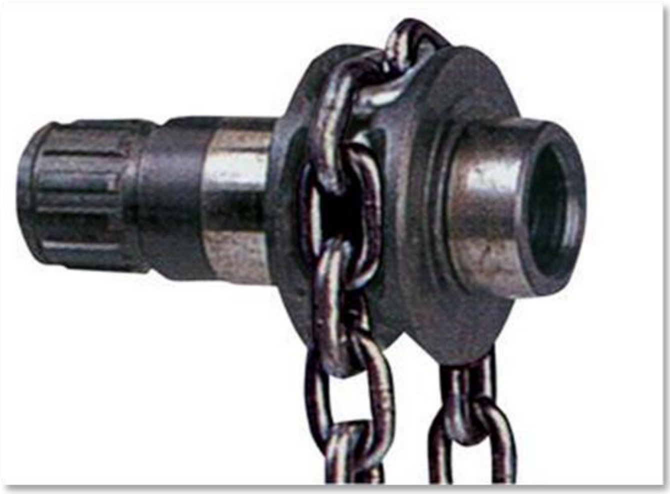
Check chain load chain for pitch elongation and link reduction in material diameter (wear) and refer to the manufacturer's discard criteria:

- Diameter
- Pitch
- Width

- **Maximum reduction in material diameter Is 8%**
- **Maximum elongation (due to wear) is 3%**




The load wheel should be examined. A badly fitting, or stretched/deformed link or roller chain can jump during operation, making the operation dangerous for the operator, and can jam in the mechanism.



- Check condition and security of the operating lever.
- A bent or distorted lever will become loose and can cause the mechanism to jam.
- If the handle is cracked it might fail in use, presenting a hazard to the operator.

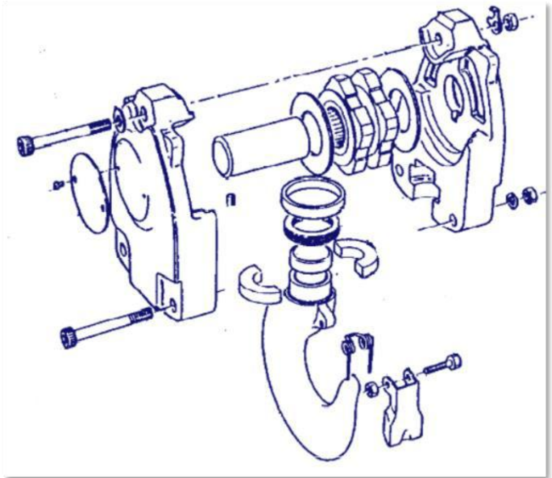
Check the top and bottom hooks for the following faults:

- Distortion, e.g. twisting, deformation and stretching of the hook opening
- Check for cuts, indentations and cracks
- Ensure that the hooks can articulate and rotate freely
- Ensure that safety catches are fitted (see BS EN 13157 section 5.2.9.)
- Maximum wear in the cross sectional area of the hook is 8%

**Free rotation and movement of hooks.**

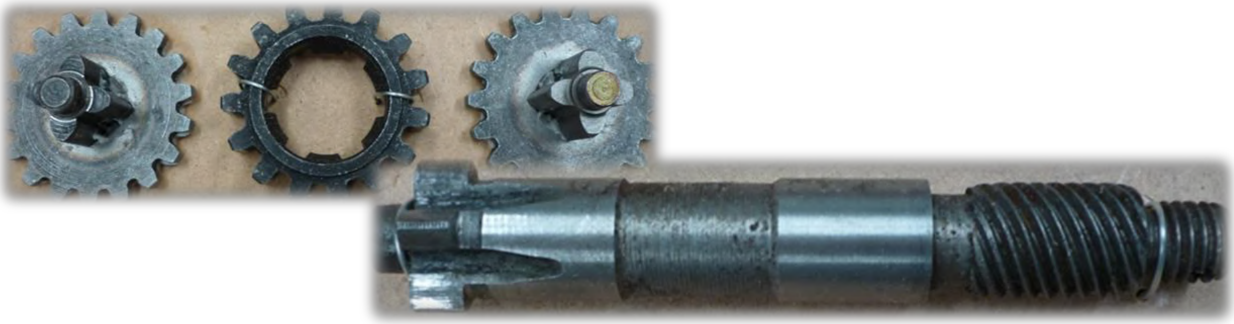
If there is excessive movement or float of the hook in the cross head it will be necessary to remove the hook from its housing in order to examine the seating and bearing surfaces.

Well-designed housings are bolted together to allow this but in many cases they are riveted, in which case the rivets must be drilled out and subsequently replaced with bolts and nuts.



Where necessary the block should be stripped down, degreased and cleaned to enable a full examination of all or any of the following:

- Gears for wear, fracture and alignment, paying particular attention to the load wheel gear and axis
- Side plates are in proper alignment and free from wear
- Load wheel for wear on splines
- Brake discs for contamination, wear and damage (it is preferable to replace the discs rather than attempt to clean them)



Where the competent person deems a proof test is necessary as a part of the thorough examination, the test load applied will be governed by the standard to which the hoist was manufactured and by the requirements for the overall installation, e.g. runway, which form a part of the thorough examination and which may differ from those of the hoist.

The proof load for hand operated chain lever hoists will usually be 150% of the working load limit, unless the standard to which the hoist was manufactured states otherwise. (BS EN 13157 only requires a dynamic test of 1.1 times the WLL).

Functional testing at the WLL and a light load test to ensure the integrity of the brake may also form a part of the examination.

A **light load test** should be made to ensure the correct and safe operation of the brake. This is the most important test that can be made and is necessary if the tester and examiner is to certify that the block is 'safe to operate' on the report of thorough examination.

A load between **2% and 10%** of the WLL should be raised a height of at least 500mm and then lowered. To be acceptable, when the operating lever is released at any point during the test, the brake must hold the load.

Notes:

# 9. LIFTING AND PULLING MACHINES (JAW WINCHES)

Lifting and pulling machines (otherwise known as 'jaw winches') are, by their very nature, versatile pieces of equipment and are widely used throughout industry for both permanent applications and temporary or rigging applications.

Manufacturers of this type of machine may permit a lower factor of safety (and therefore a higher safe working load) when the machine is used for pulling applications as compared to lifting applications.

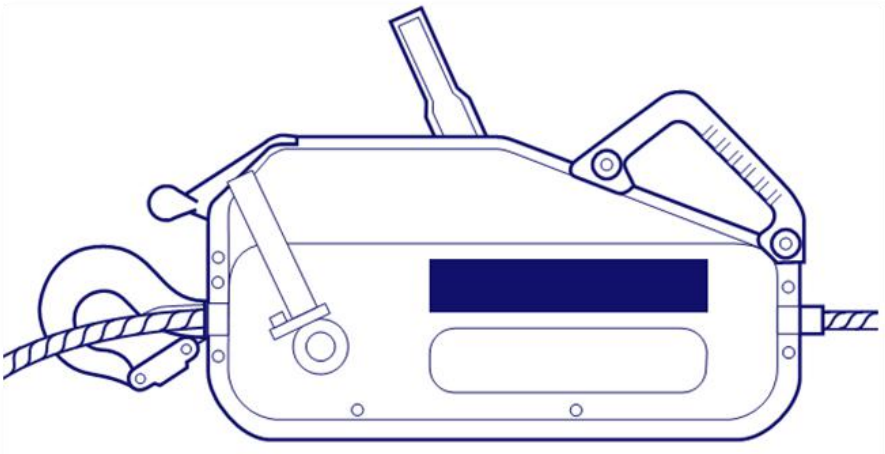
The advice given in this training module is aimed solely at lifting applications or applications involving an element of lifting.



The principles laid down for lifting applications may be applied to pulling applications if so desired, although in some cases they may be found to be excessively restrictive.

Until the introduction of BS EN 13157: 2004 – Cranes – Safety – Hand Powered Lifting Equipment no standards existed for lifting and pulling machines. Until its introduction they were produced to the manufacturer's specifications. BS EN 13157 refers to lifting and pulling machines as jaw winches.

This section of the code does not include any information on wire rope machines where the rope is wound onto a drum (see module 10 – Hand Operated Winches).



# Definitions

### Lifting Application

A lifting application is any application where, in the event of the machine or any of its associated equipment failing, the load does not become stationary.

For lifting applications, under normal operating conditions, i.e. where there are no hazardous conditions, the safe working load will be the same as the working load limit.

Lifting applications will have a factor of safety of 4:1.

### Pulling Application

A pulling application is any application where, in the event of the machine or any of its associated equipment failing, the load becomes stationary. (Factor of safety = 3:1).

Therefore, if for example, a load were being 'pulled' up an incline on wheels it would be regarded for the purpose of this section as a lifting application as, in the event of a failure, the load would descend the incline under gravity.

For man-carrying applications, the factor of safety of the machine, rope and terminal fittings should be increased to a minimum of 8:1 i.e. the safe working load should not exceed 50% of the working load limit.

If the machine is to be used for a man-carrying application, reference should be made to the manufacturer for additional safety requirements, e.g. the installation of descent arrestors.

As an alternative to adapting a standard lifting and pulling machine for man-carrying, the manufacturer may be able to offer a machine purpose designed for such work.

### Types of Lifting and Pulling Machines

In hand operated machines a hand operated lever activates a mechanism to provide a direct pull on an integral rope which is attached to the load.

The pull is applied by means of two pairs of self-energising jaws, which exert a grip on the rope, the distance of travel being limited only by the length of the rope.

The initial pressure which causes the jaw to grip the rope and give the self-energising action is provided by powerful springs.

Notes:

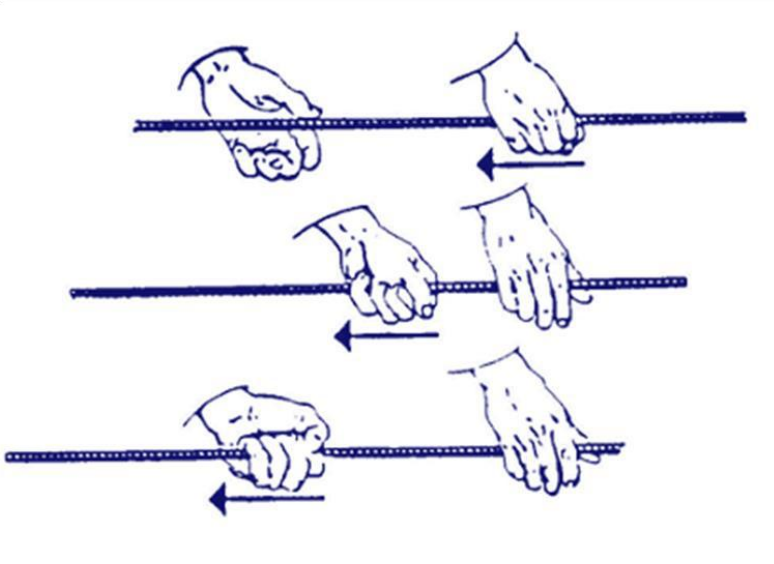
Hydraulic machines are based on the same mechanical principle of operation as the manual type but with the addition of an integral hydraulic mechanism to provide power operation.

The hydraulic system is of piston and cylinder design, the piston rods being directly connected to the forward and reverse operating handles.

These machines may be used singly or ganged with the addition of a purpose designed hydraulic system approved by the competent person or manufacturer.

## Principles of Operation

All jaw winches operate by the same general principle, which may be described as the 'hand over hand' principle, like a man pulling on a rope. In the jaw winch there are two sets of jaws which act as the hands. Whilst one set of jaws grips and pulls the wire rope the other set of jaws change position. The second set of jaws then grip the rope and the first set of jaws release it, allowing the second set jaws to pull the rope and so on.

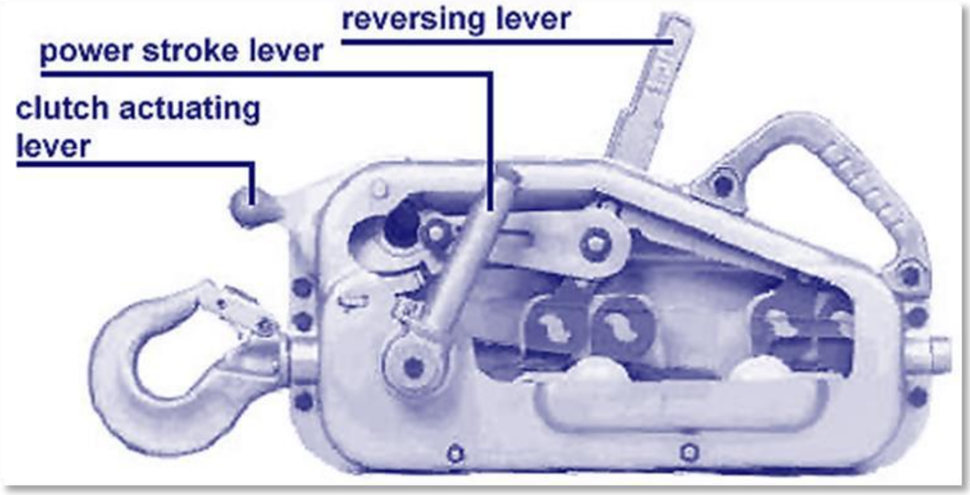


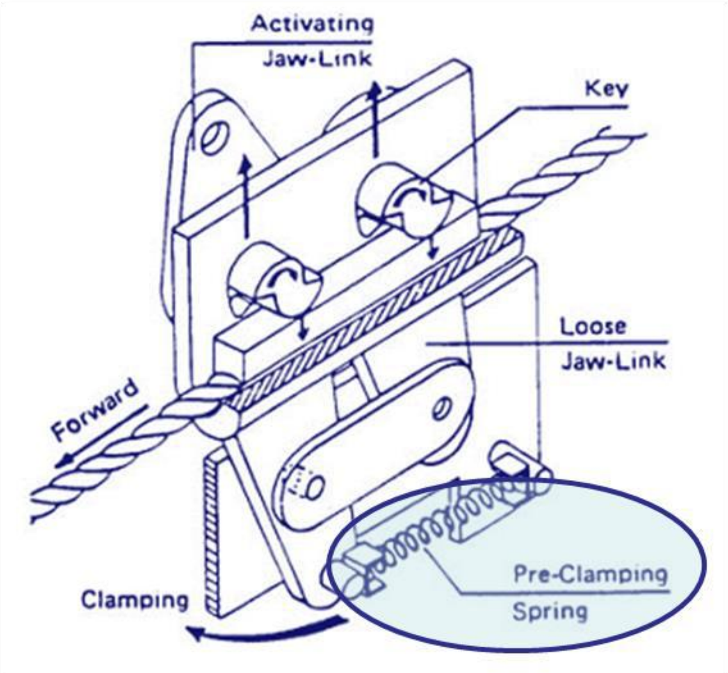
The effort to the rope in a jaw winch is provided by two levers, one forward and one reverse motion. These act via a lever and cam system on keys which command the clamping of the jaws on the rope.

Each set of jaws is made up of a top and bottom jaw which are brought together (clamped), or separated (unclamped), by means of half-moon shaped keys actuated by levers known as jaw links.

When the jaw link is moved clockwise, the jaws are clamped on to the wire rope in order to draw it forward or maintain it in position. When the jaw link is moved in an anti-clockwise direction the jaws are unclamped in order to allow the wire rope to move through, but only in the direction opposed to the motion of the wire rope. This is due to the fact that the jaws are held together by a pre-clamping spring and any effort to pull the wire rope forward when the jaws are unclamped will result in them clamping onto the wire rope.

An illustration of this is shown on the next page.



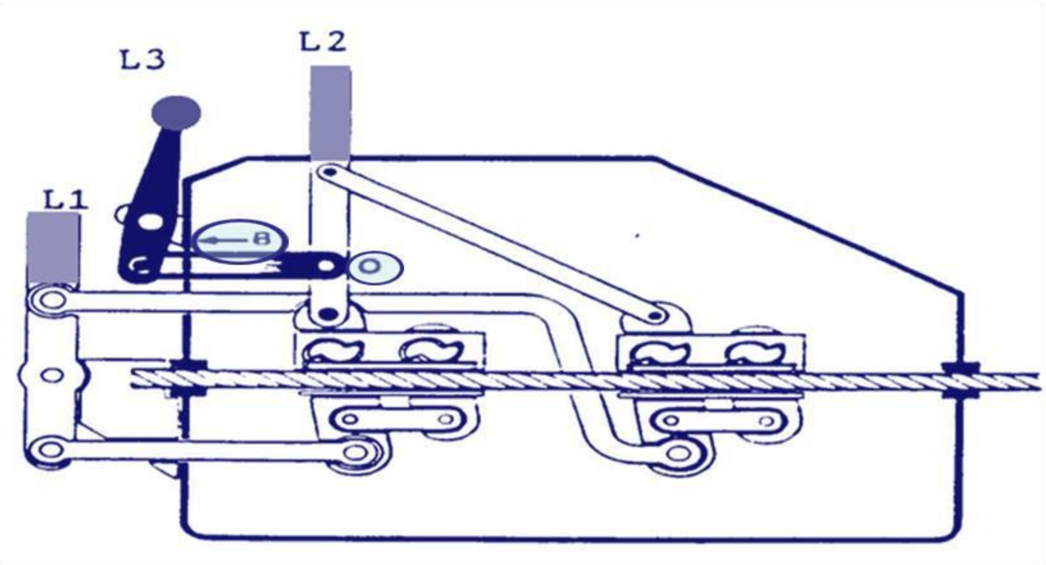



Notes:

## Basic Layout of Main Components

A typical basic layout of the internal mechanism and operating levers of a jaw winch is shown below. A to and fro motion of lever L1 achieves forward motion whilst the other levers are static. In the same way, a to and fro motion of lever L2 obtains reverse motion whilst the other levers are static. To release both sets of jaws so that the rope is free to be removed from the jaw winch, lever L3 is actuated and this pulls on point O via lever B.

The grip is relying on friction which is essential for the operation of the machine. The friction between the wire rope and the jaws prevents the wire rope from slipping. Mechanical advantage is provided by a system of levers.






## Lubrication Requirements

It is important that the linkages operate freely. They should be well packed with a suitable grease.

**Note:** It is impossible to over lubricate the mechanism and the presence of oil and grease will not affect the safe operation of the machine.

