Lift Supervisor

Fire Alarm, Tests and Evacuation
Welfare Facilities
Breaks and Refreshments
Phones

Introduction

Donald Ritchie

- Over 30 Experience in Management, HSE, and Machine Operator
- Training ranging from:
  - Director (2014)
  - Ritchies Training Centre
  - Regional Training Manager
    - Stirling Group (Kurdistan) 2014
  - HSE Manager / TLA (Dubai)
    - Restrata Group (Nov 2015)
  - Director / Team Leader
    - High Access Rescue Team
Class Introduction
Tell us a little about Yourself....
Job Role / Experience / Knowledge....

Mutual Respect and Confidentiality.....
Why do we need to train?

- To teach necessary skills and relevant job safety required for safe operations
- To encourage future good practice in order to maintain and promote skills
- To create a safe working environment and procedures within the work place
- To conform with all Company Procedures
- To provide greater productivity and cost saving as a direct result of training

How?

- Theory Lessons
- Discussion
- Practical Demonstrations
- Assessments

Your input is vital to a successful course

Aims of Course

- Know the importance of safe lifting operations / procedures
- Be aware with the consequences of the misuse lifting operations
- Selecting the correct type of lifting equipment
- Responsibilities of lifting team
Legal Concerns

You and Your Employer can be subject to criminal fines and prosecution.

The Ultimate Aim:
Is to encourage high standards of health and safety at the work place.

The Main Aim:
To involve everyone, Management, Employees and Contractors.

Deals with all safety risks, health risks in the workplace and gives protection to the public (Affected by work activities).

Moral Concerns

Organisations – have moral obligations to ensure that its activities are not harmful to employees and others.

Individually - we have a duty to ourselves, our families and work colleagues to work in a safe manner.

PPE

- Look after your PPE (HASWA 74)
- Only wear company issued PPE (Risk Assessed)
- Replace any damaged PPE (Last Line of Defence)
Company Policies / Procedures

3. Application
4. Strength and stability
5. Lifting equipment for lifting persons
6. Positioning and installation
7. Marking of lifting equipment
8. Organisation of lifting operations
9. Thorough examination and inspection
10. Reports and defects
11. Keeping of information
12. Exemption for the armed forces
13. Amendment of the Shipbuilding and Ship-repairing Regulations 1960
15. Repeal of provisions of the Factories Act 1961
Management of Operations

As with all other operations on site, effective management of operations should ensure safety and efficiency.

Management Principles

- Plan
- Resources
- Communicate
- Monitor

(Fit for Purpose)

Assess the operation and provide such planning, equipment and personnel as necessary to complete any task safely (Planning).

Provide instruction and supervision as is necessary for the task to be undertaken safely. (Supervising)

Taking responsibility for the organisation and control of all operations. (Organisation)

Ensuring that everyone is fully briefed on the content of the method statement/risk assessment and permits to work.

Every one has the Authority to stop the operation if they consider any operation is dangerous.

HSE INFORMATION SHEET
Construction Sheet No 19

Accidents and dangerous occurrences
The main cause of accidents and dangerous occurrences involving cranes are lack of planning, training and maintenance, in particular:

- Selecting the wrong type of crane to undertake the lift.
- Incorrect positioning of the crane when carrying out the lift:
- Failing to correctly calculate the load
- Use of wrong lifting gear
- Failure of personnel to carry out the correct procedures
- Lack of proper maintenance
- Absence of properly trained personnel
Safe Systems of Work (Fit for Purpose)

All operations large or small must be controlled by establishing a Safe Systems of Work (Legal Requirement)

- Planning the operation
- Selection of correct crew and equipment
- Maintenance of equipment
- Selection of trained competent personnel
- Provision of competent supervision
- Safety of those involved or other affected by the operation
- Effective communication between all parties
- Ensure all necessary test certificates / documentation is in order
- Preventing unauthorised movement / use of equipment

Method Statement / Risk Assessment (Fit for Purpose)

The production of a written method statement is one of the most important duties of the Company

- It will highlight any risks and how they are to be addressed
- It explains the method of operations and ensures that suitable equipment is used
- It provides a basis for the communication (Tool Box Talk) to other members of the team

Reporting of Incidents (Near Miss)

The appointed person should ensure that there is an effective procedure for reporting any incidents or near misses.

This procedure should include the notification of the following:

a) any unsafe acts
b) incidents or accidents, however slight;
c) shock loads, however they occur;
d) dangerous occurrences or reportable accidents.
Lifting Operation

Lifting Operations Must Consider
- The Foundations
- The Crane
- The Load
- The Rigging

For the Lift Plan to Work Safely

Lifting Appliances (Machines)

Equipment performing the lift

“A mechanical device capable of raising or lowering a load, e.g. cranes, forklift trucks, powered hoists, manual hoists, lever hoists, etc...”
Lifting Accessories

- Slings
- Shackles
- Eye-bolts
- Plate Clamps

**CE Marking** on a product is a manufacturer's declaration that the product complies with the relevant European health and safety legislation.

Daily Pre-use or Post Use Inspections

A visual and functional check of all equipment to check for any obvious signs of damage. A pre-use must be carried out every time before a piece of equipment is used and a post use every time, before it is returned.

In Service Inspection

A more in-depth inspection than daily or weekly checks and are carried out by a competent Pearson / Fitter. Thorough Examination: In Depth and Detailed Inspection

It involves a comprehensive, inspection into the mechanical workings or components of the equipment.

**Exceptional Circumstances**

- Any Concerns Regarding the Safety of Equipment
- Equipment Has Been Shock Loaded
- Long Periods Without Use

Get Equipment Retested / Certified Before Use
### INSTUTION, TESTING & MAINTENANCE

<table>
<thead>
<tr>
<th>No</th>
<th>Daily Inspection</th>
<th>Monthly Inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tagged Crane or Hook</td>
<td>Visually inspect all critical items.</td>
</tr>
<tr>
<td>2</td>
<td>Control devices</td>
<td>Measure hooks for deformation or stretching</td>
</tr>
<tr>
<td>3</td>
<td>Hooks</td>
<td>Inspect hooks for cracks, missing or broken parts</td>
</tr>
<tr>
<td>4</td>
<td>Hook</td>
<td>Measure lifting chains for excessive stretch, twisting</td>
</tr>
<tr>
<td>5</td>
<td>Hook Latch</td>
<td>Inspect for twisted, broken or kinked cables or chains</td>
</tr>
<tr>
<td>6</td>
<td>Reening</td>
<td>Follow any additional recommendations of the manuf.</td>
</tr>
<tr>
<td>7</td>
<td>Limit Switches</td>
<td>Check for corrosion, no water ingress, seals intact</td>
</tr>
<tr>
<td>8</td>
<td>Oil Leakage</td>
<td>Daily check under crane</td>
</tr>
<tr>
<td>9</td>
<td>Unusual sound</td>
<td>Stop immediately</td>
</tr>
</tbody>
</table>

**REVIEW THE MANUFACTURERS INSPECTION REQUIREMENTS!**

### Responsible Person

**Appointed Person:** Plans the whole lifting operation from conception to completion (Crew, Equipment, Lifting Plans, JHA’s)

**Crane Supervisor:** person who controls the lifting operation and ensures that it is carried out safely

**Crane Operator:** Movement of all items in a safe and controlled manner as instructed by the Banksman

**Banksman:** Relays instructions to the crane operator during lifting activities.

**Slinger:** Prepare loads for their lifting and release loads at their destination.

### ROLE OF THE APPOINTED PERSON

The Appointed Person is responsible from when the crane arrives at the site, for its passage through the site, to the “setting up” position

For the crane set up itself, for the lifting operation and for the crane dismantling and for access and egress from the site.

