Developing Professionals for the Lifting Equipment Industry

City & Guilds | Accredited Programme

Overhead Travelling Cranes

Advanced Programme

Training Course Step Notes

City & Guilds | Accredited Programme

LEEA Learning and Development Agreement

In the interests of all parties and to ensure the successful achievement of the LEEA Overhead Travelling Cranes 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 ____

Disclaimer

These Step Notes are a useful and authoritative source of information for the LEEA OTC 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........................Revised December 2016

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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.

Notes:

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 of the 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 a couple examples of such regulations:

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

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

Duties of the 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 (MHSWR) 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

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.

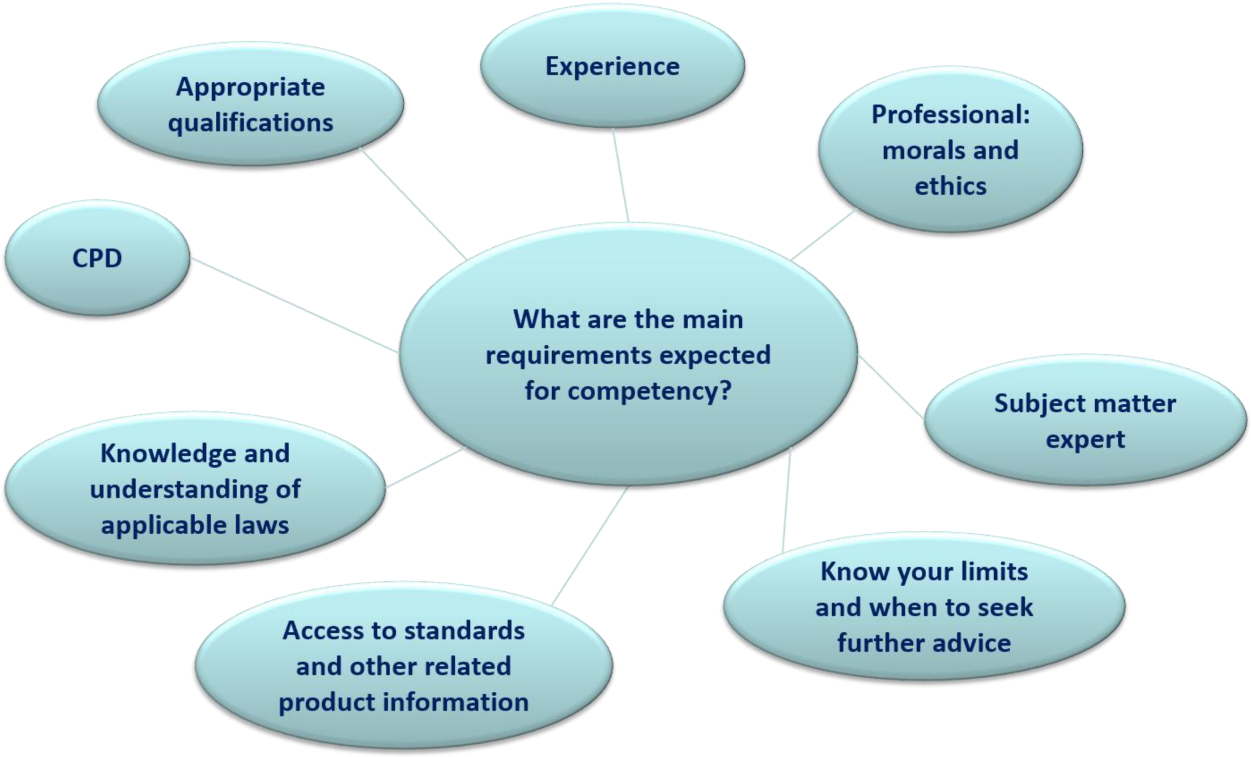
Primary Elements of Competency

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

Note: LEEA Foundation Course and Advanced Programme certificates are not evidence, declaration or proof of competency.

Notes:

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.

Notes:

Definitions

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.

Net Result (Risk) = Likelihood x Severity
i.e. How likely x How severe the consequence

Notes:

5 Steps to Risk Assessment

- Identify the hazards
- Decide who might be harmed and how
- Evaluate the risks and decide on **control measures**
- Record your findings and implement them
- Review your assessment and update if necessary

Control Measures:

Hierarchy of control measures: **(ERIC-PD)**

Eliminate

Reduce

Isolate

Control

PPE

Discipline

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.

Notes:

Are You Following a 'Safe System of Work'?

- You have identified the hazards
- You have decided who may be harmed
- You have evaluated the risks and decided 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'?

"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".

Note: As an example, a manual slew jib without hoist that could be fitted inside an offshore service container would not be within the scope of the Directive. The example below shows the hoist fitted to the slew jib so would be within the scope of the directive.

Notes:

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

The 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
    - 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

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:

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

PUWER and LOLER Regulations

Provision and Use of Work Equipment Regulations 1998 (PUWER)

- Applies to all work equipment

Lifting Operations and Lifting Equipment Regulations 1998 (LOLER)

- Applies to lifting equipment in addition to PUWER

Both PUWER and LOLER apply to all sectors of industry.

Status of PUWER and LOLER

United Kingdom:	legal requirement
International:	good practice demanded by customers and local authorities, integral to the LEEA code of practice

Notes:

The Essentials of PUWER

PUWER places duties on the employer to ensure that:

- It is the duty of 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 (refer to 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

Note: **Offshore container standards slightly differ and require a Certificate 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 offshore containers requesting the Certificate of Conformity which shows compliance with BS EN 12079 will ensure that the offshore containers meet this requirement.

Notes:

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Provision and Use of Work Equipment Regulations (PUWER)

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 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)

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.

Notes:

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: -

- 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.

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 latest date by which the next thorough examination must be carried out

- Where the thorough examination included testing, particulars of any test

- The date of the thorough examination

- 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 are available for LEEA members on the LEEA website.

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.

Notes:

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.

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.

Notes:

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

Manual Handling Operations Regulations 1992

- Refers directly to lifting operations and adds to the employers 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:

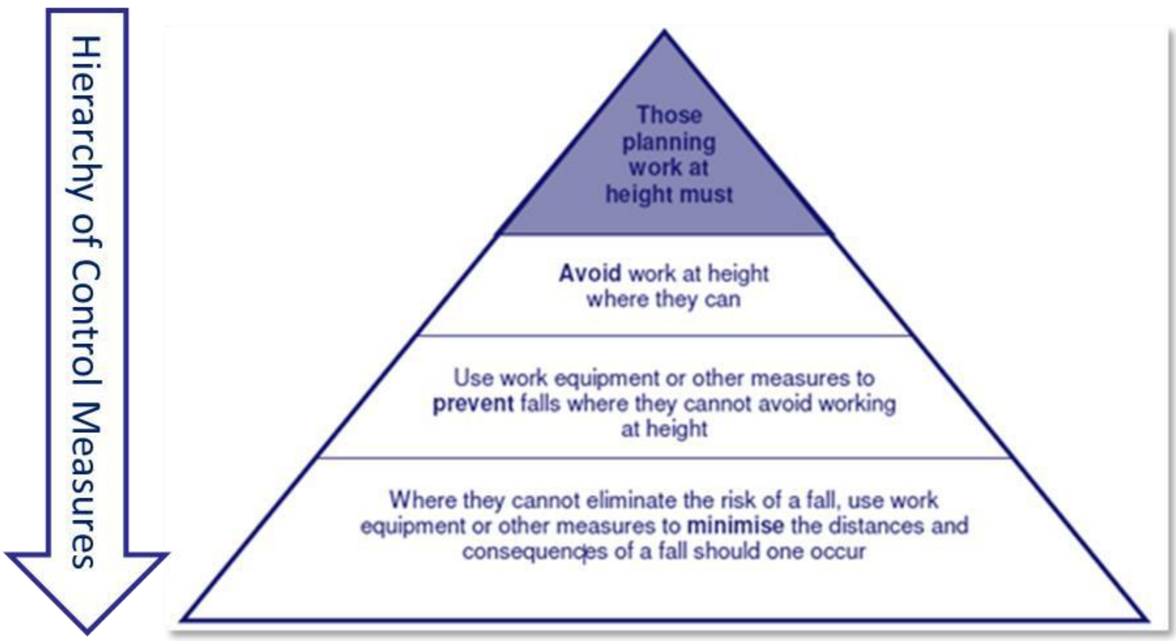
Avoid work at height where it is reasonably practicable to do so
Where work at height cannot be easily avoided, prevent falls using either an existing place of work that is already safe or the right type of equipment
Minimise the distance and consequences of a fall, by using the right type of equipment 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.



Dos and Do Nots of Working at Height

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

Electricity at Work Regulations

The Electricity at Work Regulations apply to almost all places of work. The Regulations were enacted to impose duties to limit the risks involved with using electricity at work.

The following people are subject to the Regulations:

- Employers and the Self-Employed
- Employees

The duties under the Regulations are not just in relation to employers but also place a duty on employees in the following circumstances:

- To co-operate with his employer so far as is necessary to enable any duty placed on that employer by the provisions of these Regulations to be complied with
- To comply with the provisions of these Regulations in so far as they relate to matters which are within his control
- Many employees in the electrical trades and professions for example have responsibilities which are part of the duties of their employment of safety in relation to the installation of electrical equipment and systems

The definition of electrical equipment provided by the regulations includes anything used, intended to be used or installed for use, to generate, provide, transmit, transform, rectify, convert, conduct, distribute, control, store, measure or use electrical energy.

For further information, please read the HSE documents: "The Electricity at Work Regulations 1989 – Guidance on Regulations" and "Electricity at Work – Safe Working Practices". These can be found at www.hse.gov.uk.

The Electromagnetic Compatibility Directive

In order to facilitate a single European market for goods some 20 years ago the European Union began what is described as the 'New Approach'. A number of Directives were adopted with the aim of setting objectives for the harmonisation of technical rules, primarily but not exclusively, affecting the health and safety of new products by design and construction.

The principal aim of the 'New Approach' was to remove barriers to trade by requiring all products to meet common minimum health and safety objectives, which would be supported by agreed standards at the product level.

The Electromagnetic Compatibility Directive 2004/108/EC (EMC) will apply to equipment with an electrical aspect, primarily to prevent interference with other electrical equipment and its own immunity from such disturbance.

The Electromagnetic Compatibility Regulations

The EMC Directive is implemented in the UK by the Electromagnetic Compatibility Regulations which apply to electrical and electronic equipment liable to cause or be affected by electromagnetic disturbance.

The aim of the regulations is to ensure that electromagnetic disturbance generated by electrical or electronic equipment doesn't reach levels which would prevent radio, telecommunications and other equipment from working properly. They also exist to ensure that such equipment itself has adequate immunity from electromagnetic disturbance.

The rules don't deal with safety-related matters.

Whilst this is not a matter for the tester and examiner of lifting equipment, we should note that when the manufacturer affixes the CE mark to an item it implies that all the necessary directives have been complied with.

The EC Declaration of Conformity for electrically operated lifting equipment should therefore refer to both the Machinery Directive and the Electromagnetic Compatibility Directive.

Notes:

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

LEEA COPSULE – Methods of Operation

Whilst the LEEA COPSULE does not include operation of powered equipment, users should be reminded of the need for power systems to be installed, maintained and examined in accordance with the relevant regulations, e.g. The Electricity at Work Regulations, The Pressure Systems Safety Regulations etc., and their need to meet any obligations these regulations impose.

Power operated equipment has the advantages of quicker operation than with manually operated equipment, often operatives can be remote from the load and heavier loads can be handled conveniently without operative fatigue.

In summary, where no power source is available, light loads are to be lifted, infrequent operation is called for or precision placement of the load is required, manual operation may be considered. Where heavy loads are to be lifted, frequent operation is called for or a more rapid operation is necessary power operation should be considered.

Summary

In this module, we have looked at the various laws that are applicable to lifting equipment and it's examination in the United Kingdom.

Examiners of lifting equipment should always make themselves familiar with the national regulations of the country in which they are operating.

Failure to do so may lead to prosecution, due to breaches of the law.

Notes:

2. Standards

Standards for Overhead Travelling Cranes

There are many different standards that are directly related to overhead travelling cranes. In order to provide a simple reference guide, we have divided these standards into 5 categories:

1. Design
2. Classification
3. Gantries
4. Thorough Examination
5. Other Relevant Standards

These categories, and the standards pertaining to each will be shown as you work through this module.

It is advisable that the Competent Person has access to relevant standards in the course of their work in the thorough examination of overhead travelling cranes.

Notes:

Types of Standards

Manufacturing standards detail dimensions, materials and safe working loads, e.g. BS EN 14492 (Winches and Hoists).

Performance standards offer a range of criteria that the final product must meet, e.g. BS EN 13001 – Cranes (General Design).

ISO (or **International Standards**) generally take the form of performance standards, which are agreed internationally by a majority vote. Their use is optional but they are often used as the basis for writing National Standards. Where the UK accepts these as written, they are published in this country as British Standards. A new practice has been adopted in recent years of using the ISO number and adding the prefix BS, for example ISO 2330 - Fork lift trucks - Fork arms - Technical characteristics and testing is published as BS ISO 2330.

ISO 9927-1 (Cranes – Inspection – General) is an example of an International Standard that sets out the minimum criteria for the inspection of overhead cranes.

In the UK, **BS 7121-2-7: 2012** is the standard that should be followed for the thorough examination of Overhead Travelling Cranes.

Standards Relating to Overhead Travelling Cranes

OTC Design

- BS EN 13001: Design of Cranes – General Design
- BS 466 (withdrawn, but to be used for cranes designed to this standard): Design of Cranes
- BS 2573-1: Rules for the Design of Cranes
- BS EN 15011: Cranes – Bridge and Gantry Cranes

OTC Classification

- BS ISO 12482: Cranes – Monitoring for Crane Design Working Period (Duty Holder/Owner)
- ISO 4301-1: Cranes and Lifting Appliances – Classification

Gantries

- BS EN 1993-6: Design of Structures – Supporting Structures (Deflections)
- BS EN 1991-3: Gantries – Actions on Structures Induced by Cranes
- DIN 536-199: Rail Sections
- BS EN 13674-1: Rail Sections
- ISO12488-1: Cranes – Tolerances for Wheels and Travel/Traverse Tracks – General

Thorough Examination

- *BS 7121-2-7: 2012: OTC – Inspection, Maintenance and Thorough Examination
- ISO 9927: Cranes – Inspection – General
- BS ISO 4309: Wire Ropes – Discard Criteria

*This training course has been primarily constructed in relation to the standard BS 7121-2-7:2012 for the inspection, maintenance and thorough examination of Overhead Travelling Cranes.

Other Relevant Standards

- BS EN 13411: Terminations for Steel Wire Ropes
- BS EN 12385: Steel Wire Ropes
- BS EN 14492-2: Cranes – Power Driven Winches and Hoists
- BS EN ISO 9606-1: Approval Testing of Welders for Fusion Welding – Steel
- BS 4: 2005: Rolled Steel profiles

Notes:

3. Lifting Media – Load Chain

Fine Tolerance – Short Link Chain

- **BS EN 818 – 7, covering:** Short link chain for lifting purposes — Safety — Part 7: Fine tolerance hoist chain
- Grades: **(Types T, DAT and DT)**, 4mm to 22mm diameter
- BS EN 818-7 is applicable to electrically welded round steel short link hoist chains conforming to EN 818-1
- **ISO 3077** - Short-link chain for lifting purposes, - Grade T, (types T, DAT and DT), fine – tolerance hoist chain

Chain Finishes

Fine tolerance chain can be recognised primarily by the Grade mark.

- Type DAT and type DT hoist chains possess a surface hardness greater than core hardness and are used for power driven chain hoists to offer greater resistance to wear
- Type DT hoist chain differs from DAT hoist chain in having higher surface hardness and/or greater case depth to optimise wear resistance

Fine Tolerance – Short Link Chain

- The chain is made to precise dimensions in order that it engages freely, and without jamming into pocketed load wheels

- The application of a tensile force at the final stages of manufacture (pulled to precise pitch) has the effect of work hardening the chain

- Fine tolerance chain is less ductile than chain used for general sling manufacture (medium tolerance)

- Fine Tolerance chain has better wear characteristics

Load chains must:

- Be strong
- Be reasonably resistant to corrosion
- Have good resistance to wear

These properties are partially achieved by material selection.

Further improved by case hardening and/or plated with corrosion resistant finishes at the time of manufacture.

Fine Tolerance Chain

Guidance on the applications for which the different types of Grade T hoist chain shall be used is as follows:

- **Type T manually operated hoists,** or **power operated hoists with slow speeds,** where the working environment does not involve abrasive conditions

- **Type DAT power driven hoists** where **chain speeds are high** in combination with high working capacity and where wear resistance is required to give longer chain life

- **Type DT** power driven hoists used in **abrasive conditions**

Note: Case hardened chains are not suitable in portable manually operated hoists.

Notes:

WLL Comparison of Chain Grades

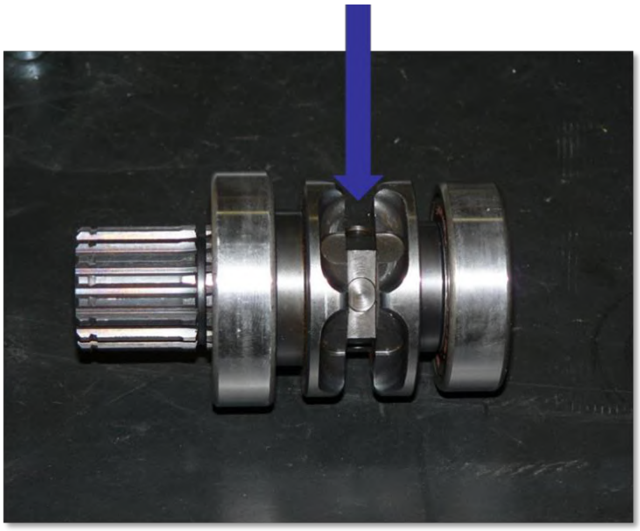
Nominal size d_n mm	Chain type T t	Chain type DAT t	Chain type DT t
4	0,5	0,4	0,25
5	0,8	0,63	0,4
6	1,1	0,9	0,56
7	1,5	1,2	0,75
8	2	1,6	1
9	2,5	2	1,25
10	3,2	2,5	1,6
11	3,8	3,	1,9
12	4,5	3,6	2,2
13	5,3	4,2	2,6
14	6	5	3
16	8	6,3	4
18	10	8	5
20	12,5	10	6,3
22	15	12,5	7,5
mean stress N/mm^2	200[1)]	160	100

[1)] Only for hand operated hoists. For power driven hoists: see annex B, Table B.1.

Fine Tolerance Chain

Dimensional incompatibility between the hoist chain and mating parts of the hoist (chain wheel, chain guide and loading device) may lead to premature failure of the chain.

BS EN 818-7 contains dimensional requirements for correct assembly and fit.



Notes:

Key Points

- **Correct alignment** with the load wheel
    - Use of suitable chain guide
    - Hoist not to be used if direct entry to load wheel is prevented, or:
    - Where the chain is twisted

- Chain must be under tension to engage the load wheel correctly
    - A few links of load chain will be sufficient

- Chain **should not be corroded or covered in dirt or debris**

- **Chain stripper fitted** to ensure disengagement of slack load chain from the load wheel

- **Adequate and appropriate lubrication**
    - Lubricants should be able to withstand high bearing pressures
    - Colloidal graphite used in adverse working conditions such as foundries, or:
    - Where lubricant may contaminate (e.g., food or pharmaceutical industries)
    - Must be acid free

- Chain collector box or bag usually fitted
    - Adequate size and alignment
    - Provide a means of drainage
    - Slack chain should never pile too high in the bag/box – this will remove the tension from the slack end of the load chain
    - Could result in a twisted link entering the load wheel and cause disastrous consequences

- Load chain must always hang in a straight line
    - No twists
    - Load hooks fitted with a swivel to prevent live side of chain from twisting

- Load chains are never to be back hooked or choked
    - Separate sling attachments

Frequent Inspection

In addition to the requirements for statutory periodic examinations, hoist manufacturers will issue instructions for user inspections. The type and frequency of inspections depends basically on the working conditions of the hoist. General classifications are given for these inspections as 'frequent' and 'periodic'.

Frequent inspections are visual inspections carried out by the operator or other designated person, with or without a record being made, to determine if damage or deterioration has occurred in service.

The following inspection intervals are recommended when carrying out frequent inspections and are in addition to a daily pre-use check which should be made by the operator:

- Light service - every month
- Moderate service - every 2 weeks
- Heavy service - every week

- Very heavy service - every day

Periodic Inspection

Periodic inspections are more thorough inspections by appointed persons making records of the external conditions to provide a basis for a continuing evaluation. The following periodic inspection intervals are recommended:

- Light service - yearly
- Moderate service - six monthly
- Heavy service - quarterly
- Very heavy service - every six weeks

If at any of these user inspections external conditions indicate it necessary, the machine should be referred to a Competent Person for thorough examination.

Thorough Examination

Thorough examinations are made by a Competent Person, i.e. the tester and examiner. They are usually associated with statutory requirements calling for records to be made and certificates or reports issued which permit the hoist to enter or remain in service. This is far more thorough than the user inspection and will usually include disassembly of parts to permit detailed examination. Each of the regulations lays down a maximum time period between such examinations.

When carrying out thorough examinations the chain should be examined throughout its length to detect any evidence of wear, distortion or external damage. The block should then be operated under 'no load' and 'load' conditions in both directions to check for the smooth functioning of the chain and wheels. If the chain jumps, binds or is noisy after cleaning and lubrication then a more detailed examination must take place.

Competent Person – Thorough Examination

- Preparation for examination
    - Chains should be cleaned (no strong alkalis or acids – hydrogen embrittlement)

- **Visually examine** chain throughout entire length, link by link

- **Operate hoist** under no-load and loaded conditions
    - Check for directional smoothness
    - Look for chain jumping in the pocket wheel
    - Listen for binding and noisy operation
    - If minor faults are not corrected by cleaning and lubrication, a detailed examination is necessary

- Link by link examination in adequate light. Check for NCCG (nicks, cuts, cracks or gouges), wear, elongation and other damage including build-up of debris

- Wear and elongation to be measured in accordance with 'original equipment manufacturer' (OEM) instructions

Notes:

Stretch and Elongation

A common misunderstanding is that stretch in a load chain is the same as elongation. This is incorrect. Stretch in a load chain is not permitted as this is actually the chain having exceeded its elastic limit and now will have permanent set (it is now in the plastic deformation stage) and this should be withdrawn from service. Elongation is wear that has occurred due to articulation of the interlinking chain links at the intrados of the connection point.

- Manufacturers may have different instructions for measurement and the acceptance/rejection criteria may vary

- Where there are no OEM instructions:
    - 2% increase in length (due to wear) over a minimum length of 5 links should be used as a rejection value

Note: This is less than 5% which is used for chain slings

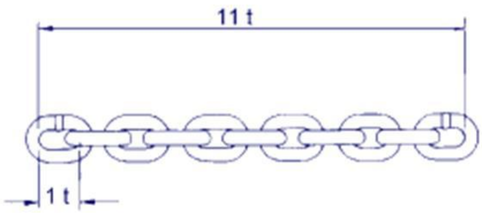
- This is because the load chain in a machine has to mate with the load wheel and therefore elongation would cause a poor fit and dangerous consequences

Some hoist manufacturers issue a gauge for checking of elongation.

The example below is taken from a manufacturers maintenance manual and is typical for most brands of hoists:

Checking stretch

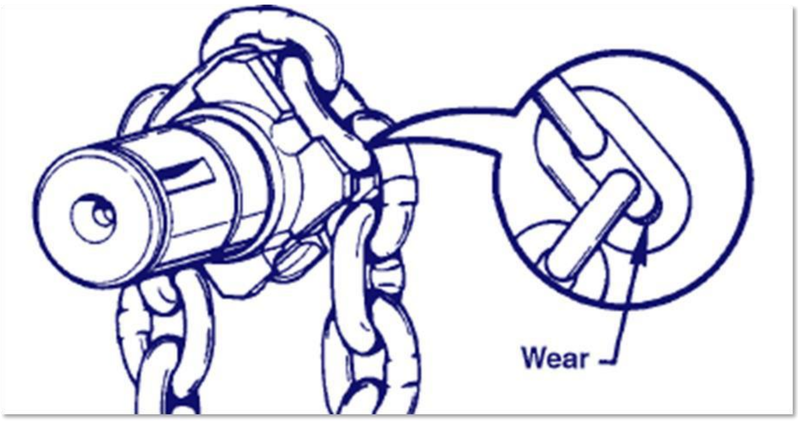
1. Using a Vernier gauge or similar, take measurements over eleven links at various points along the length of chain. Ensure the chain is within tolerance



1t = LENGTH OF ONE CHAIN PITCH
11t = DIMENSIONS TO BE MEASURED

Chain size	Length of 11 links (mm)	
	Nominal	Maximum
5x15	165	168
6x18	198	201
8 x 24	264	269

Chain Elongation due to Wear



Rejection Criteria

Load chains should be rejected if any of the following conditions are observed:

- Cracks
- Nicks or gouges
- Visible distortion
- Severe corrosion
- Deposits which cannot be removed
- Increase in length which exceeds the OEM recommendations or 2% over 5 links

Wear
In the case of wear, rapid wear can lead to sudden failure of the chain. This is shown as a rough appearance of the mating surfaces. Such chains should be replaced even if they are within the OEM wear limits.

Chain Replacement

Calibrated chain for powered lifting hoists varies in dimensions, particularly pitch, for different manufacturers. For this reason it is important that only chain specified by the hoist manufacturer should be used for replacement. Each manufacturer provides details on the best methods of chain replacement for their particular units and it is recommended that these be closely followed.

When replacing worn chain with new chain it is advisable to also replace the pocketed wheel(s) as the pockets will have worn with the chain.

Manufacturer's Criteria

The certificate of test and examination shall give at least the following information:

- The name and address of the manufacturer or his authorised representative, including date of issue of the certificate and authentication
- Number and parts of BS EN 818
- Quantity and description of the chain of which the test sample is representative

- Identification of the chain of which the test sample is representative
- Nominal size of chain in millimetres
- Manufacturing proof force in kilonewtons
- Breaking force, in kilonewtons (confirmation of whether this was met or exceeded)
- Total ultimate elongation at fracture, as a percentage (i.e. confirmation that the specified minimum total ultimate elongation has been met or exceeded)

Notes:

4. Lifting Media – Wire Rope

Wire Rope and Wire Rope Examination

Wire Ropes for Lifting Appliances

Wire ropes are generally regarded as an expendable component.

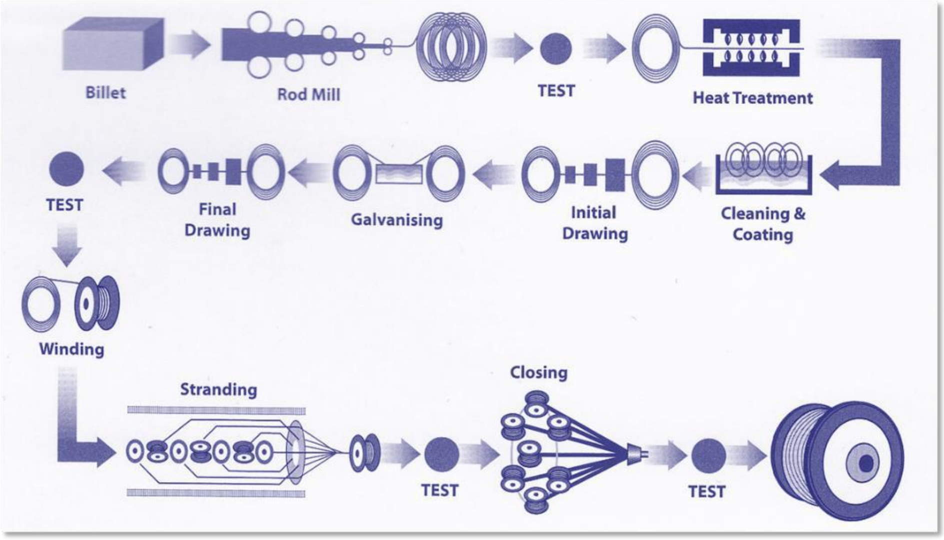
The load rope requires replacement when inspection shows that its condition has deteriorated and further use would not be suitable for safety reasons.

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' (OEM) of the crane or hoist and/or by the manufacturer of the rope, this criteria should never be exceeded.

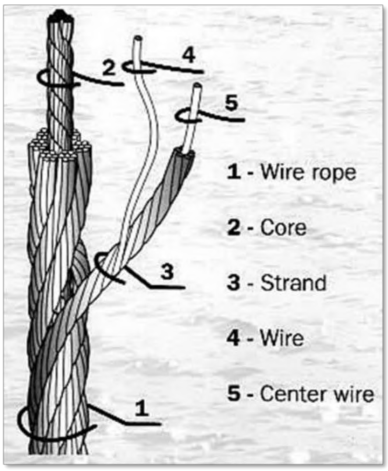
When correctly applied, the discard criteria given in full in BS ISO 4309 are aimed at retaining an adequate safety margin.

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

How Wire Rope is Made



Elements of a Wire Rope



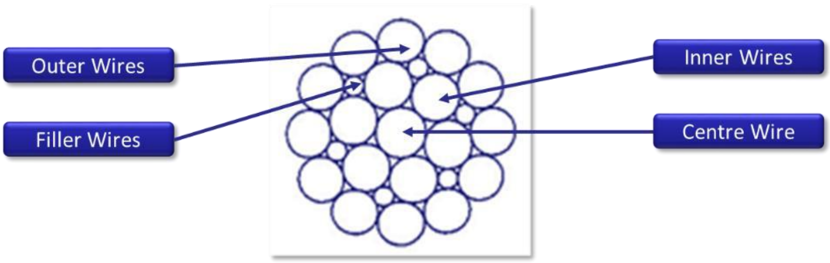
Definitions

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.

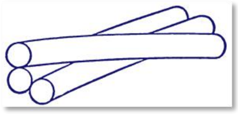
Filler wires: wires used in filler construction to fill up the gaps in between the layers.

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

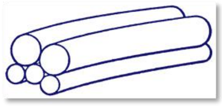


Strand Construction

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

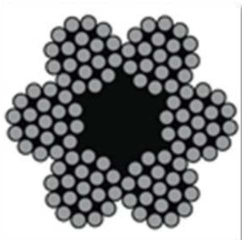


Equal Lay Rope (Parallel)

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.

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.

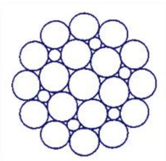


6 x 19 Construction

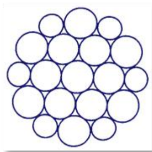
The three basic methods of laying up a **strand:-**

Seale Construction

Filler Construction



Warrington Construction

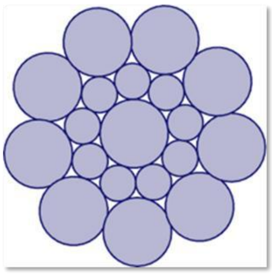


Notes:

Seale Construction

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

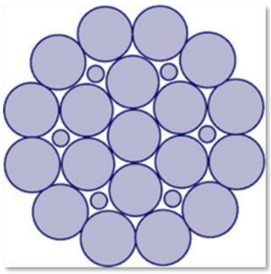
In the example shown below, the construction consists of 1 x centre wire, 9 x inner wires and 9 x outer wires:



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.

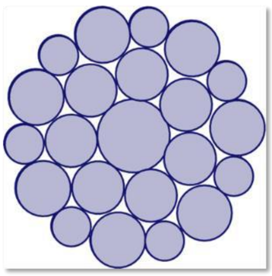
In the example shown below, the construction consists of 1 x centre wire, 6 x inner wires, 6 x filler wires and 12 x outer wires:



Warrington Construction

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

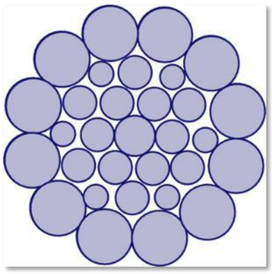
In the example shown below, the construction consists of 1 x centre wire, 7 x inner wires and 14 (7 large and 7 small) x outer wires:



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.

Warrington Seale (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.

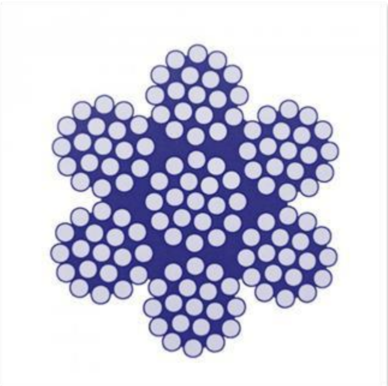
Wire Stranded Core (WSC)

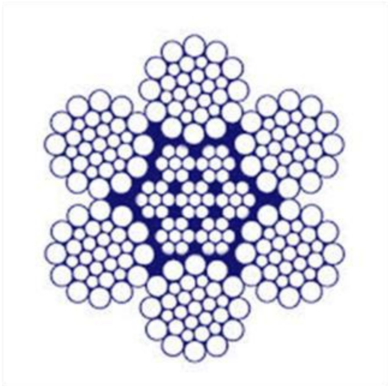
Wire Stranded Core (WSC)

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)





Grades of Wire Rope

Wire Tensile Strength/Grade

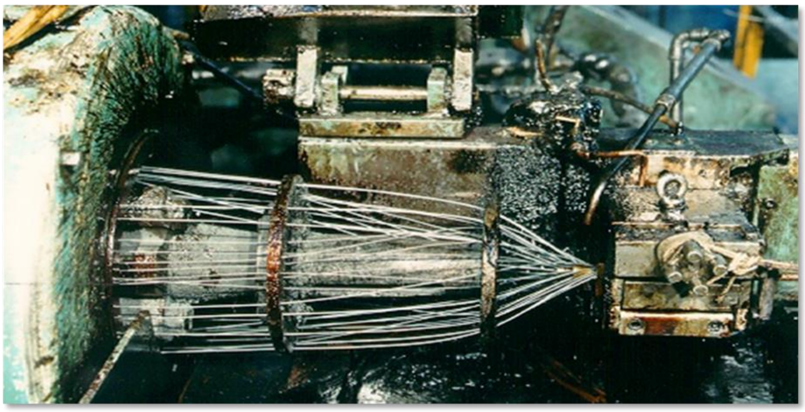
The grade of the wire rope based upon the tensile strength of the wires in N/mm^2.

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

Note: Rope Grade 2160 is not covered by European Standards.

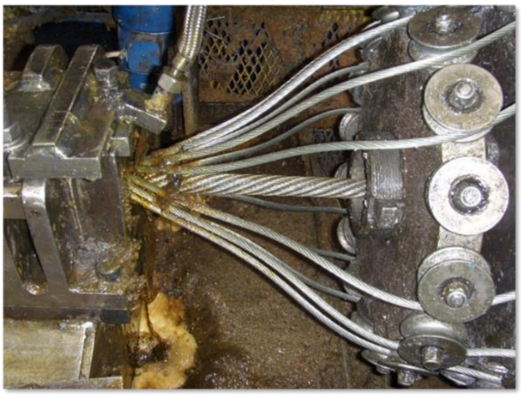
Stranding

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.

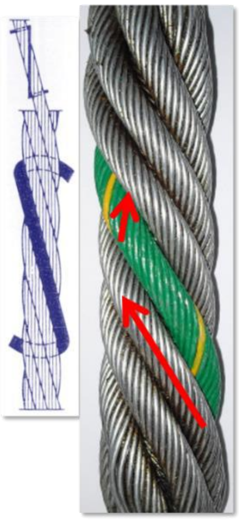
- Results in a relatively inert (dead) rope
- Resistant to kinking
- Easy to handle so when such a rope is cut:
    - Wires will stay in position
    - Broken wires do not stick out
    - Less dangerous to the user
- Rope is more flexible

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 (regular) 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.



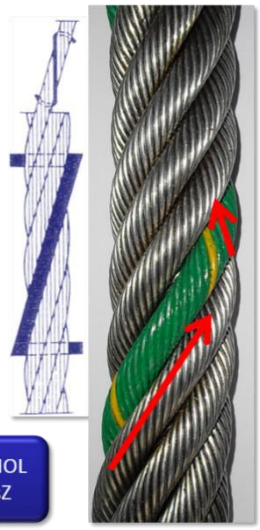
LHOL
zS

Ordinary Lay

Wires in the strands are laid in the opposite direction of lay to the strands in the rope.

The lower-case letter indicates the direction of the wires and the capital letter, the direction of the strands.

Note: Ordinary Lay ropes will be letter designated with different letters.



RHOL
sZ

LHLL
sS

Lang's lay

Wires in the strands are laid in the same direction of lay as the strands in the rope.

Not suitable for the manufacture of wire rope sling legs.

Note: Lang's Lay ropes will be letter designated with the same letters.

RHLL
zZ

Lang's Lay

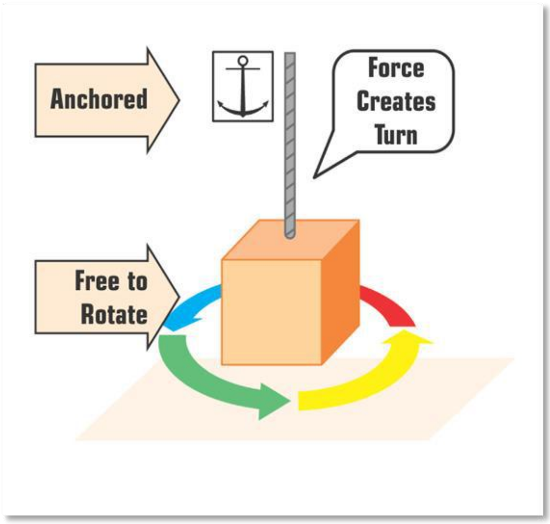
- The advantage of Lang's lay is that this construction offers a much better wearing surface than ordinary lay
- Lang's lay rope is more flexible than one of ordinary lay
- Its disadvantage is that it can only be used in applications where both ends of the rope are secured, such as a lift or multi-fall 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

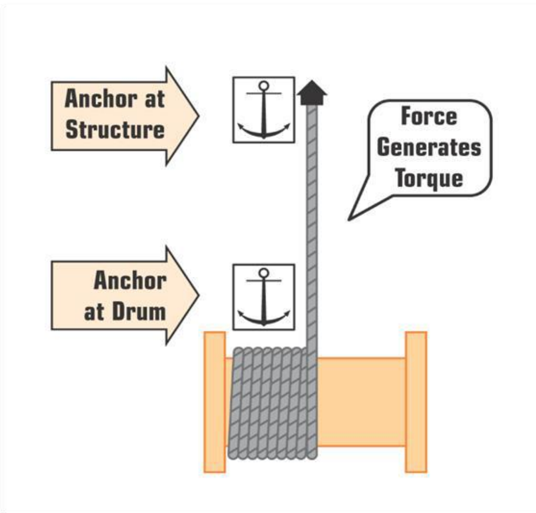
Low-Rotating Rope

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:

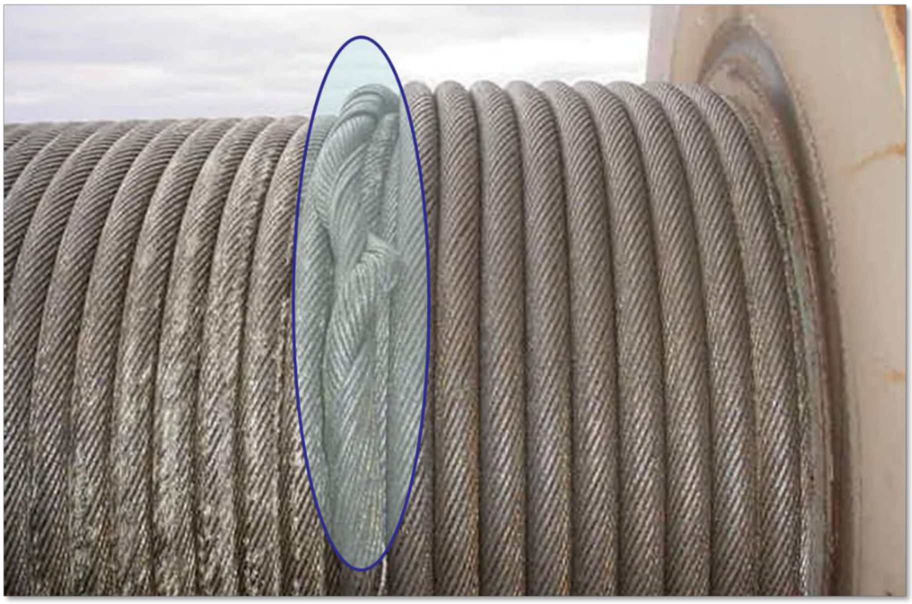
- An undesirable characteristic especially on long multi-fall hoist blocks where it can cause the bottom block to twist
- It may be overcome by using what is known as a multi-strand rope, which has low-rotating qualities by having two or three layers of 7 wire 1-6 strand laid in opposite directions



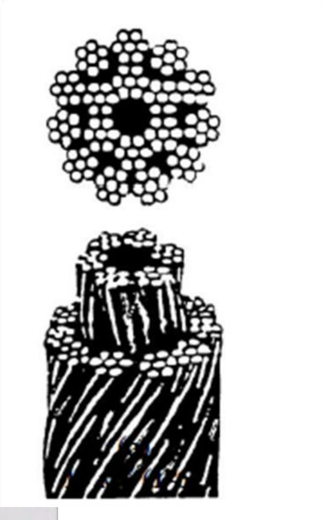


Notes:

Effect of Rope Rotation



Low-Rotating Rope



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.