**Load Rope**

Although the various manufacturers of jaw winches use slightly different wire rope constructions, they have some important common features which we should note. In order to withstand the crushing effect of the jaw grip and provide the necessary friction, the rope needs to be resilient to crushing.

In order to withstand the crushing effect of the jaws, some manufacturers a load rope that has a wire core.

Other manufacturers use a non-preformed rope.

The number of strands used in any jaw winch rope are also important for its correct operation.



In all cases the rope is of non-standard size, usually slightly larger diameter than a standard rope and this is made to a far tighter tolerance than standard production wire rope.

It is therefore vital to the safe operation that only a rope recommended by the manufacturer is used and that ropes are not exchanged between machines of different manufacture. If the wrong rope is used, it might slip due to insufficient grip, be crushed by the gripping action or jam in the jaws.

Load ropes can be supplied in any length to suit the particular application.

One end is plain tapered and fused to allow entry into the machine and the other end is fitted with a terminal fitting for attachment to the load.

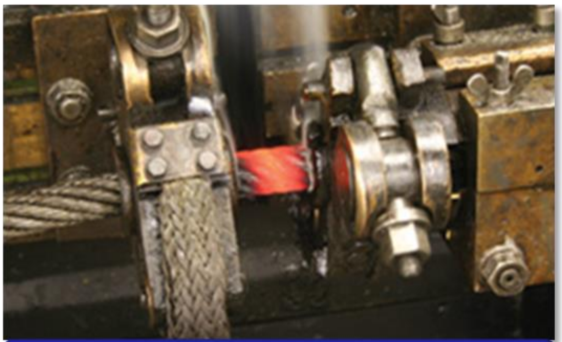
Load Attachment End

Fused and Tapered End

It is important that the rope is kept in good order and inspected by the user regularly as even one broken wire can jam in the jaws causing the rope to birdcage and become stuck in the machine.

## How a Fused and Tapered End is Made

1. Rope Clamped Into Position



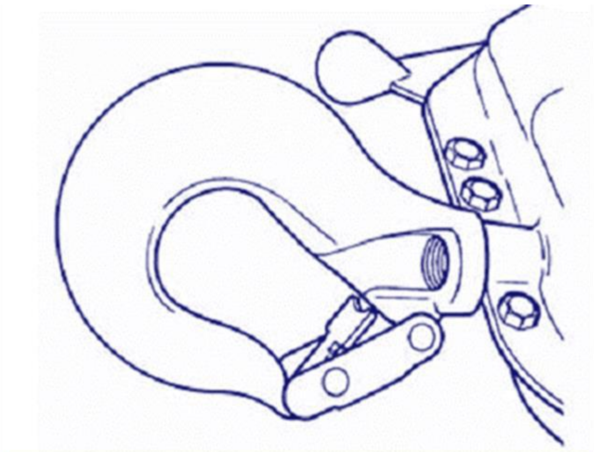
2. Induction Heated

3. Rope Twisted Until it Parts

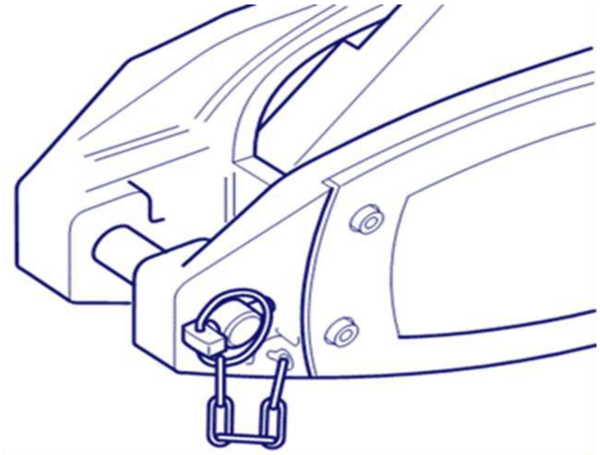
4. Finished Fuse and Taper End



## Types of Machine Anchorage



Machine Hook and Safety Latch



Machine Anchor Pin and Spring Clip

Hooks and anchorage shall be fitted with safety latches or locking devices to prevent unintentional detachment.

## Safety Requirements of BS EN 13157

### Mechanical Strength

BS EN 13157 requires that jaw winches have a factor of safety of at least 4:1 (for lifting). They must be designed to withstand 400 continuous cycles with a load equal to the WLL (for lifting) moved through a distance defined by the rope length, without failure or the need for maintenance or replacement parts, other than lubrication of the rope.

### Brakes

The braking function must be automatic during lifting and lowering motions and must allow controlled descent in all positions. This will be assured if one set of jaws is always gripping the rope throughout the operating sequence and both sets of jaws close when lever operation stops. If one of the sets of jaws fail the motion must stop and the other set of jaws must hold the load.

### Operation

Detachable operating handles must be capable of being secured against accidental disconnection. The maximum effort to lift the rated capacity must not exceed 55daN. The mechanical advantage gained must not allow a load greater than 2.5 times the rated capacity to be lifted when a force of 100daN is applied to the operating lever.



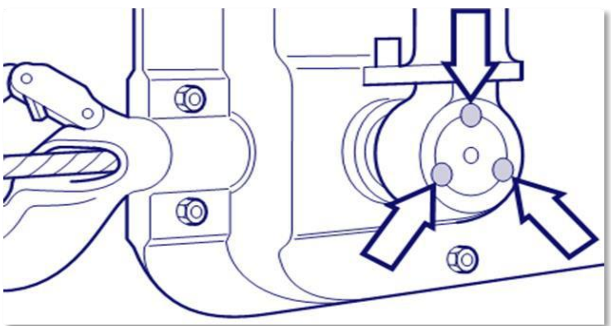
The lifting lever must be fitted with a force limiting device so that the lifting force does not exceed 2 times the rated capacity.
It must only be possible to open both sets of jaws for rope engagement and disengagement under a no load state and it must not be possible to open the jaws unintentionally.

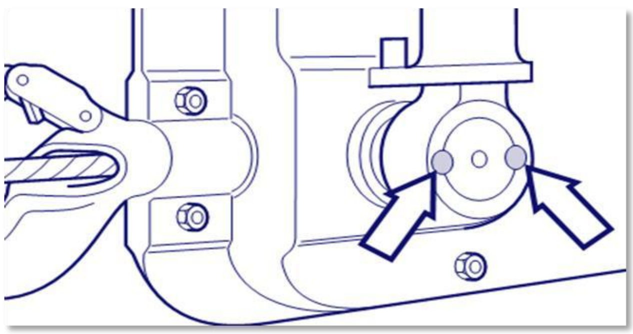
Jaw winches and their components must be capable of operation within the temperature range of -10ºC to +50ºC.

### Shear Pins

In order to limit the lifting force of the lifting lever so that it does not exceed 2 times the rated capacity, shear pins are commonly fitted into the lifting handle.

If the force on the lever is too excessive, the pins (being softer than the handle and operating pinion steel) will simply shear and prevent further drive to the operating pinion.





Although there is an overload shear pin arrangement, this is set at a comparatively high level. The shear pins should only be replaced with those supplied with the machine and substitute components should not be fitted in their place. This will lead to various types of damage, including bent/broken linkages.

**Testing of Hand Operated Lifting Machines**

New hand operated lifting machines are within the scope of the machinery directive 2006/42/EC and EN 13157 Cranes – Safety – Hand Powered Cranes.

Section 4 of annex 1 of the Directive contains the essential health and safety requirements (EHSRs) specific to lifting operations. Clause 4.1.1 defines two tests: static test and dynamic test.

The static test is defined in a way that permits the force to be applied by external means. That is appropriate for lifting accessories but not for lifting machines as it will not test all the teeth of each gear or ratchet wheel nor will it test the ability of the brake to arrest a descending load. Therefore for lifting machines the load should be applied through the machine's own mechanism. The static test for hand operated lifting machines is 1.5 x WLL.

The dynamic test requires the lifting machine to be operated in all possible configurations and this is explained further in EHSR 4.1.2.3. The test should be made at the nominal speeds and combine all movements which the control system allows to be operated simultaneously. For a complex lifting machine such as a mobile crane, that could mean operating the hoist, slewing, derricking and telescoping motions simultaneously. The dynamic test is 1.1 x WLL.



Notes:

**Safe Use of Jaw Winches**

Care must be taken not to overload jaw winches.

Particular care is necessary where two or more machines are being used in tandem to avoid one of the machines taking more than its share of the load.

The operating handle should not be replaced with a longer tube in order to reduce the required effort as this will cause the shear pins to fail and may also lead to overload damage.


The correct wire rope must be used. It must be in good order, free of any bends, kinks or broken wires as this will cause the rope to jam in the machine.



Care should be taken not to drop the jaw winch, e.g. when handling, dismantling or erecting. This can cause damage to the casing which can then catch on the linkages.

**Documents to be supplied by the Manufacturer**

In accordance with relevant legislation and standards, the following documents are to be supplied by the manufacturer for all hand operated chain hoists:

EC declaration of conformity (guidance LEEA 030.1e)

Manufacturer's instructions for use (guidance LEEA SI.21.2)

**Information to be exchanged between the User and Designer/Supplier**

The following is the minimum information which should be exchanged between the user and the designer or supplier of a lifting and pulling machine:

- Intended application, e.g. lifting, tensioning, pulling or man-carrying.
- Total maximum weight of the load to be lifted together with any other forces which may be superimposed on the load
- Frequency of use
- Environmental considerations such as heat or corrosive atmospheres
- Length of rope required
- In the case of hydraulically operated machines, the available power supply

**Marking**

**Marking Requirements**


- CE mark
- Business name and address of the manufacturer
- Identification mark, if any
- Application for which the machine is intended i.e. lifting, pulling, man carrying
- Safe working load (or loads if intended for more than one application)
- The series or type designation
- The size and grade of the ropes
- The marking of the direction of movement
- Year of manufacture

**Note:** If the manufacturer does not provide a unique identification mark, then the owner of the equipment will be responsible for ensuring that the equipment is marked with one.

**Note:** Wire ropes used with lifting and pulling machines are detachable, and providing the correct specification, i.e. diameter and construction, are interchangeable. The following information should therefore be marked on the ferrule or terminal fitting of the wire rope:

- ID mark
- Safe working load
- Rope length

Notes:

## Thorough Examination

The definition of lifting equipment and accessories used in LOLER make it clear that lifting and pulling machines using a gripping action on the wire rope are lifting equipment unless their use is restricted to purely pulling operations.

Unless a written scheme of examination, drawn up by a competent person, is in place and operating they must be examined at intervals not exceeding 12 months (6 months in the case of man-carrying equipment).

Reports of thorough examination should be retained and cross referenced to the machine's historical records for inspection by the competent person or HSE.

Note: As these machines are designed and intended for both lifting and pulling operations, unless a machine is installed in such a way that its use is restricted solely to a pulling operation there is always the possibility that they may be used to lift.

It is therefore the view of LEEA that machines which are, or could be, used for both lifting and pulling operations should be treated as lifting machines and be subject to the full requirements of LOLER.

The general appearance and operation of the jaw winch. A functional test should be made to ensure the smooth operation of the machine, correct operation of the levers and the jaw grip of the rope.

- Any damage to the casing should be assessed, this may cause rubbing on the levers/linkages, hindering the smooth operation
- The operating levers should be free of damage or distortion and the operating lever should fit positively. The operating handle should not be bent or distorted. This is a sign that excessive force has been applied and may indicate internal damage
- The rope release should only operate under a no load condition and should open both sets of jaws, allowing the rope to be easily removed from the machine
- The shear pins should be of the correct type and should not be damaged or distorted as this is a sign of overloading
- The anchor pin should be free of damage and distortion
- The rope guide should be free of wear, burrs or nicks in the bore which might damage the rope
- The jaws should positively grip the rope
- The machine should be clean and free from a build-up of dirt and grease

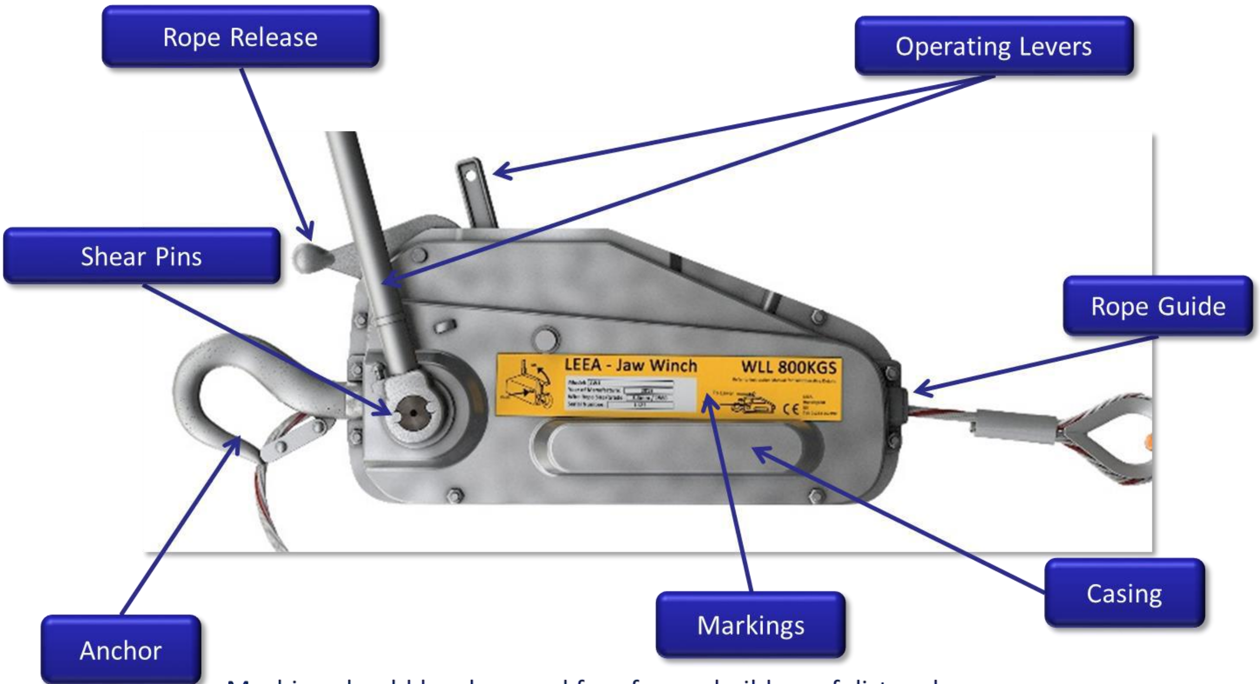
The rope should be examined to ensure it is undamaged. No broken wires should be permitted as these can protrude for the rope and snag between the jaws. This will result in the rope 'bird caging' and jamming in the machine. The tapered and fused end should be in good condition so as to permit the rope to enter the machine freely. Terminal fittings should be free from nicks, cracks, gouges and wear. Hooks should be checked for opening and correct operation of safety catches.

Both the rope and machine should be well lubricated. It is impossible to over lubricate the machine and doing so will not affect the safe operation.

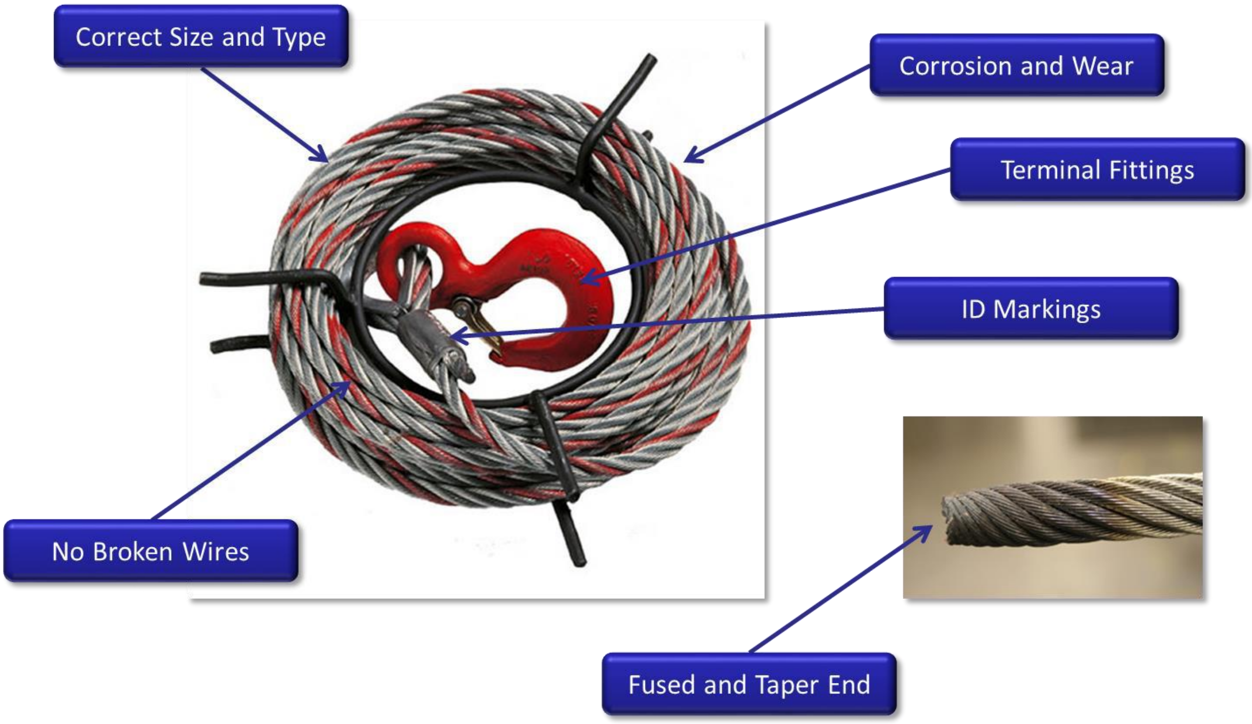
Where necessary the jaw winch should be stripped down (by a suitably trained and competent person), degreased and cleaned to enable a full examination of the following:

- The bearings in the frame
- The linkages, which should be straight and of good form
- The compressive spring should be in good order
- The jaws are free from damage and are unworn






Machine should be clean and free from a build up of dirt and grease.






**Load Testing**

In most cases a proof load test will not reveal anything new as the strength of the jaw winch is already known, and therefore serves no purpose, but will shorten the working life of the unit.