For complying with all relevant Acts and Regulations, Approved Codes Of Practice and for producing the necessary Risk Assessments and Method Statements.
**Safe Working Load (SWL)**

The maximum load that Lifting Equipment can raise, lower or suspend *(When in Use)*

- the SWL can be lower than, but can never exceed, the WLL *(Working Load Limit)*.

**Working Load Limit (W.L.L)**

The maximum load, determined by the manufacturer, which an item of Lifting Equipment is designed to raise, lower or suspend.

*Note: Always lift the load as per SWL.*

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**Types of Crane**

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**Truck Mounted Crane**

- Crane unit on a truck chassis
- Travels on public highways
- Fitted with outriggers
- Requires good access
- Fixed or variable counterweights
- Must be used on firm level ground
- Range: 360 degree or over side and rear
- Must be used in Blocked Duties Only
Ritchies Offshore Services Ltd

Rough Terrain.
- Off road
- Large balloon tyres to spread load
- Blocked and free on wheels duties
- Highly manoeuvrable
- All wheel drive and steer

All Terrain Crane.
- Hybrid - truck and rough terrain
- Compact with variable counterweights
- Most models have all axle drive and steer, therefore highly manoeuvrable
- Small capacity all terrain’s cranes have blocked or free on wheels duties

Crawler Crane.
- Used on sites with high duty work cycles.
- Used on sites with poor ground bearing pressure
- Crane is transported to site in parts.
- Erection and dismantling may need auxiliary crane
- Requires large area for erection especially for long boom configurations.
As with any crane the operators must follow manufacturer's advice for:

- Rigging Crane Up
- De Rigging Crane
One Operators Cab (Folding arm) Driving, Operating, Raised Cab (Visibility)

CRANE TERMINOLOGY

Chassis
- gives the crane mobility

Slew Ring
- ability to rotate through 360 degrees

Upper-works/Superstructure
- joined to chassis via slew ring

Power Source
- diesel electric, hydraulic, Mechanical single engine / dual engine and power take off
Outriggers.
  increase stability base
  varying beam extensions from the crane chassis

Jacks and Jack Floats.
  vertical telescoping rams
  enable crane to be set level
  floats spread point loading

Wheels Off Ground.
  Wheels must be off ground for all lifting
  Operations

Jib/Boom.
  main lifting arm

Hook Block.
  pulley block attached to crane hook
  which is suspended with hoist rope

Falls of Rope.
  mechanical advantage of reeving hoist rope between pulley blocks

Crane Capacity.
  Important factors - Boom length and Radius
  the longer the jib/boom or greater radius the less the capacity
Safe Use of Cranes

Inspect the crane every day (before the start of each shift). Don’t operate a damaged or poorly maintained crane.

Pre – Op Checks

Running Checks

Radius
The TELEMATIK Telescoping System
It operates using just one hydraulic cylinder and an internal locking system for the individual telescoping sections. The lifting capacity properties are excellent since the various telescopes can be extended in any sequence and independently of each other.

- Boom Locking Pins
- Boom Wear Pads

Telescope: Load on?

Y Guying

Superlift: Long boom configurations over 350t
Provides better lateral stability
**Vario Ballast**

Adjustable counterweight

*Reduced*: Small confined areas

*Fully Extended*: Maximum capacities

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**Minimum Counterweight Clearance**

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When visibility is bad due to poor weather conditions stop work and do not start again until conditions have cleared.

Maintain a good work site for the machine. Before you start work always check that your working area is free of people and obstructions.
Safe Working Load (SWL)

- Never exceed SWL.
- Prevent pendulum swings.
- No dragging of loads.
- Hoist ropes must remain vertical.
- Prevent any form of side loading.

Do not unwind so far that the hook touches the ground
Never use the main coil and the auxiliary winches at the same time.

Lower the hook sufficiently before you extend the boom. Extending the boom can put the winch into an over hoisted condition.

Switch triggers alarm in cab and cuts out movement.

Confirm the boom extension! Retraction sequence.
Never use the boom to push or pull objects.
ANTI 2 BLOCKING (A 2 B)

Can cause the wire rope to break
Can damage sheave
Can cause structural damage to the crane
Can cause the load to drop

Rooster Sheave

Limiting and Indicating Devices

Load / Inductor sensor
Control of boom

When you lower the boom the working radius increases as the angle of the boom decreases, increasing the risk of tip over.
**Eminox Spark Arrester** (Chalwyn Valves)

When operating vehicles in potentially explosive atmospheres, spark arrestors are fitted for safety and they are also a legal requirement.

Soot/ash from diesel engines can be heated by the combustion process, capable of igniting flammable gas or dust atmospheres.

Rotating flow: Particles are reduced in size, rendering them unable to transport enough energy to ignite the explosive atmosphere.

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**Crane Stability**

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**CONSEQUENCES OF MISUSE LIFTING OPERATIONS**

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Proximity Hazards.
Can effect stability, by not making allowances for the load once it is on the crane hook.
It is important to take due account of all factors that effect the safe system of work.

Ground Conditions
Precautions should be taken to ensure that the crane foundation is clear of any underground services or, where this is not possible, that the services are adequately protected against damage.

Ground Conditions.
Confirm what the ground can support (site survey, “geo tech report”)
Check what loadings the crane will impose, and ensure that the specified support pads are used.
When setting outriggers check for ground conditions, under the outrigger. Surfaces paved with plain asphalt or with thin concrete, bricks or cobbled road surfaces.
Areas where soil under the road paving has been eroded by water to leave a void.
Road shoulders or near excavations.

Set the machine on level ground with full consideration for the above points.

Allowable Bearing Capacity

“Allowable Bearing Capacity of the soil at a given site is a loading intensity which is so limited that it provides an adequate factor of safety against soil rupture. It also insures that settlement due to static loading will not exceed the tolerable value.”

Basic Soil Engineering
In order to determine the correct outrigger pad size required for a crane, it will be necessary to gather some information about the ground conditions on site.

It will be necessary to know:

- The character of the ground (i.e. Cohesive or Non Cohesive)
- The water conditions (Water tables)
- The engineering properties of the ground relevant to the design of the foundations
- The location of any underground hazards

**NOTE:**
If you have any doubt regarding ground conditions the Appointed Person must seek the advice from a specialist Geotechnical engineer.

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**Determining Ground Conditions**

**Site Categories**
Sites can be categorised to highlight the most likely potential problems that need to be considered.

More attention is required to establish the strength of the ground where ground conditions are poor or where there is lack of data on the nature of the sub-soil.

**Greenfield Sites**
No previous construction activities

Problem areas are: adjacent to rivers with high flood plains or on sites with high water tables.

**Beaches**
Low sand density and / or high/variable water table create difficult conditions.

**Filled Construction Sites (Brownfield)**
Unknown previous conditions, e.g. basements, poorly filled open pits, storage tanks, variable and compacted fill.
Soils - Presumed Bearing Values

Guidance to presumed bearing loads are widely available. This is not a substitute for a proper ground investigation which must be carried out.