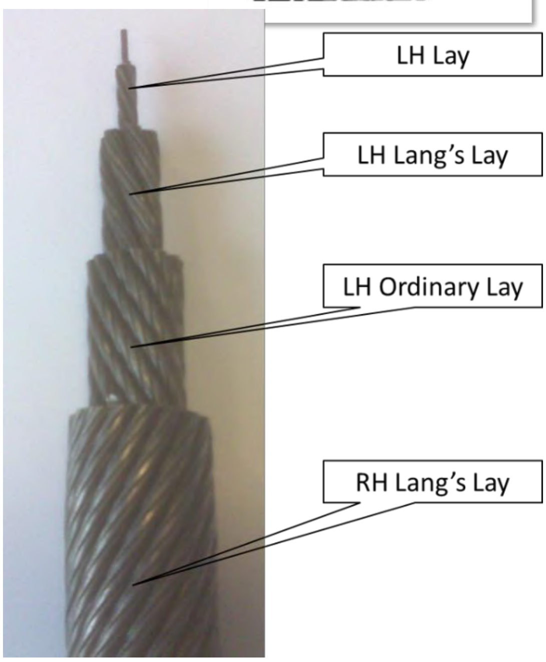
The construction is 11 strands/6 strands/1 strand all 7 wire 1-6.

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

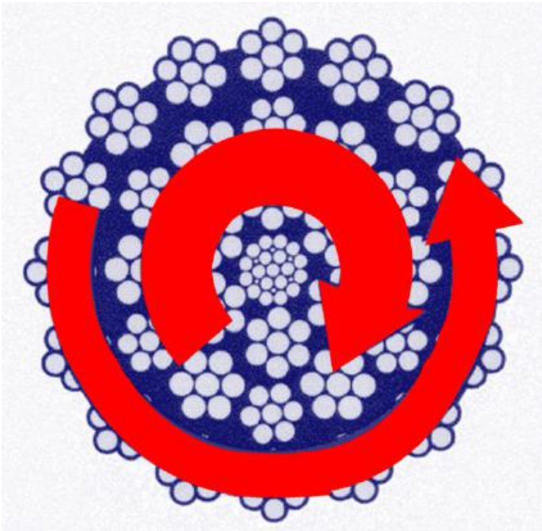
A more flexible version is the 34 x 7 (1-6), which is simply a 17 x 7 with an additional layer of seventeen strands laid around it.

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

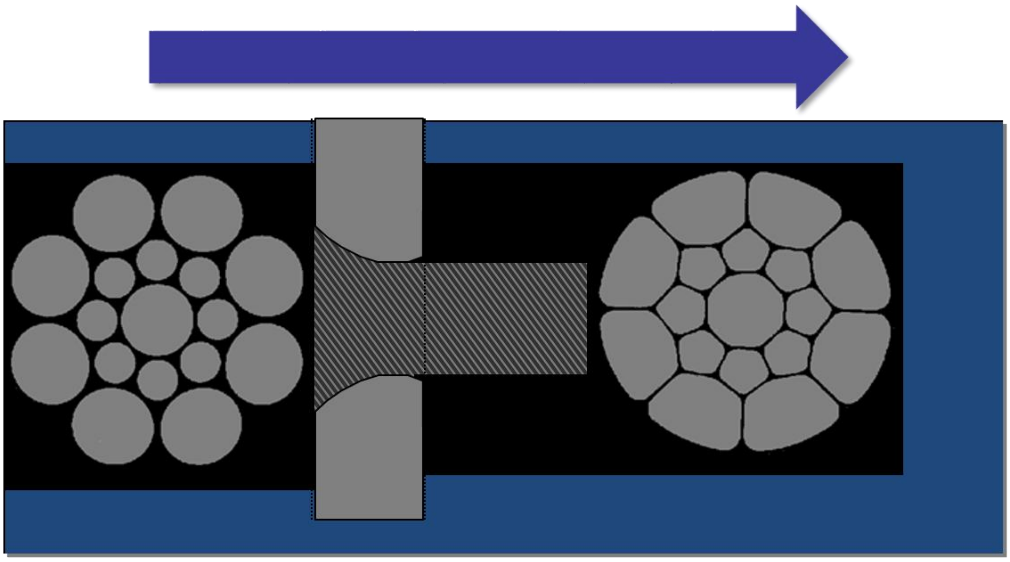
The layers of strands are laid in opposing directions to prevent the rope from spinning under load.



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

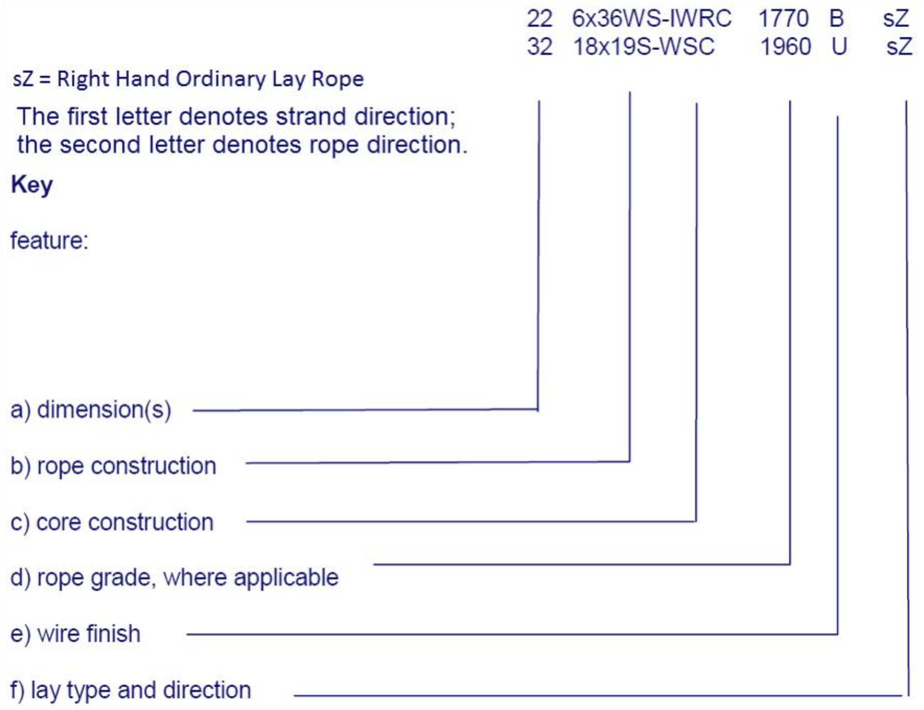
Rope Finish

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



Wire Rope Examination

Safe operation of manual lifting machines 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, not withstanding 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 powered 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

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

Wire Rope Examination

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

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.

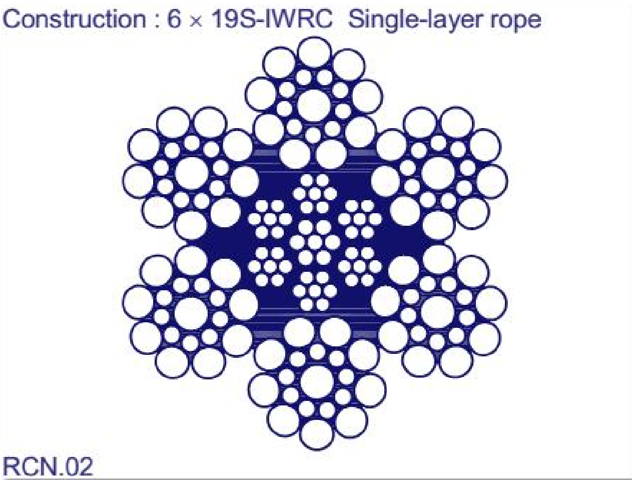
All examinations shall take into account these individual factors, recognising the particular criteria.

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.

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

Notes:

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.

Wire Rope Examination

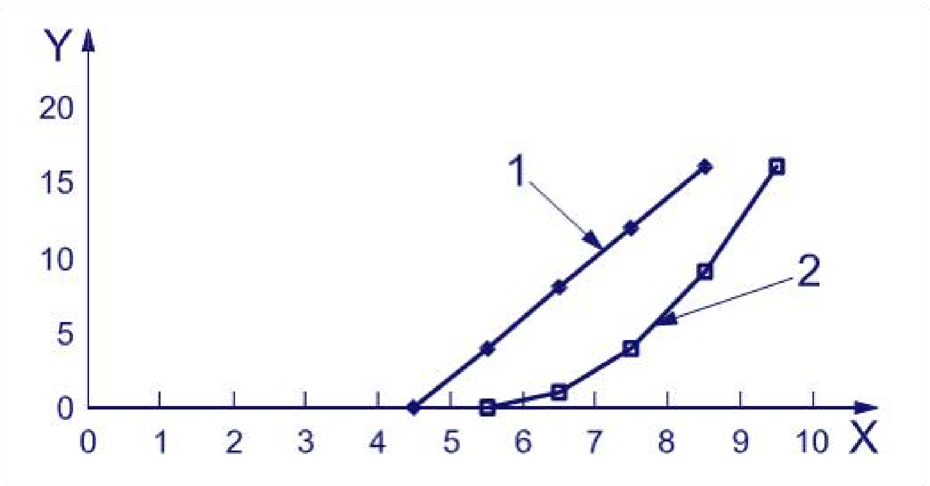
The Competent Person can find it prudent to initiate or recommend more frequent periodic inspections than those required by legislation.

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

Broken Wires

- Check entire length of the rope!
- Crane wire ropes do not have an indefinite life
- In 6 or 8 strand wire ropes, the wires tend to break at the surface
- In rotation resistant ropes, it is likely that the majority of broken wires will be internal
- One broken wire in a valley may be deterioration, but two or more should be considered grounds for discard
- Termination broken wires indicate high stress and therefore discard, although rope can be shortened if practicable

Decrease in Rope Diameter

Uniform Decrease Along the Rope

Discard criteria values for uniform decrease in rope diameter for sections of rope which spool on a single layer drum and/or run through a steel sheave.

Example:

Table 4 Uniform decrease in diameter signalling discard of rope Rope spooling on a single layer drum and/or running through a steel sheave

Rope type	Uniform decrease in diameter (expressed as % of nominal diameter)	Severity rating	
		Description	%
Single-layer rope with fibre core	Less than 6 %	—	0
	6 % and over but less than 7 %	Slight	20
	7 % and over but less than 8 %	Medium	40
	8 % and over but less than 9 %	High	60
	9 % and over but less than 10 %	Very high	80
	10 % and over	**Discard**	**100**
Single-layer rope with steel core or parallel-closed rope	Less than 3,5 %	—	0
	3,5 % and over but less than 4,5 %	Slight	20
	4,5 % and over but less than 5,5 %	Medium	40
	5,5 % and over but less than 6,5 %	High	60
	6,5 % and over but less than 7,5 %	Very high	80
	7,5 % and over	**Discard**	**100**

- **Rotation-resistant rope – 5% maximum wear**

Notes:

Calculation of Wear on Rope

Calculation 1

For a 40mm diameter 6 x 36-IWRC rope having a reference diameter of 41.2mm and measuring 39.5mm at inspection, the percent decrease is equal to.

Formula:

$$\% \text{ Wear} = \frac{(\text{Ref Dia} - \text{Measured Dia})}{\text{Nominal Dia}} \times 100$$

So

$$\frac{(41.2 - 39.5)}{40} \times 100 = \% \text{ Wear}$$

% Wear = 4.25%

Note: From Table 4, the severity rating for uniform decrease in diameter is 20% towards discard (i.e. slight).

Note: Discard is reached when the rope decreases from reference diameter by an amount equivalent to 7.5% of nominal diameter, i.e. 3mm. In this case, diameter at discard would be 38.2mm.

Calculation 2

For a 40mm diameter 6 x 36-IWRC rope having a reference diameter of 41.2mm and measuring 38.5mm at inspection, the percent decrease is equal to.

Formula:

$$\% \text{ Wear} = \frac{\text{Ref Dia} - \text{Measured Dia}}{\text{Nominal Dia}} \times 100$$

So

$$\frac{(41.2 - 38.5)}{40} \times 100 = \% \text{ Wear}$$

% Wear = 6.75%

Note: From Table 4, the severity rating is 80% (i.e. very high).

Notes:

Heating and Arcing Damage

Ropes that are not normally operated at temperature, but have been subjected to exceptionally high thermal effects, externally recognizable by the associated heat colours produced in the steel wires and/or a distinct loss of grease from the rope, shall be immediately discarded.

If **two or more wires** have been affected locally, due to electric arcing, such as that resulting from incorrectly grounded welding leads, the rope shall be discarded. This can occur at the point where the current enters or leaves the rope.

Reduction of Rope Diameter Resulting from Core Deterioration

Reduction of rope diameter resulting from deterioration of the core can be caused by;

a) Internal wear and wire indentation
b) Internal wear caused by friction between individual strands and wires in the rope, particularly when it is subject to bending
c) Deterioration of a fibre core
d) Fracture of a steel core
e) Fracture of internal layers in a rotation-resistant rope

If these factors cause the actual rope diameter to decrease by 3% of the nominal rope diameter for rotation-resistant ropes, or by 10% for other ropes, the rope shall be discarded even if no broken wires are visible.

Note: New ropes will normally have an actual diameter greater than the nominal diameter.

External Wear

Abrasion of the crown wires of outer strands in the rope results from rubbing contact, under pressure, with the grooves in the sheaves and drums. The condition is particularly evident on moving ropes at points of sheave contact when the load is being accelerated or decelerated, and is revealed by flat surfaces on the outer wires.

Wear reduces the strength of ropes by reducing the cross-sectional area of the steel strands. If, due to external wear, the actual rope diameter has decreased by **7%** or more of the nominal rope diameter, the rope shall be discarded even if no wire breaks are visible.

External and Internal Corrosion

General
Corrosion occurs particularly in marine and polluted industrial atmospheres. It will diminish the breaking strength of the rope by reducing the metallic cross-sectional area, and it will accelerate fatigue by causing surface irregularities which lead to stress cracking. Severe corrosion can cause decreased elasticity of the rope.

External Corrosion
Corrosion of the outer wires can often be detected visually. Wire slackness due to corrosion attack/steel loss is justification for immediate rope discard.

Internal Corrosion
This condition is more difficult to detect than the external corrosion which frequently accompanies it, but the following indications can be recognized:

a) Variation in rope diameter; In locations where the rope bends around sheaves, a reduction in diameter usually occurs. However, in stationary ropes it is not uncommon for an increase in diameter to occur due to the build-up of rust under the outer layer of strands

b) Loss of clearance between the strands in the outer layer of the rope, frequently combined with wire breaks between or within the strands

Confirmation of severe internal corrosion is justification for immediate rope discard.

Deformation

General
Visible distortion of the rope from its normal shape is termed "deformation" and can create a change at the deformation position which results in an uneven stress distribution in the rope.

Waviness
Waviness is a deformation in which the longitudinal axis of the wire rope takes the shape of a helix under either a loaded or unloaded condition. While not necessarily resulting in any loss of strength, such a deformation, if severe, can transmit a pulsation resulting in irregular rope drive. After prolonged working, this will give rise to wear and wire breaks.

Waviness

The rope shall be discarded if, under any condition, either of the following conditions exists (see Figure 10 below):

a) On a straight portion of rope, which never runs through or around a sheave or spools on to the drum, the gap between a straight edge and the underside of the helix is 1/3 x d or greater
b) On a portion of rope, which runs through a sheave or spools on to the drum, the gap between a straight edge and the underside of the helix is 1/10 × d or greater

d = rope diameter

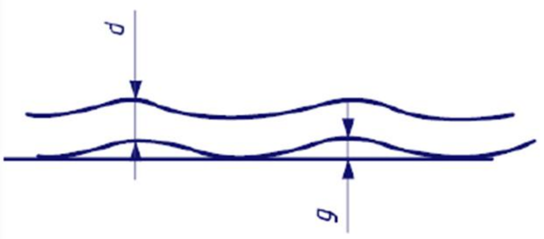


Figure 10 — Waviness of rope

g = gap

Notes:

Local Increase in Rope Diameter

If the rope diameter increases by **5% or more for a rope with a steel core** or **10% or more for a rope with a fibre core** during service, the reason for this shall be investigated and consideration given to discarding the rope.

Note: An increase in rope diameter that might affect a relatively long length of the rope, such as that resulting from the swelling of a natural fibre core, can occur due to excessive absorption of moisture, creating imbalance in the outer strands, which become incorrectly oriented.

Other Conditions which affect the safe use of wire are listed below:
(this list is not exhaustive):

- Basket or lantern deformation
- Core or strand protrusion/distortion
- Wire protrusion
- Flattened portions
- Kinks or tightened loops
- Bends

Lubrication

Correct lubrication of wire ropes is essential if the ropes are to give satisfactory service. Good lubrication not only prolongs the life of the rope but also helps to reduce friction and preserves the internal parts.

All ropes are lubricated internally, and nearly all externally, during manufacture but care should be taken to see that an **approved neutral lubricant** is externally applied at frequent intervals during use and, if practicable, whilst not in use.

Thinner types of lubricant have the best lubricant qualities but if the rope is constantly exposed to the elements or to water, the heavy, thicker lubricants are more suitable. For certain applications dry lubricants may be preferable but in all cases the lubricant must be acid free in nature.

Wire ropes should be clean and dry before lubricants are applied.

Combined Effect Assessment

- Although broken wires are a common reason for discard, deterioration often results from a combination of factors

- In such cases, the Competent Person needs to:
  - Take account of the different modes of deterioration, particularly when they occur at the same location in the rope;
  - Make an overall assessment of the "combined effect" of the different modes of deterioration;
  - Decide whether the rope is safe to remain in service and, if so, whether it needs to be subjected to any revised inspection/discard provisions

- One method of determining the combined effect is as follows:

  - Inspect the rope and record the type and amount of each individual mode of deterioration, e.g. number of broken wires in 6d, decrease in diameter in millimetres and extent of corrosion

  - For each of these individual modes of deterioration, rate the severity and express it either as a percentage of the respective individual discard criteria, e.g. if 40% of the allowable number of broken wires according to the individual discard criteria are found to exist, this represents a rating of 40% towards discard, or in words, e.g. slight, medium, high, very high or discard

  - Either add together the individual ratings at selected locations, only when they occur at the same location and express the severity as a combined per cent value or make a judgement as to the combined degree of severity and express the rating in words, e.g. slight, medium, high, very high or discard

Notes:

Rope Examined Record

- For each periodic or special examination, the examiner shall provide a record containing information relating to the examination
- (Form 1 – ISO 4309) can be viewed for typical examples of examination records

Rope Storage and identifications

Clean, dry and non-polluted storage shall be provided to prevent deterioration of rope not in use. Means shall be provided to enable ropes to be clearly identified with respect to their examination records.

Methods of Forming Eyes

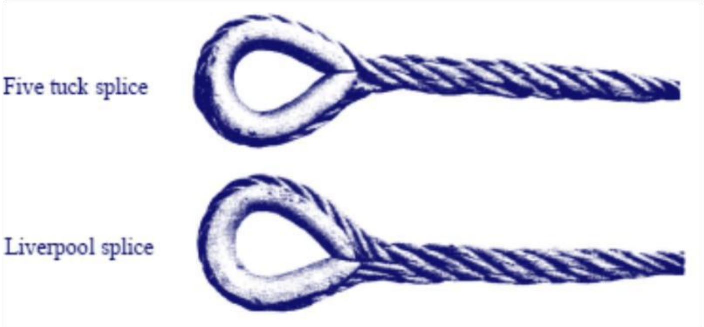
In order that hoist wire ropes may be used for lifting purposes it is generally necessary that end fittings of one kind or another be attached. This is often achieved by forming an eye that allows for the insertion of a link etc.

- For single part ropes as used on powered hoists there are three ways in which the eye can be secured:
    - Splicing
    - Grips
    - Ferrule secured eyes
- These forms of end termination are rare and usually seen on older hoists
- Wire rope grips are used in conjunction with a wedge type socket

Notes:

Spliced Eyes

Splicing: opening the strands at the end of the rope and weaving them between the strands of the standing part so that they lock and do not slip when a load is applied.



Recommended: Five Tuck or Dock Splice

Not to be used: Liverpool Splice

Grips

- Commonly known as "Bulldog Grips"
- Found commonly on winches to make temporary eyes
- Practice always been found questionable as safety of the eye depends on several variables:
    - Number of grips used
    - Spacing of the grips
    - Which way the grips are fitted
    - The torque applied to tighten the grips
    - Wide range of different qualities and types available
    - Competency of the person making the eye

- Following testing by HSE in 1991, BS462 (Hot Dip Galvanised Malleable Wire Rope Clips) was immediately withdrawn
- BS462 did not provide torque settings and provide a maximum of 50% efficiency but DIN1142 grips achieved a maximum grip efficiency achieved of 80%
- **Note: In Germany, the DIN1142 standard prohibits the use of grips for lifting applications**

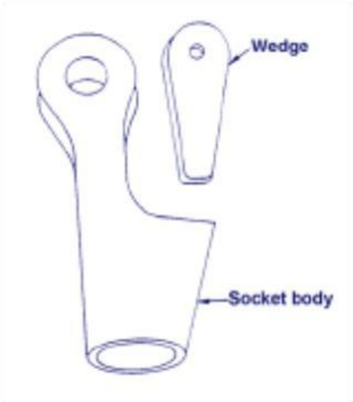
For LEEA Best Practice Guidelines: See Unit 6-7u page 28.

Notes:

Ferrule Secured

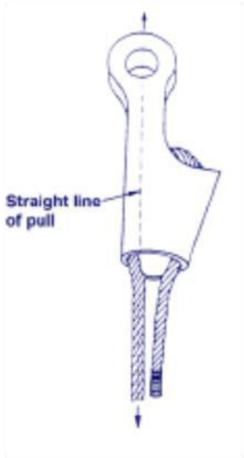
- As with wire rope grips used to form a termination, this method used to be found on older type wire rope hoists but is now very rare.
- Ferrule secured eye made using the turn-back-loop method and securing with a compressed ferrule forming a homogenous joint
- Today, the use of this termination is mainly used in winching operations

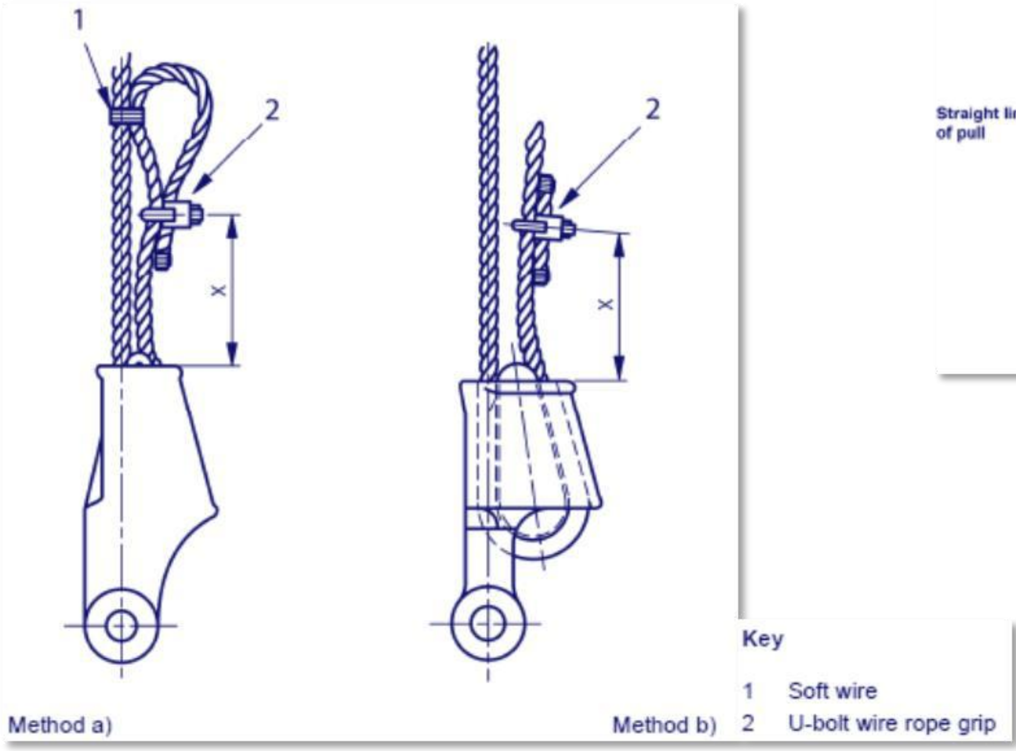
Asymmetrical Wedge Socket



- Live side of the load rope enters the straight edge of the socket in line with the load pin
- The line of pull is then in axial alignment and kinking / cutting of the rope is prevented
    - **BS EN 13411 – 6: 2004 refers**

Section C.2.10 (a&b) of BS EN 13411 allows for two methods of securing the dead end of the rope, preventing it from being pulled through the wedge:

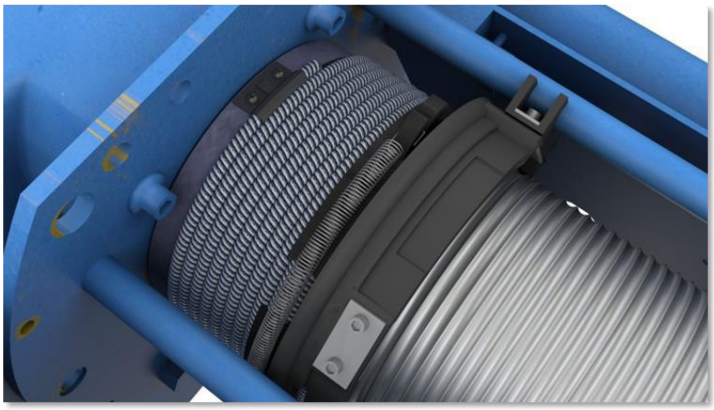


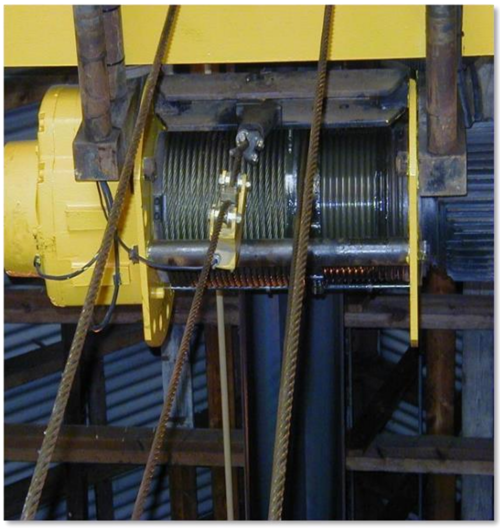


Rope to Rope Drum Connection

- Rope fastening onto the rope drum shall be made in such a way that at least 2.5 times the remaining static force at the fastening device is accommodated when the rated capacity of the hoist is applied to the hoist taking into account the friction effect of the winding on the drum

- There shall be at least two rope windings remaining on the drum before the fixing point of the rope
  - The fastening elements of the fixing point of the rope shall be selected taking into account the rope and drum contours





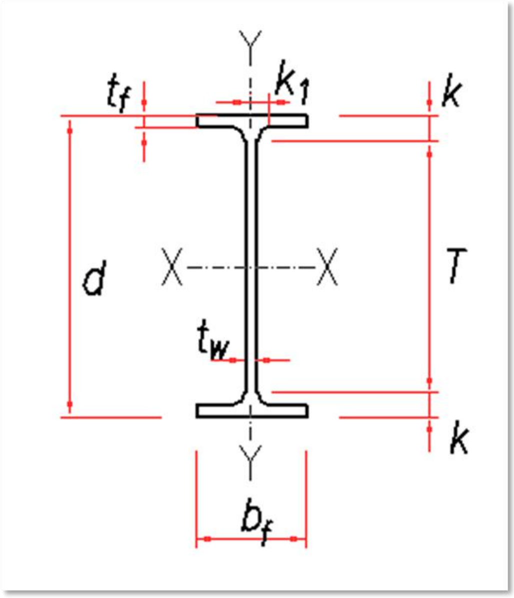
- Anchorages on the rope shall resist 2.5 times the static rope force resulting from the rated capacity of the hoist without permanent deformation

- Terminations can include:
  - Asymmetric wedge socket to BS EN 13411-6
  - Symmetric wedge socket for rope diameters up to 8mm to BS EN 13411-7
  - Metal and resin sockets to BS EN 13411-4
  - Wire rope clamps to BS EN 13411-3

- **Wire rope grips and rope eyes in conjunction with wire rope grips cannot be used as rope-end terminations!**

Notes:

5. Materials



The Competent Person must be familiar with materials and sections used for cranes and their supporting structures.

Design and verification standards:

BS EN 1993 (Part 6) – applies to crane supporting structures manufactured from rolled steel sections:

- The standard provides design rules for the structural design of runway beams and other crane supporting structures

- It covers overhead crane runways inside buildings and outdoor crane runways, including runways for:
    - Overhead travelling cranes, either
    - Supported on top of the runway beams
    - Underslung below the runway beams
    - Monorail hoist blocks

Note: The standard does not cover special sections or proprietary track systems.

BS EN 13001 Cranes – General Design

- Part 1 – General Principles and Requirements
- Part 2 – Load Actions
- Part 3.1 – Limit States and Proof of Competence of Steel Structures
- Part 3.2 (draft) – Limit States and Proof of Competence of Wire Ropes and Reeving Systems
- Part 3.3 (draft) – Limit States and Competence of the Wheel/Rail

Notes:

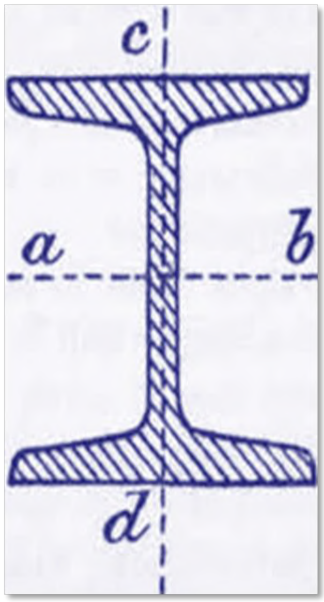
Steel Section

The following materials will be explored in this unit:

1. Rolled Steel Joists
2. Universal Beams
3. Universal Columns
4. Rolled Steel Angle
5. Rolled Steel Channel
6. European Sections
7. Steel squares, flats and plates
8. Hollow sections and tubes
9. Rail sections

Competent Person must be able to identify various beam sections by measurement so that design checks and calculations can be carried out if required.

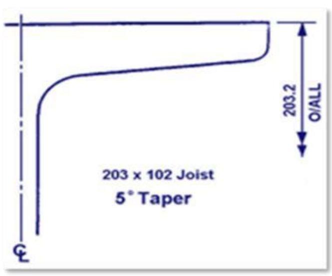
Rolled Steel Joists

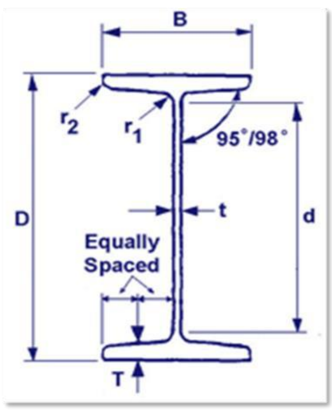


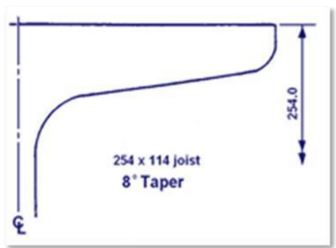
BS4: 1980

- Tapered flanges
- RSJ's 5" x 3" and above are now superseded by universal beams
- Better suited to supporting structures for under-slung cranes
    - Greater thickness at the root than with other sections
    - Much greater strength to resist the transverse bending due to the runners
- Replaced by the universal beam which is stronger, weight for weight

RSJ Section Features



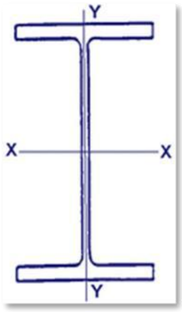




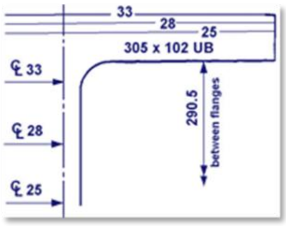
Notes:

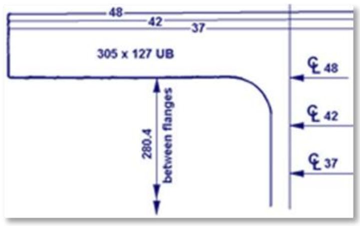
Universal Beams

BS4: 2005 (Part 1)



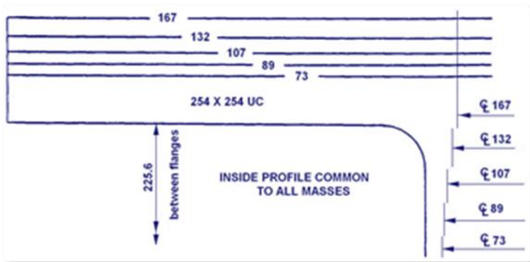
- Parallel flanges
- Each nominal size has varying weights
  - Outer rolls adjusted during rolling to thicken flanges and webs for larger beam sections
- Older UBs were rolled with a tapered flange of just under 3°
  - Important to note if friction grip bolts are used! These will not grip efficiently





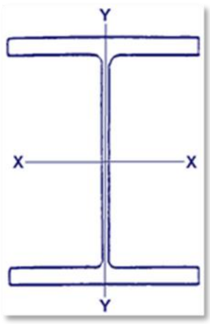
Universal Column

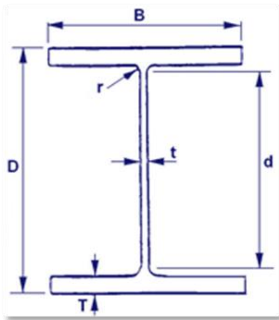
- Found on some cranes but mainly used for supporting structures



BS4:2005

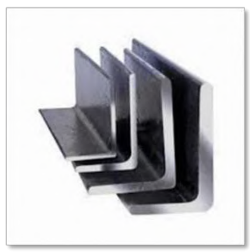
- Square section but can be made with very thick flanges
  - Suitable for high transverse stresses due to wheel loadings
- More likely to be used as supporting columns in supporting structures





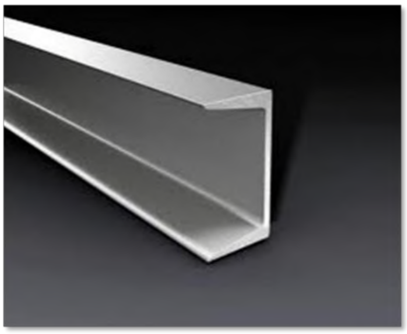
Rolled Steel Angles

- Generally used as strengthening ribs, particularly in box section crane girders
- Found in service as bracings for lattice structures

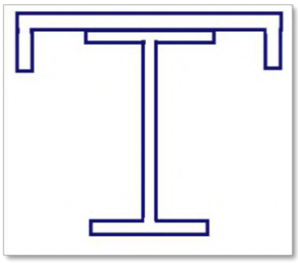


- Can be found in between gantry support columns as strengthening braces

Rolled Steel Channel

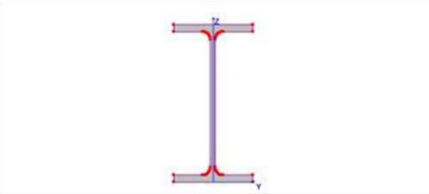


- Used for strengthening standard beam sections
- Mainly used to cap a beam which increases strength in X and Y planes

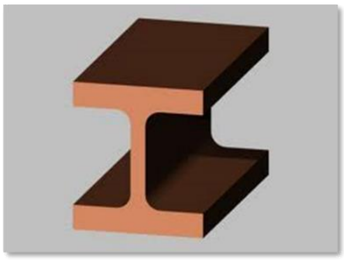


- Using a capped beam (composite section) achieves spans in excess of those that can be achieved using standard universal beams

European Sections

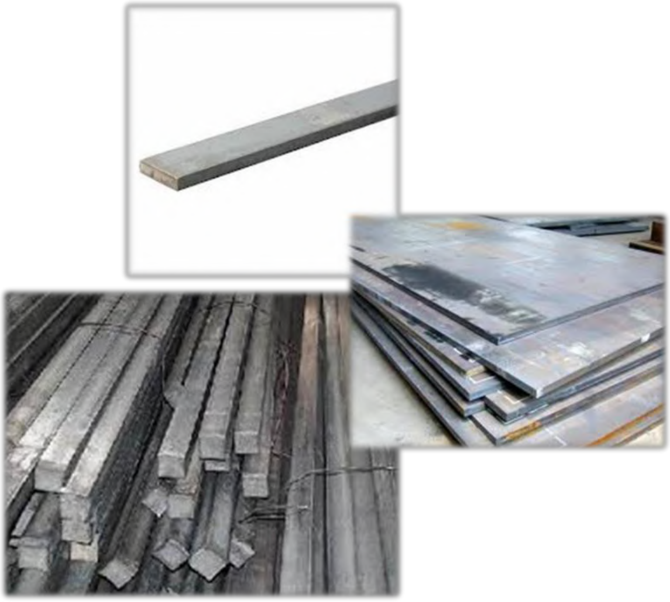


- Can be used as an alternative to Universal Beams
- IPE sections
    - DIN 1025
    - EN 19-57 (Dimensions)
    - EN 10034 (Tolerances)



- HE – European Wide Flange sections
    - HEA, HEB and HEM sections available

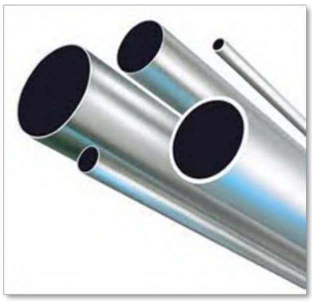
Squares, Flats and Plates

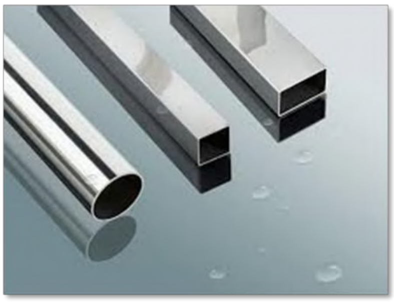


- Sometimes used as strengthening members
- A cost-effective alternative to standard crane rail sections

Hollow Sections and Tubes

Generally used as supports in structures.



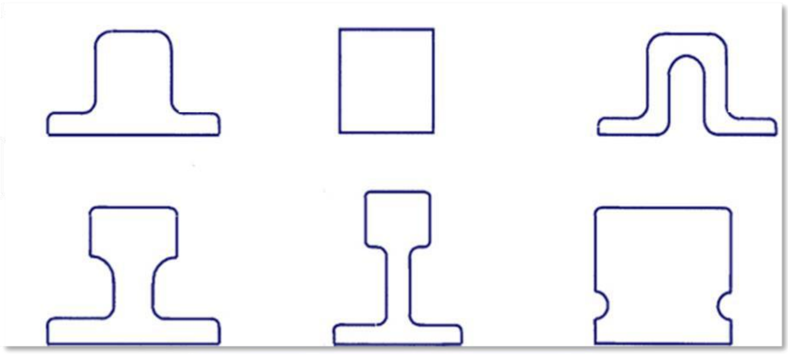


Rail Sections

DIN 536-199

BS EN 13674-1

Available in a variety of sizes to suit standard crane wheels.

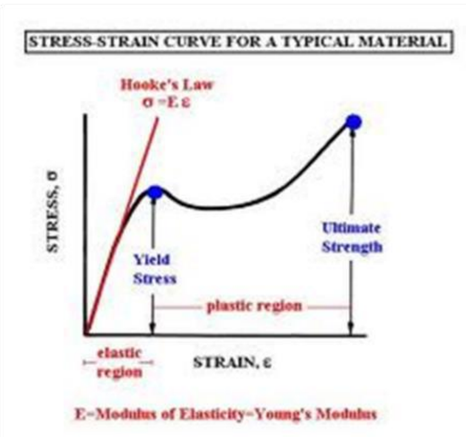


Various Types of Rail Used

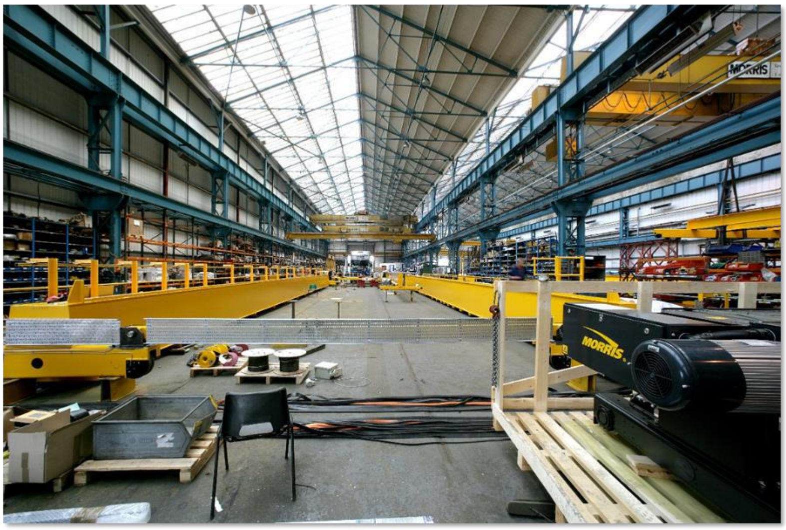
The steel sections we have looked at are available in varied grades:

1. S235
2. S275
3. S355

The grade number indicates the maximum yield strength (elastic limit) of the material.