However, if a repair has been made using certified and traceable load bearing components it will be necessary to proof load test the jaw winch. Care is needed to establish the correct proof load to be applied by reference to the manufacturer’s literature. Usually the proof load will be 150% of the WLL, although for jaw winches made strictly to the harmonised standard it will only be 110%.

Note: If a jaw winch is to be repaired it is advised that the manufacturer's certificate is consulted and damaged components are replaced with only those that are identified in the list. The use of equivalent components from other system manufacturers may result in the original declaration of conformity becoming void.

In this case LEEA recommend that following the work the details of the repairs are recorded in maintenance log and the equipment is thoroughly examined by a competent person and also recorded in the report of thorough examination.

Notes:

# 10. HAND OPERATED WINCHES

There is a wide range of manually operated winch designs in use today, from those that are floor, or base, mounted to those that are wall, or column, mounted. For many applications, particularly repetitive or heavy usage, power operated equipment has replaced them. Even so many types of smaller hand operated winches are available on the market today. They are used both for lifting and for pulling, usually in a permanent location, although some are used for temporary applications. They are referred to as drum winches in the current standard, so as to distinguish them from jaw winches.

## Types of Winches

The current harmonised standard for drum winches is BS EN 13157, cranes – safety – hand powered lifting equipment. Clause 5.5 of this standard gives the specific requirements which drum winches must meet.

Vehicle Mounted

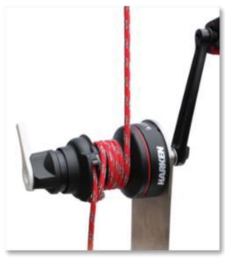
Wall Mounted

Winches are available for use with fibre rope, wire rope or webbing.

Whilst the characteristics of these materials are very different, the basic requirements for the winches are very similar.

It is, however, very important that the correct lifting medium for which the winch is designed is fitted and used with the winch.

**In this module, we will only cover winches using a wire rope.**



## Safety Requirements of BS EN 13157

**Mechanical Strength**

BS EN 13157 requires that jaw winches have a factor of safety of at least 4:1.

They must be designed to withstand 1,500 continuous cycles with a load equal to 110% of the rated capacity, lifted through a path that ensures that every tooth of the gearbox comes under load at least once, with no resting time and without failure or the need for maintenance or replacement parts, other than lubrication or the replacement of the lifting media (wire rope).

**Brakes**

The braking function must be automatic during lifting and lowering motions and must allow controlled descent in all positions.

To enable free spooling of the lifting medium for quick positioning, it may be possible to open the brake when no load is applied. It must not be possible to declutch or disengage the drive to obtain this condition. In such designed systems the brake must automatically engage when a load greater than 30kg is applied in the case of winches up to 1t capacity, or 3% of the rated load for winches over 1t capacity, and the brake must arrest the load in no more than 300mm.

**Operation**

Operating wheels and handles must be secured from accidental disconnection. After a movement of no more than 150mm a pawl or other load retaining device must engage.

The maximum effort to lift the rated capacity must not exceed 25daN on the operating wheel or handle.

Drum winches and their components must be capable of operation within a temperature range of -10°C to +50°C.

**Winch Drums**

The diameter of the drum must be at least 10 times the diameter of the rope it is designed and intended to be fitted with. (10 x D/d)

The flanges of the drum must project at least 1.5 times the rope diameter above the last layer of rope when the maximum designed length of rope is wound onto the drum.

The rope anchorage must be capable of withstanding 2.5 times the nominal force in the rope and a minimum of two turns of rope must remain on the drum at all times.

The winch/rope must be marked to show this condition.

It must not be possible for the rope to wind onto the drum in the wrong direction. This condition can be met if the braking function does not operate in the wrong direction, i.e. is only effective in the direction of lifting.

**Testing of Hand Operated Lifting Machines**

New hand operated lifting machines are within the scope of the Machinery Directive 2006/42/EC and BS EN 13157 Cranes – Safety – Hand Powered Cranes.

Section 4 of annex 1 of the Directive contains the essential health and safety Requirements (EHSRs) specific to lifting operations. Clause 4.1.1 defines two tests: static test and dynamic test.

The static test is defined in a way that permits the force to be applied by external means. That is appropriate for lifting accessories but not for lifting machines as it will not test all the teeth of each gear or ratchet wheel nor will it test the ability of the brake to arrest a descending load. Therefore for lifting machines the load should be applied through the machine's own mechanism. The static test for hand operated lifting machines is 1.5 x WLL.

The dynamic test requires the lifting machine to be operated in all possible configurations and this is explained further in EHSR 4.1.2.3. The test should be made at the nominal speeds and combine all movements which the control system allows to be operated simultaneously. For a complex lifting machine such as a mobile crane, that could mean operating the hoist, slewing, derricking and telescoping motions simultaneously. The dynamic test is 1.1 x WLL.

**Safe Use of Hand Winches**

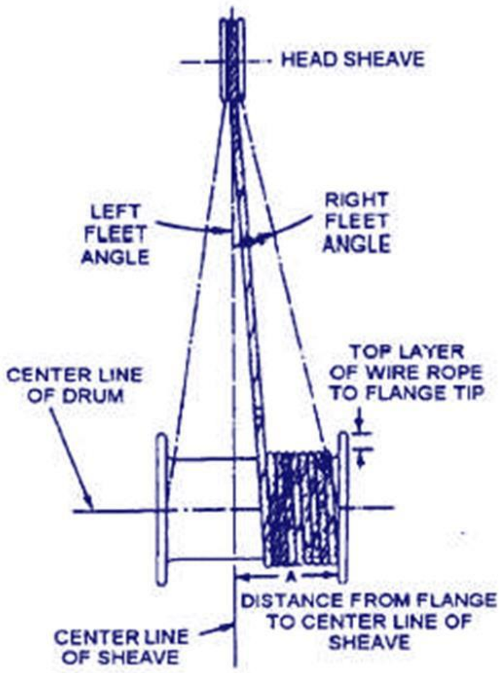
**Sheave Alignment**

Sheaves must be aligned so that the axis of the rope travelling over the sheaves will coincide with a line drawn from centre to centre of sheave grooves.

Poor alignment will result in severe wear on both the rope and the sheave flanges. Even the slightest misalignment accelerates rope wear and shortens rope life.

Poor alignment of the first sheave off the drum may result in poor winding.

A ready indication of poor alignment will be the rapid wear of one flange of the sheave.





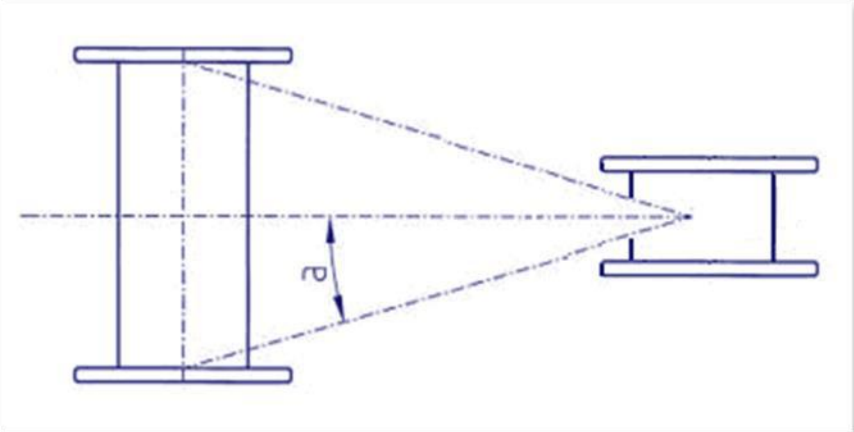

Notes:

**Fleet Angle**

The fleet angle is formed by running wire rope between a sheave and a hoist drum whose axles are parallel to each other (see below).

Too large a fleet angle can cause the wire rope to climb the flange of the sheave and can also cause the wire rope to climb over itself on the hoist drum.

Maximum angle of fleet should be no more than 2.5° for grooved drums and 1.5° for plain drums.




**Note:** The diameter of a sheave should never be less than 20 times the diameter of the wire rope as this will hasten fatigue in the rope.



**Documents to be supplied by the Manufacturer**

In accordance with relevant legislation and standards, the following documents are to be supplied by the manufacturer for all hand operated chain hoists:

- EC declaration of conformity (guidance LEEA 030.1e)
- Manufacturer's instructions for use

**Information to be exchanged between the User and Designer/Supplier**

As winches are frequently used for miscellaneous lifting purposes, precise details of the load to be lifted and rigging arrangement to be used are not always available. In these circumstances, only a general specification can be given and this should include the following information:

- Details of the rigging arrangement in so far as is known, e.g. use of pulley blocks, diverters etc.
- Maximum load to be lifted or line pull required
- Winch mounting details, e.g. wall, floor, built into a structure
- Type of winch, e.g. worm geared, power operated
- Rope drum storage capacity
- Effective and actual length of wire rope required
- Details of wire rope termination, e.g. hook, eye
- Details of any other lifting equipment and accessories required, e.g. pulley blocks, tripod (shear-legs)

- Details of application in so far as is known, e.g. nature of load, duty cycle, whether temporary or permanent installation
- Special service conditions which may affect the winch or its associated equipment, e.g. flammable atmosphere, chemical environment, outdoor use
- Special safety considerations, e.g. positive limits to prevent over-winding, overload protection, use for man-riding applications
- Any special requirements for painting or protective finish
- Any other special requirements

It may subsequently be found that a more detailed exchange of information is necessary to ensure correct selection.

Where the winch is committed to a single purpose use or is a permanent installation, this is not difficult, but similar consideration should be given to units that are to be used for multipurpose or temporary installations.

For all but the simplest installations, a visit by the supplier to survey the site should always be considered as this will minimize the information exchange and reduce the chance of incorrect selection.

**Marking**

**Marking Requirements**

- CE mark
- Identification mark
- Safe working load
- Name of manufacturer or supplier
- Rope drum storage capacity. Where a winch must be fitted with a specific size and/or construction of steel wire rope, this should also be clearly marked on the winch

Further information may also be marked on the winch but in any event should be readily to hand. This will vary with the type of winch but some or all of the following information will be necessary:

- Model or type
- Year of manufacture
- Details of operating handle if this may vary. Number of operatives required for operation at full load
- Direction of rotation of drum when lifting
- The minimum number of dead rope turns which must remain on the drum at all times

**Note:** The wire rope fitted to the winch, together with any permanent attachments made to the rope, must be considered as individual items.

They must therefore carry their own marking in accordance with the individual requirements applicable.

Similarly, any pulley blocks used in association with the winch must also be treated as individual items and marked accordingly.

| Notes: |
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## Thorough Examination

The definition of lifting equipment and accessories used in LOLER make it clear that, when used in a lifting application, winches are lifting equipment. Unless a written scheme of examination, drawn up by a competent person, is in place and operating they must be thoroughly examined by a competent person at intervals not exceeding 12 months (6 months in the case of man-carrying equipment).

Reports of thorough examination should be retained and cross referenced to the machine's historical records for inspection by the competent person or HSE.

For some applications it may also be necessary to have the installation thoroughly examined by a competent person before the winch is put into service.

**Note 1:** As winches are designed and intended for both lifting and pulling operations, unless a winch is installed in such a way that its use is restricted solely to a pulling operation there is always the possibility that they may be used to effect a lift.

It is therefore the view of LEEA that winches which are, or could be, used for both lifting and pulling operations should be treated as lifting machines and be subject to the full requirements of LOLER.

**Note 2:** An important point to remember is that the winch, its associated wire rope, any fittings and pulley blocks used in the rigging assembly will be deemed to be separate items. In this respect, each item must be thoroughly examined to the appropriate requirements and individual records kept in accordance with the requirements of LOLER.

The winch mounting must be secure and in good order, e.g. no missing, loose, damaged or corroded fixing bolts, cracked or crumbling foundation or wall etc. If this condition is not met it will not be possible to carry out any functional or load tests and a visual examination will only be possible for the rest of the winch.



- The general appearance and operation of the winch. A functional test should be made to ensure the smooth operation of the machine:
  - Any damage, distortion or corrosion of the frame or body
  - Damaged or missing guards
  - Damaged rope drum and flanges. Damaged, distorted or loose rope anchorage. Signs that the rope has pulled or slipped in the anchorage, loose, corroded, damaged or missing anchorage bolts or fixings
  - Rope does not feed onto the drum correctly. Insufficient dead turns of rope left on drum when rope is in the required fully extended position. Bent, damaged, distorted or badly fitting operating handle/hand wheel. Operating handle/wheel jumps or jams when turned. Damaged, worn or distorted winding gears or gear shaft
  - Damaged, distorted, corroded or worn pawls or ratchet wheel. Worn, torn, pitted, cracked or contaminated brake lining. Damage, corrosion or contamination of the brake face/plate

- The wire rope and terminations should be included in the examination:
  - Corrosion, any increase or decrease in the rope diameter, which are indicative of internal corrosion
  - Kinks, crushing, flattening, cutting and similar mechanical damage
  - Exposed core, damaged core or opening of the strands. Broken wires
  - Worn, damaged or distorted terminal fittings. Ineffective swivels

**Load Testing**

New installations will usually require a load test to form part of the examination. The type of test and load to be applied will depend on the circumstances and will be a matter for the person making the particular examination. A test at the rated capacity may be sufficient or a full proof load test may be necessary.

In the event of it being considered necessary to make a full proof load test, care will be necessary to establish the correct load to be applied.

Older winches, or winches produced to older standards and specifications may be capable of a proof load of 150% of the WLL, but the mounting structure may only be capable of a proof load of 125% of the WLL, whilst winches designed strictly to the requirements of BS EN 13157 will only be capable of 110% of the WLL.

It is therefore essential that the correct load to be applied is established, by reference to the manufacturer's instructions, prior to any overload being applied.

During a load test the following additional points must be considered:

- The load will not lift
- If the winch or its fixings distort under load
- The load slips when lifting or does not hold when the motion ceases
- When lowering the load continues to travel after the brake is applied or the load descends faster than the expected controlled speed



Notes:

# 11. TRAVELLING TROLLEYS

Beam (girder) trolleys are generally used as a means of moving a load suspended on a rolled steel structural section in conjunction with a hand or power operated lifting appliance. They are therefore commonly used on runways, jib cranes, mobile gantries and overhead travelling cranes.

No specific training is given in respect of power operated trolleys in this section of the course as it is more usual for them to be 'combined' with their associated block and treated as a part of that machine, therefore these will be covered in the Powered Lifting Machines Advanced Programme.

Until the publication of BS EN 13157: 2004 – cranes – safety – hand powered lifting equipment, which covers manually operated girder trolleys, there was no British standard dealing specifically with girder trolleys, which were produced to the various manufacturers own specifications.

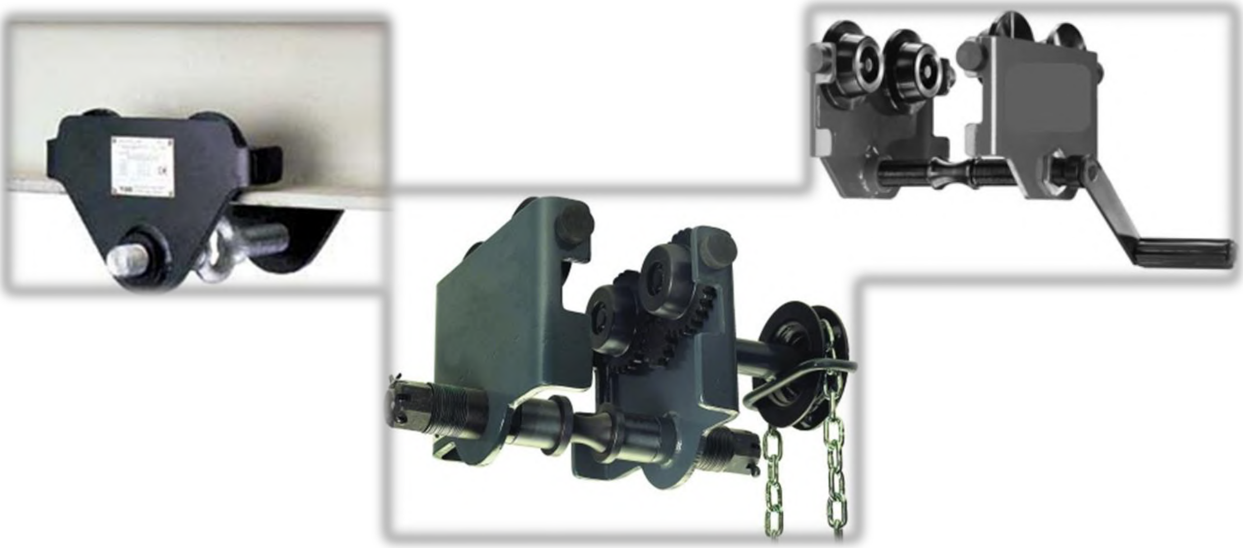


The examiner should be familiar with the various structures on which trolleys may be found and with which they must be compatible. This is covered in detail in the **Runways and Crane Structures Advanced Programme.**

# Types of Trolley

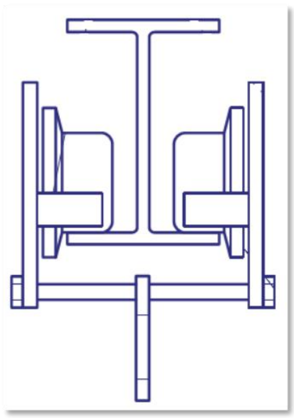
Most trolleys run on the bottom flange of the track.

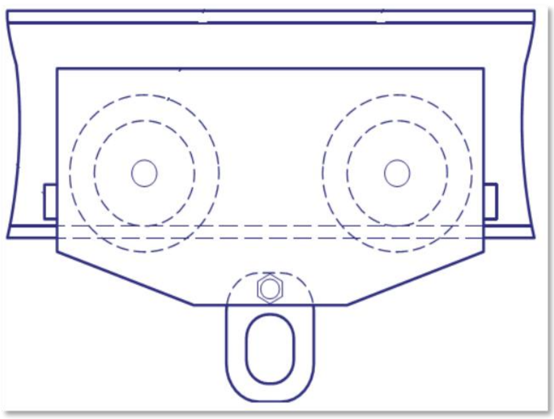
Some are designed to run on top of the track and others are captive within special track sections.