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Minimum Bearing Pressure</th>
<th>Maximum Bearing Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense Gravel</td>
<td>&gt;61.2 kN/m²</td>
<td>&gt;500 kN/m²</td>
</tr>
<tr>
<td>Medium-Dense Gravel, Medium Dense Sand and Gravel</td>
<td>20.4—61.2 kN/m²</td>
<td>200—600 kN/m²</td>
</tr>
<tr>
<td>Loose Gravel, or Loose Sand and Gravel</td>
<td>&lt;20.4 kN/m²</td>
<td>&lt;200 kN/m²</td>
</tr>
<tr>
<td>Compact Sand</td>
<td>&gt;30.8 kN/m²</td>
<td>&gt;500 kN/m²</td>
</tr>
<tr>
<td>Medium Dense Sand</td>
<td>10.2—30.8 kN/m²</td>
<td>100—500 kN/m²</td>
</tr>
<tr>
<td>Loose Sand</td>
<td>&lt;10.2 kN/m²</td>
<td>&lt;100 kN/m²</td>
</tr>
</tbody>
</table>

* Depends on degree of looseness

Cohesive Soils

<table>
<thead>
<tr>
<th>Cohesive Soil</th>
<th>Minimum Bearing Pressure</th>
<th>Maximum Bearing Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Hard Boulder Clay and Hard Clay</td>
<td>16.2 kN/m²</td>
<td>300—600 kN/m²</td>
</tr>
<tr>
<td>Soft Clay</td>
<td>15.5—30.4 kN/m²</td>
<td>150—300 kN/m²</td>
</tr>
<tr>
<td>Firm Clay</td>
<td>7.6—15.3 kN/m²</td>
<td>75—150 kN/m²</td>
</tr>
<tr>
<td>Soft Clay and Silt</td>
<td>&lt;7.6 kN/m²</td>
<td>&lt;75 kN/m²</td>
</tr>
<tr>
<td>Very Soft Clay</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Bent</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>

Effective Bearing Length of Crane Mats

Mat Length Based on Soil Bearing Capacity

Once the load from the crane has been calculated (outrigger load or crawler track pressure), the required crane mat area is calculated by dividing the crane load plus the weight of the mat by the allowable ground bearing pressure.

Divide this area by the width of the mat and we have the required effective bearing length.
Effective Bearing Length of Crane Mats

This mat length is then used to calculate bending and shear stresses in the mat.

Based on the assumption of a uniform pressure equal to the crane load divided by the bearing area acting upward on the bottom of the mat.

If the actual stresses are equal to or less than the allowable stresses, the mat is acceptable.

Crawler Crane / Excavator
Load Bearing Pressures

Crawler Track (Side View)
**Bearing Length (Side View)**

Minimum Bearing Length = 6.8m

**Bearing Length (End View)**

Track Plate Width = 1.2m

**Crawler Crane (In Line)**

No Load

With Load
Crawler Crane (Cross Track)

No Load

With Load

Track / Outrigger Loadings Worst Case

Counterweight : 64.0te
Machinery Deck: 37.6te
Body: 21.7te
Crawler: 42.6te
Boom: 11.3te
Hook / Load: 49.8te
= 227.1te

Bearing length (First – Last Track Roller) = 6.8m
Track Shoe Width 1.2m

6.8 x 1.2m x 2 = (16.32 Area)

Average (Minimum) Bearing Pressure = 13.9te/sq/m (Crane in Line with Tracks)

Track Bearing Pressure (Side Loaded)

Crane: 177.2te (75%)
Hook / Load: 49.8te (100%)

= 182.7te

22.38te/m²

Track Size = 6.8m
Track Shoe Width 1.2m

6.8 x 1.2 x 2 = 16.32 m²
182.7te = 16.32 = 11.19t/m²
11.19 x 2 = 22.38t/m² (Single Track)
Safe Use of Outriggers

Outrigger Remote Control

Set up the machine using the level gauge to ensure that the body is level. If the outriggers are not set properly the crane’s lifting capacity will be reduced and the crane may tip over.
SAFE USE OF OUTRIGGERS

Correct

Wrong

OUTRIGGER LOAD BEARING AREA

Typical Outrigger Mat Sizes & Areas

<table>
<thead>
<tr>
<th>MAT SIZE (m)</th>
<th>MAT MATERIAL</th>
<th>THICKNESS (mm)</th>
<th>AREA (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.76 x 0.76</td>
<td>NYLON</td>
<td>50mm</td>
<td>0.56m²</td>
</tr>
<tr>
<td>0.76 x 1.14</td>
<td>NYLON</td>
<td>50mm</td>
<td>0.99m²</td>
</tr>
<tr>
<td>1.14 x 1.14</td>
<td>NYLON</td>
<td>50mm</td>
<td>1.32m²</td>
</tr>
<tr>
<td>1.00 x 1.14</td>
<td>ALUMINIUM</td>
<td>50mm</td>
<td>0.59m²</td>
</tr>
<tr>
<td>1.14 x 1.47</td>
<td>ALUMINIUM</td>
<td>50mm</td>
<td>0.93m²</td>
</tr>
<tr>
<td>2.00 x 1.29</td>
<td>STEEL</td>
<td>200mm</td>
<td>2.53m²</td>
</tr>
<tr>
<td>2.00 x 1.29</td>
<td>STEEL</td>
<td>200mm</td>
<td>2.08m²</td>
</tr>
<tr>
<td>2.00 x 1.29</td>
<td>STEEL</td>
<td>250mm</td>
<td>2.53m²</td>
</tr>
<tr>
<td>2.00 x 1.29</td>
<td>STEEL</td>
<td>300mm</td>
<td>3.08m²</td>
</tr>
<tr>
<td>2.50 x 1.70</td>
<td>STEEL</td>
<td>200mm</td>
<td>4.25m²</td>
</tr>
<tr>
<td>2.50 x 1.70</td>
<td>STEEL</td>
<td>250mm</td>
<td>5.25m²</td>
</tr>
<tr>
<td>2.50 x 1.70</td>
<td>STEEL</td>
<td>300mm</td>
<td>6.25m²</td>
</tr>
<tr>
<td>3.00 x 2.30</td>
<td>STEEL</td>
<td>200mm</td>
<td>7.35m²</td>
</tr>
<tr>
<td>3.00 x 2.30</td>
<td>STEEL</td>
<td>250mm</td>
<td>9.35m²</td>
</tr>
<tr>
<td>3.00 x 2.30</td>
<td>STEEL</td>
<td>300mm</td>
<td>11.35m²</td>
</tr>
<tr>
<td>4.50 x 3.30</td>
<td>TIMBER (250mm)</td>
<td>300mm</td>
<td>5.43m²</td>
</tr>
</tbody>
</table>
Imposed outrigger loads.

Lift Supervisor and operator must consider the increased loadings during the placing of support mats.

Operators **MUST** carry out set-up checks i.e.

Slew through 360° and check support bases.

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**ANGLE OF REPOSE**

![Diagram: Angle of Repose](image.png)

The crane must not be set up to close to slopes or trenches and depending on the type of soil, a safe distance is measured from the foot of the trench and is:

- Natural soil, not loose = 1 x depth of trench
- On loose or filled soil = 2x depth of trench
Outrigger Loadings Worst Case

It is possible when the crane is lifting a load for up to 75% of the total crane rigged weight plus all of the lifted load weight to go through any one outrigger jack when the laden boom is over it.

In order for the Appointed Person to calculate the correct area of crane structural supports for each outrigger jack, the Allowable Bearing Pressure of the ground needs to be determined by the Employing Organisation / Client or Principal Contractor.