6. Crane Construction



Crane Bridges

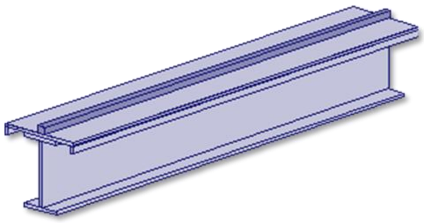
- Previously, bridge beams were designed to **BS2573-1**
    - This was replaced by the **EN13001** series of standards which use 'limit states' for design

Overhead crane bridges can be constructed in various ways, the most common of which are as follow:

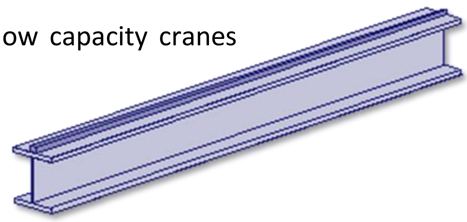
Lattice

- Not usually manufactured nowadays
- A composite of metal beams, channels and angles
- Hot riveted or thread locator bolted connections
- High strength, minimum weight, but complex

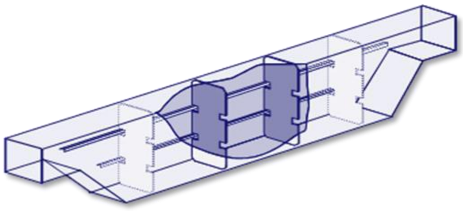
Rolled Section



- Readily available from steel-stock holders
- Profiles can be purchased in a variety of shapes and sizes
- Can be used in as stand-alone profiles (e.g. UB or HEA sections) or combined with rolled steel channels to improve sectional properties, keeping manufacturing costs relatively low
- This type of bridge section is most commonly used for low capacity cranes and/or short span construction



Box Girder



- Desirable when a high strength to weight ratio is required

- Generally constructed from sheet steel with internal rolled steel angles to provide support to the webs of the beam and prevent the plates from buckling

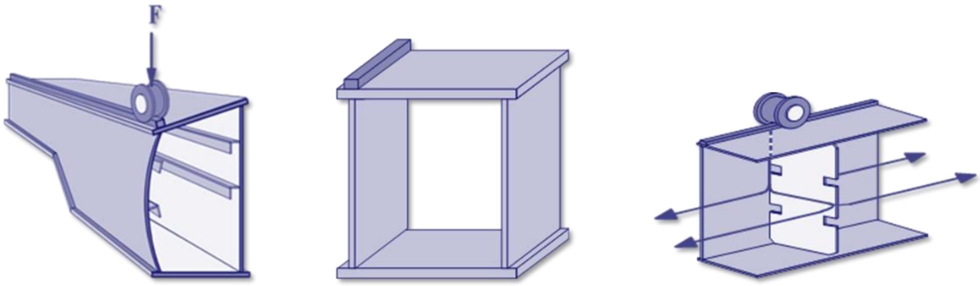
- Internal diaphragms in the box make it stronger in vertical and horizontal loading and prevent it from buckling under load

- Suitable for single or double girder crane configurations
    - Single girder configuration carries an under-slung hoist and therefore it is usual for the bottom flange to be fabricated from thicker steel plate in order to compensate for transverse flange bending resulting from the wheel loadings

Box Girder

- Double girder configuration
    - In order to maintain the structural integrity of the beam under load, the cross traverse rail needs to be central to one of the web plates

    - This will result in an eccentric loading being applied to the girder which is accommodated by the high torsional rigidity properties of the structure

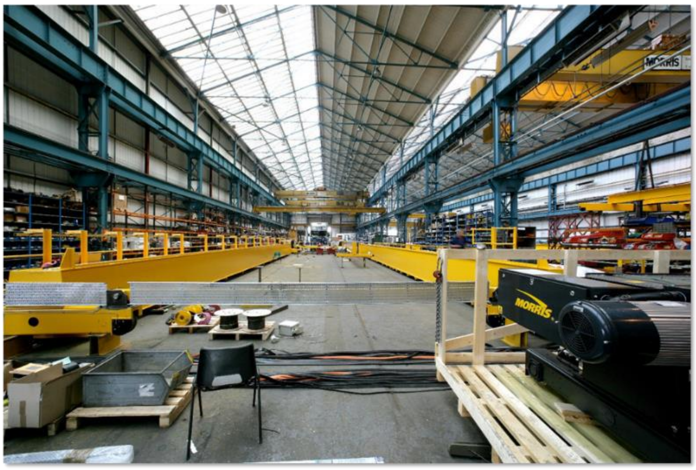


Spliced Bridge Beams

- Some cranes may be split for transportation due to long girder lengths and the availability of suitable transport modes

- Shipping containers are limited to approximately 40 feet long (~12 metres) for overseas transportation and therefore main girders have to be reduced in length

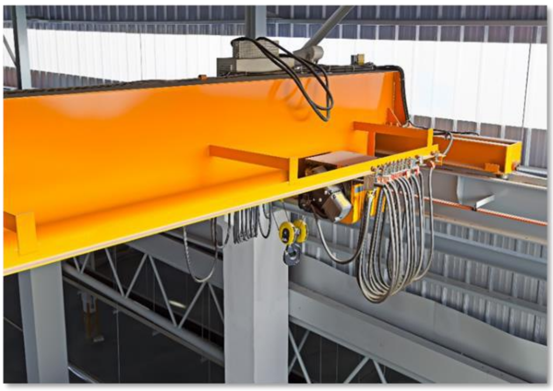

7. Crane Configuration

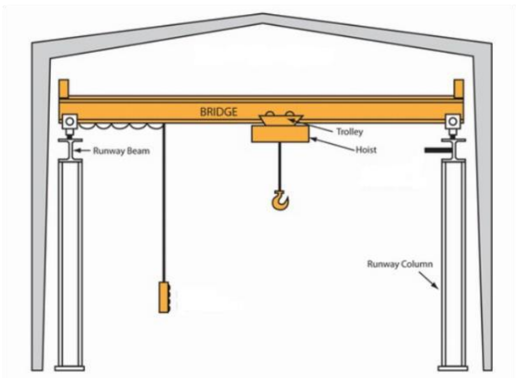


Crane Construction/Configuration

Single Girder Crane

- Fitted with an under-slung hoist unit (normal or low headroom configuration) and are used generally for lower capacity or short span applications





Double Girder Crane

- Fitted with a traversing trolley (sometimes referred to as a 'crab') mounted between the two girders on crane rails
- Used generally for higher load capacities and longer spans


Portal Crane (Goliath)

- Can be of single or double girder configuration
- Main advantage of the crane running on ground tracks is that an overhead steel gantry is not required
  - Most suitable for outdoor applications where lifting facilities are provided
  - No requirement for additional support steelwork and increased cost
- Also suitable for indoor applications where existing building structures are not capable of taking overhead travelling cranes or where additional support steelwork would reduce floor area


Notes:

Semi-Portal Crane (Semi-Goliath)

- Configured to run one end carriage of the crane on overhead gantry steelwork

Underslung Crane

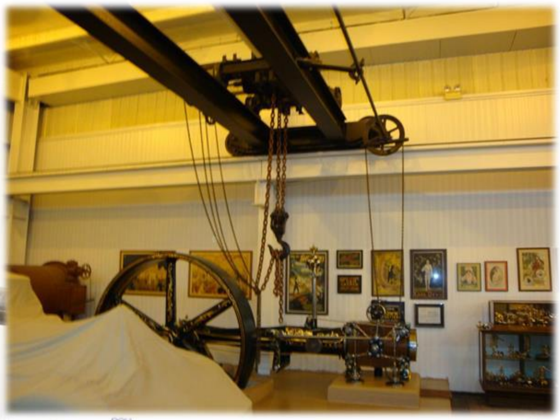
In single or double girder configuration and runs on the lower flange of a runway beam that is mounted to an overhead supporting structure.

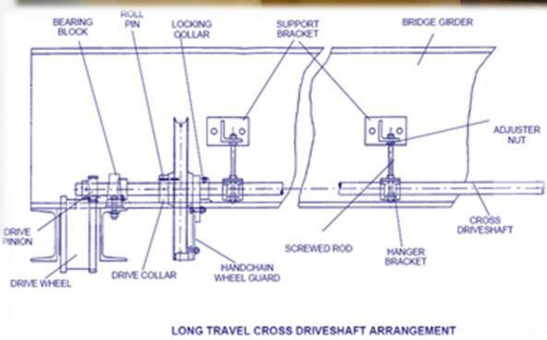
Wall Travelling Crane

- In single or double girder configuration and runs on the lower flange of a runway beam that is mounted to an overhead supporting structure

Manually Operated Cranes

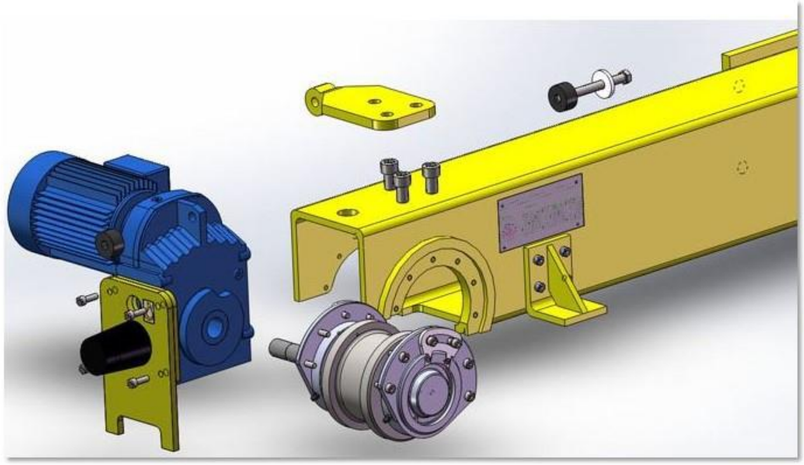
- BS EN 13157 refers to cranes – safety – hand powered winches and is relevant to manually operated overhead travelling cranes
- Can be single, double and under-slung crane types
- Primary drive for the long travel and cross traverse can be a simple push system or manually geared
- Normally used in applications where a low-capacity or maintenance type crane is required
- Push travel cranes are limited to the amount of force that an individual would have to apply to the load in order to control its movement
- Manually geared cranes allow heavier loads to be moved but the amount of force applied still needs to be restricted to the capabilities of the individual
- The system will move the load slowly which makes them ideally suited for maintenance only applications



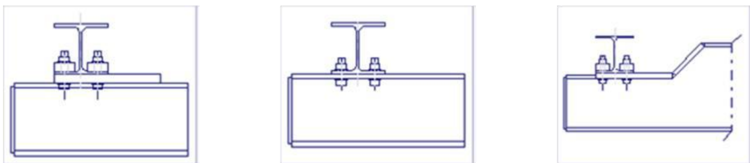


Notes:

8. End Carriages



Underslung End Carriages

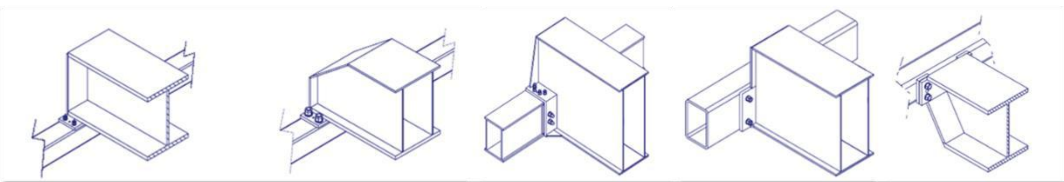


End Carriages

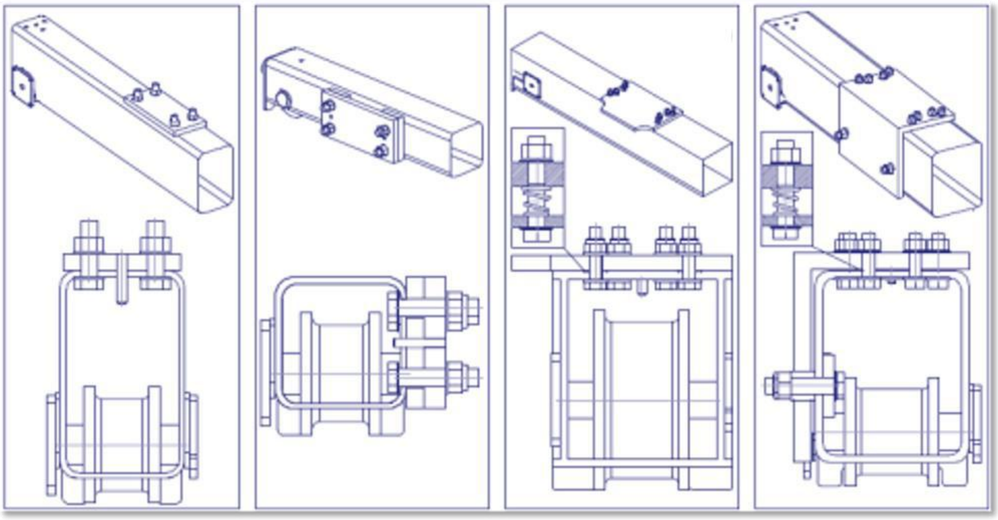
The main girder(s) of a crane can be fitted to the end carriages by one of two common methods:

- **Top connection**
- **Side connection**

The decision as to which method is used is normally the preferred method of the manufacturer and/or technical constraints (work envelope).



Typical End Carriage to Bridge Connections

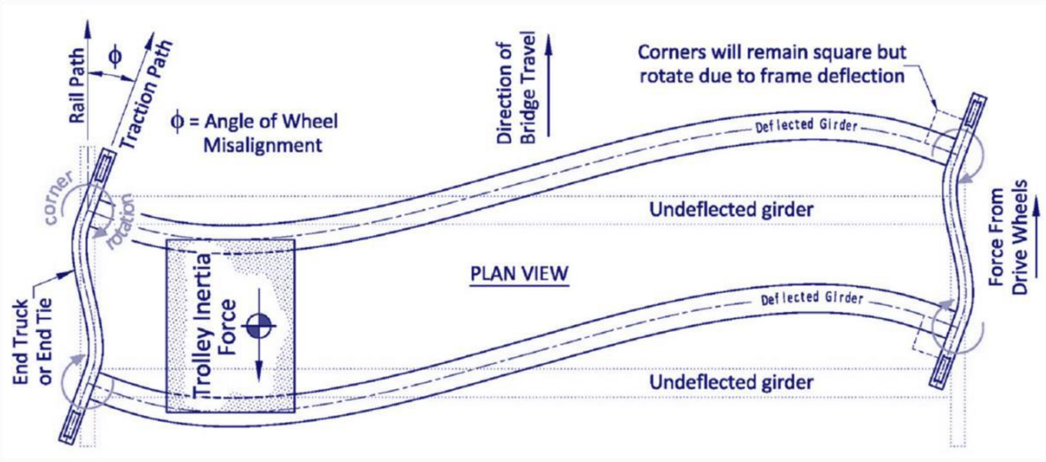


Skew Loading

- Skew loads due to travelling
  - When two wheels (or two bogies) roll along a rail, the horizontal forces normal to the rail and tending to skew the structure shall be taken into consideration
  - The end carriage wheelbase must be sufficient to minimise skew loadings on the supporting structure from the crane (BS 2573 Pt1 and BS EN 1991 Pt3 refer to evaluation of skew loadings)

Notes:

Consequence of Skew Loading



Bolts used for Connections

- Bolts used for bridge to end carriage connections should be of a minimum grade 8.8
    - In side mounted applications, manufacturers use a higher grade bolt due to increased tension and shear stresses. Grade 10.9 would be typical in this configuration

- Due to inherent vibrations within the crane, bolted connections must be formed so that the nuts are prevented from coming loose
    - 'Nyloc' nuts, full nut/half nut locking, serrated washers or split washers are used for this purpose

Note: When replacing or fitting connection bolts it is imperative that the manufacturers' instructions are followed with regard to type and torque settings.

End Carriage Buffers

- Each end carriage should be fitted with buffers to prevent the crane from heavy impact with the gantry end stops

- It is usual that the long travel motion of a power driven overhead crane will have electrical limit switches fitted in the control circuit of the travel motions

- End carriage buffers are usually made from rubber and polyurethane

Buffer Extensions

- Used to extend the length of the end carriage but not the wheelbase
  - Can be used to keep multiple cranes at a certain distance away from each other on the same gantry
  - They also accommodate the width of maintenance platforms on the crane and can also be used to limit crane wheel loadings in a particular span of the gantry beam

Anti-Collision

Machinery Directive s4.1.2.6: Where several fixed or rail mounted machines can be manoeuvred simultaneously in the same place, with risks of collision, such machinery must be designed and constructed in such a way as to make it possible to fit systems enabling these risks to be avoided.

Para. 342 Guidance: The risk of collision may exist when machines are used in the same area, such as, e.g. when two or more gantry cranes are installed in the same building. For lifting machinery intended to be used where this risk may exist, the manufacturer must ensure that the necessary anti-collision devices can be fitted to the machinery and provide the necessary fitting instructions.

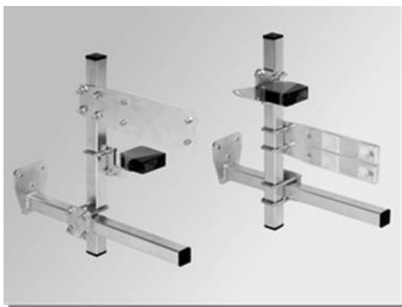
Remote Control Cranes

Machinery Directive s3.6.1: Remote control machinery which, under normal conditions of use, exposes persons to the risk of impact or crushing must be fitted with appropriate means to signal its movements or with means to protect persons against such risks.

Para. 323 Guidance: Where there is a risk of collision between remote controlled or driver-less machinery and persons. Such machinery must be equipped with appropriate means to signal its movements such as acoustic and/or visual warning devices.

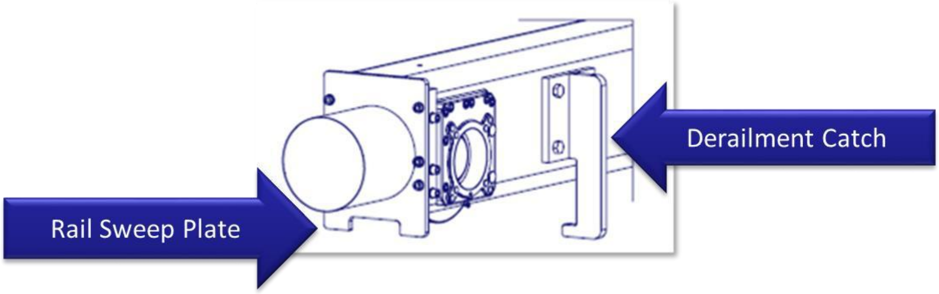
- Where necessary, *protective devices must be fitted to prevent collisions.
  - These can be mechanically or electrically operated

*We will revisit the subject of limit switches later in this training course



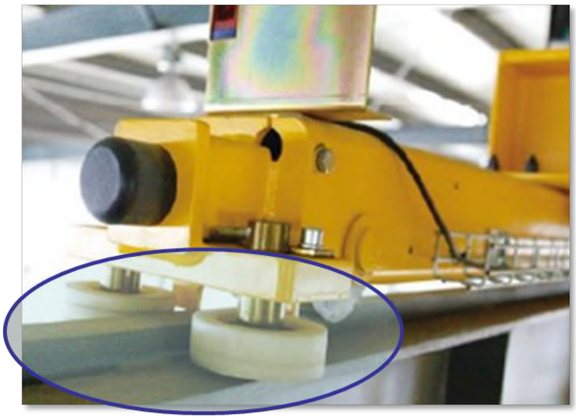
Derailment Facility

- Machinery must be provided with devices that act on the guide rails or tracks to prevent derailment
  - If despite such devices, there remains a risk of derailment or failure of a rail or running component (wheel flange) devices must be provided which prevent the equipment, component or load from falling or the machinery from overturning



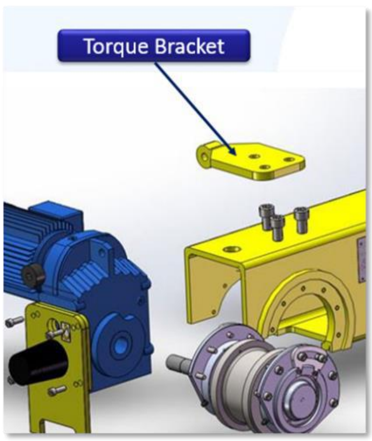
Guide Rollers

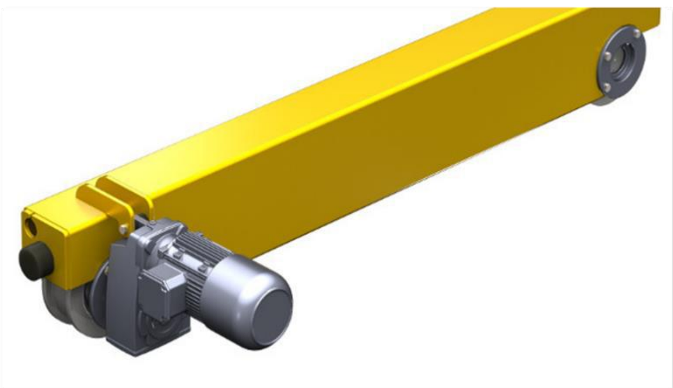
- May be fitted by some manufacturers
- Selected when flangeless wheels are used
- Designer will consider using this system if application requires it



Torque Brackets

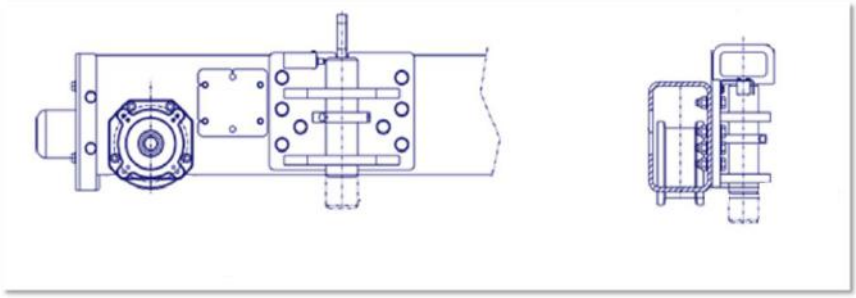
Used to prevent the starting torque of the motor putting undue stress on mounting bolts and gearbox connections:





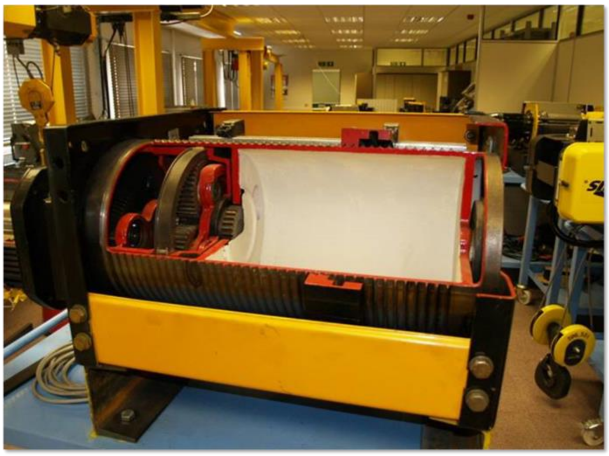
Storm Locks

Portal and Semi-Portal cranes must be fitted with storm locks where wind loadings could move the crane along its tracks when not in operation.



Notes:

9. Hoist Construction



Introduction to Electric Wire Rope Hoists

Irrespective of the manufacturer, the new generation of hoist units all tend to be very similar in their construction. In an extremely competitive industry, electric wire rope hoists must provide performance, reliability, flexibility, satisfy the BS and ISO requirements, and be reasonably priced.

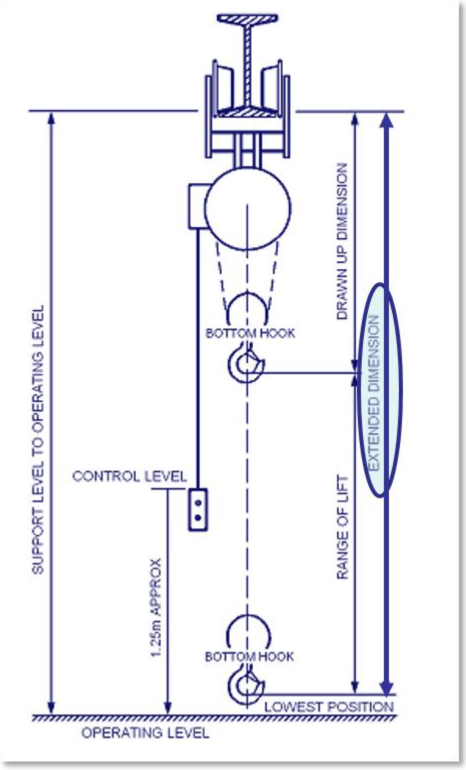
The earliest of these designs dates back some twenty-five years to a period when a lot of research and development was done.

In more recent times standard unit engineering practices have been adopted which enable a wide range of units to be produced from a small range of standard components. However, the general design principles remain the same.

Notes:

Definitions and Terminology

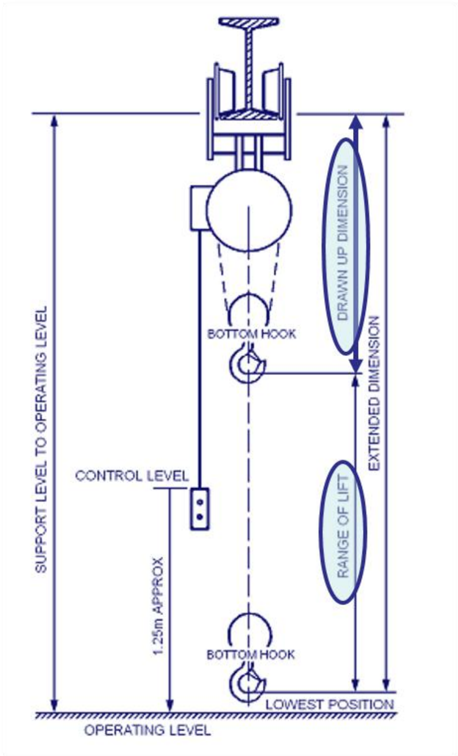
Extended Dimension
The extended dimension is the distance between the support level and the bottom hook seat in the extended position, as shown opposite:



Drawn up Dimension
The drawn-up dimension is the distance between the support level and the bottom hook seat when the bottom hook is in the raised position.

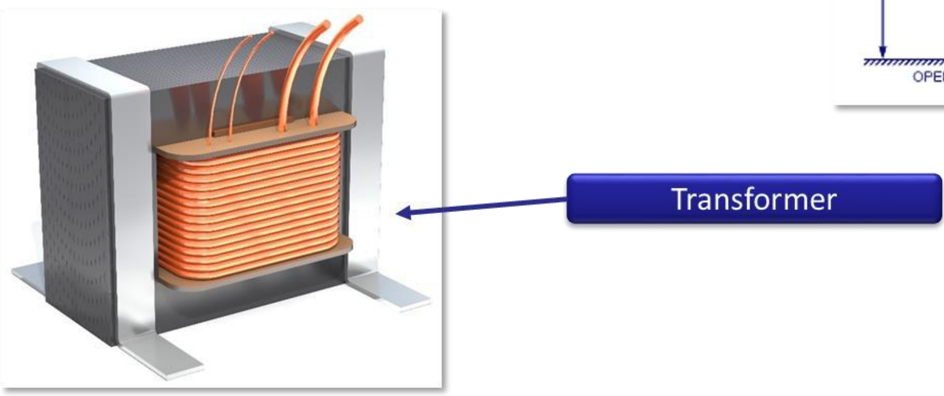
This is sometimes referred to as the 'headroom' as it is the effective headroom taken up by the hoist. However, the term headroom has not been used as it is sometimes used in everyday language to have other meanings.

Range of Lift
The range of lift is the vertical distance which the bottom hook travels between the extended and drawn up positions



Electrical Supply
Electric chain hoists usually require a 3 phase AC supply current. Some of the lower capacity models are available with single phase or low voltage motors.

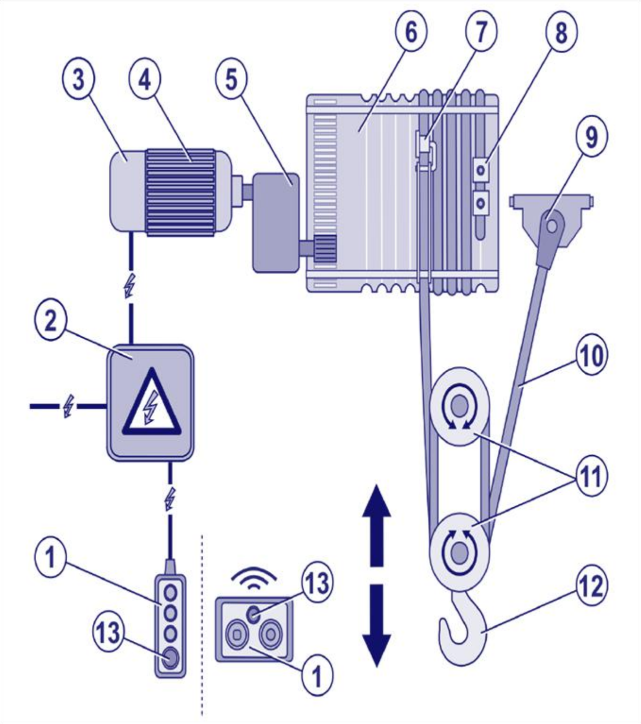
Low Voltage (LV) Control
Modern electric chain hoists are normally fitted with low voltage control which is derived internally within the unit by transformer. This is usually in the range of 24 to 50 volts AC or DC and is often known as 'Extra Low Voltage'. Older hoists and special purpose hoists may not have LV control. It should also be noted that it is common in many European countries to use mains voltage control.



Basic Components

Most electric wire rope hoists consist of similar basic components as illustrated:

1. Pendant controller
2. Control panel
3. Brake
4. Motor
5. Gearbox
6. Rope drum
7. Rope Guide and pressure arm
8. Rope end clamps
9. Dead end anchor
10. Load rope
11. Return sheave and pulley block assembly
12. Load hook
13. Radio/Infra-red remote controller

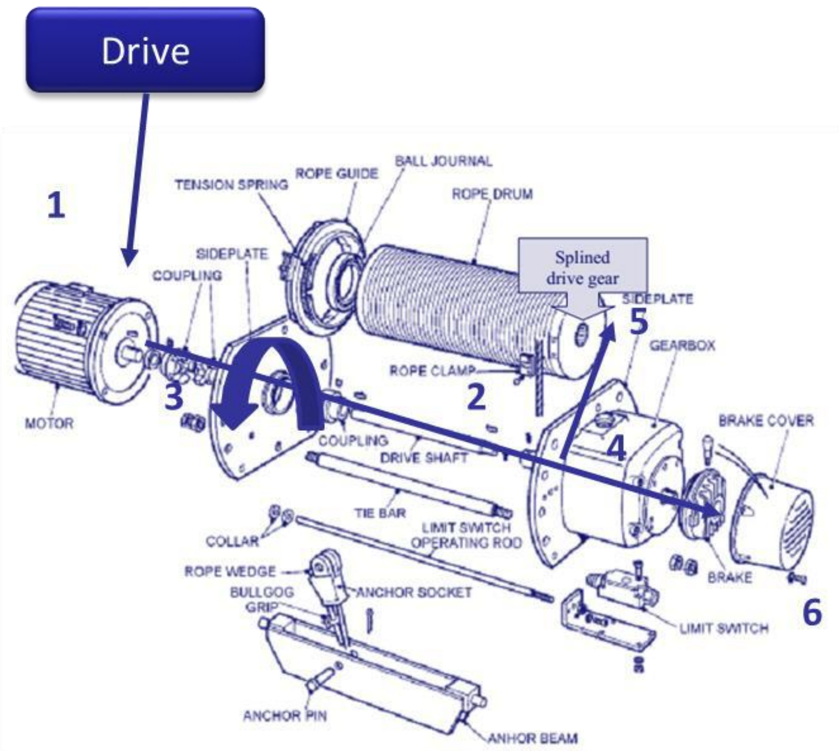


Old Generation Hoist Design

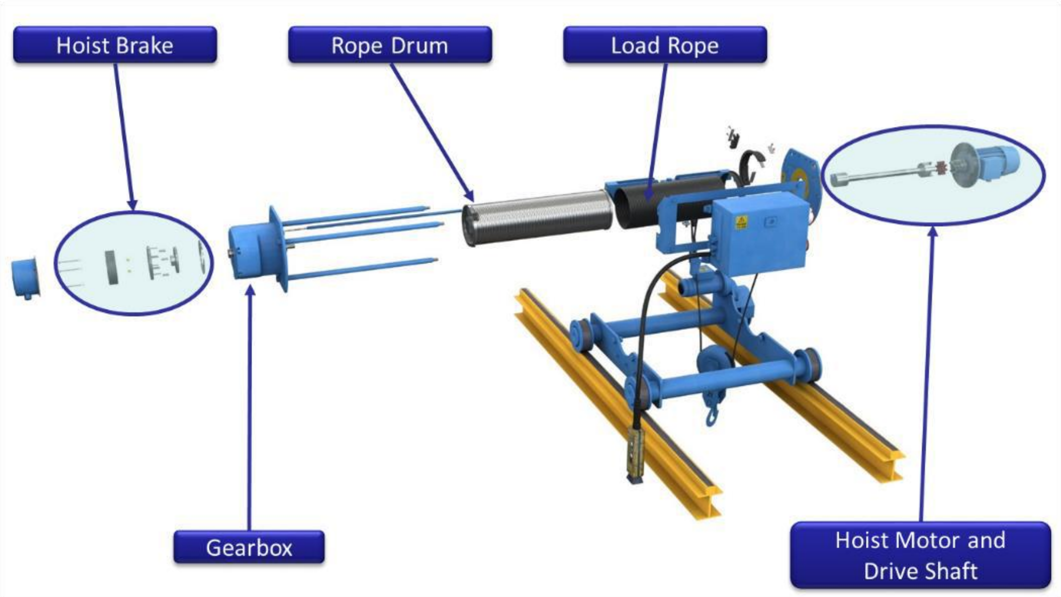
General Operation

In this older, coaxial type wire rope hoist, power is transmitted from the motor **(1)**, via a transmission shaft **(2)** which connects to the motor using a spider coupling **(3)**, through to the gearbox input pinion **(4)** and onto a drive pinion to a splined drive gear inside the rope drum **(5)**.

Note: The hoist brake **(6)** is situated on the hoist gearbox as opposed to the hoist motor.



General Arrangement

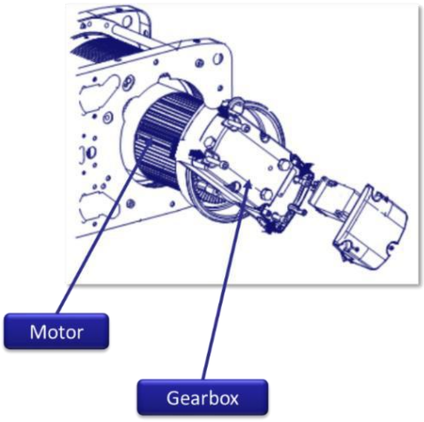


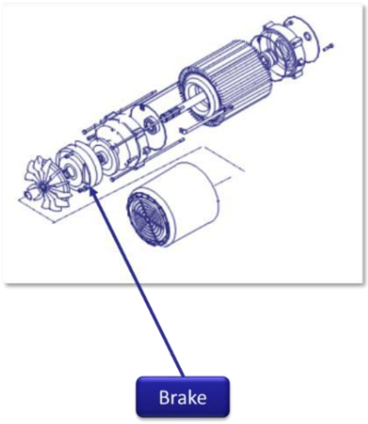
General Arrangement (Reversed)

New Generation Hoist Design

Irrespective of the manufacturer, the new generation of hoist units all tend to be very similar in their construction. In an extremely competitive industry, blocks must provide performance, reliability, flexibility, satisfy the BS and ISO requirements and be reasonably priced.

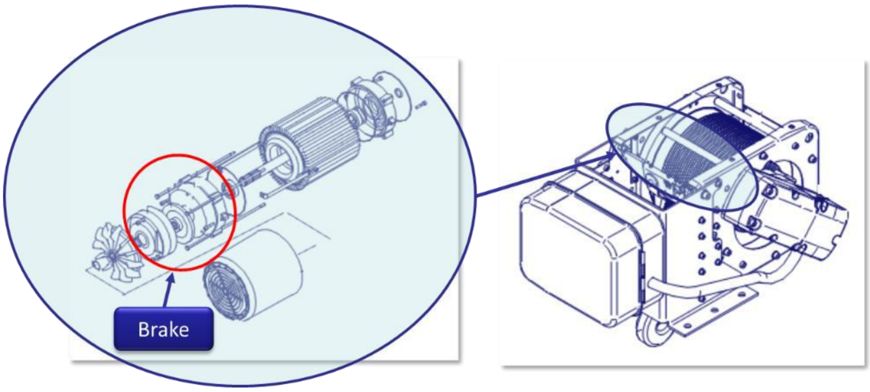
By rotating the component parts around a common axis a very compact hoist unit has been developed.





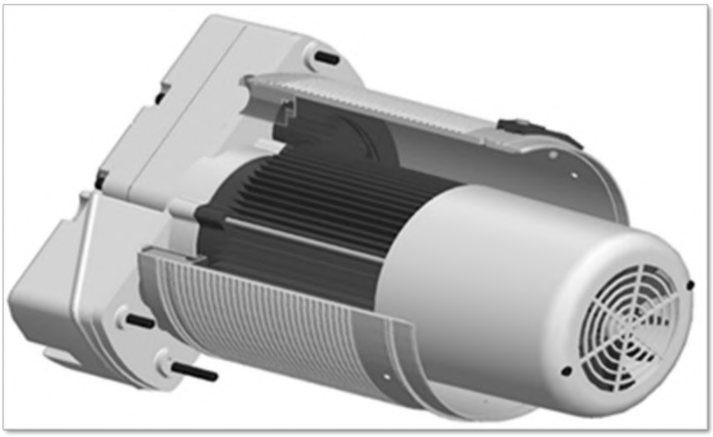
General Operation

The drive motor is mounted inside the hoist drum. The drive is then transmitted via a coupling to the hoist gearbox, which is totally enclosed. On this model, the electro-magnetic hoist brake is of the disc type. Other models may incorporate a tapered rotor motor and conical brake unit.



General Arrangement

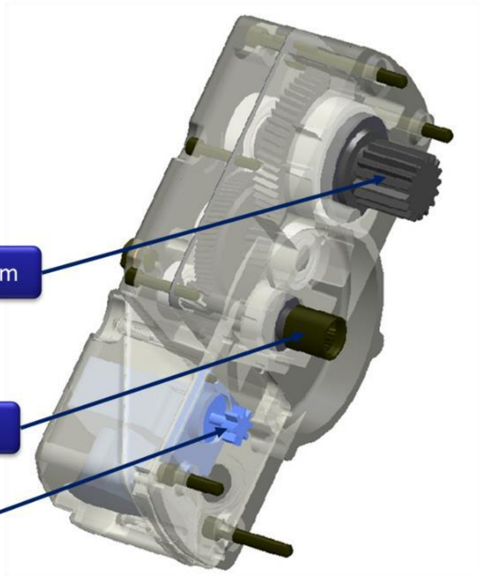
Note that the drive motor is located inside the rope drum which saves space and the fan on the motor drives cooling air through the rope drum which improves cooling efficiency. The hoist motor and brake are accessible outside of the drum.



General Operation

Modern hoists typically have enclosed, compact gearboxes that are lubricated with semi-fluid grease, sealed for their service life.

The illustration opposite shows a typical compact gearbox of this nature.



General Arrangement

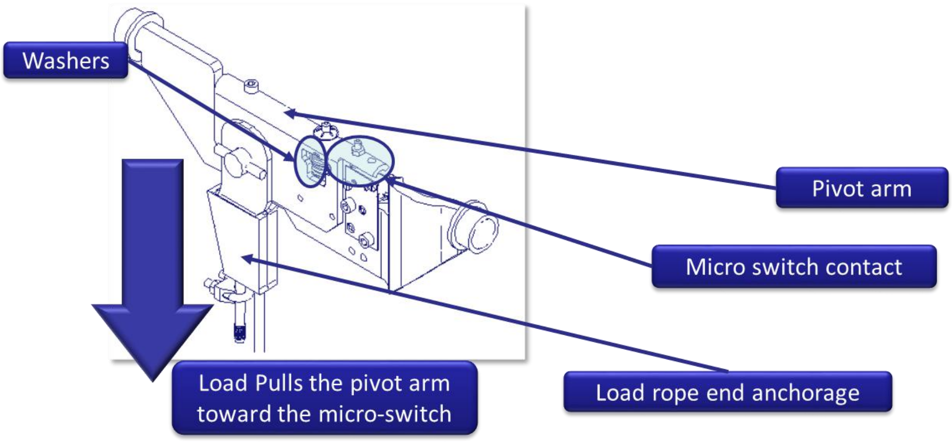
The illustration below shows a typical load rope end-anchor assembly arrangement which is usually supported by a cross beam incorporating an overload limiting device.

