Bridge and Gantry Cranes (BGC) Diploma (Global)

Workbook

Welcome to the Bridge and Gantry Cranes Diploma (BGC)

1. Introduction

The Diploma is LEEA's globally recognised, industry standard qualification for lifting equipment testers, inspectors, examiners, repairers and maintainers. This Diploma qualification is essential for anyone engaged in the testing, inspection, examination and repair/maintenance of bridge and gantry cranes and responsible for assessing equipment's suitability to return to service following statutory examination.

Note: whilst this Diploma is based upon LEEA's COPSULE and global best practice, references are made to certain standards throughout this course; these standards, where specified, have been adopted in the formulation of LEEA guidance and best practice.

2. Learning outcomes

On successful completion of this Diploma course, students will be able to perform the 'thorough examination' of specific bridge and gantry cranes and their supporting structures, validating or otherwise their fitness for a further period of service, applying conditions as may be necessary. Students will be able to refer to and extrapolate information from sources to support their analysis of lifting equipment suitability for continued service.

3. Scope of the BGC course

a. Working on site

b. The examiners' tools and equipment

c. Types of examination

d. Assessment criteria

e. Preparation for a thorough examination

f. Competency

g. Rated Capacity Indicators and Rated Capacity Limiters (RCIs and RCLs)

h. Load testing of cranes and supporting structures

i. Chain and wire rope examination

j. Hoist and trolley machinery

k. Crane types

l. Light crane systems

m. Crane supporting structures

n. Power feed systems

3a. Working on Site

Pre-job information	Representing your employer: your role as an Ambassador	Controlling risks	Communications
Returning equipment back to service	Removing equipment from service	Sign-off meetings	Leaving site

As a professional in the lifting equipment industry, there are high expectations of you to perform your role to mitigate risk and keep people safe. This is of paramount importance and should always be the priority focus of your work. Secondly, our stakeholders, customers and employers rightly expect the highest professional standards from all those working in such a high risk industry. So you are expected to be competent in your technical abilities, but moreover, as a professional you must also manage your standards of service, both internally to your employer, and externally to your customers and other stakeholders.

Let us now look at LEEA's vison statement:

> "Lifting and height safety industries which have eliminated accidents, injuries and fatalities"
>
> LEEA's Vision Statement

NOTES:

On successful completion of this training course and the associated end-point assessment, you will be awarded the LEEA Diploma in Bridge and Gantry Cranes (Global), and where applicable, the LEEA TEAM Card.

As a TEAM Card holder, there is an expectation that you will perform your role to the very best of your ability, meeting the requirements of a 'competent person' as defined by LEEA in COPSULE.

Our industry 'end-users' are actively encouraged to use LEEA member companies who employ qualified and competent individuals. They are assured that by using LEEA TEAM Card holders, they are putting their lifting equipment into safe hands and minimising their risks as duty holders and owners of such equipment.

In order that we continue ***"raising standards in the lifting equipment industry"***, each of us has our own part to play. As a lifting equipment examiner/inspector/tester, employed by a LEEA member company, you share this responsibility and have a particularly important role!

During this section of the course, we will look at how we approach our work on a day-to-day basis.

Our considerations must include:

a. Pre-Job Information

b. Representing your employer: your role as an ambassador

c. Reporting and signing-in

d. During the job

e. Completing the job

So before getting into your vehicle and travelling to the customer's site, you should pause and think about the following:

a) Pre-Job Information:

1. What task(s) am I expected to do at the site today?
2. Who am I to report to when I get there?
3. Do I have all the necessary paperwork and work instructions from my employer?
4. What equipment will I need to complete the task(s)?
5. Any requirements for access machinery or scaffolding?
6. How to access to the site, particularly access for test weights and adequacy of floors and passages?
7. How long is the task(s) expected to take?

b) Representing your employer:

1. Is my vehicle and uniform/overalls in a clean, presentable fashion?
2. Do I have appropriate footwear?
3. Is my PPE suitable for the task(s) expected of me? Do I have alternatives in case I have to change my method of work?
4. Has the risk assessment or JSA (job safety analysis) been completed, or do I have to conduct this alone when I arrive at the site? Will I simply have to review the existing RA/JSA?
5. Is there a method statement for the work? Has this been discussed and agreed?
6. Make sure you notify the customer of your arrival time on site

c) Reporting and signing in:

1. Report to main reception and sign in officially
2. Meet with your designated contact
3. Information is to be exchanged about the work to be done and safety precautions to be adopted, both from the examiner's and site personnel point of view
4. Agree a meeting time for when you have finished your work for a debrief
5. Discuss communication arrangements so that your whereabouts is known, and you can be contacted at all times to ensure you are safe and well whilst working on site

NOTES:

d) During the job:

Firstly, you must consider the basic requirements for the examination to be effective:

1. Adequate access to the equipment shall be provided

2. The equipment should be reasonably clean, and the examiner should have means to clean local areas

3. The examiner should have visual aids and tools required for the examination, including adequate natural or artificial lighting

Then;

4. Conduct your job safety analysis/risk assessment review before starting work – make sure any changes are recorded as they arise.

5. Is a permit to work required?

6. Confirm the identity of the equipment against the work sheet instruction or users record of the lifting equipment

7. Isolation (lock-out/tag-out) and cordoning off the work area as necessary

8. Toolbox talk with colleagues if applicable before starting the job

9. Talk to equipment operators/user. Are there any issues they may have noticed with the equipment?

(**Note:** this is particularly important for lifting machines as the operator is usually the first to recognise intermittent faults or other issues arising)

10. Make sure all information is recorded regarding the equipment (e.g. location, serial numbers, ID numbers and safety marking)

11. Detail your findings for the report together with any defects found

12. Maintain the safety of the area you are working through awareness of your surroundings and what is happening. You may need to change the JSA/risk assessment if new control measures are needed due to changing hazards

e) Completing the job:

1. Have you ensured any isolated equipment has been put back into service?

2. Have all machinery guards been replaced?

3. Did you carry out post-examination running checks on equipment, where necessary? Operational checks?

4. Do you need to colour-code equipment? What colour is needed?

5. Has equipment been stowed in designated storage areas or parked in a safe area?

6. Have all barriers and signs been removed from cordoned areas?

7. Let equipment users know that you have finished your work and that the equipment has been returned to service

8. Complete your reports, identifying any issues and your recommendations; safety critical issues are your priority, and the owner of the equipment must be notified of these immediately. If the equipment is to be removed from service, ensure it is suitably quarantined and marked, **"DO NOT USE"**

9. Identify and detail any repairs that may need carrying out and a timescale in which this should be completed

10.Have your debrief meeting with the site contact to present your report summary

11.Ensure your customer is completely satisfied before you leave site

IMPORTANT!

LEEA Members represent the highest standards within our industry. You are an ambassador for your company and your profession; it is essential that your personal behaviours are exemplary, and your competencies are consistently maintained through our active participation in continuous professional development (CPD).

<u>3b. The examiners' tools and equipment</u>

Tools

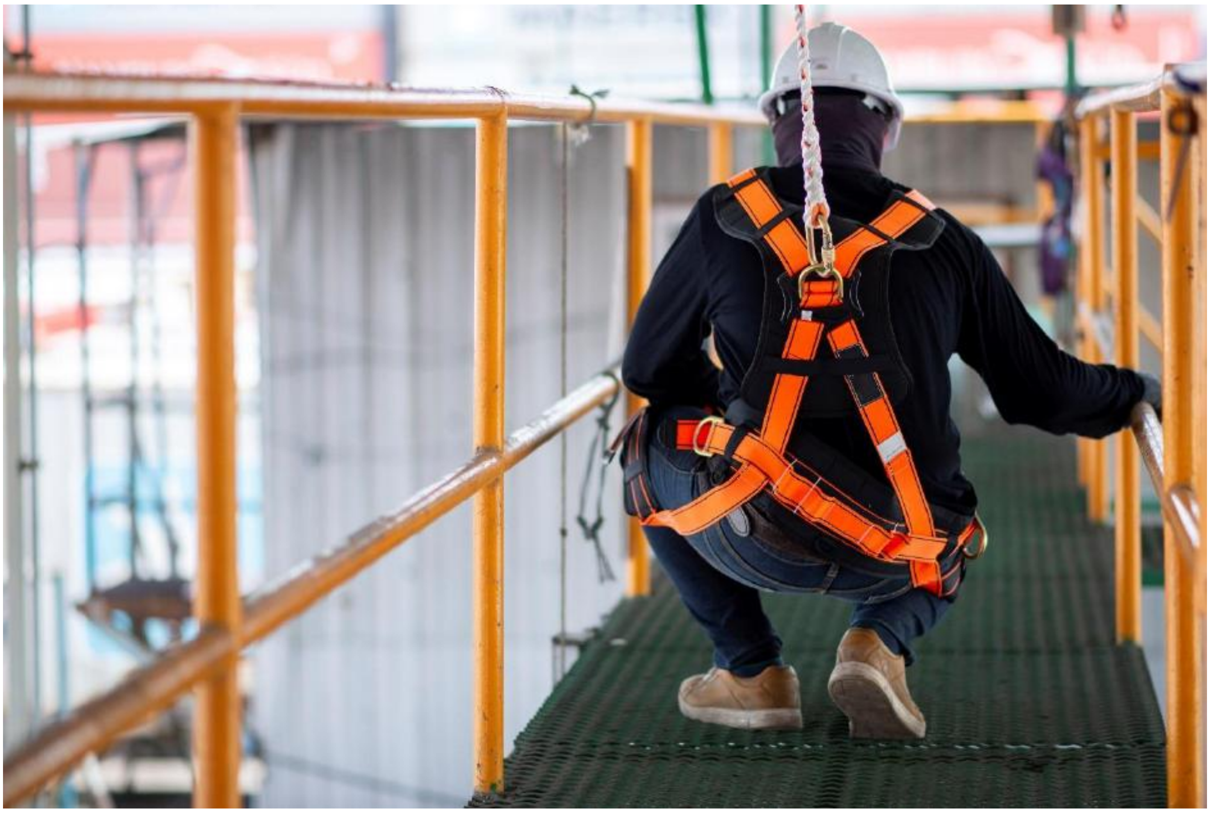
For the lifting equipment examiner/inspector/tester, a selection of hand tools will be required at work, which may be required for the thorough visual examination of bridge and gantry cranes. The selection of tools will depend on the nature of the job and the crane.

A broader perspective on tools required may include access equipment (MEWP, scaffolding etc.).

You may also need to consider types of lifting equipment of you need to hoist/lower spares, lubricants, cleaning or test equipment.

You should be appropriately trained to use all equipment you are supplied with and have the appropriate PPE. Both hand and power tools should be maintained in a safe and operable condition.

NOTES:



Measuring Equipment

Calibration of measuring equipment should be carried out in accordance with relevant standards, and this is verified by LEEA during compliance audits.

Lighting

It is very important that the area of inspection is well lit with natural or artificial light so that defects can be identified. Torches or portable lighting stations may be required to help you.

Cleaning Materials

The area where you are carrying out the inspection should be reasonably clean and free of contaminants that may affect the equipment you are inspecting. As an examiner you may not be able to see deterioration or damage that may be present due to excessive dust, oils and greases etc. It is therefore imperative to ascertain whether the crane needs cleaning prior to the examination taking place.

It is recommended that you carry basic cleaning materials such as rags, dustpan and brush, a wire brush and PH neutral cleaning fluids in the event that you have to clean the item(s) being inspected.

NOTES:

Biohazard!

In some instances, bird faeces may present a biohazard to the examiner whilst also hindering access to critical components and structures.

Breathing dust or water droplets containing contaminated **bird droppings** can lead to several diseases including:

- Psittacosis – this is a rare infectious disease caused by a bacterium called Chlamydia psittaci. It is mainly associated with parrots and other similar species but does affect other birds, including pigeons. Symptoms are commonly a flu-like illness and pneumonia usually appearing 5-19 days after exposure
- Salmonella – this may also be present in some bird droppings. It is a bacterial infection that can cause significant diarrhoea

Note: Pre-cleaning the crane prior to examination <u>IS NOT</u> the responsibility of the examiner.

Ensure any data sheets and chemical warnings are adhered to for the use of such products and your JSA/risk assessment reflects this.

3c. Types of Examination (Defined Scopes of Thorough Examination)

Note: whilst this Diploma is based upon LEEA's COPSULE and global best practice, references are made to certain standards throughout; these standards, where specified, have been adopted in the formulation of LEEA guidance.

The following is based upon BS7121-2-7. It is to be noted that ISO9927 also provides similar criteria for the inspection of cranes. It is therefore important that the examiner uses the specific National or International standards used or adopted in their region of operation.

We will look at 3 specific levels of inspection:

1. Pre-use inspection

The pre-use inspection is normally carried out by the operator of the equipment prior to use. The operator will visually check for any signs of obvious defect, damage or failure that give cause for concern, and that it is safe to use. If any such issue is found, the operator must report their findings to the appropriate maintenance/inspection personnel for further investigation before operating the equipment.

Pre-use checks of cranes should be carried out by people who have been deemed competent to do so. Competence should involve elements of training and assessment.

2. Interim inspection

The interim (sometimes referred to as the 'frequent inspection') is determined by risk assessment as to how often, and to what extent the inspection is performed. This level of inspection normally focuses on critical components that may become problematic prior to the next periodic thorough examination. The number and frequency of these inspections is also determined by the risk assessment and the manufacturers literature.

Interim Inspections are often done at the same time as planned maintenance or following a repair.

3. Thorough examination

These examinations are performed at specified intervals; after installation at a new site, following major refurbishment, repair or alteration and following an exceptional occurrence which may have affected the safety and integrity of the crane.

The competent person will decide if any supplementary testing should be carried out as part of the thorough examination. For example, this could include non-destructive testing, overload testing and magnetic wire rope examination.

The principal **defined scopes of thorough** examination are:

a. Scope of thorough examination before the crane is put into use for the first time *(Ref: BS7121-2-7. 8.3)*

- The scope of this examination is decided by the competent person
- Risks, likelihood and consequences of failure(s) should be in included in the scope
- Account for the age of the crane and likely deterioration which may increase risk of failure
- Manufacturer's records of inspections and tests should be considered

b. Scope of thorough examination following installation *(Ref: BS7121-2-7. 8.4)*

- The scope of this examination is decided by the competent person
- The scope should confirm that the crane has been installed, checked and tested in accordance with the manufacturer's instructions
- The complexity of the crane installation will determine the scope of the examination and all previous thorough examinations should be taken into account

c. Scope of periodic examination *(Ref: BS7121-2-7. 8.5)*

(General)

- The competent person should carry out the thorough examination aligned to the specific scope of examination for the particular crane
- The defined scope of thorough examination will have been drawn up by a competent person in advance and will identify the parts of the crane that require examination.
- Requirements of supplementary reports and tests should be included in the defined scope, to include;
    - Witnessing requirements for supplementary testing
    - Details of any NDT requirements for the crane structure and mechanisms
- The person carrying out the thorough examination can add items to the defined scope but cannot remove any items
- Dedicated ancillary equipment must be included in the defined scope with particular attention paid to the wire rope(s)
- The defined scope should be checked periodically to ensure it is current and fit for purpose
- A copy of the defined scope of thorough examination should be kept in the machine history file
- As a minimum requirement, the defined scope should include:
    - An operational check in all motions observing movement and sounds that may indicate issues
    - Inspection of the components listed
    - Relevant criteria for component assessment
    - The path of the load and the structure
- The defined scope should be risk-based, accounting for any probable failures of the crane
- The thorough examination should be carried out systematically, logically and critically ensuring all components and structures are examined
- Parts of the supporting structure that are only used for support of the crane <u>are included!</u>
- Any parts of supporting structures that are not only used for support of the crane <u>are not included</u> in the defined scope of thorough examination

Components to be included

The defined scope of examination should include the following components where applicable. <u>This list is not exhaustive</u>:

- Bridge girders

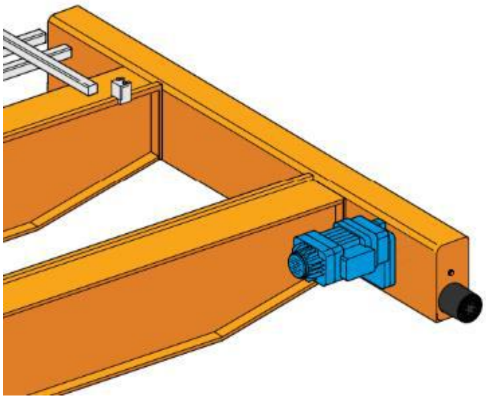
- Crab structure (sometimes referred to as a trolley)

- Cross travel drives, axles, gearboxes, wheels, bearings and brakes

- Cross travel rails

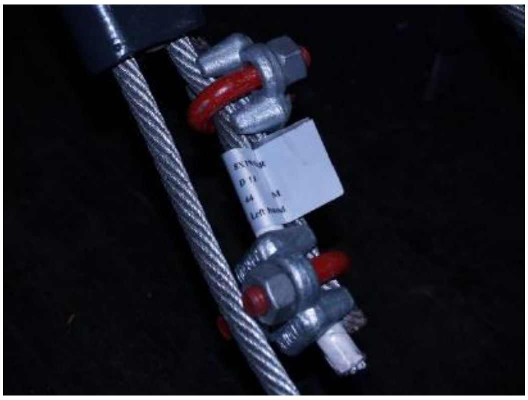
- End carriages

- Long travel drives, axles, gearboxes, wheels, bearings and brakes



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

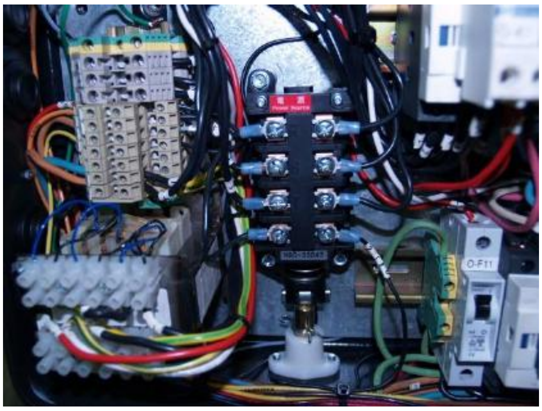
- Wire rope, rope terminations, sheaves and sheave pins/bearings



NOTES:

- Bottom block and hook assembly

- Electrical panels and wiring



- Operator cab/seating

- Controls for operation (cab, remote or pendant)

- Platforms and means of access/egress

- Supporting structures, gantry beams, rails and fixings, including end stops and buffers

- Down shop conductors (including power feed isolator)

NOTES:

3d. Assessment Criteria

The thorough examination is focusing on defect in any part of the crane or its supporting structure that will affect its strength or functionality. When considering the components defined in the scope of examination, the criteria for assessment should include the following. This list is not exhaustive:

- Alignment (within the manufacturer's tolerance or in accordance with the standard the crane was manufactured to)
- Corrosion
- Cracks
- Damage
- Distortion
- Functionality (see manufacturer's documentation)
- Leaks (including slip hazards)
- Lubrication (adequate)
- Markings (clearly shown and accurate)
- Mode of operation (see manufacturer's documentation)
- Obstructions (affecting safe access)
- Security (welds, fasteners etc.)
- Seizure
- Tidiness (general housekeeping)
- Wear
- Rope fit (as specified by the manufacturer)
- Rope reeving (as specified by the manufacturer)
- Rope specification (as specified by the manufacturer)
- ***Rope condition (in accordance with ISO 4309)***

Cranes which operate in areas or conditions where the wire ropes and the equipment they are used with are more liable to damage, e.g. corrosive or abrasive atmospheres will require the assessment of the condition of the rope and the equipment to be carefully carried out and the rope removed from service when the damage might affect its safe operation.

When carrying out inspections and examinations to assess the fitness of the wire rope for further service, both general deterioration and localized deterioration or damage should be considered. The entire length of the rope is to be examined, with particular attention to the rope near to rope terminations, rope that has been running or stationary over drums, sheaves and deflection pulleys and any other areas likely to sustain damage.

Note: A common misconception regarding the thorough examination of bridge and gantry cranes is that their supporting structures (previously referred to as gantries) are not included in the scope of work.

Bridge and gantry cranes rely on their supporting structures for safe functioning and therefore they are integral to the safety of the entire crane system. They should therefore be thoroughly examined.

Structures can be examined separately to the crane, but they cannot be used together unless both have a current report of thorough examination stating that they are safe to operate.

NOTES:

Second-hand (previously used) cranes

Note: Anyone purchasing a second-hand crane should ensure that it is fit for service by having it thoroughly examined before it is placed into service. The purchaser will not be aware of any damage or defects that may exist, including poor quality repairs, and these may not be exposed until the crane enters service.

The thorough examination of second-hand cranes is to include a full review of maintenance records and previous reports of thorough examination; the manufacturer should also be contacted so that details of any major repairs etc. can be obtained. The contents of any data logger should be accessed and reviewed by a competent person.

The duty to ensure that the thorough examination is completed rests with the user (owner). It is up to the user (owner) to decide who undertakes this work. This may be the crane company tendering for the work or some other provider. Whoever is selected should be sufficiently independent and impartial to allow objective decisions to be made. This does not mean that competent persons must necessarily be employed from a company separate to that undertaking the modifications. If employers and others within their own organisations have the necessary competence, then they can use it. However, if they do, they must ensure that their 'in-house' examiners have the genuine authority and independence to ensure that examinations are properly carried out and that the necessary recommendations arising from them are made without fear or favour.

Further information is available in **LEEA Guidance 067 'Guide to Second Hand, Modified or Refurbished Factory Cranes'.**

The inspection and assessment might require the removal of access covers or removal and dismantling of major components to reveal parts that would not otherwise be seen. Following the inspection and assessment, repairs (where required) should be carried out and an inspection and maintenance regime should be written up.

Amending the Intervals of Periodic Thorough Examination

The recommended, and in some regions statutory maximum interval between thorough examinations (6 and 12 months), can be reduced if environmental factors or the crane's age or condition warrant more frequent examinations. This decision is taken by the crane uses, owner and the competent person.

Let's consider why this may be required:

1. If the crane frequently works near or above personnel
2. If the crane is used for lifting people in exceptional circumstances – the crane maybe used for rescue purposes
3. If the crane is used in extremely demanding environments, such as extreme temperatures and sandy or dusty atmospheres

4. In cases where a competent person has reviewed an in-service lift plan through risk assessment of method statement etc. to determine the expected load spectrum and frequency of use for the crane (changes in duty)

Thorough Examination following Exceptional Circumstances

It is recommended that a thorough examination is carried out following exceptional circumstances, which may include:

1. **Overload**
2. **Collision**
3. **Use in arduous duties**
4. **Failure of a structural component**
5. **Subjected to weather in excess of design**

In all cases, the competent person will determine the scope of the thorough examination, proportional to the type of exceptional circumstance and the repairs that may be required.

Where necessary, previous reports of thorough examination should be referred to.

NOTES:

3e. Preparation for a Thorough Examination

Earlier in this course, we looked at the tools and equipment that the examiner may require to carry out the thorough examination of bridge and gantry cranes and their supporting structures. We will now look at the preparation requirements that need to be considered prior to conducting a thorough examination.

SAFE
The crane should be positioned in an area that is safe and suitable area in which the examination will take place.

LIGHTING
Try to find a well-lit area; if this isn't possible then you will need portable lighting.

CLEAN
The crane must be clean enough for the examination to be conducted without the potential to conceal any defects. **Remember that it is not the responsibility of the examiner to clean the crane!**

ACCESS
Ensure that safe access and egress arrangements are in place. This may be a combination of fixed access structures such as walkways, mobile elevated work platforms, or scaffolding. Personnel should be suitably trained and competent to use any portable access equipment and temporary access facilities.
PPE requirements must be agreed between the owner and the competent person prior to access.

IDENTIFICATION
I.D. and rated capacity markings should be present and clearly marked, but these are also to be verified against the crane records. This may include the test certificate, legal documents required in a particular country/region (e.g. a Declaration of Conformity), manufacturer's instructions/manuals and the previous report of thorough examination.

HISTORY
The competent person should check to see if any defects or malfunctions have been recorded for the crane, and whether any modifications or alterations have been carried out. The previous thorough examination report, in-service inspections and maintenance log should be viewed.

HIDDEN PARTS
Where the condition of hidden parts is unknown, these will need to be dismantled prior to the examinations, as required by the competent person.

ISOLATION
The crane should be isolated using an appropriate lock-out / tag-out method.

3f. Competency

Competency of personnel carrying our thorough examinations is a critical factor in ensuring that bridge and gantry cranes and their supporting structures are examined correctly, methodically and thoroughly.

All thorough examinations must be carried out by a competent person. The following information provides key elements of competency requirements, but you are advised to revisit your LEEA Foundation Certificate training notes in which the wider scope of competency was visited in depth.

Further details can also be found in LEEA's COPSULE and the BS7121 series of standards.

Competent persons should have the necessary attributes, competencies, knowledge and experience to enable them to carry out effective thorough examinations of cranes. These requirements 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. *(Ref: BS7121-2-1. 5.3)*

Continuous Professional Development (CPD)

CPD enables individuals to continuously develop their knowledge and skills, maintaining currency with developments in their field of work and the quality and relevance of their skill set. Engaging in a programme of CPD is not onerous and doesn't necessarily involve additional training courses and time away from work; in fact CPD is commonly achieved through many elements of our day-to-day work.

CPD is however a joint responsibility between the competent person and their employer. The employer should maintain a CPD record for each competent person. This record should include details of how CPD is being achieved.

There are 3 methods of CPD that may be considered:

1. **Active**
2. **Reflective**
3. **Self-directed**

Examples of these are shown in the table below, together with some of the benefits for each method:

TYPE OF CPD	EXAMPLE	BENEFITS
ACTIVE	Attending a training course, conference, workshop, seminar, lecture, e-learning course or CPD certified event such as LiftEx, Technical or Members' Meetings.	Ensure knowledge, skills and behaviours are up to date and relevant to your role. Enable any shortfalls to be corrected whilst developing confidence and competence
REFLECTIVE	Reading relevant news articles, podcasts, case studies and industry updates.	Increase self-awareness, developing the skills to recognise and articulate what you have learned in recording CPD activity.
SELF DIRECTED	Regular reading of LEEA's 'Lifting Engineer' publication and News Bulletin, industry standards, guidance notes. Internet browsing for relevant learning material.	Diagnosing your learning needs: reading books and articles, internet searches, journals and other sources of relevant information.

Note that further information is available in BS7121-2-1. 5.3.11 and the LEEA Team are always happy to help answer any questions you may have regarding CPD. Email us at academysupport@leeaint.com

3g. Rated Capacity Indicators and Rated Capacity Limiters (RCIs and RCLs)

As an examiner, you are likely to find many different types of RCI (Rated Capacity Indicator) or RCL (Rated Capacity Limiter) in service. You may find that older types of cranes will not have any such devices fitted.

RCIs and RCLs should be included in the thorough examination; this should be a thorough visual examination of the individual parts and components.

Where reasonably practicable, a calibration check and functional test of RCIs and RCLs to be carried out in addition to testing as part of the thorough examination.

A calibration check is to be carried out after any major repairs of modifications have been made to RCIs or RCLs.

Calibration is normally carried out by suspending calibrated weights from the crane to a maximum of 110% of rated capacity.

NOTES:

3h. Load Testing of Cranes and Supporting Structures

There are 3 occasions when an overload test should be carried out to supplement the thorough examination of cranes and their supporting structures:

1. **Following installation**
2. **Re-installation (relocation)**
3. **Following major repairs or modification**

Before the testing is carried out, it is important that the competent person seeks advice from the crane manufacturer (or other suitable design authority) so that the nature of the test and how it should be carried out is decided. This includes how much load is to be applied.

Supporting structures should be tested after:

1. **After major repairs**
2. **After modifications**
3. **After any changes to loading conditions in the crane(s) running on the structure**

Sometimes the load testing of the crane(s) must be carried our separately from that of the structure. An example of this would be where the structure supports more than one crane.

Note: The details and extent of testing should always be made clear in the test report.

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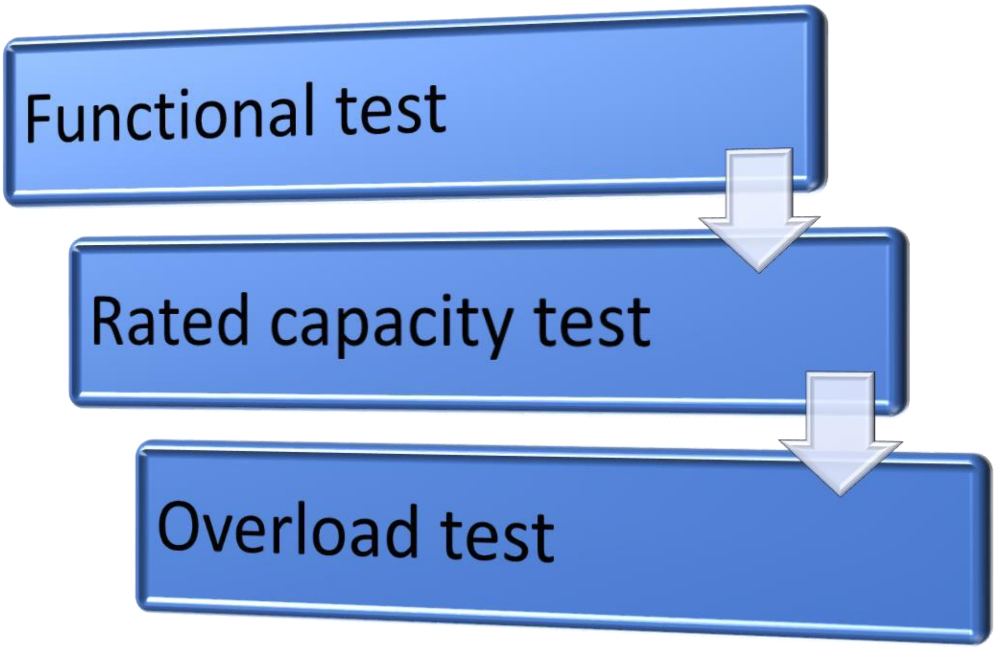
Testing sequence



1. **Functional Test:** a thorough examination of the crane and the relevant sections of supporting structure should be carried out before any testing takes place. This examination is to ensure that the crane and supporting structure is in a safe condition to be load tested.

    - No load is to be applied for the functional test
    - Check controls, limit switches, contactors, brakes etc.
    - Any other safety and emergency systems should be checked for correct operation

2. **Rated Capacity Test:** this test is carried out at **full rated capacity** of the crane.

    - Position the crane over a supporting stanchion or column of the gantry, or under the connection point of a suspended track as required
        - The crab or hoist should be positioned next to the end carriage
        - Means of measuring the deflection of the crane girders at centre span should be in place at this stage

NOTES:

- Raise the load until the gearbox has completed enough movement to ensure that each tooth of the drive train has been under the load
- Lower the load to between 100mmm and 200mm from the ground

- Hold the load in this position for 10 minutes and check that the brake is functioning correctly, and no slippage is evident
- Lift the load from this position another 200mm checking that the hoist is able to lift from suspension point
- Lower the between 100mm and 200mm from ground level above ground level
- Traverse the crab/hoist to mid-span of the crane and measure the deflection
    - This deflection must be recorded

Optical Level & Staff

- Lower the load to the ground, relieving the structure
- Raise again and re-measure deflection to ensure the deflection is constant

Then:

- Traverse the load to the opposite side of the gantry from where you started
- Travel the crane along the track until the gearbox has completed enough movement to ensure that each tooth of the drive train has been under the load
- Traverse the load across the crane bridge to the opposite side of the gantry and return it to the original starting lift position

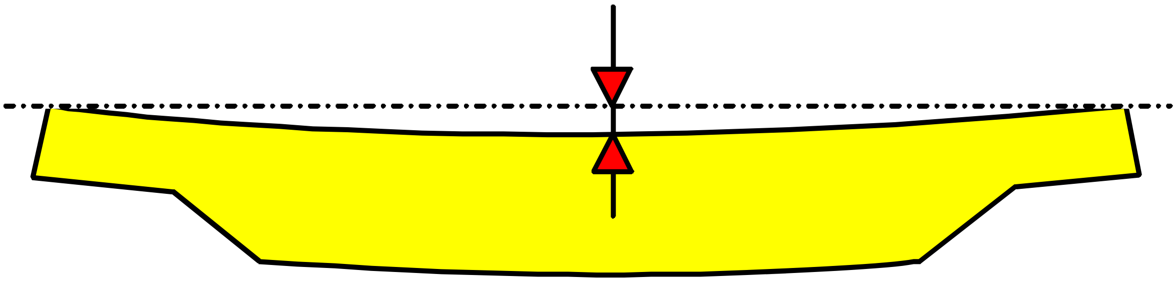
NOTE: The deflection of the main bridge with the crab and load at the centre of the bridge should not exceed the maximum deflection permitted in the standard to which the crane was manufactured. The measured deflection should be recorded and compared to the calculated design value. Conformance within 10 % or 5 mm, whichever is greater, is considered acceptable.

Ensure that the measured values are kept in the machine history file so that they can be used in comparison with any future tests.

NOTES

Defined Deflection Limits

When a crane bridge or supporting structure span is loaded, it will deflect at centre span as shown here:



The amount of deflection is to be measured and recorded as part of the test routine. There should be no permanent deformation caused by the load test.

The following table shows the allowable deflection limits for cranes, depending on the standard to which they were manufactured:

Standard	Deflection Limit
BS466 (1984)	1/750
BS466 (1960)	1/900
EN15011	Manufacturer should specify the deflection limits to be used in the tests

NOTES:

3. Overload test: following the rated capacity test, the load should now be increased to **110% of rated capacity**.

    - This test should include repeated starts and stops in each motion
    - Combined movements should also be tested (as per manufacturer's intended use)

    This ensures that the entire sequence and ranges of movement are tested.

    NOTE: Do not test the emergency stop or end stop buffers during the overload test!

- Lower the load to between 100mm and 200mm from the ground
- Increase the load to **125%** of rated capacity **without the use of the hoist drives**
    - **NOTE:** This may involve loading the hoist using a forklift or other mechanical means as you may not operate the hoist with the 125% overload applied
    - **This is a static overload test only!**

NOTE: The hoist mechanism may be used to lift and lower the 125% overload if they were built to BS2573. This should however be limited to between 100mm and 200mm from the ground.

For all other cranes, guidance must be sought from the manufacturer.

- The overload test should be conducted with the crab/hoist in various positions on the crane bridge
    - Extremities of traverse (cross travel)
    - Ends of cantilevered sections
    - Mid crane span

- All movements in any direction should be made independently from any other motion
    - Do not start a new movement without the structure having settled from and vibration following the previous movement
- The competent person should apply the overload test for as long as required to make observations and any measurements
- During the test the crane should be stable and structurally sound
    - Brakes (traverse and travel) should function effectively with the overload applied

NOTE: Cranes fitted with more than one hoist that can be used independently should be tested individually before the crane test, unless the manufacturer states otherwise.

The most unfavorable, or worst possible loading combinations should always be used in the test.