Example 1
Outrigger Loading (From Ground Pressure)
Based on AP Drawings
**Outrigger Loading (Ground Pressure)**

- Weight of crane: 50 tonnes
- Weight of load: 22 tonnes
- Weight of Block / Tackle: 1.5 tonnes

Crank: 50t X 0.75 (Point Load) + Load: 22t + Tackle 1.5t = 61t

\[
\frac{61t}{25t} = 2.44m^2
\]

\[\sqrt{2.44} = 1.56\] Round up to 1.6m

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**Example 2**

**Outrigger Loading (From Pad Size)**

- Weight of crane: 50 tonnes
- Weight of load: 22 tonnes
- Area of Outrigger Pad: 1.44 m²

Area of Outrigger Pad: \[1.2 \times 1.2 = 1.44 m^2\]

72 tonnes = 1.44 X 75% X 10

\[= 37,500kN\]

Land Rigs 50 kN (Rig Base Pad BP Oman Sites)
Example 3
Calculate using Ground Bearing Pressures Tables

1. Crane Weight
The maximum weight of the crane to be used 50,000kgs (worst case scenario)

2. Load
The maximum load to be lifted 22,000kgs + Hook / Tackle 1,500kgs

3. Outrigger Load
Point load = (1+2) x 100% = (50,000 + 23,500) X1 = 73,500kgs or 73.5t

4. Ground Type
Ground comes in granular and cohesive types.

Bearing Values BS:8004

1. Crane Weight
The maximum weight of the crane to be used 50,000kgs (worst case scenario)

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3. Outrigger Load
Point load = (1+2) x 100% = (50,000 + 23,500) X1 = 73,500kgs or 73.5t

4. Ground Type
Ground comes in granular and cohesive types.

Non-Cohesive Soils

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Sand &amp; Gravel</th>
<th>Gravel &amp; Gravel</th>
<th>Loamy Sand, Fine Sand &amp; Fine Gravel</th>
<th>Clay &amp; Gravel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing Value</td>
<td>160 kN/m²</td>
<td>120 kN/m²</td>
<td>100 kN/m²</td>
<td>60 kN/m²</td>
</tr>
</tbody>
</table>

Cohesive Soils

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing Value</td>
<td>800 kN/m²</td>
<td>600 kN/m²</td>
<td>400 kN/m²</td>
<td>300 kN/m²</td>
<td>250 kN/m²</td>
<td>200 kN/m²</td>
<td>150 kN/m²</td>
<td>Not Applicable</td>
</tr>
</tbody>
</table>
1. Mat size

Mat size deducted from point load number 3 (in kNs) / (Soil type value 2)

\[
721,035 \text{ kNs} / 300 \text{ kN/m}^2 = 2.40 \text{ m}^2
\]

A. Soil type is compact ground (gravel 100mm in depth) covered in tar. Two outriggers will be placed here. The other two will be placed on medium dense gravel [Dense gravel has a bearing value of >600kNm/ medium dense gravel <200 – 600kNm²]. Area has transport trailers carrying ISO containers so a pessimistic ground bearing value of 300kNm has been selected.

<table>
<thead>
<tr>
<th>Non-Cohesive Soils</th>
<th>Bearing Value 1</th>
<th>Bearing Value 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dense Gravel or Dense Sand and Gravel</td>
<td>&gt;600kNm²</td>
<td>&gt;900kNm²</td>
</tr>
<tr>
<td>Medium Dense Gravel or Medium Dense Sand and Gravel</td>
<td>200-600kNm²</td>
<td>150-600kNm²</td>
</tr>
<tr>
<td>Loose Gravel or Loose Sand and Gravel</td>
<td>&gt;40kNm²</td>
<td>&gt;100kNm²</td>
</tr>
<tr>
<td>Coarse Sand</td>
<td>&gt;100kNm²</td>
<td>&gt;300kNm²</td>
</tr>
<tr>
<td>Medium Sand</td>
<td>&gt;50-150kNm²</td>
<td>&gt;200-400kNm²</td>
</tr>
<tr>
<td>Loose Sand ²</td>
<td>10-50kNm²</td>
<td>&lt;50kNm²</td>
</tr>
<tr>
<td>Loose Sand *</td>
<td>10-50kNm²</td>
<td>&lt;20kNm²</td>
</tr>
</tbody>
</table>

Example 4

Outrigger Loading (Azerbaijan)

<table>
<thead>
<tr>
<th>Stage 1.</th>
<th>Gross Load Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Load</td>
<td>= 5,500 kg</td>
</tr>
<tr>
<td>+Accessories (Slings)</td>
<td>= 100 kg</td>
</tr>
<tr>
<td>+Hook Block</td>
<td>= 500 kg</td>
</tr>
<tr>
<td>Gross Load</td>
<td>= 6,100 kg</td>
</tr>
</tbody>
</table>
Stage 2  Mat Calculation Template

Gross weight of crane including additional ballast = 64.0 tonnes
× 0.75 = 48.0 tonnes
+ Gross load 6.1t (Maximum point loading) = 54.1 tonnes

Minimum area of mat required = 5.41 m²
Actual area of mat to be used = 6.25 m²
Mat size = 2,500 mm X 2,500 mm
or 2.5m diameter if circular

Actual Bearing Pressure

Stage 3  Actual Bearing Pressure Under Selected Mat

Resulting loading: Maximum point loading 54.1 tonnes
Divided by the actual area of mat used 6.25 m²
= Resulting loading 8.7 t / m²

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>t/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mud, Peat, Marsh</td>
<td>0</td>
</tr>
<tr>
<td>Cohesive Ground Soils</td>
<td>4</td>
</tr>
<tr>
<td>Cohesive Ground Firm</td>
<td>10</td>
</tr>
<tr>
<td>Filling, Concrete Plinths, Heavy Duty Roads</td>
<td>50</td>
</tr>
<tr>
<td>Ground Load Bearing Capable Known</td>
<td>t /m²</td>
</tr>
</tbody>
</table>

Outrigger Point Loading (25t G.B.P)

Weight of crane: 72t
Weight of counterweight: 65t
132t
Weight of load: 11.4t
Block / Tackle: 0.7t
Fly Jib (if fitted) 0t

132 x 0.75 (Point Load) = 11.4 + 0.7 = 111.1
111.1 = 25t + 4,444 m³
4,444 = 2.1080

Pad size 2.1m
Increase pad size

Outrigger Point Loading
2.3 x 2.3 = 5.29 m²
111.1 ÷ 4.444 = 25t
111.1 ÷ 5.29 = 21t
Calculation of Area of Circular Mat

Area of Mat = \pi \times R^2
\pi = 3.14
R^2 = R \times R

Example: Mat Diameter is 0.9m
Radius = 0.9m ÷ 2 = 0.45m
R^2 = 0.45 \times 0.45 = 0.2025
Area of Mat is 3.14 \times 0.2025 = 0.636m²

Converting Square to Round Pads

1.6 \times 1.6 = 2.56m
2.56 ÷ 3.14 = 0.815
\sqrt{0.815} = .903 (Radius)
X 2 = 1.8m (Dia)

Rated Capacity Indicators (RCI)
Rated Capacity Indicator.
Rated capacity indicators are fitted to the crane to comply with regulations. It has to be properly maintained and working. (Weekly / 6 Monthly Checks)

The function of the indicator is to monitor the crane under load and to warn the operator of approach to maximum safe working load

- Legal requirement
- Basic source of information
- Configurations of outriggers
- Duties of crane
- Critical boom angle
- 75% capacity for tipping/structural strength
- 100% of safe working load

Strength and stability factors
Cranes are limited by both Structural Strength and Stability Factors

- Stability means the ability of a crane to resist tipping
- Structural strength the ability of a crane to resist damage

Load Moment Indicators (LMI) or Rated Capacity Indicators (RCI) measure and display the weight / mass of the load being lifted.
RCI – Stages of Activation

Initial Warning.
Approach to safe working load is visual and takes place at approximately 90% to 97.5% (Green) of maximum safe working load. (Amber) 102.5%.

Warning of Overload.
Visual and Audible and the audible alarm is sufficiently loud enough to be heard by those persons working in the vicinity of the crane.
The overload warning is activated at 110% (Red) of safe working load at any radii or boom length.