Notes:

Lever Operated, Electro-Mechanical Load Limiter

The lever operated, electro-mechanical load limiting device illustrated below prevents the hoist from overload. When load is applied, the pivoting load arm is pulled down towards the operating micro-switch and the calibration is set by a pack of spring washers.

When the load exceeds the set limit, the micro-switch will operate and stop the 'up' motion, only allowing the operator to lower.



Principles for Selection

Electric wire rope hoists are suitable for a wide variety of purposes. For all applications, initial consideration should be given to the following:

- Capacity
- Range of lift
- Speed(s)
- Duty classification
- Suspension
- Operating level(s)
- Availability and suitability of power supply, including protection and isolation facilities
- Service conditions
- Nature of load

- The documentation required by legislation (EC Declaration of Conformity or report of thorough examination as appropriate). If this is not on record refer the hoist to a Competent Person for thorough examination

Note: It should be recognised that power operated hoists are designed to lift in the vertical plane only. The application should be fully discussed with the supplier to ensure that the correct equipment is selected.

Service Conditions
Standard electric chain hoists are manufactured to meet normal service conditions and assume:

- Use under cover, i.e. not directly exposed to the elements
- Use at ambient temperatures between -10°C and 40°C without high local heating or cooling
- Use in clean air free from excess of humidity, contamination and deposits

Environmental Conditions
Examples of environmental conditions requiring special attention are:

- Outdoor use
- Salt air
- High humidity
- Ambient temperatures above or below the normal range
- The presence of local heat sources, e.g. furnaces
- Dust/abrasives in the atmosphere

Hazardous Substances
Hazardous substances fall into two main groups; those that would harm the hoist or its associated electrical equipment, e.g. corrosives; and those that may be affected by the operation of the hoist, e.g. explosives. Examples of hazardous substances requiring special attention are:

- Flammable or explosive gases, vapours or dust
- Corrosive vapours and liquids
- Volatile liquids
- Toxic substances
- Molten metal

The manufacturer's or supplier's specific advice should be sought if power operated hoists are to be operated in an acidic or alkaline environment. Such conditions can cause stress corrosion cracking for example on some types of chain (hydrogen embrittlement)

Other Potential Hazards
Other potential hazards may arise as the result of the work being carried out in the general location or be caused by the hoist performing lifting and moving operations over the heads of personnel or similar. Examples of such potential hazards requiring special attention are:

- Use in mines and quarries
- Use in laundries
- Use in galvanizing, pickling and hot dipping processes
- Use in paint shops
- Use over work areas
- Use over walkways and footpaths

Notes:

Standards

BS EN 60204 Pt 1 and Pt 32 – Safety of Machinery – Electrical Equipment of Machines – general requirements deals with the electrical safety of machines covered in this module. Part 32 deals specifically with hoisting machinery. The standard promotes safety of persons and property, consistency of control response and ease of maintenance.

BS EN 60204-32:2008

Safety of machinery — Electrical equipment of machines —

Part 32: Requirements for hoisting machines

General Requirements of BS EN 60204

Electromagnetic Compatibility

- Hoists shall be in accordance with BS EN 60204-32:
- The hoist must not generate electromagnetic disturbances that will interfere with other machinery, and additionally, it must have a level of immunity from being affected by other machinery creating electromagnetic disturbances

Electrical Supply

- The hoist shall be designed such that it operates reliably in the event of a voltage drop at the hoist of up to 5% between no-load operation and the peak current of the largest motor

Outdoor Use – Protection

- The enclosures for electrical equipment, with exception of the motor, shall have at least a degree of protection IP 55
- The enclosure of the motor shall have a degree of protection of at least IP 54

5	Protected against dust - limited ingress permitted but no harmful deposits allowed. Full protection against human contact	5	Protected against low pressure jets of water (6.3mm nozzle) from all directions. Limited ingress is permitted

Electrical Disconnection

The electrical equipment of a hoist shall contain devices for the following functions:

- Isolation of the electrical equipment from the mains power supply so that work may be performed without the risk of electric shock or burning
- Switching-off in the event of emergency switching off or emergency stop

Standards

The following standards are applicable to electric chain hoists and this module:

BS EN 14492 – Power driven winches and hoists **– Part 2 – Power Driven Hoists.**

BRITISH STANDARD

BS EN 14492-2:2006 +A1:2009

Incorporating corrigendum March 2010

Cranes — Power driven winches and hoists —

Part 2: Power driven hoists

This standard covers pneumatic, hydraulic and electrically powered hoists, using chain, wire rope and belts as lifting media.

General Requirements of BS EN 14492-2

- Connections and individual components of hoists shall incorporate features so that they cannot self-loosen
- Moving transmission parts (shafts, fans, wheels, gears, belts, couplings) shall be designed, positioned or guarded in order to protect against the risks associated with possible contact of exposed persons during the intended use

Control Devices

- Devices for starting and stopping manually-controlled hoists shall be fitted with 'hold-to-run' control elements so that the power supply is interrupted when the actuating elements are released (usually a pendant control station)

Electromagnetic Compatibility

- Hoists shall be in accordance with EN 60204-32:
  - The hoist must not generate electromagnetic disturbances that will interfere with other machinery, and additionally, it must have a level of immunity from being affected by other machinery creating electromagnetic disturbances

Notes:

Overload Protection

Hoists manufactured since the Machinery Directive came into force and which have a WLL of 1 tonne or more or which are installed such that the overturning moment is 40,000Nm or more, must be fitted with devices to warn the operative and prevent dangerous movements of the load in the event of overload or of the moments conducive to overturning being exceeded.

Older equipment may not be fitted with such devices and we recommend that, if not, consideration is given to upgrading it.

Overload protection devices take different forms but may usually be set so that a load up to the proof load can be lifted or to allow a load in excess of the SWL but less than the proof load to be raised. This protects the hoist from accidental overloading but allows for variations in the imposed load due to dynamic loading.

Electric wire rope hoists can be protected from the worst effects of physical overload in several ways depending on the design of the appliance.

Overload protection devices take different forms but may usually be set so that a load up to the proof load can be lifted or to allow a load in excess of the SWL but less than the proof load to be raised. This protects the hoist from accidental overloading but allows for variations in the imposed load due to dynamic loading.

Load measuring or sensing devices are used to prevent physical overload by stopping the appliance operating if the load exceeds that intended. At one time these were not generally fitted as standard but since the implementation of the European Machinery Directive, they have become a standard feature of many appliances.

Rated Capacity Limiters (Overload Protection)

Rated Capacity Limiters and Indicators (RCL)

- Hoists with a rated capacity of 1000kg or more shall be fitted with a rated capacity limiter (overload protection)
    - For **'direct acting'** RCLs, it will be set at 110% of rated capacity to allow for dynamic load testing (see note 1 below)
    - For **'indirect'** RCLs, it will be set at 125% of rated capacity (see note 2 below)

Note 1: A **'direct acting'** RCL act directly in the chain of the drive elements of the chain hoist, for example, a slipping clutch (friction torque limiters)

Note 2: 'Indirect' RCLs measure the load using a sensor and switch off the energy supply for the lifting operation. This usually engages the hoist brake simultaneously.

Notes:

Hoisting and Lowering Limits

- For safety reasons, to prevent the bottom hook 'over travelling' and causing damage to the hoist, a hoisting or upper limit is used

- For modern hoist units it is a mandatory requirement of EN 14992-2 to have upper and lower limits fitted that conform to the minimum requirements of EN 12077-2. In the case of a power operated hoist found in-service and not fitted with a bottom limit, it is advisable that one is fitted

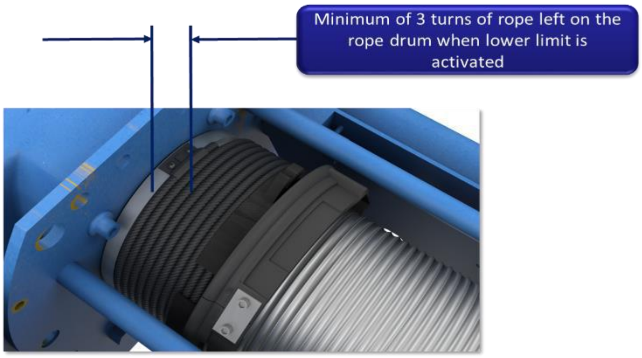
- The type of limit used will depend on the hoist design and may be a mechanical device, e.g. a slipping clutch, or an electro mechanical device which uses a mechanical method of actuating a limit switch

- Whichever type is used, hoist limits are not intended for regular use, they must be considered as emergency safety devices. There are several electro-mechanical methods of actuating a limit which all utilize the movement of the mechanism to disconnect the power to the motor and thereby apply the brake

- In most cases, hoisting and lowering limits are easily reset by reversing the direction of the hoist however in some cases manual resetting may be necessary

Lowering Limit Requirement

The lowering limiter shall ensure that the minimum engagement of the lifting medium is maintained at all times during operation, e.g. minimum of 3 turns of the rope on the rope drum. The lowering limiter shall also stop the motion to prevent unwanted coiling in the reverse direction.



Back-Up (Second) Limit

For normal operation a second limiter is not necessary.

A risk assessment based on the particular application may result in the need of a second limiter for certain motions. This second limiter shall not be approached during normal operation, whereas the first limiter can be approached during normal operation.

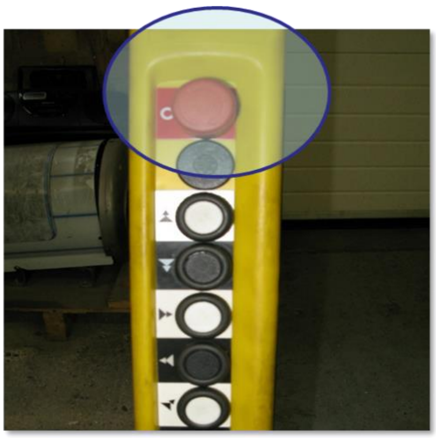
Note: Based upon the risk assessment, a second limiter may be necessary, for example when the hoisting limiter is activated with regularity and this limiter is not designed for regularity.

Once a second limit has been activated, a restart of the hoist should only be possible once the limit has been manually reset, e.g. by using a key-lockable reset on the control station or a manual reset on the hoist. This is due to the fact that the primary limit has failed, therefore the reason has to be investigated as it should have operated under normal circumstances.

Emergency Stop

The standard requires the fitting of an emergency stop function which is to be available at all times

- The emergency stop must override all other functions and operations of the hoist



Hoist Brakes

Brakes should be fitted to the hoist, enabling the load to be arrested at any point during the lifting operation should any of the following occur:

- The operator releases a hoist/lower control button, returning to the neutral position
- The emergency stop is pressed and activated
- The external power supply to the brake is interrupted
- The power supply to the hoist motor is interrupted or switched off
- 2 x phases of the power supply to the hoist motor are interrupted (3 phase motors)

- The general principle of "power off = brake on" shall be used in all cases (fail-safe)

Notes:

Hooks

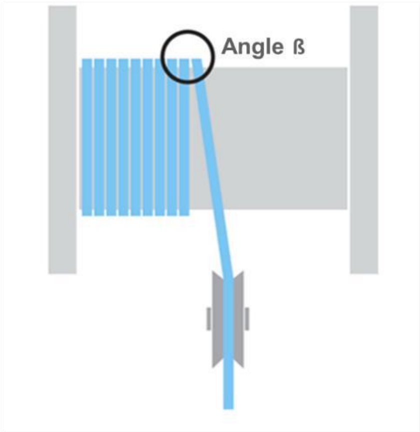
Load hooks must be designed so that they prevent unintentional displacement of the load. This can be done by either of the following methods:

- Incorporating a safety device (usually in the form of a latch)
- Designing the safety requirement into the shape of the hook

The ACoP to Regulation 6(1) of LOLER. This states that:
"Hooks and other devices provided for lifting should be of a type that reduces the risk of the load becoming displaced from the hook or other devices."

Rope Drives

The fleet angle (indicated below by Angle ß) for grooved drums and rope sheaves should not exceed **4°** for all ropes and **2°** for rotation-resistant rope.

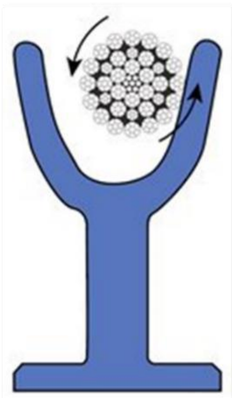


Fleet Angle

If a rope enters a sheave under a fleet angle, it will first touch the flange and then roll down into the bottom of the groove, twisting the wire rope slightly every time.

With increasing fleet angle, the amount of twist increases.

If the rope enters the sheave at a fleet angle of 1° it will touch the flange in a very deep position and will only be twisted by 5°. If the rope enters the same sheave at a fleet angle of 5°, it will touch the flange at a very high position and will be twisted by up to 50°.



Ropes rotate as they enter and exit the sheave groove

Rope Drums

The design of the electric wire rope hoist must ensure that the load rope cannot run off the side of the rope drum.

Note: Suitable preventative measures on drums could include, for example, flanged drum end plates, frame/housing, or rope guides.

Rope Drives

- Flanged drum end plates shall protrude beyond the rope wound on the drum at the top layer by at least 1.5 x the nominal rope diameter

- Single layer rope drums must be grooved
    - Grooving must be smooth and free from surface defects liable to damage the rope
    - Grooves must have a radius of 0.525 to 0.56 x nominal rope diameter
    - The rope groove depth must be between 0.28 and 0.45 of the nominal rope diameter
    - The groove pitch must provide sufficient clearance between adjacent rope turns on the drum, taking into account the rope tolerance

- The fixing point of the rope shall be easily accessible for maintenance and replacement of the rope

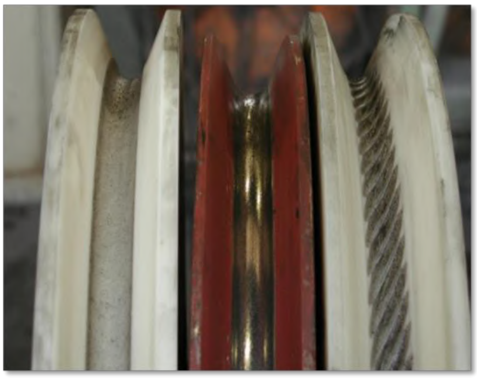
Example Rope Fixing Point (End Anchor)

- Ropes used for electric hoists are to be selected specifically for a given application and manufactured from suitable materials

- Rotation-resistant ropes must be use in cases of single-fall application so that they will not unwind under load conditions

- All wire rope discard criteria used during a thorough examination should be aligned to the requirements of BS ISO 4309

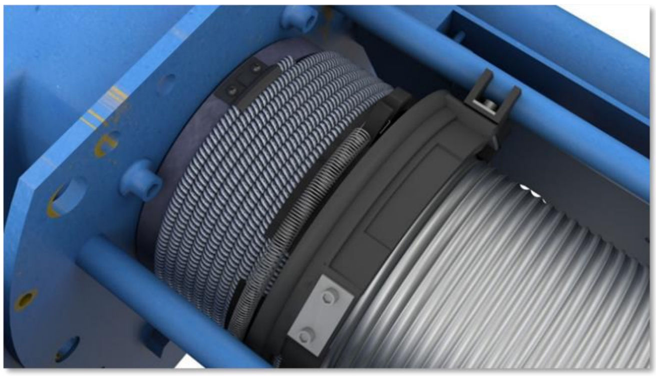
Wire Rope Sheaves



- Sheaves must be designed to prevent the rope from jumping out if the grooves when the wire rope is slack
- Rope grooves on rope sheaves should have a groove radius of (0.52 to 0.56) x nominal rope diameter
- The opening angle of the rope sheave shall be symmetrical and between 30° and 60°
- The depth of the grooves shall not be less than 1.4 x nominal rope diameter

Rope to Rope Drum Connection

- Rope fastening onto the rope drum shall be made in such a way that at least 2.5 times the remaining static force at the fastening device is accommodated when the rated capacity of the hoist is applied to the hoist taking into account the friction effect of the winding on the drum.
- There shall be at least two rope windings remaining on the drum before the fixing point of the rope
  - The fastening elements of the fixing point of the rope shall be selected taking into account the rope and drum contours



Rope Anchorage / Terminations

- Anchorages on the rope shall resist 2.5 times the static rope force resulting from the rated capacity of the hoist without permanent deformation
- Terminations can include:
  - Asymmetric wedge socket to BS EN 13411-6
  - Symmetric wedge socket for rope diameters up to 8mm to BS EN 13411-7
  - Metal and resin sockets to BS EN 13411-4
  - Wire rope clamps to BS EN 13411-3
- **Wire rope grips and rope eyes in conjunction with wire rope grips cannot be used as rope-end terminations!**

Environmental Protection

- When wire rope hoists are required to operate both inside and outdoor, consideration should be given to the use of a weatherproof cover. This should form a large enough canopy to prevent the hoist being directly exposed to rain etc.

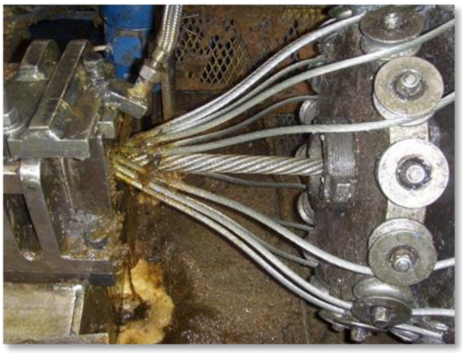
- When wire rope hoists are required to operate over furnaces and quench tanks etc., the use of a heat shield should be considered. This should be large enough to prevent the hoist being directly exposed to flames

- In steam-laden atmospheres, such as dye houses and laundries, special precautions are necessary to limit corrosion. Consideration should therefore be given to the use of galvanised wire rope and additional lubrication points

Wire Rope Lubrication

- Wire rope is lubricated during the manufacturing process
- In order to maintain a satisfactory working life it is therefore necessary to provide adequate and appropriate lubrication
- Suitable lubricants are those which can withstand these high pressures and will adhere to the rope
  - In adverse working conditions, such as foundries, or where the lubricant may contaminate other items, e.g. food stuffs, the use of dry lubricants in the form of colloidal graphite dispersions are recommended
  - All lubricants must be acid free in nature

It is important that the manufacturer's recommendations for lubricants and their application are followed.



Notes:

Information to be Supplied by the Manufacturer

The manufacturer must provide operating instructions containing information and instructions for the commissioning, use, regular examination and maintenance of electrically operated chain hoists. The following information should also be included:

- The use for which the hoist mechanism is intended shall be clearly described
  - Warnings shall be provided with regard to misuse of the hoists which, according to experience, may occur
  - This information should include any limitations of the design, for example the intended duration of service

- Information about the operation of the hoist and lower limits and their periodic inspection

- Training requirements for the operating personnel

- Maintenance and repair work required to ensure the safe functioning of the hoist unit
  - Including inspection and lubrication requirements, operating principles, safety devices etc.

Marking

Electric wire rope hoists are to be marked with the following information:

- CE Mark
- Business name and address of the manufacturer
- Designation of the machinery
- Type designation
- Identification number, if any
- Year of manufacture
- Explosion proof class (if applicable)
- IP rating
- Safe working load
- Range of lift
- Group of mechanisms
- Details of lifting media, wire rope construction and minimum breaking force
- Power supply information, voltage, phase(s), frequency, rated flow (hydraulics) and rated pressure (pneumatics)
- Motor size (kW)
- Rated hoisting speed
- Rated traverse speed if fitted with combined trolley

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:

Information which Should be Exchanged Between the User and Designer or Supplier

As electric power-operated 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:

- Maximum load to be lifted or SWL
- Type of hoist, i.e. chain or wire rope
- Range of lift
- Maximum drawn up dimension
- Maximum extended dimension
- Type of suspension, e.g. hook/eye, push/geared/electric travel trolley, in the case of a trolley suspension, details of the runway beam section and size
- Lifting speed(s)
- Power supply, voltage, phase(s) and frequency
- Details of the power feed system if required
- Type of control, e.g. pendant, remote etc., including pendant length etc. If unspecified, the manufacturer will assume pendant control and this will be arranged to suit the hoist on the basis of the operating level being at the extended dimension
- Special service conditions or safety requirements which may affect the hoist design, e.g. outdoor use, use in a flammable atmosphere etc.
- Classification if known or details of the state of loading and duty cycle etc.
- Any accessories that may be required, e.g. slack chain collecting box, working limits etc.
- Any other special requirements

It may subsequently be found that a more detailed exchange of information is necessary to ensure the correct selection. For all but the simplest or repeat 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.

Further technical information may be required by the user at the time of installation or for maintenance purposes. It will be contained in the manufacturer's operations and maintenance handbook, which will be supplied with the hoist, and does not otherwise form part of the information exchange.

Pre-Use-Checks

Operator pre-use checks should include:

- Visual check for any obvious signs of damage
- Check operation of upper and lower limit switches (no load condition)
- Hoist brake
    - No slipping or overrun when lowering
    - No unusual noises
- Load rope
    - Free from any obvious signs of damage
    - Kinks and twists
- Check the bottom hook for smooth operation, ability to swivel and safety latch operates correctly
- If the hoist is fitted to a runway beam, ensure the trolley operates correctly and that the beam appears undamaged with no obvious obstructions
    - Ensure end stops are fitted at both ends of the beam

- Check the operation of the emergency stop button and ensure that you are aware of the location of the hoist power isolator switch

In-Service Inspection

In addition to the statutory thorough examination by a Competent Person, electric wire rope hoists should be visually inspected by a Responsible Person prior to use or on a regular basis, taking account of the conditions of service and statutory requirements. The inspection should include the fixings, suspension points and supporting structures, guidance on the in-service inspection of runways, slewing jib cranes and mobile gantries is given in further sections of this code and reference should also be made to BS 7121-2.

The inspection should include the following points in addition to any specific checks recommended by the supplier:

- State of the wire rope
- Correct operation of the brake
- Correct operation of hoist and, where fitted, lower limits
- Correct operation of controls
- A visual check for any obvious defects

If any of the following faults are found, the hoist should be withdrawn from service and referred to a Competent Person.

- Signs of wear, deformation or damage to hooks, trolleys or other terminal or suspension fittings
- Hook safety latch damaged or inoperative. In the event of the latch appearing to be too short, this is an indication of the hook having opened out and may be the result of the hoist being overloaded
- Signs of wear and fretting corrosion to screw threaded shanks
- Load slips when hoisting or load will not lift although motor is running
- Load stops midway through a lifting cycle. In this case, where possible action must be taken to lower the load. If this cannot be done, the area must be cordoned off to prevent anyone approaching
- Hoist will not operate although power is on
- Spasmodic or erratic lifting operation and similar symptoms on the travel motion
- Trolley slips or skids on the runway
- Damage to any electric cable or cable gland
- Damage to the pendant control hand set including cable, rubber covers, legends or labels and support wire, chain or cord
- Excessive noise or unusual sounds from any part of the hoist, including motor, clutch, gearbox or brake
- Travel and/or hoist motions operate in opposite direction to control indication
- Load continues to travel excessive distance after motion control has been released
- Load rope worn or damaged, in particular any increase or decrease in diameter, opening of strands, kinks or broken wires. Any signs of mechanical damage such as flattening, crushing, cuts, burring and corrosion. Faults are most likely to occur at the terminations and where the rope passes over sheaves and pulleys, in particular compensating sheaves
- Wire rope does not feed onto the drum correctly or winds in the wrong direction in relation to the control direction selected
- Damaged or worn rope guides and bands
- Signs of damage or distortion of the anchorage points or of the wire rope pulling through any clamping devices

- When bottom hook is fully extended to its lowest working position, there are less than 2 full turns of rope remaining on the drum
    - Under no circumstances must there be less than 2 full turns of rope remaining on the drum but consult the manufacturer's instructions as with some units 3 full turns must remain
- Wire rope is cabled, i.e. multiple falls of rope are twisted together

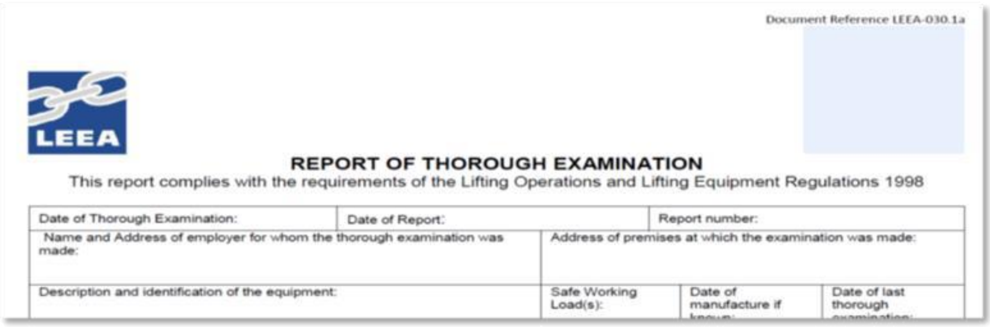
Further guidance on inspection procedure and rejection criteria for wire rope is given in BS ISO 4309, BS EN 12385-3 and BS 7121-2.

Legal Requirements

The definition of lifting equipment and accessories used in LOLER make it clear that power operated chain hoists 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.

Reports of thorough examination should be retained and cross referenced to the hoists historical records for inspection by the Competent Person or HSE.


Document Reference LEEA-030.1a

LEEA

REPORT OF THOROUGH EXAMINATION

This report complies with the requirements of the Lifting Operations and Lifting Equipment Regulations 1998

Date of Thorough 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:

Inspection/Examination - Ensure Lock Out-Tag Out Isolation!

The Thorough Examination

For some applications, it may also be necessary to have the installation thoroughly examined by a Competent Person before the hoist is put into service.

Regulation 9 of LOLER states:
(2) Every employer shall ensure that, where the safety of lifting equipment depends on the installation conditions, it is thoroughly examined:

(a) after installation and before being put into service for the first time

and

(b) after assembly and before being put into service at a new site or in a new location, to ensure that it has been installed correctly and is safe to operate

Note: Although not required by legislation, new power operated hoists 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 hoist. It should be retained and cross referenced to the hoists historical records for inspection by the Competent Person or HSE.

- The examinations shall be carried out in adequate natural or artificial light

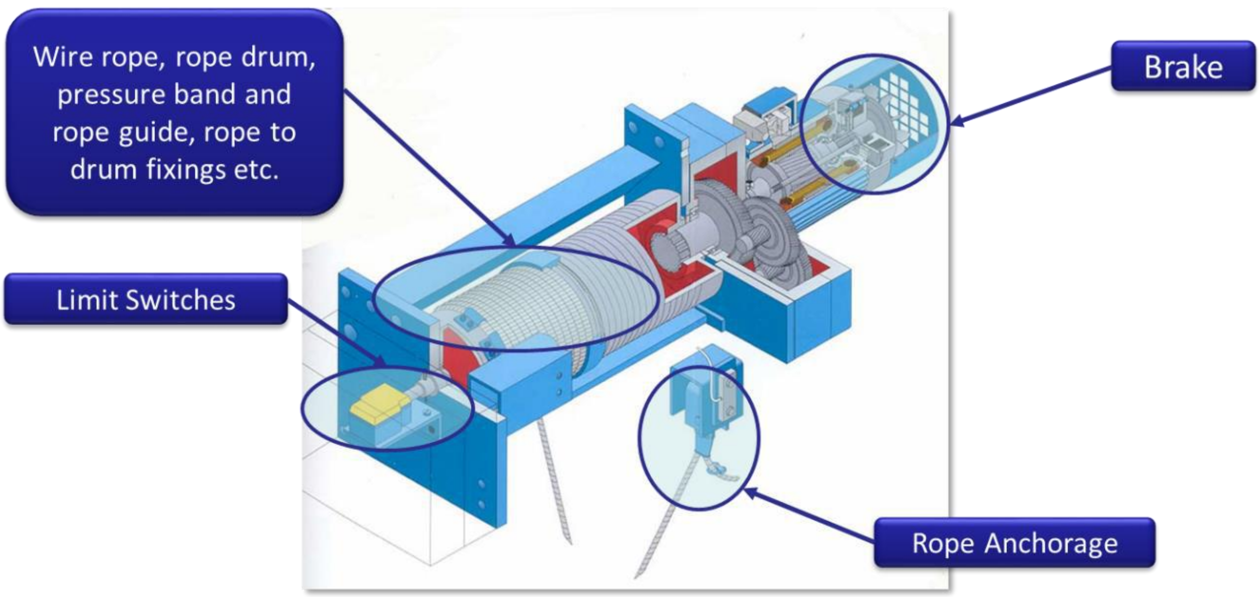
- The machine shall be clean or cleaned and free from rust to enable a proper visual examination of all parts to be carried out

- The examination shall be carried out by a competent person in accordance with the schedule of requirements aligned to the employers' quality policy and site procedures reference material and LEEA's Technical Requirements/ COPSULE which are available to support them

- Where appropriate the standard procedures of examination, checking of hooks, chain sizes, pitch and diameter of wires and allowable wear and stretch shall be those recommended by the product manufacturer
    - Further criteria may also be given in British Standards, LEEA technical publications and in the LEEA correspondence courses

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

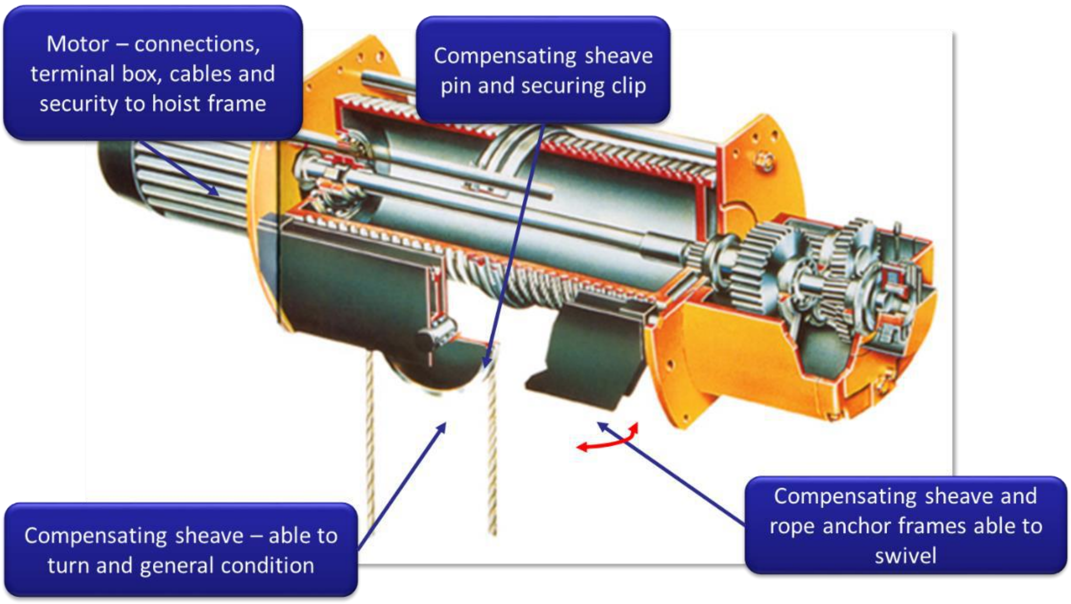
The operation of mating parts must be checked and observed, e.g. a load rope, rope drum (as detailed in Module 3 of this course), rope guide and pressure band, brakes (as detailed in Module 13) and other vital mechanisms must be checked for safe and correct operation.

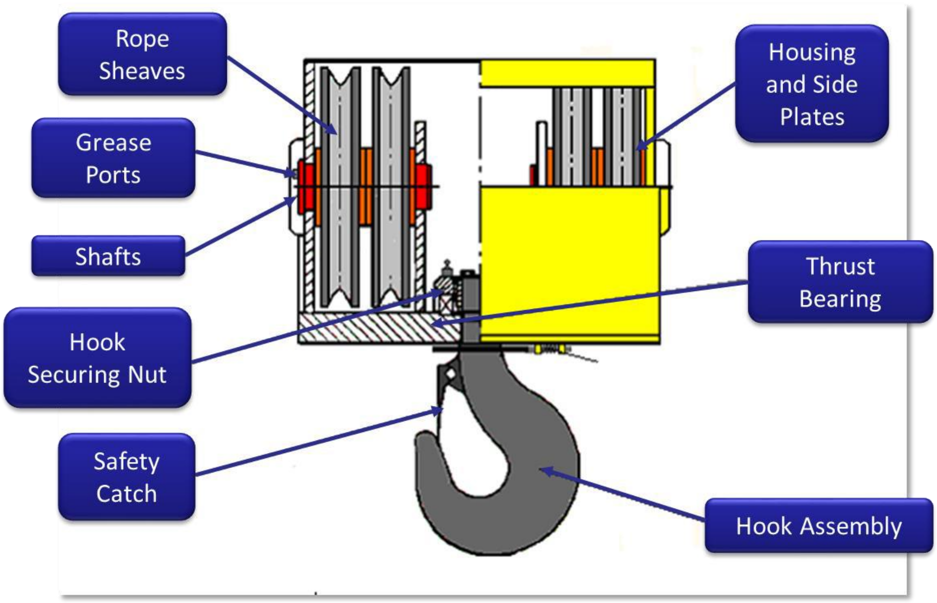


The assembly of parts, reeving and anchorages must be checked for correctness and proper operation and all locking and securing devices must be checked as being sound and in place

- All power supply, current collecting systems, 'fail safe' mechanisms, limit mechanisms, protective and running equipment must be examined for correctness, safety and proper operation

- The identification number and WLL/SWL shall be checked with the last Report of Thorough Examination or the Certificate of Conformity, and where markings have become illegible be re-stamped or marked





- The written report is to provide a description of the article examined, the date of the examination and a clear statement of its fitness for further use or details of the defects which affect the WLL/SWL and other observations
    - Where an article is defective, a responsible representative of the user must be informed
    - If dangerously defective, arrangements must be made for its immediate withdrawal from service
    - Where Regulations or Acts require statutory notification of defective equipment, steps must be taken to ensure notification to the correct authority, for example LOLER gives requirements for reporting certain matters to the HSE

Training

It is of paramount importance that **lifting equipment inspectors or examiners do not work on live electrical equipment**. Lock-out/Tag-out routines should always be considered as part of your risk assessment.

10. Rope Drums and Pulleys

Pulleys

The shape of the pulley groove is shown below. The finish must always be smooth, with sharp edges removed to reduce the risk of accidental damage to the rope.

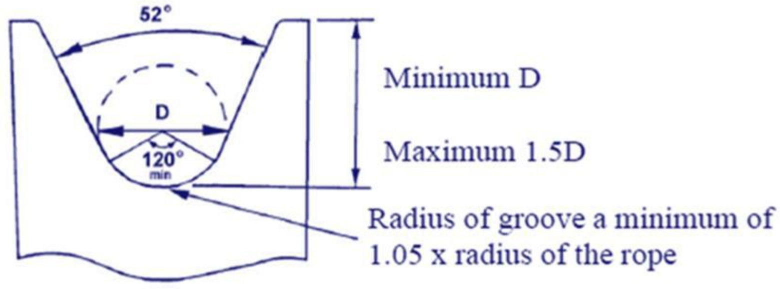


Diagram of Pulley Groove

Drums and Pulleys

- The diameter around which the rope is bent and the depth and shape e.g. pulley and drum grooves that support the rope must be carefully considered

    - **Check the condition of all sheave and drum grooves** to ensure that they are capable of accepting the size of the new rope, do not contain any irregularities, such as corrugations, and have sufficient remaining thickness to safely support the rope
    - For optimal performance, the effective **sheave groove diameter should be larger than the nominal rope diameter by about 5 % to 10 %,** and ideally, at least 1 % greater than the actual diameter of the new rope

- For those ropes that are subjected to multi-layer spooling, apply a back-tension to the rope during installation that is equivalent to about 2 ½ % to 5% of the minimum breaking force of the rope. This helps to ensure that the rope on the bottom layer is tightly wound, forming a firm base for succeeding layers

Sheave Gauges

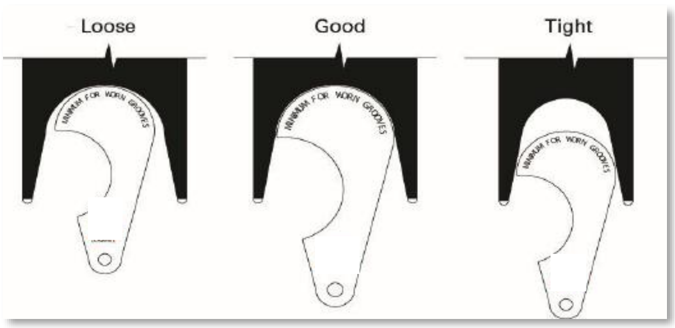
How to Determine the Amount of Wear Using a Wire Rope Sheave Gauge

Use a wire rope sheave gauge to regularly check sheave grooves for wear, which may slow or block a wire rope:

1. Place the proper size gauge in the sheave
2. Shine a light behind the gauge
3. Check for light between the gauge and the root of the groove. If you detect light, replace or re-tool the sheave

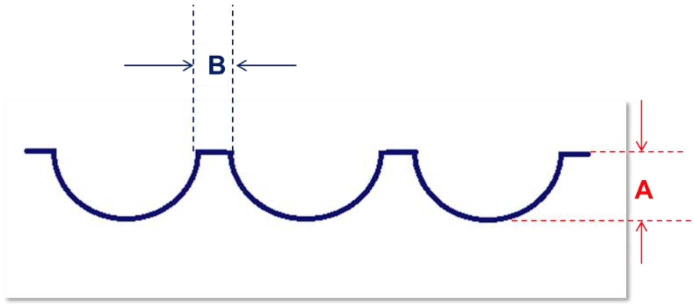
Wire rope will wear the bottom of the sheave groove to a radius smaller than the radius of the sheave. To determine the amount of wear, place the proper size gauge in the sheave and shine a light behind the gauge. Light should not be detected between the gauge and the root of the groove. If wear is evident, the sheave should be re-machined or replaced.

LEEA Sheave gauges are available online at www.leeaint.com from the web shop.

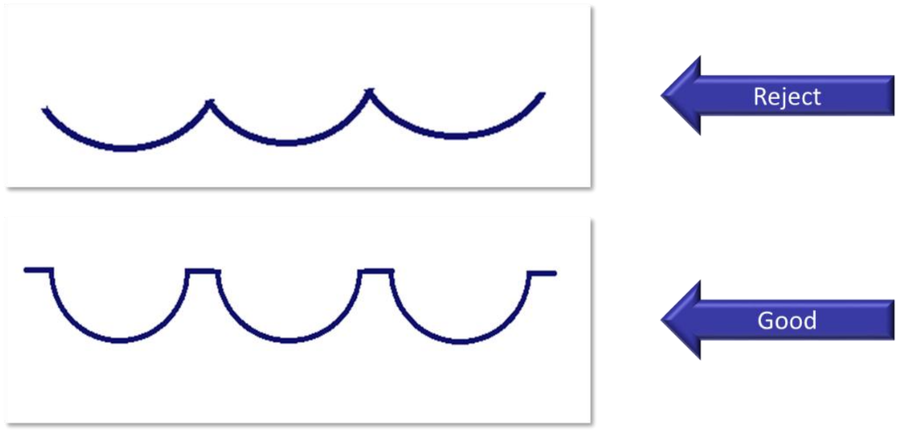


Rope Drum Helix Wear

Check manufacturers tolerances which are usually stated for dimensions A and B.



Drum Helix Wear



11. Power Feed Systems

Electric Power Operation

Electricity is the most common form of power used with lifting appliances. It is used on blocks, winches, trolleys and cranes to provide power for both lifting and travelling or slewing motions.

Although examples of DC supply appliances still exist, AC supply is considered to be the norm. Most types of electric power operated lifting appliances are available for three phase operation. Single phase and low voltage hoists and winches are available in the lower capacities and some types of vehicle winches are available for battery operation.

Pneumatic Power Operation

Pneumatic power operation is used on hoists, trolleys, winches and some cranes. It is less efficient and more difficult to carry to the appliance than electricity. For this reason, it is less common in general use than electricity, but it has many advantages making it more suitable for certain applications.

Hydraulic Power Operation

Hydraulic power is the least common form of power operation associated with lifting appliances, usually being restricted to special purpose equipment and to some types of winch.

Electrical Supply Systems

The use of electricity is highly developed throughout industry. It has the advantage over other forms of power of being more readily available and is easily carried from the power source to the appliance by cable or bus-bar conductor systems.

As a result, electricity is the most common form of power associated with general purpose lifting appliances.

The dangers associated with electricity are well known and there is much experience in protection to guard against them and in overcoming them. It is necessary to protect the operative from the dangers of electric shocks, either by insulation or by the use of low voltages.

Single phase and low voltage drives are less common in lifting appliances and are restricted to the lower capacity items due to the difficulties associated in providing motors of adequate capacities and ratings. It is therefore more normal to protect the operative by the use of low voltage control circuits as it is in this area that the main danger to the operative exists.

The current supply should include a means of isolating the equipment from the power source. In practice, switch fuses and isolators are used to fulfil this requirement. The isolator, which is considered to be part of the supply system, should be positioned at the start of the conductor system so that the system will be isolated from the power source as well as the appliance.