### The Push Travel Trolley

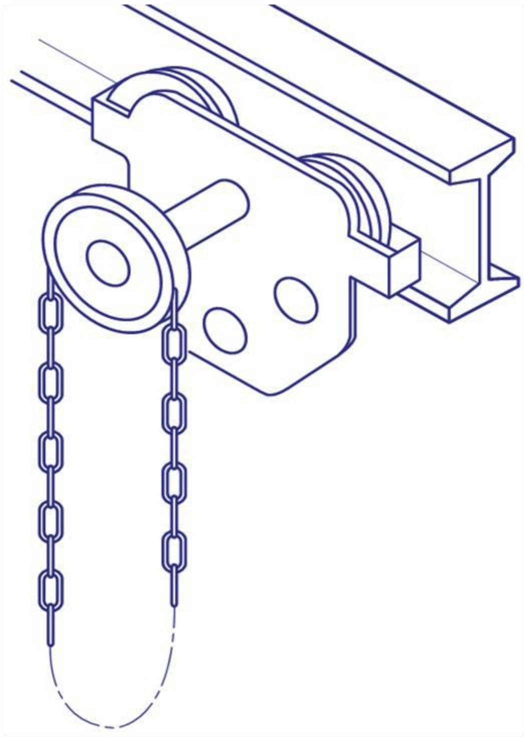
The push travel (hand powered) trolley facilitates horizontal travel by pushing or pulling manually on the load.





Notes:

**The Geared Travel Trolley**



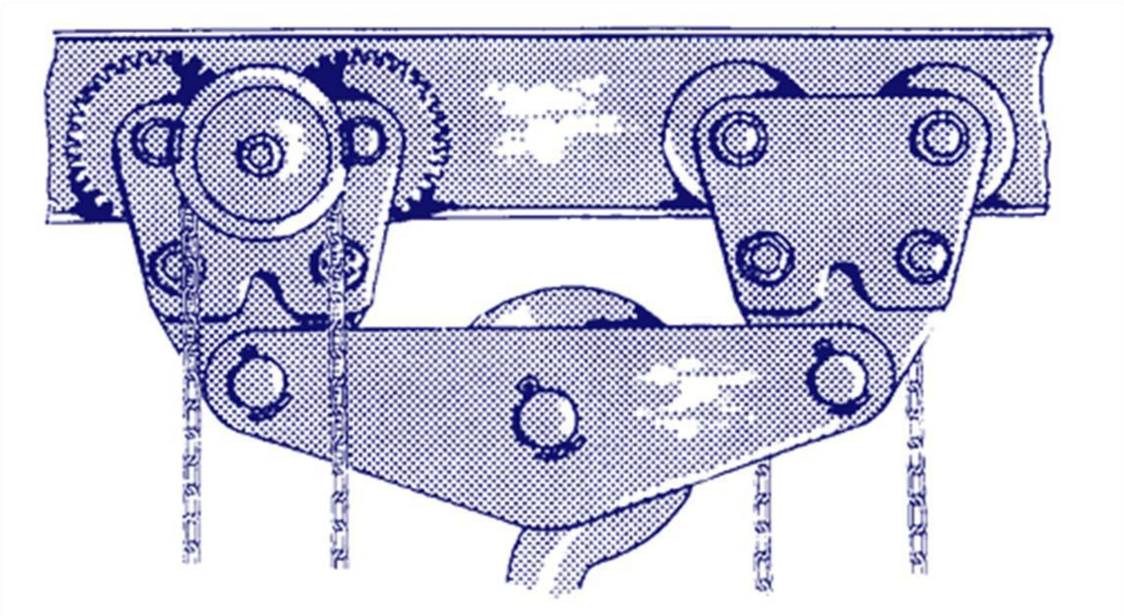
The hand powered trolley facilitates horizontal travel, driven by a hand wheel which is operated by an operating chain.

The most common types of trolley have a four wheel arrangement, i.e. two pairs.

Two wheel trolleys are available for certain applications and are usually associated with lighter loads.

In certain cases two or more two wheel or four wheel trolleys may be connected together by a purpose made load bar to provide for a greater working load limit.

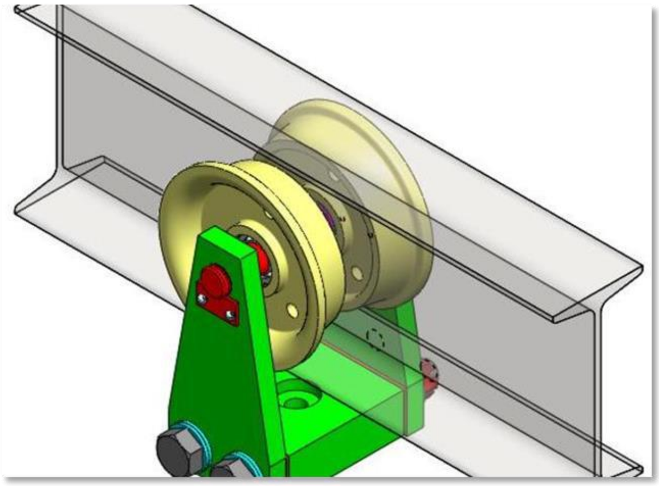




Multi-Wheel Trolley for High Capacity Applications

**The Articulated Trolley**

Articulated trolleys are also available. These have four or more wheels and are designed so that each pair or set of wheels is free to pivot relative to the others in plan. This allows the trolley to travel around radiuses in runway beams.



2 Wheeled Trolley

Difficulty may be experienced in negotiating small radius bends (typically less than 2 or 3 metres).

Manufacturers state recommendations on the minimum radius bend their equipment can negotiate. Articulated trolleys will negotiate smaller radii than rigid trolleys with the same wheel centres.

A two wheel trolley will negotiate any radius of curve that can be practically manufactured on a runway beam provided the wheel flanges do not foul the beam flange on the inside of the curve.



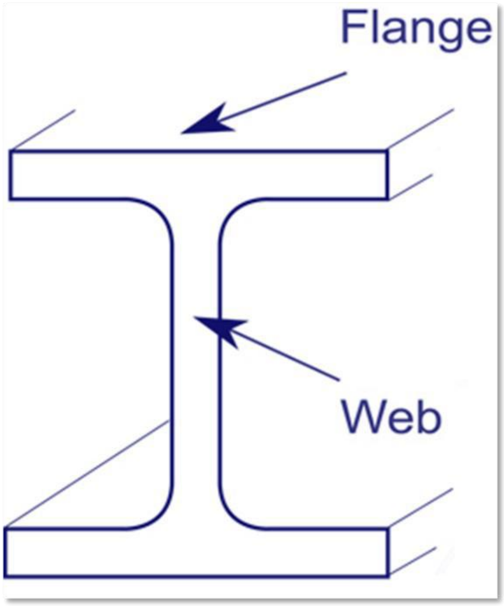
**The Demountable Trolley**

Combined hoist and trolley appliances are usually used in permanent applications.

Similarly plain trolleys are more commonly used in applications where they will be left in place on the beam, even if the lifting appliance is removed after use.

Another design variation of the rigid trolley is available for use in temporary applications, this is known as the demountable trolley and is suitable for use where the trolley has to be frequently moved from one runway beam to another.

**Definitions of a Runway Beam Section (for Illustrative Guidance Only)**



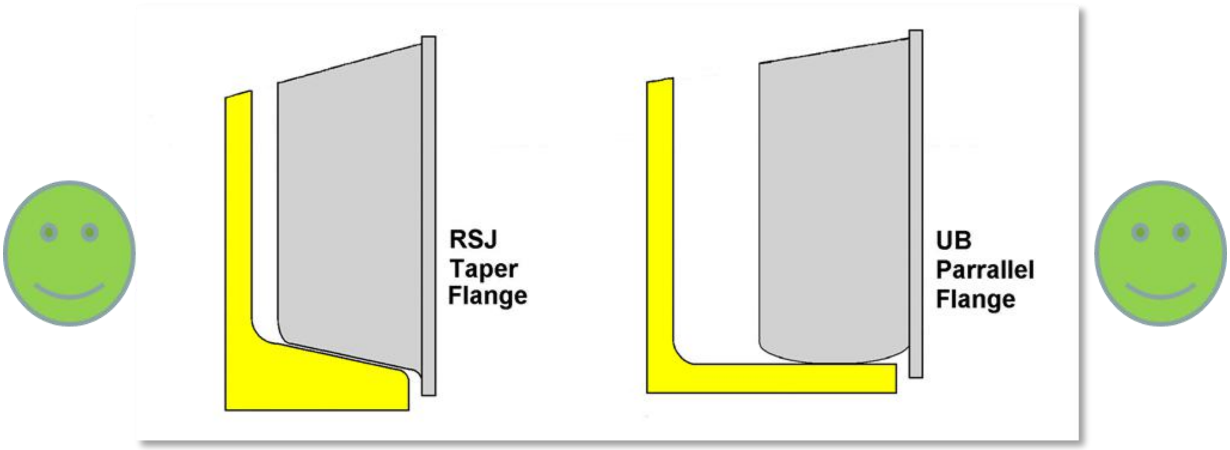

## Trolley Wheels

**Wheel Profiles and Runways**

Rolled steel joist (RSJ) had a tapered flange and trolleys were fitted with tapered wheel treads to suit this, giving contact with the runway flange across the full width of the wheel tread.

Standard rolled steel sections e.g. **universal beam (UB) and universal column (UC)** have parallel flanges.

Modern trolley wheels have a 'universal' wheel tread which is curved in profile to allow them to be used on all three of the rolled steel sections.

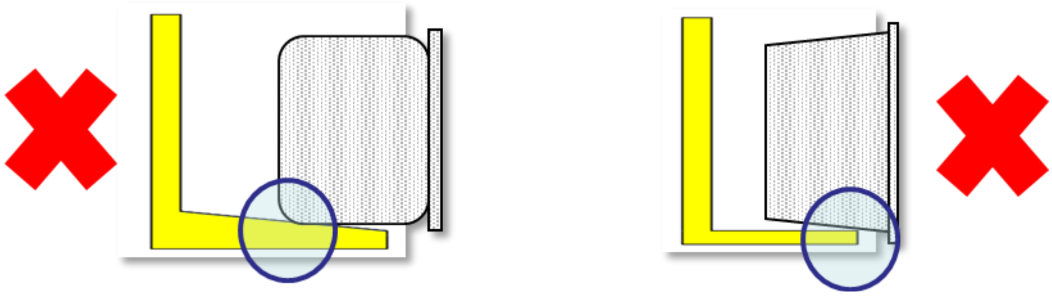



A trolley with tapered wheels for RSJ must never be fitted to a runway of UB or UC section, because:

- The wheels would only make a point contact with the edge of the beam flange causing rapid wear
- This would also increase the transverse stress in the flange, producing a bending effect, overloading the flange and causing it to turn down

A trolley with parallel tread wheels must not be fitted to an RSJ runway because:

- The wheels would lead to a point contact between the point of the wheel and the beam flange
- Application of a load would produce bending in the wheel axles and/or the trolley side plates and also lead to a groove being worn in the flange of the track



Notes:

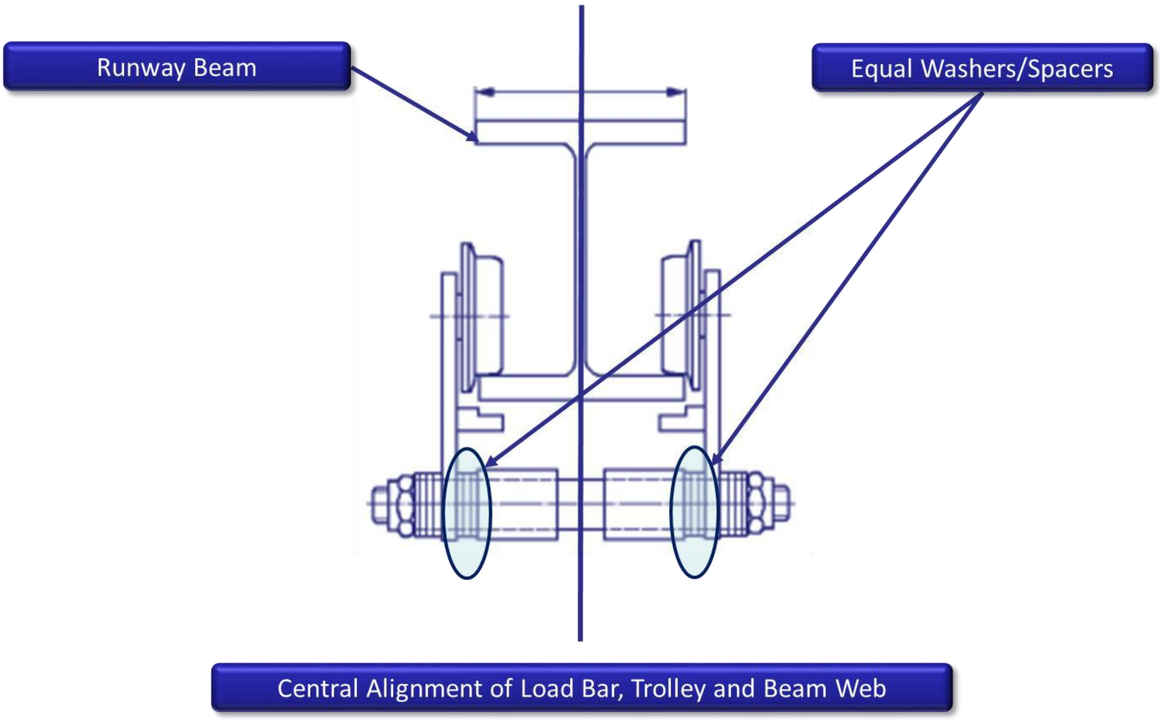


## Trolley Alignment

### Adjustment

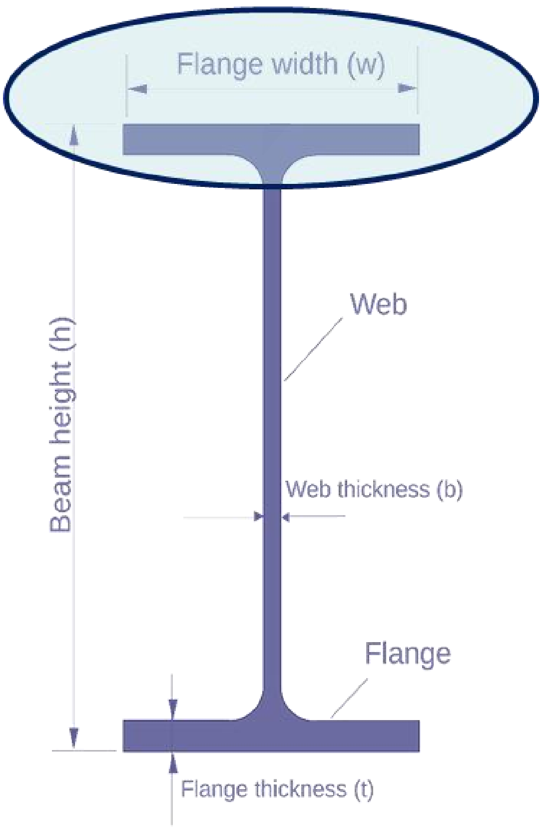
There are several different methods of adjusting the trolley to suit the width of girder flange on which they are to run and some are made to a fixed width. Attention must however be paid to the following points in all cases:

- The load suspension point must always be central to the beam web and trolley frame
- Spacer bars and washers is one common method of setting the beam width
    - The correct number and size of spacers must be placed each side of the load suspension point
- Another method of adjustment is the use of a load bar which is threaded left and right hand into the side plates.
- Caution is needed to ensure that one side plate has not been turned on the screw more than the other making the trolley and suspension point off centre to the beam web




## Beam Flange Width

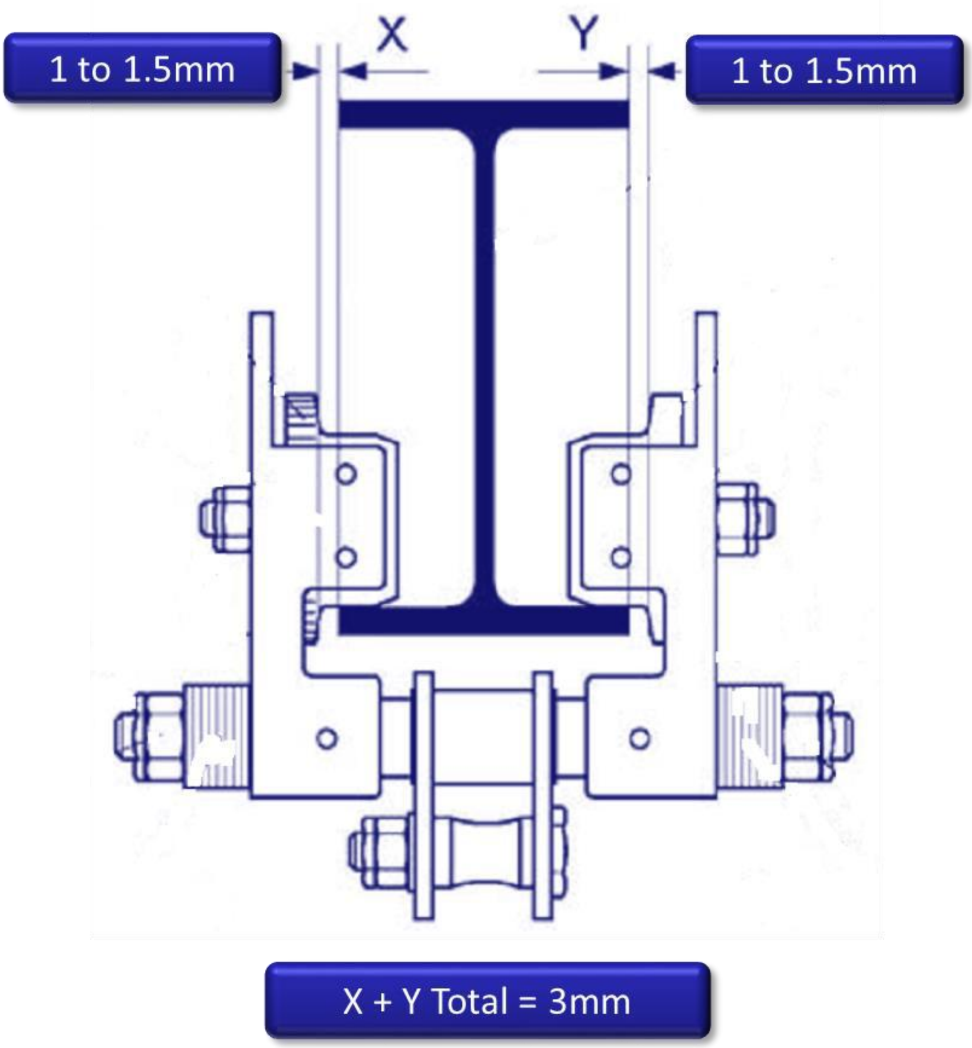
Trolleys are available to suit a wide range of beam flange widths. Most modern trolleys are designed to suit a limited range of sizes and must be set to suit the specific beam onto which they are to be mounted. Some types, particularly older trolleys and those for special applications, may be suitable for mounting on one width of beam only.