112.5% RCI cuts all critical crane motions

Load Charts

10.2m – 26.2m Boom

Fly Jib
Fly jib operations the rated lifting capacity is determined on the basis of the boom angle, not the working radius.

**Fly Jib Reductions**

<table>
<thead>
<tr>
<th>rating/lyt</th>
<th>shd</th>
<th>0.5 tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6m</td>
<td>arched</td>
<td>0.60 tonnes</td>
</tr>
<tr>
<td>1.6m</td>
<td>arched</td>
<td>1.10 tonnes</td>
</tr>
</tbody>
</table>

**Counter Weights**

- **Fixed Counterweight**
- **Additional Counterweight**

Slew locking pin Not engaged

Weight of ballast rotated crane when transporting
Crane Utilisation

Gross load not recommended to exceed 80% of the SWL of the crane configuration selected

Note: Must not exceed 90% of the SWL

Crane Configuration – Radius: 12m – Boom length: 32.4m (Crane can lift 4.5 tons)

Crane Utilisation

Load 4t x 100 ÷ 4.5 = 88.8% Crane Utilization to high (Complex Lift)

You would need to Reduce Boom Length or Reduce Crane Radius

Load 4t (@10m) x 100 ÷ 5t = 80.0% Crane Utilization Good (Routine Lift)

RADIUS: Straight Line Lifts

All Operators must fully understand Where & How to position their crane safely

To many accidents are caused by the operator not positioning the crane correctly

Lift: You have to position a load centred on the roof of a building

The easiest lift you can do is a straight line lift (from point A to point B)

Stage 1: Position crane (centre of slew ring) on the X directly in front of the drop point X B

Note: Do not position the crane to close or to far away from building (Safe distance)

Step 2: Find centre point of building and pace distance back to centre of slew ring (in metres)

Step 3: You can now check cranes load charts to see if you can lift the load at that radius
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RADIUS: Angled Lifts

Angled lifts need more planning

Let: You have to position a load on the corner of a building

No lifting within shaded area

Stage 1: We need to measure from B to A X then from A X to X B

Step 2: We now have 2 known distances 36 and 13

Step 3: If we times 36 x 36 = 1296 and times 13 x 13 = 169. Add both numbers together 1296 + 169 = 1465 and square root √1465 = 38.2

Radius from point A – B is 38.2 metres

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Basic / Intermediate / Complex
Routine / Non Routine / Engineered
Lifting Operations

BASIC LIFTS (Routine)

Where the loads to be lifted is of established weight and there are no known hazards or obstructions within the area of the operation

The duties of the person in control will include the following:

- SWL of Load.
- Maximum Boom Length.
- Maximum Radius.
- Maximum Height of Lift
Check when loads have to be lifted over an extended period of time, or with repetitive lifts that no changes are required.

The person appointed controlling a simple lifting operation should be aware of when they have reached their limit of experience.

At that point they must seek appropriate help.

Intermediate Lift (Standard / Non Routine)

Where the load to be lifted is of established weight or possibly not known accurately.

There are hazards to be considered within the working area.

Investigate all hazards in the work area. These maybe from surrounding buildings or structures or over ground or underground services.

Liaise with any other person or authority as required to overcome any hazard for a safe system of work.

Complex Lifting (Engineered)

Where the lifting operation is to take place at a location with exceptional hazards.

Gas / Chemical Plants, (Man Riders)

Safe system of work requires two or more cranes to be used to lift a single load.

Planning must given greater attention than for more straightforward lifting operations.
COMPLEX LIFTING (Engineered)

If the safe system of work requires two or more cranes to be used to lift a single load, lift supervisions and ground crew should ensure:

- A written method statement is drawn up outlining the steps to be followed to ensure compliance with the safe system of work.
- The method statement is given, understood and followed by those involved.
- This is in addition to the briefing (tool box talks).

(No other Personnel on the project has the authority to approve plans).

Crane operators involved in lifting operation should be aware of when he/she has reached the limit of experience and knowledge.

TANDEM LIFTS

You should have an restriction on tandem lifts.

- The only tandem lifting should be engineered through the office.
- Avoid slewing operations.
- Crane jibs must be kept parallel.
- Work with two cranes of the same model.
- Set machines which have ample capacity for the job.
- Appoint one signaller for the entire operation.
- As a rule control the cranes by single lever operations and avoid compound lever operations.
- The dangers in tandem lifts are the cranes are going to side load each other.

When all the factors cannot be accurately evaluated, appropriate down-rating should be applied to all the cranes involved. The down-rating might have to be 20% or more.
TANDEM LIFTS

Tandem lifts are dangerous.

They can be done safely if they are planned and every one involved is trained.

IF IN ANY DOUBT GET HELP FROM YOUR OFFICE OR SUPERVISOR.

\[
\frac{(\text{Load weight} \times \text{Distance 2})}{(\text{Distance 1} + \text{Distance 2})} = \text{Crane 1} \\
\frac{(\text{Load weight} \times \text{Distance 1})}{(\text{Distance 1} + \text{Distance 2})} = \text{Crane 2}
\]

Load 30t

Distance Crane 1: 20m
Distance Crane 2: 15m
TANDEM LIFTS

Crane 1

\[
\text{(Load weight } \times \text{ Distance 2)} \div (\text{Distance 1} + \text{Distance 2})
\]

\[
\frac{30 \times 15}{15 + 20} = \frac{450}{35} = 12.86
\]

Crane 1: \(12.86 \times 1.2 \text{ (Safety Factor)} = 15.43t\)

Crane 2

\[
\text{(Load weight } \times \text{ Distance 1)} \div (\text{Distance 1} + \text{Distance 2})
\]

\[
\frac{30 \times 20}{15 + 20} = \frac{600}{35} = 17.14t
\]

Crane 2: \(17.14 \times 1.2 \text{ (Safety Factor)} = 20.57t\)

Topping & Tailing Lifts

Crane 1

\[
\text{(Load weight } \times \text{ Distance 2A)} \div (\text{Distance 1A} + \text{Distance 2A})
\]

Crane 2

\[
\text{(Load weight } \times \text{ Distance 1A)} \div (\text{Distance 1A} + \text{Distance 2A})
\]

Load 30t
D1A: 20m
D2A: 15m
D3: 1m
**Topping & Tailing Lifts**

Crane 1 Sling Distance | Crane 2 Sling Distance
--- | ---
Distance 1A = @ 30° | Distance 2A = @ 30°

- 20 x cos 30° = 17.32m
- 20 x 0.866 = 17.32m
- 20 x 0.866

Loadings on Crane 1 (Load weight X Distance 1A) ÷ (Distance 1A + Distance 2A)

- (30t x 13.49) ÷ (17.32 + 13.49)
- = 13.14t

Loadings on Crane 2 (Load weight X Distance 2A) ÷ (Distance 1A + Distance 2A)

- (30t x 17.32) ÷ (17.32 + 13.49)
- = 16.86t

---

**Topping & Tailing Lifts**

Loadings on Crane 1: @ 30° (Cos = 0.866)
- = 13.14t

Loadings on Crane 2: 30°
- = 16.86t

Loadings on Crane 1: @ 60° (Cos = 0.5)
- = 13.6t

Loadings on Crane 2: 60°
- = 16.3t

Loadings on Crane 1: @ 90° (Cos = 0)
- = 30t

Loadings on Crane 2: 90°
- = 0t

---

**DISMANTLING OPERATIONS**

The safe system of work should include steps to ensure all loads are free from adhesion, steel wedges, jacking equipment may be needed to break the suction.

There will be a final inspection of the load by the Crane Supervisor before the lift commences.

Lifting loads in mid-air should be avoided if possible. It is necessary to handle a load by attaching the crane then cutting free, the Appointed Person should ensure that a 100% uplift has been added to the estimated weight when selecting the craneage.