Electricity has the disadvantage of requiring special protection in certain environments, e.g. explosive atmospheres, and steps are necessary to contain the danger within the appliance. Such explosion proof appliances and their power feed systems are far more expensive than standard equipment. They tend to be heavy and bulky and armoured cable offers little flexibility making travel difficult.

Various types of conductor systems may be used to carry the supply to travelling hoists and cranes.

The main factory supply is taken to a point adjacent to the equipment and terminated with a switch fuse/isolator. The power feed to the actual hoist or crane is then taken from this in one of several ways.

There are five basic power feed systems that are commonly used for electrically powered hoists:

1. Coiled cable
2. Cable reeling drum
3. Festoon cables
4. Insulated conductors
5. Energy chain cable carriers

In the past, bare copper conductors were used to provide a power supply for overhead travelling cranes. They are no longer considered suitable in all cases and are not used for new power supply installations. We will consider these systems and the limitations/dangers they present.

Bare Copper Conductors

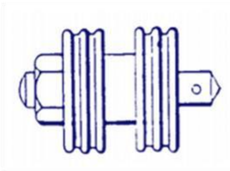
Although this system is considered unsuitable for new installations nowadays, it was widely used in the past on all types of installations. Many of these old installations may still be found in service.

The general advice is to review the installation;

- It may be that the bare wires present a possible danger to people working in the area
  - In this case the advice must be given to change this for a more suitable supply system
- On the other hand it may be considered that the system is safe by virtue of its position
  - In this case it may be left in service

The owner has a responsibility under section 2 of the Health and Safety at Work Act to provide safe systems of work and it is his responsibility to change this if it is considered necessary.

In this system copper wires are stretched parallel to the beam by means of strainer screws with insulators. A collector bracket is fitted to the hoist on which are mounted the collectors.

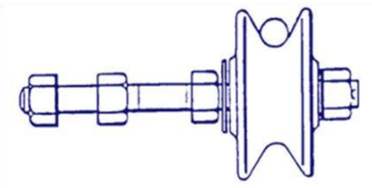


Insulating Conductor Bracket

The most common form of collector is the bronze roller, graphite bushed, thus providing good electrical contact and bearing surfaces. Each collection shaft is insulated from the collector bracket.

For long runs the wires are supported on porcelain reels, the collectors lifting the wires off the reels as they pass over them.

As bare copper wires are not generally recommended they have been superseded by safer and more efficient systems.

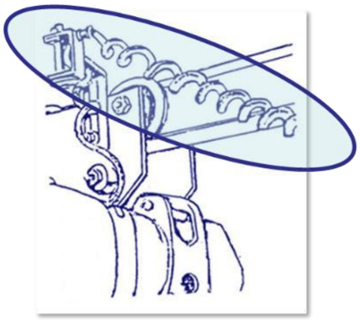


Wheel Type Collector

Coiled Cable

In the coiled cable the conductors are contained in a PVC compound insulate which is coiled in a similar manner to a tension spring. The cable is fixed to a swivelling bracket on the side plate of the trolley with the supply end fixed at a convenient point adjacent to the runway.

As the hoist is moved along the runway so the cable expands, when the hoist is moved back so the cable contracts. This type of cable is suitable where only short travel distances are required due to the sag in the cable. The normal extension ratio of such a cable is 3 to 1 with a nominal 3 metres extended length.



Cable Reeling Drum

The cable reeling drum provides a means of power on control using a flexible cable wound onto a drum which can be played out and then recovered. At the heavy end of the range reeling drums can be very large and equipped with geared motors actuated by torque sensing for cable recovery. This unit deals only with the more common spring operated type.

Construction is very simple, comprising a steel drum mounted on to a fixed shaft and rotating on sealed bearings. The power feed cable is clamped to the drum, the wire ends being connected back to carbon brush gear which rotates with the drum. The power feed to the drum passes through the fixed shaft to the slip rings which are fixed.

Slip Rings

Slip Ring Assembly

Slip Ring Brushes

Cable Reeling Drum

Since a reeling drum spiral wound spring does not provide a constant torque, spring selection is very important.

The cable should not be overloaded by too great a tension or have too much slack, nor should the appliance run back (a possible hazard with coiled cables and reeling drums if used in association with light weight push/pull trolleys).

Before a drum can be selected the cable size must be determined taking a number of factors into account:

- **Voltage Drop** - Unless it is otherwise stated it is usual to work to IEE Regulations which state that voltage drop shall not exceed 5% of the rated voltage based on the normal operating current
- **Temperature Correction** - Generally for ambient temperatures above 30°C the continuous rated current capacities should be eliminated
- **Reeling Configurations** - Rated cable capacities should be further de-rated according to the configuration of the reel to be chosen
- **Short Time Rated Motors** - In many cases the motors on a lifting appliance may be short time rated thus allowing cable carrying capacities to be increased

Note: Although not expected to design electrical power supply systems the Tester and Examiner would be expected to understand the fundamental requirements of a system to enable him for example to identify the reason for a performance deficiency of a hoist under test.

Notes:

Cable Selection

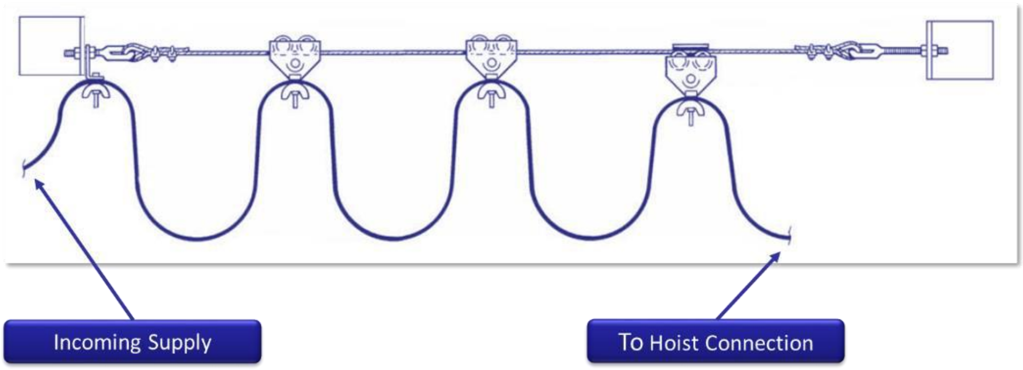
In practice the cable would be selected based on the criteria discussed against technical data provided for a particular product.

An example of cable selection will be discussed in the next section (Festoon Cable Systems) since it could apply to both systems.

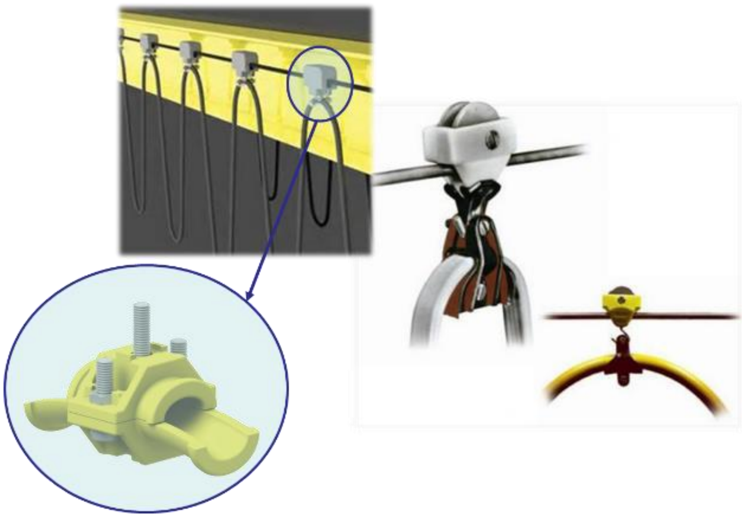
Festoon Cables

Taut Wire

The taut wire system is suitable for light duties over lengths not exceeding 30 metres and is simple and economical to install. The strainer wire is made taut by means of straining screws whilst the cable is carried on trolleys.

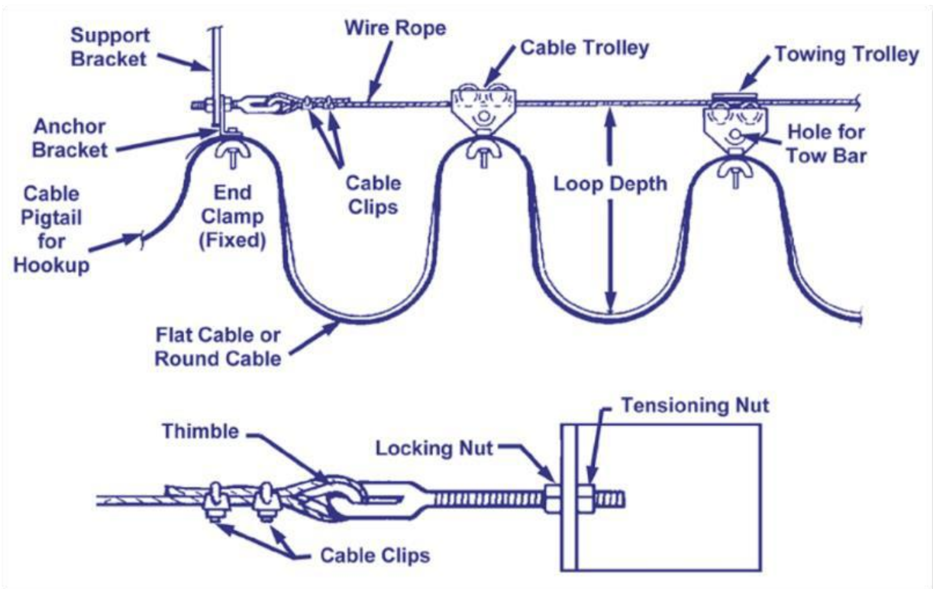


Festoon Trolleys



Festoon Cables

Typical taut wire system:



Tracked Cable Systems

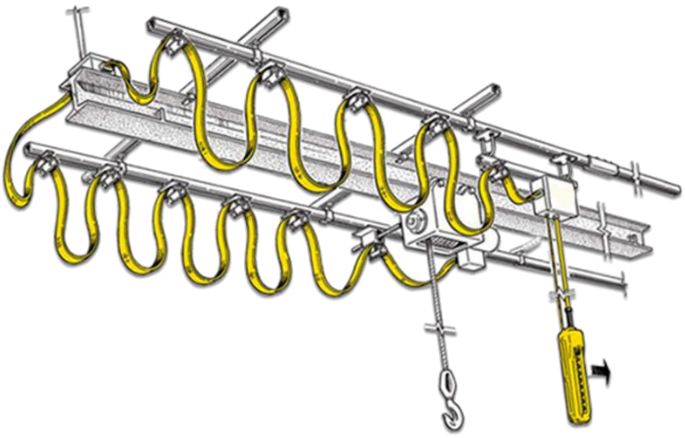
The tracked system is a development of the taut wire system. It can support greater loads and is suitable for higher speeds. Most systems incorporate an inverted `U‘ or ‘C’ section track, the cable support trolleys running on the two inner ledges.

The manufacturers of these systems offer a range of profile sections for most loading conditions from light to heavy duty.

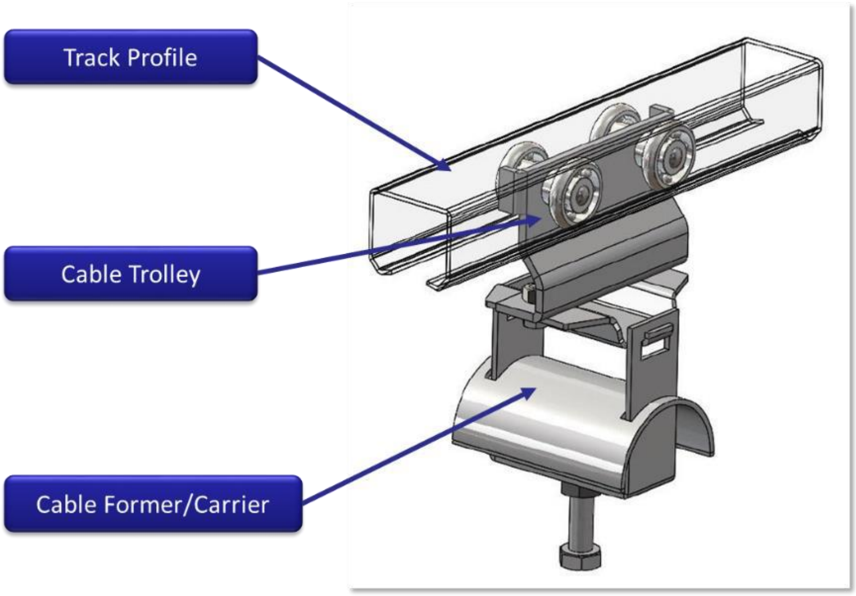
The tracked festoon systems are very safe with perfect insulation hence no loss of energy or voltage drop where current has to pass from conductor to collector. Also on long track installations the size of cables would need to be increased to limit voltage drop hence requiring a heavier track system to support them.

In many cases a lifting appliance will have two festoon tracks one to carry power to the hoist the other providing a mobile pendant push button box, e.g. on the bridge of the crane.

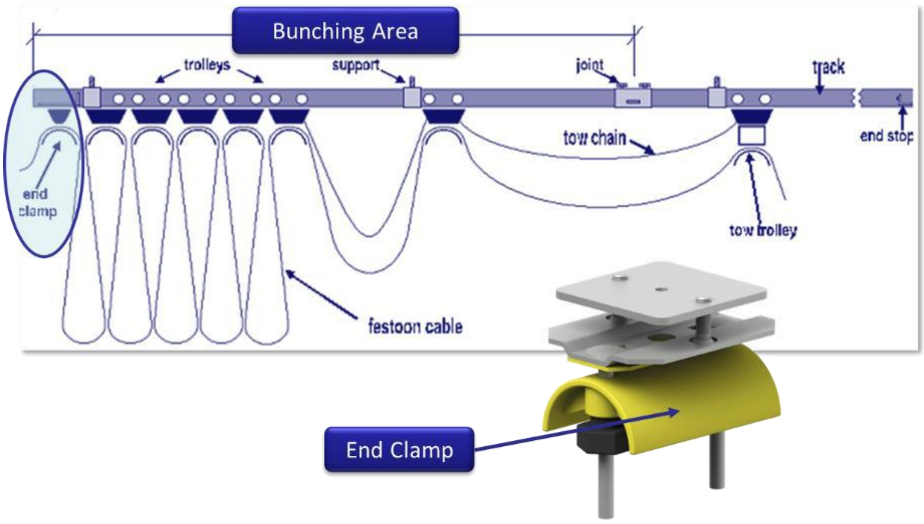
When a mobile pendant push button box is fitted the festoon cable will terminate in the pendant control box from which is suspended the push button box by means of the pendant cable.



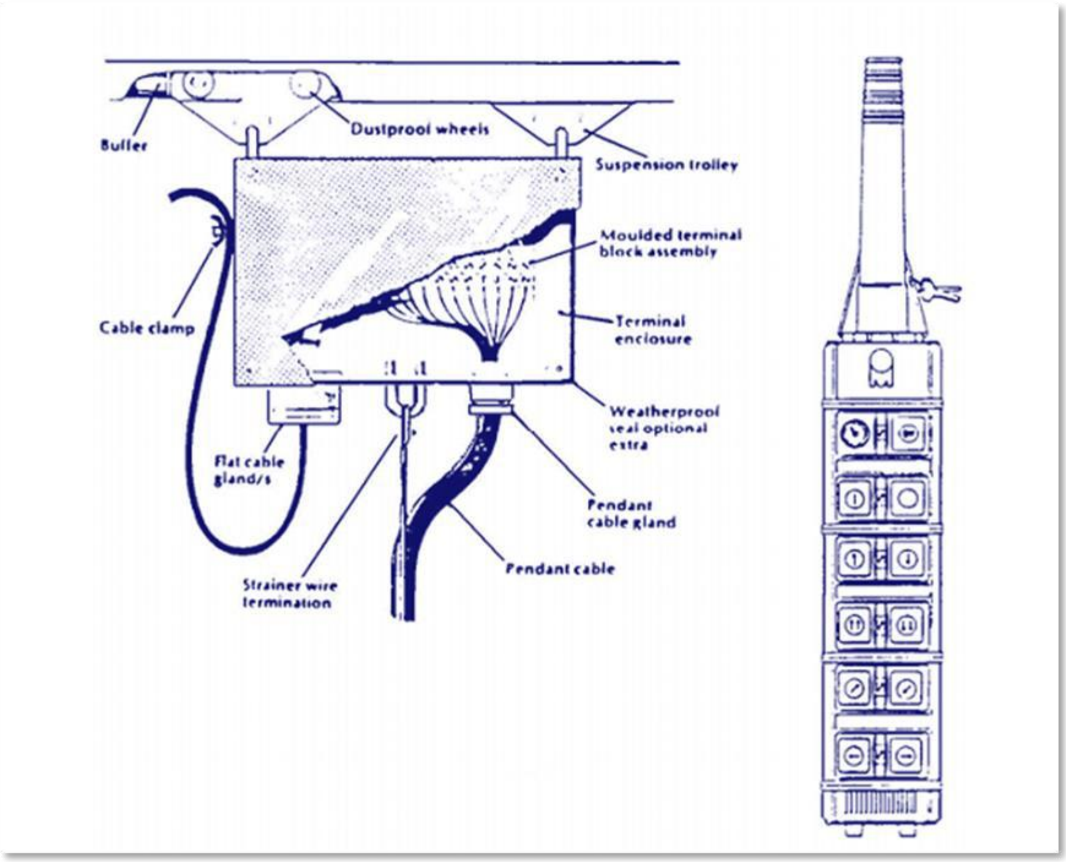
Typical components of a tracked festoon cable supply:



A limiting factor of the festoon system could be loss of travel of the hoist unit due to bunching of the trolleys especially on long track applications.



Typical mobile pendant push button box assembly and connection to the pendant connection box on the festoon:

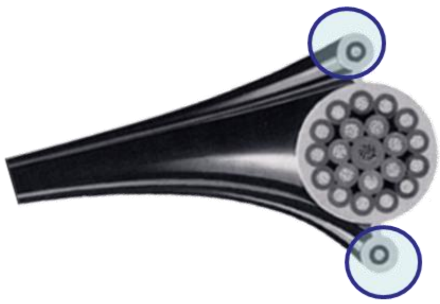


Hoist Control

With the majority of electric hoists the contactor panel is mounted on the main frame and therefore travels with the hoist. It is recommended practice that control voltages should not exceed 115 volts which is achieved by transforming down from a single phase of the three phase supply. The low voltage control signals are transmitted via the push button box and multicore pendant cable to the hoist contactor panel.

Pendant Cables

Pendant cables may have as many as 25 separate cores depending on the number of push buttons/motions required. The modern pendant cable has two independent strainer wires built in to support itself and the weight of the push button box.

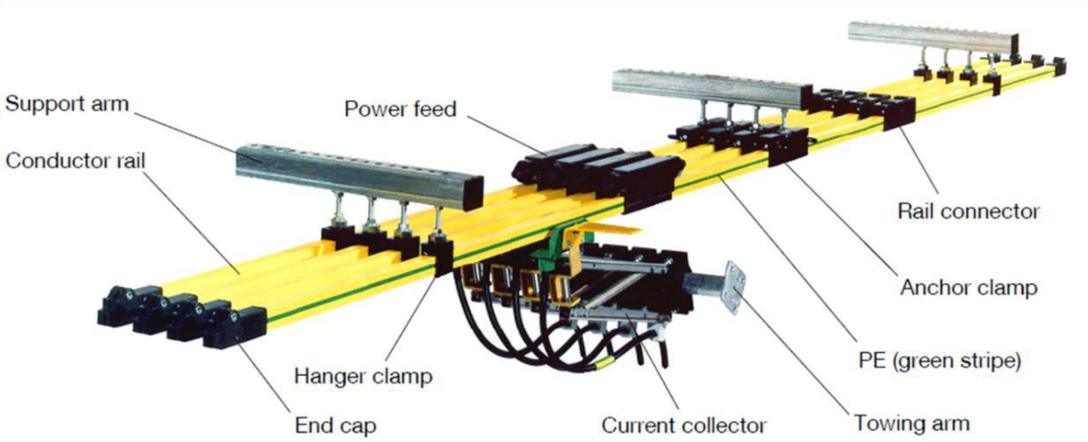


Insulated Conductors

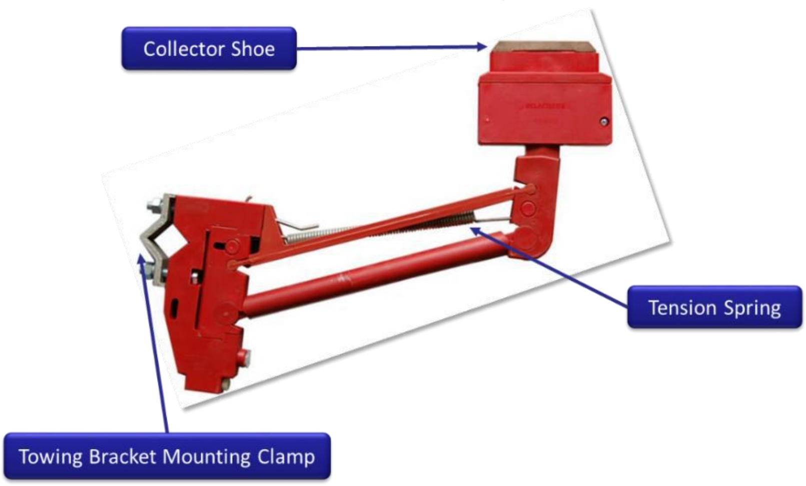
Shrouded Conductor Systems

Shrouded conductor systems are of various cross sections and the conductor bar is sufficiently shrouded with a PVC cover to ensure finger safety yet provide access for a collector shoe to pick up the current.

Typical components of a 4-bar (3 x phase and 1 x Earth conductor) shrouded system:

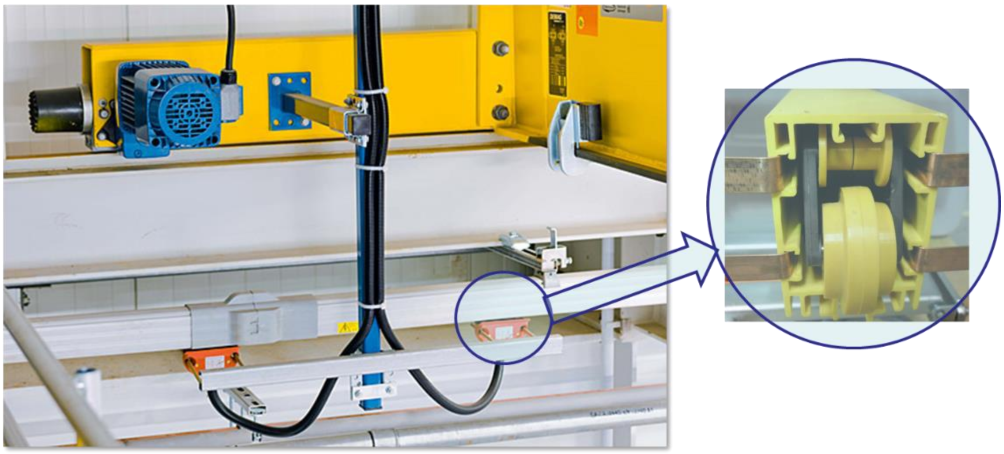


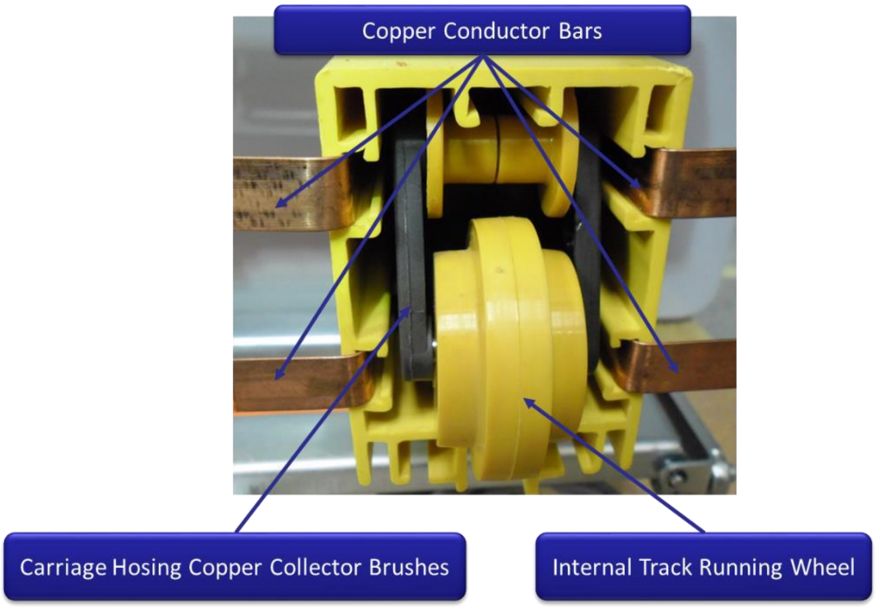
The collection assembly is spring loaded to ensure good contact with the conductor bar and articulated to enable the contact shoe to follow the track without binding.



Totally Enclosed Conductor Systems

A totally enclosed conductor system is used where multiple conductors are required in one housing. It is a rigid and compact system. They are commonly used in overhead crane applications but also for traveling hoists.





The illustration below shows how the fully enclosed conductor head collects the power from the enclosed bus-bars and feeds this direct to the hoist.

The merits of shrouded conductor systems are a much greater protection against accidental contact and a suitability for long runs since intermediate feeders can be added.

These systems are available up to 300 amps. They are however unsuitable for flame proof or similar applications.

Higher operating temperatures can be achieved by using polycarbonate covers (-40°C to 121°C) or laminated fibre glass (-45°C to 149°C).

Expansion

With any rigid system particular attention must be paid to expansion and expansion couplings fitted, in accordance with manufacturers recommendations, if problems are to be avoided.

Shrouded Conduction Systems

With the shrouded conduction system the power feed need not be connected to one end. By connecting in the centre rather than to one end voltage drop is halved and by connecting a power feed to each end the voltage drop is halved again.

Energy Chain Systems

Most energy chain cable carriers have a rectangular cross section, inside which the cables lie.

Cross bars along the length of the carrier can be opened from the outside, so that cables can be easily inserted and plugs connected.

Internal separators in the carrier separate the cables. Cables can also be held in place with an integrated strain relief.

Mounting brackets fix the ends of the carrier to the machine.

Besides only bending in one plane due to the rigid jointed structure, cable carriers also often only permit bending in one direction.

In combination with rigid mounting of the ends of the carrier, this can prevent the enclosed cables from flopping in undesired directions and becoming tangled or crushed.

Cable carriers are used anywhere on cranes where moving components require power, control and communication power feeds in a flexible media.

Energy Chain cable carriers are quiet in operation, lightweight and provide covered cable design and that can be quickly opened. They can be used in extreme conditions such as heat-resistant or clean room environments.

Compressed Air Supply Systems

- The production of a clean, dry supply of compressed air suitable for pneumatic power operated lifting appliances is expensive and it is less easily carried from the power source to the appliance than electricity
- Due to these reasons, its use is more limited than that of electricity
- Although electric power operated lifting appliances are the usual choice for general purposes, pneumatic power operated appliances have advantages for certain applications as most of the dangers associated with electricity do not exist with compressed air
- Standard pneumatic equipment is flame proof
- It can therefore be used in atmospheres where electric equipment would require special insulation and protection to contain the danger
- With pneumatic equipment, this danger does not exist

Pneumatic motors offer variable speeds of operation.

Air flow rate to the motor is controlled by the operative via a supply valve. By careful manipulation the operative can control the air delivery rate, the motor speed being governed by the volume of air supplied. At normal working pressure it is impossible to overload a pneumatic motor.

Once the load increases beyond the design load of the motor, it will stall and, unlike an electric motor, it will not be harmed by this.

Although pneumatic motors are robust in design, capacity for capacity they tend to be smaller and lighter than equivalent electric motors. They will withstand a high degree of heat and moisture. Due to the internal pressure whilst in operation, the motor is self-purging.

This makes standard pneumatic equipment suitable for use in steamy atmospheres, such as paper mills and laundries, and in dusty conditions, such as flour mills without any special steps being taken, unlike electrical equipment which requires enclosures to protect the equipment from their effects.

Compressed air is less efficient than electricity. It contains a high proportion of moisture which has to be removed.

Whilst motors will purge and expel this moisture when in operation, condensation will occur when the motor is idle. This will lead to corrosion and contamination of residual lubricants unless steps are taken to prevent this.

Pneumatic appliances usually exhaust spent air to atmosphere direct from the motor. Although compressed air is generally considered to be less dangerous than electricity, some dangers do exist. Small leaks are usually harmless, though expensive. However, in dusty environments exhausting air and leaks can cause particles to be propelled through the air and be a hazard to eyes etc.

Inspection/Examination

Ensure Lock Out-Tag Out Isolation!

Following total isolation of the power supply using a lock-out/tag-out routine:

Bare Copper Wires
Assess if the system is safe, if it is the following checks should be made. Check wires for burns due to arcing, replace if burns exceed 25% of diameter. Check collector shoes for burns and if roller collectors check for burns, loss of metal and wear of graphite bearings.

Most burns are caused by vibrations or defective collector mechanisms. Wires must not be greased as this will cause arcing.

Coiled Cable
Check PVC cover for cracks in the insulation especially at terminations. Replace if cracked or damaged. Check security of terminations, cable glands etc.

Cable Reeling Drum
Check drum for smooth running. If movement is erratic bearings should be checked. Check slip rings, carbon brushes and pressure springs. Check cable tension with drum fully wound, check cable tension with cable fully extended, i.e. the hoist at the opposite end. Check spare rotation capacity of drum and for a minimum of two remaining turns of cable on the drum. Check cable for cracks and damage.

Festoon Systems
Check taut wire anchors and runners for free movement. If a track system, inspect each joint section is tight and properly closed up. Inspect cable for cracking, check for loose trolley clamps. Additionally, in the case of festoon control systems, check pendant control box is running freely, festoon and pendant connections are secure. Check pendant secure to push button box. Check operation of buttons including any emergency stop and key switch etc.

Shrouded Conductor Systems
Check for tightness of joints, signs of burning and that covers are in place. Check shoes for wear and alignment. Check spring tension and general operation.

General

All power feeds must terminate at a fused, lockable isolator. This should have good access from the shop floor and be clearly identified. The isolator is considered to be part of the power feed system and should also be carefully examined for correct operation.

When examining a supply system, hoist or crane, the isolator should be locked off with an approved locking mechanism for safety.

Safety and Training

It is of paramount importance that **lifting equipment inspectors or examiners do not work on live equipment.** Lock-out/Tag-out routines should always be considered as part of your risk assessment and equipment must be checked by a Competent Person to confirm power supplies are isolated before work commences.

Notes:

12. Motion Limit Switches

- Mechanical
- Electrical
- Electro-Mechanical

***Hoists shall be fitted with hoisting and lowering limiters in accordance with EN 12077-2:1998, 5.6.1. (Cranes safety – Requirements for health and safety)**

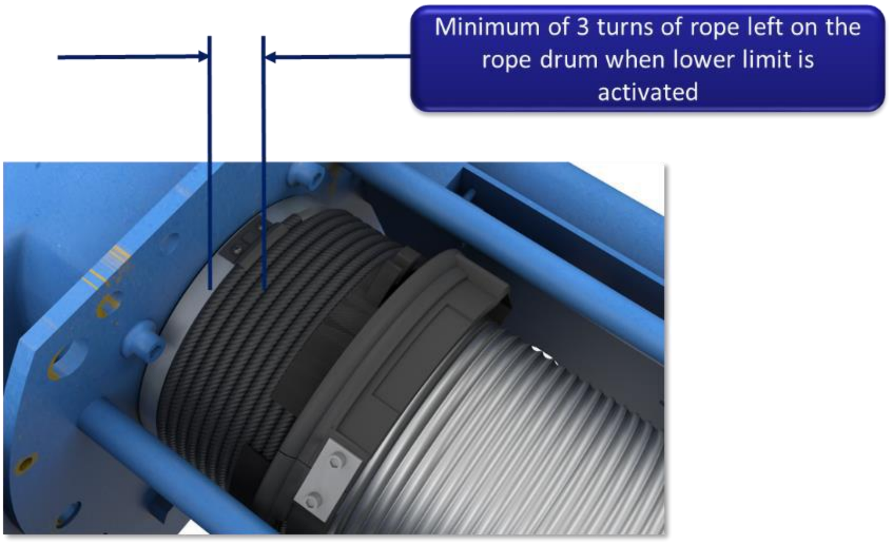
- Older hoists may only have an upper limit switch

- If lowering, care needs to be taken because over-lowering will result in the bottom block being lifted but with no hoist limit to prevent block to block impact

- Electrical limiters need to have a positive opening system

**Reference taken from BS EN 14492:2006 +A1 2009 Cranes – Power driven winches and hoists – Part 2 (Hoists) section 5.2.4.1*

Note: Lower limit needs to account for minimum engagement of load-rope or chain on the machine at its lowest point of travel.



Limit Switch Bar

- Typical application on a Morris 400 Series EWRH

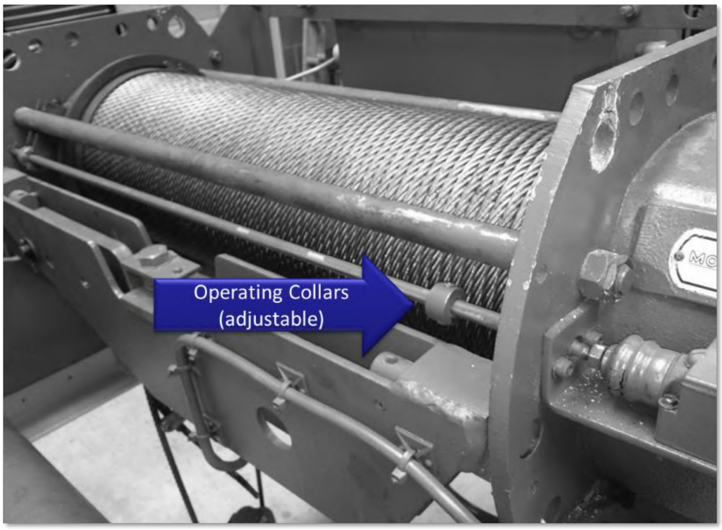
- A common with electric wire rope hoists for control of upper and lower hook positions

- The mechanism comprises a bar, spring loaded into the neutral position. The bar carries two stops which are actuated by the rope guide as it moves along the drum and reaches the upper or lower limits of travel

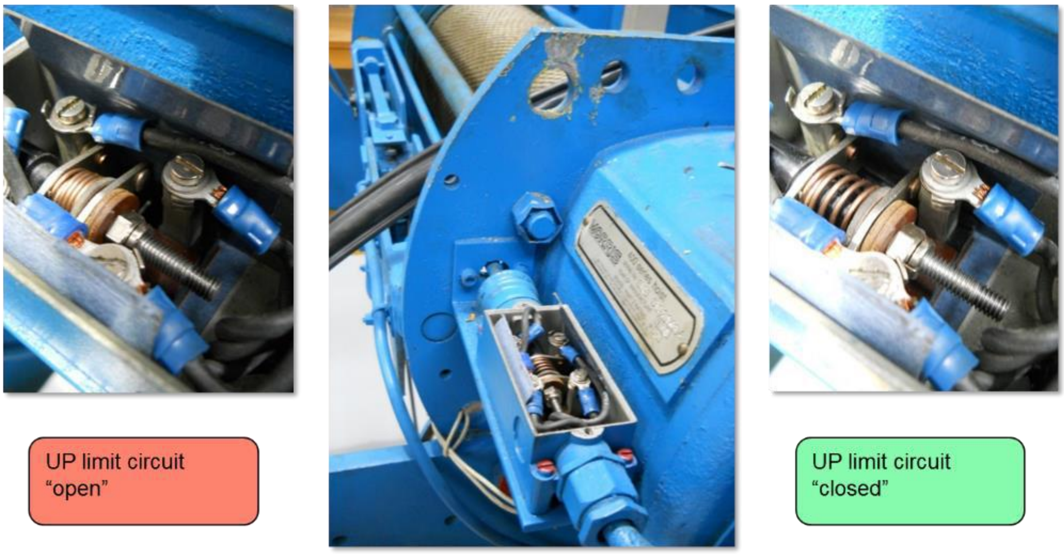
- Two micro switches are situated at the end. When the bar is moved by the guide contacting a stop, one micro switch is depressed, stopping the motor and applying the brake

- The mechanism is reset by operating the block in the opposite direction
- On most hoists the micro switches are easily accessible for maintenance and adjustment

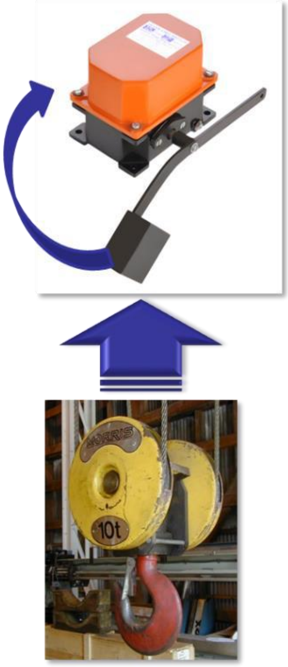
Limit Switch



Limit Operation



Weighted Lever



In operation, the knock off weight assembly is suspended from lever arm and is raised by the bottom block of the hoist which in turn rotates the shaft and a cam. The rotation of the cam opens a limit switch and the hoist (UP) contactor drops out, the motor is then de-energised and the hoist brake applied.

The mechanism is reset automatically by reversing the direction of the hoist.

The mechanism is situated beneath the hoist and is readily accessible for maintenance and adjustment.

However, being external it is liable to damage if the hoist is incorrectly used.

Hook Operated

- Hook operated limit switch trips hoisting movement when hook reaches the adjustable lever
- Hook operated limit switch can be automatic reset or manually reset
- With automatic reset hoisting movement is possible again after tripping as soon as hook has been lowered from the switching area
- Hook operated limit switches with automatic resets can be used as a working limit before standard upper limit tripping height

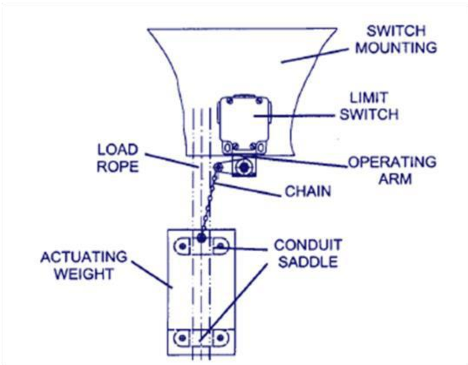
Rotary Limits

Hoisting Limit Switch

- The rotary hoist limit switch contains sets of contacts for default functions
- The rotary limit switch unit for hoisting is usually located in the connection box on the hoist gearbox

Ultimate Limit

To meet European (CE) regulations, a hoist ultimate limit switch prevents damage to the crane by contact between the bottom block and the hoist unit in the event of failure of the over-hoist limit switch by tripping the hoist motor.



Control and Series Limit Switches

- Most electric power hoists have the limit switches connected in the control circuit in a parallel arrangement
- This arrangement means that when one switch is 'open' then the other switch is 'closed' and motion is still possible in this direction when the push button is depressed. In practice, only one switch can be open at any time
- Some electric hoists have a second limit switch called the **ultimate limit switch**
- This operates when the control limit switch fails. It disconnects the supply to the contactors and should only be reset when the faulty shunt limit has been adjusted or replaced
- This switch is connected in series and **must be reset physically**

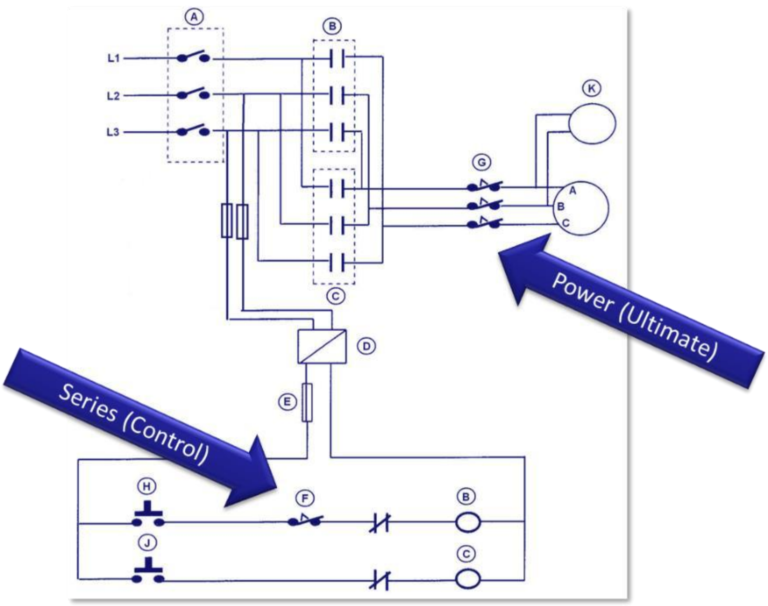
There are two versions of the **ultimate limit switch.**

Control Circuit Type
The limit is wired in the main contactor stop circuit and therefore if the normal direction limit fails, the main contactor will break the main supply to the contactors.