## Trolley to Beam Clearance

Trolleys fitted to runway beams should have a suitable and sufficient clearance between the wheel flanges and the edge of the flange of the beam itself, this is to allow the trolley to move freely without rubbing against the beam flanges which would also cause wear and damage to components over time. It may also hider the smooth movement of loads along the length of the runway beam.

In all cases, the original equipment manufacturers instructions should be consulted for the measurement of this clearance gap. In the absence of such instructions, a gap of 2-3mm (1 to 1.5mm each side) should be suitable and sufficient.






Notes:

# Safety Requirements of BS EN 13157

### Mechanical Strength

BS EN 13157 requires push travel and hand geared travel trolleys to have a factor of safety of at least 4:1 when the load is at 5° to the vertical.

### Brakes

If there is a risk the trolley might move by itself due to the longitudinal slope of the runway it must be fitted with a brake.

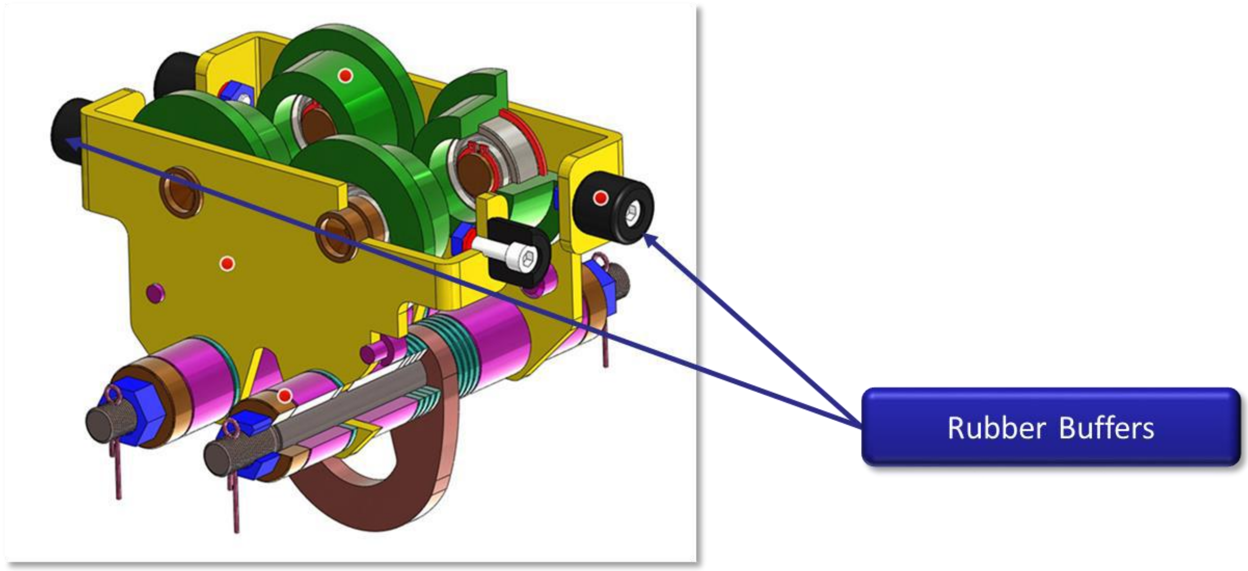
### Operation

Hand geared trolleys: the hand chain must be fitted in such a way that it cannot become unintentionally disengaged from the chain wheel.

### Buffers

Trolleys must be fitted with buffer stops to soften the impact of the trolley side plates with the runway beam end stops. (In practice this is rarely found)



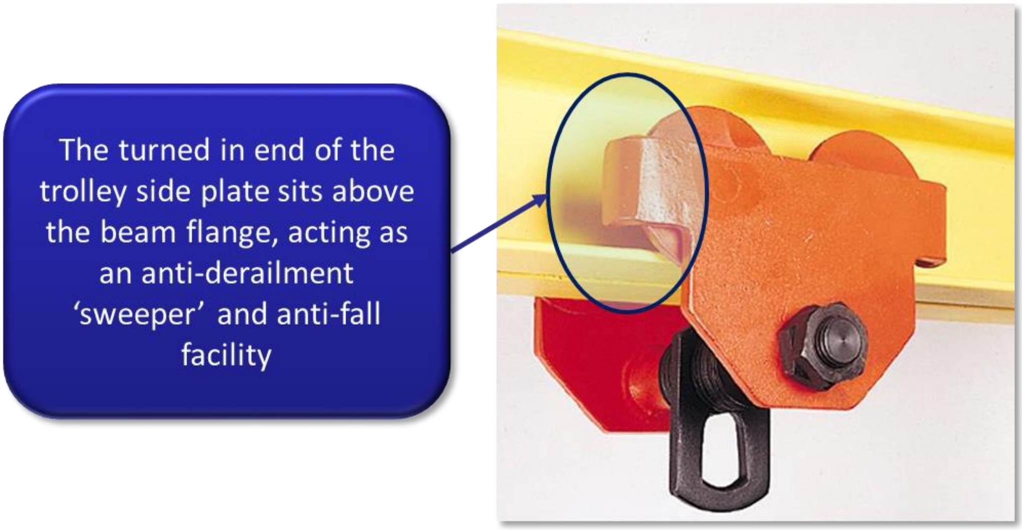



### Anti-Derailment

A trolley must be fitted to prevent derailment, features such as guide rollers, slide bar or flanged trolley wheels.

## Anti-Fall

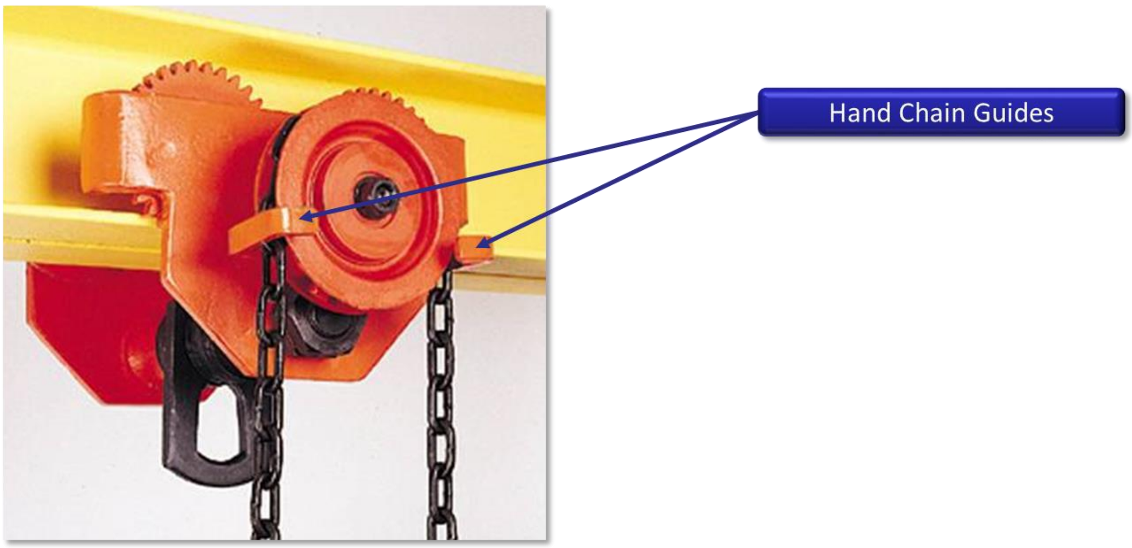
A trolley must be fitted with anti-fall devices so that in the event of a wheel or axle failure the trolley remains on the track.




## Operation

All hand chains are to be prevented from disengaging with the hand chain wheel. This is usually facilitated by the fitting of 'hand chain guides'.






## Temperature

Trolleys and their components shall be capable of operating within an ambient temperature range of - 10°C to + 50°C unless another temperature range is agreed between the manufacturer and the purchaser.

**Safety Devices**

If there is a braking system, it shall only be able to be removed, modified, replaced, interfered or neutralised by the use of tools.

**Wheels**

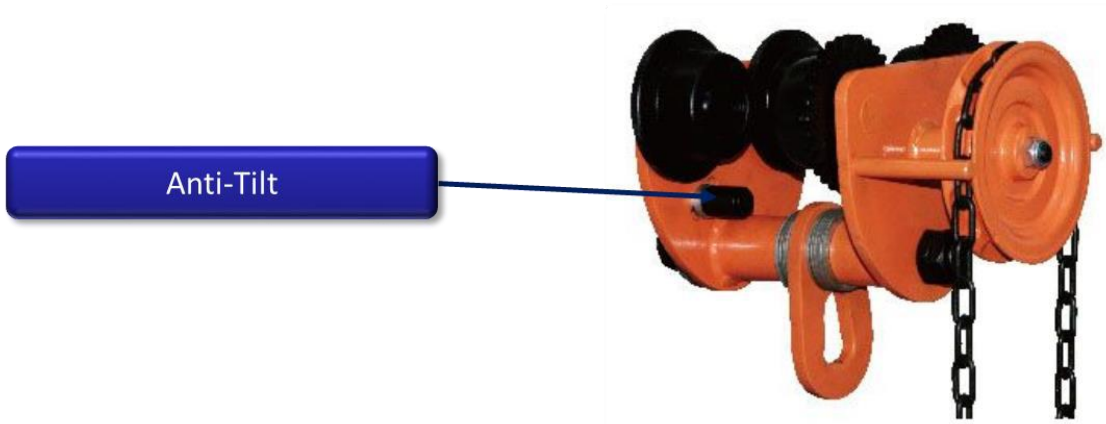
If the trolley is not fitted with guide rollers then the wheels shall be fitted with a device, such as wheel flanges, to prevent any derailment or overturning.

**Anti-Tilt**

An anti-tilt device is an adjustable roller or similar device fitted to a gear operated trolley.

This operates against the underside of the bottom flange of the runway to prevent the trolley tilting when the hand chain is operated.

Certain manufacturers also fit similar devices to hand pushed trolleys






**Marking**

BS EN 13157 requires trolleys to be fitted with a permanent identification plate in a clearly visible position. This must give the following minimum information for trolleys:

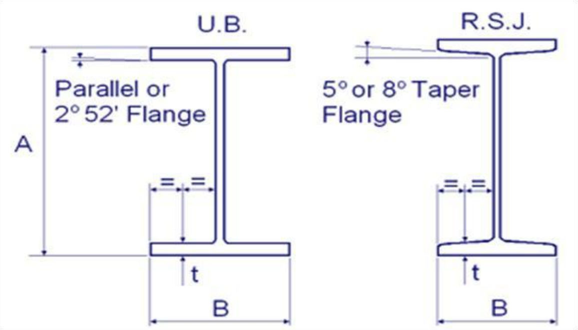
- CE mark
- Business name and address of the manufacturer
- Series or type designation
- Identification number/mark
- Safe working load
- Year of manufacture
- Indication as to whether it is suitable for use with hand or power operated hoists
- The range of beam sizes the trolley is designed to fit

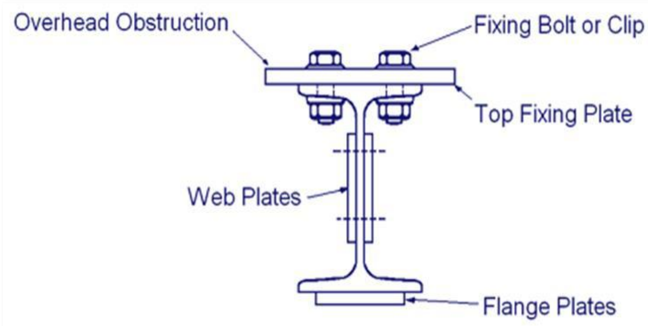
Notes:

**Information to be exchanged between the User and Designer/Supplier**

As travelling trolleys are frequently used for miscellaneous lifting applications, precise details of the load to be carried are not always available. In these circumstances, only a general specification can be given and this should include the following:

- Type of trolley required
- Details of the runway beam section to which the trolley is to be fitted. These details must be sufficient to fully identify the particular rolled steel section or in the case of a fabricated section, the various elements from which it is manufactured. In addition, details of fixing bolts, clips, splices etc. are required to ensure that they will not foul the load bar, trolley wheels or device where fitted




Indicate whether: universal beam (UB), rolled steel joist (RSJ), rolled steel channel (RSC), etc. Also indicate end stops, joint plates etc.



- Details of the supporting structure of the runway including clearance dimensions to other structures or items of plant to ensure that there will be no external obstruction to the operation of the trolley and lifting appliance
- The total maximum weight to be lifted
- The type (including whether manual or power operated) and class of use of lifting appliance to be used with the trolley
- Details of the load bar or suspension point of the trolley and the attachment point of the lifting appliance(s) to be fitted
- If a geared trolley is specified, then the suspension and operating levels are required so that the length of hand chain may be determined
- The minimum radius curve, if any, of the runway
- Environmental considerations such as extremes of temperature or corrosive atmospheres

**Documentation**

**Note:** Although not required by legislation, new trolleys will usually be issued with a manufacturer's record of proof load testing in addition to, although possibly combined with, the EC declaration of conformity.

This document forms an important part of the record of the trolley.

It should be retained and cross referenced to the trolleys historical records for inspection by the competent person or HSE.

## Thorough Examination

The definition of lifting equipment and accessories used in LOLER make it clear that trolleys are considered as part of the lifting appliance that they support.

Unless a written scheme of examination, drawn up by a competent person, is in place and operating they must be thoroughly examined at intervals not exceeding 12 months.

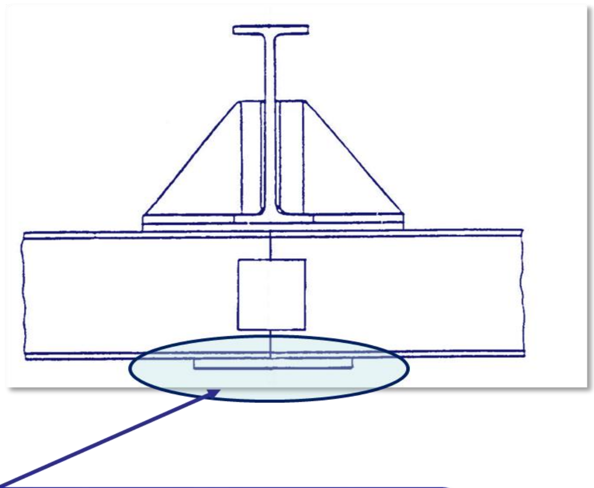
Reports of thorough examination should be retained and cross referenced to the trolley's historical records for inspection by the competent person or HSE.

During the examination the following should be checked:

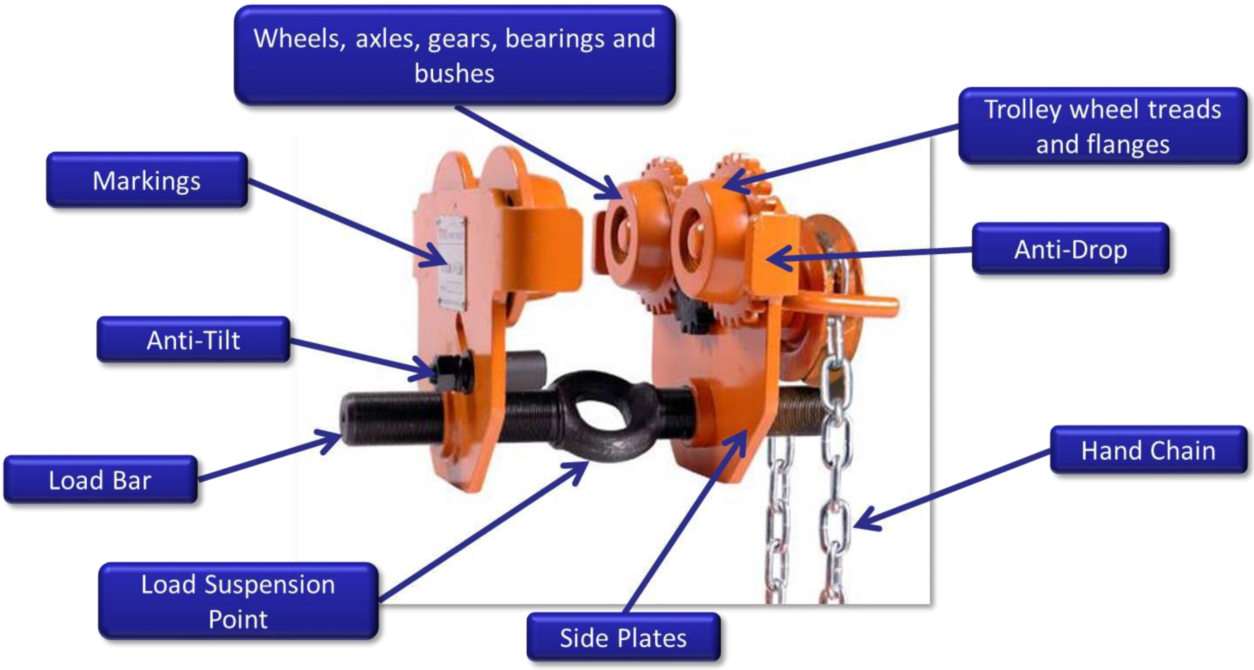
- Missing or illegible markings
- General appearance of the trolley, free-running of the wheels and gears etc., condition of the wheels, pinions and gears
- Hand geared trolley - check the operation of the chain drive system and ensure that it has good engagement of the hand chain with the hand chain wheel. Check the hand chain guides are present to prevent the hand chain becoming disengaged with the hand chain wheel
- Check for wear on the trolley wheel treads, particularly if flat spots have become apparent on the tread. Also check for chipped, cracked or worn wheel flanges
- Check lubrication in the bearings. In the case of plain bearings a check must also be made for wear in the bearing and on the axle pin
- Insecurity of the wheels and axle pins
- Distortion of the side plates. Cracked or defective welding. Loose or missing nuts and bolts
- Wear to the load suspension point; bent or distorted load bar; damaged threads
- Condition of anti-tilt devices, drop stops and buffers
- In the case of hand geared travel trolleys, the condition of the hand chain should be checked, bearing in mind possible damage to operators hands
- Cracked or defective welds

**Trolleys (mounted to a runway beam and in operation)**

- Incorrect size of trolley for the runway beam.
- Incorrectly adjusted trolley width for wheel flange to beam flange clearance
- Hoist fitted incorrectly or insecurely
- Anti-tilt adjusted incorrectly or catching on runway splice plates



This splice plate (used to stiffen the flanges at the joining section) could interfere with the anti-tilt mechanism on the trolley




## Action Following Repairs

141 Following repair, trolleys must be re-verified by a competent person.

The report of the verification should be retained and cross referenced to the equipment's historical records for inspection by the competent person or HSE.