---

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### Hoisting Over Live Facilities:

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live facilities (process plant or equipment)</td>
<td>Further safety precautions to be considered</td>
</tr>
<tr>
<td>Equipment, potential or storage</td>
<td>Additional authorization from the manager of the area</td>
</tr>
<tr>
<td>Equipment having any single or combination as hazardous, pressurized, energized or containing strategic &quot;fluid&quot;</td>
<td>Shutting down, isolating, depressurizing and purging the live process plant, equipment or other facility</td>
</tr>
<tr>
<td>Example of hazards:</td>
<td>Selecting higher rated equipment so that it is not used to exceed 75% of the capacity</td>
</tr>
<tr>
<td>Pipes</td>
<td>The use of data input safety fixtures, such as high-impact resistant shut-off valves to control the load in the event of a hoist brake failure</td>
</tr>
<tr>
<td>Vessels containing hydrocarbons</td>
<td>Wire or emergency plan in place</td>
</tr>
<tr>
<td>Electric cables</td>
<td>Being readily to shut down</td>
</tr>
<tr>
<td>Equipment cooling water supplies</td>
<td>Having emergency crew standing by</td>
</tr>
</tbody>
</table>

**Note:**
- Generally, Lifting operations over live facilities should be avoided at all times.
- Only in exceptional circumstances will this restriction be lifted, but strict procedures should be followed and there should be additional controls in place.

---

### Lift Plan Development

**POST LIFT REVIEW**

After the Lift Review, inspect and update.

---

### Personnel Transfer Carriers

**The Reflex Marine "FROG"**
Man Riding Carriers

Man riding carriers should only be used when the particular circumstances make it essential.

- Transfer personnel by less hazardous means (MEWP)

Duty holders and operators need to have clear written risk assessments and procedures which cover all aspects of personnel transfer operations, including effective communication.

Only approved lifting equipment, which has been marked as suitable for man riding or suitable for personnel transfer should be used.

Hoist System
Two hydraulic motor for below drum

Choose outrigger placement positions with particular care. Be particularly careful in all aspects of the operations.

Master links must be used for single point lifts.
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Synthetic Rope

Spooling and Reeving

Left Lay - Left Hand
- Underwind Left to Right
- Use Left Lay Rope
- Underwind Fasten on Left

Right Lay - Right Hand
- Overwind Left to Right
- Use Right Lay Rope
- Overwind Fasten on Right

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Twists (Hook Block)

Should a twist in the hoist rope occur, remove hoist rope anchor point and twist the anchor point in the opposite direction to the twist in the rope the same number of turns as were originally in the hoist rope. Attach hoist anchor point and check again for twisting. Repeat procedure if necessary.
Factor of Safety

Mobile Crane Hoist
Rope 4.5:1 – 6:1

FALLS OF ROPE

To work out maximum weight per fall of rope
divide maximum capacity of the crane to
maximum falls of rope

| Falls of Rope | Weight Calculation | Weight
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>25 / 9</td>
<td>25 / 9 = 2.7</td>
<td>2.7 x 2.7 = 18.9 ton</td>
</tr>
<tr>
<td>70 / 12</td>
<td>70 / 12 = 5.8</td>
<td>5.8 x 10 = 58.0 ton</td>
</tr>
<tr>
<td>21 / 7</td>
<td>21 / 7 = 3.0</td>
<td>3.0 x 4 = 12.0 ton</td>
</tr>
</tbody>
</table>
Choose a hook and parts of line suitable for the mass of the load from the rated lifting capacity table.

Hook Check for
- Damage
- Cracks
- Nicks or twist
- Gouges
- Deformity of the throat opening
- Wear on saddle or load bearing point
- Refer to the manual furnished by the original manufacturer of the crane or hoist.

Hook Latch
Check that hook latch, if provided, is not missing and that it operates properly.
Proximity Hazards

Weather Conditions – Wind

Refer to manufacturers instructions

Mobile Cranes: 9.8 m/s or 7.0 m/s (man riding work)
Crawler Cranes: 14 m/s

The speed of a gust is the average value of the wind speed measured for a duration of 3 seconds. The gust speed is higher than the average wind speed, which is measured over a period of 10 minutes.

Beaufort Scale

<table>
<thead>
<tr>
<th>Beaufort Scale</th>
<th>Wind Speed (m/s)</th>
<th>Severity Level</th>
<th>Effects on Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Under 1</td>
<td>Calm</td>
<td>Gentle breeze</td>
</tr>
<tr>
<td>1</td>
<td>1 – 3</td>
<td>Light Air</td>
<td>Light breeze</td>
</tr>
<tr>
<td>2</td>
<td>4 – 7</td>
<td>Light Breeze</td>
<td>Light breeze</td>
</tr>
<tr>
<td>3</td>
<td>8 – 12</td>
<td>Breeze</td>
<td>Breeze</td>
</tr>
<tr>
<td>4</td>
<td>13 – 16</td>
<td>Fresh breeze</td>
<td>Fresh breeze</td>
</tr>
<tr>
<td>5</td>
<td>17 – 20</td>
<td>Strong Breeze</td>
<td>Strong Breeze</td>
</tr>
<tr>
<td>6</td>
<td>21 – 30</td>
<td>Moderate Gale</td>
<td>Moderate Gale</td>
</tr>
<tr>
<td>7</td>
<td>31 – 40</td>
<td>Fresh Gale</td>
<td>Fresh Gale</td>
</tr>
<tr>
<td>8</td>
<td>41 – 50</td>
<td>Strong Gale</td>
<td>Strong Gale</td>
</tr>
<tr>
<td>9</td>
<td>51 – 60</td>
<td>Gale</td>
<td>Gale</td>
</tr>
<tr>
<td>10</td>
<td>61 – 72</td>
<td>Whole Gale</td>
<td>Whole Gale</td>
</tr>
<tr>
<td>11</td>
<td>73 – 85</td>
<td>Storms</td>
<td>Storms</td>
</tr>
<tr>
<td>12</td>
<td>86 and Higher</td>
<td>Hurricane Force</td>
<td>Hurricane Force</td>
</tr>
</tbody>
</table>

Maximum

Cock, tree leaves rustle, paper in sky, waves on water
Waves and tides are subject to wind, cause small waves on water
Gale
Great trees begin to creak
Large branches of trees in motion
Choking branches are moved by the wind
Large branches are moved, fence rails may bend

Cock, tree leaves rustle, paper in sky, waves on water
Gale
Large trees begin to creak

Cock, tree leaves rustle, paper in sky, waves on water
Gale
Large trees begin to creak

Cock, tree leaves rustle, paper in sky, waves on water
Gale
Large trees begin to creak

Cock, tree leaves rustle, paper in sky, waves on water
Gale
Large trees begin to creak

Cock, tree leaves rustle, paper in sky, waves on water
Gale
Large trees begin to creak

Cock, tree leaves rustle, paper in sky, waves on water
Gale
Large trees begin to creak

Cock, tree leaves rustle, paper in sky, waves on water
Gale
Large trees begin to creak

Cock, tree leaves rustle, paper in sky, waves on water
Gale
Large trees begin to creak

Cock, tree leaves rustle, paper in sky, waves on water
Gale
Large trees begin to creak

Cock, tree leaves rustle, paper in sky, waves on water
Gale
Large trees begin to creak

Cock, tree leaves rustle, paper in sky, waves on water
Gale
Large trees begin to creak

Cock, tree leaves rustle, paper in sky, waves on water
Gale
Large trees begin to creak

Cock, tree leaves rustle, paper in sky, waves on water
Gale
Large trees begin to creak

Cock, tree leaves rustle, paper in sky, waves on water
Gale
Large trees begin to creak
Wind on Suspended Loads

Wind can have a significant effect on suspended loads:

- Increase in the load radius or side loadings on jibs.
- The aerodynamic drag on the load.
- The area and weight of the load.