Series Type
The limit has either two or three contacts and is wired directly in the main supply cables to the motor. It must be noted that on older cranes, this is the only type of limit switch fitted.

Both types when used as ultimate limits are usually only re-settable manually by maintenance staff who must investigate the reason why the normal limit switch has failed.

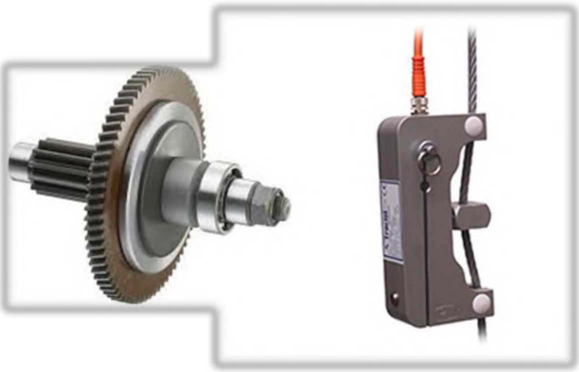
Series and Parallel Limit Switches



Notes:

13. Overload Devices

Overload Devices for Electric Hoists



Circuit and Hoist Overloading

- **Too much electrical current**
- **Too much physical load**

A range of devices are used to avoid circuit overloading, i.e. the circuit being subjected to too great a current, and Mechanical Overloading, e.g. an attempt to raise too great a load, which can result from a fault or from incorrect use.

If an attempt is made to use a hoist to raise too great a load the motor will demand an increased current. This raises the motor temperature, leading to insulation burning, shorting and cause the motor to burn out, in addition to the obvious dangers of load bearing components failing.

Protective devices are used in various ways to limit or prevent such occurrences and each type has its own intended function.

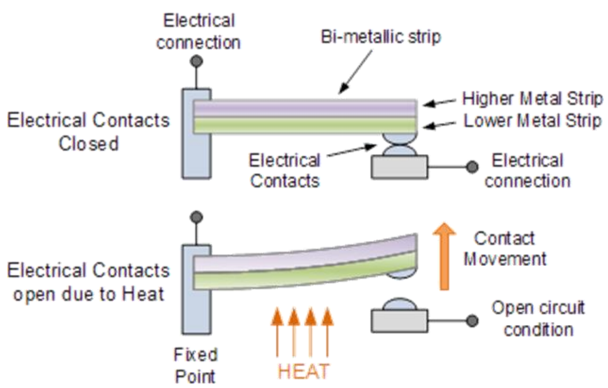
Types of Protective Device

- A **fuse** or **circuit breaker**, if properly designed, will prevent circuit overload by isolating the circuit from the power supply before any damage is done
    - Once they operate, everything on the working side of them is isolated and is inoperative until they have been repaired, replaced or re-set, they are **ultimate protection devices**
- Other devices are incorporated into equipment to protect certain parts from damage, e.g. a **hoist limit switch**, these may then operate to isolate a single component or function but permit other functions to operate. When a hoist limit operates it prevents the block from operating in the hoist mode but still allows the load to be lowered, they are **intermediate protection devices**

Notes:

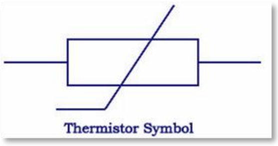
Bi-Metallic Strips

Widely used for motor protection and unbalanced currents.
The bi-metal strip consists of two dissimilar metals (e.g. copper and steel) fixed together as a bar.
When heated, the strip will bend because one metal will expand at a greater rate than the other.
This movement can be used to break contacts in the control circuit to the hoist motor. The illustration below shows a simple arrangement of a thermal relay in a single-phase circuit:



When the load supply exceeds a predetermined value its heating effect causes the deflection of the bi-metal strip to open the micro switch and disconnects the supply.

Thermal Devices



Thermistors

- **Negative Temperature Coefficient**
    - With NTC, resistance decreases with temperature to protect against inrush overcurrent conditions. Installed series in a circuit
- **Positive Temperature Coefficient**
    - With PTC, resistance increases with temperature to protect against overvoltage conditions. Installed parallel in a circuit

Some hoist motors have thermistors embedded into their stator windings during manufacture.

The thermistors are connected via a terminal strip to a relay wired in the control circuit of the contactors. In the event that the temperature of the motor rises to an unacceptable level, the thermistors will trip the relay and render the motor inoperative until it has cooled sufficiently.

When the hoist motor has been de-energised by either an electro magnetic or a thermal device it cannot be restarted until the relay has been reset, normally by a push button.

In-Line Thermal Overload

- Connected in series between the motor contactor and the motor terminals
- The thermal overload is set at a pre-determined level to trip in the event of temperature increase

Fuses

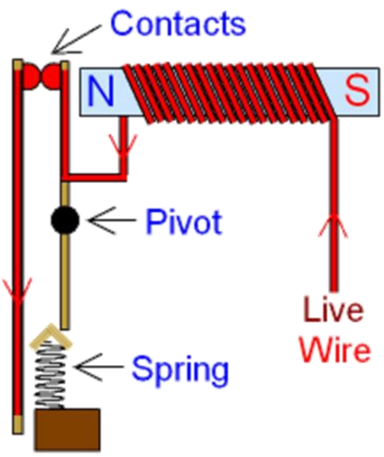
- A safety device in a circuit that acts as a weak link
- The fuse breaks the circuit if a fault in an appliance causes too much current flow
- This protects the wiring and the appliance if something goes wrong
- The fuse contains a piece of wire that melts easily. If the current going through the fuse is too great, the wire heats up until it melts and breaks the circuit

- Must be situated in the live conductor, never the neutral conductor
- Rated in accordance with their current carrying ability, e.g. 13-amp fuse
    - The rating is the maximum current, which the fuse can carry continuously without deterioration
- Fuses used with electric hoists should be of the high rupture capacity type (HRC)

- They have good non-ageing characteristics and they have a high breaking capacity (i.e. will clear short circuits before the equipment is damaged)

- If equipment is 'earthed' to prevent the machine frame becoming live and causing possible electrocution, it is necessary that a fault current 3 times that of the fuse rating can occur in order to blow the fuse quickly. This requires that the earth path resistance must be very low

Miniature Circuit Breakers



- The MCBs disconnect the supply if too large a current flow

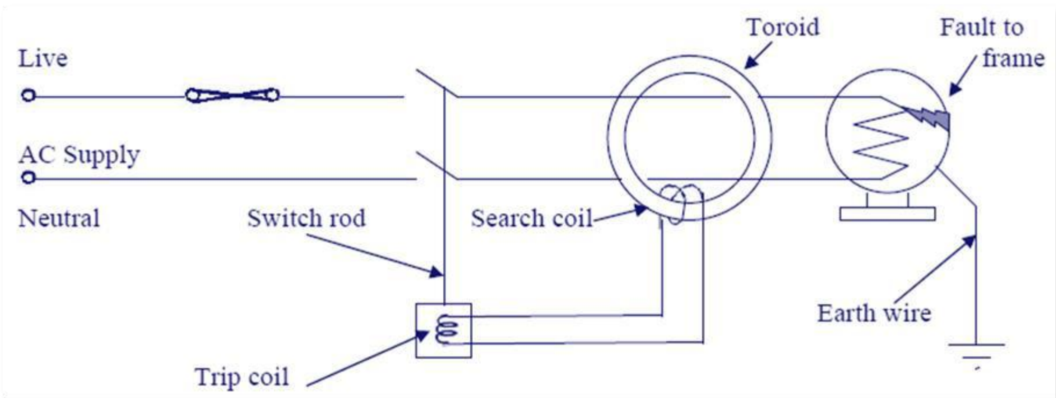
- When the live wire carries the usual operating current, the electromagnet is not strong enough to separate the contacts

- If something goes wrong with the appliance and a large current flow, the electromagnet will pull hard enough to separate the contacts and break the circuit
    - The spring then keeps the contacts apart

- After the fault is repaired, the contacts can be pushed back together by lifting a switch on the outside of the circuit breaker

Earth Leakage Circuit Breakers

The polarity of the phase winding and neutral winding on the toroid ring is so chosen that, in normal condition of magnetic force, one winding opposes that of another. We assume that in normal operating conditions the current that goes through the phase wire will be returned via neutral wire if there's no leakage in between. As both currents are same, the resultant mmf produced by these two currents is also zero-ideally. The trip coil is connected with another third winding, wound on the toroid ring as secondary. The terminals of this winding are connected to a relay system. In normal operating condition there would not be any current circulating in the third winding as there is no flux in the core due to equal phase and neutral current. When any earth leakage occurs in the equipment, there may be part of the phase current that passes to the earth, through the leakage path instead of returning via metal wire. Hence the magnitude of the neutral current passing through the RCCB is not equal to phase current passing through it.



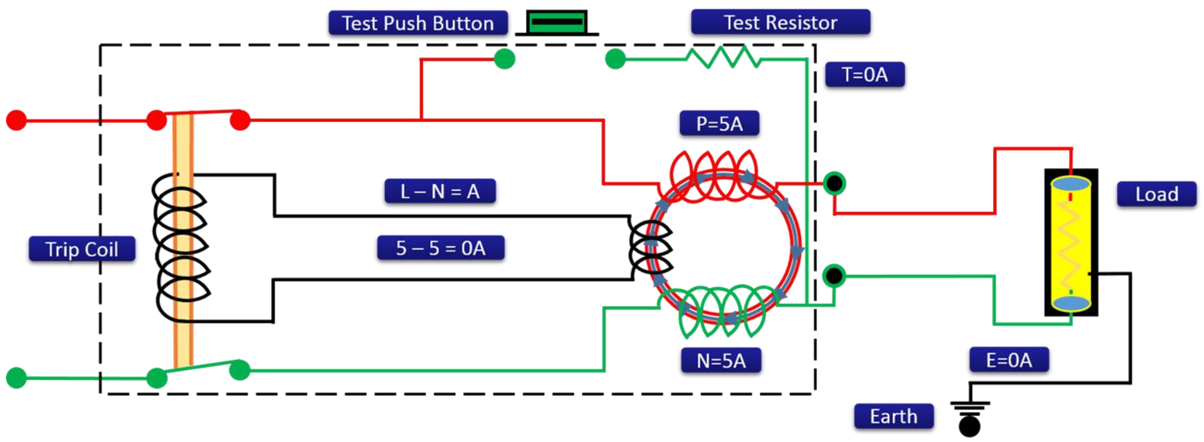
Notes:

ELCB Operation

Normal Condition

Load (L) – Neutral Coil (N) = Current (A)

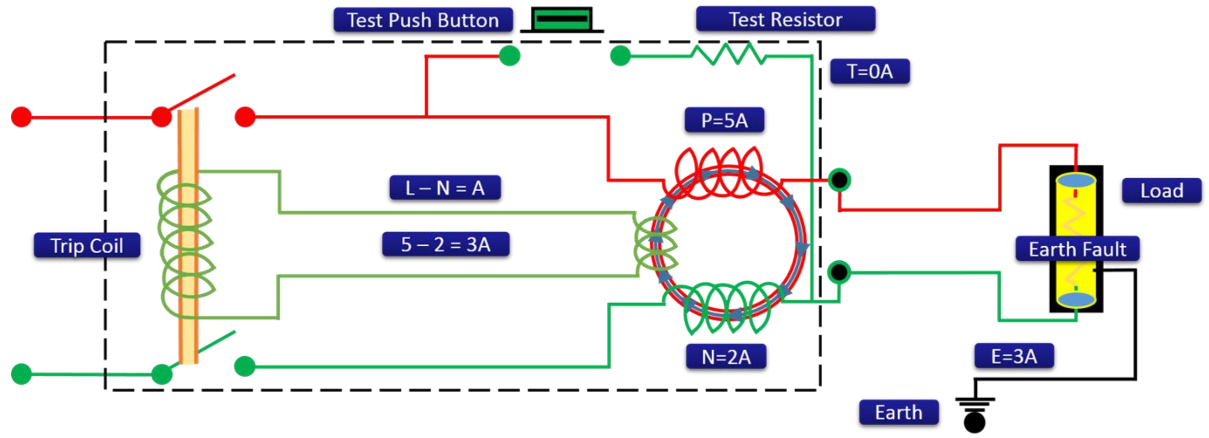
As shown in the circuit below, the line input and output are equal therefore the search coil shows no imbalance.



Earth Fault

Load (L) – Neutral Coil (N) = Current (A)

Due to earth leakage, the line voltage output current will less than that of the input. The search coil registers an imbalance and generates a current activating the trip coil and opening the circuit.



Important Reminder

The failure of ultimate devices, such as fuses, call for a thorough investigation by a suitably qualified person before any attempt is made to repair or replace them.

It should also be realised that in the case of a serious fault more than one of the protective devices may have operated.

Notes:

Slipping Clutch

Slipping clutches, also known as Friction Torque Limiters, are sometimes used in power operated chain hoists and may occasionally be found on overhead travelling cranes.

These devices are set to slip when the load increases beyond a predetermined amount, e.g. working load limit plus an allowance which takes into account the effects of dynamic loading.

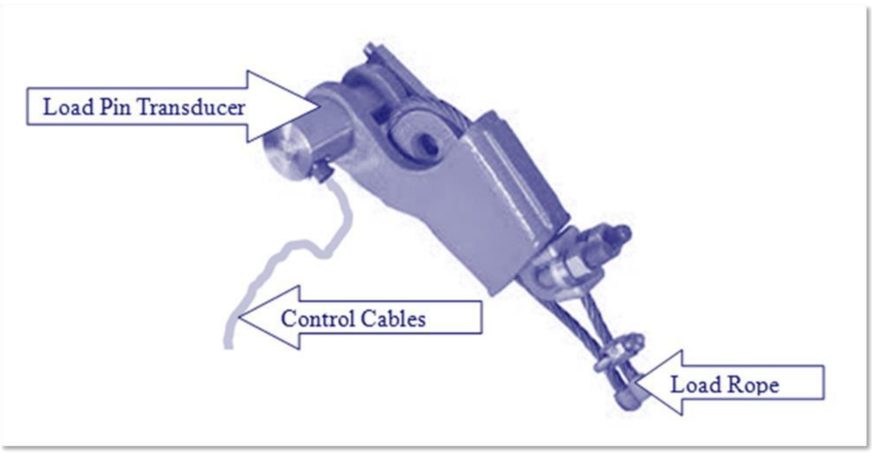
Slipping clutches are 'direct acting' rated capacity limiters and act directly in the chain of the drive elements of the hoist.

Slipping clutches are also used in some designs of lifting appliances as the upper (hoisting) limit, thereby serving a dual purpose.

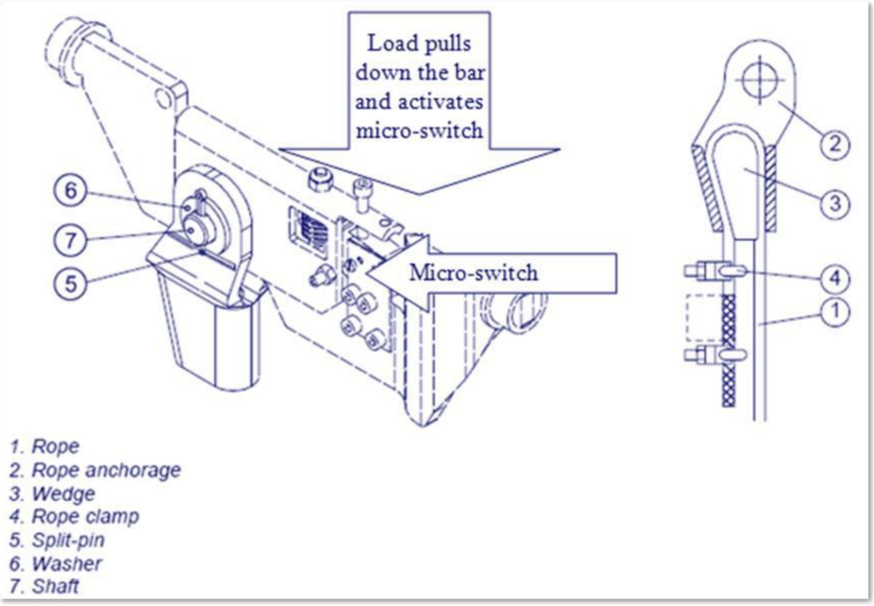
Slipping Clutch

Load Pin Transducer Limit Switch (WLL)

- Used as an additional form of overload protection on certain wire rope or chain electric hoists
- The device protects both the hoist and the supporting structure from physical overload



Lever Operated, Electro-Mechanical Load Limiter

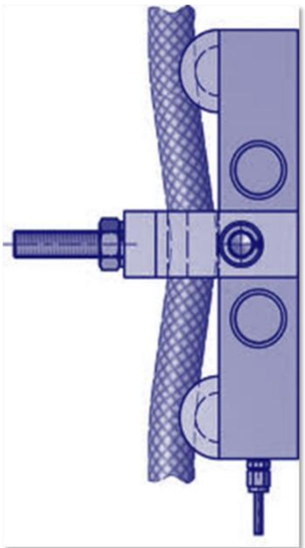


A lever-operated overload limiter works in the following manner:

1. The dead-end of the load-rope is fitted to the mechanism.
2. As the load increases, the tension in the load rope increases and pulls the dead end anchor downwards, moving the lever arm.
3. The lever arm is restrained by a combination of cupped washers that are calibrated to offer a resistance to the lever.
4. At the end of the lever is a striker: when the arm overcomes the set resistance of the cupped washers, it has moved downwards enough for the striker to contact a micro-switch and disable the 'up' control circuit.
5. When the load is reduced, the lever arm us pushed back into its upper position by the cupped washers: the striker releases the micro-switch and the 'up' circuit is now closed ready for hoisting to commence.

The load limiter is set to 110% of WLL to account for dynamic overloading.

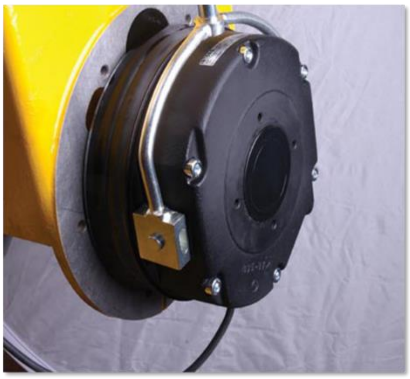
Rope Operated Load Limiter



This device is fitted to one fall of the load rope and the rope is deflected at a shallow angle between the jaw of the strain gauge and the positioning wheels

When the rope is under load condition, it tries to pull itself straight. As it does, it pulls the strain gauge anchor with it which is attached to a shaft. Once the shaft reaches a certain pre-set limit, it will open a micro-switch that opens the control power supply to the hoist motor.

14. Braking Systems



Hoist Brakes

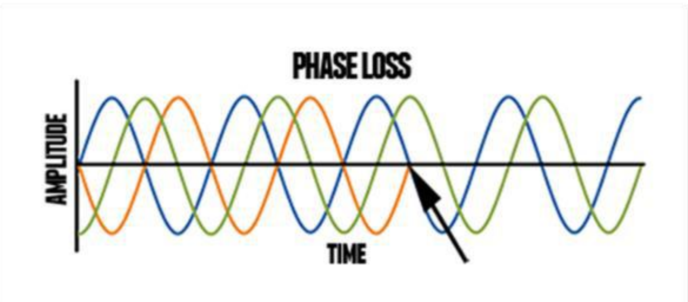
BS EN 14492-2 states the requirements for brakes that are used for hoisting and lowering movements.

Hoists shall be designed in such a way that movements can be decelerated, the load can be held, and that unintended movements are avoided. In addition the rotating masses, the triggering limit of the rated capacity limiter and the maximum speed, e.g. in the event of a phase failure, shall be taken into account.

Brakes shall engage automatically in the following cases when:

- The control device returns to its neutral position;
- The emergency stop function is activated;
- The external power supply to the brake is interrupted;
- The power supply of the corresponding drive (= motor) is interrupted or switched off

In addition, in the case of 3 phase motors, brakes must engage when two phases of the power supply to the drive (motor) are interrupted.



Failure of Power Supply

Electric hoists shall incorporate features so that:

- The load cannot lower in an uncontrolled manner if a phase should fail
- The load cannot drop if a phase should fail

When one phase of a three-phase system is lost, a phase loss occurs. This is also called 'single phasing'.

Typically, a phase loss is caused by a blown fuse, thermal overload, broken wire, worn contact or mechanical failure. A phase loss that goes undetected can rapidly result in unsafe conditions, equipment failures, and costly downtime.

Phase loss protection devices are relatively inexpensive and simple to install. They provide protection by disconnecting the equipment from the circuit when phase loss is detected. Phase or voltage monitors are the most common solution.

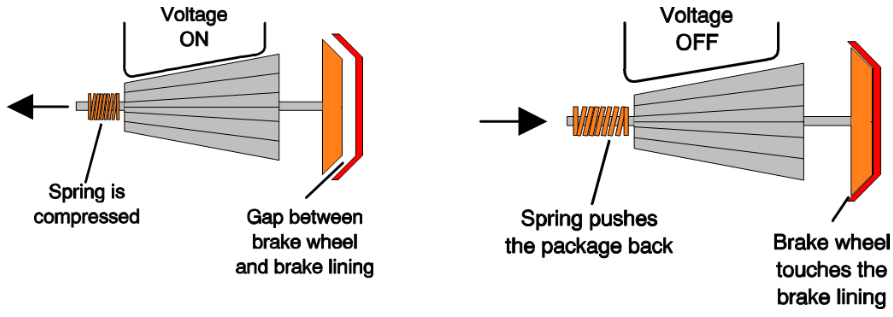
Notes:

Conical Rotor Motor

The sliding rotor principle uses an electric motor specially designed with a conical rotor and stator windings.

When power is applied to the motor windings the magnetic field is angular to the centre line of the rotor shaft, operating in effect, two components of force at right angles to each other.

The radial component rotates the rotor whilst the horizontal component, pulls the rotor into the windings.



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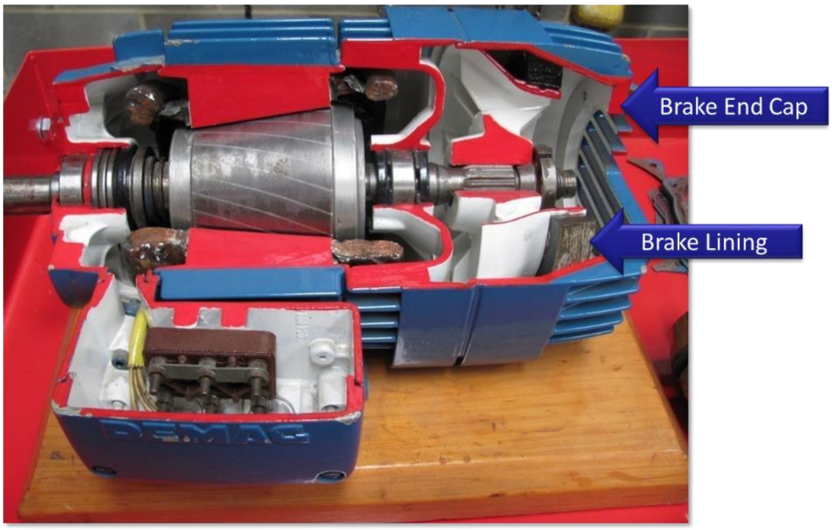
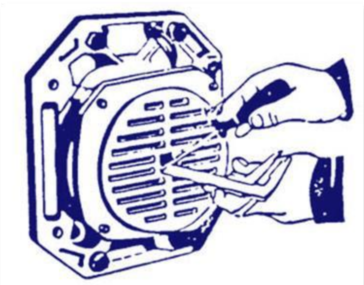


Notes:

Adjustment



Brake adjustment must always be carried out in accordance with maker's instructions since incorrect settings will upset motor performance.

When the brake lining wears the air gap between the rotor and stator increases and, if not adjusted, will produce erratic motor operation because the magnetic forces will not be powerful enough to move the rotor forward and so will not release the brake.

To check if brake adjustment is necessary the rotor should be moved forward manually either by pushing directly onto the shaft or by way of a lever between the brake end cap and the brake wheel.

When the rotor is forward as far as it will go, measure the distance between the end of the rotor shaft and the front of the brake end cap. Release the rotor and take a further measurement.

The difference between the two measurements is the air gap (stroke length) and is usually be between 0.5 and 1.5mm and must never be allowed to exceed 3mm, however LEEA recommends that the appropriate manufacturer's instructions are always followed.

If brake adjustment is required, remove the four screws that secure the brake end cap.

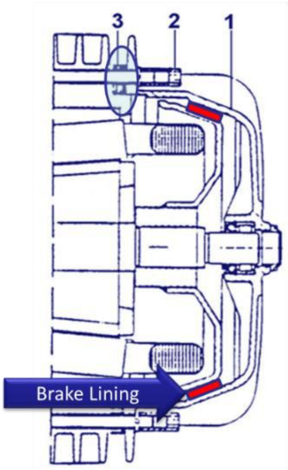
The brake end cap (which is threaded) can now be turned, and each 90° turn will reduce the air gap (stroke length) by approximately 0.5mm.

The securing screws should now be replaced and the air gap checked once more to ensure correct setting.

During the first week of operation or after changing the brake lining, the brake should be checked daily, since the lining may wear unequally until bedded in.

Ideally it could be argued that the hoist brake should be positioned as near to the hoist drum as possible. For reasons of design accessibility, cooling etc., it is usually on the end of the rotor shaft.

The examiner should take the utmost care to satisfy himself that all components are in good working order. Should for example a key shear or the coupling fail, then the load would fall.



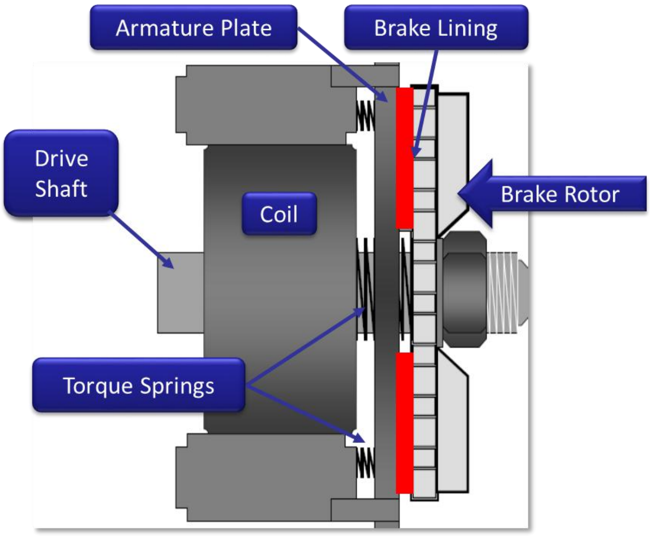
This drawing shows a cross section of a conical hoist brake. Adjustment is made by removing shims (3) as the lining wears. As shims are removed, the brake end cap and brake lining (1 – shown in red) moves further toward the brake rotor at the end of the rotor shaft and closes the gap.

As the brake linings wear down, the path of the rotor displacement increases to a maximum of 3.5mm, after which the braking would become ineffective. It is essential that the movement of the rotor is regularly checked and maintained within the manufacturers limits (approximately 1-1.5mm).

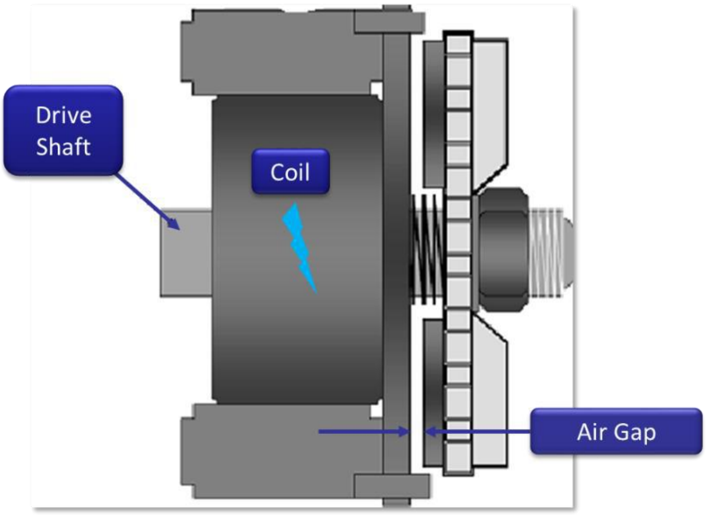
Notes:

Parallel Rotor Principle

The brake shown is in the power OFF / brake ON position. The torque springs force the armature plate to the brake rotor and linings preventing the motor drive shaft from moving.



Power OFF



Power ON

The brake shown is in the power ON / brake OFF position with the coil energised and pulling the armature plate against it. This allows the brake rotor to turn as the motor is powered.

The air gap is clearly shown between the brake rotor and the coil. The air gap should be checked to ensure that it meets the requirements of the manufacturer to ensure effective use.

Brakes (DC Electromagnet)

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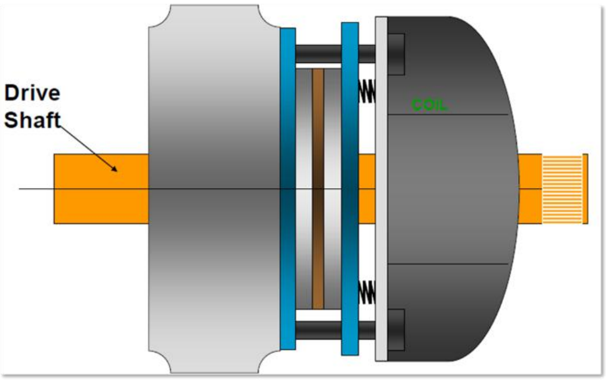
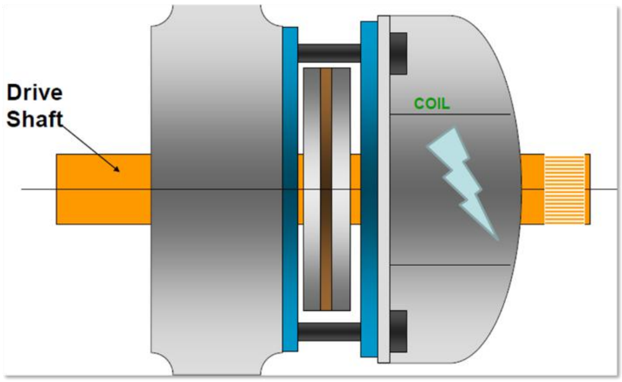
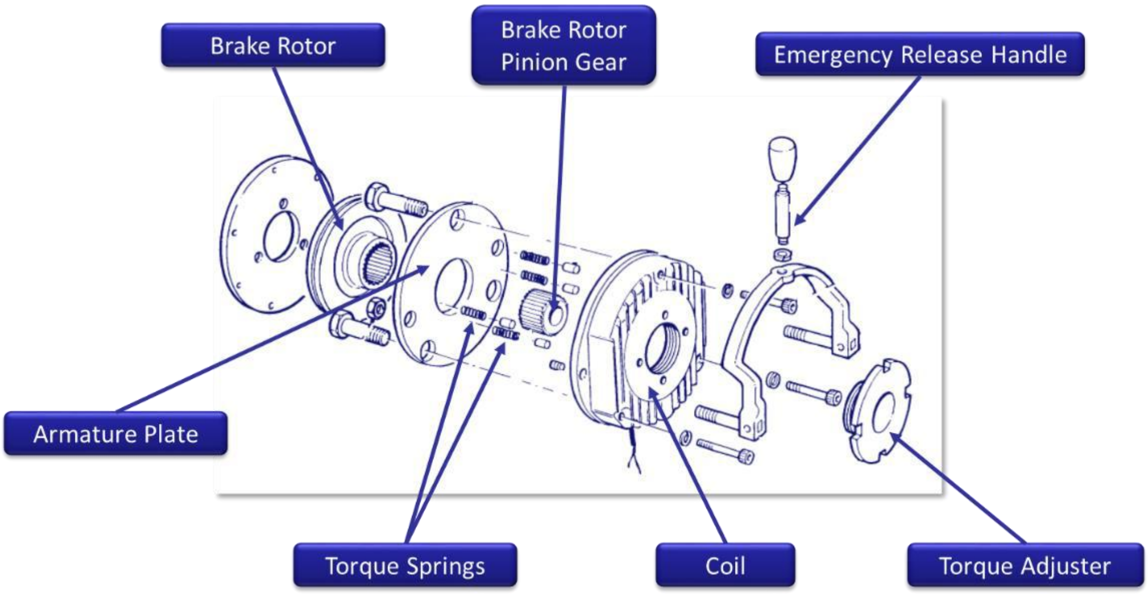
- The hoist brake is a single disc brake, electro-magnetic spring applied, DC coil release
- The coil configuration is of the stator rotor type, direct current is energised to ensure positive action
- The brake is directly fixed to the main gear case or motor frame and operates on the primary drive shaft
- Torque is pre-set on factory assembly and should not require further adjustment during its working life
- The brake is readily accessible for periodic safety checks
- For additional safety, it is switched independently of the motor supply
- The fail-safe operation maintains the load in the event of an interruption to the power supply
- A hand release mechanism is fitted to enable the load to be lowered in the event of power failure
- The hand release operating handle is detachable and is stored in the brake cover



Power "Off"



Power "On"



Notes:

Example of Manufacturer's Air Gap Settings

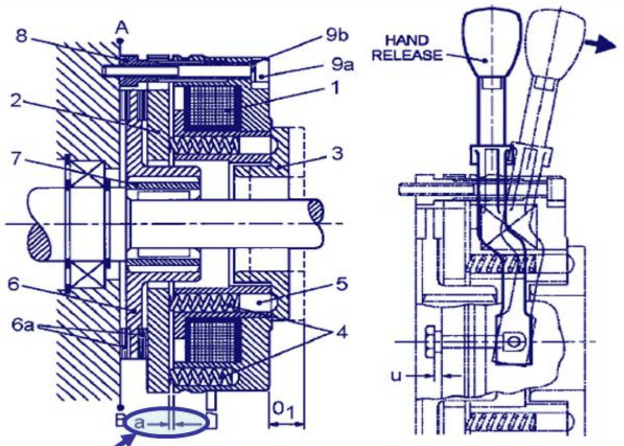


FIGURE 13-11 TYPE L BRAKE ADJUSTMENT

Brake Size:	08	10	12	14	16	18	20	25
Air gap 'a' (mm)								
nominal:	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5
maximum:	0.5	0.5	0.7	0,8	1.0	1.0	1.2	1.4
Gap 'u': (mm)	1.0	1.0	1.3	1.3	1.5	1.5	1.5	2.0
Rotor thickness (mm)								
new	9.0	12.0	12.0	12.0	13.0	15	19	23
minimum	5.3	7.3	6.0	6.6	7.0	8.0	9.6	12.5

TABLE 13-6 TYPE L BRAKE SETTING

NOTICE

The brake size is the 6th and 7th digit of the brake type number, which is shown on the torque adjusting nut (item 3).

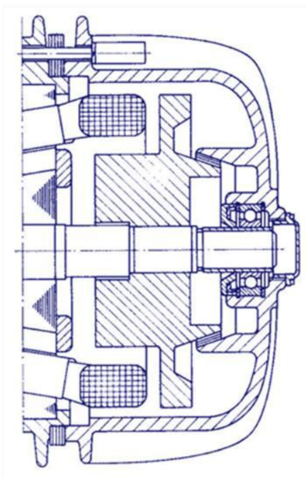
Travel Brakes

Travel brakes may be either the disc or the drum type but in both cases their characteristics need to be a lot different to a hoist brake

Braking characteristics have to be finely tuned in order to avoid excessive braking under no load conditions and providing reasonable braking when travelling with a maximum load

Disc Travel Brake

This is a cross section of a travel brake fitted to a conical rotor motor.



- A good example of soft travel braking
- The brake has been greatly reduced on disc and the equivalent of a flywheel has been fitted to the motor shaft
- This flywheel would have the effect of allowing much smoother acceleration as well as decelerations

Notes:

Thruster Brake

- Heavy duty applications
- Usually electro-hydraulic in operation
- Centrifugal pump and impeller spinning in oil and developing a pressure head
- Pressure exerted on a piston directly coupled to the load to be lifted (brake arm)
- Centrifugal pump driven by AC motor – pressure developed depends on speed of motor
- Class B insulation, 400v 3Ph 50 Hz motor

Main Parts of the Thrustor Brake

Base/Arms
Rigid wielded construction.

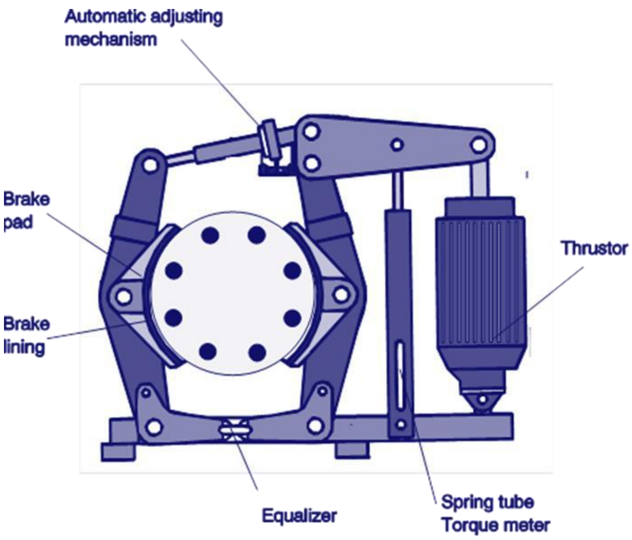
Shoes
Self-aligning, easily removable high grade cast iron filled with best quality linings fitted with stops.

Rods/Grid Rods
The tie rod transmits the spring force on shoes by simple lever system.

Springs
Compression springs are vertically mounted through the grid rods and are held securely between guide plates. One or more springs are used depending on the brake size and thrustor capacity so as to obtain the required braking torque.

Operation

The braking pressure to the shoes is transmitted from the springs and means of extremely rigid and simple lever/tie rod mechanism. Braking is smooth and positive. Release of the brake shoes is by introduction of a 3 phase mains voltage supply to the thrustor which overcomes the spring force and the shoes are moved clear of the drum by the lever/arm linkage system.



Checking the Thrustor

ALWAYS REFER TO OEM INSTRUCTIONS!

Correct operating limits and settings must be gained from the manufacturers data sheets or the crane maintenance manuals.

Notes:

15. Electric Motors and VFDs

Electric Motors

Electric motors are the most common motive source used with lifting equipment. They therefore form an important part of the study of power operated lifting equipment. Not only are they used to provide the motive force to raise and lower loads, as in hoists and winches, but also to move them, as in travelling hoists and cranes.

These different duties call for the motors used for the various functions to have differing characteristics.

In this unit we will consider how electric motors work:

- We will briefly look at how AC motors work
- We will consider motor duty rating factors

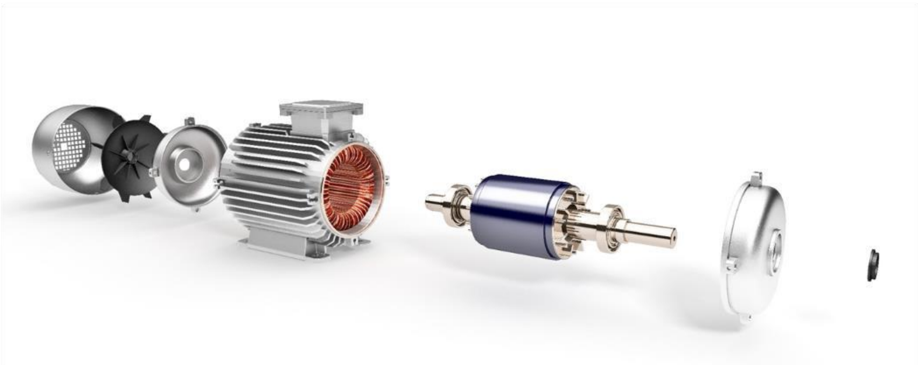
AC Motors

3 – phase AC induction motors are used extensively in lifting appliances.