Notes:

# 12. MECHANICAL AND HYDRAULIC JACKS

**Mechanical Jacks**

Jacks are widely used in industry where loads need to be raised or lowered a limited distance.

They are often used to afford access for other means of handling or lifting equipment and for levelling purposes.

Their versatility of use and portability make them ideal for many maintenance functions. It is due to this that, in the past, they have generally been incorrectly considered to be a tool rather than a lifting appliance.

Jacks are either hydraulically or mechanically motivated by manual or power systems.

The range of designs, sizes and capacities is almost limitless and many manufacturers produce as standard jacks designed for a specific function, e.g. re-railing locomotives.

BS EN 1494: 2000 + A1: 2008 - Mobile or movable jacks and associated lifting equipment, covers a wide range of jacks for various applications. The range includes hydraulically-operated, pneumatically operated, electrically-operated and manually-operated jacks and jacks for road vehicles.

Prior to this standard there was no British standard for general purpose jacks and, as a result, most manufacturers produce a range of jacks to their own specifications.

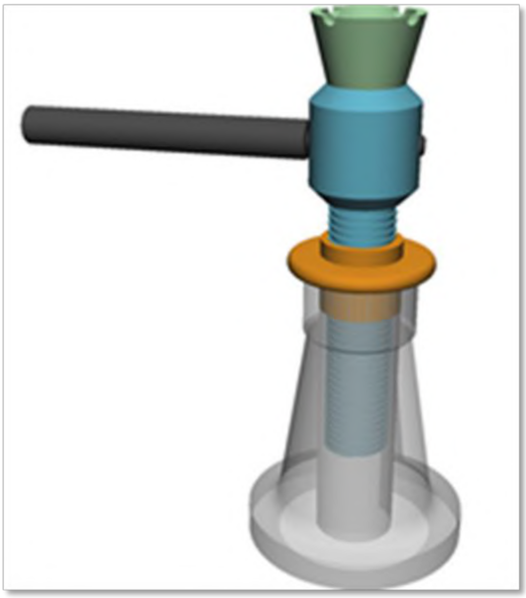
Hydraulic cylinders (rams), with independent pumps connected by hoses, are often used in jacking applications. Although no specific guidance is given, the principles set out in this section of the code may be equally applied to certain cylinders when they are used for jacking purposes.



This course module covers manually operated hydraulic or mechanical jacks for supporting a load on the head or toe of the jack to raise or lower the load in a vertical path.

## Types of Mechanical Jacks

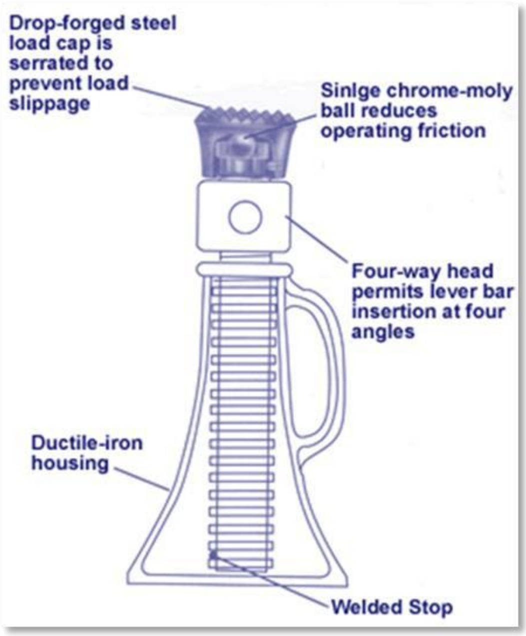
**The Screw Jack**
A screw jack is a mechanical device that can increase the magnitude of an effort force.



The jack comprises a hollow body, usually cast iron or cast steel, with a female thread at the top, into which a screw fits.

A large acme or square thread form is used as this is strong in compression and resists stripping. It also offers a large 'land' area so that the effects of wear are minimised.

As the efficiency is less than 50% the screw remains in the position it is placed, whether under load or not.




The top of the screw has a large head which is cross drilled and a tommy bar is fitted through this to enable the screw to be turned directly by the operator.

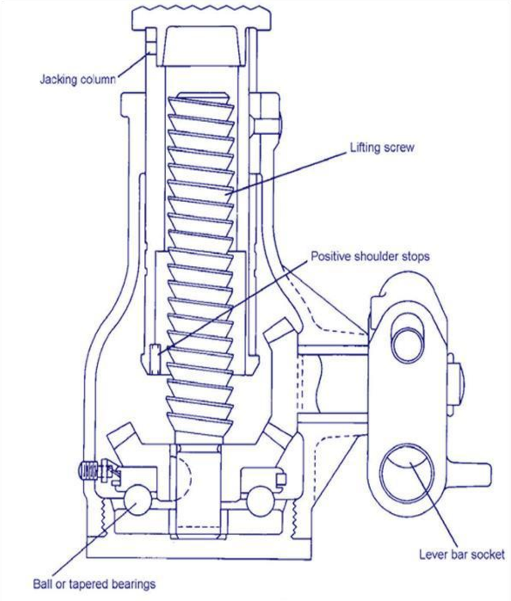
The head of the screw is then fitted with a swivel bearing.

Another common type of screw jack is the **'trailer jack'** which is used as parking jacks on mobile gantries.

Notes:

## The Journal Jack

The journal jack also uses a screw thread form to gain lift and obtain the load sustaining feature necessary. The illustration opposite shows a cross section through a typical journal jack.




A ratchet handle is used to turn a pair of bevel gears, which in turn cause the screw to rotate. The jacking column, or lifting journal, has a female thread in its base into which the screw is fitted, thus providing the lifting/lowering motion.

The thread form used in this case is a buttress thread. Buttress threads are designed to resist heavy axial loads in one direction making them ideal for jacking operations.

This arrangement gives fast, but very controlled, lifting so enabling precise load positioning and levelling.

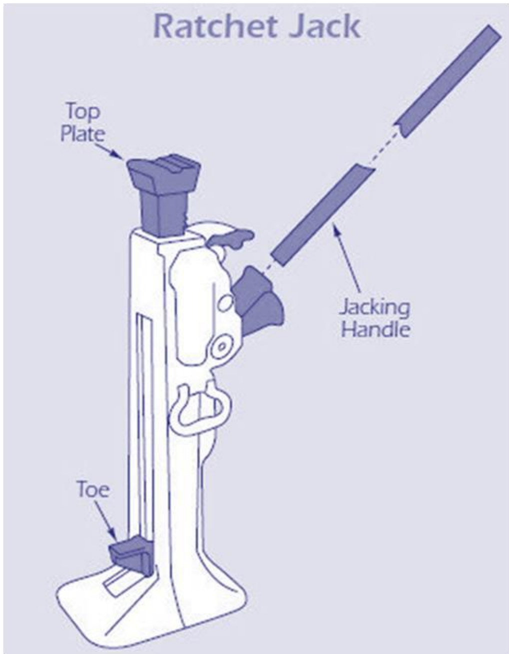


## The Ratchet Jack

The ratchet jack utilises the lever and fulcrum principle to raise and lower the load, via a rack and pawl mechanism. However, it requires great physical effort to lift the rated capacity although lowering the load is somewhat easier. For this reason they are often referred to as lowering jacks.

They have the advantage of faster operation than screw jacks.

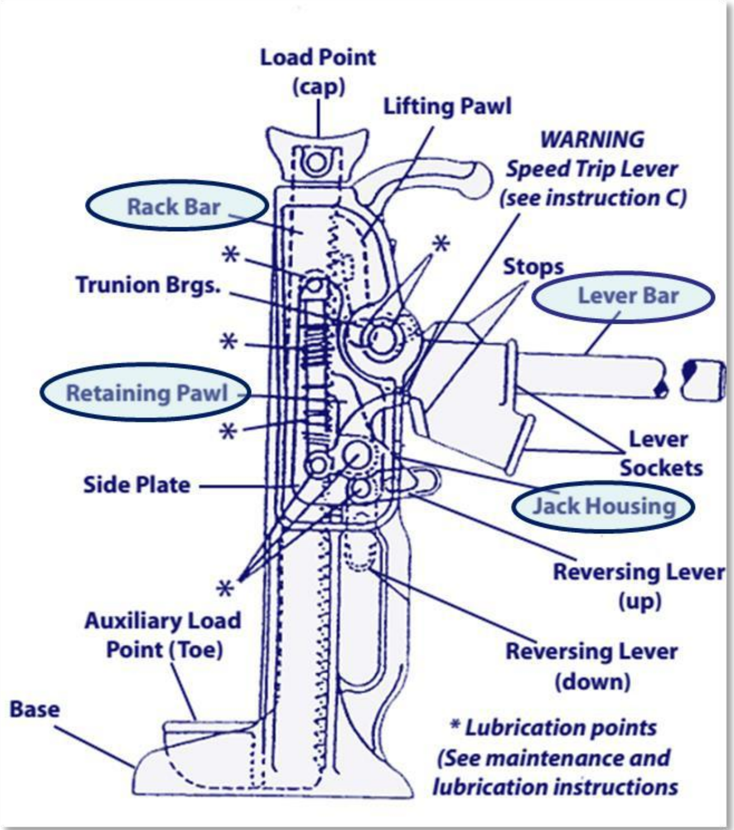
A toe on the lifting rack enables them to be placed under much lower items than with screw jacks, although the load that can be taken on the toe is only 25% of that that may be taken on the head of the jack.



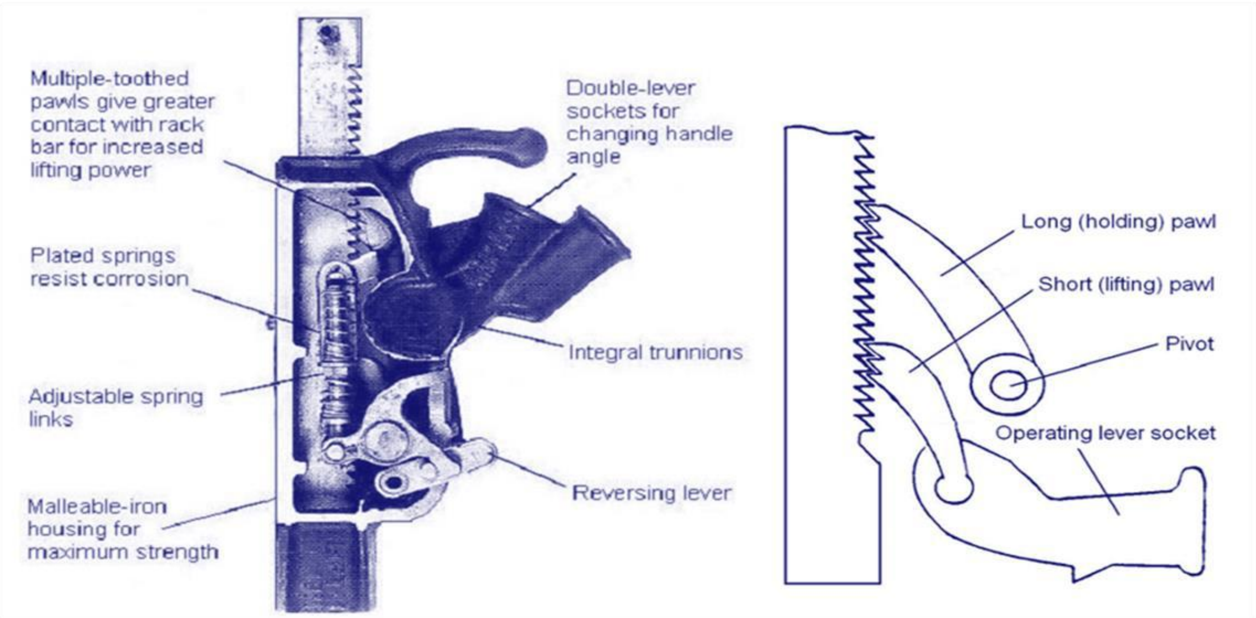
**Ratchet Jack Principle of Operation**

A ratchet jack comprises 4 basic parts:

1) The body/jack housing holding together the working parts and supporting the load bearing rack/rack bar
2) The rack/rack bar, which is the moving part that supports the load on its head
3) The operating lever/bar, which is linked to the lifting pawl
4) The holding/retaining pawl




The operating lever is linked to a short pawl, the lifting pawl, that engages with the rack and lifts it a single tooth at a time. A long pawl, holding pawl, also engages with the rack. This holds the rack in position sustaining the load whilst the lifting pawl is moving to another tooth.



- A downward effort on the lever exerts pressure on both pawls, keeping them in contact with the rack
- As the short (lifting) pawl lifts the load, the holding pawl rides over the teeth in the rack
- The lifting pawl is held firmly in place by the weight of the load acting downward on the rack
- At the end of the stroke the long pawl engages the teeth of the rack and holds the load
- The holding pawl is kept firmly in place by the downward force of the load
- Whilst this is happening the short pawl travels downward for another bite on the rack
- This process continues with every stroke of the lever until the required height is achieved

When the mechanism is placed in the downward position, effort on the lever allows the short pawl to carry the load while the long pawl is kept out of the way.

As the rack approaches the lower limit of each lever operation the mechanism pulls the long pawl forward to engage in the teeth of the rack.

This in turn holds the load whilst the short pawl travels upward to take the next bite.



## Safety Requirements of BS EN 1494

### General

Mechanical jacks must be designed to sustain the load with steps taken to avoid unintentional descent. The failure of springs must not lead to the release of the load.
The head of the jack or face of the toe must be designed to counteract any tendency of the load to slip off.

### Mechanical Strength

BS EN 1494 requires that mechanically operated jacks must be capable of withstanding a load of at least 150% of the rated capacity without deformation of any part. The materials used must be such that they will give an adequate fatigue life for the required duty cycle.

### Operation

The maximum effort necessary by each operative to start moving a load must not exceed 400N and 300N to maintain its movement.
Mechanical jacks must be designed to operate within the temperature range of -20ºC to +50ºC.

## Documentation

Documents to be supplied in accordance with the relevant legislation and relevant standard:

- EC declaration of conformity (guidance LEEA 030.1e )
- Manufacturer's instructions for use (guidance LEEA SI.21.2)

## Markings

- CE mark
- Business name and address of the manufacturer
- Design of series or type
- Product code and designation of the machinery
- Serial number or batch code

**Note:** If manufacturer only provides a batch code, then the owner of the equipment will be responsible for ensuring that the equipment is marked with a unique identification.

- Year of construction
- Rated load or loads if dependent on configuration.
- All necessary hydraulic, pneumatic or electrical information if an external hydraulic, pneumatic or electrical power supply is used
- Hint on residual risks



## Information to be exchanged between the User and Designer/Supplier

Jacks are readily available in a wide range of designs, sizes and capacities, some including special features making them suitable for certain applications.

The exchange of information should therefore be as detailed as possible. As by their nature jacks are often moved from site to site and used to handle a wide variety of loads, precise details are not always available and in these cases only a general specification can be given. In many cases, the requirements will be basic and the information easily exchanged. In all other cases the following minimum information should be exchanged:

- Capacity. Where possible, full details of the load to be lifted, including dimensions, weight and details of jacking points
- Type of jack, i.e. hydraulic, ratchet, screw or journal
- Details of working dimensions e.g. closed height, extended height, size of head of jack, height and size of toe etc.
- Details of the intended use, including utilisation and required accuracy of load placement. Where the jack is required for general purpose use, it may be necessary to impose limits on the use. The manufacturer's instructions should therefore be sought and their recommendations followed
- Environmental conditions, e.g. outdoor or indoor use, use in corrosive atmospheres, use in hazardous areas, use with dangerous loads etc.
- Details of finish, including any special paint or protective finish
- Any special features or optional fittings such as claw attachment, gauges etc.
- Any other technical requirements
- Operational and maintenance instructions, including limitations of use

## Thorough Examination

Mechanical jacks fall under the heading of 'lifting equipment' in modern legislation and therefore should be examined by a competent person at periods not exceeding twelve months.

The requirements for load tests to be made as part of the examination will vary dependent on the circumstances, as will the extent to which it may be necessary to dismantle and clean the jack.

Furthermore, some organisations have laid down procedures for dealing with these matters, which their employees will need to follow. It must, however, be understood that these matters are the responsibility of the competent person making the examination and that he may be held to account to justify his/her decisions.

During the examination the following should be checked:

- The general appearance and operation of the jack. A functional test should be made to ensure that it operates correctly and smoothly

    - The jack fails to lift or lower the load
    - The load slips back after each stroke of the operating handle
    - Base of jack twisted, bent or cracked
    - Body or main frame of jack bent, cracked or similar damage
    - Swivel head seized or does not turn freely

During the examination the following should be checked:

- It may be necessary to strip the jack down to make a full examination of the internal components, paying particular attention to the following:

    - Damage to the rack, chipped, worn or corroded teeth.
    - Distorted rack.
    - Bent, cracked, distorted toe
    - Screw bent, worn, chipped, corroded
    - Pawls chipped worn or cracked
    - Linkages bent, worn or loose
    - Sliding faces and wear plates, worn, nicked, scored, corroded or distorted
    - Incorrect set spring pressure. Distorted, corroded or broken springs
    - Bearings lacking lubrication, seized, corroded or damaged

In most cases an overload test will not reveal anything new as the strength of the jack is already known, and therefore serves no purpose, but will shorten the working life of the jack.

However, if a repair has been made a load test will be necessary to verify the repair. Care will be needed to ensure that the correct test load is applied and it will be necessary to establish and follow the manufacturer's instructions. In the past a proof load of 125% of the WLL was usual and older jacks will be tested this way.

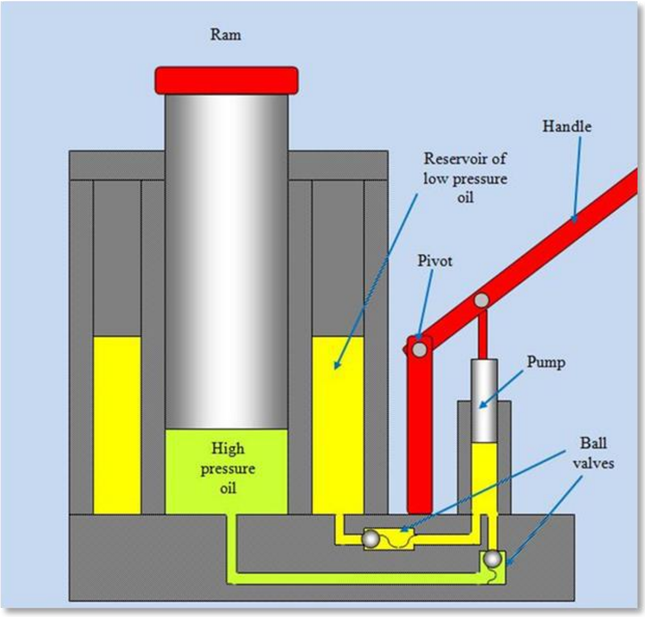
For jacks made strictly to the harmonised standard the proof load will only be 110% of the WLL.

Functional tests, with no load or a light load will be helpful in confirming the correct function of the jack, however, it is normal to make a functional test by raising and lowering a load equal to the rated capacity where any doubt as to the condition of the jack exists.

Notes:

## Hydraulic Jacks

BS EN 1494: 2000 + A1: 2008 - Mobile or movable jacks and associated lifting equipment, covers a wide range of jacks for various applications. The range includes hydraulically-operated jacks.




Prior to this standard there was no British standard for general purpose jacks and, as a result, most manufacturers produce a range of jacks to their own specifications.

Hydraulic cylinders (rams), with independent pumps connected by hoses, are often used in jacking applications. Although no specific guidance is given, the principles set out in this section of the code may be equally applied to certain cylinders when they are used for jacking purposes.

## Types of Hydraulic Jacks

### Aluminium Construction



Jacks constructed of aluminium tend to be of robust design and are used for high capacity, heavy duty jacking operations.

They are generally available in a range of capacities up to 150 tonnes, although other capacities may be available. Lifting rams used in this construction of jack are normally single stage giving a range of runouts (lifts) of 152mm, 305mm or 457mm.

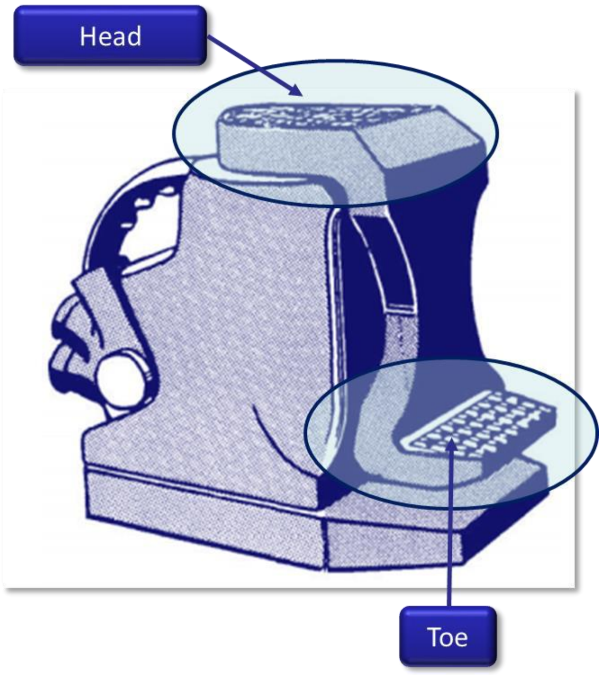
The profile of the base is usually rectangular and the body casting incorporates a carrying handle. Operation of the jack is commonly from the back of the unit and the front face of the body is flat to allow the use of a claw attachment.

**Claw Attachment**

The use of a claw attachment provides the means of supporting the load on the head of the jack or on a toe.

It should however be noted that the maximum load permitted on the toe of the claw attachment is considerably less than on the head, usually only 40% of the head load.

Furthermore, it should also be noted that only jacks with extended bases can be used in conjunction with claw attachments as these prevent the jack from overturning.




**Screwed Locking Collar**

Some models are available with a screwed locking collar.

In this case the lifting ram has a robust male thread along its length and a screwed collar is fitted to this.

This enables a raised ram to be locked in position against the base of the jack.

Should there then be any loss of pressure within the hydraulic system, the load will be supported by the collar against the base, preventing the ram from creeping down.



Hydraulic jacks use oil as the lifting medium, the body of the jack acting as a reservoir for the oil.

When the jack is operated, oil is passed under pressure through a system of non-return valves to the base of the ram chamber. As more oil is delivered with each stroke of the operating lever, and as the oil cannot be compressed, it forces the ram out of the chamber providing a lifting motion. Lowering is achieved by releasing a valve which allows the oil to return to the reservoir. The operation of the release valve may be by depressing a lever, turning a screw or opening the valve directly. The ram is then returned by gravity, although in some cases this may be spring assisted.

The controlled use of hydraulics, where known pressures are applied over known areas, enables jacks to be used for load weighing purposes. Calibrated gauges may be fitted to some models to enable them to be used for this purpose.

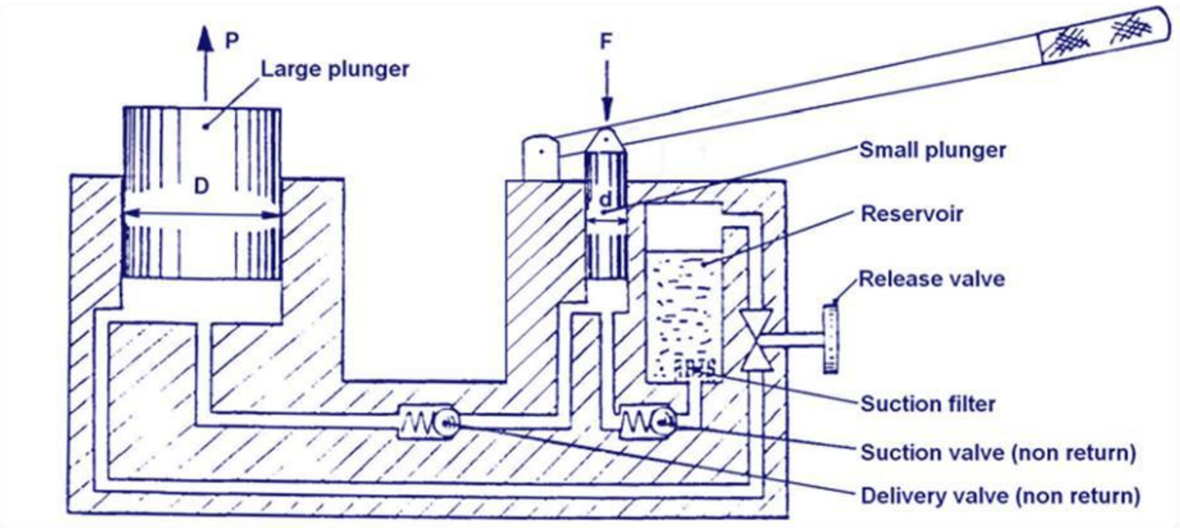
Hydraulic jack bodies are commonly manufactured from aluminium, steel or cast iron. The material used affects the design, size, self-weight and capacity of the jack.

**Basic Operation of a Hydraulic Jack**

In hydraulic pump and rams, or jacks, the liquid is a light oil. Generally this flows easily, offers considerable resistance to compression and is not greatly affected by changes of temperature. So, although not strictly true, we can consider the oil to:

- Be incompressible, so that when put under pressure it will flow
- Unaffected by temperature so that it will not expand
- If put under pressure will seek an increase in the volume of the space

In the hydraulic jack we make the oil flow into a confined space under pressure, but as we cannot compress the oil, the space must expand. If the space cannot expand, the weakest part of the jack would fail, e.g. the seals would blow. The space is expanded as a result of the oil pushing the ram out of the jack. In the illustration we see a schematic sketch of a jack showing the principle of operation. (An independent pump and ram would be the same except the pump is connected to the ram by a hose with the delivery non return valve in the entry port to the ram.)



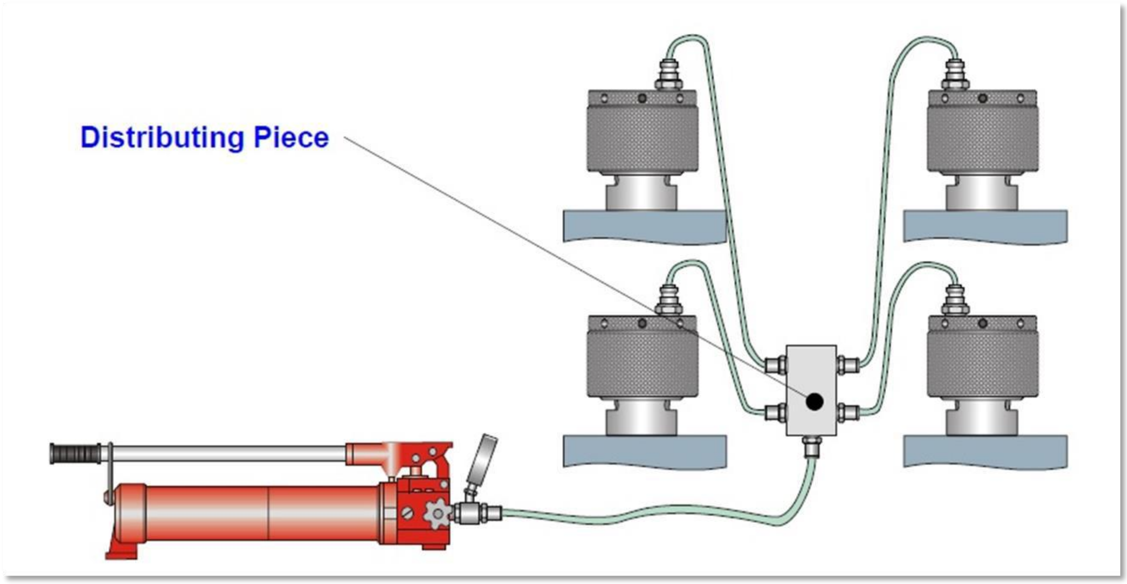

When the lever is raised the small (pump) plunger is lifted. This causes oil to be sucked from the reservoir into the area previously occupied by the plunger. The oil passes through a filter and a non-return valve (suction valve). When the lever is then depressed the plunger is lowered putting pressure on the oil, which, due to the non-return valve is unable to return to the reservoir. The oil is therefore made to flow into the large plunger chamber via another non return valve (delivery valve).

Further pumping of the lever causes more oil to flow under pressure and, as the pressure acts equally in the enclosed system, it seeks to expand the space available to it. This it does by pushing the large plunger (ram) out of its chamber, the pressure in the system being greater than the downward pressure of the large plunger and load.

To lower the jack a valve is opened (release valve) which allows the oil to return to the reservoir. The downward action of the ram puts pressure on the oil, which, unable to return the way it came because of the non-return valves, flows back to the reservoir by this alternative route.

If the load were too great the jack would fail due to the high internal pressure. In practice a pressure release valve is fitted so that if the pressure builds to an amount greater than for which the valve is set the oil is allowed to flow back to the reservoir.

**Example of a Multiple Jacking Operation from One Power Pack:**




## 153 Thorough Examination

Hydraulic jacks fall under the heading of 'lifting equipment' in modern legislation and therefore should be examined by a competent person at periods not exceeding twelve months.

The requirements for load tests to be made as part of the examination will vary dependent on the circumstances, as will the extent to which it may be necessary to dismantle and clean the jack.

Furthermore, some organisations have laid down procedures for dealing with these matters, which their employees will need to follow. It must, however, be understood that these matters are the responsibility of the competent person making the examination and that he may be held to account to justify his decisions.

During the examination, the general appearance and operation of the jack should be checked and a functional test made to ensure the correct and smooth operation. The following should also be checked:

- Oil patches or obvious leaks, particularly during the operation of the jack. This is usually due to failed seals or 'O' rings but may also be a sign of cracked jack body
- The jack fails to lift or after a short period of movement the load rises and falls with each stroke of the lever. When operation ceases the load begins to lower on its own. These may be due to blown seals or non-return valves not operating correctly and can be caused by dirty/emulsified oil, or due to scored, nicked or otherwise damage to the ram face
- The ram fails to lower, fully retract or lowering is jerky. Usually due to dirty/emulsified oil causing valves to stick, but may be due to other damage. Similarly, the release valve may be difficult to operate or fail to release the load

During the examination, the general appearance and operation of the jack should be checked and a functional test made to ensure the correct and smooth operation. The following should also be checked:

- Cracks, dents and mechanical damage to the body and base and/or base distorted
- In the case of jacks with claw attachments, the claw does not sit on the head of the jack correctly, the claw is cracked, distorted or otherwise damaged
- The ram fails to lower, fully retract or lowering is jerky. Usually due to dirty/emulsified oil causing valves to stick, but may be due to other damage

The examination of a hydraulic jack will always include some form of test, usually with a load imposed on the jack. Functional tests, with a light load will be helpful in confirming the correct function of the jack. A load test at the rated capacity, lifted through the full range of lift, then held for a period of time will help to reveal faults and defects within the hydraulic system, e.g. leaking seals or valves not operating correctly, which might not otherwise be apparent.

| Notes: |
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# 13. PULLEY BLOCKS

Pulley blocks are one of the simplest and oldest forms of lifting machine. They are widely used in a variety of lifting and pulling applications where:

The direction of the line pull needs to be changed

Higher loads than the WLL of the winch, or other pulling/lifting force provider, are to be lifted or pulled


The simplest form of pulley block is the gin block to BS 1692. Gin blocks are intended for use in simple manual lifting operations where a light load can be easily raised by a man pulling on a rope with no gain of mechanical advantage.

Pulley blocks intended for use with winches and jaw winches are covered by clause 5.6 of BS EN 13157 – cranes – safety – and powered lifting equipment.



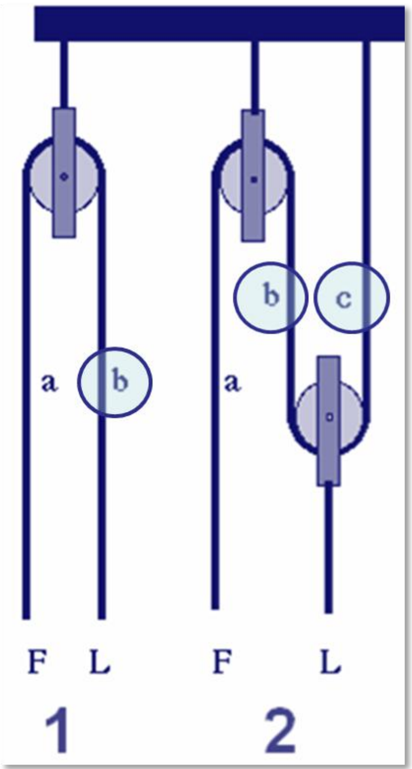
## Mechanical Advantage

A pulley block utilises a single continuous rope to transmit a tension force around one or more pulleys to lift or move a load.

Its mechanical advantage is the number of parts of the rope that act on the load. The mechanical advantage of a pulley block system dictates how much easier it is to haul or lift the load.

The illustration opposite shows two variations of mechanical advantage obtained in the pulley block systems shown.

The left hand side of the following picture on the right clearly shows 1 part of rope supporting the load and, the right hand side picture showing 2 parts of rope supporting the load.



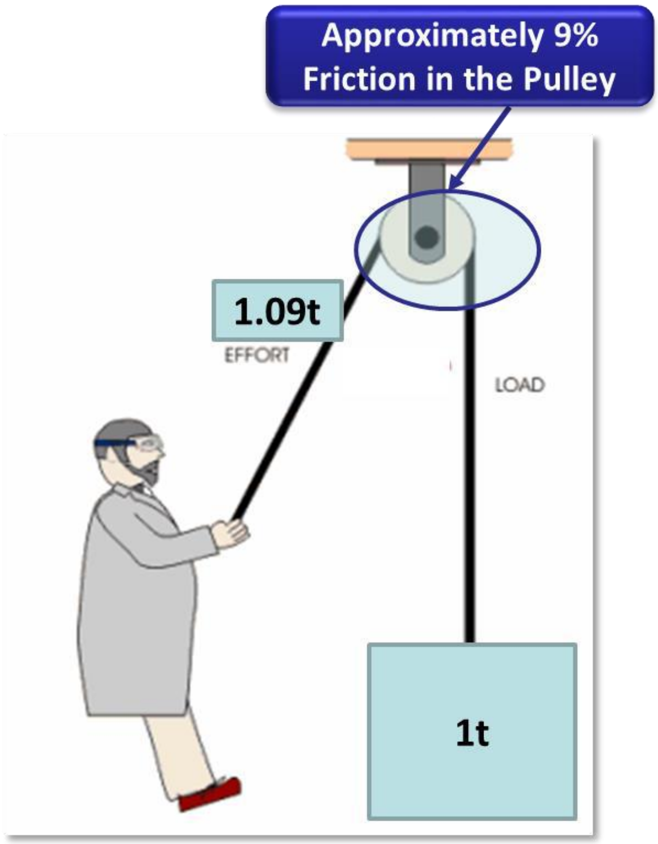
**Effects of Friction**

In a perfect pulley system with no frictional loss, the efficiency of the system would be 100%. However, we know from module 2 that friction losses will occur.

If we consider the single sheave pulley arrangements as shown opposite (assuming that the pulley is in good working order) we can see that frictional loss in the pulley is approximately 9% when fitted with plain bearings. (Manufacturer's data may be available for greater accuracy.)

Therefore, it is clear that in order to overcome the friction in the pulley, the effort required to lift the 1t load will be 1t x 9% = 1.09t.

There is no mechanical advantage gained from this arrangement as we are simply changing the direction of the effort applied.




**Mechanical Advantage**



Mechanical advantage (as we have studied previously) = load ÷ effort

If we ignore frictional loss, we can say that the mechanical advantage of a pulley block system is equivalent to:

$$MA = \frac{F_B}{F_A} = n,$$

$F_B$ = Load $F_A$ = Effort $n,$ = Rope sections supporting the load

### Mechanical Advantage (Ignoring Friction)

If (in the example shown opposite) we have n = 2 legs of rope supporting the load $F_B$, the tension in each leg of the supporting rope will be $F_B \div n$.

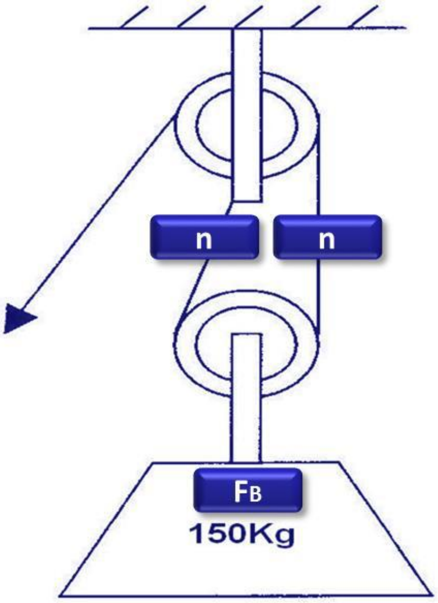
Therefore the tension in each of the supporting legs (n) will be:

$n = F_B \div 2 =$ **75 Kg per leg**

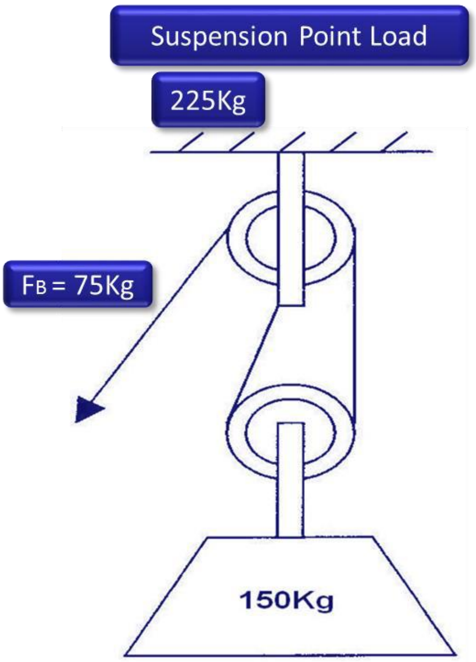
The effort required to lift the load ($F_A$) is therefore:

$F_A = F_B \div n$

**= 150 ÷ 2 = 75Kg**




### Load on Suspension Points




If we consider the resultant loading on pulley block suspension point, we can calculate the value as:

$F_A$ (Load) + $F_B$ (Effort) = 150 + 75 = **225Kg**

**Note 1:** In reality, we would also need to include for frictional effect which would increase the suspension point loading in this example.

**Note 2:** Force and load are shown as equal measurements for the purposes of this illustration.



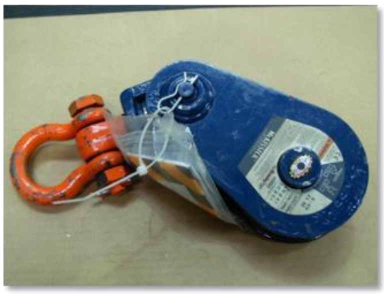
Notes:

## Head Fittings and Load Suspension Fittings

Pulley blocks are available with swivel eye or hook fittings.

It should be noted that BS EN 13157 shows a swivel eye in the illustration of a pulley block but only mentions hooks in the text.

It can be assumed from this that it is intended to cover both types of head fitting.

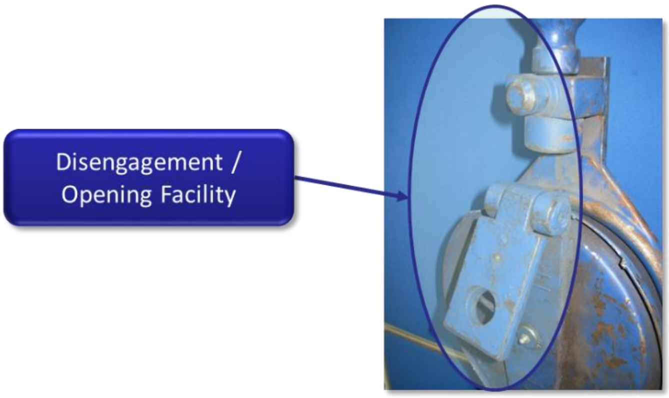


## Design Requirements

### Mechanical Strength

The mechanical strength shall be checked by an appropriate calculation method.
Pulley blocks and sheaves elements subjected to the direct action of the load shall have a coefficient of utilisation (safety coefficient) of at least 4:1.

### Opening System – Disengagement




If pulley blocks and sheaves are of the opening type to permit reeving, the opening system shall be captive and prevent inadvertent opening.

### Means of Attachment

Two hooks shall be fitted, one to suspend the pulley block/deflection pulley, the other to attach the load.

Hooks shall be fitted with safety latches to prevent unintentional detachment.

### Hook Test Requirements

Load hooks used as lifting medium, which are not manufactured in accordance with a recognised standard shall not show permanent deformation at a static load of 2-times the rated capacity. At a static load of 4-times the rated capacity, the hook shall be allowed to bend however the load shall remain held safely.

This shall be ensured by selecting the appropriate materials and by the heat treatment.

**Sheaves for Wire Rope**

The pitch circle diameter to the centre line of the rope (D) shall be at least 12 times the nominal diameter of the rope (d).

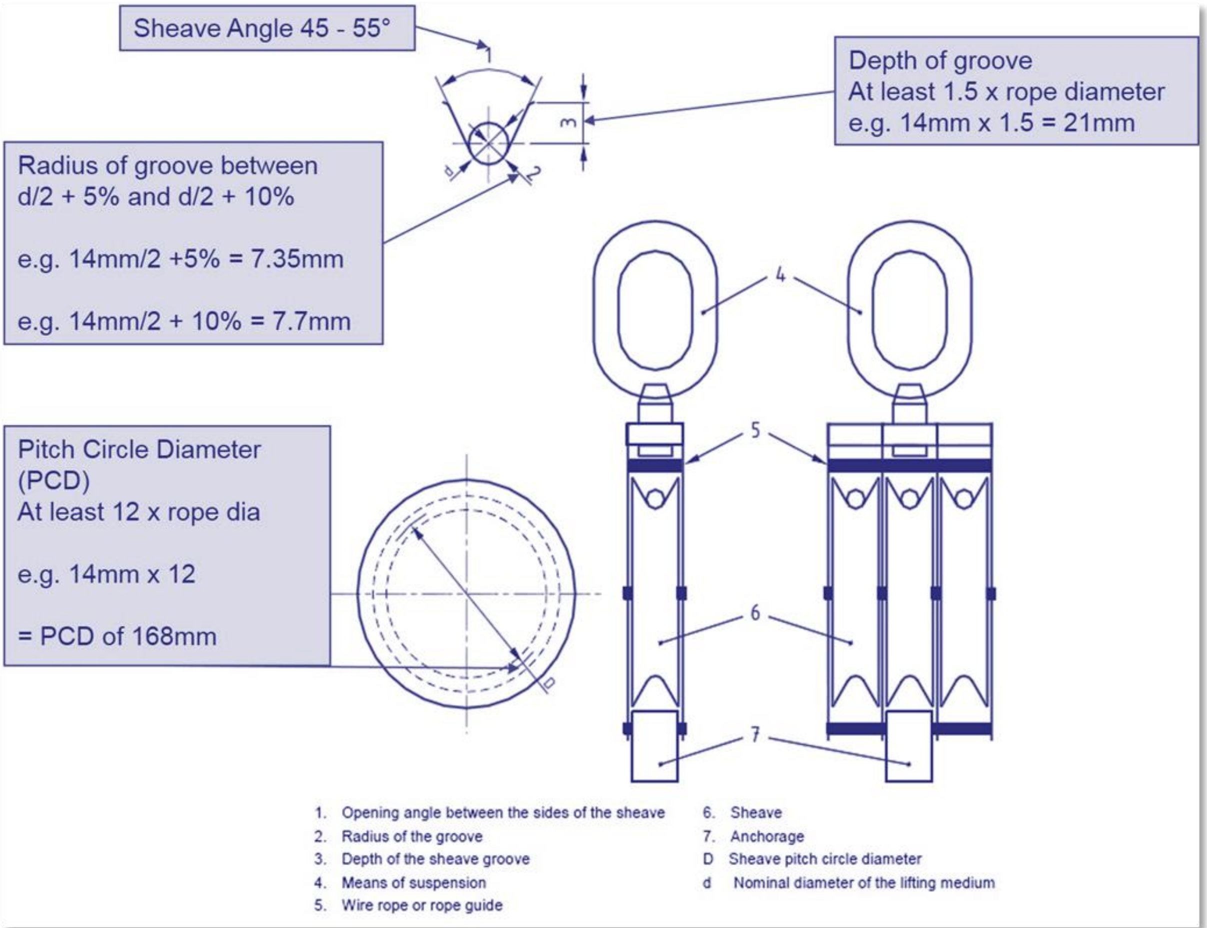
The groove angle shall be between 45° and 55°.

The radius of the groove shall be between d ÷ 2 + 5% and d ÷ 2 + 10%.

The depth of the groove shall be at least 1.5 times the nominal diameter of the rope.

**Note:** An illustration of these dimensions is shown on the following page.

**Pulley Block Components and Dimensional Requirements**






Notes:

**Sheaves for Fibre Ropes**

The groove of sheave for fibre rope shall be radiused. The radius shall be at least equal to half of the fibre rope diameter.

**Rope Guide**

Pulley blocks and sheaves shall be fitted with a rope guide system to ensure that the rope stays located in the groove of the sheave, in case of slack rope, manual intervention.

**Temperature**

Pulley blocks and sheaves, and their components shall be capable of operating within an ambient temperature range of -10°C to + 50°C unless another temperature range is agreed between the manufacturer and the purchaser.

## Manufacturer's Tests

**Type Tests**

To prove the design and performance of pulley blocks prior to series manufacture, BS EN 13157 requires the manufacturer to make certain tests as follows:



- Calculation of mechanical strength, attachment device and suitability for use in the specified temperature range
- Static test of 1.5 times the rated capacity for blocks less than 20t WLL and 1.25 the rated capacity for blocks with a WLL of 20t or more
- Breakage test for blocks designed for a rated capacity of less than 5t
- Functional test to ensure correct operation of rope guide
- Measurement of sheaves
- Visual examination of instructions, periodic examination requirements and marking

Each block must be subject to a dynamic test of 1.1 times the rated capacity, a functional test of the rope guide and a visual examination on completion of manufacture and subject to a visual examination.

**Information to be supplied by the Supplier**

The supplier is to provide information and advice as instructions for use in accordance with specifying in particular:

- Intended use
- Technical data
- Operating instructions
- The fastening, installation, transport and storage conditions
- The table of loads as a function of the pulley blocks or deflection pulleys configurations and support conditions
- Uses presenting particular hazards and information on foreseeable inappropriate uses, particularly

in the case of jamming hazard between the lifting medium and the frame or the puncture hazard from broken strands in the rope

- Ambient operating temperature between - 10°C and + 50°C
- Forbidden use of equipment in a specific environment (explosive, corrosive, etc.)
- Use of the opening system
- Maintenance instructions for each of the constituent elements of the equipment with regard to servicing, periodic maintenance, corrosion protection, repair and storage conditions when not in service. In particular, instructions to specify the frequency of overhauls, and elements whose deterioration would involve a risk to health and safety and the criteria leading to replacement of these original items such as number of operations carried out and wear factor. In addition, rope characteristics and instructions for their replacement shall be specified
- The utilization coefficient of the wire ropes used with the pulley block or the sheave shall be at least equal to 5
- The utilization coefficient of the fibre ropes used with the pulley block or the sheave shall be at least equal to 7
- Lifting medium used with the pulley block or sheave shall be supplied in single lengths with splices or connections only at the ends
- If necessary, advice on the training of operators

- The following requirements for rope terminations:
    - Terminations shall withstand a force of at least 85 % of the minimum breaking force of the rope without rupture
    - Asymmetric wedge socket clevis shall be in accordance with EN 13411-6
    - Metal and resin socketing shall be in accordance with EN 13411-4
    - Rope eyes with wire rope grips shall not be used as rope-end terminations
    - Symmetric wedge socket clevis shall be used only for rope diameters up to 8 mm



**Marking**

BS EN 13157 requires that all pulley blocks and deflection pulleys are fitted with a permanent identification plate which gives the following information:

- Name and address of the manufacture
- Series type or designation
- Serial number (identification mark)
- Rated capacity
- Year of manufacture
- Dimensions and quality of rope (for which the block is intended)
- Minimum breaking force of the rope

Notes:

## Examination

Nothing will be achieved by a load test during the examination as the strength is known prior to the examination. However if a repair has been made to a load bearing part it will be necessary to load test the block in accordance with its initial verification by the manufacturer.

It is necessary to establish the standard to which the block has been manufactured and/or obtain the original manufacturer's instructions to ensure that the correct test load is applied.

All in-service pulley blocks should be carefully visually examined. In particular the following should be checked (it may be necessary to strip down the block to make the examination):

- Ensure that the marking is clear and legible
- Wear/fracture in eye of block, maximum 8% reduction in diameter
- Check for wear and/or fractures in shank of eye, maximum wear 1.5mm on a 25mm (6%) of shank (25 – 6% = 23.5mm) diameter, also:
    - Check the shank for distortion and crosshead hole for wear. Where the eye of a block has been secured by welding around the retaining collar or nut, wear in the shank of eye may be assessed by moving the collar
    - Should it be suspected that the shank is excessively worn, bent or otherwise defective, the welding should carefully be removed and the eye extracted for closer examination
- Check for distortion or torn side straps/bindings, as well as distorted or worn side plates and/or chafed edges to side plates
- Check for fractures leading from centre pin hole
- Check for worn/distorted/fractured centre pin, maximum wear 1.5mm for each 25mm of pin diameter, i.e. 6% of pin diameter
- Check for worn/distorted/fractured bush, or bush slack in sheave housing. Ensure oil or grease ways in pin and bush, and the sheave and shell are clear
    - In the case of self-oiling sheaves the leathers must be renewed. If roller bearings are fitted these should be checked for wear, freedom of movement etc.
- Check that the sheave(s) are not chipped/cracked/worn; score should be checked using a suitable gauge (available online from LEEA at www.leeaint.com)
    - Particular attention must be paid to rope imprint which can damage the rope
- Check becket for wear or distortion

Notes:

# 14. SITE TESTING AND EXAMINATION OF LIFTING MACHINES MANUAL

- Methods of carrying out Examinations.
- Precautions when working at a client's premises.
- Identify the terms which are used to describe various tests and their relationship with a thorough examination.

## Site Examination and Testing

When thoroughly examining Lifting Machines Manual for whatever reason, the examiner is called upon to make a judgement about its fitness for service.

Some of the assessment is objective and measured against established criteria.

For in-service thorough examinations, much of the assessment is subjective, relying on the experience and professional judgement.

This will take into account of various factors and assessing their combined effects on the safety of the item.

## Working On-Site

The examiner should always report to a responsible person on the site before commencing any work or unloading tools or materials.



## Pre-Examination Requirements

The area in which the examination is to be carried out should be clean and clear of any materials or contaminants which may harm the examiner or the equipment under examination.

The examiner should have adequate access to the equipment or any part of the equipment which it is necessary to examine.

## The Thorough Examination

The established acceptance/rejection criteria should be considered as the maximum permitted and used as guidance when considering their combined effects before reaching a conclusion as to the fitness for a further period of service of the equipment.

For example, it must be remembered that an item worn nearly to the maximum will continue to wear with further use and may not last until the next examination date.

A full visual examination should be made to establish the general condition of the item. With most machines a functional test with no load will be necessary.

If necessary other tests should be made, e.g. to establish that brakes are working correctly.

## Repairs



Enquire about any repairs that have been made as they might affect the safety of the equipment.

The purpose of a periodic examination is to monitor that the item has been correctly maintained and is in a safe working condition.

When repairs are made, only components which are the correct size, material grade and, if appropriate, approved by the manufacturer should be used.

The original equipment manufacturer's instructions should be followed.

A record should be made of all repairs, if necessary the examiner should view this.

## Tests

Various tests may be necessary to ensure the equipment is safe.

Carried out in accordance with the manufacturer's instructions, the relevant standards and statutory requirements and should at least meet the minimum requirements given below.

Test areas should be carefully selected and steps taken to protect personnel and property.

In particular when load testing, ensure a clear area to facilitate the lifting and movement of test weights with the minimum of ground clearance.

**Functional Test**

Used in lifting machines to verify that the unit operates correctly with no load. This is a necessary part of any thorough examination and should be carried out both before and after any thorough examination.

**Light Load Test**

Used in lifting machines to verify that the brake functions correctly. Between 2% - 10% of its SWL. This is a necessary part of any thorough examination and should be carried out both before and after any thorough examination.

**Operational Testing**

Used in lifting machines to verify that it functions correctly with up to full SWL. Used periodically and after repair of a machine. Always carried out if commencing an overload test.

**Overload Testing (Dynamic)**

Modern standards use 110% of WLL. Used periodically to check structural integrity of the machine and the moving parts.

**Overload Testing (Static)**



Modern standards use 110% of WLL to 150% WLL (depends on standard used) used periodically. This test can only check structural integrity of the machine.

| Notes: |
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## TRAINING

**Operative training for all the equipment covered in these step notes should always take the manufacturer's information and instructions for use into account.**




Notes:

# FEEDBACK

We would be grateful for your feedback regarding these Step Notes, after completing this training course. Please make your comments known to us – 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 in advance for your participation.

*Andrew Wright*
*LEEA Learning and Development Manager*

| Step Notes - feedback to LEEA: |
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