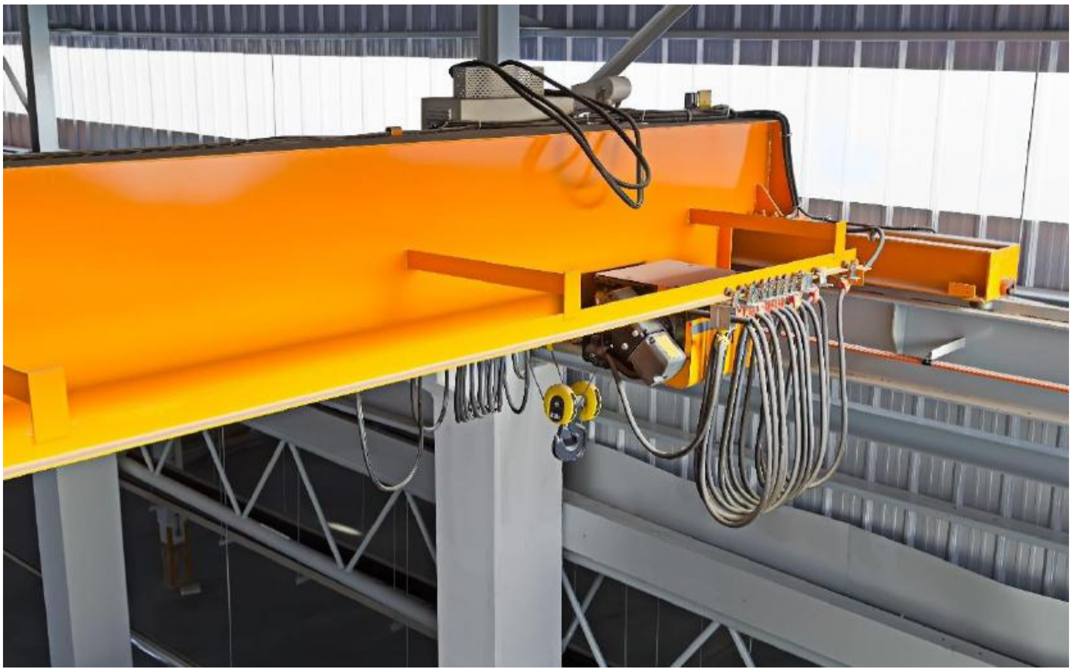
NOTES:

Load Testing of Supporting Structures

The examiner will come across many types of crane supports, for example:

Free-standing structure:

Gantry supported by the structure of the building:



Any part of the crane supporting structure that is not in place solely for the support of the crane is to be assessed by a structural engineer before any testing is carried out.

All parts of the structure that are solely intended to support the crane should be load tested.

The competent person must conduct a thorough examination of the crane supporting structure before any load testing is carried out so that its condition may be assessed as safe for testing.

The unloaded crane should be travelled along the entire length of the supporting structure to check alignment.

NOTE: ISO12488-1 refers to information regarding structural alignment criteria.

Testing

A combination of loadings, crane and crane positions which place maximum loadings on the structure under test should be used.

Rated Capacity Test: Each crane involved should lift a load equivalent to its **rated capacity** 100 mm to 200 mm above the ground.

- Traverse the load lifted by each crane to the end of the crane bridge nearest to the structure under test
- Travel the cranes along the span of the structure to a position which will impose the maximum deflection at centre span
    - Measure and record the deflection
        - The deflection measurement should be taken at the longest span of the gantry
    - If the gantry has more than one beam section, the deflection should be taken at the longest span of each section
- If the gantry is supported by a structure that is solely for the support of the cranes(s), if there is any variation in construction or design of the structure, repeat this test for each different section

Defined Deflection Limits

The following table shows the allowable deflection limits for supporting structures, depending on the standard to which they were manufactured:

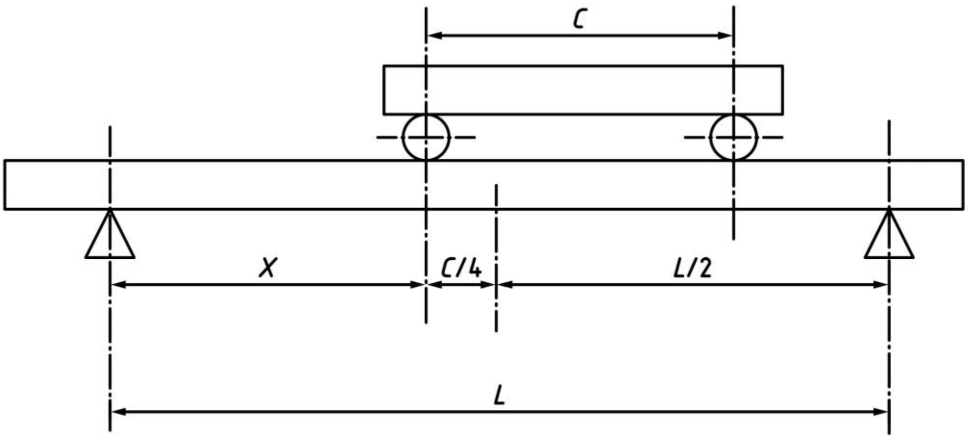
Standard	Deflection Limit
BS449-2	1/360
BS5950-1 or EN1993-6	1/600

NOTES:

Maximum stresses in supporting structures

It is necessary to place the load at the point where maximum stress would occur in the span of the gantry beam, hence we create maximum deflection of the beam.

If the end carriage wheel centres are less than the half the gantry beam span, the maximum stress will occur at point X (centre span of the gantry beam) when the end carriage is offset as shown. The maximum deflection will be at point L2.

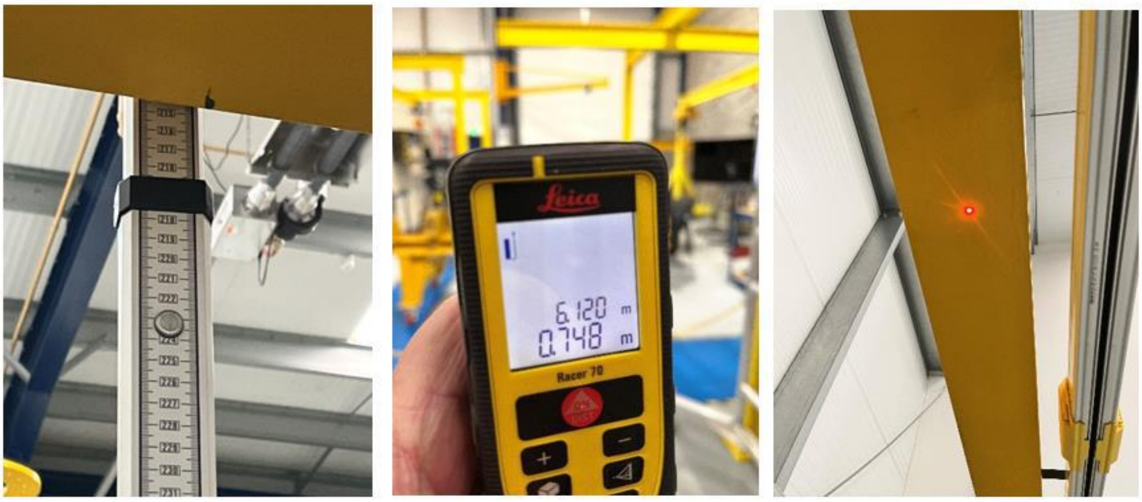


Hence:

$$X = \frac{L}{2} - \frac{C}{4}$$

The picture below shows a bridge crane on a free-standing supporting structure. L=2800mm and C=1000mm, therefore the end carriage wheel centres are less than half the span of L.

L2=1400mm which is marked on the gantry beam (half span) and X is shown in red, calculated by C÷4 = 250mm. The crane wheel is placed at point X for the load test and the deflection is measured at L2.



Measuring Staff

Laser Measuring Device

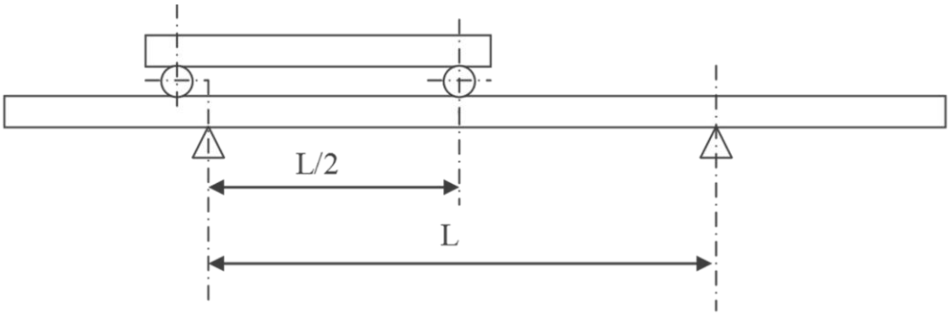
Q.

If the span of the structure (L) is 3200mm and the crane end carriage wheel centres is 1300mm, what is the required offset (C2) required in order to gain the maximum stress in the gantry beam?

Answers ***(Choose one correct answer)***

- 1325mm
- 325mm
- 275mm
- 1275mm

If the end carriage wheel centres are equal to, or more than half of the gantry beam span, then the maximum stress will occur when one crane end carriage wheel is placed directly at the centre of the gantry beam span:



IMPORTANT!

It is recommended that calibrated load cells should be used for all testing procedures

For traceability, the load cell serial number and date of calibration should be written in the thorough examination/test report

Post-test examination of supporting structures

After testing is completed, a thorough examination must then be carried out by a competent person on the structure to ensure that no issues or damage has been caused throughout the testing procedure.

IMPORTANT!

For advice on cranes and supporting structures that you may come across during your work, and are not covered directly by this training course material, please email technicaladvice@leeaint.com for further information

3i. Chain and Wire Rope Examination

Examination of Chain

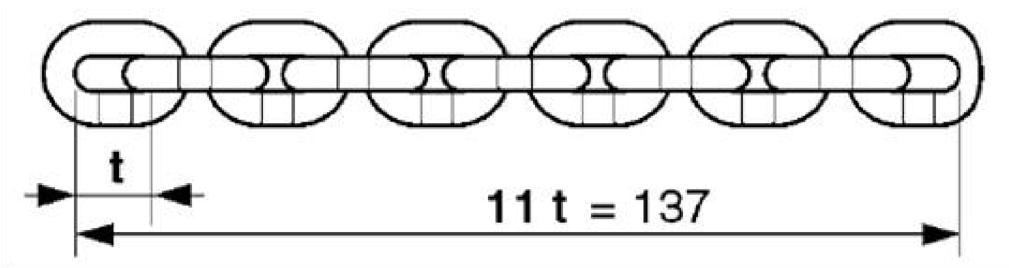
By following well-established principles, such as those detailed in various standards, LEEA COPSULE, and any additional specific instructions provided by the 'original equipment manufacturer' (OEM) of the appliance and/or by the manufacturer of the load chain; these criteria should never be exceeded.

- Preparation for the examination
  - o Hang the item from a suitable suspension point
  - o Chains should be cleaned (no strong alkalis or acids should be used as it could lead to hydrogen embrittlement)
  - o Markings - grade mark as per chain grade (every 20th link or 1 metre)
- Operate hoist under no-load and loaded conditions
  - o Check for directional smoothness
  - o Look for chain jumping in the pocket wheel
  - o Listen for binding and noisy operation
- Link by link examination of the load chain in adequate light. Check for cracks, cuts, nicks and gouges, wear, elongation and other damage including build-up of debris in the chain or load wheel

Key issues

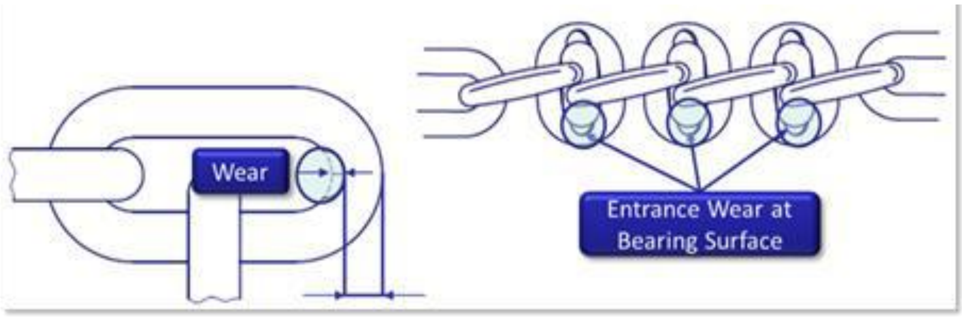
- There should be no signs of deformed or twisted links
- Articulation: ensure that the links of the load chain and coupling devices are free to articulate
- Weld structure/integrity
- Heat (direct or indirect)
- Weld splash or heat bluing
- Lubrication
- Chemical damage
- Heavy corrosion (cannot be removed easily with a wire brush and does not leave heavy pitting of the load chain)
- Nicks/cuts/cracks/gouges (stress raisers)
- Markings - grade mark as per chain grade
- Increase in gauge length which exceeds that manufacturer's recommendations. In the absence of manufacturer's recommendations, the chain should be replaced if the gauge length measured over any 5, 7, 9 or 11 links exceeds that of the unused chain by 2%. *(Ref: ISO7592)*

The illustration below shows a manufacturer's specified length for a piece of chain over 11 links, where 11 x t = 137mm:



- Wear – in the absence of manufacturer's specific information regarding discard criteria, LEEA recommend that when a maximum of 8% reduction in material diameter for the chain is reached it should be removed from service and discarded

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 original equipment manufacturers 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 appliances, 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.

Manufacturers Certificate

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 the relevant standard
- 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:

Examination of wire rope

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 appliance and/or by the manufacturer of the rope; these criteria should never be exceeded.

When correctly applied, the discard criteria given in full in ISO 4309 are aimed at retaining an adequate safety margin. Failure to recognize them can be extremely harmful, dangerous and damaging.

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.

Safe operation of powered lifting machines incorporating wire rope depends, to a considerable extent, upon the level of detailed examination that is carried out by the Competent Person during the periodic inspection, not with-standing 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.

The aim of the periodic inspection is to determine whether the rope:

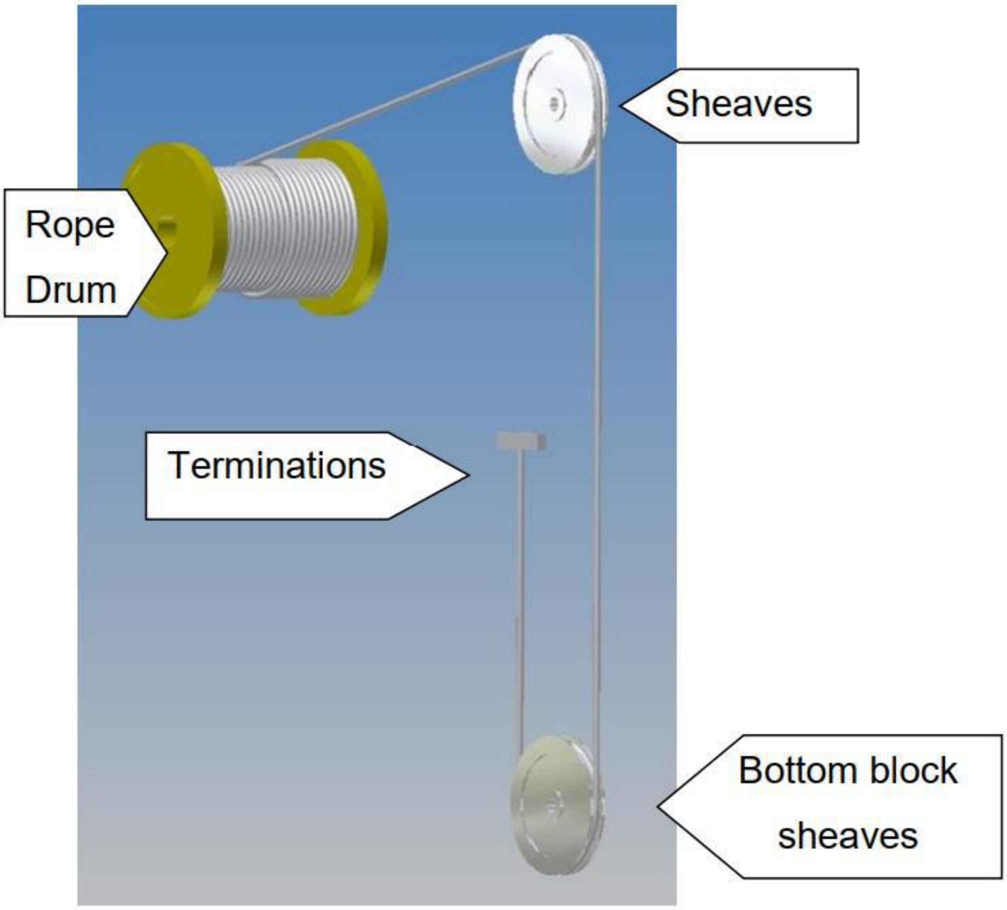
a) Can safely remain in service, and the latest time on which the next examination is to be carried out
b) Needs to be withdrawn immediately, or within a specified time

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

In the absence of original equipment manufacturer's criteria, ISO 4309 criteria may be used to determine the serviceability of the load rope fitted to a manual appliance. The relevant series of standards should be referred to for terminations in steel wire ropes.

The inspection 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
- Check entry of rope into detachable terminations such as wedge sockets for broken wires but also correct orientation of the rope through the socket
- Rope within the area of a termination point, particularly where it enters the termination point, where it is typical to find broken wires
- Sections of rope travelling through sheaves
- Sections of rope travelling through the hook block
- Sections of rope that spool onto the rope drum, especially in areas where the rope crosses over itself in multi-layer drums
- Any section of the rope that can be damaged by abrasion in contact with an external fixture such as a hatch opening
- Any part of the rope that is exposed to heat
- Spooling/ cross over damage
- Slippage in ferrules (evidence of the rope pulling through the ferrule)



Inspection frequency

As we know, the periodic inspection for lifting appliances is each 12 months, or 6 months for any people carrying machines.

The Competent Person may however decide that more frequent inspections are required for certain appliances due to several factors, which may include:

- Any specific national statutory requirements in the country of use
- Type of hoist and the environmental conditions it operates in
- Classification group of the machine
- Results of previous inspections
- Experience of other similar types of hoist in similar use or conditions
- How long the wire rope has been in service
- How frequently the hoist is operated
- Original manufacturers recommendations

Inspection record

A record of each and every inspection should be made by the Competent Person. ISO 4309 states that a running record of crane rope inspections is maintained. An example of this is available in the standard in Appendix E.

Combined effect assessment

As we have seen, there are several areas of the rope that need to be checked during the visual examination. There are many faults that may exist in a wire rope, and this is not limited to broken wires! The examiner therefore needs to be aware of the many different defects that will affect a wire rope's performance and service life, which we will explore in this module.

It is important to note that a visual examination of a wire rope should produce a **'combined effect assessment'**, which considers all the deterioration that is identified.

Assessment from the inspection

The extent and severity of deterioration is to be assessed and provided as a percentage (% Severity Rating) for example 20%, 40%, 60%, 80%, or 100%, for each individual type of discard criteria. This can be expressed in words as, 'slight', 'medium', 'high', 'very high' and 'discard'. This assessment can be drawn from different visual inspection and/or measurement, and Magnetic Rope Testing (MRT).

The **combined effect assessment** is an overall assessment of the condition of the wire rope. The examiner will record his findings using a report format similar to the one shown below:

Crane Ref:						Rope Application:					
ROPE DETAILS											
Brand name/manufacturer:											
Nominal diameter (mm):											
Construction:											
Core type:			WSC			IWRC			FC		
Wire finish:						Uncoated			Galvanized /Zinc		
Direction and type of lay:											
Permissible number of broken outer wires in 6d:							and 30d :				
Reference diameter (mm):											
Permissible decrease in diameter from reference diameter (mm):											
Date installed:						Date Discarded:					
Visible broken outer wires (Visible broken outer wires)											
Number in length of		Severity Rating		Diameter			Corrosion	Damage and/or deformation			Overall combined assessment rating at position
6d	30d	6d	30d	Measured Dia (mm)	Actual decrease ref (mm)	Severity Rating	Severity Rating	Severity Rating	Nature	Position in rope	
Other observations and comments:											
Performance to date (cycles/hours/day/months etc.)											
Date of inspection:											
Name of competent person (PRINT):						Signature:					

NOTE: the examination record requires the examiner to enter a '% severity rating' in:

- The number of broken wires (6 x d and 30 x d)
- Decrease in diameter
- Corrosion
- Damage and / or deterioration

Having collated this data, the examiner now sums up all the individual severity ratings and determines a total combined severity in the form of a percentage. This is then added to the end column of the *combined assessment table.

If the examiner so chooses, the degree of severity may be inserted in the form of a description (words) rather than a percentage. An equivalence table has been provided her to show how percentage and description severity ratings align in the standard:

%	Definition
20	Slight
40	Medium
60	High
80	Very high
100	Discard

Ultimately, the examiner must determine whether the rope is safe to continue in service. If this is the case, the examiner may wish to reduce the period of time before the next examination is carried out due to the rope's current condition and level of deterioration.

This table shows examples of combined effect assessments (*combined assessment table):

	Severity rating of individual modes of deterioration						
	Wire breaks		Decrease in diameter	Corrosion			
Example	Visual	MRT LF	%	External	MRT LF	Combined severity rating %	Comment
1	0	N/A	20	20	N/A	40	Safe to continue in service
2	20	N/A	20	0	N/A	40	Safe to continue in service
3	20	N/A	20	20	N/A	60	Safe to continue in service
4	40	N/A	20	20	N/A	80	Examine more frequently
5	0	N/A	80	0	N/A	80	Consider discard if reduction in diameter is mainly due to external wear
6	60	N/A	0	0	N/A	60	Inspect (especially for broken wires) more frequently
7	60	N/A	20	0	N/A	80	Inspect (especially for broken wires) more frequently and prepare to repace the rope

Combined Assessment Table

NOTE: Where the term **MRT (LF)** is referred to in the table, this is technically known as a 'local fault' or 'local flaw', such as a wire break, welded wire (from production), corrosion, pitting or nicked (pinched) strands.

NOTES:

Modes of deterioration

This table shows the common types of deterioration whether or not they can be either counted or measured, or if visual or MRT inspection would be required for each type:

Mode of Deterioration	Assessment Method
No. of broken wires (including randomly distributed, localised groups, valley wire breaks and those that are at, or in the vicinity of the termination	By counting
Loss of metalic are caused by broken wires	Visual, MRT
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, MRT
Deformation	Visual and measurement (wave only)
Mechanical damage	Visual
Heat damage (including electric arcing)	Visual

When might a wire rope inspection be carried out, other than periodically?

If we consider that bridge and gantry cranes and their supporting structures are thoroughly examined in the event of exceptional circumstances, and not solely periodically, then surely the load ropes may also need to be thoroughly examined too?

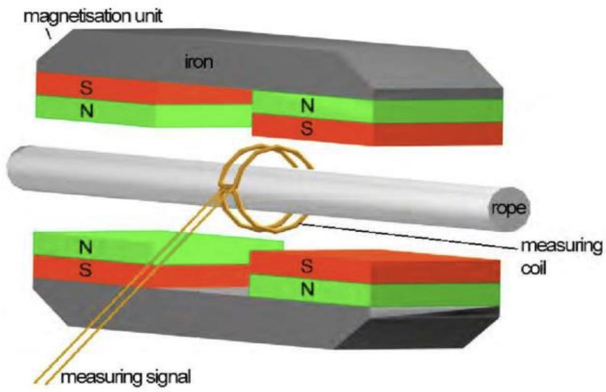
Here are two circumstances why a thorough examination of the wire rope should be carried out:

1. Following an accident
    a. Or: an exceptional circumstance such as an overload or collision
2. If the appliance has been out of action for a period in excess of 3 months

Magnetic Rope Testing (MRT)

By giving visibility right through to a wire rope's core, Magnetic Rope Testing (MRT) can play a vital role in improving lifting safety. MRT is a method used to see into the heart of wire rope used on cranes in order to detect any deterioration that might have occurred during service.

The MRT method involves passing the rope through a permanent magnet. This sets up an electromotive force, which is picked up with electronic sensors that can detect any breaks in the rope or any corrosion that occurs throughout the section of the rope, which is known as Loss of Metallic Area (LMA). There are different MRT equipment manufacturers, but the method is exactly the same with each one.



To examine the core of the rope under normal examination, without MRT, requires a special tool to open the rope's strands. But this still only gives visibility of a small percentage of the rope's length. On multi-strand crane ropes, you can never see the core because the multiple layers can't be opened up due to the underlying layers being laid in the opposite direction to the outer strands.

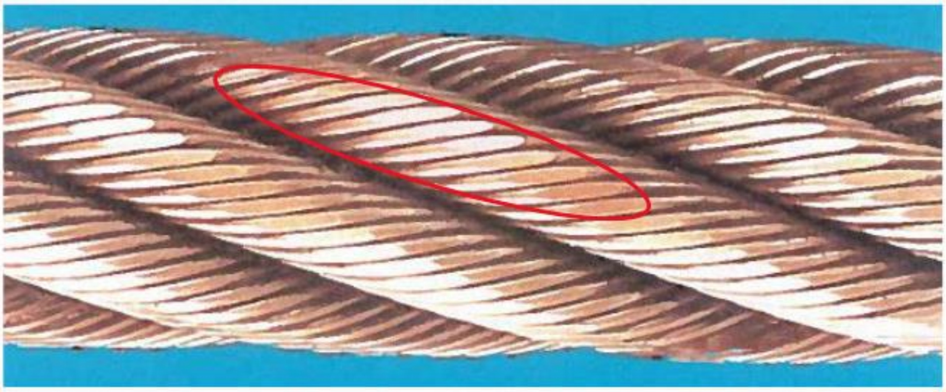
For high integrity cranes, particularly those used offshore, wire rope manufactures will use MRT to produce a 'baseline' as a 'birth certificate' for a length of wire rope. So when it enters service, the competent person knows precisely what that rope is like at the outset and can then accurately monitor any deterioration throughout its service life.

NOTES:

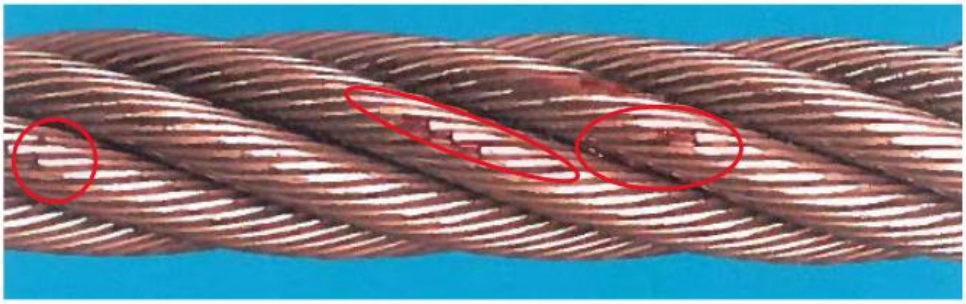
ISO 4309 discard criteria

Types of deterioration:

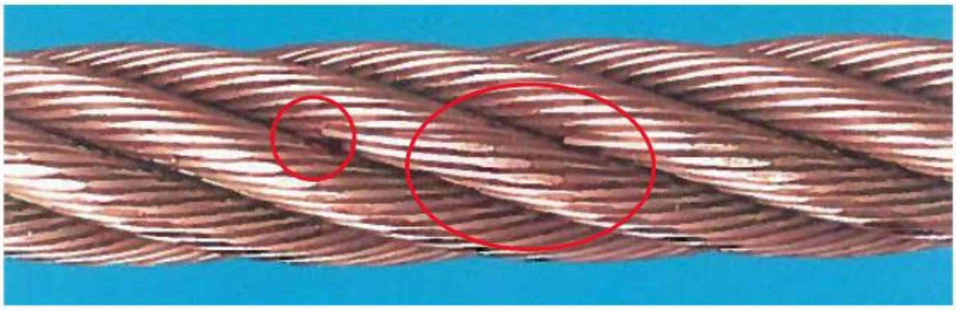
1) **External wear**



2) **Crown wire breaks**



3) **Valley wire breaks**



4) **Internal wire breaks**

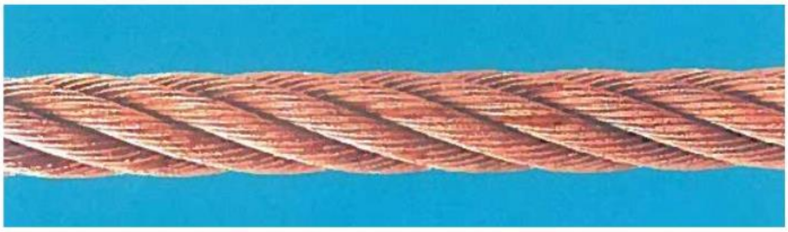
5) Local reduction in diameter (general or localised)

Possible causation:

- External wear (contact with sheaves and drums or cross-over areas on multi-layer drums)
- Inadequate or incorrect lubrication, combined with dust and grit etc.
- Internal wear
- Wire indentation
- Wear internally – caused by friction between strands (mainly due to bending)
- Fibre core deterioration or Steel core fracture
- Fractured inner strand layers in rotation-resistant rope

MRT inspection would determine the exact cause of local reduction in diameter.

6) External corrosion

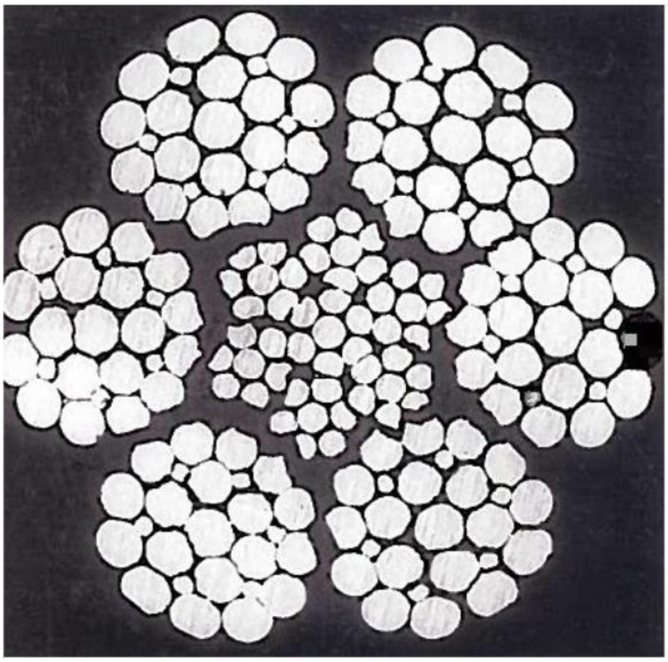


NOTES:

Wire rope corrosion is particularly problematic in the marine industry and also in polluted atmospheres. Corrosion reduce the cross sectional area of the wires in the rope which can lead to fatigue as the irregular shape of the wires can then be subject to cracking under stress.
Heavy corrosion will have a negative effect on a ropes elasticity.

Note: Galvanised rope should be considered for applications where corrosion is an issue.

7) **Internal corrosion**



MRT is particularly suitable for detecting internal corrosion and its severity.
The visual examination will not necessarily show this type of corrosion.

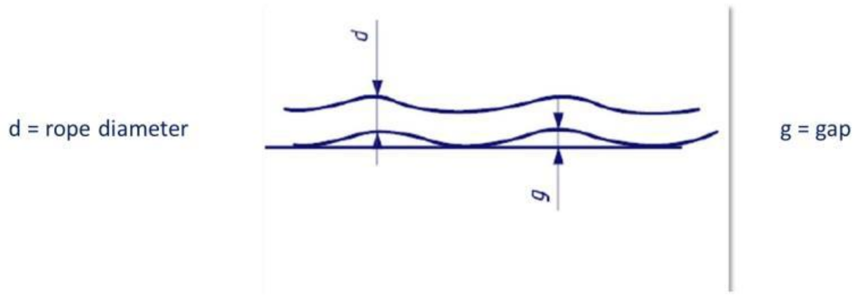
8) Waviness

Identifiable from a defined 'helix' shape in the longitudinal axis of the rope (along its length), in either a loaded or unloaded state. The helix shape can lead to abnormal stresses which leads to broken wires. Severe waviness can have an adverse effect on other components in contact with it, such as sheaves and rope guides. It is recommended to check that the sheave and drum diameter is large enough for the rope.

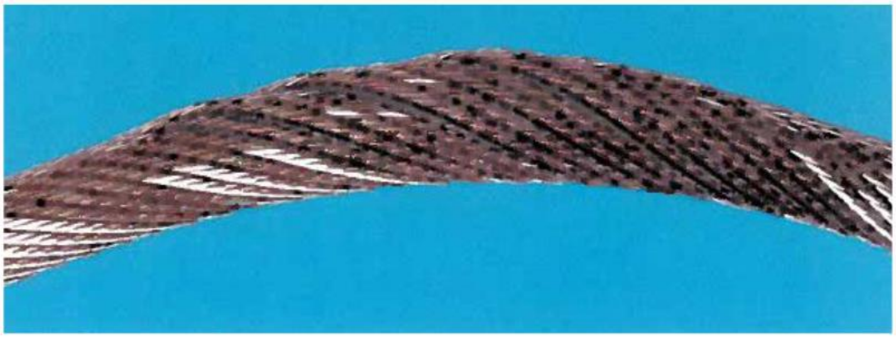
The rope shall be discarded if, under any condition, either of the following conditions exists (see Figure 10 below):

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



9) **Basket deformation**



Sometimes referred to as 'birdcaging'.

This is representative of a difference in length between the outer strands of the rope and its core. Causation can be high fleet angles and running in tight sheaves.

Opening of strands in Rotation Resistant ropes - in extreme circumstances the rope may develop a "birdcage distortion" or protrusion of inner strands.

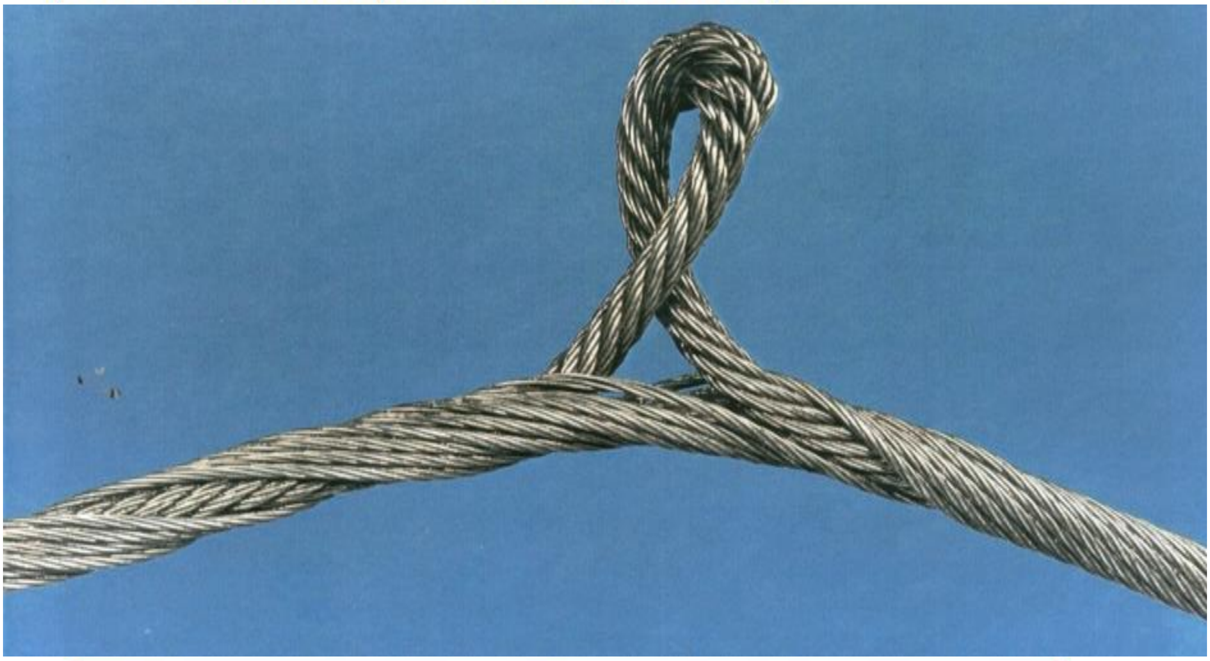
Note: Rotation Resistant ropes are designed with a specific strand gap which may be apparent on delivery in an off tension condition. These gaps will close under load and will have no effect on the operational performance of the rope.