Mobile cranes are designed with a standard drag factor of 1.2 and a wind area/weight of 1.2 m²/tonne.

<table>
<thead>
<tr>
<th>Load</th>
<th>Drag Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard values (EN1090)</td>
<td>1.2</td>
</tr>
<tr>
<td>12tn Container Cables</td>
<td>1.35</td>
</tr>
<tr>
<td>Tackle &amp; Swivel Head (1m high x 1tn wide)</td>
<td>1.4</td>
</tr>
<tr>
<td>Wind Turbine Rotor</td>
<td>1.5 to 1.8</td>
</tr>
</tbody>
</table>

This means that certain types of loads will produce higher side loads on the crane than it is designed to take.
Resistance Coefficient (See BS7121)

\[ C_W = \text{Resistance Coefficient} \]

Wind Speed on Charts

\[ 2.5 \times 8 = 20 \text{m}^2 \]

\[ 1.2 \times 15.5 = 18.6 \]

\[ 20 \times 1.4 = 28 \text{ (wind load Area m}^2\text{)} \]

\[ 18.6 + 28 = 0.6643 \]

\[ \sqrt{0.6643} = 0.81504 \]

\[ 0.81504 \times 12.8 = 10.43 \text{ m/s (Maximum wind speed)} \]
Power Lines

Recommended Safe Distances
You must not allow any part of your equipment to enter the EXCLUSION ZONE

- 400 KV
- 132 KV
- 33 KV – 11 KV
- Low Voltage
- Under 1 KV

Electricity can Arc over large distances

PROXIMITY HAZARDS

you can receive a shock even if the crane does not actually touch the cables.

Fully Extended Jib Length + 9 m
PROXIMITY HAZARDS

Keep a safe distance between the machine and the power cables.

Fully Extended Jib Length + 15m

Goal Posts

Bunny Hop Minimum 15 mts
PROXIMITY HAZARDS

- Electricity GS6
- Structures
- Other cranes
- Stacked goods
- Public access areas
- Highways - relevant authority
- Railways - relevant authority
- Rivers - relevant authority
- Services
- Airfields

Communication

What is it?

Relaying messages by Verbal Hand, Radio
Correct signals are pre-determined at the Tool-Box talk before the task begins.

Signals should be clear and not confuse the operator or other people in the area
Hoist

Hoist Slowly

Lower
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Operations Cease

While driving you are subject to the Road Traffic Regulations. Any offence committed could lead to a fine, penalty points or disqualification.

Know the area in which you are working. Familiarize yourself with work site obstructions and other potential hazards. Use caution when in the vicinity of overhanging banks or edges.
Stay alert when operating

Check load limits of bridges, dock plates, manhole covers etc.

Never reverse on site without the assistance of a banksman
When parking on slopes chock the wheels.
WHAT IS THE MOST IMPORTANT ACTION THAT THE APPOINTED PERSON MUST HAVE THE AUTHORITY AND BE PREPARED TO DO

STOP THE JOB
There are some load considerations affecting the choice of lifting gear for each lifting operation:

- Weight of the load
- Position of centre of gravity (CoG) of the load

Weight of the load can be established in the following ways:

- Weight is marked on the load
- Weight is indicated on documentation (e.g. shipping documents)
- Weight is indicated on drawings
- Weight can be identified using scale/load cell
- Weight can be estimated by a competent person
We will look at how to estimate various types of load configuration and their weight and what kind of information is required. In order to calculate it properly we need to know the density of materials. Please note that the density may vary depending on water content (some material may be saturated with water), contamination, decomposition etc. Therefore we can only estimate it – never assume that it will be precise calculation. There is a table of Densities of Materials on the next slide recommended by BS 7121-3:2000.

### Densities of Materials
(BS 7121-3:2000)

<table>
<thead>
<tr>
<th>Material</th>
<th>Density (kg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>2700</td>
</tr>
<tr>
<td>Brass</td>
<td>8500</td>
</tr>
<tr>
<td>Brick</td>
<td>2100</td>
</tr>
<tr>
<td>Copper</td>
<td>8800</td>
</tr>
<tr>
<td>Concrete</td>
<td>2400</td>
</tr>
<tr>
<td>Earth</td>
<td>1600</td>
</tr>
<tr>
<td>Iron - Steel</td>
<td>7700</td>
</tr>
<tr>
<td>Lead</td>
<td>11200</td>
</tr>
<tr>
<td>Oil</td>
<td>800</td>
</tr>
<tr>
<td>Water</td>
<td>1000</td>
</tr>
<tr>
<td>Wood (soft)</td>
<td>350 to 1000</td>
</tr>
<tr>
<td>Wood (hard)</td>
<td></td>
</tr>
</tbody>
</table>

In order to estimate the weight of the load first of all we need to determine its volume. There are various forms of load can be encountered within the lifting industry:

- Basic forms – easy to calculate the volume
- Complex forms – need to be carefully calculated

Following formulae can be used for volume determining:

**NOTE:**
Always ensure that all measuring units are the same, i.e. all dimensions are in meters.
Basic Shapes

Area

To get a squared area we need to multiply its Length by the Width, i.e. \( S = L \times W \)

Rectangular Prism (Cuboid)

To get the volume of a rectangular prism (cuboid) we need to multiply its Length by the Width and by the Height, i.e. \( V = L \times W \times H \)

Solid Cylinder

To get the volume of a solid cylinder we need to multiply the number \( \pi \) (Pi) by cylinder's squared Radius and by its Length, i.e. \( V = \pi \times R^2 \times L \)

Note: \( \pi \) is a mathematical constant (never changes) and equals to 3.14
To get the volume of a rectangular base pyramid we need to multiply the area of the base by the Height and divide by 3, i.e.
\[ V = \frac{1}{3} L \times W \times H \]

To get the volume of an irregular cuboid we need to cut this object into rectangular prisms (cuboids) and then calculate the volume of each separately and just add the results at the end.

The calculation process is the same – cut it into sections and calculate each separately with adding outcomes at the end.
Channel Beam

The calculation process is still the same – cut it into sections and calculate each separately with adding outcomes at the end.

I (or H) Beam

The calculation process is still the same – cut it into sections and calculate each separately with adding outcomes at the end.

Hollow Tube (pipe)

To get the volume of a hollow tube we need to multiply the number \( \pi \) by a difference of squared Radii (inner from outer) and by its Length, i.e.

\[
V = \pi \times (R_0^2 - R_i^2) \times L
\]
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Rough calculation of motor’s volume can be done as shown on sketch

Calculation Exercises

Calculate the approximate weight of the steel plate with given dimensions

\[ V = 3.5 \times 1 \times 0.05 = 0.175 \text{ m}^3 \]
Plate weight = \( 0.175 \times 7700 = 1347.5 \text{ kg} = 1.35 \text{ te} \)

Calculate the approximate weight of the concrete block with given dimensions

\[ V = 4 \times 1.2 \times 1.8 = 8.64 \text{ m}^3 \]
Block weight = \( 8.64 \text{ m}^3 \times 2400 \text{ kg/m}^3 = 20,736 \text{ kg} = 20.74 \text{ te} \)
Calculate the approximate weight of the **brass** cylinder with given dimensions:

\[ V = \pi \times 0.0625 \times 10 = 1.9625 \, \text{m}^3 \]
\[ \text{Cylinder weight} = 1.9625 \, \text{m}^3 \times 8500 \, \text{kg/m}^3 = 16681.25 \, \text{kg} \]
\[ \text{Cylinder weight} = 16.69 \, \text{te} \]