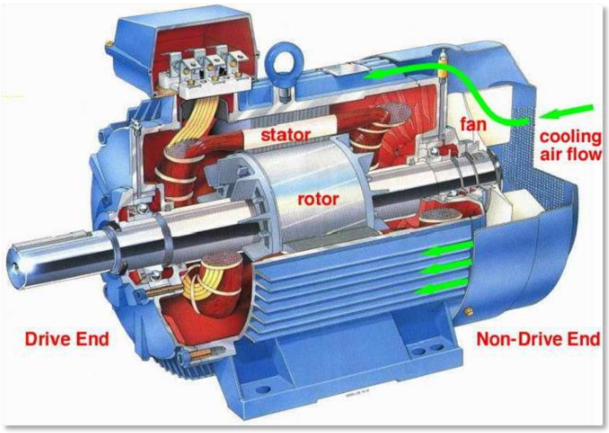
There are 3 main parts to the motor:

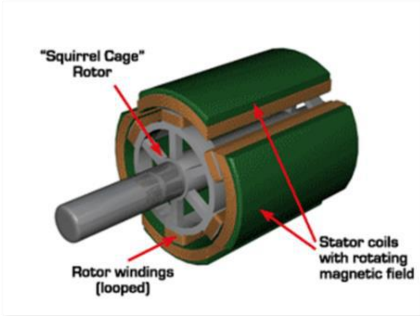
- **Enclosure (frame)**
- **Stator**
- **Rotor**

Electric Motors



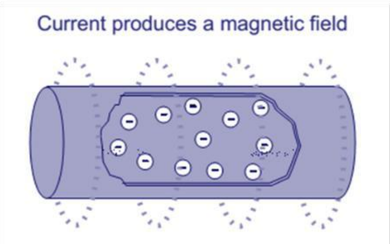
AC Motors

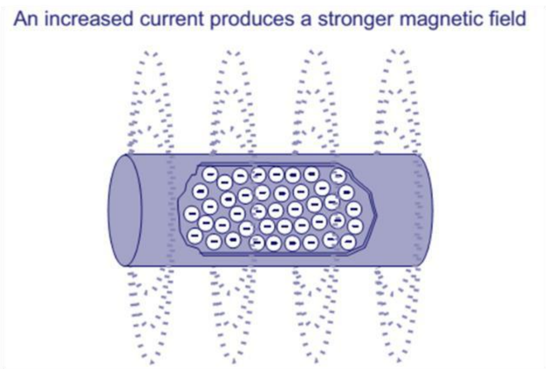




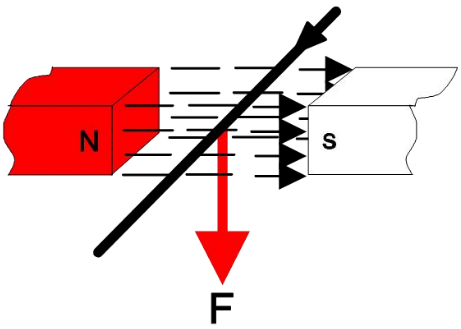
Electric Motors

When current flows through a conductor, it produces a magnetic field around the conductor. The strength of the magnetic field is proportional to the amount of current.





An electrical motor converts electrical energy to mechanical movement.



A wire that is put through a magnetic field creates a force. If the wire is moving, the force will move in the same direction.

Notes:

Squirrel Cage AC Motor

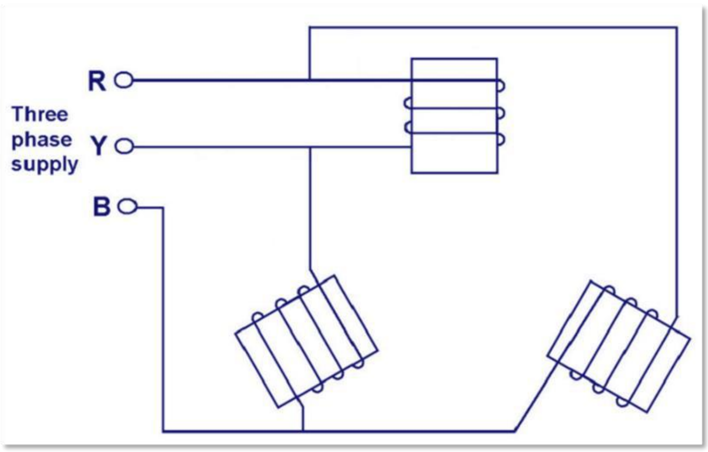
In squirrel cage motors only the stator has copper coils. The rotor package is a short-circuited aluminium or copper cage that is filled with some conductive material, usually cast aluminium. The rotor bars are slightly angled to increase the efficiency.

Cylindrical rotor squirrel cage motors require an auxiliary brake. The brake is mounted on the free end of the motor on the motor shaft.

AC Motors

In industrial applications most AC motors are three-phase although lighter capacity single phase hoists are available. A three-phase AC electric motor can be wired as shown below.

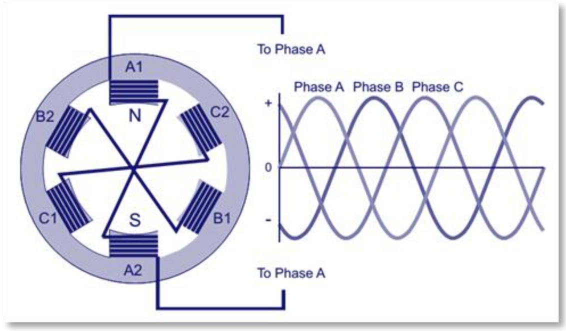
The three poles are arranged at 120� and connected as shown Each pole becomes fully energised at a different time in relation to the others.



- Hoist motors use 3 phases, the principle works as illustrated below
- An AC motor creates the revolutions on the rotor

Each leg of the 3 phases going to a motor are 120 degrees out of phase with each other, so what happens is the supply, due to the changing of polarity of the supply creates a rotating magnetic field inside the rotor.

Remember that when we put current into a wire the wire creates a magnetic field around the wire, if you constantly change the polarity of the current being applied to the wire (AC current) and then you have three phases which are 120 degrees out of phase with each other, you get a rotating magnetic field inside the stator, which is what we call the flux.



Motor Insulation

The stator core and windings are insulated. The type of insulator depends on the operating temperature of the motor.

Most motors have type E or F insulation. Class E insulation allows a temperature rise of 70°C whilst Class F permits a rise of 95°C above ambient temperature for totally enclosed motors.

Squirrel Cage Motor – Overheating

- There are no mechanically wearing parts in squirrel cage motors
- Usually the only thing that burns a motor is overheating
- A motor burns out when the insulation material around the stator coils heat up too much and melts
- This causes short circuits, and the motor is no longer functional
- A burnt motor is either changed or the stator is rewound. The rotor may also be destroyed from overheating
- Other factors that cause motors to overheat include:
    - Too many starts (inching) – operator activates high speed first before starting in slow speed
    - Lifting beyond ED% rating of motor (heavy loads plus lifting time)
    - Environmental temperature

Cooked!

Notes:

Requirements of BS EN 60204

Standard, BS EN 60204-32 Safety of machinery – Electrical equipment of machines states:

Clause 7.3 Protection of motors against overheating

- Protection of motors against overheating shall be provided for each motor rated at more than 2kW

This can be achieved by:
- Overload protection
- Over temperature protection
- Current limiting protection

Automatic restarting of any motor after the operation of protection against overheating is to be prevented if it can cause a hazardous situation or damage to the machine or work in progress.

We will look at hoist overload protection and safety devices later in this course.

Motor Ingress Protection (IP) Rating

IP ratings are used to define levels of sealing effectiveness of electrical enclosures against intrusion from foreign bodies (tools, dirt etc.) and moisture.

The table opposite explains the meaning of the IP rating, using the first and second numbers for reference, e.g.

IP 40 = 4 – Protected against solid objects over 1mm and 0 = No protection against ingress of liquids.

BS EN 60204 requires a minimum of IP23 for all motors. In dusty environments, BS EN 14492-2 requires a minimum IP protection of IP 44, and outdoor motors to have a minimum of IP 54 protection.

Ingress Protection Rating			
First Number Solids	Protection Provided	Second Number Liquids	Protection Provided
0	No Protection	0	No Protection
1	Protected against solid objects up to 50mm e.g. accidental touch by hands	1	Protected against vertically falling drops of water e.g. condensation, dripping water
2	Protected against solid objects up to 12mm e.g. fingers	2	Protected against direct sprays of water up to 15 deg from the normal position
3	Protected against solid objects over 2.5mm e.g. tools, screws	3	Protected against direct sprays of water up to 60 deg from the vertical
4	Protected against solid objects over 1mm e.g. wires	4	Protected against water sprayed from all directions – limited ingress permitted
5	Protected against dust – limited ingress permitted but no harmful deposits allowed	5	Protected against low pressure jets of water (6.3mm nozzle) from all directions. Limited ingress is permitted
6	Dust tight – totally protected against dust, Complete protection against human contact	6	Protected against strong jets of water (e.g. for use on ship decks) – limited ingress permitted
		7	Protected against the effects of immersion at a depth of 1m
		8	Protected against long periods of immersion under pressure (beyond 1m) – depth specific by the manufacturer

ED Rating

Electrical motors are not only rated according to the power they can generate, but also according to their heat resistance. This is called Efficient Duty.

- Every motor that is running gets hot due to electrical resistance in the motor
- The temperature of the motor must not increase above specified values
- Motors require rest periods to cool down

Hoist duty classification specifies the duty factor (ED % = Efficient Duty in percent) and starting frequency (maximum starts per hour) of hoisting motors according to the table below:

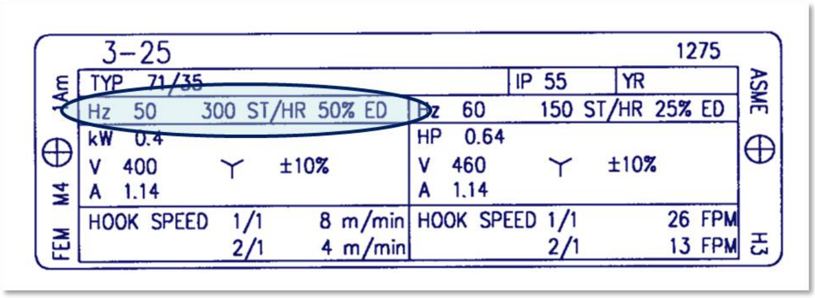
Hoist group	M3 (1Bm)	M4 (1Am)	M5 (2m)	M6 (3m)	M7 (4m)	M8 (5m)
Duty factor	25 % ED	30 % ED	40 % ED	50 % ED	60 % ED	70 % ED
Max starts / hour	= 150 / h	= 180 / h	= 240 / h	= 300 / h	= 360 / h	= 420 / h

More starts per hour increases the ED% as well as how much lifting the hoist will do in its work cycles.

- The ED% is calculated from how much the hoist will lift per each lift and how long each lift will take
- The ED% is based on a 10-minute period of time
- An ED rating of 40% means the motor can be operated for an average of 4 minutes in any 10 minute period whilst resting 6 minutes of that period
- Be aware that after 4 minutes of lifting the motor requires a 6 minute cooling down period

Another general way of explaining ED% is the maximum number of continuous minutes a motor can be used to lift nominal load in a 10 minute period without overheating the motor.

The example hoist data plate below shows that when this particular motor is suppled with a 400v 3 phase 50 hertz supply, the ED rating will be 50%. (Able to run continuously for 5 minutes in every 10).



Duty Classification

Safe and effective operation of the hoist is dependent on correct classification of the hoist's operating group.

Hoists shall be classified in groups of mechanism in accordance with ISO 4301-1 according to the operational requirements and conditions of application.

Hoists shall be designed in accordance with **FEM 1.001**, booklets 1, 2, 3, 4, 5, 8 and 9 and **FEM 9.901.**

We will consider duty classification in the specific hoist modules during this course.

Notes:

Requirements of BS EN 14492 Parts 1 & 2

BS EN 14492 is the current harmonised standard for Cranes – Power driven winches and hoists:

- Part 1 – Winches
- Part 2 – Hoists

The standard applies to the design, information and use, maintenance and testing of power driven hoists with or without travelling trolleys for which the prime mover is either an electric, hydraulic or pneumatic motor.

Annex J of the standard details the requirements for selection of motors in 3 ways:

1. General criteria for the selection of motors and dimensioning of motors according to thermal aspects, usually applying on all sorts of drives in intermittent service
2. Special criteria to dimension motors according to the maximum torque required for lifting motions and according to data on stress occurring during the use of these drives
3. As 2. but details requirements for horizontal drive motors (e.g. travel and traverse motions)

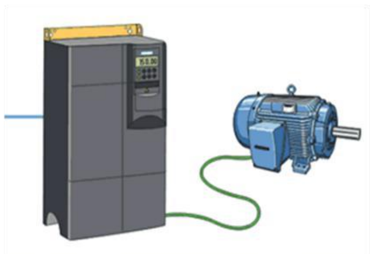
Inspection and Examination
It is recommended that the following points are checked during the inspection/examination of an electrically powered lifting appliance:

- **Overheating** - check cleanliness and correct venting of the motor
    - Look for signs of burning or paint discolouration on the motor body/housing
- **Vibration**
    - Ensure mountings and fixing bolts are secure
    - Check that the motor shaft is incorrectly aligned
    - Check for excessive play in the coupling between motor and transmission equipment
    - Electrical imbalance, e.g. one phase burnt-out etc. (Only qualified personnel to check)
- **Running Sound** - this will be mainly due to bearings
    - If they are suspected they should be checked with a listening rod. A perfect bearing gives a whirling sound, whereas a damaged bearing gives a rattle
- **Lubrication** - ensure the motor bearings and attachments are adequately and properly lubricated
- **Attachments** - check connecting shafts and gears etc. for play and damage which could adversely affect the running of the motor

Inverters (Variable Frequency Drives)

As we have already studied, the speed of a 3 phase squirrel cage motor can be changed by either changing the number of pairs of poles, or by altering the supply frequency.

Many industrial applications require a motor to be operated at a constant speed. Other applications, such as cranes, require the motor to change speed and running direction at a particular point in the operation. Sometimes, speed must remain constant and precise.



Inverter Drive to Motor

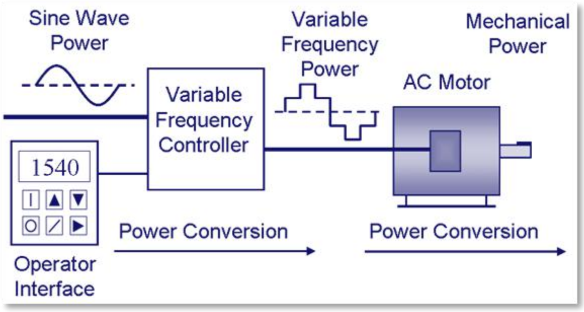
VFD inverters have become very commonplace in the control of overhead travelling crane and other machinery AC squirrel cage motors.
Inverter drives can also reduce operating costs while improving productivity. Reduced costs can be realised from:

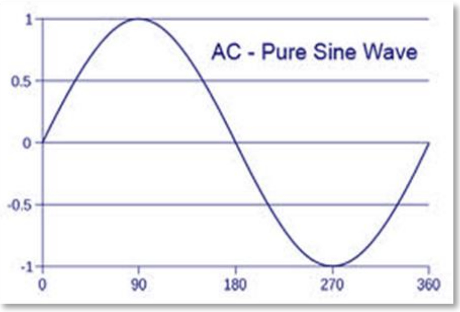
- Reliability of drive mechanisms is improved
- Less downtime
- Reduction in energy consumption
- Maintenance costs are reduced
- Precise and smooth operation reduces wear on mechanical components

Inverters can therefore not only provide precise speed control, but also reduce overall operating costs.

A **VFD (Variable Frequency Drive)** inverter operation is sometimes referred to as PWM (Pulse Width Modulation).

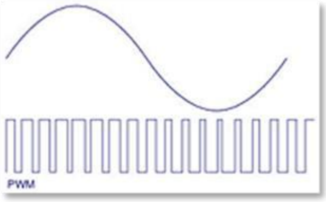
The inverter changes the 3-phase alternating current (AC) into pulses of positive and negative direct current, (DC). The pulses are combined to simulate the rising and failing sine wave required by the AC motor.





PWM is the process of pulsing the DC on and off by quickly switching a number of switches on and off (this can be thousands of times per second), and when this is fed to the motor it has an effect on the current flow.

The current actually resembles AC current and so fools the motor into running with an AC power supply, when it is in fact DC.



The inverter's control board signals the power device's control circuits to turn "on" the waveform positive half or negative half of the power device. This alternating of positive and negative switches recreates the 3 phase output.

The less time the power device is on, the lower the output voltage and the longer the power device is off, the lower the output frequency.

We simply adjust the pulses of DC to the motor in order to adjust its torque and speed.

Mechanical Brake Control

An inverter decelerates a motor to a stop (dynamic braking). The slow down rate is dependent on the set deceleration time when the run command is switched off.

The brake simply becomes a 'parking' brake as it does not engage until the motor has completely stopped and the inverter switches off the drive command to the motor.

This way brake wear is minimized. Only if a failure occurs or the emergency stop button is pushed, the brake closes immediately stopping the motor.

It is critically important that the untrained, or inexperienced inspector/examiner does not tamper or interfere with a VFD inverter as this could cause serious health and safety risks and/or physical damage to the crane. Covers should remain intact and safety notices should be strictly adhered to at all times. If in doubt, refer to a Competent Person for advice.

Important Reminder

It should also be noted that the initial section of the unit is written in a simplistic form that is intended to establish only some basic principles. The aim is to give those with little or no knowledge of the subject a basic understanding and to provide the basis for further study.

This module will help examiners/inspectors whom have dealings with electrically powered lifting equipment to understand the principles, recognise the layout and individual items, and be aware of associated dangers.

It is in no way intended to provide competence to deal with electrical matters, which must always be dealt with by a suitably qualified person.

Safety and Training

It is of paramount importance that **lifting equipment inspectors or examiners do not work on live electrical equipment.** Lock-out/Tag-out routines should always be considered as part of your risk assessment.

Under no circumstances should inspectors/examiners whom are not suitably and sufficiently qualified (as required by local legislation) attempt to work on live electrical equipment; this should not be required as part of a thorough examination as the equipment should be isolated following the initial operational/functional checks.

Notes:

16. Duty Classification

Introduction

During module 2 of this course, we looked at the various standards that are applicable to overhead travelling cranes, whether they may be for design, gantries, thorough examination, or indeed ‘classification’.

Two particular standards were listed for crane classification:

1. **BS ISO 12482: Cranes – Monitoring for Crane Design Working Period (Duty Holder/Owner)**

Principally for the use of the crane owner/duty holder to monitor crane ‘design working period’. The standard specifies a method for monitoring, during long-term operation, the actual duty of the crane, and a means of comparing this to the original design duty which was specified through classification.

2. **ISO 4301-1: Cranes and Lifting Appliances – Classification**

This standard establishes a general classification of cranes based on the number of operating cycles to be carried out during the expected life of the crane and a load spectrum factor which represents a nominal state of loading.

Duty Classification

Cranes are designed for a finite lifetime duty and this is not principally related to calendar working time. Typical operational periods are between 10 and 20 years but specific crane classification can be relative to a particular use, e.g. 5 to 10 years special use or 30+ years for a long term investment.

There are essentially two types (or uses) of classification:

1. **The appliance as a whole (contractual and technical purposes)**

Classification agreed between the purchaser and the manufacturer is only provided for the overall classification of the crane as a whole and is intended for contractual and technical reference purposes, not design purposes.

2. **Classification for design purposes**

Allows a designer to analyse the design and verify it is capable of achieving the desired life under the expected conditions of service.

Notes:

Group Classification of the 'whole crane'
Two factors are used to decide which group a crane belongs to:

1. Class of utilisation
2. State of loading

Class of Utilisation

Based on the users expected number of 'operating cycles' over the duration of the crane life.

- 1 x operating cycle commences when a load is ready for hoisting and ends at the moment when it is ready to hoist the next load
- Total operating cycles in the life of the crane is usually determined from:
    - Total operating hours per day

And

    - Number of cycles per hour
- The overall number of operating cycles is the total of all operating cycles during the specified life of the crane

ISO 4301 – Class of Utilisation of Cranes

Class of Utilisation	Maximum Number of Operating Cycles	Remarks
U0	1.6×10^4	Irregular use
U1	3.2×10^4	
U2	6.3×10^4	
U3	1.25×10^5	
U4	2.5×10^5	Regular light use
U5	5×10^5	Regular intermittent use
U6	1×10^6	Irregular intensive use
U7	2×10^6	Intensive use
U8	4×10^6	
U9	Greater than 4×10^6	

We can clearly see from the previous 'Class of Utilisation' table from ISO 4301-1 that a class U4 crane would be undertake a maximum of 2.5×10^5 operating cycles in it's expected lifetime.

i.e. $2.5 \times 10^5 = 2.5 \times (10x10x10x10x10)$
= 2.5 x 100,000
= 250,000 operating cycles

Notes:

State of Loading (Load Spectrum)

This element of crane classification looks at how many times a load of a particular weight is lifted, relative to the rated capacity of the crane.

E.g.

1. A 10t WLL overhead crane may lift 2.5t for 80% of its total number of operating cycles per day, and 10t for the remaining 20%

2. A 5t WLL crane may lift near to full load for 70% of its daily operating cycles and less than 1t for the remaining 30%

The following table provides a general view of how the state of loading (load spectrum) of a crane is established, based upon the magnitude of loads and the number of times these will be lifted over the crane's design life:

State of Loading	Notes
Q1 – Light	Cranes which hoist the SWL very rarely, and, normally light loads.
Q2 - Moderate	Cranes which hoist the SWL fairly frequently and, normally, moderate loads.
Q3 - Heavy	Cranes which hoist the SWL frequently and, normally, heavy loads.
Q4 – Very heavy	Cranes which are regularly loaded close to the SWL

Once the **class of utilisation** and the **state of loading** have been established, the overall classification of the crane as a whole can be determined by using the following table:

State of Loading	Class of Utilisation of Mechanisms									
	U0	U1	U2	U3	U4	U5	U6	U7	U8	U9
Q1 – Light			A1	A2	A3	A4	A5	A6	A7	A8
Q2 - Moderate		A1	A2	A3	A4	A5	A6	A7	A8	
Q3 - Heavy	A1	A2	A3	A4	A5	A6	A7	A8		
Q4 – Very heavy	A2	A3	A4	A5	A6	A7	A8			

Notes:

Group Classification of a Mechanism as a Whole (for design purposes)

We will now look at the class of utilization of a mechanism. This is characterized by the assumed total duration of use in hours. This is usually obtained from the assumed average daily utilization time in hours, the number of working days per year, and the number of years of expected service:

Class of Utilisation	Total Duration of Use (Hours)	Remarks
T0	200	Irregular use
T1	400	
T2	800	
T3	1600	
T4	3200	Regular light use
T5	6300	Regular intermittent use
T6	12500	Irregular intensive use
T7	25000	Intensive use
T8	50000	
T9	100000	

The **total duration of use (hours)** are theoretical values only, which only provide a basis for the design of parts of mechanisms for which the utilization time is a criteria for the choice of the part (e.g. bearings, gears and shafts).

The hours stated are not considered as any guarantee of service life for a mechanism.

When we now consider the state of loading for the mechanism, we are considering the extent of loading, whether that be maximum loadings or reduced loadings:

State of Loading	Notes
L1 – Light	Mechanisms subjected very rarely to the maximum load and, normally, to light loads
L2 - Moderate	Mechanisms subjected fairly frequently to the maximum load, but, normally to moderate loads.
L3 - Heavy	Mechanisms subjected frequently to the maximum load, and, normally to loads of heavy magnitude.
L4 – Very heavy	Mechanisms subjected regularly to the maximum load

Once the **class of utilisation** and the **state of loading** have been established, the group classification to the design of specific mechanisms can be determined by using the following table:

State of Loading	Class of Utilisation of Mechanisms									
	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
L1- Light			M1	M2	M3	M4	M5	M6	M7	M8
L2 – Moderate		M1	M2	M3	M4	M5	M6	M7	M8	
L3 – Heavy	M1	M2	M3	M4	M5	M6	M7	M8		
L4 – Very Heavy	M2	M3	M4	M5	6M	M7	M8			

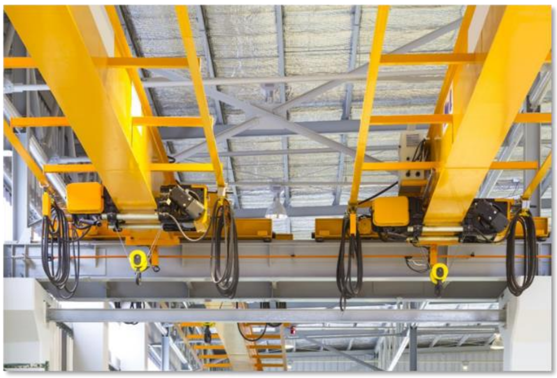
Important Reminder
It should also be noted that the initial section of the unit is written in a simplistic form that is intended to establish only some basic principles. The aim is to give those with little or no knowledge of the subject a basic understanding and to provide the basis for further study.

This module will help examiners/inspectors whom have dealings with electrically powered lifting equipment to know the basic principles relating to duty classification and how this effects the overhead travelling crane during its service life.

Notes:

17. Safety Essentials – Working on OTCs

Safety Essentials: Working on Overhead Travelling Cranes



There is no job so important and no service so urgent
that we cannot take the time to perform our work safely and correctly!

A Few Essential Rules

- Do not take shortcuts in the planning of safety for the work to be done
- Do not take risks
- If your job cannot be done safely, your employer will not want you to do it
    - Always talk to your line manager if you have any concerns
- Report any unsafe conditions or working behaviour immediately

Isolation of Energy – Basic Rules

- The basic rules are that there should be isolation from the power source (usually, but not exclusively, electrical energy)
- The isolator should be locked in position (for example by a padlock), and a sign should be used to indicate that inspection work is in progress
- Isolation requires use of devices that are specifically designed for this purpose; not devices such as key-lockable emergency stops or other types of switches that may be fitted to the machine
- Any stored energy (hydraulic or pneumatic power, for instance) should also be dissipated before the work starts
- If more than one examiner is involved in the work, each of them should lock off the power with their own padlock. Multi-padlock hasps can be used in such circumstances. Such isolation procedures can also be applied to locking off valves for services (such as steam) and material supplies

- Before entering or working on the equipment, it is essential that the effectiveness of the isolation is verified by a suitably Competent Person

Electrical Isolation

Unqualified personnel should not perform any electrical examinations or testing of any kind on any electrical equipment associated with overhead travelling cranes unless they can demonstrate competency in electrical service and hazardous energy isolation, have been suitably and sufficiently trained in electrical safety, and authorised by their company management to perform such tasks.

Unqualified personnel should not be allowed to perform any work on or near energised electrical equipment.

Accident Report

"Two dock workers suffered injuries in a high voltage electric shock when they were trying to fix a crane. The maintenance worker was temporarily blinded – and is now scarred permanently - and both he and an electrician were burned. Two other men working on the job could also have suffered burns as a result and all four could easily have been killed. None of the men had received adequate training or been given sufficient information about the electricity supplies to the dockside cranes. All four workers were put at risk because their employer did not have procedures in place to ensure electrical work was carried out safely".

Source: http://www.hse.gov.uk/safemaintenance/experience.htm

Personnel Carrying Out Thorough Examinations

BS7121-2-1 2012 (5) states:

"It is essential that the in-service inspection and maintenance of cranes is always carried out by personnel who have been assessed by their employer as competent and have adequate training and information to carry out the work required."

LOLER also requires that thorough examinations are carried out by Competent Persons.

"Competent Persons should have the necessary attributes, competencies, knowledge and experience to enable them to carry out effective thorough examinations of cranes. The nature and extent of these will depend on the purpose of the examination to be undertaken, the complexity of the cranes to be examined and the consequences of failure of those cranes. It is essential that such persons have adequate training, information and independence to carry out the work required"

Note: Module 1 of this OTC Advanced Programme provides the definition of a Competent Person.

Attributes of the Competent Person

Competent Persons should:

- Be physically fit for the tasks they are to undertake
- Have adequate eyesight (with correction if needed)
- Be comfortable working at height, over water or in a confined space (if required)
- Have a responsible attitude
- Be able to communicate clearly with other personnel in the location where thorough examination is taking place, including the need to take the crane out of service if it is unsafe to use
- Be able to demonstrate adequate literacy and numeracy;
- Be aware of their own limitations in knowledge and experience

Source: BS7121:2-2012 5.3.2

Competencies of the Competent Person

Competent Persons should be:

- Fully conversant with the machinery they are required to examine and its hazards, including operation necessary for thorough examination activities
- Properly instructed and trained
- Familiar with the procedures and precautions required for safe work at height, over water or in a confined space (where required)
- Have a responsible attitude
- Fully conversant with the appropriate sections of the manufacturer's instruction manual
- Familiar with the use of permit to work systems where they are required by the safe system of work, and able to operate them correctly
- Familiar with site specific safety requirements (e.g. manufacturing, construction, process plant, nuclear, docks, airports, railways)

- Trained and competent in the selection, pre-use inspection and correct use of their personal protective equipment

Source: BS7121:2-2012 5.3.2

Knowledge Base of the Competent Person

Competent Persons should have:

- An understanding of the applicable crane design standards and codes of practice for the selection and use of the relevant cranes, together with the applicable examination criteria
- An understanding of the safety rules and associated codes of practice that are applicable to the relevant cranes
- An understanding of the inspection and maintenance requirements of cranes
- Knowledge of appropriate test procedures which may be employed and the interpretation and limitations of those techniques
- An understanding of drawings and manufacturing literature relevant to the cranes to be examined
- Knowledge of the materials and techniques used in the manufacture and assembly of the type of cranes to be examined

Source: BS7121:2-2012 5.3.4

Practical Skills of the Competent Person

Competent Persons should have:

- Be capable of detecting defects or weaknesses in cranes which could compromise the safety of the crane
- Have sufficient knowledge and experience to assess the importance of defects or weaknesses in the crane and identify what actions need to be taken in order to rectify them. In particular they should be able to:
    - Determine whether the crane is operating as intended
    - Specify the appropriate time-scales within which identified defects or weaknesses need to be rectified
    - Determine whether defects identified in the previous report of thorough examination have received attention
    - Determine whether all safety devices are functioning correctly
    - Check whether warning notices are correctly fixed and legible, and where necessary specify any limitations on the use of the crane
    - Witness any testing required as part of the thorough examination and evaluate the results
    - Report on the findings of the thorough examination

Source: BS7121:2-2012 5.3.5

Assessment of Competence

Employers should determine through a formally documented assessment process the competence of each individual person, both existing employees and new entrants, based on the attributes, competencies, knowledge and skills listed in 5.3.2 to 5.3.5. A shortfall in attainment level does not necessarily preclude employment in this role but it is essential that such shortfalls are addressed before the person is allowed to carry out unsupervised thorough examinations of cranes.

All Competent Persons should be assessed on appointment, again within their first 12 months, and at regular intervals (not exceeding 4 years) thereafter. Assessment should form part of any training.

*Source: BS7121:2-2012 5.3.9

Training Records

A comprehensive individual training record should be established for all personnel carrying out thorough examinations. This should be updated as training is undertaken and as a minimum should include:

- When the training, refresher training, assessment or re-assessment took place
- Where the training took place
- The scope of the training, including types and models of crane
- The duration of the training
- The outcome of the training
- Who delivered the training
- When refresher training is required

Source: BS7121:2-2012 5.3.10

Continual Professional Development

Continuing professional development is a joint responsibility between the Competent Person and their employer.

The employer should maintain a CPD record for each Competent Person. The record should include details of how CPD is being achieved and should include for example:

- Specific training towards enhancements/additions to competency
- Familiarization/re-familiarization, ongoing training and mentoring
- Any alterations and/or withdrawals of competency
- Enhancements to qualifications
- Membership of professional bodies/institutions
- Attendance at seminars and refresher training courses
- Visits to manufacturers and trade shows

Source: BS7121:2-2012 5.3.11

Maintenance and Thorough Examination

Selection of the Competent Person

It is essential that the Competent Person undertaking the thorough examination of a crane has not been involved in the maintenance of the crane. This also applies to the inspection of cranes under MCA LOLER 2006:6 Regulation 12(1).

Preparation for the Thorough Examination

- The crane should be checked to determine whether it is clean enough not to conceal the structure or mechanisms to an extent that would prevent an effective examination. If necessary, the crane should be cleaned as required

- The crane should be positioned in a suitable area to enable the thorough examination to be undertaken safely

- Additional means of safe access should also be provided as required by the Competent Person, e.g. scaffolding, working platforms or mobile elevating work platforms

These recommendations also apply to an inspection made under MCA LOLER 2006:6 Regulation 12(1).

Note: Attention is drawn to the Work at Height Regulations 2005 (as amended) [15].

Access

- Employers and Competent Persons should ensure that procedures are in place to enable the Competent Person to access all relevant parts as and when required

- Some parts might be accessible by using permanent facilities such as access ladders to the gantry combined with gantry and cross-bridge walkways

- Such facilities do not always provide access to all parts, and the Competent Person might need to use personal protective equipment (PPE) to protect against the risk of a fall

- Use of PPE requires suitable anchor points and a recovery plan in the event that a fall occurs

- Temporary access facilities, such as a mobile elevating work platform (MEWP) or scaffolding, might be required to reach some parts

- Such temporary facilities usually stand on the ground or floor of a building and require a suitable surface, space for access, space to operate in and time to deploy

- The Competent Persons who deploy and use such facilities should be trained for the purpose, and the equipment used should be in a serviceable condition

Preparation for the Thorough Examination

- If the local lighting is not adequate for examination purposes it should be supplemented by portable lighting

- The identification and rated capacity marked on the crane should be checked against the records, for example the test certificate, declaration of conformity, the manufacturer's instructions for use and the report of the last thorough examination
- The crane should be made safe by isolating and locking-off the power supply when necessary and reinstating it as appropriate

- The Competent Person carrying out the thorough examination should determine if there is any history of defects or malfunctions, and whether any repairs, alterations or additions have been made. The last report of thorough examination and in-service inspection reports should be consulted

- Where it is not possible to ascertain the condition of hidden mechanism parts, for example ropes, chains, sheaves or terminations, dismantling prior to thorough examination should carried out as required by the Competent Person

Notes:

Method Statements and Work Instructions

- Generic risk assessments will normally suffice
- Unusual or potentially hazardous tasks may require specific risk assessment
- Always follow a 'Safe system of work'
- Toolbox talk
    - All team members are fully briefed
    - Focussed
    - Discuss the 'job specific' method statement
    - Briefings should be recorded
    - Unusual features of the job to be highlighted

Notes:

Working Above Ground Level

Hierarchy of Control Measures

1. Working Platforms (crane walkways etc.)
2. Scaffolding
3. MEWPs
4. Controlled Zones
5. Safety Nets and Air bags
6. Work Positioning
7. Horizontal and Vertical Lifelines
8. Fall Arrest Equipment

Rescue Plan
A Rescue Plan must be developed whenever fall-arrest systems are in use and when personnel may not be able to perform a self-rescue should a fall occur.

Before requesting a Rescue Kit (which is the last resort) you must first consider whether ladders, stepladders, MEWPs, controlled decent devices or other equipment can be used to perform a rescue.

If all else fails, then a Rescue Kit should be utilised.

Other Things to Consider for a Rescue Plan
You must never rely upon the emergency services as a primary rescue plan

- What obstructions may be in the way of reaching a suspended worker?
- How will the rescue be assured within 10 minutes of the fall to minimise the risk of further injury or suspension trauma?
- How will the safety of the rescuers be assured as well as the suspended worker?
- What communications will be used between the suspended worker and the rescue team?

Notes:

Monitor and Review

Continuously monitor activities in all three dimensions of your surroundings!

- Additional hazards may be presented
    - Traffic, pedestrians etc.
    - Changes in production activity
    - Additional hazards presented
- Record your findings and change the risk assessment as necessary This may result in the requirement for additional control measures

High Ambient Temperatures

Where Applicable:

Special attention and planning are required for inspecting cranes in hot areas. Due to the adverse environment, these cranes may not receive the inspection time they deserve.

The temperature in certain applications/environments (coupled with seasonal high temperatures) may mean that on occasion, the crane structure may be hot, and gloves are recommended for manoeuvring on the structure during an inspection.

Your risk assessment may identify reduced exposure time for the personnel working on the crane(s).

Summary

In this module, we have looked at the various safety considerations that are to be incorporated into our risk assessments, method statements and review procedures to ensure that all examiners involved in work on overhead travelling cranes are afforded the highest level of protection from injury or fatality.

Examiners of overhead travelling cranes should always make themselves familiar with any national regulations of the country in which they are operating.

Failure to do so may lead to prosecution, due to breaches of the law.

Notes:

18. Testing as Part of the Thorough Examination

General

- All cranes and supporting structures should be overload tested before first use
    - In some circumstances, it might be necessary to treat them as separate entities, for example where a structure supports more than one crane

- The extent and magnitude of the testing should be clearly stated in the thorough examination report/test report

- Cranes and supporting structures should be overload tested after major repairs or modifications

Overload Testing of Cranes

Thorough Examination and Functional Testing

- Before overload testing, the crane and the part of the supporting structure within the test area should be thoroughly examined to determine whether it is in a safe state and condition to be overload tested

- The crane should be functionally tested without a load applied to determine whether the controls, switches, contactors, relays and other devices operate correctly

- The operation and correct adjustment of the brakes and limit switches should be checked and tests carried out to determine whether primary safety and emergency systems are operating correctly

Tested at Rated Capacity

- After the functional tests, the crane should be tested with a load equivalent to the rated capacity

- At the start of the test, the crane should be positioned over a supporting stanchion or column of the gantry or beneath the connection point of a suspended track, as appropriate, with the crab or hoist positioned adjacent to the end carriage

- With the crane in this position, provision should be made for measuring the deflection of the crane main girders at the centre span
- The load should then be raised until each tooth on the gearbox system has been subjected to the load
    - Lower the load to approximately 100/200mm from the floor
    - Leave the load in this position for 10 minutes
    - Check that the brake is holding

- Lift the load again from the suspended position by a further 200 mm to check the hoists ability to re-hoist

- Lower the load again to 100/200mm above the ground

- Travel the crab (trolley) to centre span of the crane
  - Measure the deflection
  - Lower the load to the ground to relieve the structure and then raise load again to ensure the amount of deflection is constant

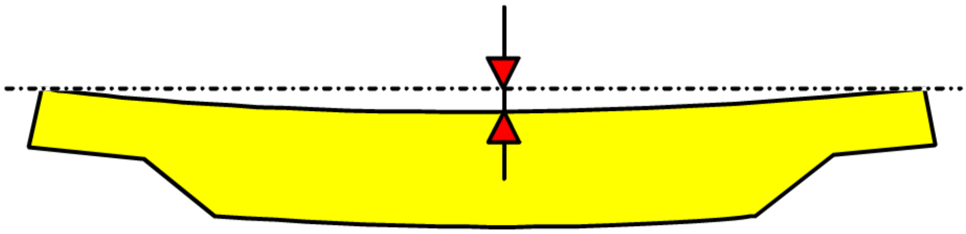
- The maximum deflection of the main bridge with the crab and load at the centre of the bridge should not exceed 1/750 of the span

Deflection

Note:
Cranes manufactured to **BS 466:1984** have a maximum permissible deflection of **1/750** of the span

Cranes manufactured to BS 466:**1960** have a maximum permissible deflection of **1/900** of the span

For cranes manufactured to BS EN 15011:2011, sub clause 5.2.2.5 of that standard specifies, **'the elastic deformations of the crane structure shall not have a detrimental influence on the function of the crane.'**



Testing as Part of the Thorough Examination

Overload Test

- The load should then be increased by 25% to form an overload test load and the overload test load should be hoisted until each tooth of the train of gears has been subjected to the overload
  - Lower the load to 100/200 mm above the ground
  - Leave the load in this position for 10 minutes
  - Check that the brake is holding

- Lift the load again from the suspended position by a further 200 mm to check the hoists ability to re-hoist
  - Lower the load again to 100/200mm above the ground

- During the overload test the crane should remain stable and structurally sound and the brakes on each motion should function effectively. The traverse and travel braking systems should also function effectively with the overload applied

- During the overload test the crane should be operated at speeds appropriate to the safe control of the load, for example the lowest speed possible for the crane

Testing of Cranes with 2 or more Hoists

- For cranes with two or more hoists, separate tests in accordance with 'rated capacity' and 'overload test' should be carried out for each hoist

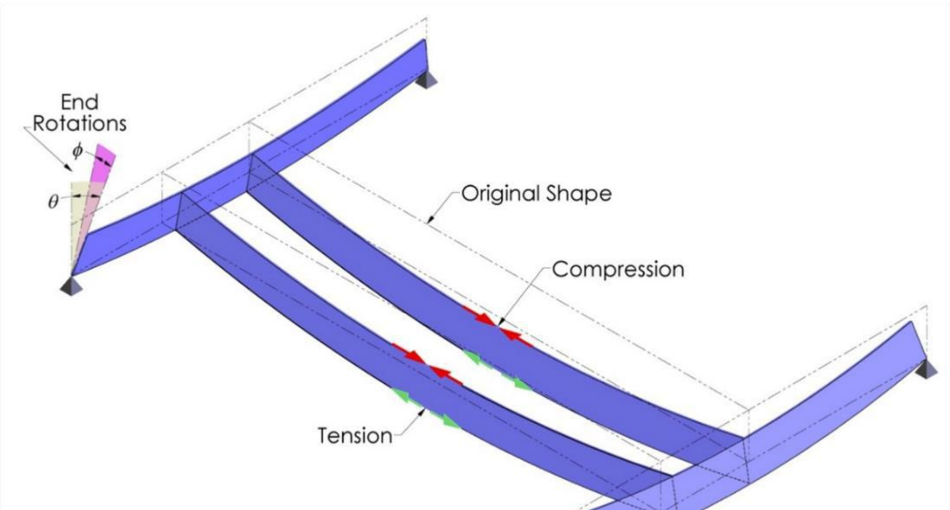
- Where the use of more than one hoist at a time is permitted, all tests including the measurement of deflection should be carried out with all these hoists loaded simultaneously

Post Testing Thorough Examination

- On completion of the tests, a further thorough examination of the crane should be carried out by the Competent Person

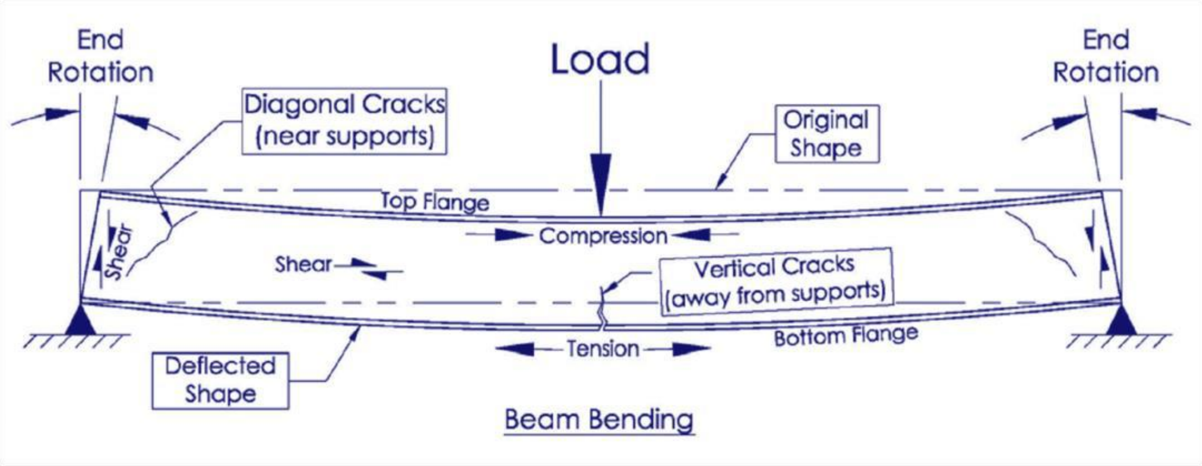
- Any overload protection devices should be reset and their correct operation checked

Structural Stresses Due to Loading

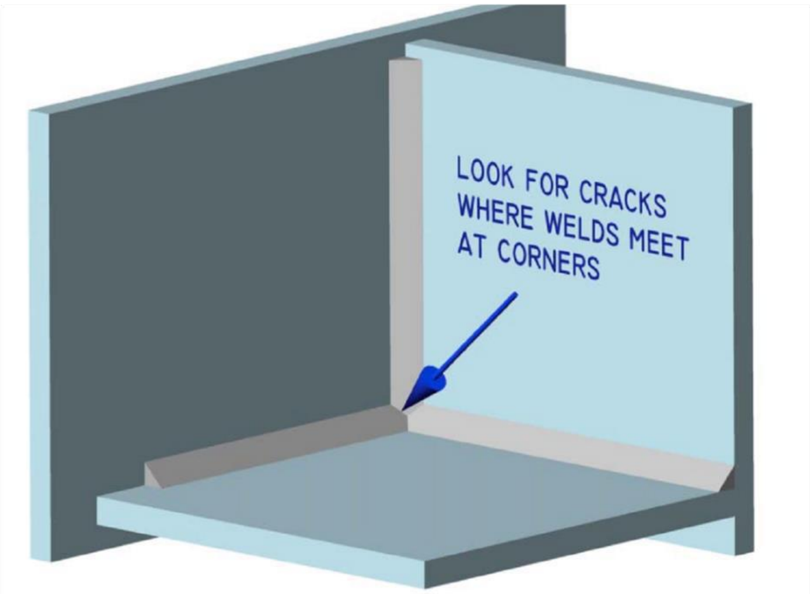


Trolley Frame Deflection
(Deflected shape greatly exaggerated)

Collateral Damage
What damage may have been caused?