10) **Core protrusion (single layer ropes)**

Indicative of repetitive shock-loading.

NOTES:

11) Protrusion of inner rope in a rotation-resistant rope



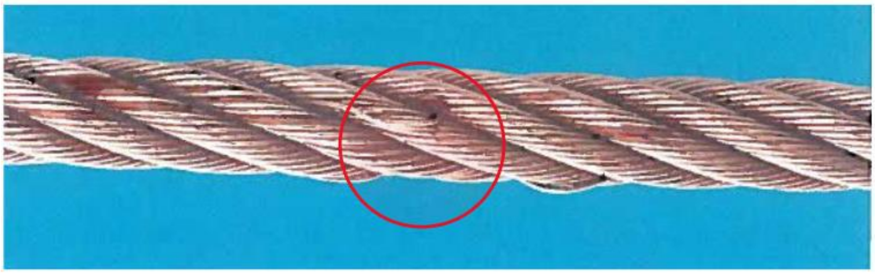
This is likely to be caused by induced turning (twisting) of the rope along its axis.

12) Strand protrusion/distortion

Sometimes referred to as 'basket' or 'lantern' deformation.

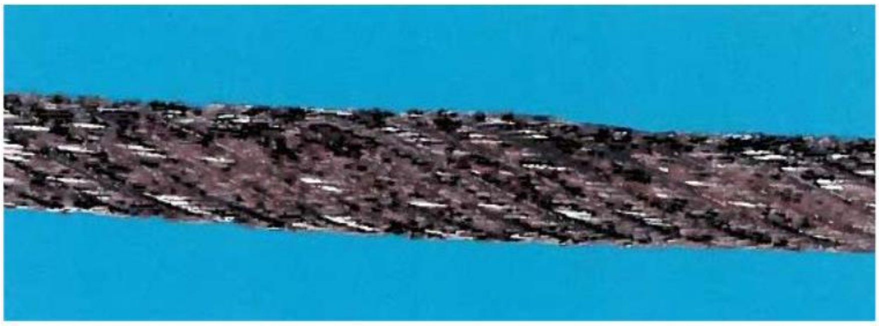
NOTES:

13) Wire protrusion



Individual wires or groups of wires stand out from the rope in loops. This is commonly at the opposite side of the rope to the side which is in contact with sheaves.

14) Local increase in rope diameter due to core distortion



Can be caused by the degradation of the rope's core. Eg. When a fibre core is subjected to excessive moisture, or the build-up of corrosion debris in a steel core wire rope.

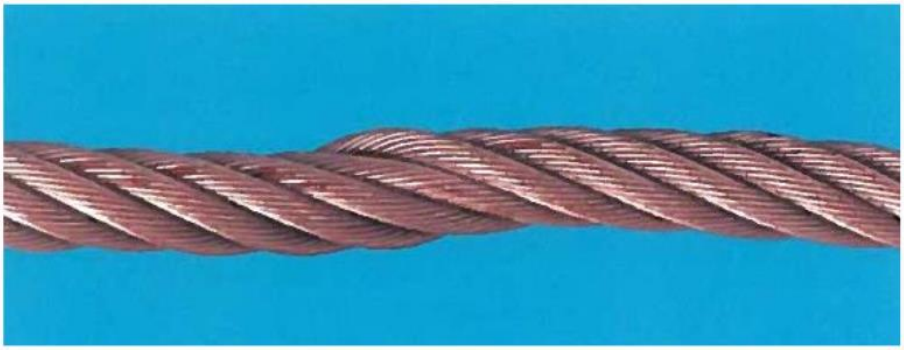
15) Flattened portion

Normally caused by continual running through sheaves. Particular attention should be given to broken wires in these areas which may even damage the sheave(s).

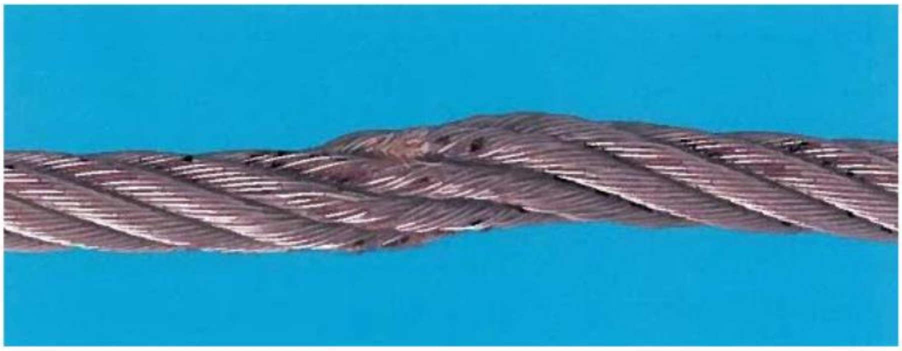
NOTES:

16) Kinks (positive and negative)

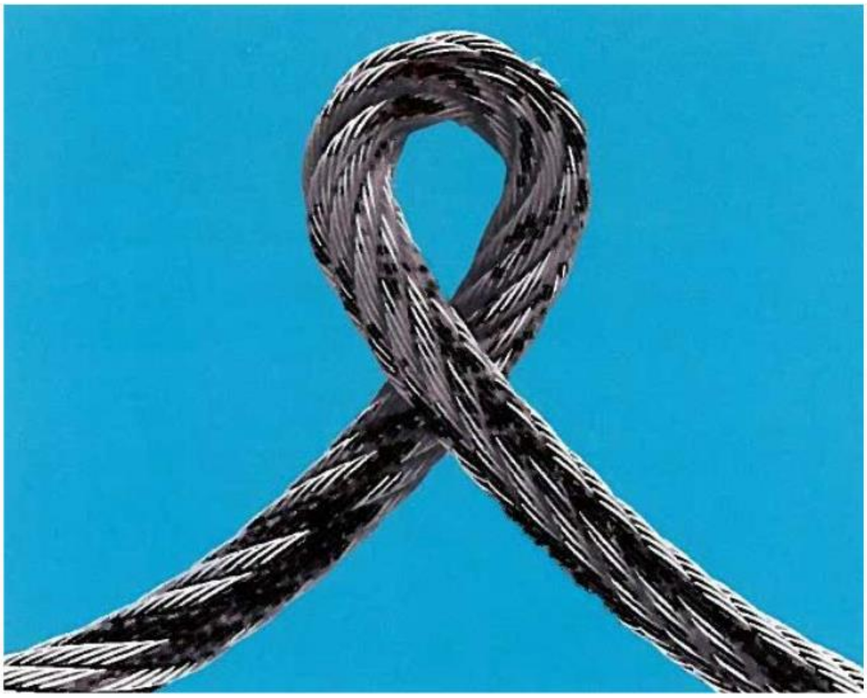
Positive:



Negative:



Kink:



Kinks and tightened loops are cause for immediate discard.

17) Heat or electric arcing damage

Can be shown by a 'blueing' of the steel in the area affected.

MRT is the preferred method for further investigation.

18) Mechanical damage

Usually caused by the rope coming into contact with the structure of the crane on which it fitted or an external structure/load.

19) Decreased rope elasticity

This is often caused by:

- A decrease in the rope's diameter
- Elongated ropes
- Insufficient clearance between strands and wires

A decrease in elasticity is normally identified by fine powder coming from the valleys of the rope (known as fretting corrosion) and a notable stiffening of the rope as it is being handled.

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. It is therefore the reason why the allowable number of visible broken wires for a rotation-resistant rope is less than allowable in a single-layer rope.

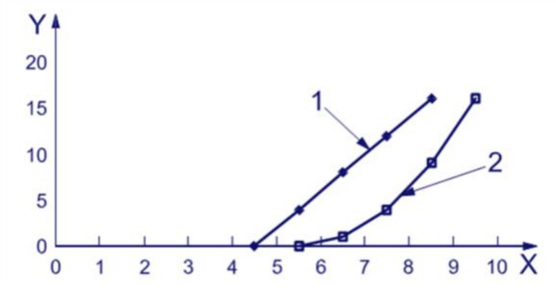
NOTE: students are reminded that access to relevant standards, such as ISO 4309, is necessary in order to carry out thorough examinations correctly.

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 must consider these individual factors, recognising the particular criteria:

- **One line of broken wires:** One line of broken wires running along the length of the rope would suggest that the rope has insufficient support, generally caused by oversize sheave(s) or drum grooving
- **Fatigue breaks** Fatigue induced wire breaks are identified by the flat ends on the broken wires

IMPORTANT! Wire ropes are known to increase the rate of broken wires the longer they are in service. Have a look at the following graph which shows examples of this in two different ropes:



Key:

X = time (in cycles)

Y = number of randomly distributed broken wires per unit length

Multi-layer drum spooling

Powered lifting machines utilising a multi-layer rope drum where the rope is spooling on top of itself, layer after layer tend to suffer from broken wires and deformation where the ropes cross each other. These areas should be the main focus of attention for the examiner.

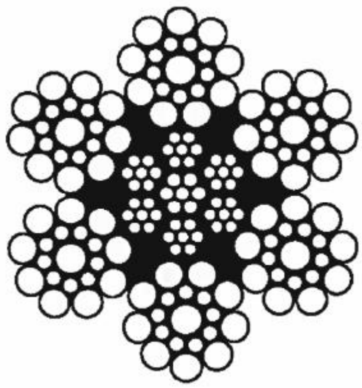
Valley wire breaks

The examiner should pay particular attention to broken wires in the valley of a wire rope as these could indicate that internal rope deterioration, particularly in smaller diameter ropes. Such breaks can be exposed by flexing the rope from its natural position under no tension.

IMPORTANT: If 2 or more valley breaks are discovered in one lay length, it is likely that the core is no longer supporting the outer strands. An MRT inspection would be able to confirm this.

BS ISO 4309 details the discard criteria for the allowable number of broken wires, depending upon the 'Rope Category Number' of the rope (RCN). Before determining the discard criteria for load ropes under, it is necessary to identify the ropes RCN. By way of example, we are going to look at an RCN 02:

Construction: 6 × 19S-IWRC Single-layer rope



RCN.02

Viewing the example from ISO 4309 above, we can see that it is an ordinary-lay rope, categorized as an RCN 02 (single-layer or parallel-closed rope).

The extract from Table 3 in ISO 4309 below shows that an RCN 02 rope of this construction may have a maximum of 3 broken wires over a length of 6 x its diameter, or 6 broken wires over a length of 30 x its diameter, fitted to an electric wire rope hoist, M3 duty, using a single-layer drum.

Rope category number (RCN) (see Annex H)	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) Classes M1 to M4 (ISO 4301-1:1986) or class unknown[d]				Sections of rope spooling on a multi-layer drum[c] All classes	
		Ordinary lay		Lang lay		Ordinary and Lang lay	
		Over a length of 6*d*[e]	Over a length of 30*d*[e]	Over a length of 6*d*[e]	Over a length of 30*d*[e]	Over a length of 6*d*[e]	Over a length of 30*d*[e]
01	$n \leq 50$	2	4	1	2	4	8
02	$51 \leq n \leq 75$	3	6	2	3	6	12
03	$76 \leq n \leq 100$	4	8	2	4	8	16
04	$101 \leq n \leq 120$	5	10	2	5	10	20

Important note 1 – <u>Seale construction ropes with less than 19 wires in each strand</u>: In the example provided above (RCN 02 rope), you may have noticed that the illustration represents a Seale construction rope. The total number of load-bearing outer wires in the outer layer of strands in this rope equals 6 x 19, = 114, therefore ordinarily it would be classed as an RCN 04 in the table above, having between 101 and 120 outer load-bearing wires. However, ISO 4309 states that for Seale construction rope where the number of wires in each strand is 19 or less, they are placed in the table (shown above) 2 places higher than where they would normally be placed for the total number of outer wires, hence it is moved from RCN 04 to RCN 02.

Important note 2 - M5 to M8 duty classification: Ropes fitted to machinery having a duty classification of M5 to M8 may have twice the number of broken wires listed in the ISO 4309 tables.

RCN (Rope Category Number)

If the RCN number of the load rope cannot be found in annex H of 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 H)	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) — Classes M1 to M4 (ISO 4301-1:1986) or class unknown[d]				Sections of rope spooling on a multi-layer drum[c] — 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	$n \le 50$	2	4	1	2	4	8
02	$51 \le n \le 75$	3	6	2	3	6	12
03	$76 \le n \le 100$	4	8	2	4	8	16
04	$101 \le n \le 120$	5	10	2	5	10	20

Uniform decrease in diameter

For wire ropes that are fitted to a single-layer rope drum, ISO 4309 provides guidance to the examiner in the form of suggested % severity rating and discard criteria.

The figures in the table below are derived from a calculation which determines the amount of decrease in diameter from the nominal diameter of the rope:

Or simply:

$$\frac{\text{Reference diameter} - \text{measured diameter}}{\text{Nominal diameter}} \times 100\ \%$$

Rope type	Uniform decrease in diameter (% of nominal diameter)	Severity rating	
		Description	%
Single layer with fibre core	Less than 6%	N/A	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 with steel core or parallel closed	Less than 3.5%	N/A	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	Less than 1%	N/A	0
	1% and over but less than 2%	Slight	20
	2% and over but less than 3%	Medium	40
	3% and over but less than 4%	High	60
	4% and over but less than 5%	Very high	80
	5% and over	**DISCARD**	**100**

NOTES:

3j. Hoist and trolley machinery

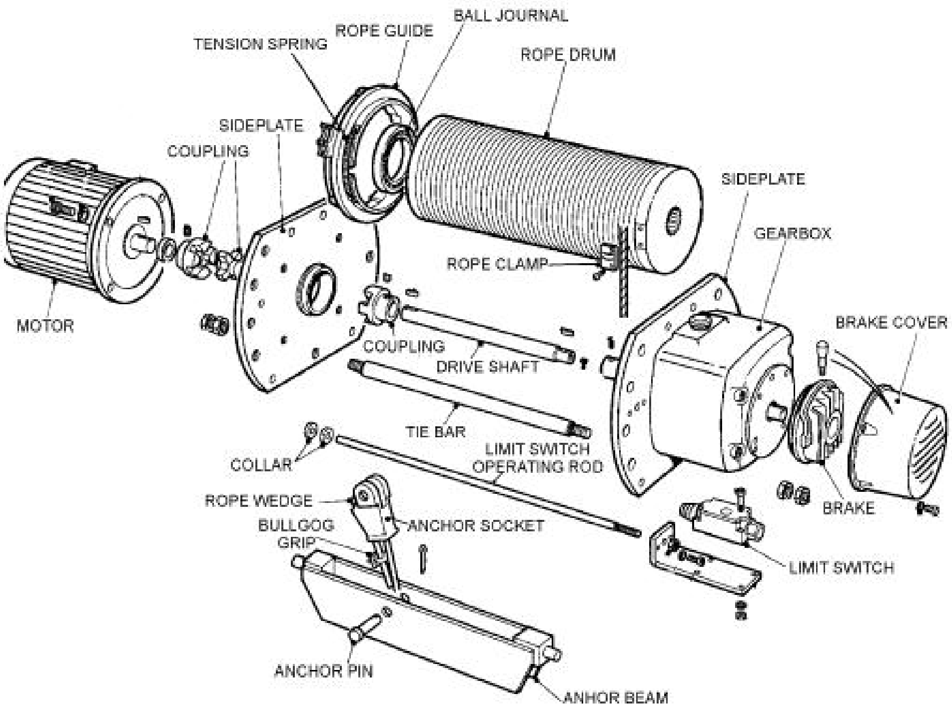
Hoist types

In this unit, we will be looking at wire rope hoists and the types of trolleys that are available for use on bridge and gantry cranes. Although we have reminded you about loach chain examination, we will not be covering types of chain hoist in th is training course. Students are therefore advised that the LEEA Powered Lifting Machines (PLM) Diploma is the course that covers electric chain hoists in depth.

Traditionally, lifting equipment had always tended to be on the heavy side. In recent years however equipment has become more refined and less bulky. Materials are better and manufacturing facilities and controls far superior. The modern wire rope hoist is built as a composite unit suitable for runway mounting or mounting in trolley frame for an electric travelling crane.

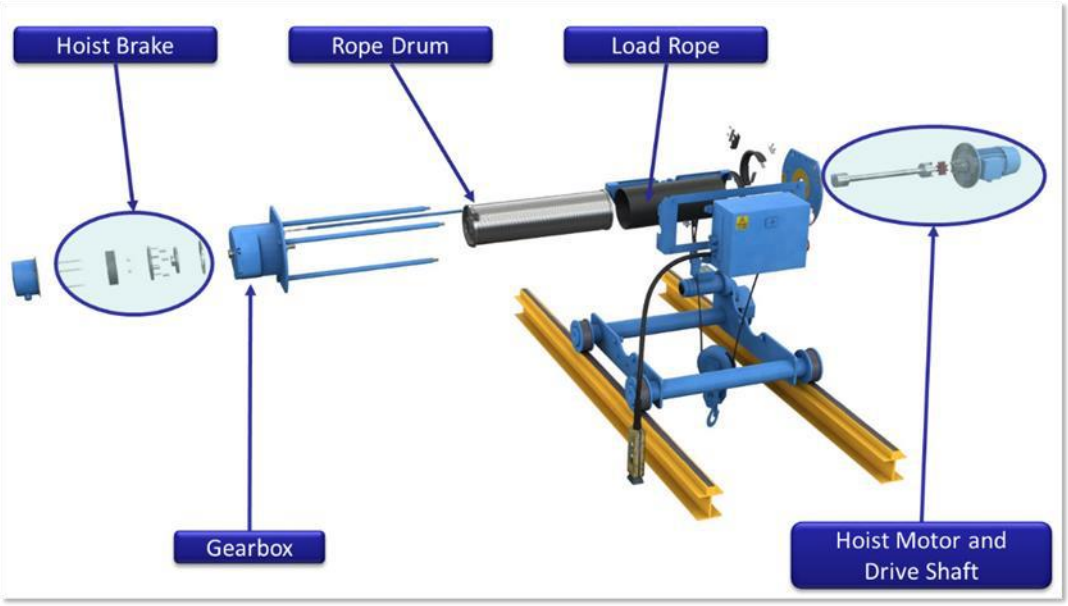
The Morris 400 Series is a hoist which for many years played a dual role, as a single girder travelling hoist block, or fitted with extended end plates and powered runners as a trolley unit for a double girder EOTC. It is a good example of an older hoist design which, due to its sturdy and reliable design can still be found in use today fitted to runways and also a vast number will be found as trolley units of cranes.

The following image shows an exploded view of the hoist. Power is transmitted from the motor, via a transmission shaft which connects to the motor using a spider coupling, through to the gearbox input pinion onto to a drive pinion to a splined drive gear inside the rope drum. Note that the hoist brake is situated on the hoist gearbox as opposed to the hoist motor.

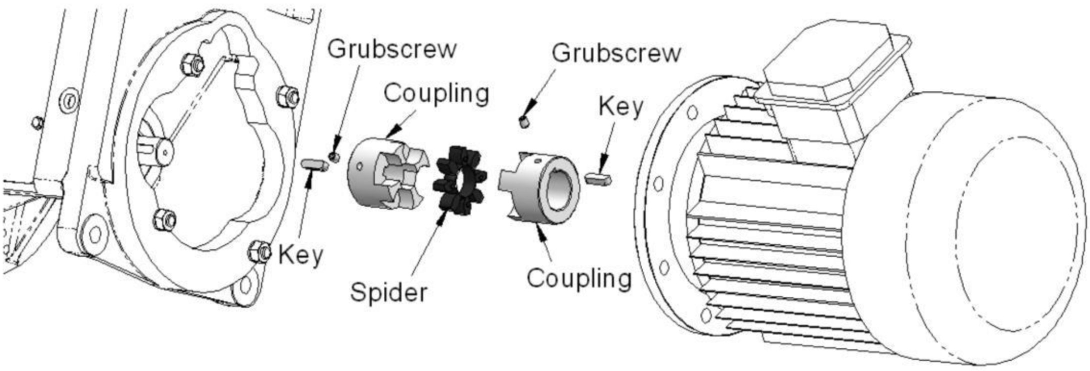


Spider coupling arrangement


Gearbox output gear to internal rope drum gear
Drive from motor to gearbox via drive shaft
Gearbox input shaft


Hoist Brake
Rope Drum
Load Rope
Gearbox
Hoist Motor and Drive Shaft

A variant of hoist drive coupling from a different manufacturer:



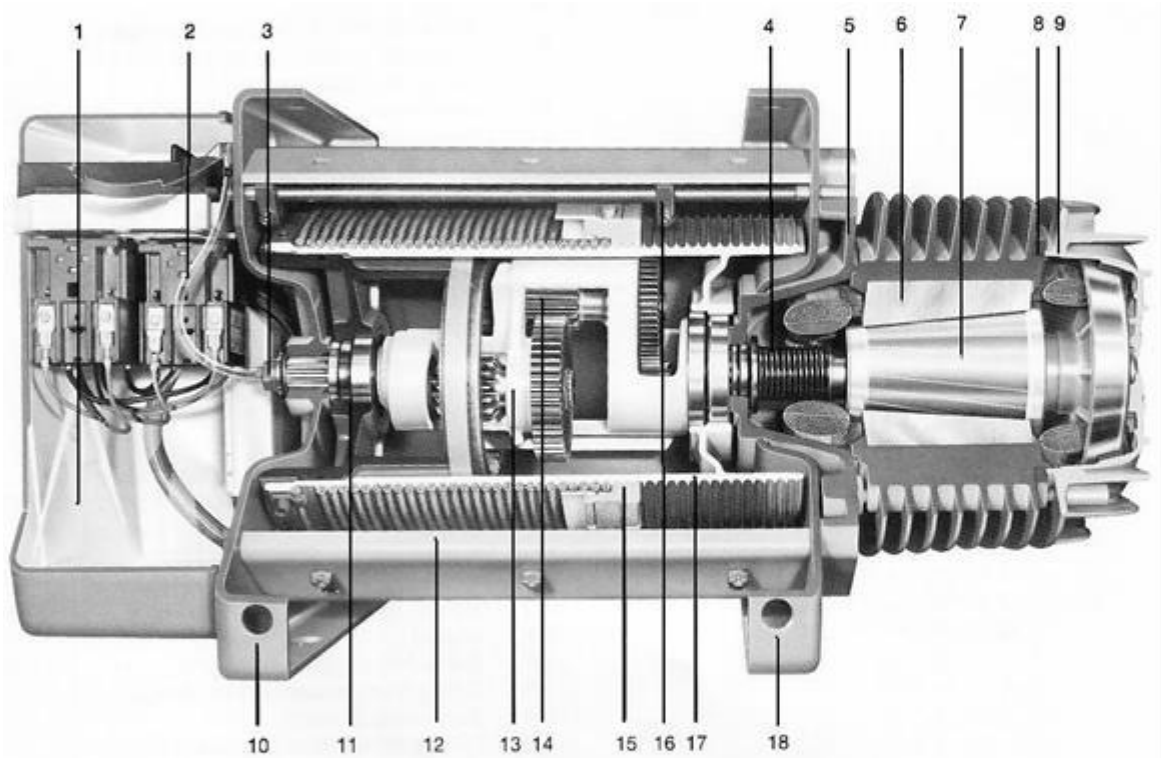
Modern electric wire rope hoists are generally designed in accordance with the crane standards, in particular EN 14492-2. Some older existing units may have also been designed to BS 466 or FEM standards.

Coaxial design

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

Here, 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. The electro-magnetic hoist brake and tapered rotor motor and conical brake unit can be found in service.

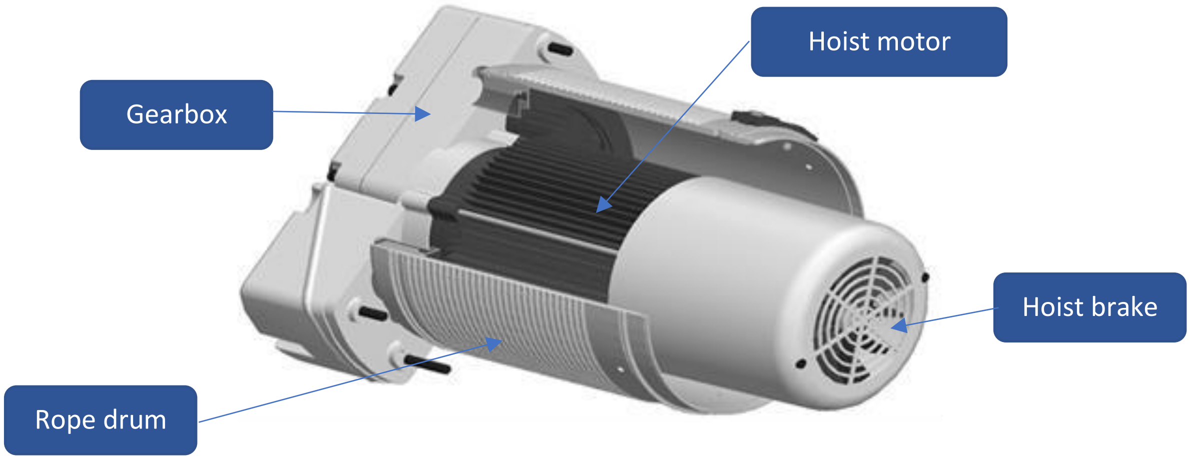
The hoist shown in the following illustration has the motor mounted externally with the complete drive mounted inside the drum.



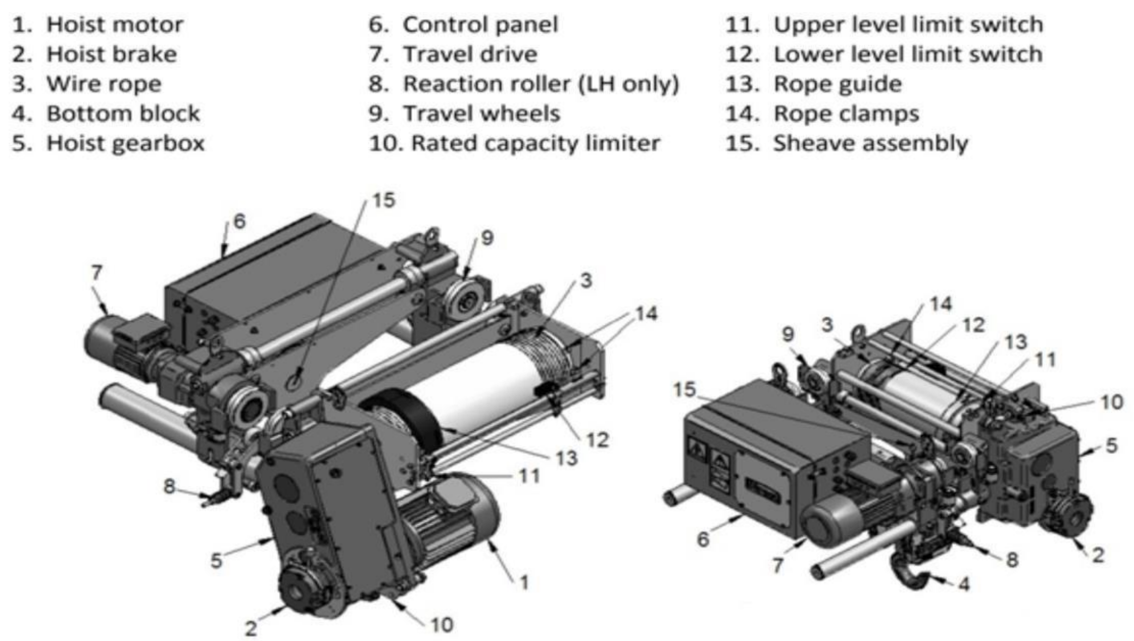
No	Item	No	Item
1	Electrical equipment	10	Mounting flange, gear end
2	Emergency limit switch	11	Drum bearing support
3	Reduction gear vent hose	12	Connecting channel
4	Rotor return spring	13	Internal gear frame
5	Motor end cap, drive side	14	Gears and pinions
6	Stator windings	15	Rope guide and pressure ring
7	Sliding rotor with brake	16	Limit switch operating rod with limit stops
8	Shims for brake adjustment	17	Rope drum
9	Brake end cap with lining	18	Mounting flange, motor end

The hoist units in the market today have even more advanced designs than the ones we have discussed. The market has forced designers to use materials such as higher-grade steels and higher-grade wire ropes to reduce the size and weight of the new hoists. These materials, although strong enough, are not as tolerant of misuse. This has resulted in more exacting requirements when maintaining and examining these hoists and care should be taken to study the manufacturer's manuals carefully.

Modern hoists typically have enclosed, compact gearboxes that are lubricated with semi-fluid grease, sealed for their service life. The hoist motor can be mounted 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:



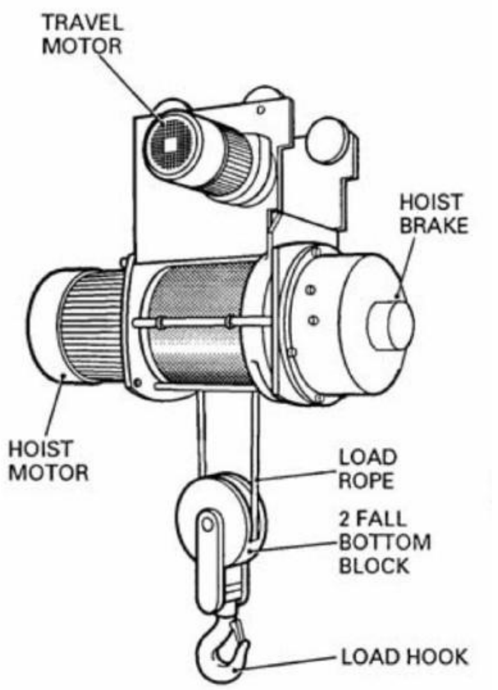
In the Street hoist shown below, we can see that the hoist motor is external from the gearbox (item 1):



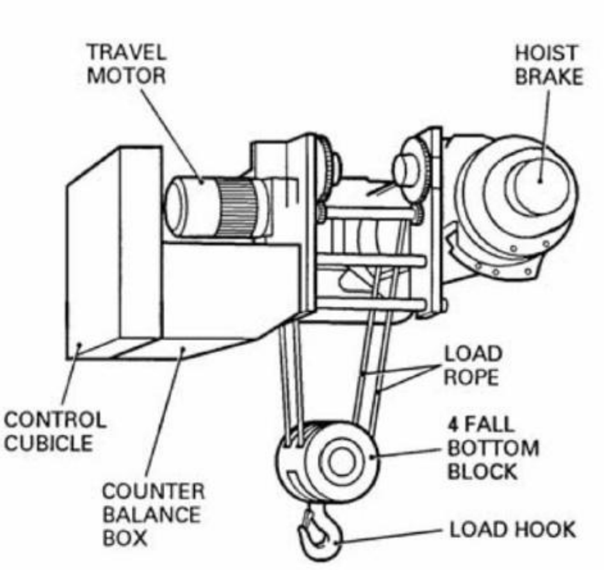
Trolley types

There are 3 basic types of trolley found in service:

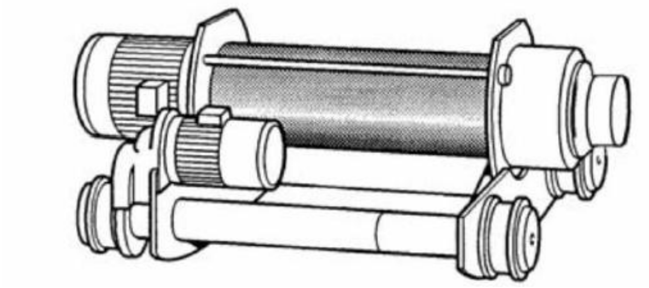
- Standard headroom
- Low headroom
- Crab unit / trolley unit



Standard Headroom



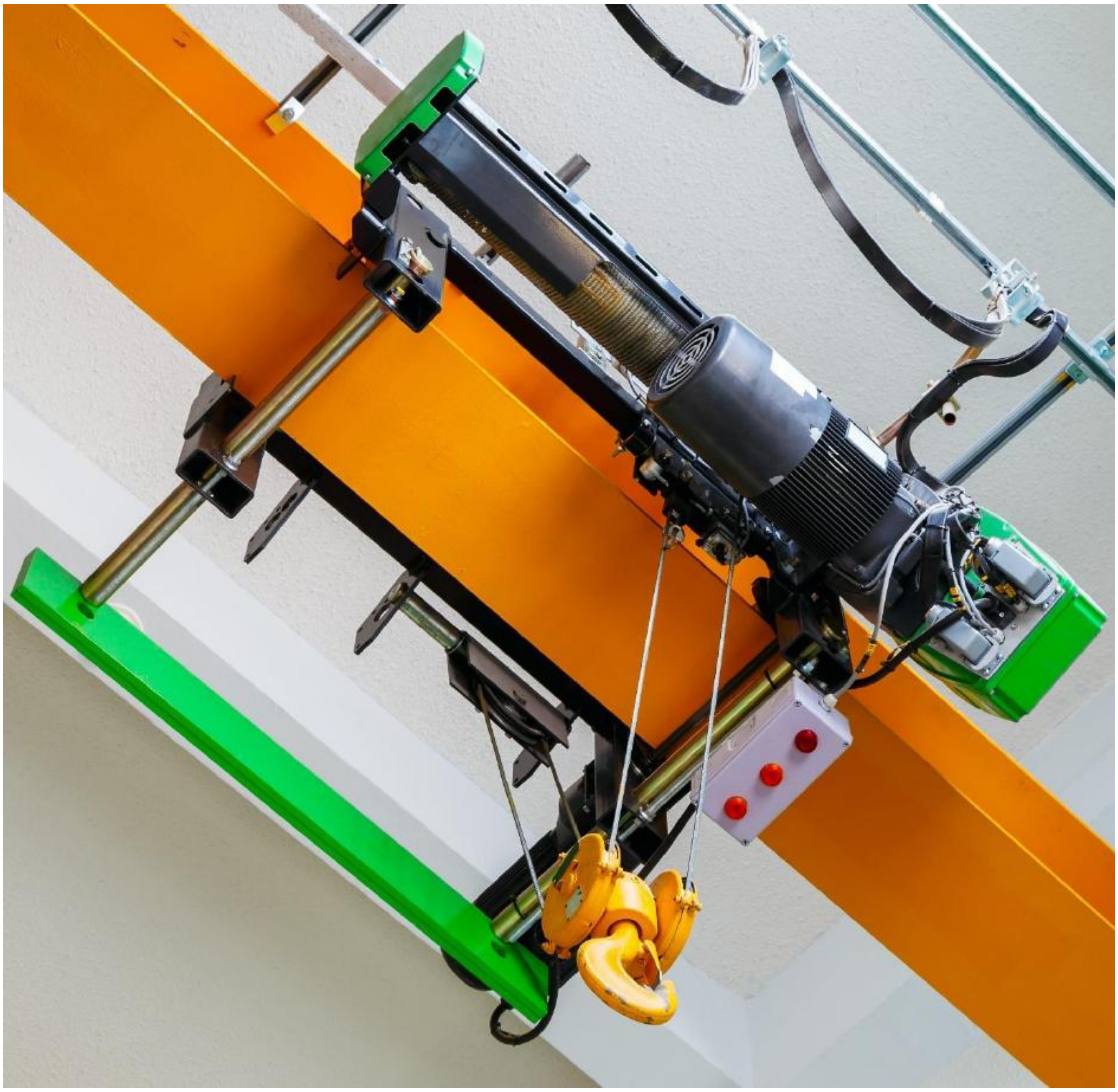
Low Headroom



Crab Unit/Trolley Unit

Most electric traverse trolleys are of the four-runner type driving on two runners on the same side. Long boomed hoists tend to use two four wheeled trolleys.

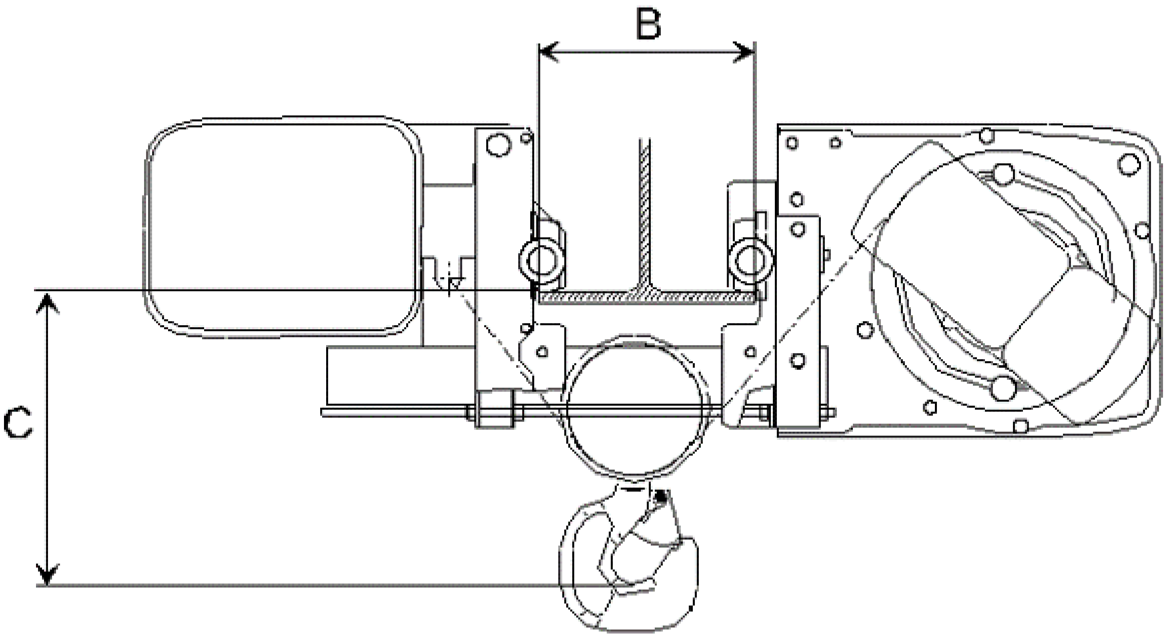
Where headroom is limited, the hoist may be mounted on one side of the runway beam with a counterbalance on the other.



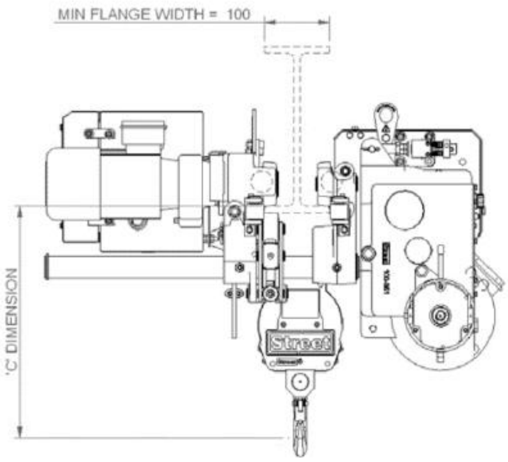
When the B-dimension increases, the fleet angle of the ropes, with the hook in the up most position changes accordingly. To avoid overloading the ropes, overload device, return sheaves and other structures, the minimum C-dimension may not be smaller than recommended by the hoist manufacturer.

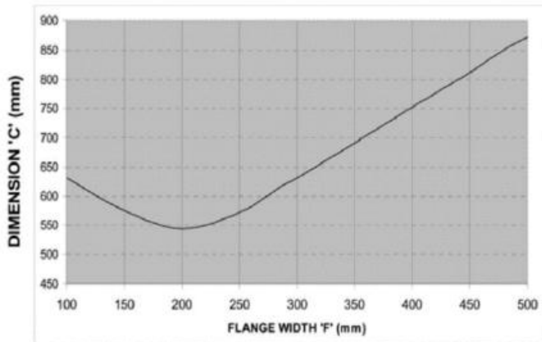
In this arrangement the ropes fall at an angle. When using such a hoist it is especially important that the overwind limit is correctly set. This is because, as the bottom block approaches near to the trolley the angle between the rope falls from the drum and compensating sheave increases. This increases the load in each rope which may eventually exceed the breaking strength of the rope.

The same limitation would be true of any multi fall hoist where the rope or chain falls at an angle to meet the bottom block.



Manufacturers will supply the data required to ensure that these dimensions are accurately set:





In the low headroom trolley, the 'C' dimension is improved over that of the standard trolley as the bottom block is able to travel higher from the ground in this arrangement.

The crab or trolley unit is used when the hoist is mounted to a traveling trolley and sits between the bridge rails of the overhead crane:

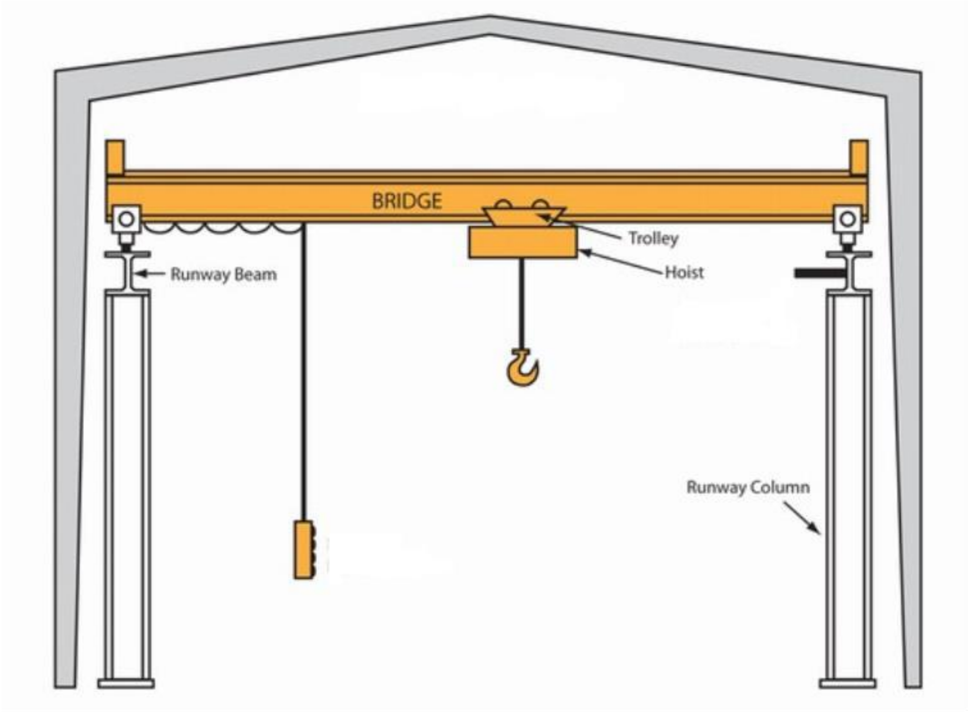
NOTES:

3k. Crane Types

It is recommended that all cranes are designed and manufactured in accordance with the applicable national standards and legislation.

Single Girder

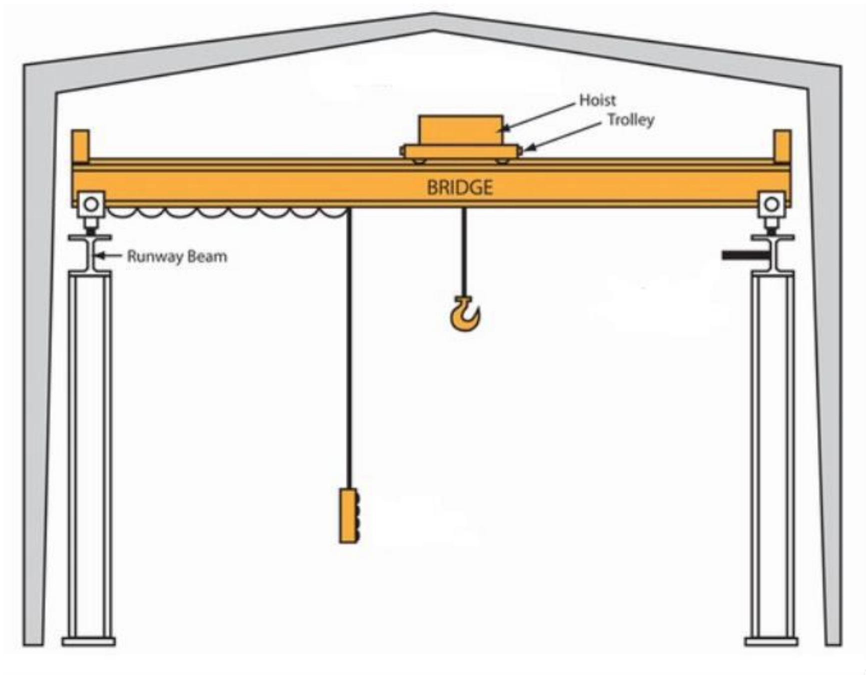
Fitted with an under-slung hoist unit (standard or low headroom configuration) and are used generally for lower capacity or short span applications:



NOTES:

Double Girder

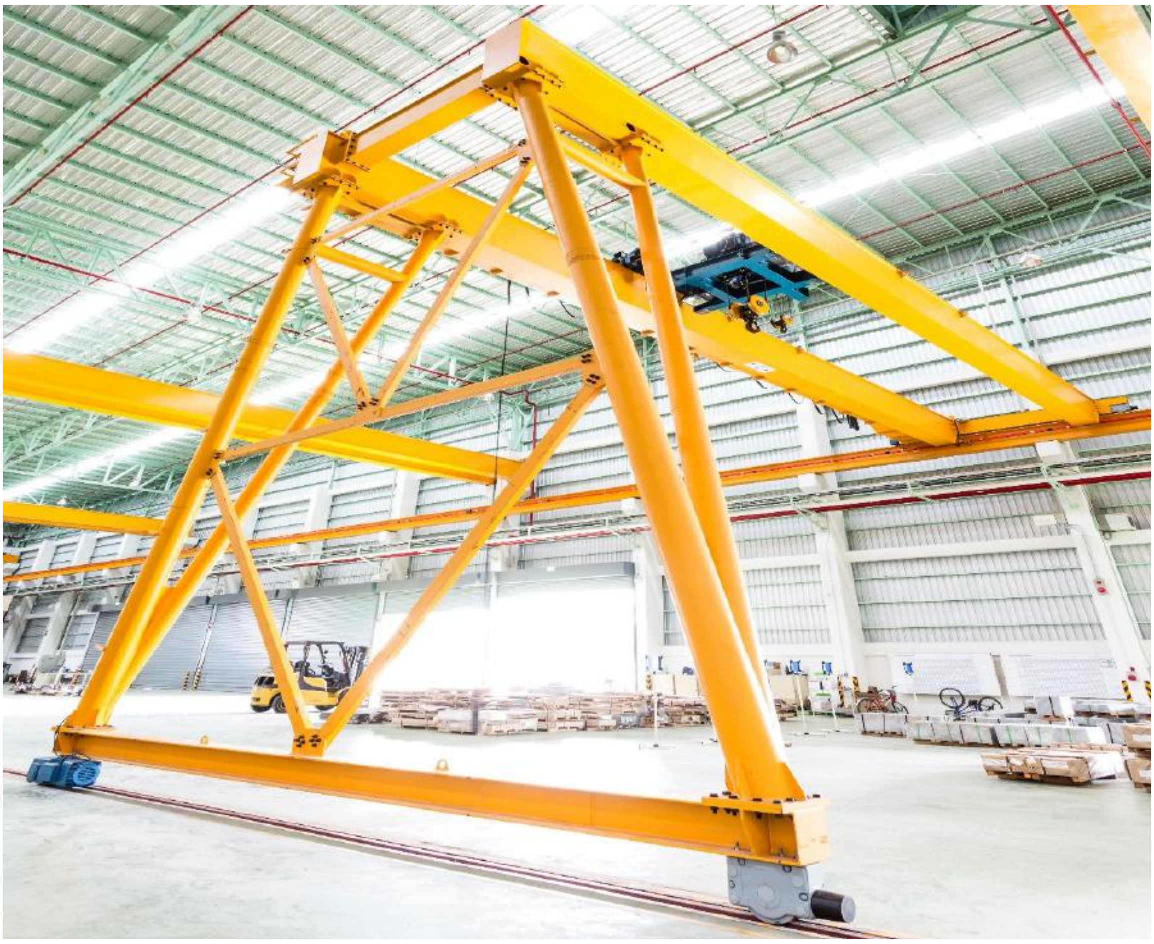
Fitted with a traversing trolley (referred to as a 'crab') mounted between the two girders on crane rails. Used generally for higher load capacities and longer spans:



NOTES:

Gantry

Previously referred to as Goliath or Semi-Goliath, and Portal/Semi-Portal cranes. Gantry cranes may be of single or double girder configuration and travel along tracks in the ground or a combination of ground track and crane supporting structure.



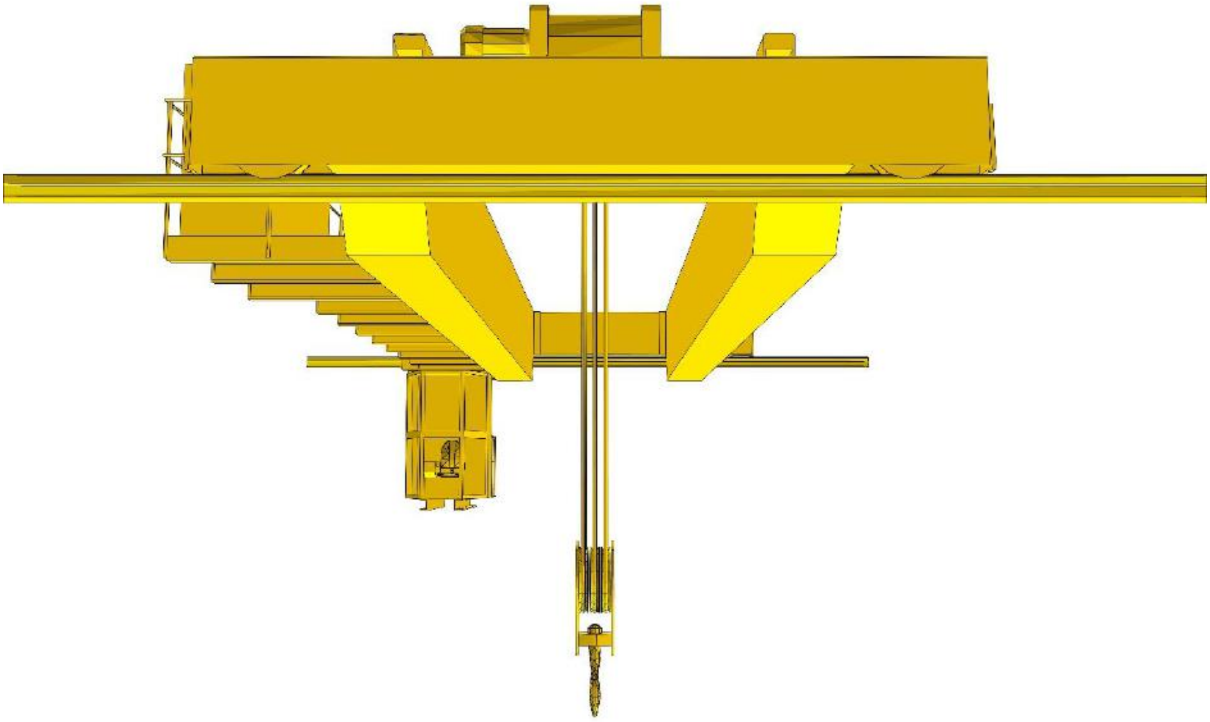
The main advantage of the crane running on ground tracks is that an overhead steel gantry is not required

- Most suitable for outdoor applications where lifting facilities are provided
- No requirement for additional support steelwork and increased cost

Gantry cranes are 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:

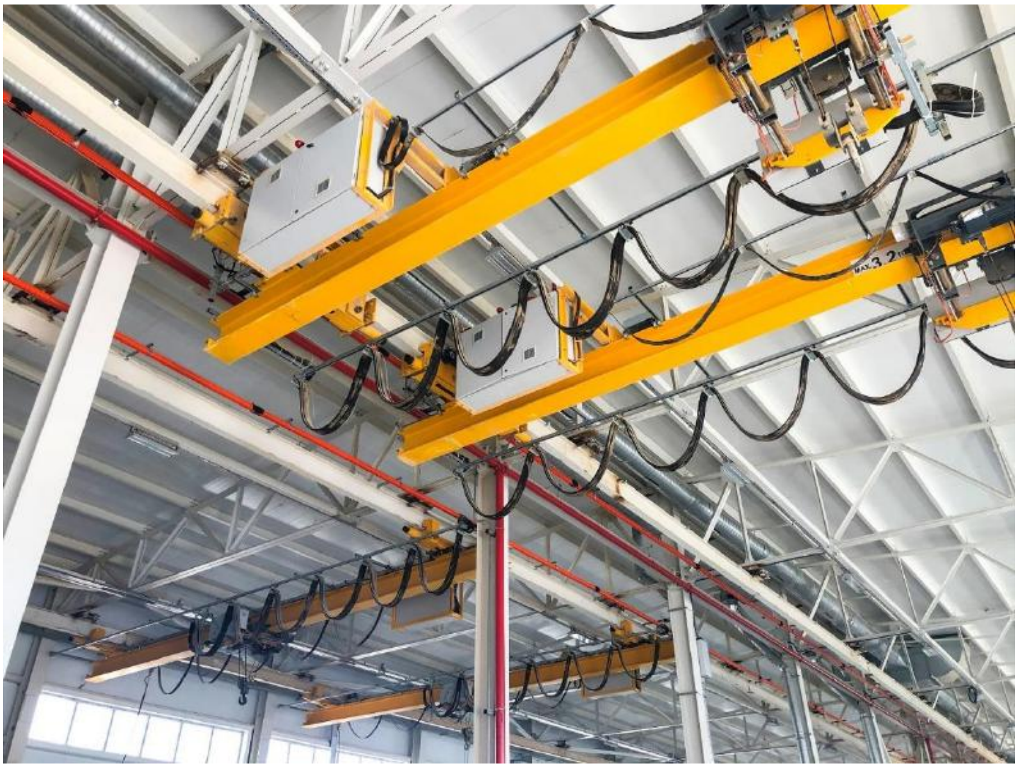
Top Running

Top running bridge cranes use end carraiages that sit on rails mounted to the top of gantry beams which are part of the crane supporting structure.



Underslung

This configuration consists of the crane bridge(s) and end carriages. The end cariages run on the bottom flange of the gantry beams which are mounted to an overhead supporting structure.



Wall Cranes

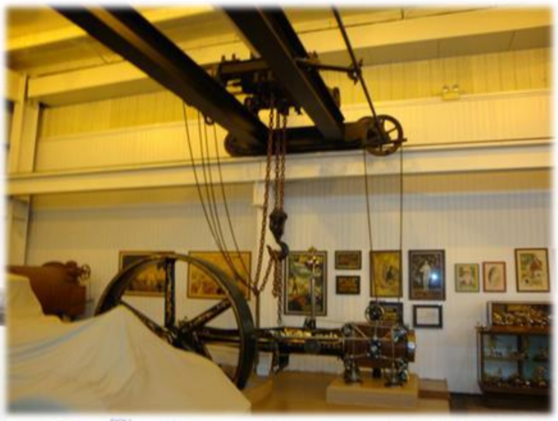
Wall cranes run on the lower flange of a runway beam that is mounted to an overhead supporting structure.

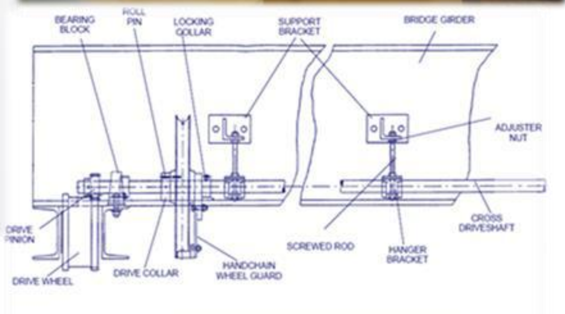
Manually Operated Cranes

Manually operated cranes are found in service in both top running or underlung configurations. The primary drive for the long travel and cross traverse are normally manually geared, hand chain driven gears. They are 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.





LONG TRAVEL CROSS DRIVESHAFT ARRANGEMENT

NOTES:

End Carriages

End carriages vary depending on the manufacturer. Typically, the main body is made from hollow steel sections, fabricated rolled steel sheet or channel.

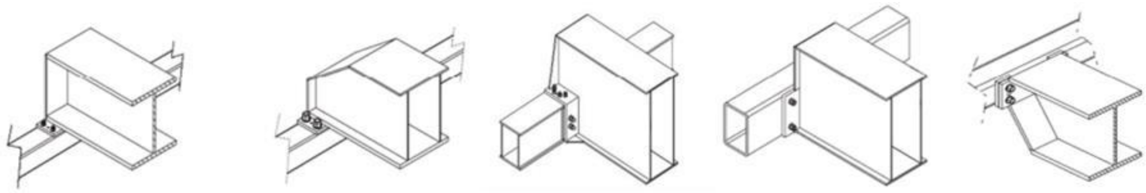
Depending on the load and the speeds of the crane, there are different types of end carriage-main girder configurations:

Normally, there is only one two wheeled carriage per side. Loads on larger cranes would be too much for 4 wheels therefore the best solution is to put one end carriage per girder and then connect the two carriages with a beam. In this configuration, the wheel loads are halfed, and the size of the wheels can be reduced.

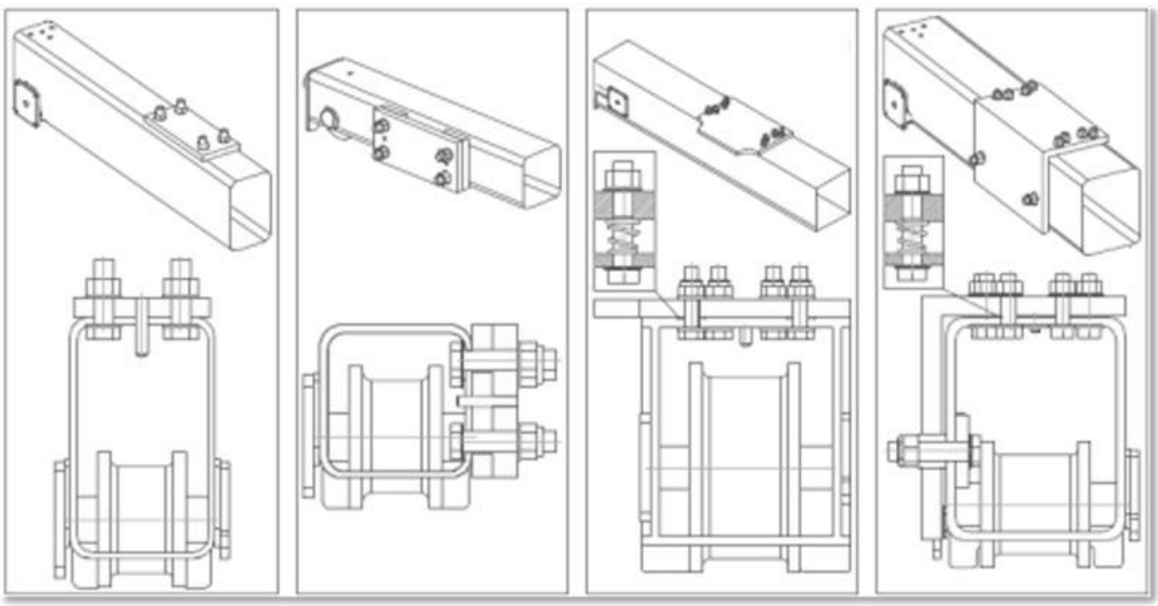
The main girder(s) of a crane can be fitted to the end carriages by one of two common methods:

- Top connection
- Side connection

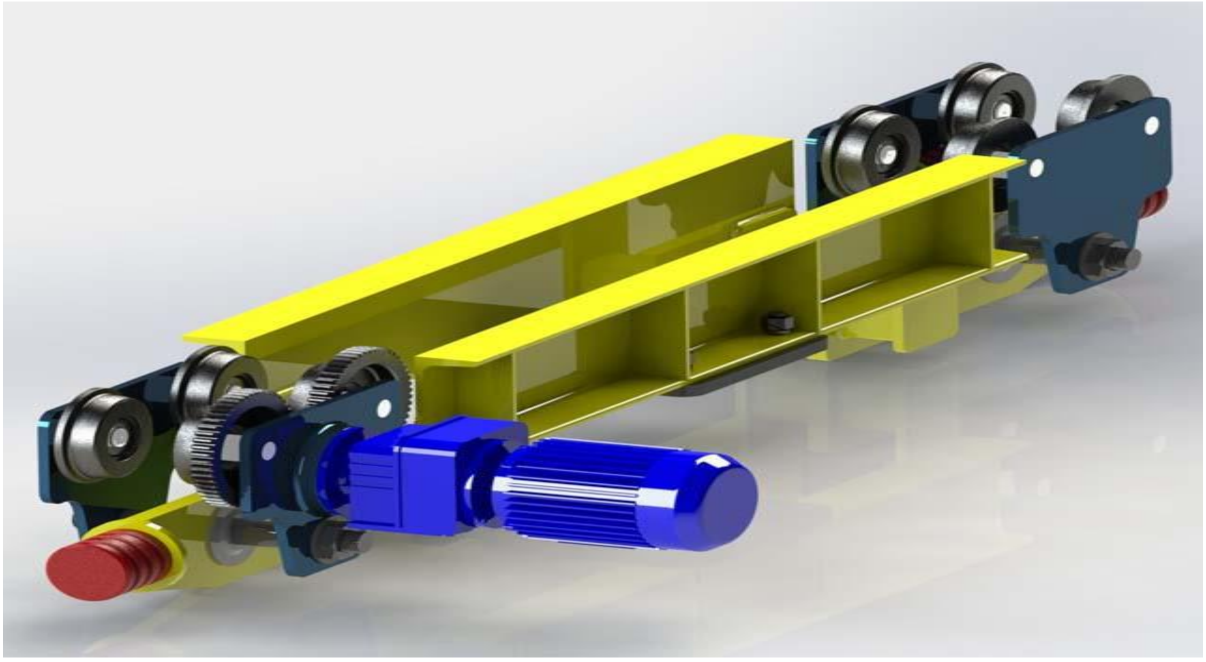
The decision as to which method is used is normally the preferred method of the manufacturer and/or technical constraints (work envelope).

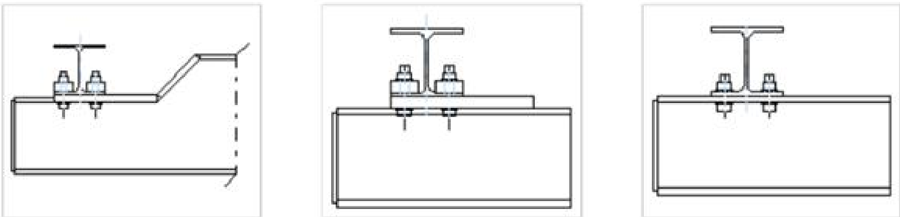


End Carriage to Bridge Connections



Underslung End Carriages





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.

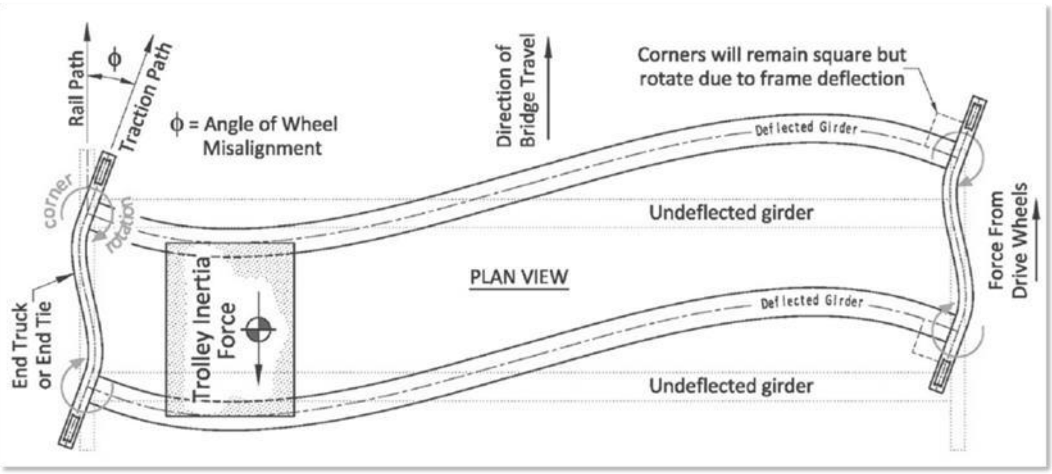
Skew Loading

In particular, bridge and gantry cranes with large spans may suffer from skew loading. Crane manufacturers provide the lateral guiding forces in the original crane data sheets for referral. If the crane manufacturer is not known, lateral guiding forces for bridge cranes can be found in EN 1991-3.

- 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 *(Ref: BS 2573 Pt1 and BS EN 1991 Pt3 refer to evaluation of skew loadings)*

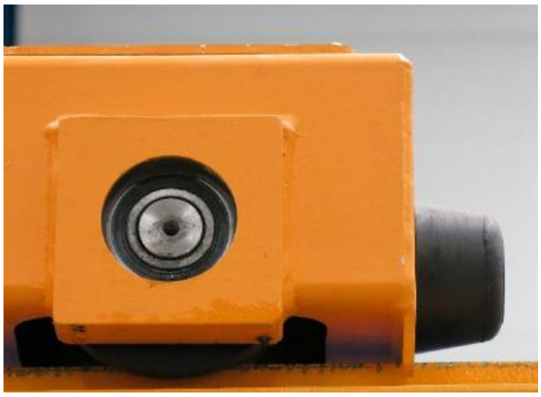
Consequences of Skew Loading



NOTES:

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

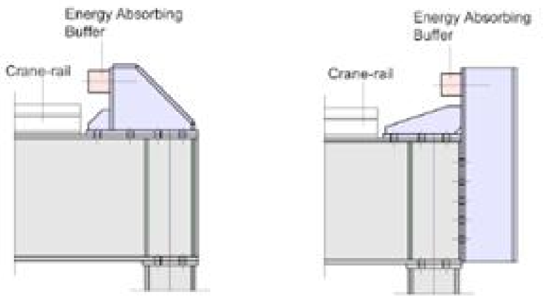


Buffer Extensions

- 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

End Stops

Designed to stop the crane traveling along the gantry beams and dismounting the supporting structure at the end of travel, once only, at full speed and full rated capacity. Thereafter they should be thoroughly examined by a competent person as this would be treated as an exceptional circumstance:



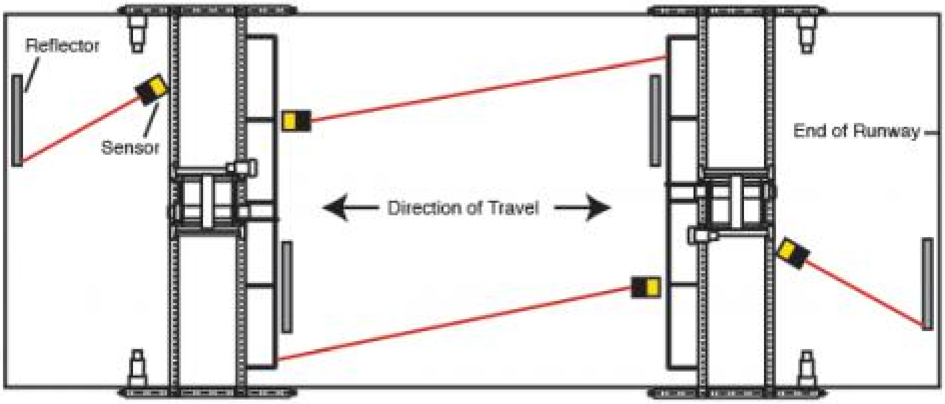
Top-Flange Rail End-Stop

End stops that are unfit for purpose can result in serious accidents or near misses:

NOTES:

Anti-Collision

The risk of collision may exist when cranes are used in the same area, for example, 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 devises can be fitted to the machinery and provide the necessary fitting instructions.



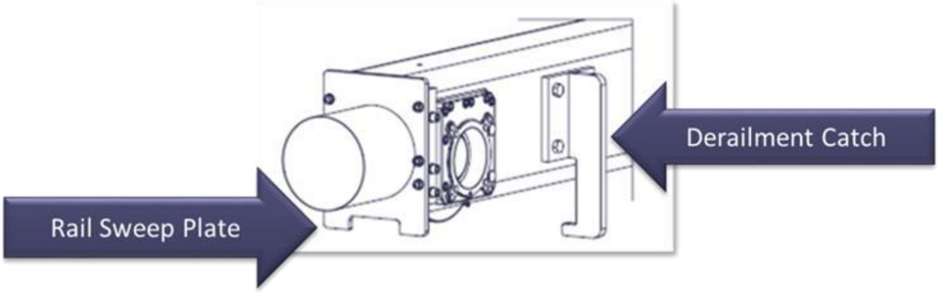
Infra-red and laser control systems are commonly fitted to cranes to provide this safety system. The anti-collision system is safety device to avoid the collision of two electric overhead traveling cranes working on the same rails.

Remote Controlled Cranes

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

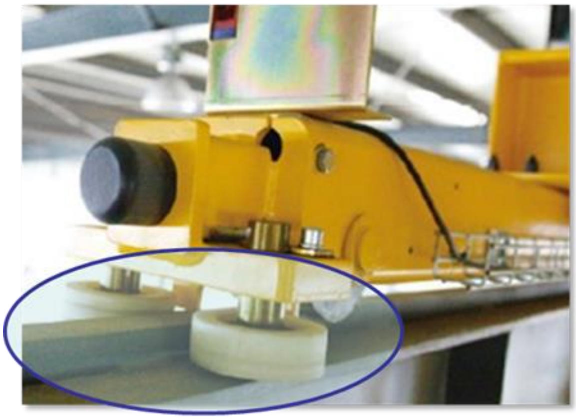
Derailment Facility

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.



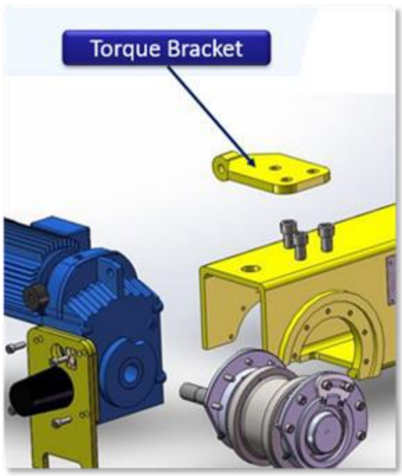
Guide Rollers

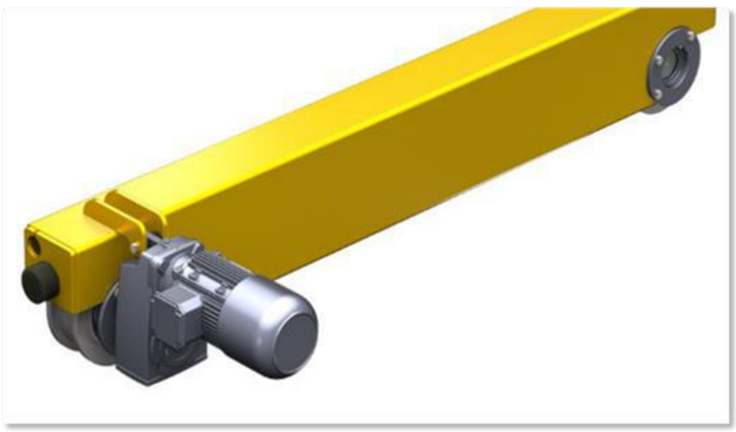
- May be fitted by some manufacturers
- They are selected when flangeless wheels are used
- Designers will consider using this system if the application requires



Torque Brackets

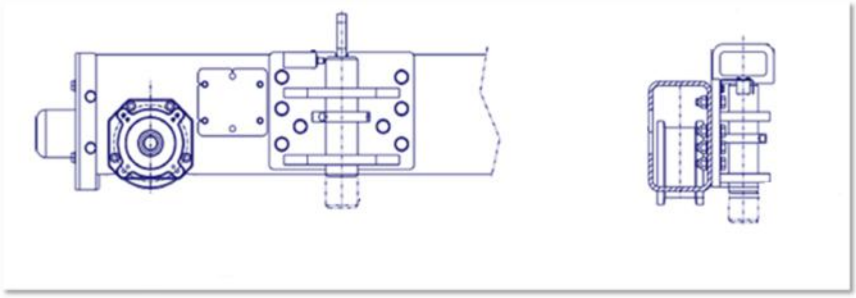
These are used to prevent the starting torque of the motor putting undue stress on mounting bolts and gearbox connections:





Storm Locks

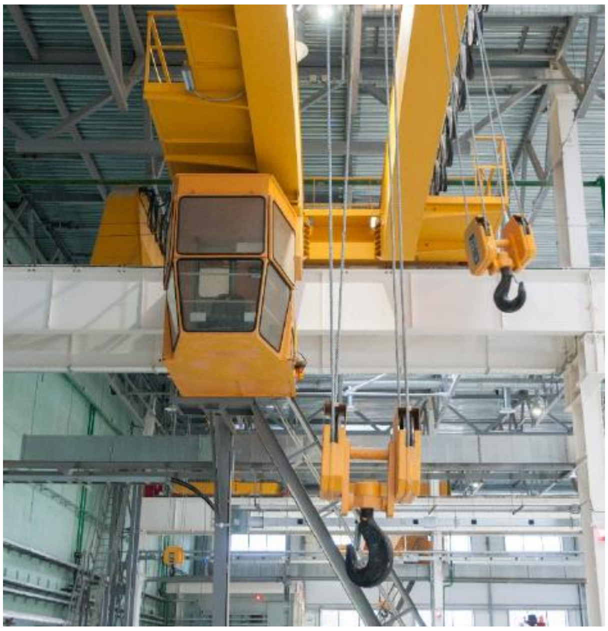
Portal and Semi-Portal cranes must be fitted with storm locks where wind loadings could move the crane along its tracks when not in operation.



Crane Controls

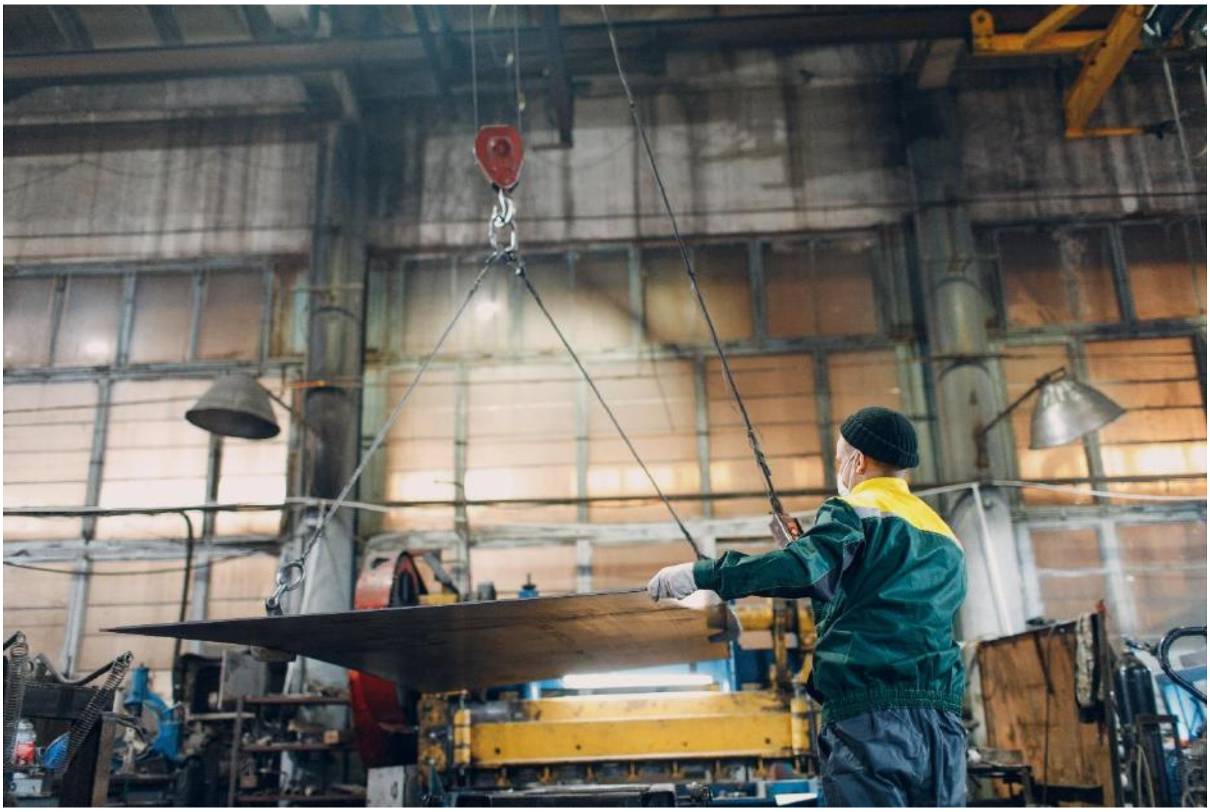
Cab Control: The crane operator controls the crane from a cab mounted on the crane. This is usually fixed at one end of the crane bridge and travels with the bridge. Before the advent of modern control systems, most electric overhead travelling cranes were cab controlled. There are still applications where cab control is the best option, in particular those where the crane is in continuous use or the application requires lengthy long travel movements. The disadvantage of cab control is the need for the operator to be continuously on duty when use is infrequent.

Another arrangement is where the cab is fixed to the crab and therefore moves with the crab. This has the advantage of giving the operator a view of the load which might otherwise be obscured. A third variation is a cab without controls from which the operator can control the crane using a pendant control or a remote control. This gives the option of cab control when appropriate, such as during a period when the crane is in frequent use yet retains the flexibility of control from other levels.



Pendant Control: The crane operator controls the crane from a low level, usually ground level, using a push button box suspended from the crane. The push button box is usually suspended from a track running across the crane bridge and connected by a festoon cable enabling it to be moved to any position. This has the advantage of enabling the operator to choose the best vantage point and also to negotiate any obstacles whilst using the long travel motion.

Less popular arrangements are for the push button box to be suspended from a fixed point on the crane bridge or from the crab or hoist unit.



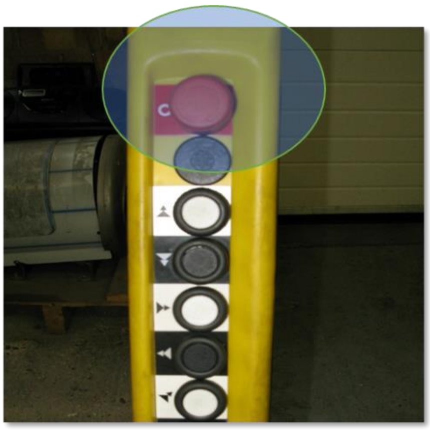
Remote Control (Cable-less Controller)

The crane operator controls the crane from a remote operator station without a cable connection to the crane. This has the advantage of enabling the operator to choose the best vantage point with virtually no limitations.

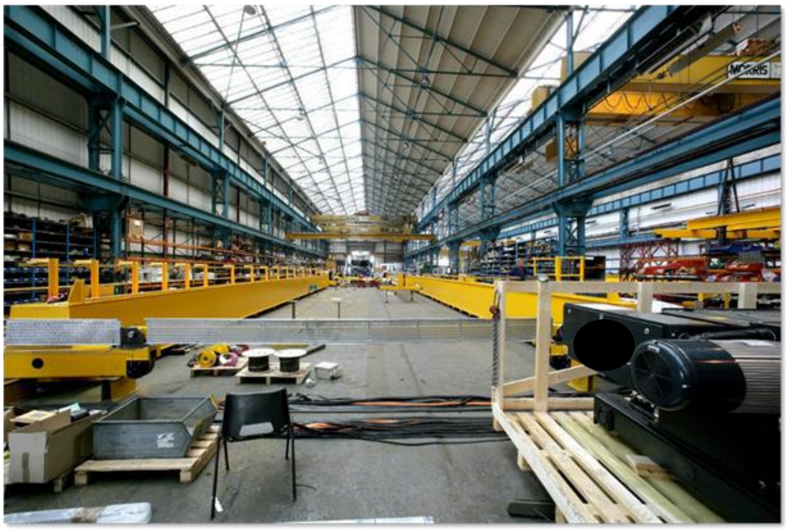
Early forms of remote control were of the infra red type similar to the controls used for domestic equipment such as televisions. A significant drawback was the need for a clear line of sight between the controller and the receiver mounted on the crane. These have largely been replaced by radio controls which do not require line of sight.

Emergency Stop

All crane controls should incorporate an emergency stop button. Unlike the other buttons this should not be of the self-resetting type and should require manual resetting once activated. It should be mounted in a readily accessible position, normally with the crane controls, for example in the operator's cab or in the pendant push-button box.



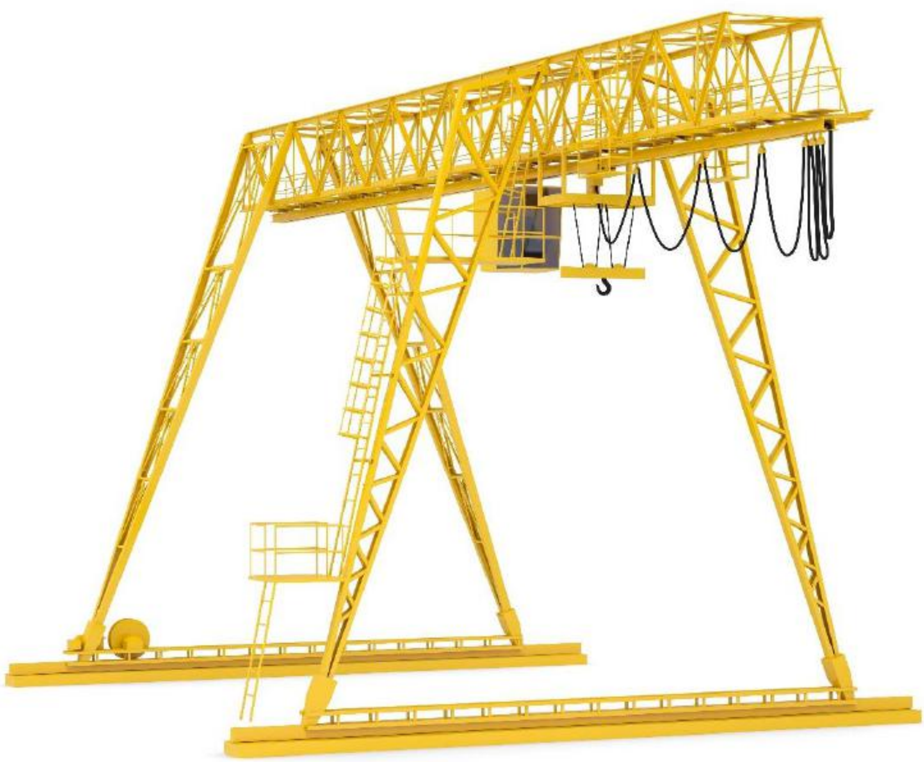
Crane Bridges



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

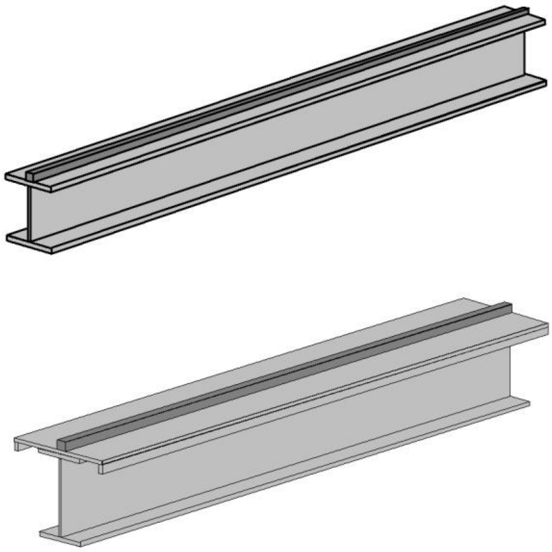
Lattice

- 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 to build, maintain and inspect



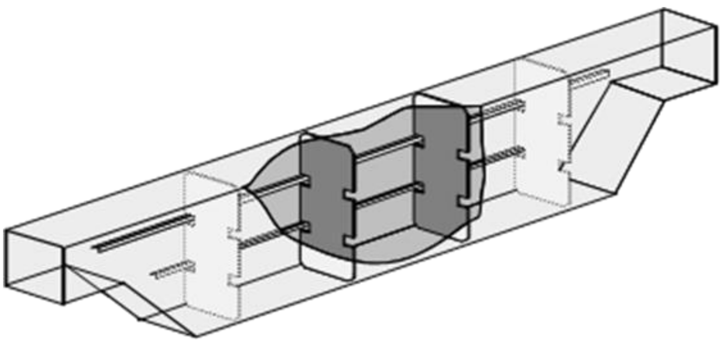
Rolled Section

- Readily available from steel-stock holders
- Profiles can be purchased in a variety of shapes and sizes
- These 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

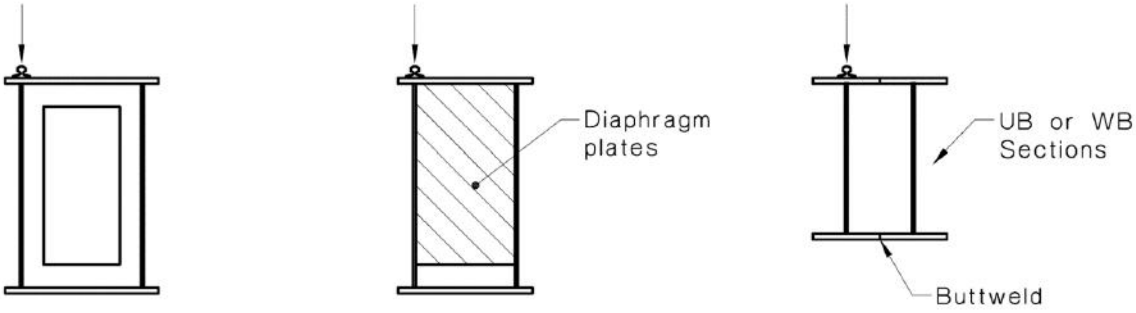


Box Girder

- 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
    - o 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



Types of Box Girder

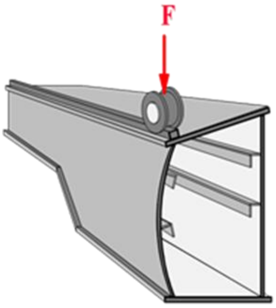


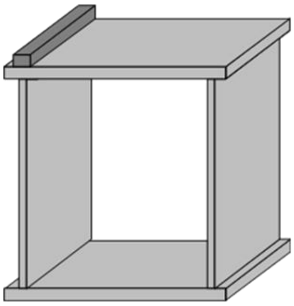
Construction of a Bridge Crane – Baffle Plates Exposed

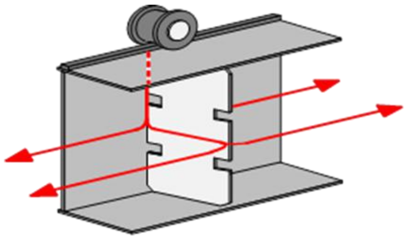
NOTES:

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 (approximately 12 metres) for overseas transportation, and therefore main girders have to be reduced in length.

The illustration below shows a spliced connection with two alignment pins and a bolted flange plate connection:

Thorough Examination

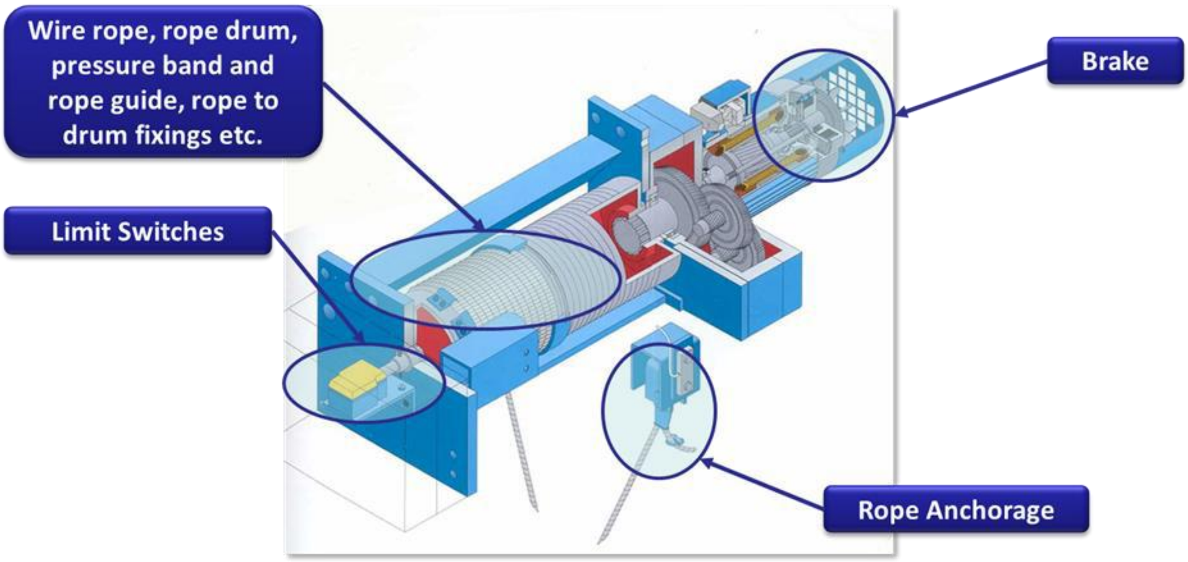
The defined scope of examination for light crane systems should include the following critical components:

- End carriages
- Long travel drives, wheels, axles, bearings and brakes
- Bridge girders
- Crab unit/trolley structures
- Cross traverse drive, wheels, axles, bearings and brakes
- Cross travel rails
- Hoist mechanism including motor, brake, couplings, gearbox, drum and bearings
- Wire rope(s), rope terminations and anchorages, guides, sheaves/pins, bearings, bottom block and hook(s)
- Electrical control panel(s) and wiring
- Operator cab and seating
- Operator controls, whether cab, pendant or Infrared/radio controls
- Limit switches
- Platforms and access ladders
- Supporting structures
- Gantry beams, rails and fixings
- End stops and buffers
- Down shop power conductor system

The competent person conducting the thorough examination of bridge and gantry cranes will work to a **checklist**, drawn up from the defined scope. The following information is given by way of example as to what would usually be included in such a checklist:

- Inspect all wire ropes in accordance with crane manufacturers specifications and ISO 4309: check for broken wires, flattening, basket deformation or other signs of damage, excessive wear and surface corrosion
- Carry out a visual inspection of all rope terminations, pins and retaining devices, and inspection of all sheaves, for damage, worn bushes or seizure
- Visually inspect bottom block units and hooks, safety catches and other load lifting attachments for damage, free movement or wear and a visual inspection of the hook shank thread and securing nut for undue movement, which might indicate wear or corrosion
- Carry out a visual inspection of the structure for damage, for example cracked welds and loose bolts and other fasteners
- Check whether all moving parts are adequately lubricated with an appropriate lubricant
- Check whether all controls are clearly marked and operate correctly
- Operate the crane though all its motions while checking for any unusual noises or erratic movement during operation
- Check the operation of all motion limiting devices, anti-collision devices and emergency stops
- Carry out a visual inspection of any load limiter. This should at least comprise a physical check of the load limiter components, paying particular attention to cables, connectors and mountings

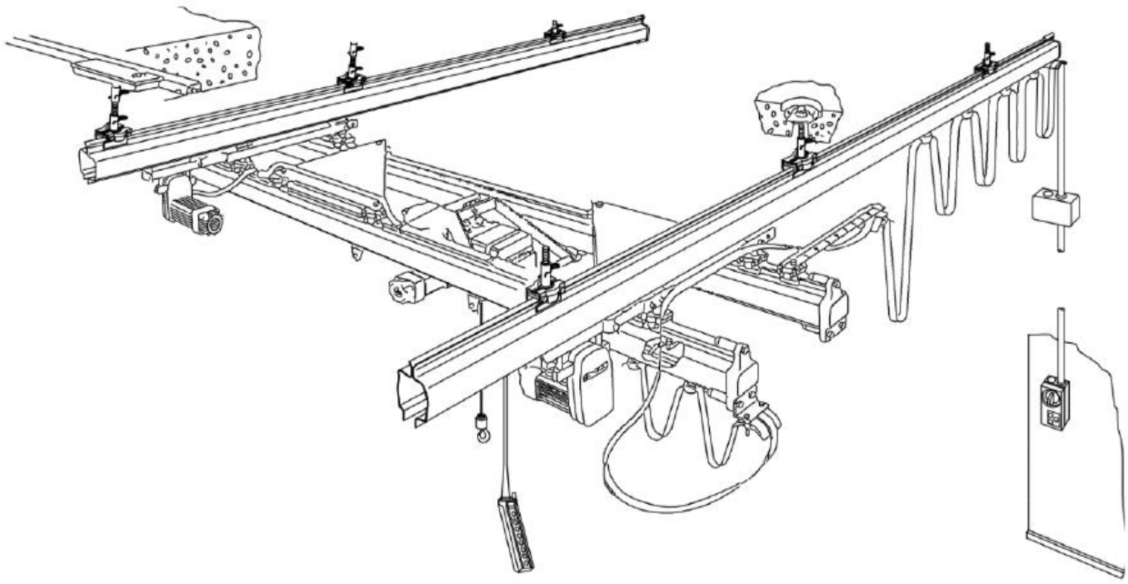
- Carry out a visual inspection of the electrical equipment and a check for exposure to contamination by oil, grease, water or dirt
- Check the functional effectiveness of the braking system and that it is suitable for the application. This might need to include seeking confirmation from the crane operator
- Carry out a visual inspection of rails and end stops
- Check for the presence of, and the condition of, all guards



NOTES:

3l. Light Crane Systems

In this session, we will look at light crane systems, either suspended or free-standing systems.



Light crane systems are usually classified as structures made from steel or aluminium, excluding aluminium structures containing welded joints. They may be defined as an assembly of lifting devices, bridges, trolleys and tracks with their suspensions for lifting operations.

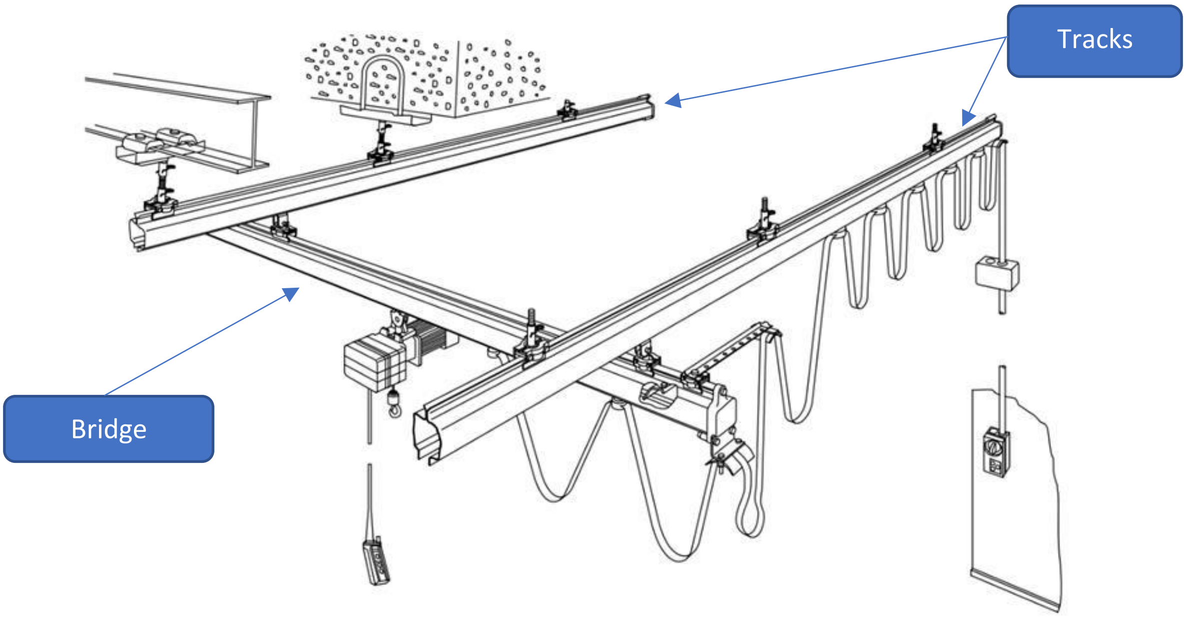
Light cranes are suspended by several types of clamps, hanger rods and other fittings from which a track is suspended from a building or other supporting structure.

Light cranes have a WLL of 10t in most cases, but some standards do cover light cranes that exceed this capacity *(e.g EN 16851).*

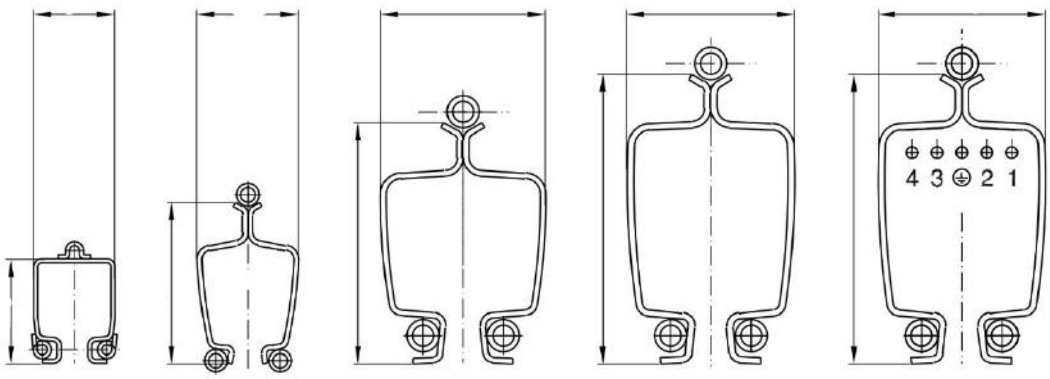
NOTES:

Track Sections

Tracks are supported by the building structure for suspending a monorail or crane bridge.



Various track profiles are available, both in formed steel and extruded aluminium structure. The track profile and size depend on the capacity.



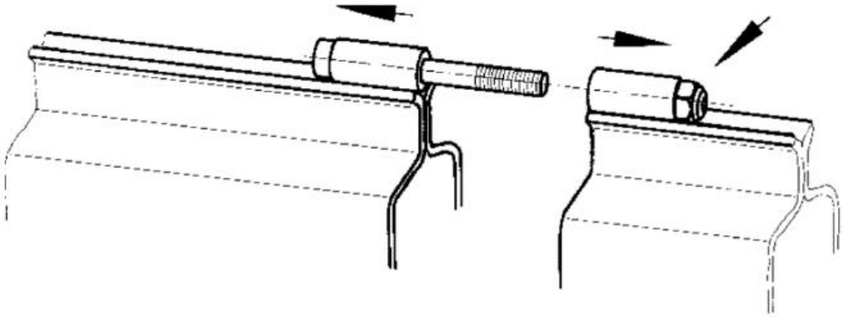
NOTES:

Some track profiles have a 4-bar conductor bar system incorporated which supplies power to a motor traveling trolley via a collector shoe.

4-bar Internal Conductor System Incorporated into the Track

Connections are usually made by pins and bolted splice plates (typically used in aluminium sections) or bolted connection for steel profiles.

Aluminium Track Splice Connection Plate



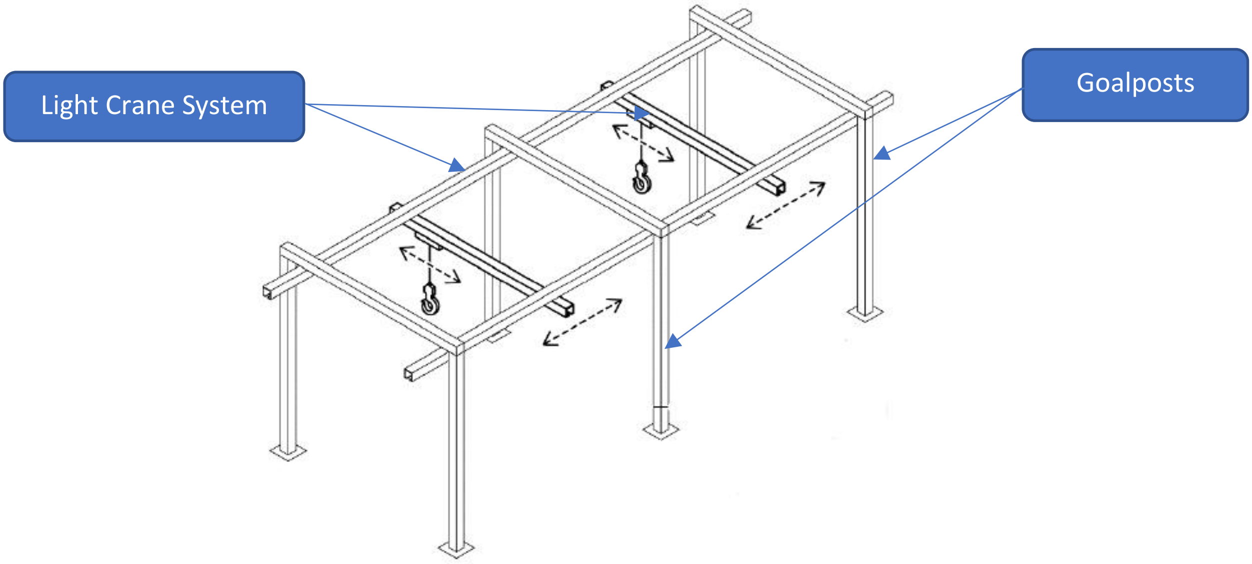
Steel Profile Connection Bolts

Steel Profile Connection Bolts with Internal Power Conductor System Connection Joint

NOTES:

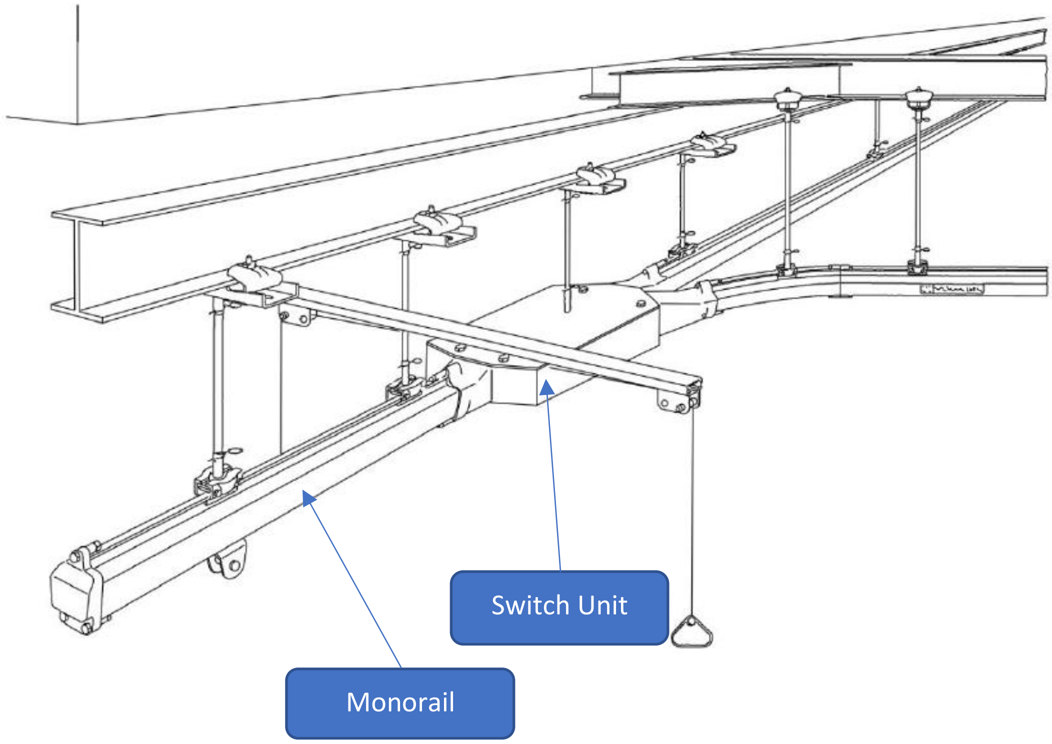
Floor Mounted Light Crane System

Defined as a free-standing system, the light crane is supported by bracings from an external structure. This may consist of steel section 'goalpost' supports as shown in the image below:

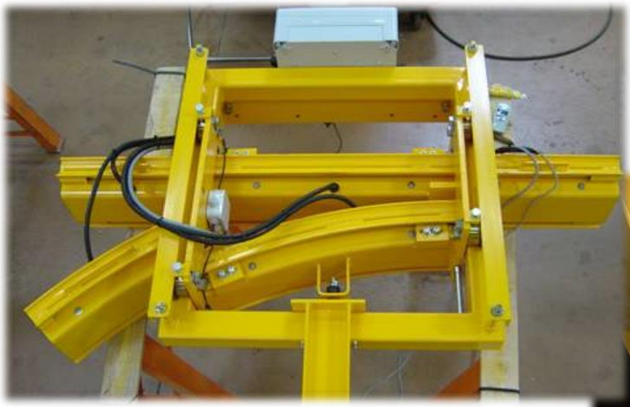


Monorail

The monorial is a continuous length of light crane section from which a trolley and hoist is susepended. The monorial may include turntables and switches to direct the trolley and hoist to different areas of operation.

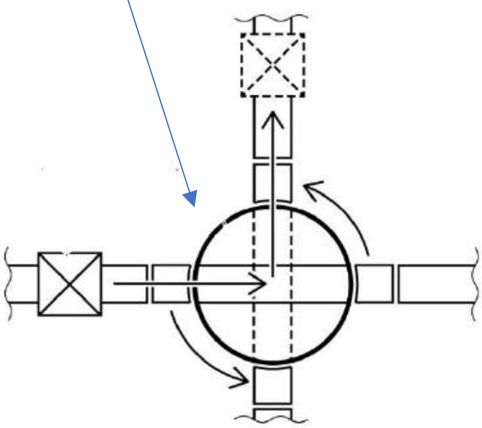


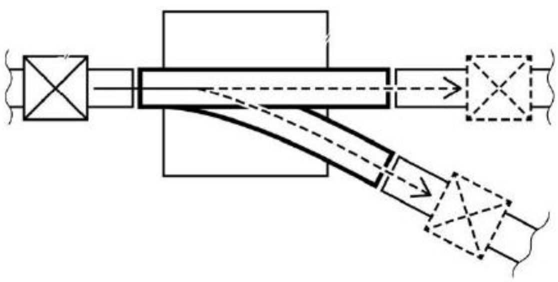
Switch



Turntable

Switch





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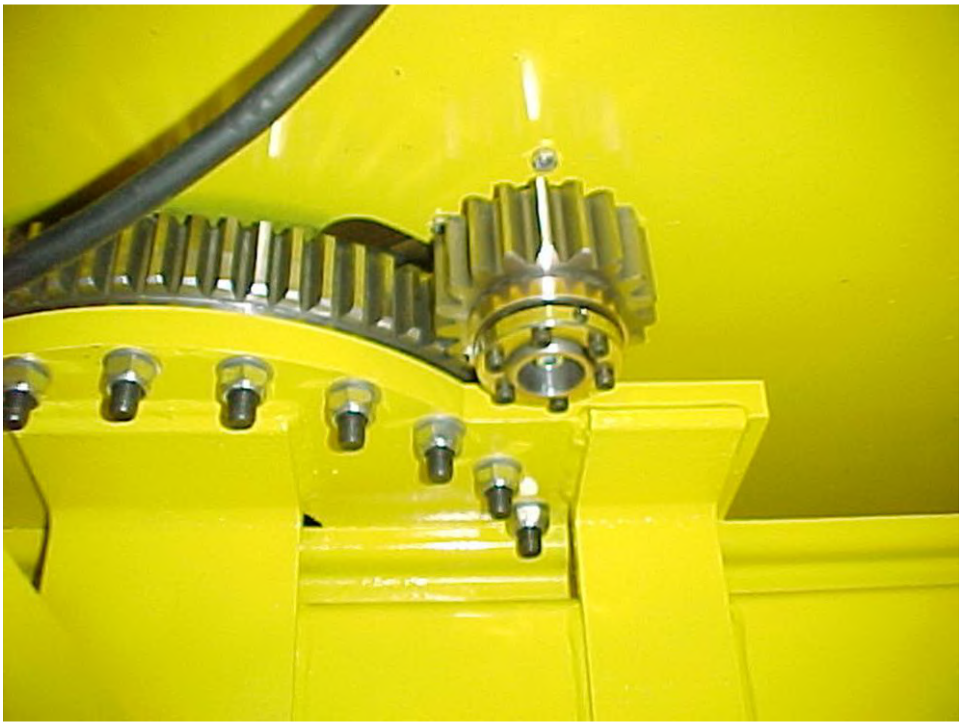
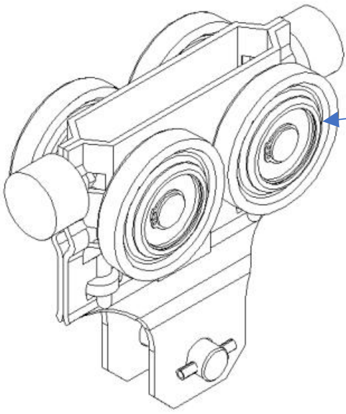


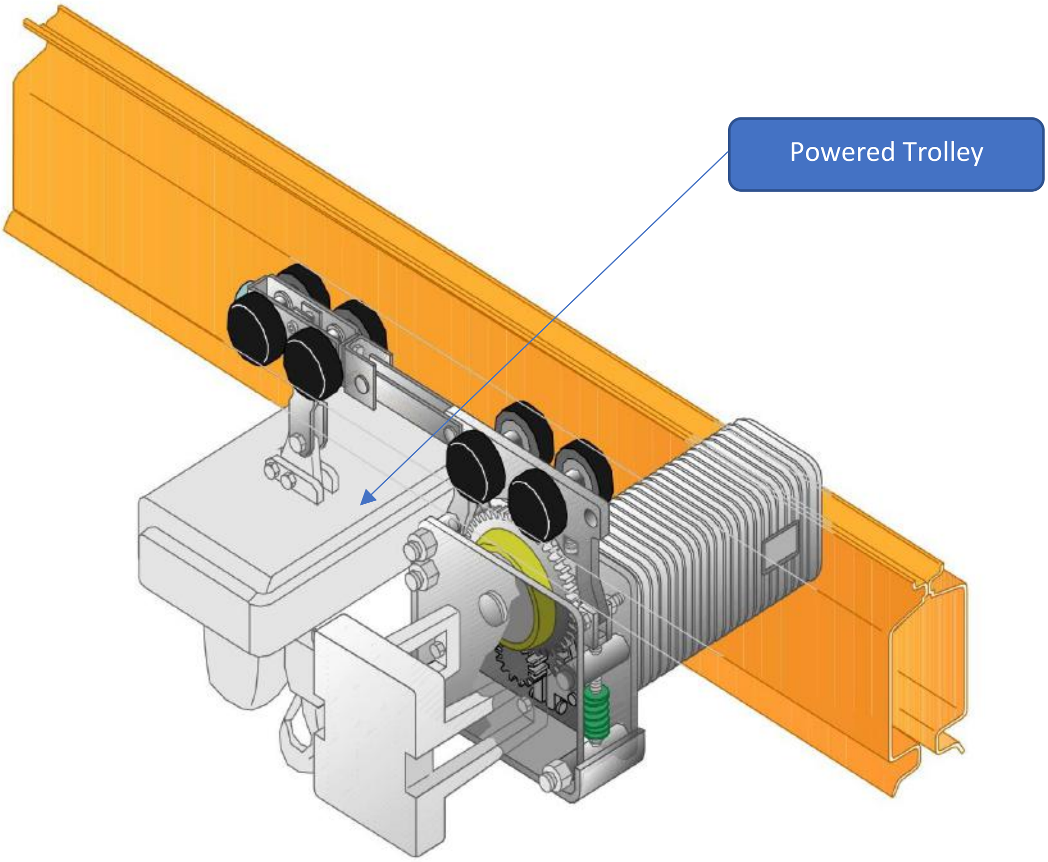
Turntable Gearing

Trolley

Defined as a wheel assembly running on a track or on a bridge and supporting a bridge or lifting device.



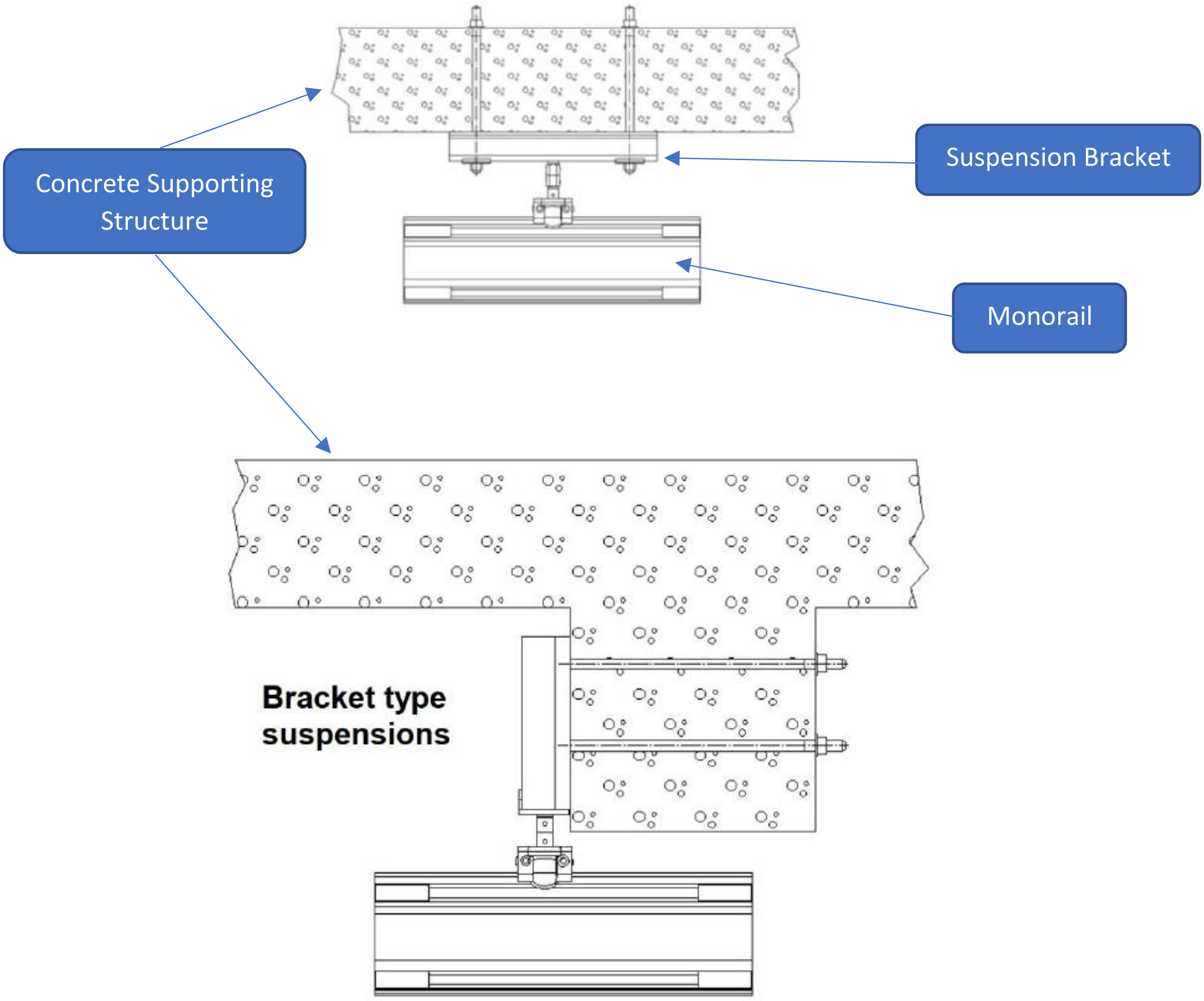
Manual Trolley



NOTES:

Suspensions

There are several types of suspensions that connect the light cranes structures to their supporting structures:



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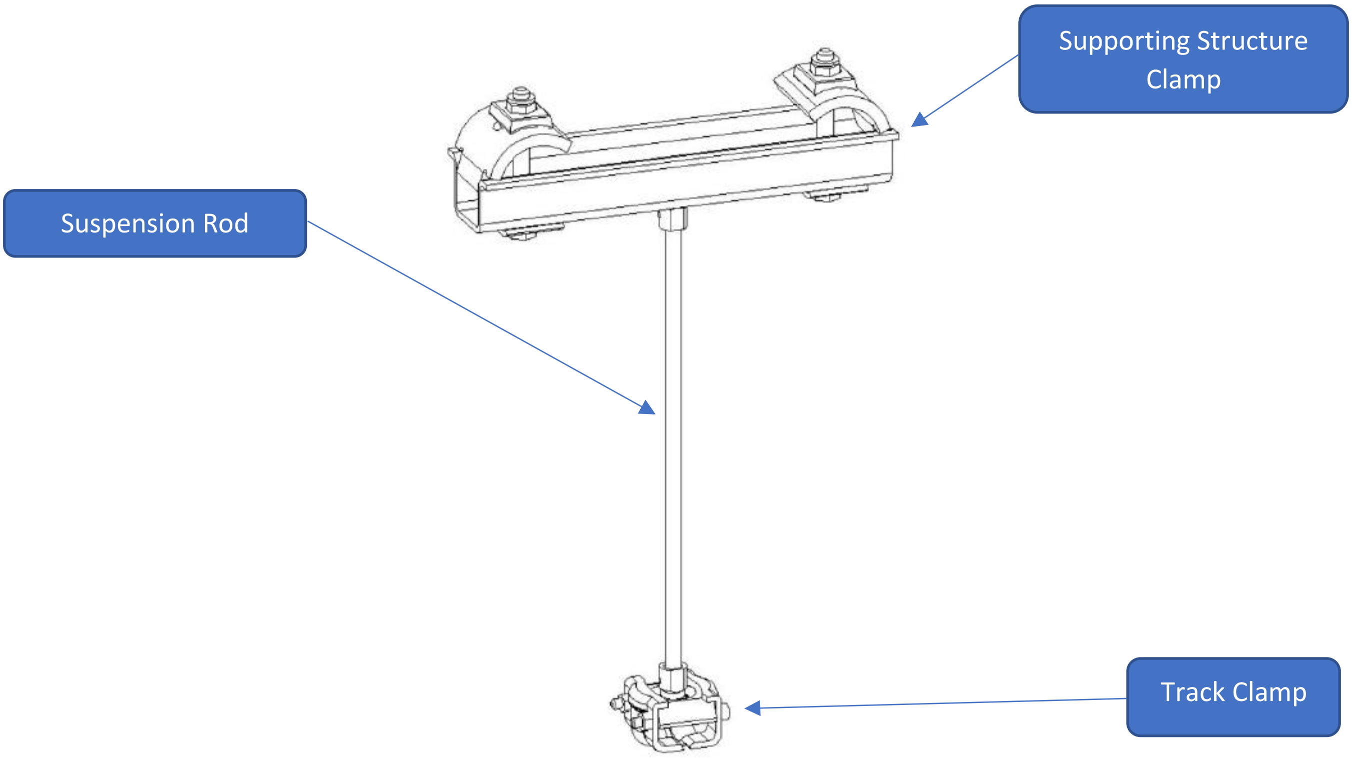
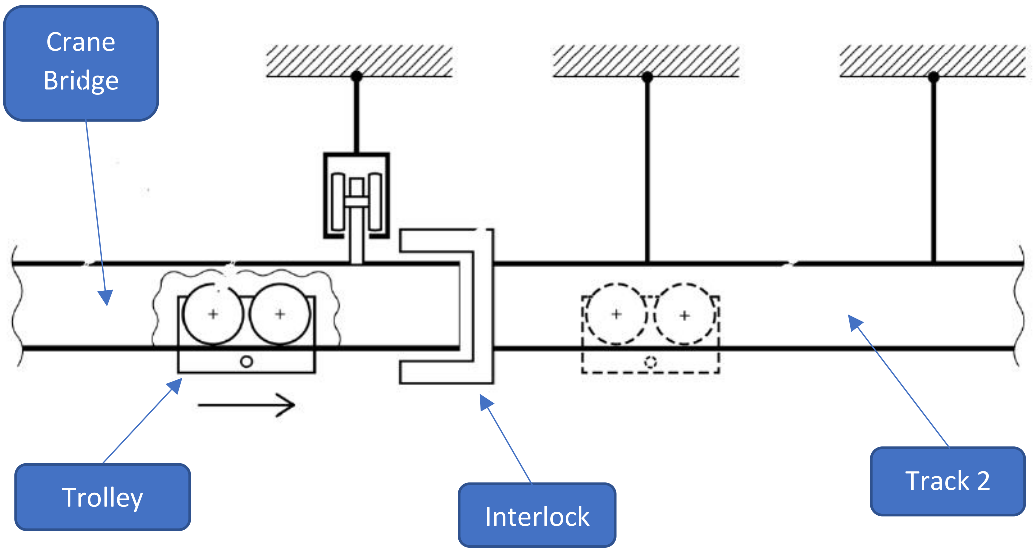


The illustration below shows how this type of suspension clamp and rod is used to support the light crane system track section from a supporting structure:

Interlock

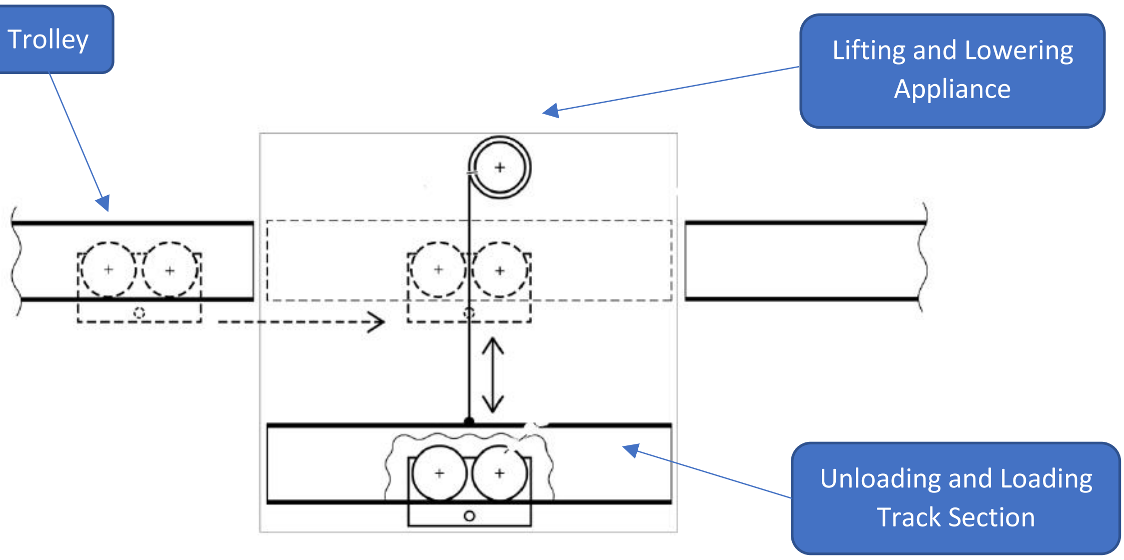
The interlock can be used to transfer a traveling trolley and hoist from one crane bridge or track system to another, without having to physical dismantle it and re-erect it.



Loading and Unloading Stations

These may be provided for maintenance or trolley/hoist exchange.

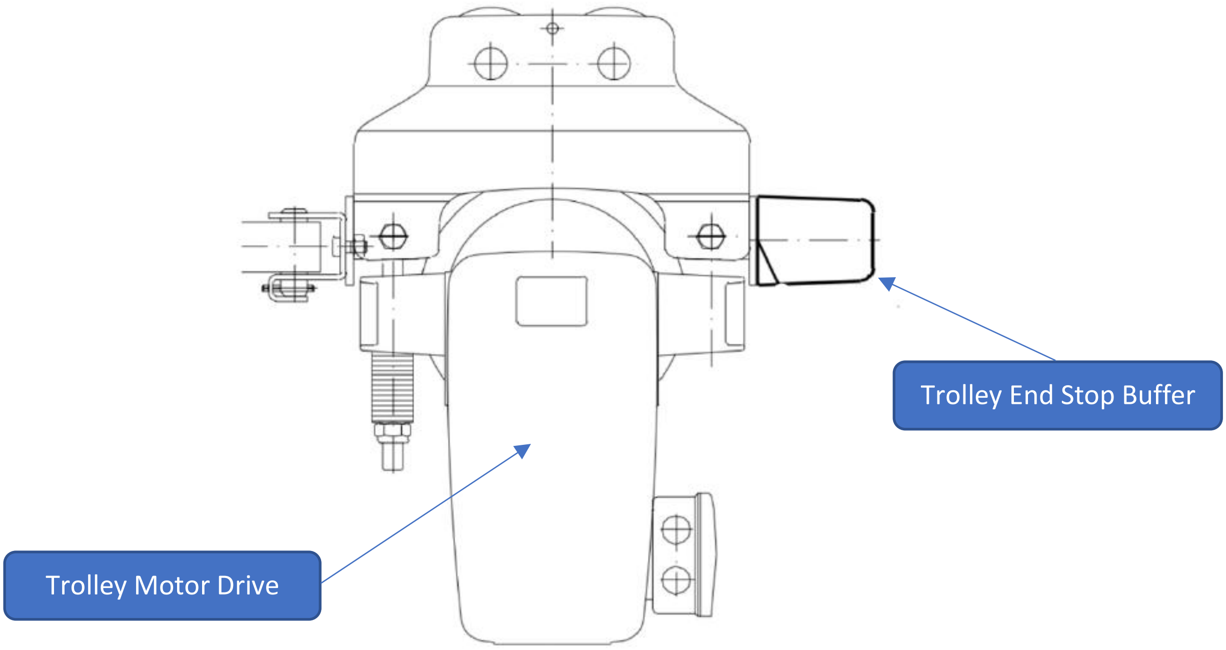
In this example, the trolley travels from its track into the loading and unloading track section and stops. The lifting and lowering appliance then lowers the unloading and loading track section with the trolley so that it can be removed from the system.



Testing of Light Crane Systems

Functional Testing: this will include the initial operation through all range of movements with no load and at full operating speed. It should be taken that hand powered (manual) trolleys in tracks and bridge cranes have a maximum travel speed equal to that of walking pace. In addition to the operational test, the following sequence should be followed:

- Motion limiters (e.g. slow down limits) and end stop buffers should be placed in contact with track end caps slowly to ensure they are fit for purpose with no defects
    - Thereafter this test is to be carried out at full speed
    - If no motion limiters are fitted, end stops should be tested at full speed



When carrying out these tests, the competent person should ensure that the crane operates smoothly and that brakes and motion limiter indicators in power driven systems work correctly and are accurate. All functions of the crane should be tested.

If the crane system is fitted with a second limiter (back-up) this should be tested at low and high operating speeds. When doing so, the initial limiter should be bypassed, ensuring that the second limiter brings the crane to a safe stop.

Static Test: carried out at 125% of the crane's WLL positioned 100 mm to 200 mm above the ground.

The static test is to be carried out at critical positions on the crane:

- Mid span of a bridge
- Extreme travel positions such as cantilever sections

If a crane has more than one hoist, each hoist should be tested separately before carrying out the combined test as a crane, unless they have been previously tested by the manufacturer. As with bridge and portal crane testing that we looked at earlier in this course, the test should include the most unfavourable loading combinations of all the lifting devices.

- The test load should be applied for a minimum of 10 minutes to ensure the crane is fit for purpose

- Measurements taken must verify that the deflections are within the specified limits provided by the manufacturer
- The test should conclude that no cracks, deformation or damage has taken place and that no fixtures or fittings have become loose
- Manual lifting appliances should be tested separately

Dynamic Test: carried out at 100% of WLL.

- The test should include all motions of the crane in all directions including starting and stopping
  - As with bridge and gantry cranes, combined movements should be included in this test
- Check for:
  - Smooth operation of the crane
  - Effective operation of the braking systems
  - Effectiveness and accuracy of limiting and indicating devices

The thorough examination following the dynamic test should conclude that all components have functioned correctly and that no cracks, deformation, loosening of fasteners or connections is evident. In addition:

- No damage to the drive or supporting structure
- No connection has loosened or been damaged

The performance of the rated capacity limiter must also be tested in accordance with the relevant product standard prior to installation of the lifting equipment onto the crane.

NOTES:

Thorough Examination

The defined scope of examination for light crane systems should include the following critical components:

- Track sections
- Suspension hangers, rods and clamps including safety pins
    - Ball and socket joints found in track clamps
- Complex track components (switches, turntables, loading and unloading stations)
- Track end caps

End Cap with Power Supply Cable Feed

- Crane crabs and trolleys
- Electric drives
- Isolator, power supplies and control systems
- Hoist unit
- Supporting structures

NOTES:

3m. Crane Supporting Structures

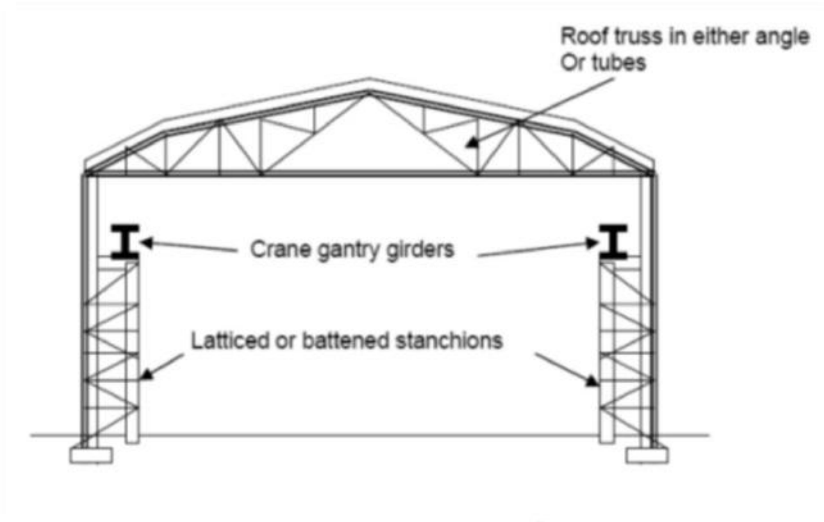
IMPORTANT: Supporting structures, previously referred to as crane gantries, are the parts of the structure that are only used for support of the crane and should be included in all thorough examinations of the crane installation.

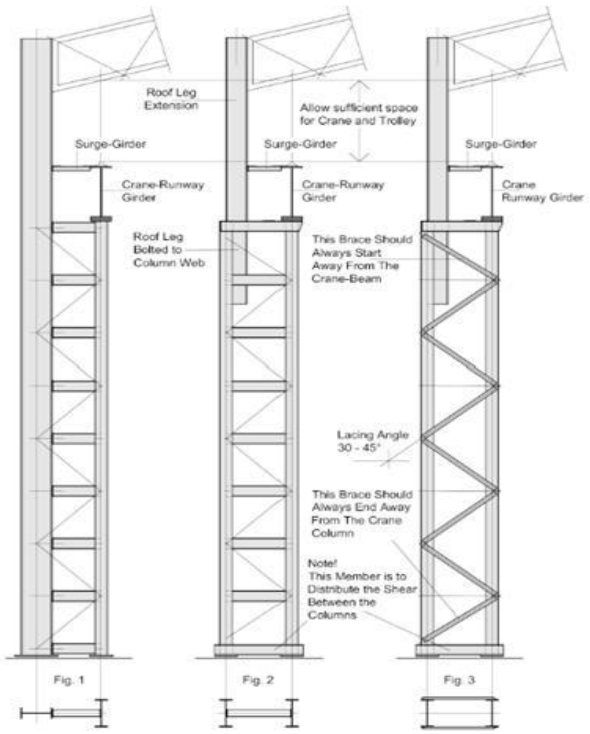
Any parts of supporting structures that are not only used for support of the crane are not included in the defined scope of thorough examination.

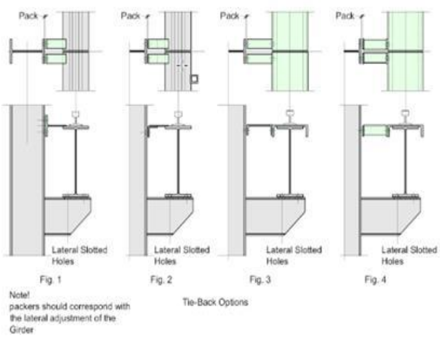
Types of Crane Supporting Structures

Generally, crane supporting structures will be defined as top running or under-slung. Top running supporting structures are supported in many ways.

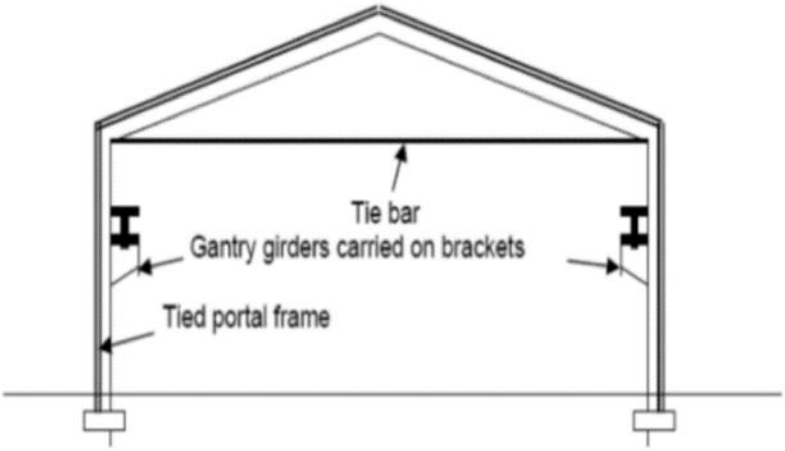
The latticed stanchion shown below tends to provide a lighter and more rigid structure since the transverse loading at the track level are all virtually transmitted through a very stiff column to the foundations:

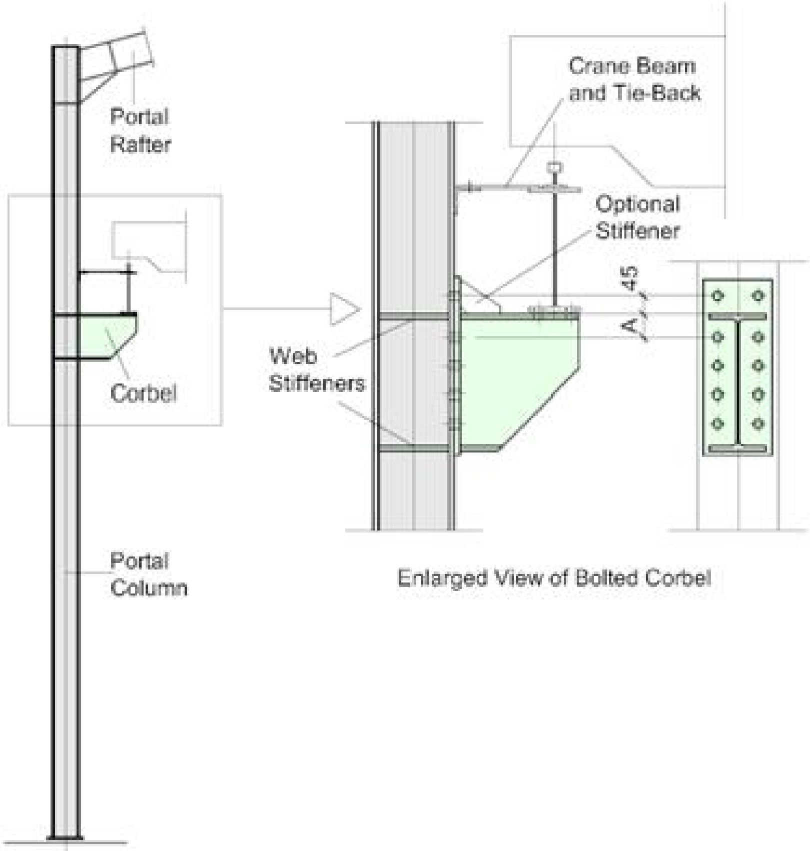




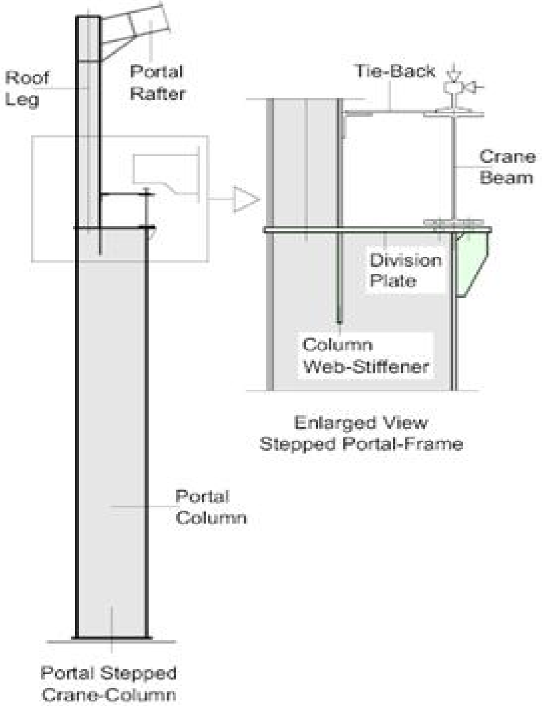


The supporting structure shown below, although cheaper to produce, could have problems of fatigue with the cantilever brackets if the crane is in constant use:

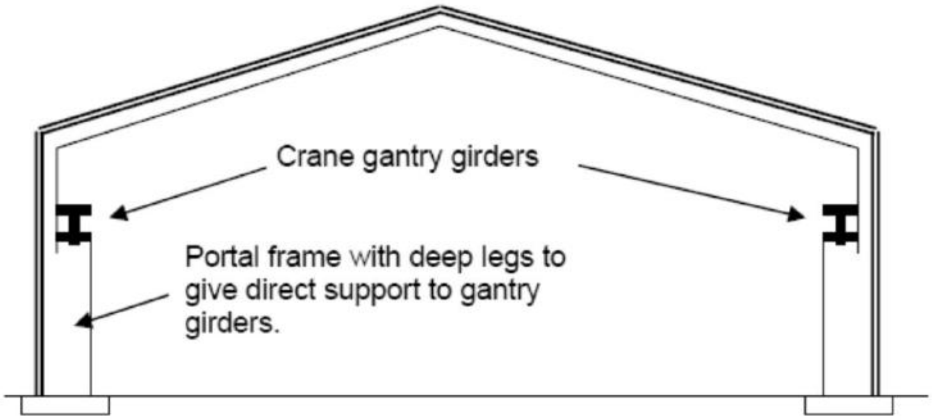




Typical Portal Frame Column



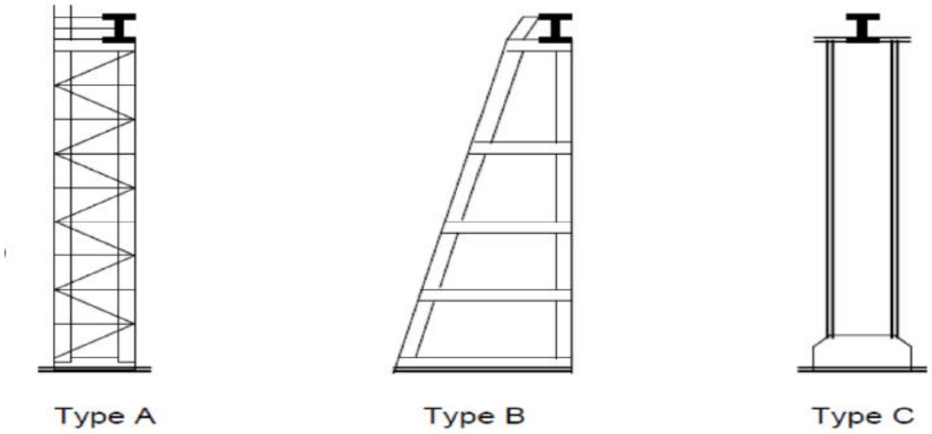
This supporting structure provides direct support for gantry girders, additional stiffness and no tie bars required:



Columns used for Crane Supporting Structures

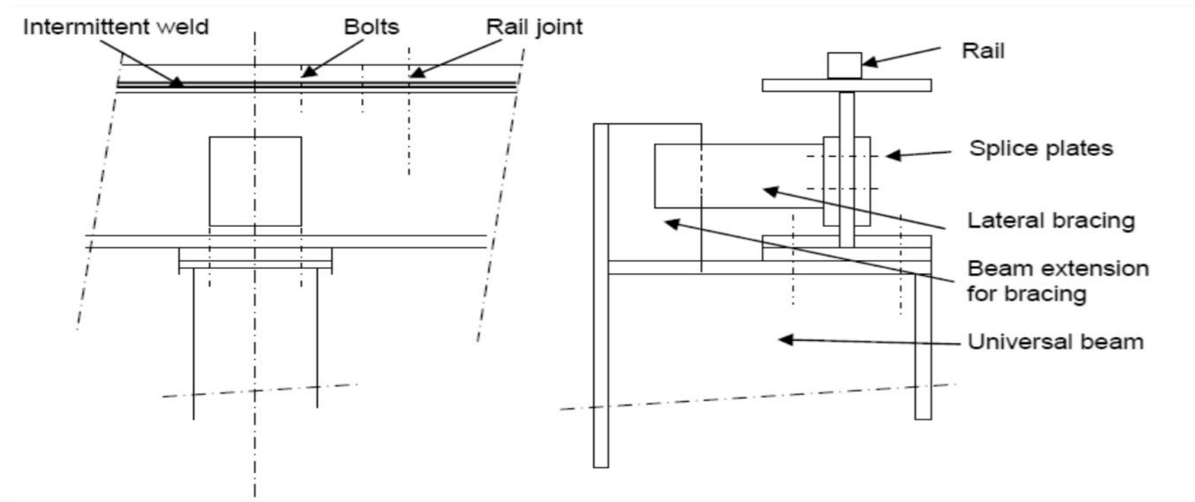
If a building has not been designed to support a crane gantry, then the gantry and stanchion may be totally free standing so that no load is transmitted to the building structure.

The illustration below shows three methods of making supporting structure 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.



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 – see illustration below.

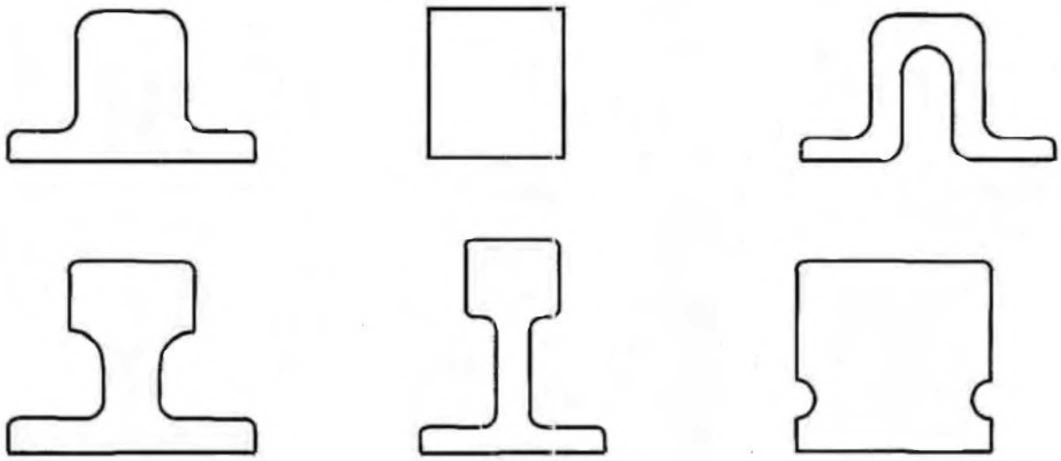
Note that the beam section used for the column is extended past the capping plate to support lateral bracing.

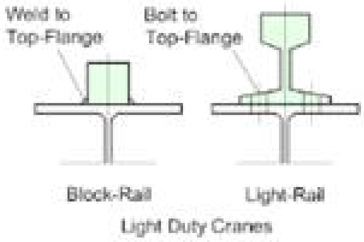


Rail Sections

Purpose-made crane rails and railway rails are normally made from special rail steels, with minimum tensile strengths of between 500 N/mm² and 1200 N/mm².

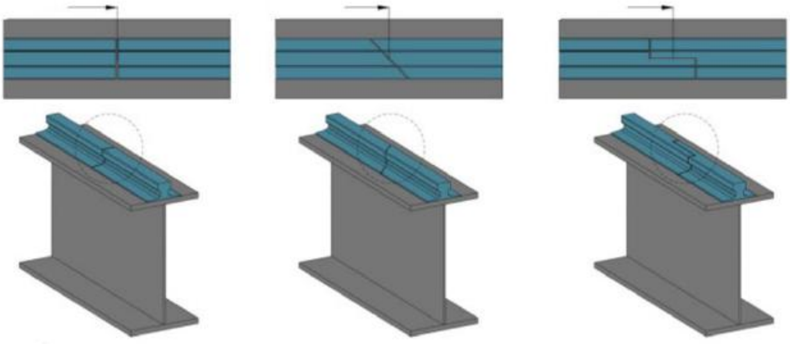
Rectangular and square bars may also be used for crane rails.





Special rail sections are fastened to the gantry beam using a variety of methods. The illustrations below show examples of special rail clips that are used for this purpose:

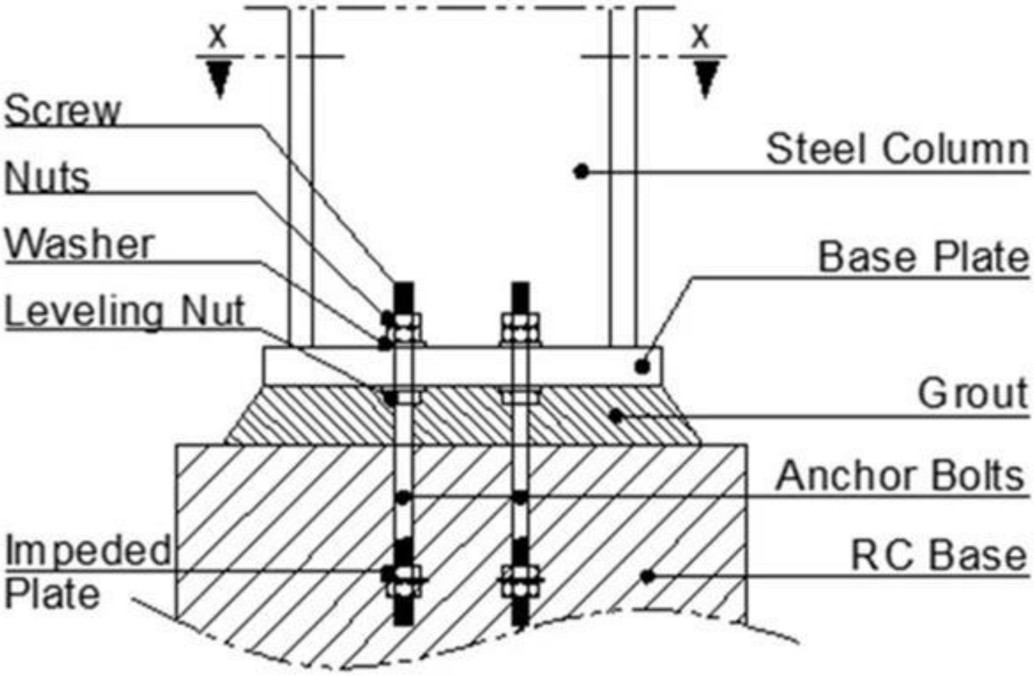
Example of rail joints:



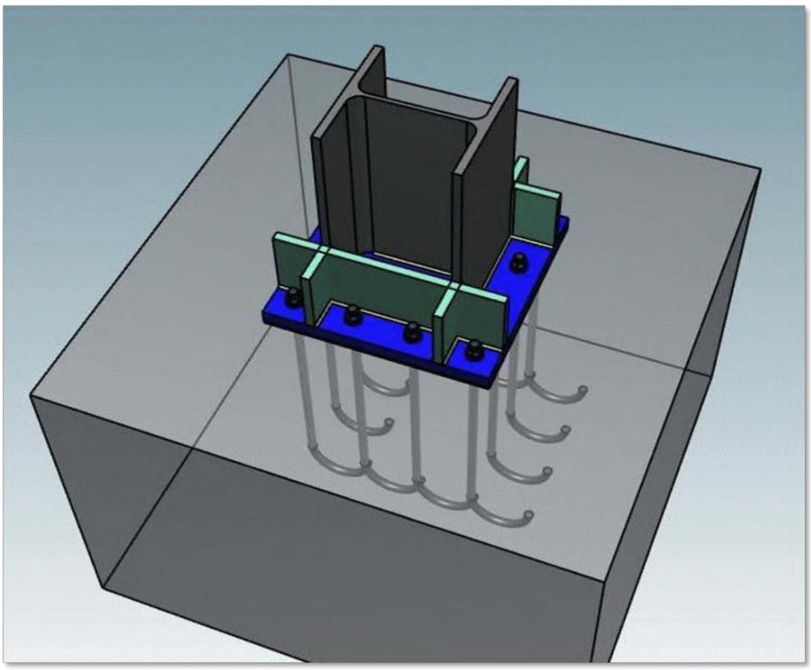
NOTES:

Supporting Structure 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.



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:

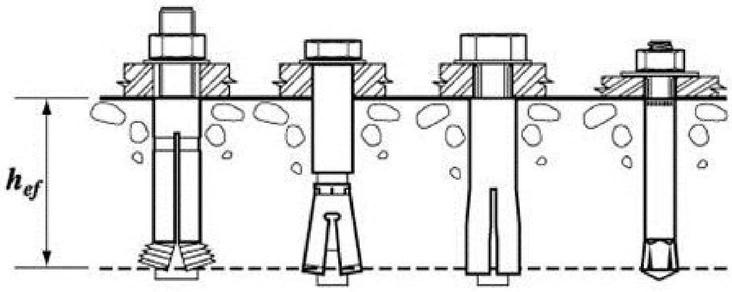


The crane and supporting structure will be tested whilst the foundation bolts are exposed so that they may be checked after testing.

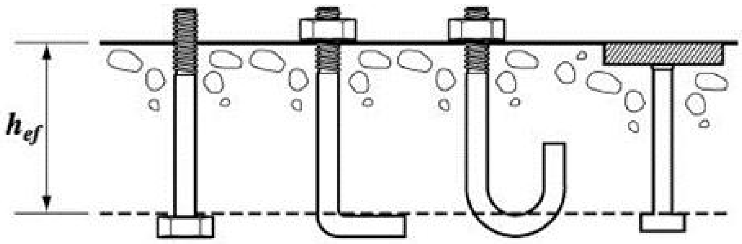
Some foundations anchors are provided by the civil engineers set into cones, allowing an amount of movement at the top of the anchors in order that they align with the column fixing holes.

Once the column in place, a non-shrink grout is poured into the foundation to set the anchors in place:

Types of Anchorage Bolts

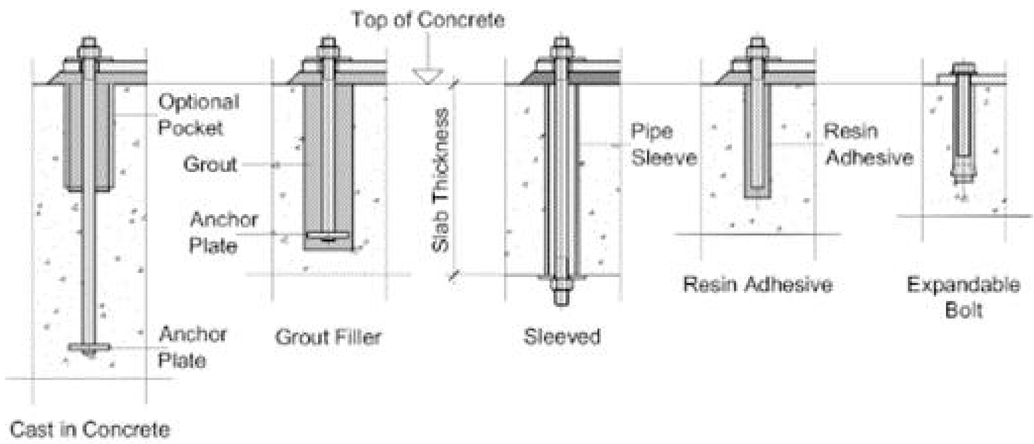


Post-Install Anchors



Cast 'in-place' Anchors

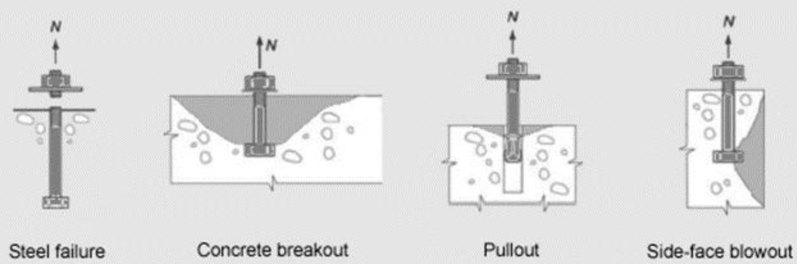
There are various forms of anchor bolts:



Thorough Examination

The defined scope of examination for supporting structures should include the following critical components:

- Supporting column ground plates, anchor bolts and grouting
- Supporting columns and braces
- Bracing to building columns/structures
- Gantry beams and splice plates
- Crane rails, clamps and welds
- Joints
- End stops
- Access ladders and platforms



Typical Anchor Bolt Faults/Failures

NOTES:

Supporting Structures Alignment

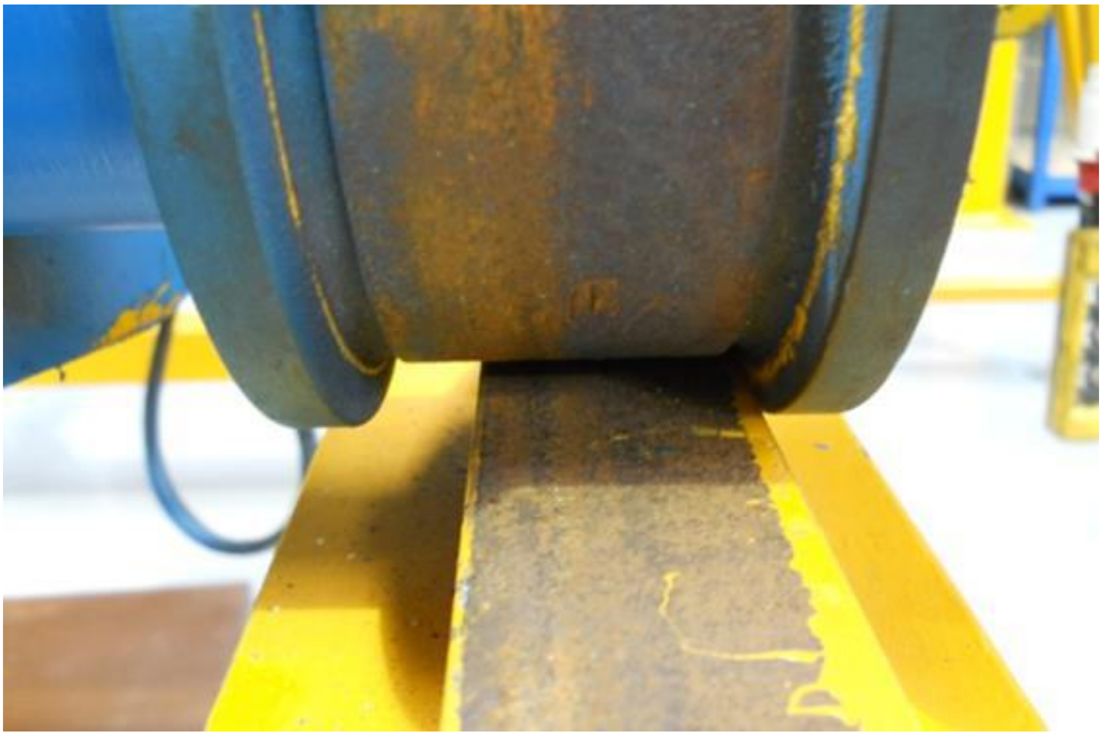
When considering alignment of the crane supporting structure, the competent person should refer to the manufacturer's specifications for crane running tolerances.

For in-service 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:

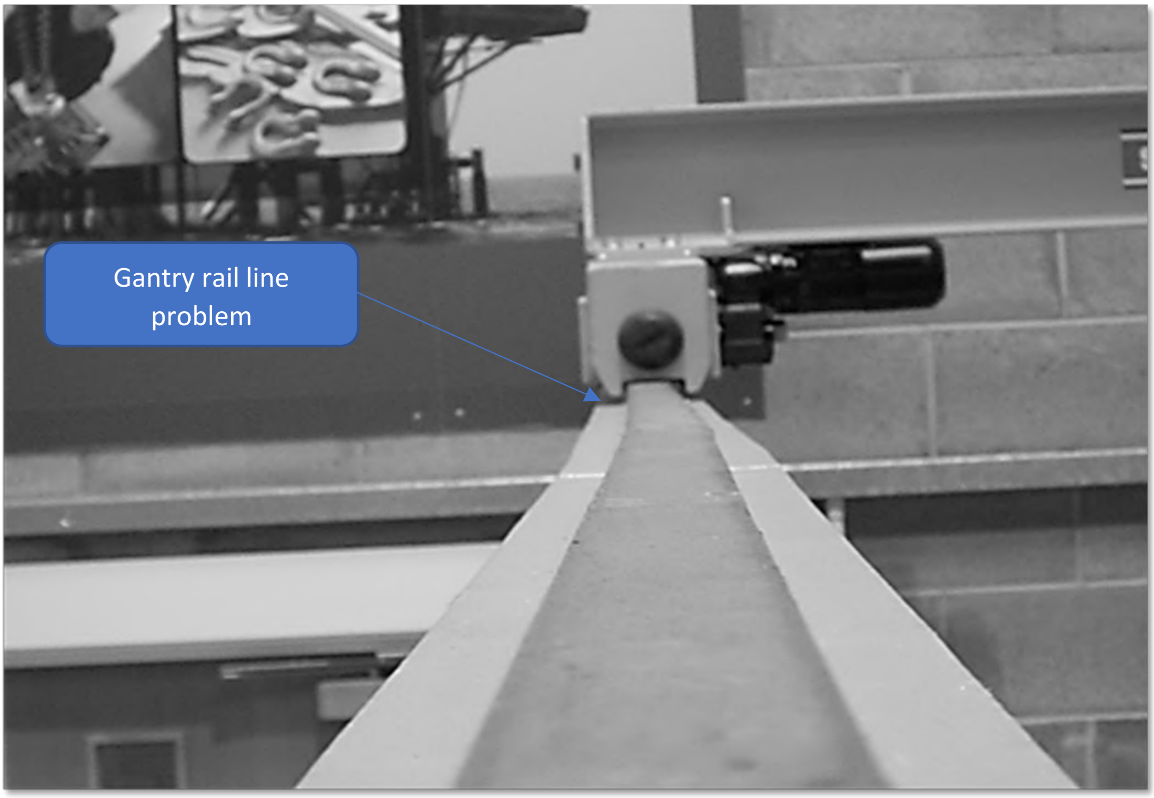
- **Level** differences between the gantry rail heights
- **Span** differences between the gantry rails
- **Line** deviation of individual gantry rails
- **Inclination** of tracks in the vertical position

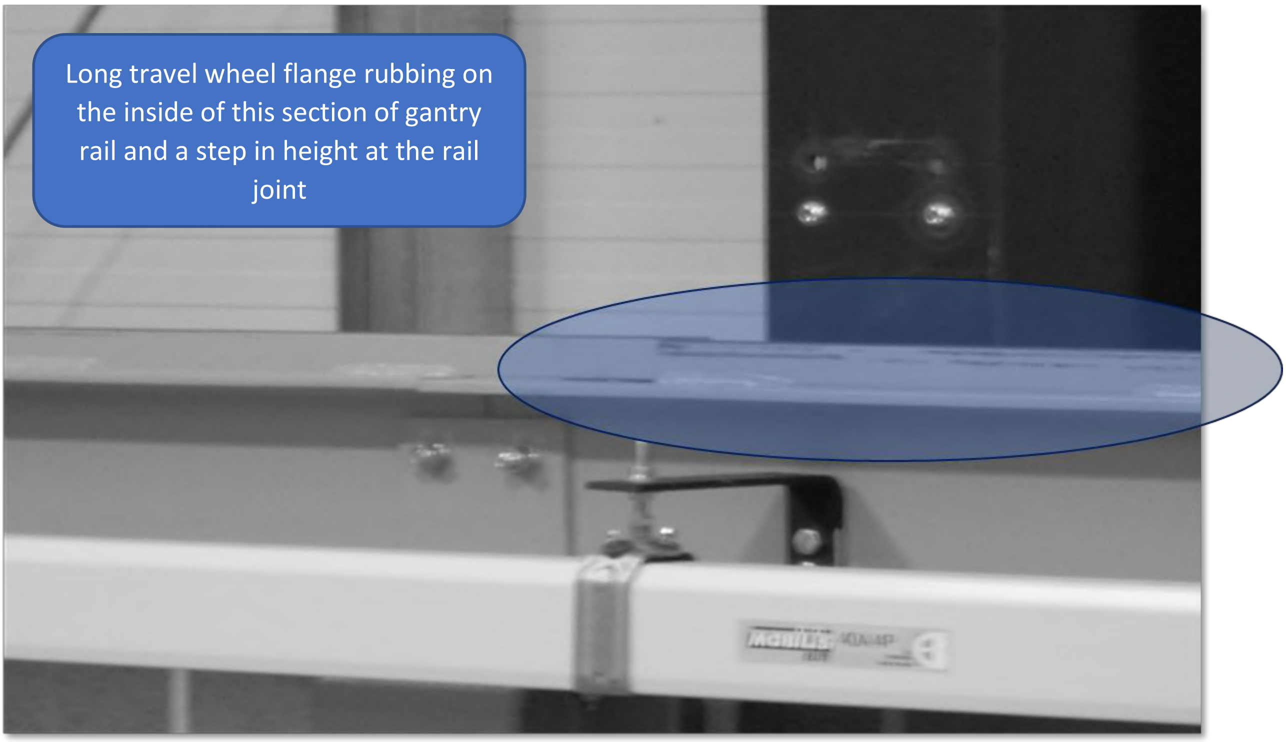
During the thorough examination of the supporting structure, the competent person should look for obvious supporting structure issues. Look for symptoms indicated primarily by uneven wear on the long travel wheels:



NOTES:


Here we see a piece of steel angle laid across the top of the joined rails showing an obvious difference in rail height

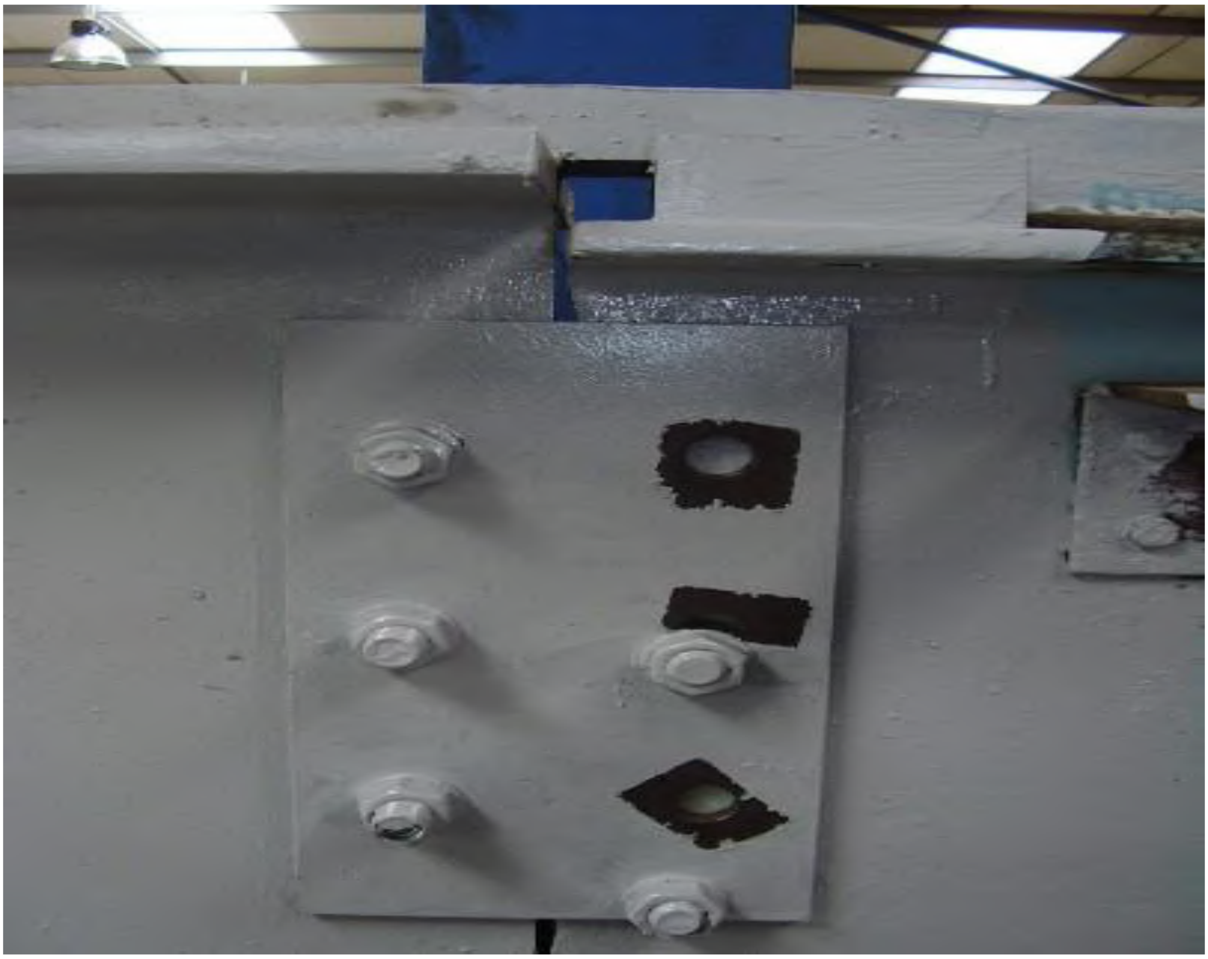

Gantry rail line problem



Bolted connections should be checked for damage and loose or missing bolts:

Bolted connections to building structures:

Misaligned and missing splice place bolts:



Gaps in between gantry beams:

Incorrect manufacture/alignment of gantry rail extensions:

3n. Power Conductor 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.

NOTES:

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 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.

Several 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 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

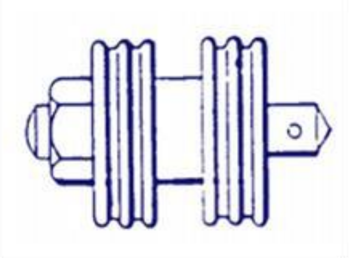
Note: that the owner of the equipment has a duty of care to ensure that a safe system of work is always provided. This must be taken into account when making assessment as to whether or not any existing bare copper conductors are safe to continue in service

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.

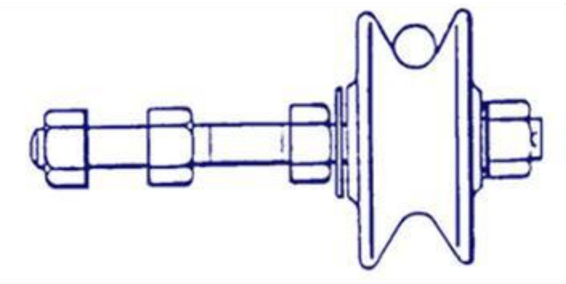
The most usual form of collector is the bronze roller, graphite bushed, thus providing good electrical contact and bearing surfaces. Each collection shaft is insulated from the collector bracket.

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

NOTES:



Insulating Conductor Bracket



Wheel Type Collector

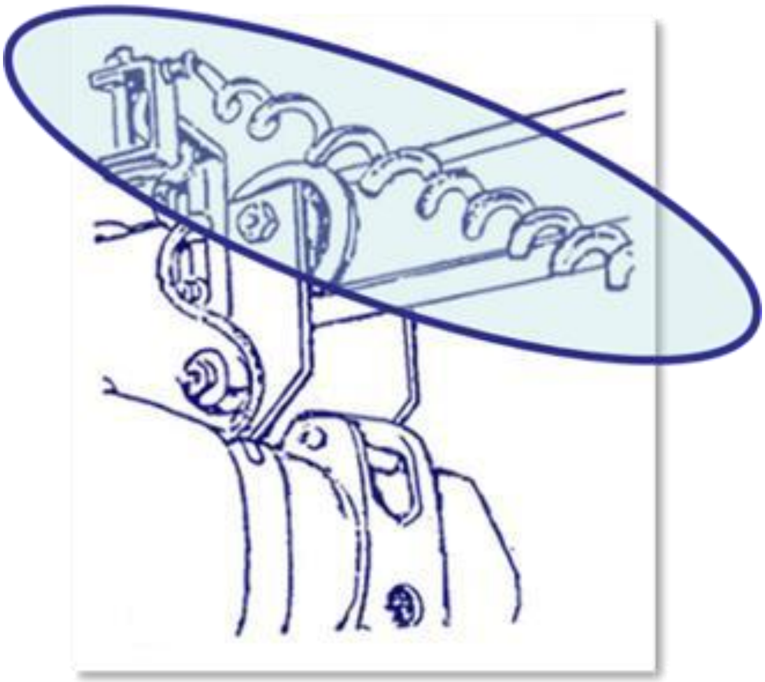
As bare copper wires are not recommended, they have been superseded by safer and more efficient systems.

NOTES:

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, 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 quite 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 Ring Assembly

Slip Ring Brushes

Since a reeling drum spiral wound spring does not provide a constant torque, spring selection is especially 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, subject to confirmation from the manufacturers of both drum and cable

- Temperature Correction - Generally for ambient temperatures above 30°C the continuous rated current capacities should be eliminated

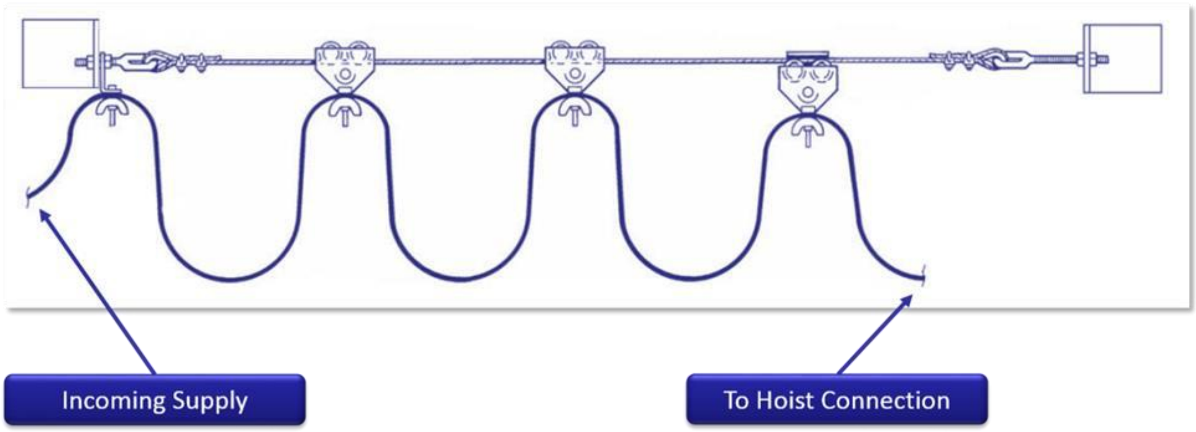
- Reeling Configurations - Rated cable capacities should be further de-rated according to the configuration of the reel to be chosen

- 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

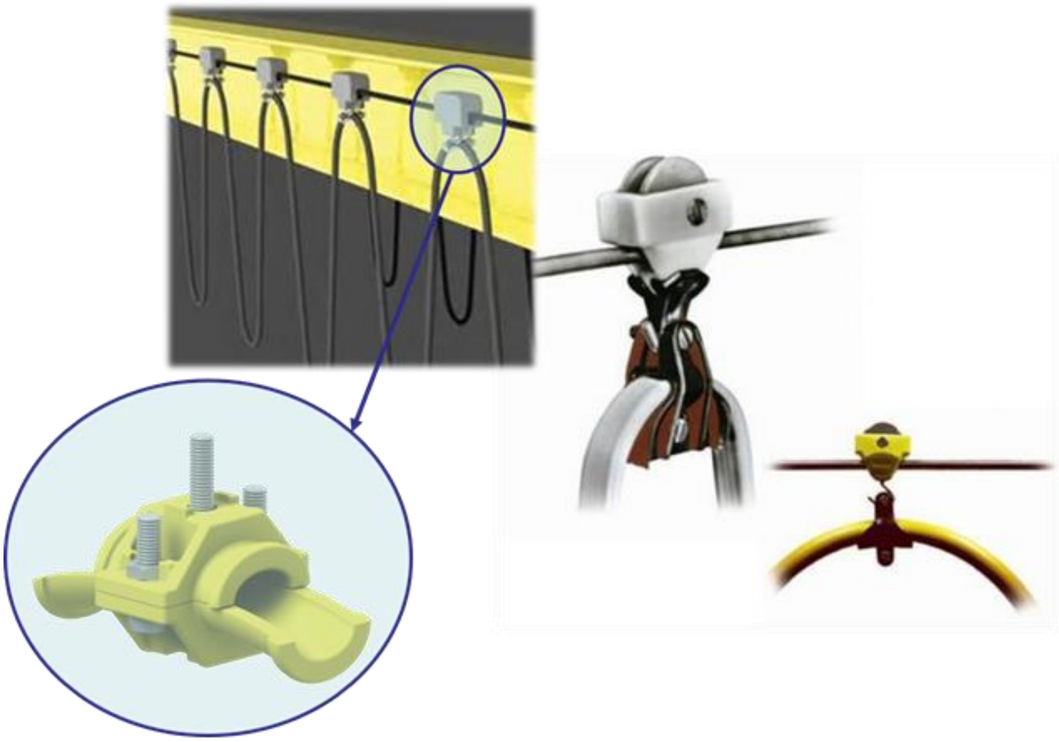
Note: Although not expected to design electrical power supply systems the tester and examiner would be expected to understand the fundamental requirements of a system to enable him for example to identify the reason for a performance deficiency of a hoist under test.

Taut Wire

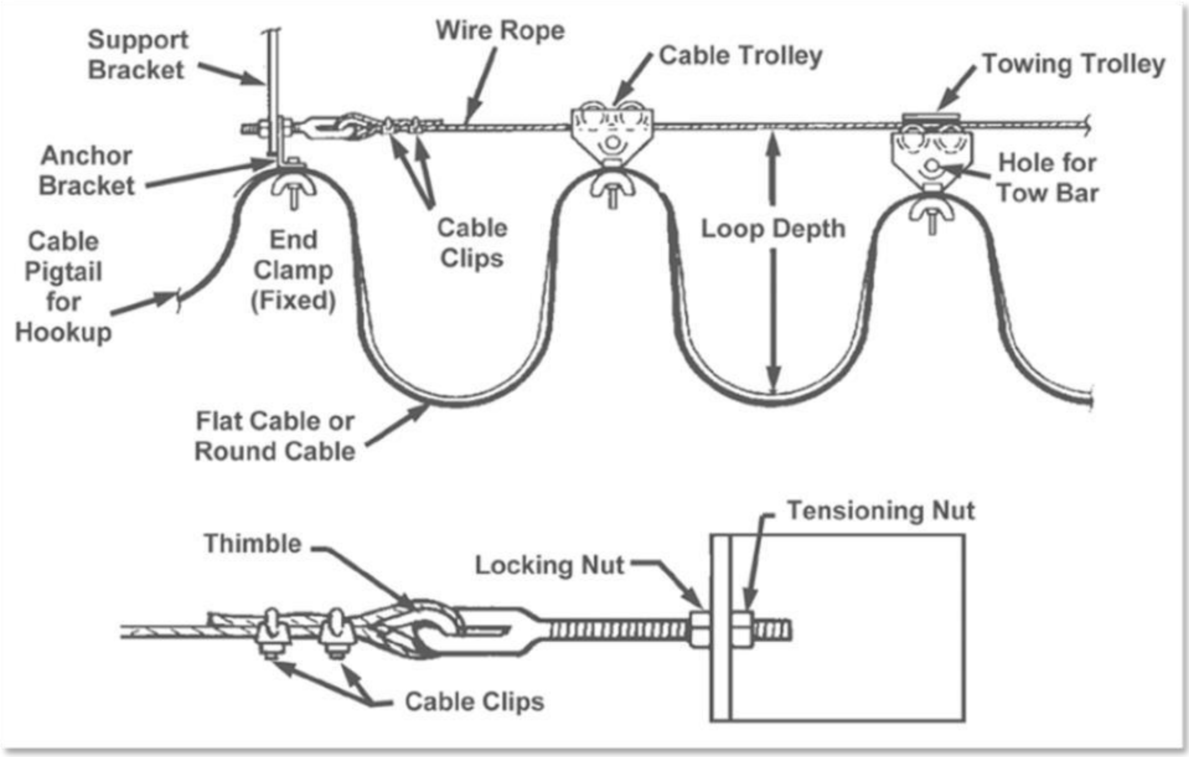
The taut wire system is suitable for light duties over lengths not exceeding 30 metres and is simple and economical to install. The strainer wire is made taut by means of straining screws whilst the cable is carried on trolleys.



Festoon Trolleys



A 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.

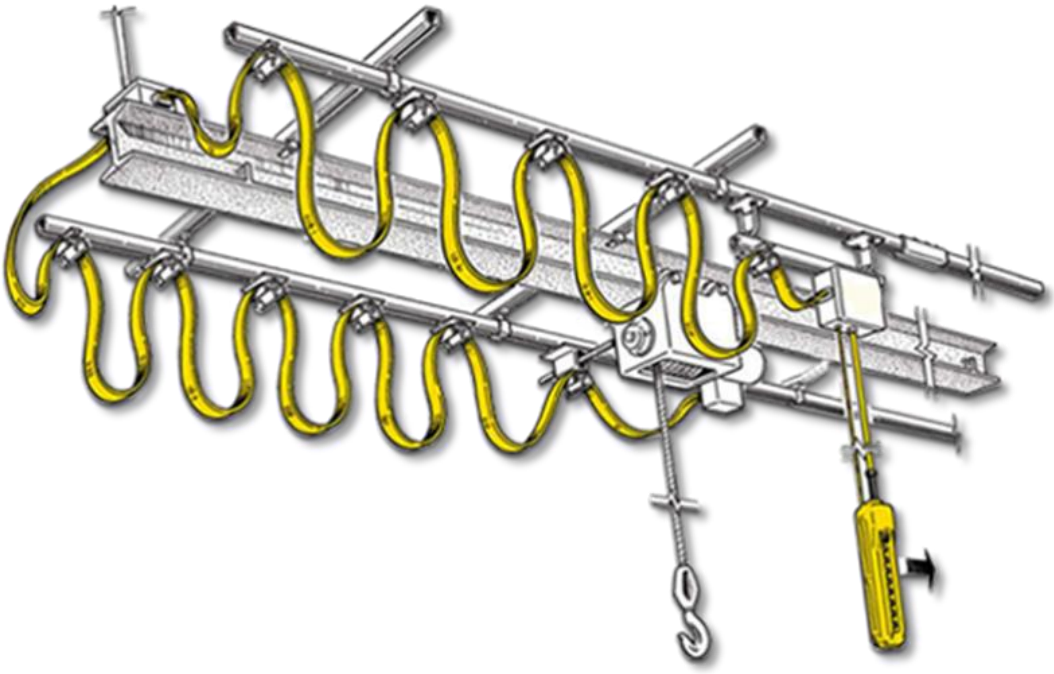
The tracked festoon systems are very safe with perfect insulation hence no loss of energy or voltage drop where current has to pass from conductor to collector. Also on long track installations the size of cables would need to be increased to limit voltage drop hence requiring a heavier track system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

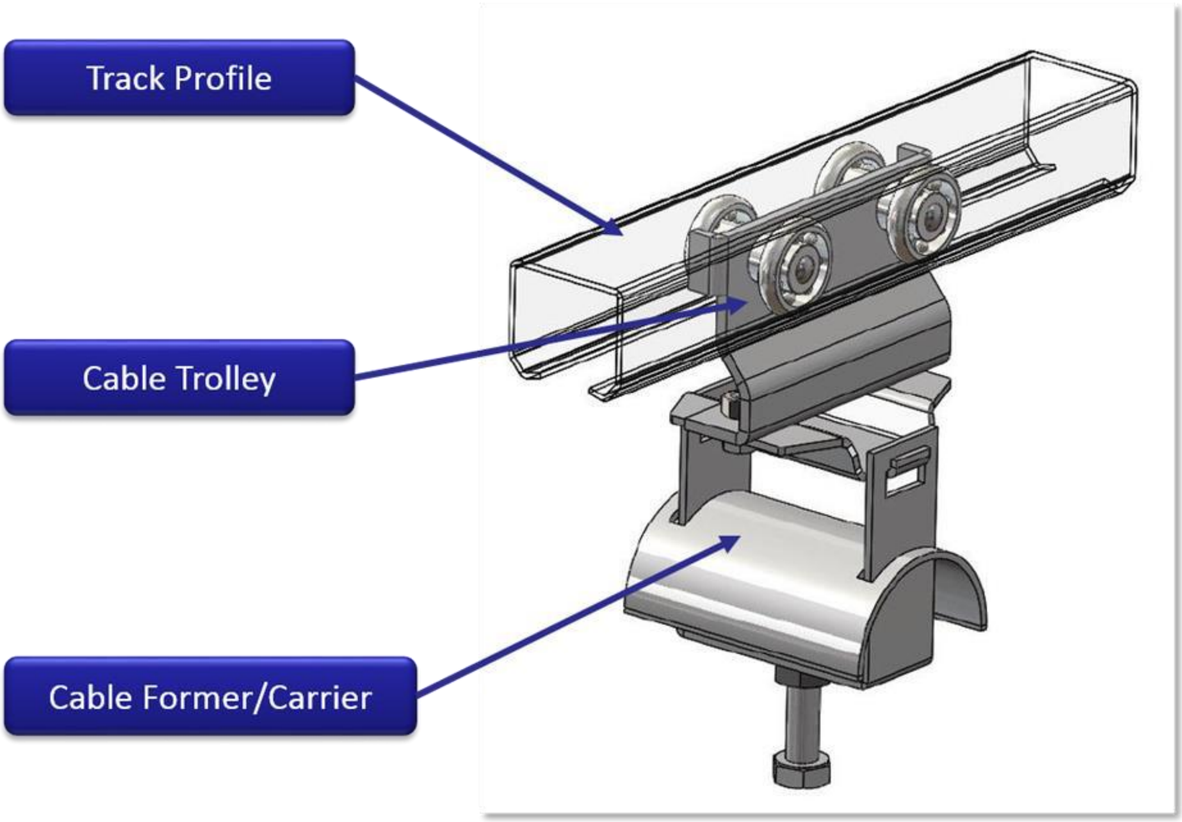
The image below provides an example of an underslung single-girder crane which incorporates a taut wire conductor system supplying power to the hoist across the span of the crane bridge, and for the power supply along the supporting gantry beams we can see that a tracked cable system has been used to incorporate the longer length, hence weight of the cables it is supporting.

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.

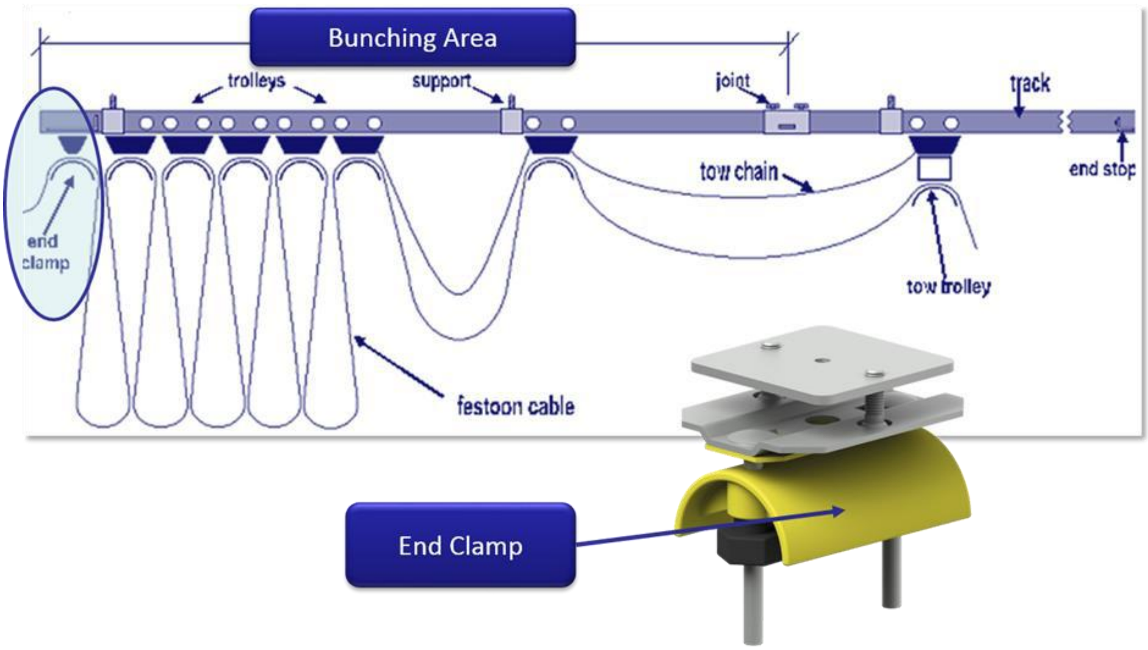
NOTES:



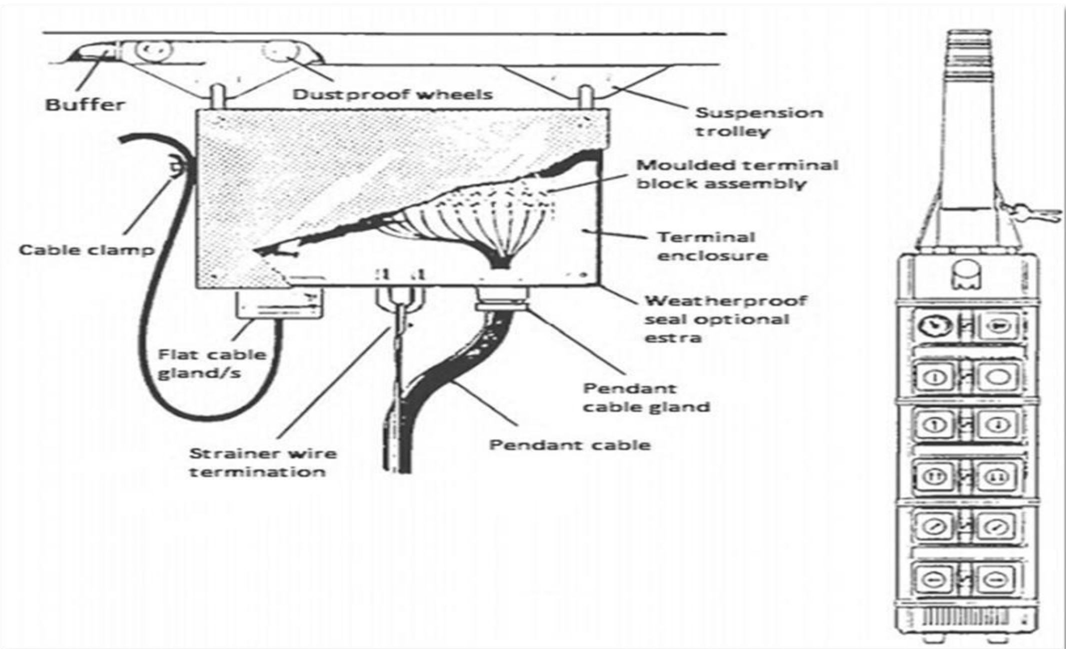
Typical components of a tracked festoon system:



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:

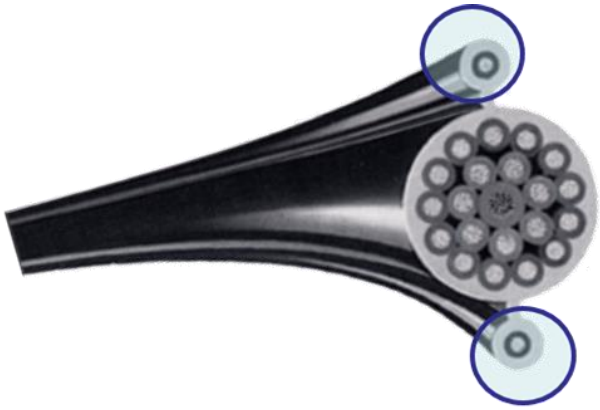


Hoist Control

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

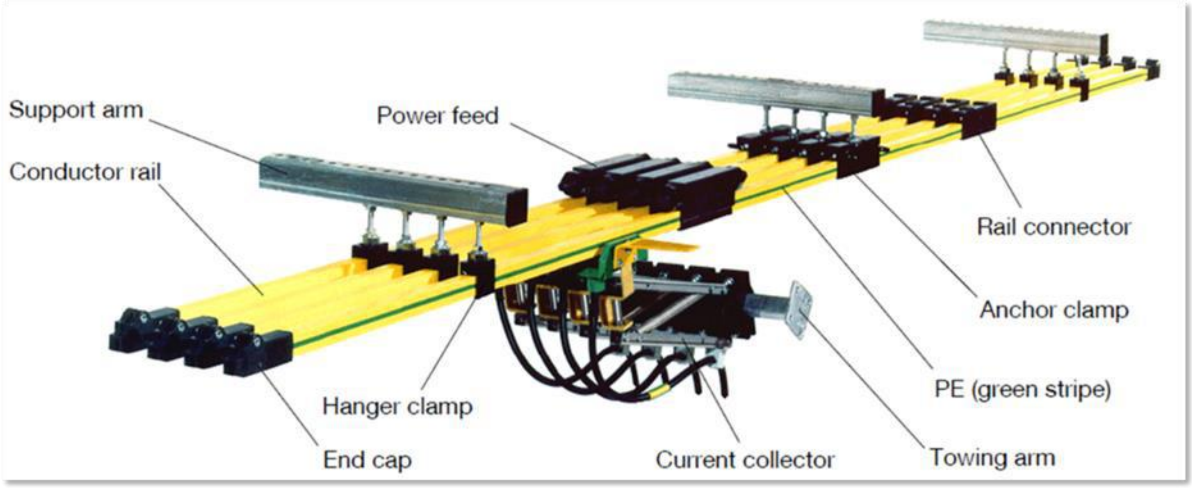
Pendant cables may have as many as 25 separate cores depending on the number of push buttons/motions required. The modern pendant cable has two independent strainer wires built in to support itself and the weight of the push button box.



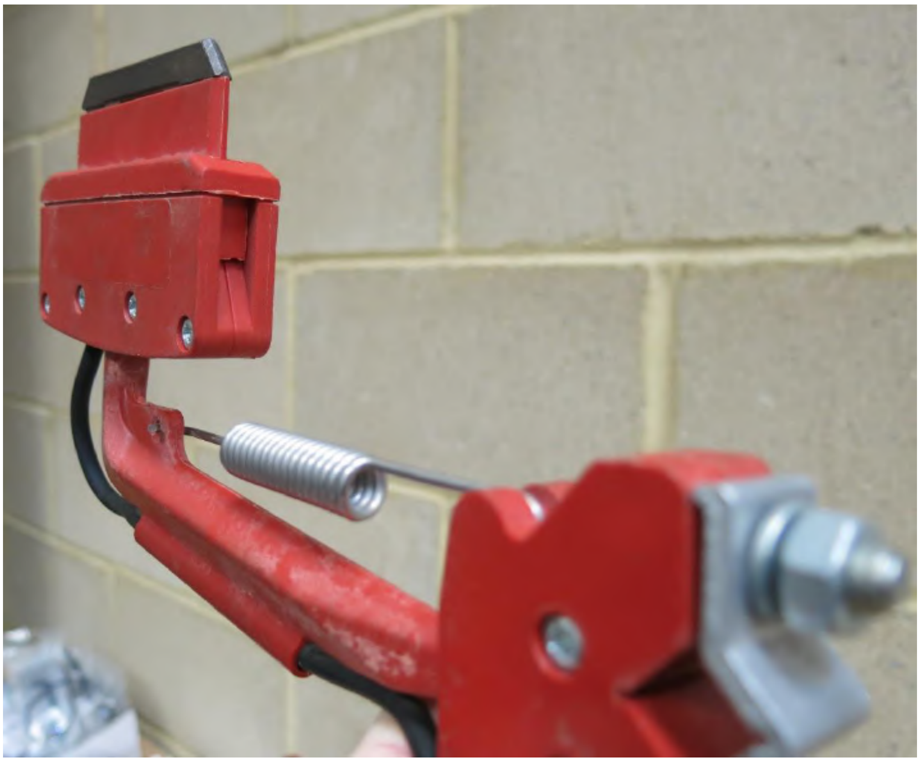
Insulated Conductors

Shrouded conductor systems 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:

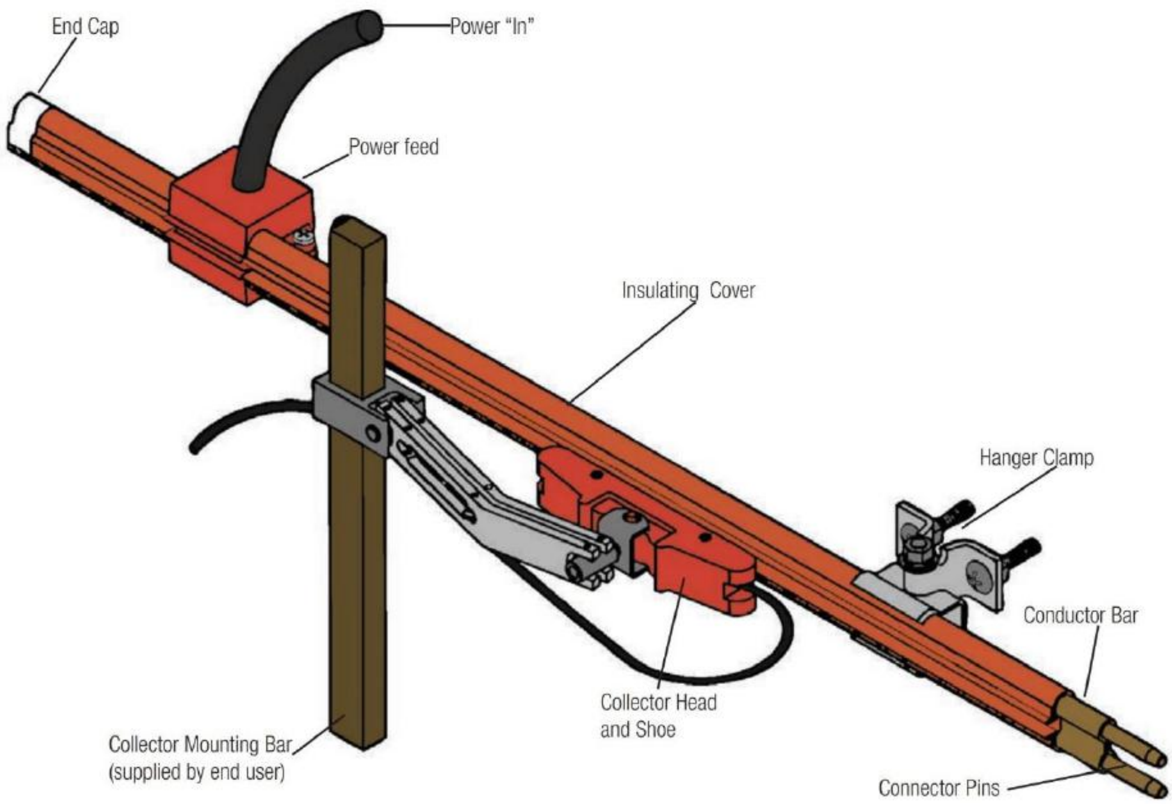


The collector assembly is spring loaded to ensure good contact with the conductor bar and articulated to enable the contact shoe to follow the track without binding.



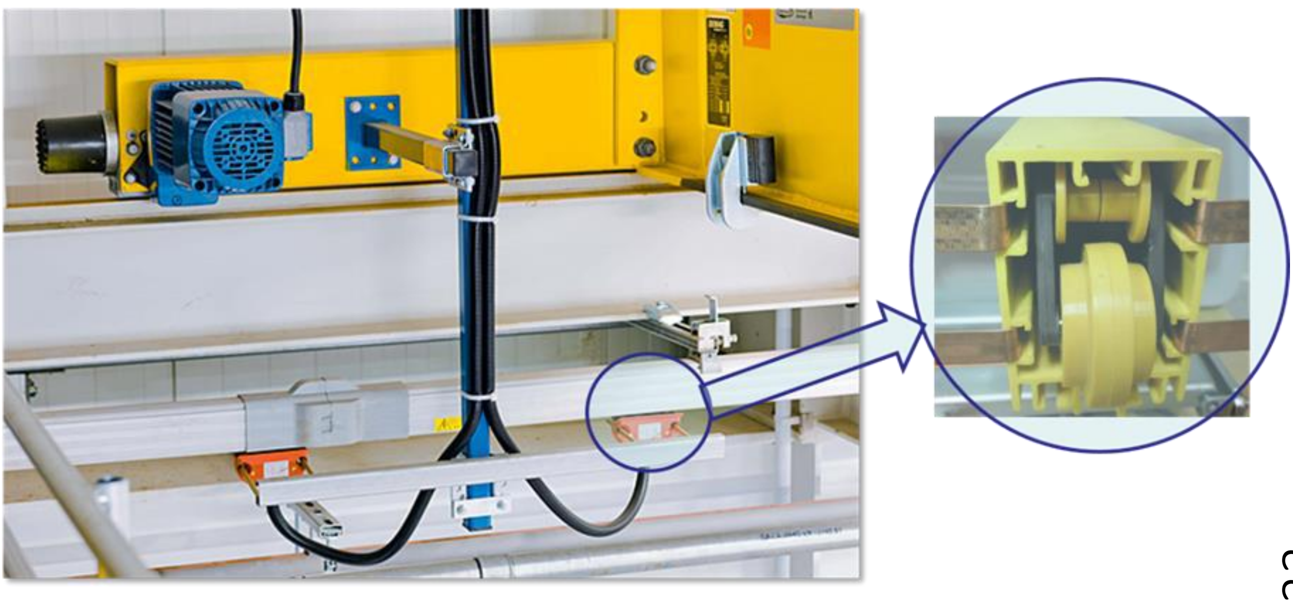
When mounted in position, note that the earth conductor is always mounted external from the gantry beam/runway so that a live conductor is not exposed externally. This mitigates risk from accidental contact with an exposed conductor.

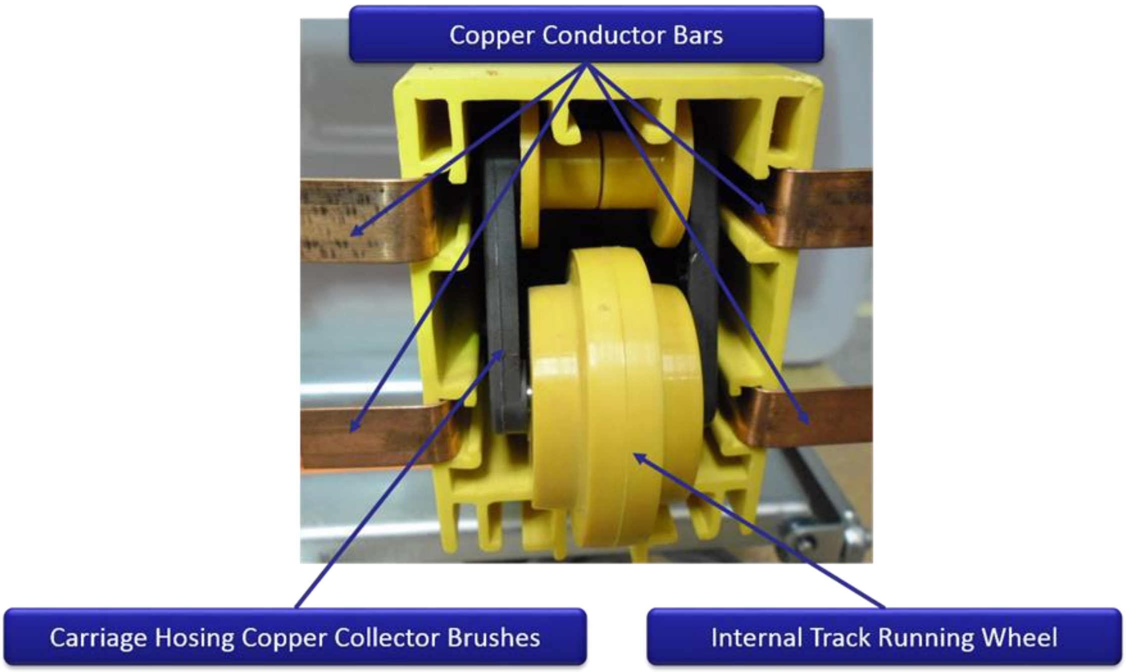
Multi-bar conductor systems may be mounted vertically, as shown above, or horizontally, as shown below:



Totally Enclosed Conductor Systems

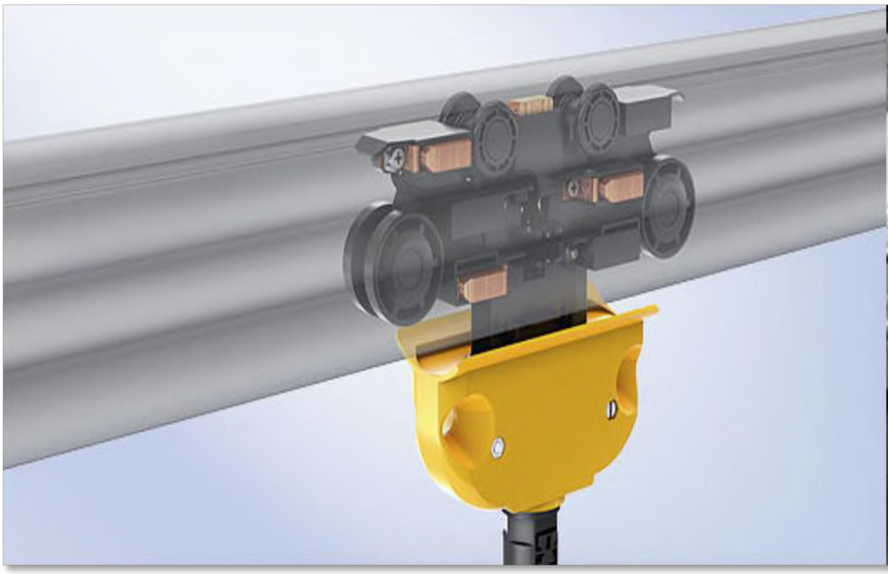
A totally enclosed conductor system is used where multiple conductors are required in one housing. It is a rigid and compact system. They are commonly used in overhead crane applications but also for traveling hoists.

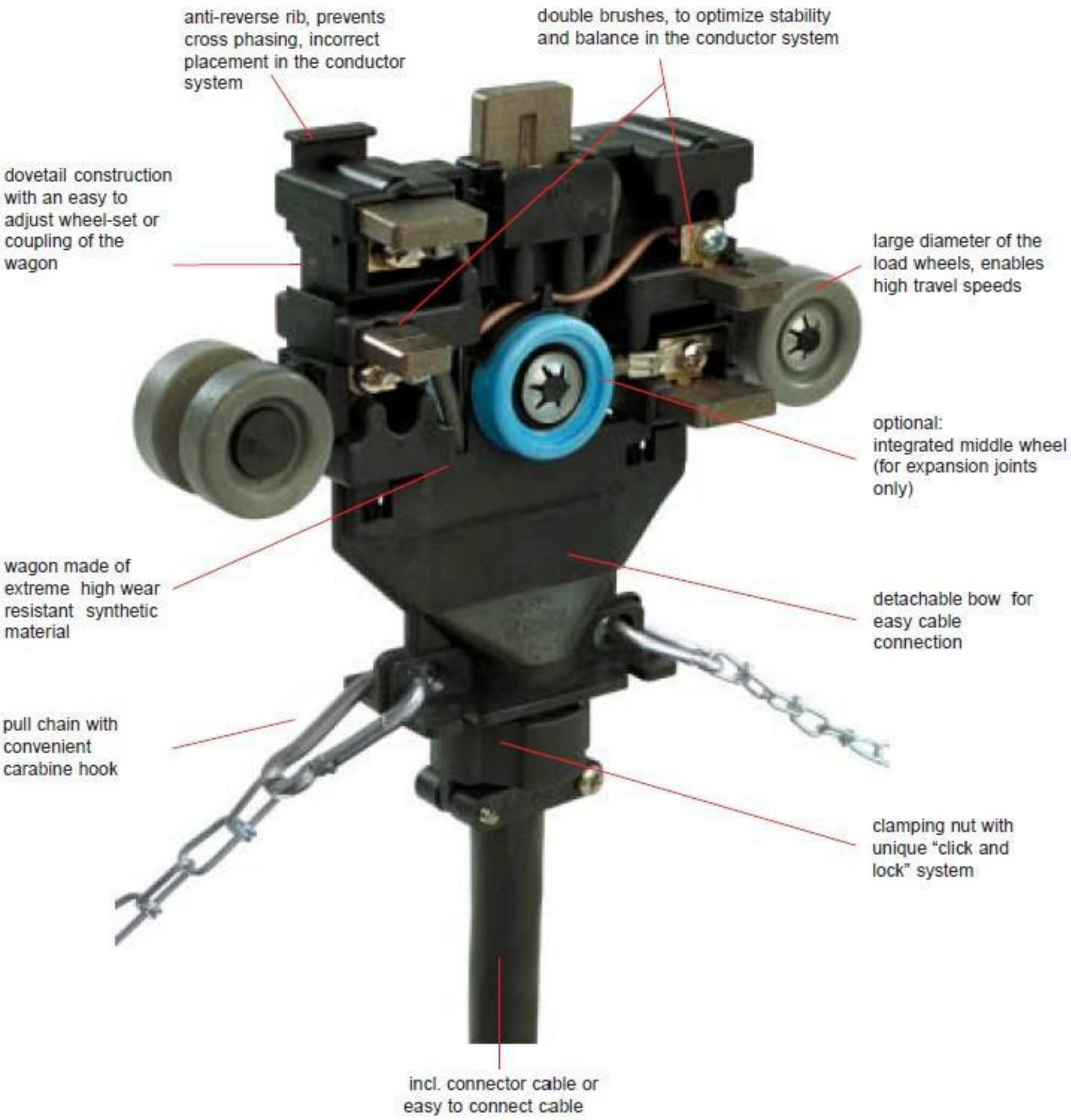




These systems have the advantage of needing little maintenance and can be provided with a flexible seal to prevent ingress of dust and moisture. They provide a compact, reliable and safe power supply for cranes and hoisting equipment:

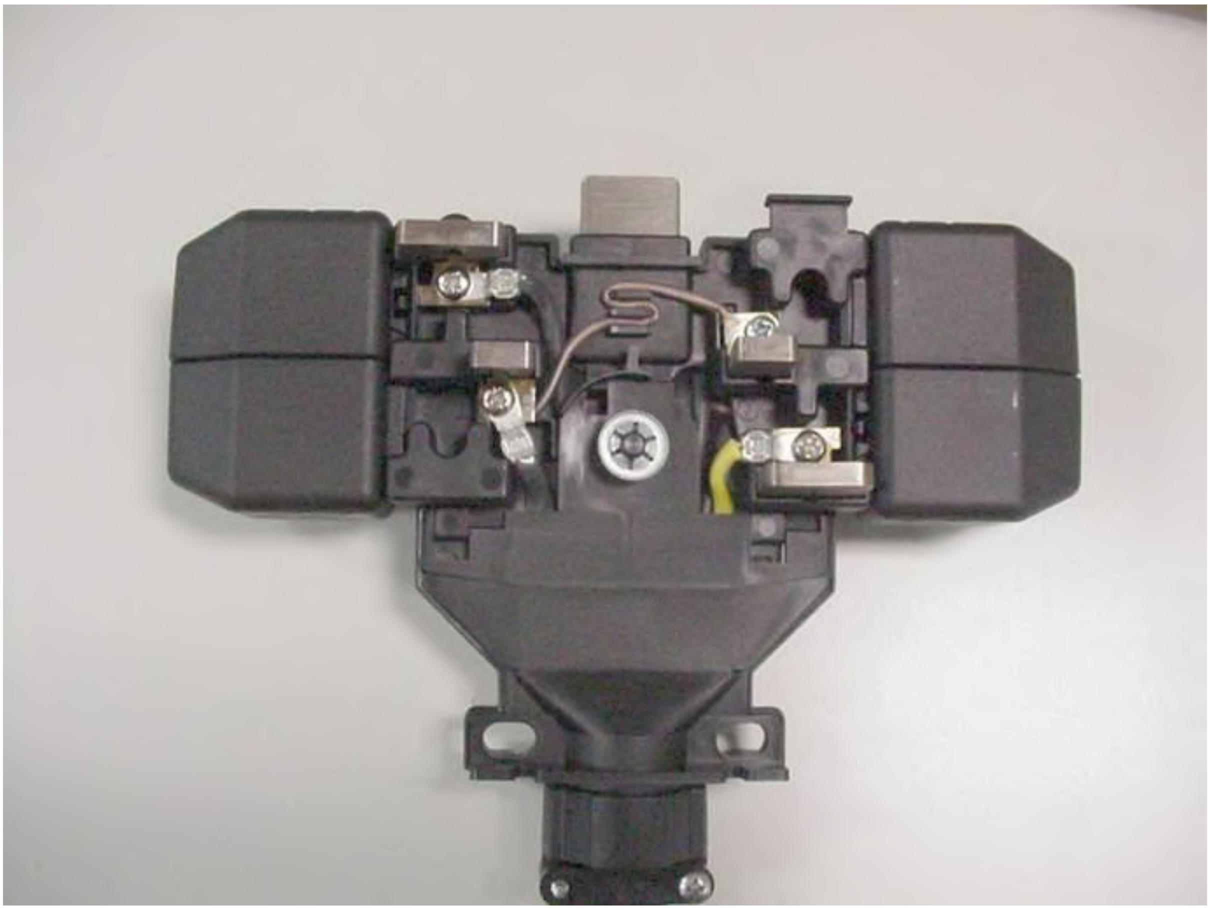
The illustration below shows how the fully enclosed conductor head collects the power from the enclosed bus-bars and feeds this direct to the hoist.





Typical enclosed collector head characteristics

NOTES:



The additional 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 conductor 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.

The picture below shows a typical power supply arrangement which feeds the conductors from one end of the conductor track. Note the isolator is lockable for safe access to carry out thorough examination of the supply system.

Energy Chain Systems

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

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.

Explosion Proof Hoist marking

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.

Thorough Examination

You are reminded that if you do not adhere to carefully controlled isolation of power supplies prior to access for examination work, the consequences may be fatal!

Seek advice if you are in any doubt!

It is essential that a 'lock-out/tag-out' isolation procedure is followed and controlled by the person conducting the examination work. Where more than one worker is exposed to the system, a multi-lock padlock hasp must be used and each worker places their padlock in the hasp. This ensures that the power supply cannot be reconnected until all workers are no longer exposed and have removed their own isolation.

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.

NOTES:

Summary

On completion of this training course, you will sit your end-point assessment (exam) for the qualification of Bridge and Gantry Cranes (Global) Diploma. On successful completion, you will receive a LEEA Diploma and TEAM Card. Existing TEAM Card holders will have this qualification added to their profile. You'll be trained to perform the 'thorough examination' of specific lifting equipment in service and validate, or otherwise, its fitness for a further period of service, applying conditions as may be necessary. Students will be able to refer to and extrapolate information from sources to support their analysis of lifting equipment suitability for continued service.

Recommended further reading

- LEEA COPSULE (Code of Practice for the Safe Use of Lifting Equipment) Edition 9 -November 2019 ISBN 978-0-9930124-0-2

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