Calculate the approximate weight of the **aluminum** pipe with given dimensions:

\[ V = 3.14 \times (0.35 - 0.3) \times 12 = 1.2246 \, \text{m}^3 \]
\[ \text{Pipe weight} = 1.2246 \, \text{m}^3 \times 2700 \, \text{kg/m}^3 = 3306.42 \, \text{kg} = 3.31 \, \text{te} \]

Calculate the approximate weight of this irregular cuboid made up of **soft wood** with given dimensions:

This figure is made from two cuboids with dimensions:

- First cuboid: 4m x 3.8m x 9m
- Second cuboid: 5m x 3.8m x 6.2m

Volume of first cuboid = 4 x 3.8 x 9 = 141.6m³
Volume of second cuboid = 5 x 3.8 x 6.2 = 117.8m³
Total volume of both cuboids = 45.8m³ + 117.8m³ = 163.6m³

Wooden cuboid weight = 163.4 m³ x 350 kg/m³ = 57790kg = 57.79te
Centre of Gravity (CoG) – is the point about which all parts of the load (body) exactly balanced against each other

To ensure safety of the lift the hook of lifting appliance should be positioned above the CoG

Estimation for basic shapes is straight forward, e.g. the CoG of a straight pipe can be found just by measuring a midpoint in each direction

For complex shapes usually CoG of subdivided parts is estimated and then combined CoG is found

In any case the determined CoG should be marked in some way, e.g. sticky tape, marker, chalk etc

On following slides we will have a look on some examples of CoG estimation

Just measure the midpoint from each end
Always ensure that the load is equally balanced

Below is an example:
- Divide the whole figure into separate cuboids
- Define CoG of each separate cuboid and estimate their weight
- Measure the distance from one end of the whole figure to each separate CoG
To determine the unknown CoG – X use the following formula:

\[(WA + WB + WC) \times Z = L1 \times WA + L2 \times WB + L3 \times WC\]

or

\[(2+1+1) \times Z = 1 \times 2 + 5 \times 2.5 + 1 \times 4\] following \(8Z = 18.5\)

\(Z = 18.5 / 8\) following \(Z = 2.3\)

Same process should be done for all other planes to find out CoG’s precise position.

There is another method of CoG calculation:

After breaking the whole figure into separate sections determine their CoGs.

After making a triangle by connecting all CoGs the combined CoG will be somewhere within this triangle.

Let see how it can be estimated on next slides.

We need to find a combined CoG between two separate sections:

The combined CoG will be closer to heavier part, therefore:

\[\frac{WB}{(WB + WA)} = \frac{8000}{8000 + 2000} = 0.8 = 80\%

The same should be done with another section and already found combined CoG.
The combined CoG will still be closer to heavier part, therefore:

\[
\frac{(WA + WB)}{(WA + WB + WC)} = \frac{10000}{10000 + 2000} = 0.83 = 83\%
\]

When more sections involved the same process should be conducted until all sections covered and main CoG is found.

This can be marked on the load by chalk or marker.

### Tension in each leg

- At 0° Vertical: 4 Te in each Leg
- At 90° Angle: 5.6 Te in each leg
- At 120° Angle: 8 Te in each leg
- At 151° Angle: 16 Te in each leg
- At 171° Angle: 48 Te in each leg

### SWL at different angles

<table>
<thead>
<tr>
<th>Angle</th>
<th>SWL Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0°</td>
<td>SWL of one sling x 2</td>
</tr>
<tr>
<td>30°</td>
<td>SWL of one sling x 2 x 0.966</td>
</tr>
<tr>
<td>60°</td>
<td>SWL of one sling x 2 x 0.866</td>
</tr>
<tr>
<td>90°</td>
<td>SWL of one sling x 2 x 0.707</td>
</tr>
<tr>
<td>120°</td>
<td>SWL of one sling x 2 x 0.5</td>
</tr>
<tr>
<td>151°</td>
<td>SWL of one sling x 2</td>
</tr>
<tr>
<td>171°</td>
<td>SWL of one sling x 1.80</td>
</tr>
<tr>
<td>180°</td>
<td>SWL of one sling x 1.75</td>
</tr>
<tr>
<td>195°</td>
<td>SWL of one sling x 1.414</td>
</tr>
<tr>
<td>210°</td>
<td>SWL of one sling only</td>
</tr>
</tbody>
</table>
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Recommended Maximum Included Angle

- 45°
- 90°

Max Lift = 3t x 0.707 x 3 = 6.3t

90° Max between any 2 adjacent legs

Max Lift = S.W.L. of one sling x 0.707 x 3 = 3t x 0.707 x 3 = 6.3t

90° Max between any 2 diagonally opposite legs

Max Lift = S.W.L. of one sling x 0.707 x 3 = 3t x 0.707 x 3 = 6.3t

When the weight is equally distributed between lifting points, the tension will be the same for each sling if they are used at the same angle.
When the weight is not evenly distributed between lifting points, the slings and fittings will not have the same tension.

Leg 2 is closer to the COG and therefore has the more tension.

\[
\text{Leg 1} = \frac{5 \times 3}{3 + 7} = 1.5 \text{t}
\]

\[
\text{Leg 2} = \frac{5 \times 7}{3 + 7} = 3.5 \text{t}
\]

If load should be lifted using two single leg slings under the angle, this method could be used to calculate tension on each leg.

\[
\text{Tension 1} = \text{Load} \times \frac{N_2 \times L_1}{H \times (N_1 + N_2)}
\]

\[
\text{Tension 2} = \text{Load} \times \frac{N_1 \times L_2}{H \times (N_1 + N_2)}
\]

When length (L) and height (H) are known you can calculate the tension on equipment using the angle factor.

<table>
<thead>
<tr>
<th>Vertical Angle</th>
<th>Length Factor</th>
<th>L/H</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 deg</td>
<td>1.15</td>
<td>2</td>
</tr>
<tr>
<td>50 deg</td>
<td>1.31</td>
<td>1.55</td>
</tr>
<tr>
<td>45 deg</td>
<td>1.41</td>
<td>1.4</td>
</tr>
<tr>
<td>40 deg</td>
<td>1.55</td>
<td>1.3</td>
</tr>
<tr>
<td>35 deg</td>
<td>1.74</td>
<td>1.21</td>
</tr>
<tr>
<td>30 deg</td>
<td>2</td>
<td>1.16</td>
</tr>
</tbody>
</table>
The maximum recommended included angle is 90°.

This angle can be approximately estimated if sling length and distance between lifting points are known.

Most slinging method calculations are based on triangle principle.

Any triangle can be subdivided into separate (smaller) triangles and calculated to find out the side needed.

**Pythagorean Theorem (right triangle)**

- Cathetus – are always shorter sides
- Hypotenuse – is always the longest side

**Pythagorean Theorem**

If you know two of the lengths of a right triangle you can always find the third one:

\[ a^2 + b^2 = c^2 \]

\[ c^2 - b^2 = a^2 \]

\[ c^2 - a^2 = b^2 \]

\[ c = \sqrt{a^2 + b^2} \]
To calculate the length of the sling multiply distance between lifting points to the angle factor.

To calculate the sling length for 4 legged sling, multiply distance between diagonal lifting points to the angle factor.

In order to calculate total slinging height always take into account all equipment used, e.g. Shackles, master link etc.

Some slinging method calculations are based on circumference length (for slinging round loads)

If you know the diameter of your load you can calculate the circumference length using the following formula:

\[ L = 2\pi R \quad \text{or} \quad L = \pi D \]