Structural Problems



Load Testing Supporting Structures

Assessment and Thorough Examination
Cranes can be supported in a variety of different ways. This could include a free-standing structure, or a gantry or track supported by the structure of the building or an engineering structure.

Prior to the application of the test loads, the Competent Person should carry out a thorough examination of the structure to determine whether it is in a safe condition to be load tested.

An unloaded crane should then be travelled the full length of the supporting structure to check the alignment.

Note: BS ISO 12488-1 contains detailed information about the alignment of crane supporting structures.

General

Testing should be carried out using the combination of loadings, cranes and crane positions that imposes the maximum loadings on the structure under test. This includes cranes in an adjacent bay.

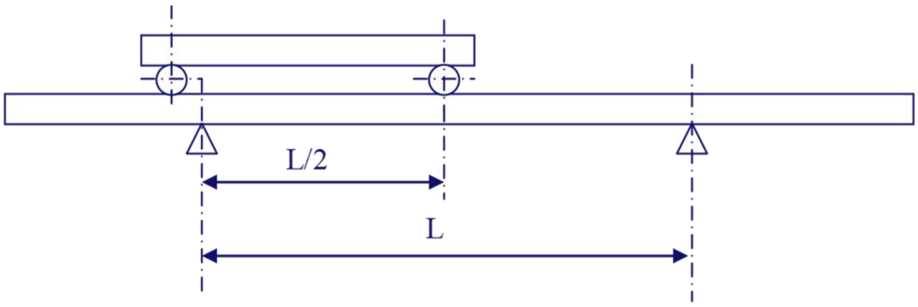
Test at Rated Capacity - Deflections

For structures built in accordance with **BS 449-2**, the maximum deflection should not exceed **1/360** of the span. For structures built in accordance with **BS 5950-1** or **BS EN 1993-6**, the maximum deflection should not exceed **1/600** of the span.

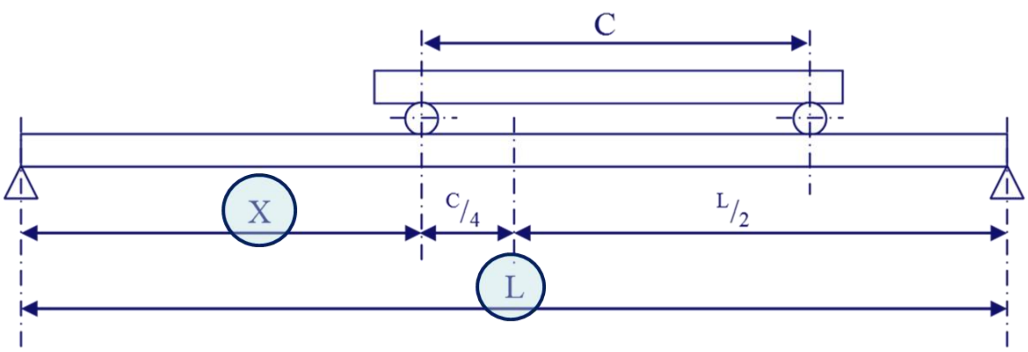
BUT: Where do we place the crane on the gantry to measure deflection effectively?

Maximum Bending Stresses and Shear Load of Gantry Girders

For testing purposes, if the end carriage wheel centres are equal to, or more than half of the gantry girder span (L/2), then the maximum stress will occur with one wheel in the centre line of the girder. The maximum deflection will occur at the centre of the girder:



If the end carriage centres are less than half of the gantry girder span (L/2), then the maximum stress will occur when the end carriage centreline is offset from the girder centre line by measurement C/4:



Maximum stress will occur at X and maximum deflection in the girder will occur at girder centreline L/2

Notes:

Testing

Overload Test

The overload test load on each crane should be that determined previously in this unit.

Each crane involved should then lift the overload test load 100 mm to 200 mm above the ground. The load lifted by each crane should be traversed to the end of the crane bridge nearest the side of the structure being tested. The cranes should be travelled the full length of the structure in such relative positions as to impose the maximum combined loading. The procedure should be repeated for the other side of the structure.

Post-test thorough examination of the supporting structure.

On completion of the test, a further thorough examination of the supporting structure should be carried out by the Competent Person.

Notes:

19. The Thorough Examination

Thorough Examination of Overhead Travelling Cranes and Supporting Structures
LOLER 1998 [2] Regulation 9 requires cranes and supporting structures to be thoroughly examined in the following circumstances:

1. Before being put into use for the first time, unless the crane is new and the owner has an EC Declaration of Conformity dated not more than 12 months prior to the crane being used for the first time

2. Where safety depends on the installation conditions:
   I. After installation and before being put into service for the first time
   II. After assembly and before being put into service at a new site or in a new location (see note 1)

3. Periodically whilst in service, at maximum intervals of 6 months for cranes that lift people and 12 months for cranes that lift goods only (see note 2)

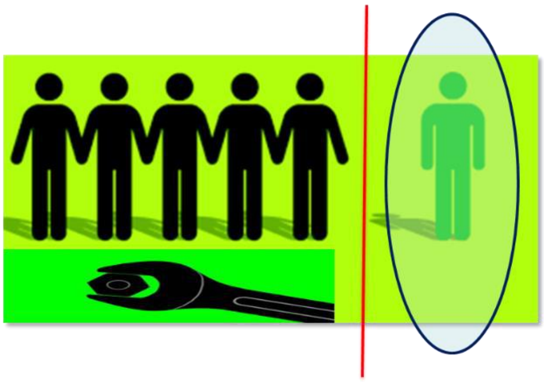
4. After exceptional circumstances have occurred

Note 1: Thorough examination does not apply to a portable gantry crane which is moved from one location to another to perform a lifting operation, is not fixed in position, and is operating within the scope of the current report of thorough examination.

Note 2: These maximum intervals may be reduced to take into account environmental factors or the general age and condition of the crane etc.

Selection of the Competent Person

The Competent Person carrying out the thorough examination must not have had any involvement with the maintenance of the crane. (BS7121:2-7 2012)

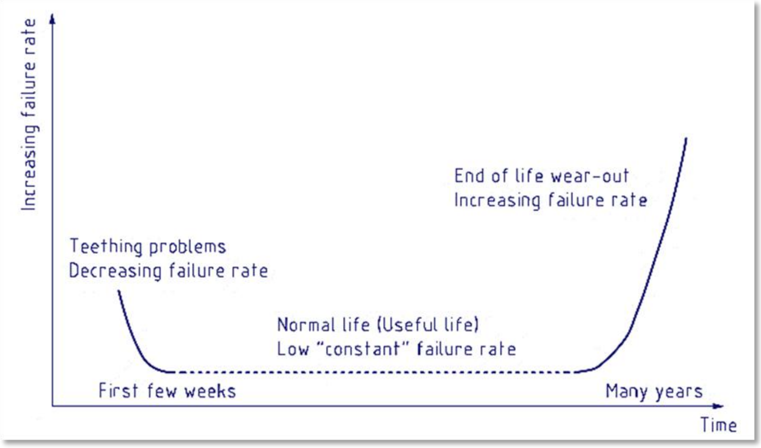


Notes:

Scope of Thorough Examination Before Putting an OTC into use for the First Time

- The scope of the thorough examination should be put together by the Competent Person. During this process, the Competent Person should give due consideration to the likelihood of anything failing and the associated risks involved from such a failure

- The Competent Person should consider the age of the crane and any deterioration that may have taken place since it was manufactured. This could lead to increased risk in operation



Scope of Thorough Examination Following Installation

- The scope of the thorough examination should be put together by the Competent Person. LOLER requires that this scope ensures that the crane has been installed correctly and is safe to use

- The crane manufacturer's instructions should have been followed during the installation
    - The crane should be checked and tested in accordance with the manufacturer's instructions

- The Competent Person should ensure that the scope of the thorough examination is in proportion to the complexity of the crane and its installation
    - Previous thorough examination reports should be consulted and taken into consideration where applicable

Scope of Periodic Thorough Examination

- The Competent Person carrying out a periodic thorough examination should work to a defined scope of thorough examination that has been drawn up specifically for the crane they are required to examine
- The scope should be made in advance of the examination
    - All parts should be identified and listed
    - Any required supplementary tests and reports should be detailed
        I. Requirements for witnessing of tests should be detailed
    - Details of NDT tests should be provided

Note: The Competent Person carrying out the thorough examination may add to the defined scope but is not permitted to reduce it!

- It is essential that the defined scope of thorough examination includes any dedicated ancillary equipment. **Particular attention should be paid to wire ropes!**

The defined scope of thorough examination should, as a minimum, include operation of the crane through all the motions:

- Listen for any sounds that might indicate defects and observing any other malfunctions

- All components should be assessed against relevant criteria (original manufacturer's instructions and guidelines and standards offer guidance here), taking into account the path of the load through the crane's structure and mechanisms

- It is essential that the scope is risk based and takes into account the consequences of failure of the crane
    - The examination should be undertaken in a systematic manner to ensure that all components and structures, including the supporting structures, are examined

Note: Parts of the supporting structure which are solely for the support of the crane should be included in the scope of thorough examination.

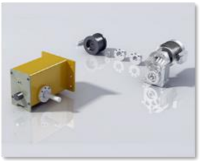
Parts of the supporting structure which are not solely for the support of the crane gantry or track are not included in the scope of thorough examination.

Components to be Included in the Thorough Examination

Note: The following list of components is not exhaustive. The scope of the thorough examination should identify all components on any specific crane.

- End carriage structures

- Long travel drive, wheels, axles, bearings and brakes

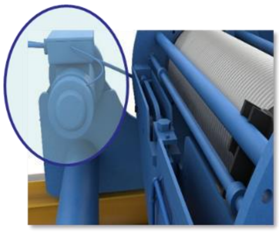


Note: The following list of components is not exhaustive. The scope of the thorough examination should identify all components on any specific crane.

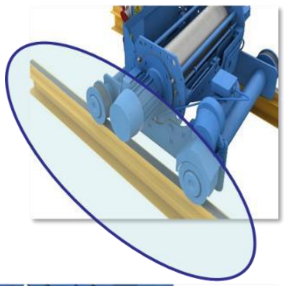
- Bridge girders

- Crab structure

- Cross travel drive, wheels, axles, bearings and brakes



- Cross travel rails

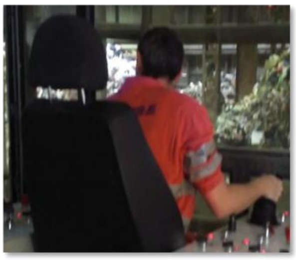


- Hoist mechanism including motor, brake, couplings, gearbox, drum and bearings

- Wire rope(s), their terminations and anchorages, guides, sheaves/pins, bearings, bottom block and hook(s)

- Electrical control panel and wiring

- Operator cab and seating



- Operator controls, whether cab, pendant or cable-less

- Limit switches

- Platforms and access ladders

- Supporting structures

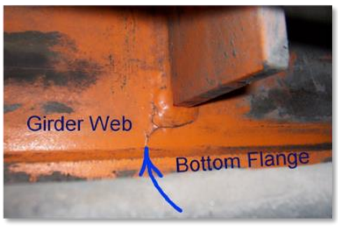
Notes:

- Gantry beams, rails and fixings
- End stops and buffers
- Down-shop conductor system

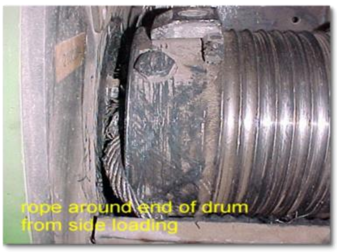
Assessment Criteria

- Alignment – within manufacturer's tolerance

- Corrosion – affecting strength or functionality

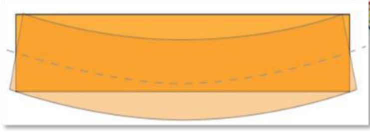


- Cracks – affecting strength or functionality

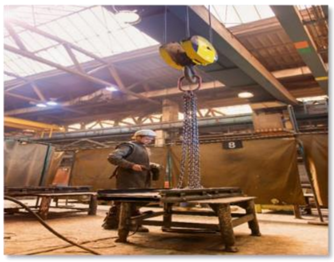


- Damage – affecting strength or functionality

- Distortion – affecting strength or functionality



- Functionality – as intended by manufacturer



- Leaks – affecting strength, functionality and slips

- Lubrication – adequacy

- Markings – presence, accuracy and condition

- Mode of operation – as intended by manufacturer

- Rope fit – as specified by manufacturer

- Rope reeving – as specified by manufacturer

- Rope specification – as specified by manufacturer

- Rope condition

- Obstructions

- Security – attachment of components and sub-structures, fasteners, welds, etc.

- Seizure – full or partial seizure of rotating components

- Tidiness – general housekeeping

- Wear – affecting strength or functionality

Periodic Thorough Examination Interval

- The statutory maximum intervals of 6 months and 12 months may be reduced to take into account environmental factors or the general age and condition of the crane, etc.
    - The decision to reduce the interval between thorough examinations may be made by the Competent Person, the crane owner or the crane user

- Reasons for reduction of the interval between thorough examinations include the following:
    - If the crane frequently works above or near **people**
    - If the crane might be used for **lifting of persons** in exceptional circumstances, including rescue, even if it is not initially planned
    - To take into account the **intensity of use** of the crane and the **environment** in which it is used
    - Following a review by the Competent Person of the in-service lift plan (risk assessment, method statement and schedule of lifts) **to ascertain the likely load spectrum and frequency of use of the crane**

Thorough Examination After Exceptional Circumstances

Examples of 'exceptional circumstances' would include:

- Use in very arduous conditions
- Failure of a structural component
- Collision
- Overload
- Subjected to extreme weather conditions in excess of design specifications

It is a requirement of LOLER that if an overhead crane is subject to and exceptional circumstance, it is to be removed from service and a thorough examination is to be carried out. The Competent Person will then decided if the crane can be returned to service.

The scope of the thorough examination should be proportional to the nature of the exceptional circumstances and the extent of any repairs, and should take into account the reports of previous thorough examinations, where applicable.

Notes:

Scope of Periodic Thorough Examination

The Competent Person who prepared the scope of thorough examination should review it periodically

- Consider any changes of use – increased productivity, heavier loading state, etc.
- Particulars from previous thorough examination reports may indicate particular areas for closer inspection
- Results of supplementary testing, maintenance and NDT activity

A copy of the thorough examination scope should be available in the crane maintenance/history file

Notes:

20. Gantry Alignment

Crane gantries will generally be constructed as 'top running' or 'under-slung'. Top running gantries are supported in various ways.

The latticed stanchion shown below tends to provide a lighter and more rigid structure since the transverse loading at the track level are all virtually transmitted through a very stiff column to the foundations.

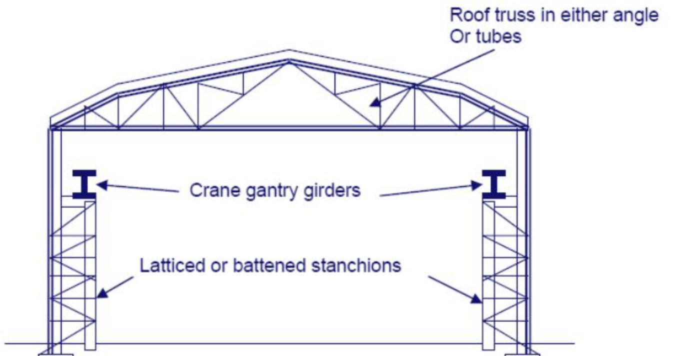
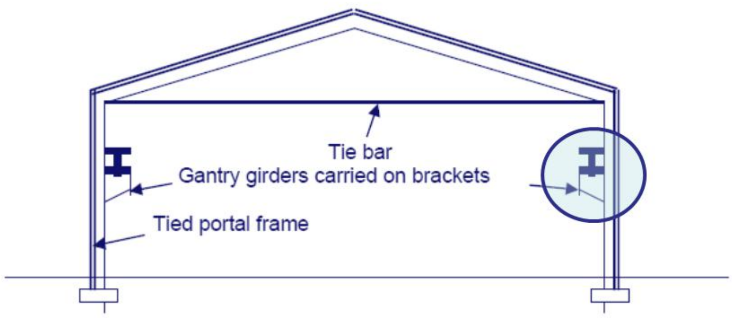


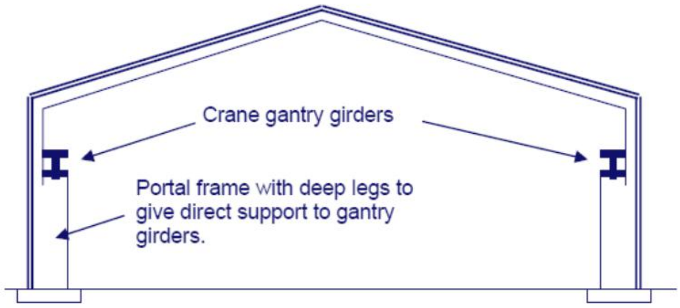
Figure 1
Latticed Crane Stanchion

The method of gantry support shown below, although cheaper to produce, could have problems of fatigue with the cantilever brackets if the crane is in constant use.



Gantry tracks supported on cantilever brackets welded or bolted to building support columns

The support steelwork shown in the illustration below provides direct support for gantry girders, additional stiffness and no tie bars are required.



Portal Frame with Deep Legs

After a number of years, gantry installations can suffer from what is known as 'settlement' which can affect the track levels and span. This is caused by the settling of the building foundations.

Serious misalignment of a crane track will cause the crane to bind and bias to one side of the track rather than float.

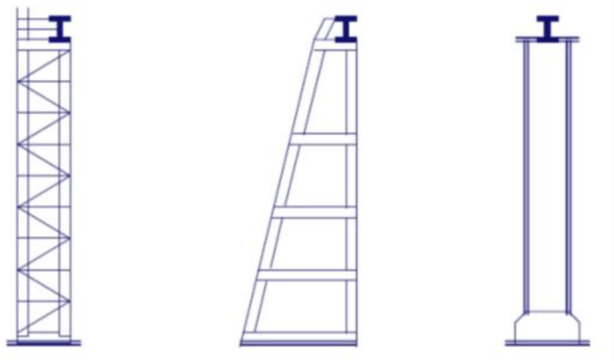
The immediate effect is to cause rapid wear on the crane runner flanges reducing their working life, often from years to months.

Misalignment will often be found to occur only in certain areas when the crane lifts continually heavy loads, for example, a loading bay when the loads are all concentrated before they are dispersed to various parts of the building.

Free Standing Crane Gantries

If a building has not been designed to support a crane gantry then the gantry and stanchion may be totally free standing so that no load is transmitted to the building structure, (See Fig. 4 below).

The illustration below shows three methods of making gantry columns. Types A and B are braced and therefore are very stiff. Type C, which is usually an edge on universal beam or column, are normally for lightly loaded light duty cranes. The Tester and Examiner will find that with rapid reversals of the crab unit type C will tend to resonate. With type C columns, down-shop surge bracings will be required.

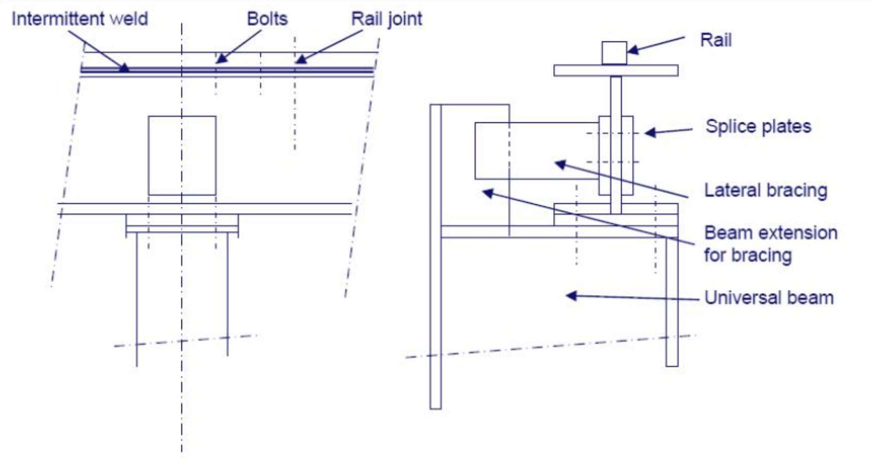


Free Standing Columns for Gantry Support

Gantry Girders

Generally manufactured from universal beams the girder will sit on top of the column cap with a packing allowance. The girder web should be laterally supported to provide a rigid connection at the cap. If two beams are joined at the cap they must be properly spliced with splice plates either side.

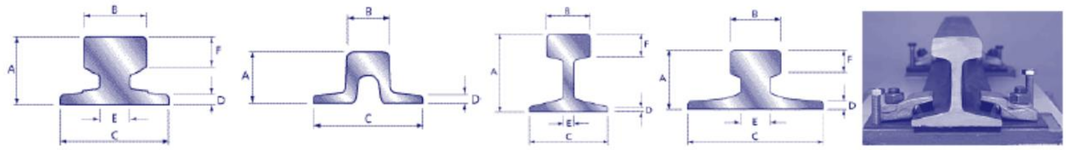
Note that the beam section used for the column is extended past the capping plate to support lateral bracing.



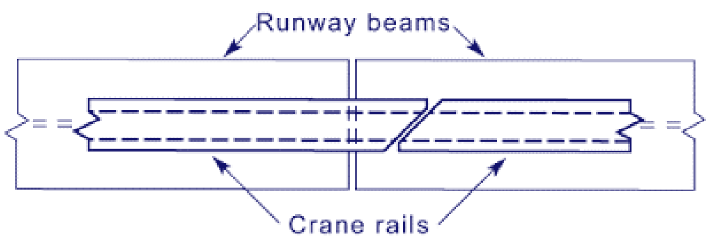
Typical Joint using Universal Beam as a Column

Bridge Rails
Depending on the duty, the bridge rail will have a profile similar to one of those shown below, but more often than not for light duties this will be square bar.

These rails are normally fixed by intermittent welding and if not welded with the rail securely clamped to the beam weld, cracking will occur in service.

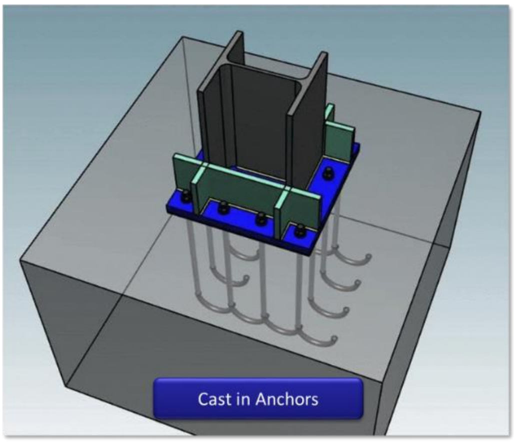

Typical crane Rail Sections

It is normal to offset the rail joint from the girder splice either bolting the overlap or welding on site. A 45° scarf joint is preferred thus avoiding point load contact at the join:

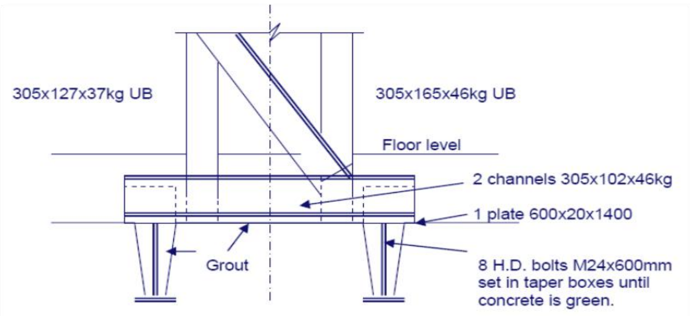


Gantry Rail Clips

Gantry Foundations



Foundation design is the responsibility of the Civil Engineer. He would be provided with foundation bolts and a template to set their position. He will be informed what loadings his foundation will be required to take. The steel erector will then erect on the prepared foundations: 188



With set in holding down bolts, these are cast into pockets which allow them to float. Once the erector has set out his stanchions, lining and levelling the caps, the stanchion bases are grouted. When the grouting is set, loose bolts can be tightened up and the erection completed.
The crane and gantry will be tested whilst the foundation bolts are exposed so that they may be checked after testing.

Grouted Anchors

Some foundations anchors are provided by the civil engineers set into cones, allowing an amount of movement at the top of the anchors in order that they align with the column fixing holes.

Once the column in place, a non-shrink grout is poured into the foundation to set the anchors in place.

Gantry Alignment
When considering alignment of the crane supporting structure (gantry) the Competent Person should refer to the manufacturer's specifications for crane running tolerances.

In the absence of such information, reference can be sought from BS466 and ISO12488, depending on the standard to which the structure was designed.

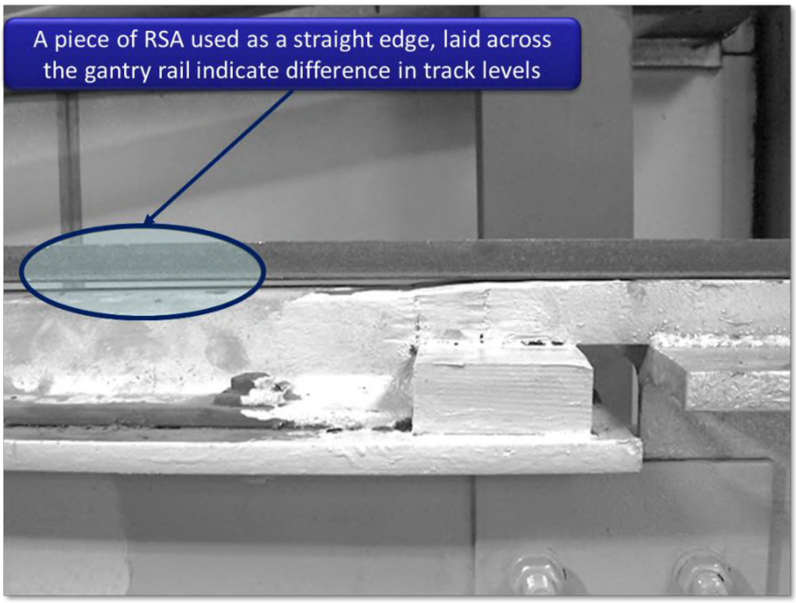
For in-service overhead cranes, it is likely that over a period of time the gantry will move; the original tolerances will then be exceeded. This can be caused by settlement of the structure or general vibrations and stresses resultant from the crane movements.

The types of gantry alignment issues that are commonly found are:

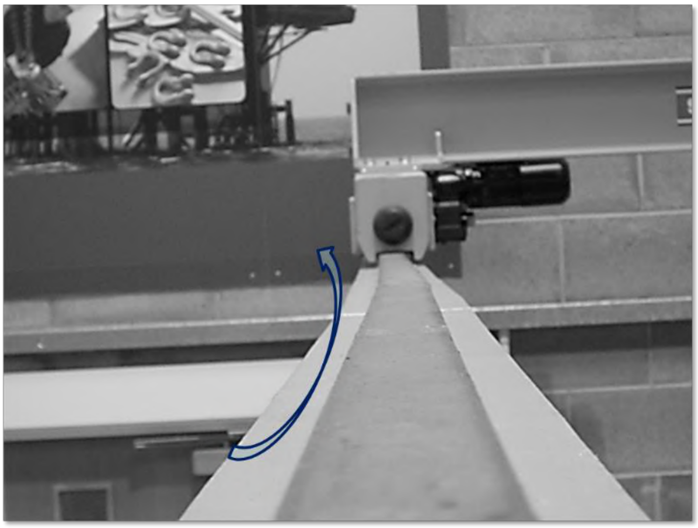
- **Level** differences between the gantry rail heights
- **Span** differences between the gantry rails (parallel running)
- **Line** deviation of individual gantry rails
- **Inclination** of tracks in the vertical position

Notes:

Gantry Levels Out of Tolerance



Gantry Rail Line Problem



Possible Span and/or Line Problem

Notes:

Gantry Tolerances

BS 466 and ISO 12488-1 specify the dimensional and geometrical tolerances of tracks for top running and under-slung cranes. BS 466 lists standard tolerances for all cranes, whereas ISO12488-1 has varied tolerances depending on the crane classification.

In the absence of manufacturers' specifications, the classification of a crane, as stated in ISO 12488-1 can be calculated as follows:

The classification of the long travel drive mechanism (from ISO 4301-1) will provide the amount of service hours (S)

L (Km travelled in crane life) = service hours (S) multiplied by the travel speed x 60

Example:

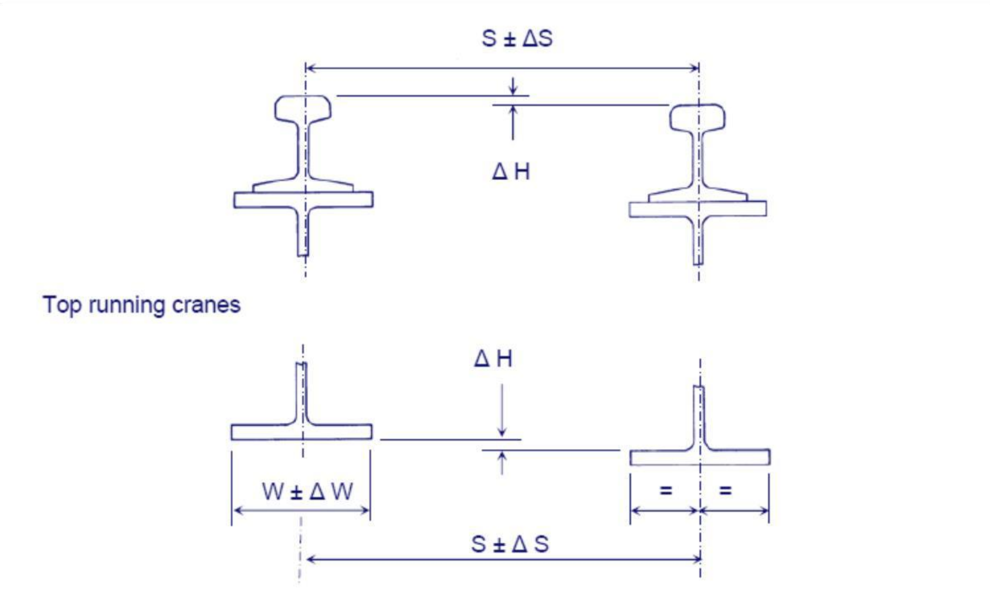
ISO 12488-1 Tolerances - M5 Duty Crane

Service hours (6,300 hours) x 32 metres/min x 60
= 12096 Km, therefore as per the table below, it would be in tolerance Class 2
and have a span tolerance of +/- 5mm.

ISO 12488-1 Tolerances

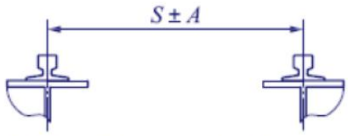
Tolerance class	Limits of travelling and traversing distance km
1	$50\,000 \leq L$
2	$10\,000 \leq L < 50\,000$
3	$L < 10\,000$, for stationary erected tracks
4	Temporarily erected tracks for building and erection purposes
NOTE L is calculated as the product of the normal travel speed and the specified working time of the relevant travel/traverse mechanism, either by application of customer specified values or through reference to the classification of the mechanism (see ISO 4301-1).	

BS 466 Tolerances



BS 466 and ISO 12488 Tolerances

Under-slung cranes



BS466 uses a tolerance of +/- 3mm for span deviation.

ISO uses the same tolerance for Class 1 cranes but this varies according to the classification of the cranes (see below).

Tolerance			
Class 1	Class 2	Class 3	Class 4
±3 Valid for all spans $S \leq 16$ m	±5 Valid for all spans $S \leq 16$ m	±8 Valid for all spans $S \leq 16$ m	±12,5 Valid for all spans $S \leq 16$ m

ISO12488-2 Tolerances for span deviation

BS 466 Tolerances

The tolerance on span should be as follows:

- $\Delta S \leq 3mm$ where $S < 15m$
- $\Delta S \leq 3mm + 0.25 (S\ 15)mm$ where $S > 15m$
- ΔS Max = 15mm

Misalignment of track running surfaces in the vertical plane

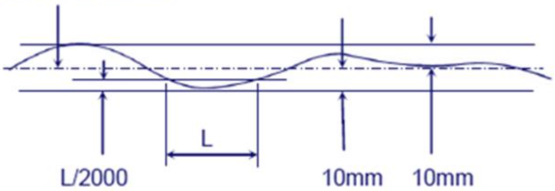
- $\Delta H \leq 0.001S$
- ΔH Max = 10mm

Tolerances on track width under-slung only

- $\Delta W = 0.025W$

Track Straightness

For the total length of track, the maximum lateral deviation from the straight line mean datum should not exceed 10mm.

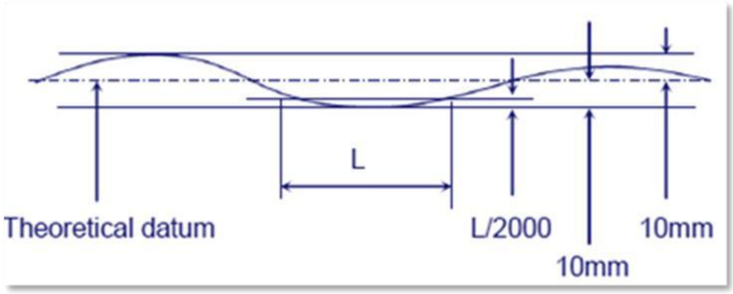


Local lateral deviation at any point of the track should not be greater than L/2000, measured over a length L of not less than 2m on a line parallel to the straight line mean datum.

Permissible Deviation in the Vertical Plane

For the total length of the track, the maximum vertical deviation from the theoretical datum line should not exceed 10mm. The theoretical datum line may be the true horizontal line or a theoretical camber line.

Local vertical deviation at any point of the track should not be greater than L/2000, measured over a length L of not less than 2m on a line parallel to theoretical datum.



Running Surface Permissible Transverse Inclination from the Horizontal Datum Position

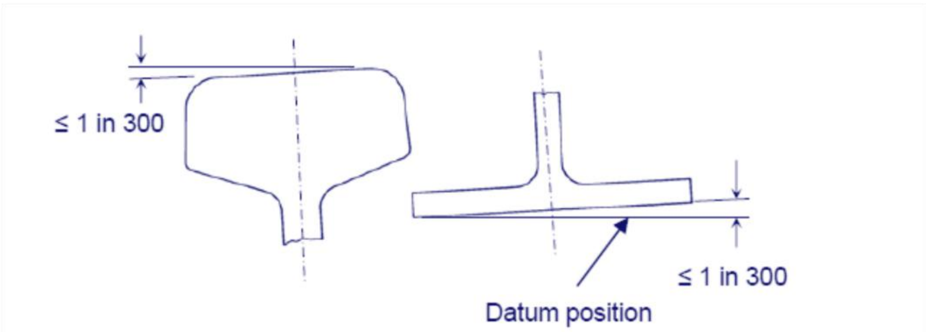
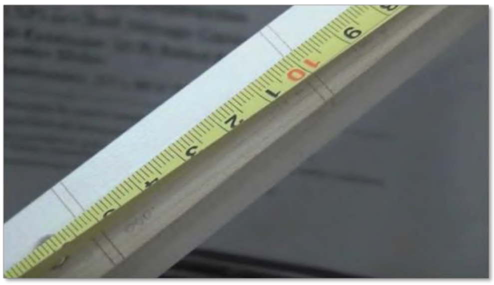


Figure 7
Permissible transverse inclination of tracks

Notes:

Measurement of Crane Tracks

When measuring crane tracks, calibrated steel measuring tapes should be used. It is important that the readings obtained are corrected to allow for sag in the tape and for temperature variation. All track measurements for a particular crane should be made with the same measuring tape and the same applied tension force.



Gantry and Crane Surveys

We have previously noted that the major cause of wear on crane wheels and tracks is misalignment.

This could be misalignment of the track or misalignment of the crane.

Check crane against end stops until buffers are touching, run crane back along track and come back to end stops. Should buffers not both be touching then the crane or buffers are out of line, but in any case this would suggest movement of the bridge girder connections.

Gantry Bridge Survey
A crane bridge can be checked for serious misalignment whilst on the track, it is not easy and requires accurate measurements. The following checks should be made to establish any serious misalignment:

1. Check end carriages for parallelism
2. Check crane wheels for diameter and flange wear
3. Check crane wheels alignment in end carriages
4. Check crane wheel diagonals, i.e. from centre line of tread plumb down to rail, if not plumb down from axles
5. Check for issues with long travel drive and/or braking mechanisms

If the crane appears reasonable the gantry should be checked.

Notes:

Line and Level Surveys

The Competent Person may be able to look along a crane track and detect serious misalignment. A line and level survey would then be required to decide what remedial action will be necessary.

Line Check

1. Working from a datum point, e.g. a string line stretched the length of the gantry, the horizontal variations of the track would be measured and tabulated using numbered stanchions for reference
2. Using a steel tape and tension gauge, the span of the tracks could be measured at the numbered stanchion positions
3. The design office would lay those dimensions out as a drawing using an exaggerated scale for the track variation

Level Check

Again working from a datum level, using either a dumpy level or some other means, deviations from the datum level would be noted at the stanchion positions for both tracks.

Line and Level Drawings

This drawing would show deviation in lines and levels and allow a decision to be made as to how best remedial action could be taken.

By adjusting the datum lines it may be possible to reduce the amount of remedial work required.

Great care must be taken to ensure end clearances are maintained between crane and steelwork.

Notes:

Levelling

Accurate levelling is far more difficult to achieve since we need to measure from an imaginary line. The traditional method is the dumpy or automatic optical level used in conjunction with a staff.

Line and Levelling

Positioning a dumpy (optical level) for sighting gantry rails will often need improvisation. Engineers tend to make up their own attachments for clamping to gantry rails etc.

The level is set up using a built-in bubble, similar to a spirit level except the glass is spherical, with a circular reticule thus providing a 360° level.

The optical level, once set up, provides our datum from which variations can be calculated as previously explained.


Dumpy Level (Optical)

Laser Levelling

A more recent innovation is the laser leveller. Power operated, the laser leveller will automatically plumb itself.

The laser beam is then rotated and becomes a continuous horizontal reference until switched off. Having set the laser the engineer can walk to where he wishes to measure and take a reading off the staff which is power operated and automatically seeks out the laser beam.

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.

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.

Notes:

Andrew Wright
LEEA Learning and Development Manager

Step Notes - feedback to LEEA: