UNIT 8 SAFEGUARDING OF MACHINERY

Structure

8.1 INTRODUCTION

Machines can significantly improve production and efficiency. But they do not come without risks. This unit is designed to focus on what mechanical operations mean and the various hazards connected to mechanical operations.

We shall then take up the study of one mechanical operation - cranes in detail, to provide an overall insight on safety in mechanical operations.

Objectives

After studying this unit, you will be able to:

- categorise mechanical operations;
- appreciate the need for safety in mechanical operations;
- enlist the types of cranes
- describe the safety factors to be observed in crane operations;
- recognise the importance of safe loading in operations of cranes

8.2 MECHANICAL OPERATIONS AND SAFETY

Mechanical operations can be broadly categorised into the following sections:

- Mechanical Design.
- Manufacturing.
- Biomedical and Engineering Fluid Mechanics.
- Combustion and the Environment.
- Ground Vehicle and other transportation Systems.
- Heat Transfer, Thermodynamics and Energy Systems.
- System Dynamics and Control.

The hazards involved in the various types of mechanical operations mentioned above cannot be individually tagged to each operation and often overlap. For example the hazard of a moving machine part not provided with proper guard, can come under the categories of Design, Manufacturing and Transportation.

So we shall broadly mention the hazards that may occur in general during mechanical operations and the safety measures needed for them. To provide further insight on safety of mechanical operations we shall discuss one operation in particular and safety measures connected to it, in detail.

Key risk areas in mechanical operations and safety measures needed for them can be broadly categorised as follows:

- Winding equipment – Safety precautions for winding euipment include suitable guards covering high speed rotating parts and general electrical safety.
- Diesel engine systems – Safety measures for diesel engine systems include safety against toxic fumes, heated pipes and parts and high speed rotating parts.
- Welding– Wearing protective gloves and clothing, using proper screen and protection from electrical hazards is required for safe operations during welding.
- High pressure hydraulic equipment – Making sure that safety valves in the system are always in working order, few routine checks like oil level, leak, clogging filters, hoses defects, hydraulic piping and connections, abnormal noise pump etc. should be the primary safety measures.
- Metal cutting operations - To ensure safety avoid wearing loose garments and using rags near running machines, wear goggles to avoid flying metal chips, stop the machine before cleaning chips or when you are away and never try to free a stalled cutter without turning the power off first.
- Mobile and transportable equipment – We shall discuss the safety measures for mobile and transportable equipment in detail with the help of the example of cranes.

8.3 HAZARDS OF WORKING WITH CRANES

Cranes are the typical example of mobile and transportable equipment used in the industry for lifting and shifting heavy loads and are quite prone to accidents.

Many a times, accidents involving tower cranes have resulted in serious injuries and even deaths. Hence, while using cranes and other lifting equipment at work, being aware of the hazards and knowing what steps one can take to reduce risk is crucial to ensuring safety of the workmen, equipment and workplace.

Common Crane Hazards:

Working with cranes poses many hazards, and unsafe working practices can result in injuries, fatalities and costly damage to buildings, equipment and materials. Therefore, it's important to be aware of the main hazards and how to avoid them.

Some of the main hazards include:

i) Falling Loads

When working with overhead cranes, falling loads are one of the most common, and most dangerous, hazards. A falling load can result in several injuries, fatalities and significant structural damage to buildings and property. Additionally, it will also lead to significant time and money costs.

Falling loads from an overhead crane could be the result of:

- **Operator incompetency.** One must ensure that the workmen are adequately trained so that they are able to carry out their roles competently and safely.
- **Slipping.** If the loads are not secured properly it can result in slipping of material.
- **Mechanical failure.** The risk of mechanical failure can be reduced if a competent person carries out routine inspections, maintenance and repairs at suitable intervals.
- **Two blocking.** Two blocking occurs when an uppermost hoist line component (i.e the load block, hook block, overhaul ball) touches the upper block, boom tip or similar component. When two blocking occurs, increased tension is placed on the line which can result in falling of loads or crane components.

ii) Electrical Hazards

Around 50% of accidents involving overhead cranes are a result of a metal part of a crane coming into contact with a power source (i.e a high-voltage power line). There's a risk of a crane's hoist line or boom touching energized power lines when moving materials nearby or underneath. While those directly touching the crane are the most likely to be electrocuted, anything in the vicinity is also at risk. Therefore, one accident can result in multiple deaths and injuries. Fatalities are also the result of contact with power lines, so it's crucial that pre-job planning is carried out prior to starting work.

iii) Crane Overload

The majority of crane structural failures and upsets are the result of somebody overloading a crane. Exceeding a crane's operational capacity may subject it to structural stresses and cause irreversible damage.

Crane overload may be caused due to the following reasons**:**

- Swing or suddenly drop loads - Sudden swinging of heavy loads at a height can topple the crane altogether and cause serious damage to life and property. Dropping of heavy loads from a height can also cause damage.
- Hoist loads beyond the cranes capacity - Electric Overhead Traction (EOT) cranes are mostly used in shop-floors. Often weight of the load to be lifted and moved is not known and people tend to overload the crane in an attempt to maintain the workflow. Such practises often lead to disaster.
- Mobile cranes are largely used outdoors. Again the tendency to manage with the available resources at site leads to overloading of cranes, often with fatal consequences. One may follow the cranes' rated load while loading but may find the hanging hook to be under-rated and may take the risk which may soon turn into a disaster.

- Use defective components – Sometimes there may be a tendency to manage things in any possible way often ignoring the safety aspect. It is the responsibility of a safety engineer to change such habits and provide the right resources. A simple defective component in a crane, like a worn out tyre or a badly welded joint in the lifting system can be dangerous.
- Dragging or side-pulling loads – Loads are always meant to be lifted vertically by cranes. However, to accommodate working conditions operators sometimes drag or side-pull loads. This is a very dangerous practise as when the load finally leaves the ground it can swing and cause a lot of damage to life and property including toppling of the crane itself.
- Not paying enough attention to the loading chart provided on the body of the crane – That crane operations require a lot of safety precautions is established by the fact that all cranes have very clear loading chart and instructions fixed to the body of the crane in a visible location where it is least likely to be damaged. This chart is particularly important for mobile cranes. One needs to pay enough attention and study the chart before loading the crane.

SAQ 1

a) Name and explain the key risk areas in mechanical operations.

b) What are the main hazards in crane operation?

8.4 TYPES OF CRANES

A crane is a tower or derrick that is equipped with cables and pulleys that are used to lift and lower material. They are commonly used in the construction industry and in the manufacturing of heavy equipment. The top 7 types of cranes are normally temporary structures, either fixed to the ground or mounted on a custom-built vehicle.

They can either be controlled from an operator in a cab that travels along with the crane, by a push button pendant control station, or by radio type controls.

Types of Cranes Used in Industry

i) Mobile Cranes

Mobile Cranes are the most standard and versatile type of cranes used in construction and other industries. The Figure of mobile crane is shown is Figure 8.1. The mobile hydraulic crane consists of a steel truss or telescopic boom mounted on a mobile platform, which could be a rail, wheeled, or even on a truck. The boom is hinged at the bottom and can be either raised or lowered by cables or hydraulic cylinders.

Figure 8.1: Mobile Cranes

What makes this crane so versatile is its footprint and mobility. In construction situations, it can sometimes be difficult to get close to where you need to hoist the materials. Moving a crane into a position that allows it to lift the material with the correct crane capacity is effected by the footprint of the crane. The foot print is the area required to have the crane set up its outriggers into position that allows it to hoist the material while remaining inside the crane chart requirements.

ii) Telescopic Crane

Telescopic cranes offer a boom that consists of a number of tubes fitted one inside the other. Telescopic crances are shown in Figure 8.2.

Figure 8.2: Telescopic Cranes

A hydraulic mechanism extends or retracts the tubes to increase or decrease the length of the boom. Most construction cranes today are in some form, a telescopic crane, except for the Lattice boom crane (picture below) that has a frame of steel structure which is bolted together to get the right height for the hoist. The Lattice Boom Crane is shown in Figure 8.3.

Figure 8.3: Lattice Boom Crane

iii) Tower Crane

The tower crane is a modern form of a balance crane. Tower crane is shown is Figure 8.4. When fixed to the ground, tower cranes will often give the best combination of height and lifting capacity and are mostly used when constructing tall buildings.

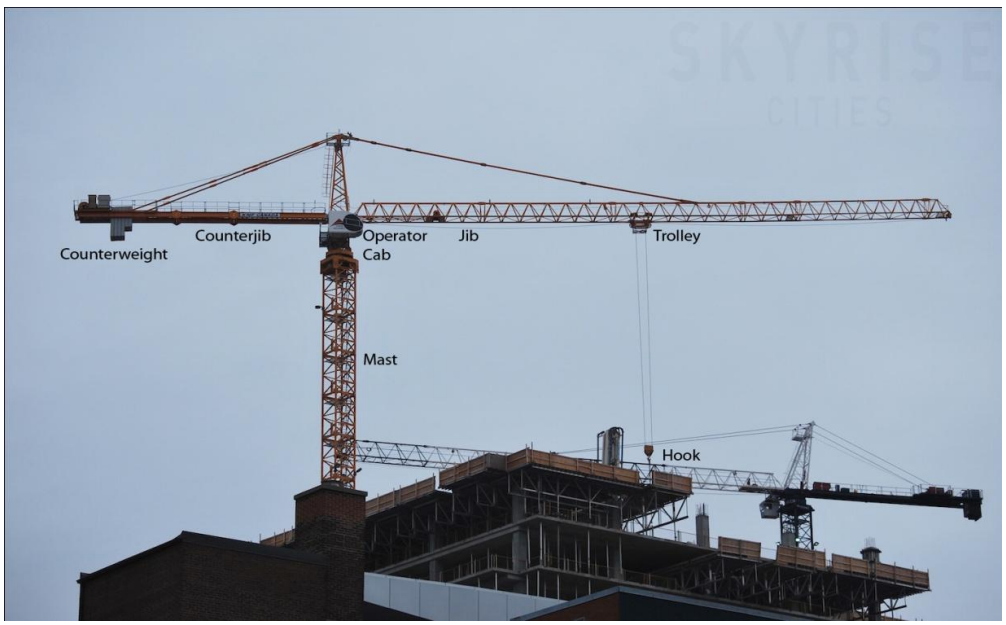

Figure 8.4: Tower Crane

Some large tower cranes reach up to 1000 meters high. With an average floor dimension of a high rise equalling 3.5 meters/floor, it equals to a 285 story building! One important thing to note about tower cranes, as they construct past a specific height is that it is mandatory to have the tower crane secured to the building to help prevent crane sway and crane tipping.

iv) Truck Mounted Crane (Also Known as Boom Truck or Picker Truck)

Boom trucks (Figure 8.5) or picker trucks are cranes mounted on a truck with rubber tires and provide great mobility. Outriggers that extend vertically or horizontally are used to level and stabilize the crane during hoisting. The capacity of these cranes rarely exceed 50 tons. As mentioned above, their versatility is found in their mobility and reach.

Figure 8.5: Boom Trucks

v) Rough Terrain Crane

A rough terrain crane (Figure 8.6) is a crane that is mounted on an undercarriage with rubber tires, designed for operations off road.

Figure 8.6: Rough Teerrain Craine

The outriggers extend vertically and horizontally to level and stabilize the crane when hoisting. These types of cranes are single engine machines where the same engine is used for powering the undercarriage as it is for powering the crane. These cranes are ideal for construction sites that have uneven, dirty and rocky terrain. The mobility and ability of the crane to

travel around the site make it an effective support crane for lighter hoists on highway, construction and infrastructure projects.

vi) Loader Crane (Also Known as a Folding Boom Crane)

A loader crane (Figure 8.7) or a folding boom crane is a hydraulic powered articulated arm fitted to a trailer, used to load equipment onto a trailer.

Figure 8.7: Loader Crane

The numerous sections can be folded into a small space when the crane isn't in use. Capacity of these cranes have increased dramatically over the years. Presently there are 200 ton capacity loader folding boom cranes in the market today.

vii) Overhead Crane

Figure 8.8: Overhead Crane

An overhead crane, also referred to as an Electric Overhead Traction (EOT) crane, is normally used in a factory, with some of them being able to lift very heavy loads. Larger overhead cranes (also known as goliath cranes or gantry

cranes) can be found in use in shipyards and large outdoor manufacturing plants. The hoist is set on a trolley which will move in one direction along one or two beams, which move at angles to that direction along elevated or ground level tracks, often mounted along the side of an assembly area.

8.5 SAFETY FACTORS TO BE OBSERVED IN CRANE OPERATION

When working with cranes, there will always be hazards. However, one can minimise the risks by taking appropriate precautions while undertaking all operations safely.

To carry out your crane operations safely, you should:

- **Appropriately train all employees.** As an employer or the man-in-charge, one has a legal responsibility to provide appropriate health and safety training to all employees so that they are competent at their jobs. This will increase workplace safety, satisfaction and profits and reduces the chances of injuries, fatalities, accidents and sickness, absence, machine down-time and repair costs.
- **Have a certified operator**. A crane in the hands of an unqualified operator can be a deadly weapon. Riggers should also be properly trained on setting the crane up for the specific load and circumstances.
- **Know what's below**. The most powerful, carefully rigged crane is only as strong and stable as the surface upon which it stands. One should know the classification of soil or other material under the crane, and adjust the setup and load limits accordingly. While many cranes are equipped with outriggers, extending them doesn't necessarily mean that the surface underneath is stable . The pad and float at the end of the outrigger carry a great deal of compression force when the crane is under load. Too much force can cause them to punch through the ground, causing the entire crane to tip.
- It's important to know the load weight and how that is affected by the conditions of the job site. The crane's load chart can help in determining whether the lift will be safe. The allowable load will depend on whether the tires or outriggers are being used, along with other factors. For example, asphalt may seem to be a stable surface, but on a warm day, it may become very flexible. Even concrete may not provide enough strength if there is a void beneath it.
- **Plan for swing**. For cranes, there is something called a swing radius. Swing radius is the distance fom the hanging point to the farthest edge of the mobile. It is this distance atleast that a mobile must be hungfrom a wall or other objects so that the mobile can rotate freely.The counterweight and boom travel within a specific arc is also called the swing radius. It's important to ensure that the area within that radius is barricaded off, and to establish a control zone for those authorized to work in the immediate area. It prevents personnel from being struck or crushed by the crane. The barricade must include the maximum swing radius of the counter weight which is past the main body of the crane. Also check the area every day to ensure that there are no objects that the boom may fowl with, such as

power lines. If such obstacles exist, one needs to ensure that the operator and other workmen are aware of the plan for avoiding them.

- **Use cranes properly**. Cranes are engineered for vertical lifting. That doesn't stop some crews from trying to use them for side loading or other improper activities. Using a crane to drag something across the ground or from under an obstacle puts extreme stress on the boom, the turn table, and all the structural members. It could potentially weaken key components and lead to their failure. If someone on the site has used a crane improperly, one should ensure that it has been inspected thoroughly to check for damages and impairment.
- **Stay in touch**. Whether one uses radios, air horns, or hand signals, there needs to be clear communication between the operator and other workmen. That's especially critical when a crane is making a lift in which the operator cannot see the load, such as when air handling equipment is being delivered through an opening on another side of a structure. One should not assume that everyone will know how instructions will be communicated. One should build specific guidelines, and make sure that everyone on the site knows exactly what each signal means.
- **Avoid man-baskets**. Sometimes the easiest way to put employees where they're needed is to lift a man-basket to the work area. However, that approach creates hazards that must be tested and addressed before work begins, such as providing proper fall protection, verifying basket capacity, and checking that the basket is properly attached. In addition, the safety of the employees in the basket is entirely dependent on the skill of the operator, and a simple mistake could have tragic consequences. Before using a man-basket, consider whether an articulating boom lift or a scissor lift might provide a safer alternative.
- **Start with a plan**. Each lift is different from another, and it's important to review load weight capacities, the integrity of the equipment, the possible effect of wind, and other factors. The operator, riggers, and other workmen involved with the lift should be part of that planning process.
- **Standing under a crane:** One must ensure that employees know they must not stand under loads and ensure that operators never lift a load over an employee. One must never stand under a crane or have a load lifted over oneself. It's crucial that the employees are aware of this and avoid walking through any zones where cranes are overhead.
- Know, understand and comply with the Lifting Operations and Lifting Equipment Regulations 1998 (LOLER). After all, the standards requiring tag lines on loads, capacity limits, ground stability, and similar factors have all been adopted because incidents, injuries and fatalities demonstrated a need for them. Following those rules and ensuring that the operators and other workmen have the right education, training, and experience will protect everyone involved.
- Carry out routine maintenance and repairs of all on-site equipment at appropriate intervals. Part of one's legal responsibility under LOLER involves carrying out routine, periodic maintenance and repairs to ensure your machinery is in safe working condition. The concerned authorities in the Government issue a fitness certificate to each crane in operation, once a year. It is grossly illegal to operate any crane without this Fitness Certificate.

- Checking the operating functions daily: It's important to check the operating functions daily to ensure that everything is working properly and that there are no defects or cracks in the support chambers. The cranes of a generation ago were made with alloys that could handle overloading and other abuse. Today's cranes use materials that are less tolerant of mishandling. Long time operators are often surprised to discover that the tricks they used to push cranes beyond the limits in the past can easily create very dangerous situations with newer cranes.
- Overhead cranes used in heavy industrial applications such as steel making need to be inspected even more carefully. Many of these cranes spend decades working in extreme environments such as melt shops. That constant exposure to intense heat and temperature swings can cause the beam and other structural members to become brittle and lose strength or even fail.
- Ensure a supervisor is present on site at all times when cranes are in operation.
- Make employees aware of, and strictly enforce your loading and lifting limits.
- Ensure clear warning signals are displayed on-site when needed. One must display the relevant hazard signs in all danger zones on-site to warn your employees of the potential hazards. All the employees must know and understand all the warning signs so that they are aware of when they are entering a danger zone.
- Select appropriate PPE for all employees. Ensure that employees wear appropriate foot, head and eye protection, along with any other PPE that has been identified during risk assessment.

SAQ 2

a) What are the different types of cranes used in the industry?

b) Name and explain the safety factors to be observed during crane operation.

8.6 SAFE LOADING AND OPERATION OF CRANES

A crane capable of operating at variable radii, for example a tower or mobile crane, will have a crane-specific load chart (also known as a 'rated capacity chart') explaining how the crane lifting capacity varies depending on how the crane is set up i.e. how far the boom is extended and the angle of the boom. Using the load chart correctly is critical in ensuring that the crane is used safely.

Where the crane has one main load chart it should be fixed in the operator's cabin in a place that is easy to see and read. Where the crane has more than one load chart, for example for different boom and fly jib configurations, the charts should be easily accessible for the operator to verify that the crane will not be over loaded. The charts may be kept electronically or in hard copy.

The lifting capacity of a crane is generally limited by:

- the structural strength when the working radius is small, and
- its stability when the working radius is greater.

However, there are structural limits at both the minimum and maximum working radius. If a crane is over loaded, a structural or mechanical component of the crane may fail, or the crane may overturn. The lifting capacities specified on a load chart should not be exceeded except during testing of the crane by a competent person under controlled conditions.

Each load chart should include enough information to identify the crane configuration it applies to.

For example:

- the safe working zone
- the counter weight mass
- whether a fly jib is fitted, in use, in place or stowed
- outrigger extension or pick-and-carry mode
- maximum speed for making a load mobile
- rope and reeving details, including number of falls of rope in the hook block
- main or auxiliary hoist in use, and
- whether the hook block is included or excluded.

Some important factors which are often overlooked when reading load charts are:

- Subtracting the mass of the hook block and lifting slings from the capacity of the crane at the particular radius. This should be noted on the load chart. For example, if the load chart states the crane can lift 20 tonnes at a given radius but the hook and lifting gear have a combined mass of a ton, the load to be lifted cannot be more than 19 tonnes. This issue is critical for heavier hook blocks and lifting gear, for example spreader beams.
- Subtracting the mass of the fly jib (adjustment mass) from the capacity of the main hook when lifting from the main hook on the main boom with a fly jib attached to the boom head. This adjustment mass should be noted on the load chart—there may be two different masses for some cranes with swing around fly jibs—one for the fly jib in place and another for the stowed position. Capacities of the main boom are generally based on the fly jib being removed. If this issue is ignored, the crane is likely to overturn.
- The increased maximum working radius that may result when using a fly jib.

8.6.1 Limiting and Indicating Devices

Limiting and indicating devices, for example rated capacity limiters, motion limiting devices, load indicators and radius indicators are intended to prevent a crane moving beyond its safe operating limits or to aid crane operators. The devices should not be relied on in place of using the crane's load chart and operating instructions. Sole reliance on these devices, especially indicating devices, in place of safe operating practices may cause an incident. Where limiting and indicating devices are to be installed on a crane the safety circuits of these devices should generally meet either:

- a reliability level of Category 4 under AS 4024.1-2006: Safety of machinery, or
- a safety integrity level (SIL) of 3 under AS 61508-2011: Functional safety of electrical/electronic/programmable electronic safety-related systems.

These categories of reliability level and SIL are related to the concept of 'fail safe'.

8.6.2 Free Fall Lock-Out

When a crane is fitted with a free fall facility this function should be able to be positively locked out and not able to be unintentionally activated.

8.6.3 Operator Protective Devices

Suitable operator protective devices must, so far as reasonably practicable, be provided for powered mobile plant including cranes. Typically these include FOPS and operator restraints e.g. seat belts. A roll-over protective structure (ROPS) may also be an appropriate device for some types of cranes.

8.6.4 Choosing the Right Location

You should choose where to site a crane during the planning phase after considering relevant factors including:

- the risk of the crane overturning or collapsing from the foundations or supporting structure failing
- crane and foundations/supporting structure combination not being able to withstand the forces likely to be imposed on it after loading
- the risk of the crane colliding with other plant, structures or objects at the workplace, and
- the loads and lift paths including the load pickup and drop off or installation locations.

8.6.5 Crane Standing Area

The crane standing design should conform to the crane manufacturer's instructions or a competent person's recommendations, for example an engineer. The crane standing should be designed to withstand the forces likely to be imposed on it by the crane while in-service, out-of-service and during erecting and dismantling. These forces include:

- the dead weight of the crane
- the dead weight of the load and lifting attachments
- dynamic forces caused from the crane moving
- bearing pressure being applied by the crane's outriggers and/or tyres/tracks
- wind loadings, and
- other loads identified by the designer of the crane standing area.

When a crane is to be supported on, or tied to a permanent or temporary structure, the design of the structure should be capable of with standing the forces designed to be imposed on it by the crane. Precautions should also be

taken to ensure the stability of the crane when the crane will be sited near underground services, excavations or embankments.

8.6.6 Collision Between the Crane and Other Plant and Structures

If there is a possibility of cranes colliding with other plant or structures they should be positioned so the clearance between the crane and its load and other plant, structures and workmen minimises the risk of collision. Where cranes are operating near one another they may share the same air space. The people in each work area should consult and develop safe systems of work to make sure there is enough space between the cranes and where they work. Each work area should nominate a person to implement the safe system of work. A safety observer (also known as a 'spotter') should be used where a collision between a crane and other plant or structures are likely to occur.

Where cranes are set up in or near flight paths, one should contact the local airport operator to find out where these are in the area where the crane is operating. Where necessary, aircraft warning lights should be fitted to the highest part of the crane.

8.6.7 Working Near Electric Lines

It must be ensured, so far as is reasonably practicable, no person or crane at the workplace comes within an unsafe distance of an overhead or underground electric line. If this is not reasonably practicable then one must carry out a risk assessment and implement control measures to manage the risks. The control measures must be consistent with requirements of the Electricity Supply Authority.

A safety observer should be used when the crane, its load, or any one working from the plant are in motion and likely to enter a restricted work zone established around electric lines. Electric lines can have significant risks including electrocution, arcing, explosion or fire causing burns, unpredictable cable whiplash and other objects being electrified like signs, poles, trees or branches. Contact with energised overhead or underground electric lines can be fatal regardless of the voltage they carry. It is not necessary to touch an overhead electric line to be electrocuted. A 'flash over' or 'arc' can electrocute when one is close to a live line.

Most risks can be controlled by observing safe working distances for people and cranes working near electric lines. Safe working distances will depend on the type of work being carried out and the voltage of the electric lines. One should contact the relevant Electricity Supply Authority to determine the type of control measures required. This may include isolating the electric line for the duration of the work.

Contact with energised overhead electric lines may have an impact on parts of the crane, for example tyres, hydraulic and electrical systems. If contact occurs, the crane should be immediately placed out-of-service until it has been inspected by a competent person and proven to be safe to resume operation.

8.6.8 Working at a Height

People installing, erecting and dismantling some types of cranes may be exposed to the risk of falling when working at a height. An activity carried out in relation to construction work where a person could fall more than 2 metres is defined as high risk construction work and requires a safe work method statement (SWMS).

To minimise the risk of workmen falling from a height control measures may include:

- temporary work platforms e.g. an elevating work platform
- travel restraint systems
- fall-arrest harness systems, and
- edge protection systems.

8.6.9 Managing the Risk of Falls at Workplaces

Pick and carry activities occur when a mobile crane carrying a suspended load travels with the load (also known as mobiling). Pick and carry activities are only to be carried out with cranes designed for this purpose and in accordance with the manufacturer's instructions. The rated lifting capacity of pick and carry cranes is de-rated by design to take into account the reduced stability when the crane moves across various terrain types. Pick and carry crane manufacturers may also provide a de-rating chart to help determine a crane's rated lifting capacity when working on specified side slopes. Operational risks such as ground conditions, intended travel pathway, and wind speed also need to be considered. Unless otherwise specified by the manufacturer, cranes designed to remain in one location during the lift, for example vehicle loading cranes, are not to be used in a pick and carry mode. When other cranes, for example earthmoving equipment or telescopic handlers are used for pick and carry activities, the manufacturer's instructions or those of a competent person must be followed.

8.6.10 Crane Stability

Failure to maintain stability is one of the key factors associated with serious crane incidents.

Things to consider are:

- crane operation parameters resulting in an overturning moment greater than the stabilising moment of the crane. The crane counterweight generally provides the primary stabilising moment
- the ground conditions and means of supporting the outrigger pads or the crane tyres
- the slope of the ground including both the side slope and the slope of the ground in the direction of the crane travel if the crane has mobile ratings.
- varying wind conditions depending on the size and shape of the suspended load and crane boom, and
- the way loads are lifted or moved e.g. a sudden stop when mobiling a load may cause the load to swing and destabilise the crane. If the crane moves

unexpectedly while mobiling or slewing (moving the load in a radius), the load may swing unexpectedly. Cranes should only be positioned and operated on stable surfaces, designed by a competent person, with the correct bearing pressure and without significant holes or indentations that may cause the crane and load to move unexpectedly due to being unstable. Further information on crane stability is in the Guide to mobile cranes.

8.6.11 Wind Conditions

Winds impose extra loads on a crane and affect the crane's stability. Where wind speeds are greater than those recommended by the manufacturer, crane operations should be stopped and if necessary, the crane should be stowed (retracted to the most stable position).The design wind speed for the crane should be listed in the manufacturer's instructions and marked on the load chart(s). Crane operators should recognise that dependent on the boom length and luffing angle (boom is the long, telescopic or fixed arm that is used to move objects. Luff is the movement of jib of crane vertically to lift a load), the wind speed may be greater at the height of the load compared to the wind speed at the height of the crane's cabin. Also wind gusts have a different effect on the crane than a constant wind. Given these variables, crane operators should make their decision to conduct a lift based on the information provided by the crane manufacturer, advice provided by competent people like an engineer, dogger or rigger.

If the crane operator considers it unsafe to lift the load it should not be lifted until:

- a written authorisation is provided by a competent person confirming the load is safe to lift and how it is to be lifted, or
- the conditions change and the crane operator decides it is safe to make the lift.

8.6.12 Licences to Operate Cranes

A person who operates a crane does not need to be licensed if the work carried out is:

- as a trainee being supervised by a licensed crane operator
- solely for manufacturing, testing, trialling, installing, commissioning, maintaining, servicing, repairing, altering or disposing of the crane
- solely for moving the crane in the workplace where the crane is operated or used without a load except when standard weights with predetermined fixing points are used for calibration and other testing
- limited to setting up or dismantling the crane and the person carrying out the work holds a high risk work licence for rigging which qualifies the person to carry out the work, or
- limited to loading or unloading plant from a vehicle or equipment used to move plant. The person that slings a load, including selecting and inspecting the lifting gear, and/or directs the crane operator in the movement of a load when it is out of the crane operator's view must hold a dogging or rigging licence (excepting for a licensed vehicle loading, bridge or gantry crane operator who can sling loads for the type of crane they are licensed to operate). Regular refresher training is important to

ensure licensed crane operators, doggers and riggers maintain the competencies gained when they undertook their high-risk work licence and understand the cranes they are working with. Refresher training should be conducted as often as necessary to ensure the crane crew continues to work safely.

8.6.13 Driver's Licence Requirements

A mobile crane may be a registered vehicle under state and territory road laws. Like a truck driver, a person must hold a current driver's licence for the class of vehicle before driving a mobile crane on a public road.

8.6.14 Operating and Lifting Procedures

Documenting operating and lifting procedures can help define responsibilities and manage crane activities in a logical and systematic way. Lifting procedures should be prepared to suit the crane, the work and the working conditions. A SWMS will be required for crane work, including work defined as high risk construction work.

Documented lifting procedures may include:

- hazards and risk controls to be applied e.g. for electric lines
- the type of crane or cranes to be used
- the loads to be lifted including the mass of the lifting equipment e.g. slings and spreader beams
- verification that the crane standing will support the maximum ground bearing pressure to be imposed by the crane during operations
- the position of the crane, loads to be lifted and where e.g. a diagram showing a plan view of the site
- the maximum wind speed for the crane and lower wind speeds for specified loads e.g. where the load has a large surface area, for example large pressure vessels and tanks.
- the load working radius range with confirmation the loads are within the crane's capacity at the maximum radius
- allowance for the factors that may require de-rating of the crane e.g. for multiple crane lifts, extra radius caused by tilting of tilt-up panels
- when a spotter is needed e.g. to prevent a collision or contact with overhead electric lines—the tasks required, who is responsible for performing them and what communication system is to be used should also be documented
- the slinging and lifting sequence, and
- the rigging requirements of the job.

8.6.15 Communication

Lack of reliable communication between a crane operator and dogger or rigger may lead to unsafe crane operations and contribute to injury to people from dropped loads and collision with other plant and/or structures. Only one dogger should give signals at a time. Signals may be visual, audible or a combination of both. When more than one dogger is involved in a lift, each dogger should understand when responsibility for their part of the lifting operation should be handed over to another dogger.

Effective communication is particularly important where the crane operator cannot see the load, the load's landing area or the path of travel of the load or the crane make an accurate judgement of distance and see if the crane or the load may contact overhead electric lines or other obstacles. People using radio equipment should be familiar with the manufacturer's operating instructions. A secure dedicated radio frequency should be selected for the duration of the crane operations to prevent interference with other radio equipment being used in the vicinity of the crane. A constant talk method should be used so the people involved are aware of the progress of the lifting operations. Work should stop immediately if there is a loss of radio communication.

Where radio communication cannot be used other ways to communicate including hand signals, bell, buzzer and whistle signals should be used. Mobile phones should not be used for directing mobile crane operations.

8.6.16 Lifting Gear

Lifting gear should be checked before and after use and inspected regularly by a competent person to determine whether it is suitable to keep using.

Checks should ensure:

- the lifting gear is tagged and relevant information listed e.g. relevant information for a chain sling includes grade of chain, rated capacity, manufacturer, chain size and the relevant standard marking.
- lifting hooks are provided with operable safety latches unless a safety latch would increase the risk e.g. a hook on a tea pot ladle at a smelter.
- shackles used as terminal fittings are prevented from unscrewing e.g. mousing.
- lifting eyes and inserts are compatible.
- lifting slings are not damaged e.g. excessive wear, damaged strands, cracks, deformation or severe corrosion, and
- the sling is suitable for the load being lifted including capacity and protection from sharp edges. The manufacturer's requirements for lifting gear should be followed including using protective sleeves and corner pieces. Although the edges of the load may not appear sharp a sling may be damaged when it is placed under tension.

8.6.17 Lifting Materials

Crane-lifted loads should be slung and secured so the load or part of it cannot fall. Tag lines or similar control devices should be used to control loads while being lifted or suspended.

8.6.18 Material Boxes

Material boxes should.

- have the tare mass and working load limit (WLL) clearly marked
- be suitable for the material being lifted and be engineer-designed and certified
- have four slings—one in each corner—attached during lifting

- have enclosed sides or robust mesh with openings less than the minimum size of materials being lifted (specifically designed material boxes should be used to lift smaller components)
- be inspected and maintained and inspection records should be properly kept.
- have loads secured against movement, and not have materials stacked higher than the side of the material box unless they are secured—but at no time should the material box become top heavy.

8.6.19 General Lifting

The following principles should be observed when using cranes for general lifting work:

- Formwork frames should be either tied together, secured in a lifting frame, or lifting slings should be wrapped around the load.
- Loads of pipes, joists, timber or sheeting should be strapped together and lifted in a flat position to prevent individual items from slipping.
- Sheets of plasterboard may be lifted in a specifically designed material box. If a material box is not used then the lifting system should
  - be certified by an engineer or a person who holds an intermediate or advanced rigging licence
  - specify the minimum and maximum number of sheets
  - specify the number and locations of lifting slings, and
  - specify the capacity of lifting slings.
- Tag lines should be used as needed to control loads.
- Loads should be supported where possible with dunnage (loose wood, matting, or similar material) and with the load distributed over the supporting surface.
- Wherever basket hitches are used the sling needs to be positively restrained from sliding along the load.

8.6.20 Lifting People

Except where exempted by the WHS regulations, people should only be lifted by implements designed specifically to lift people, for example elevating work platforms or man-baskets. If it is not reasonably practicable to use implements specifically designed to lift people, a crane-lifted work box may be used to lift workmen to perform minor work for a short amount of time in an elevated work area.

8.6.21 Crane Overload

A crane should never be overloaded. The crane operator or dogger should:

- verify if the marked load mass is correct and not lift a load in excess of the crane's rated capacity
- verify the correct counter weight is correctly mounted and the outrigger settings are in accordance with the load chart being used, and
- control crane movement including mobiling to stop excessive load swing that may overload or topple the crane.

Before lifting a load, the crane operator or dogger should ensure that the hoist rope hangs vertically over the load. Care should be taken to stop the load swinging when lifting the load. The crane operator should always have the load under control when lowering loads or when the load is suspended.

8.6.22 Falling Objects

The risk of falling objects causing injury to workmen and other people must be eliminated, or minimised, including preventing objects from falling freely, or providing a system to arrest the fall of the object. Loads should not be lifted over public access areas including footpaths, roads, highways, railways, waterways and buildings. If there is a risk of people being hit by falling objects control measures like exclusion zones or suitably designed gantries should be used to prevent people being hit by falling objects during lifting operations. Where possible, site access should be restricted to people who are directly involved with crane activities. Movement of people and other mobile equipment at the workplace should be minimised while lifting is taking place.

8.6.23 Exclusion Zones

Exclusion zones should be established around cranes and adjoining areas to stop people entering the area and risk being injured by the crane or falling objects. The size of the exclusion zone should be based on risk assessment. Where the exclusion zone crosses a public footpath or roadway that needs to be closed or an overhead protective structure should be erected. Approvals should be taken from the relevant authority. People should be safely directed to an alternative footpath. Lane closures and other operations requiring barricades and signs to be erected should meet local road authority, local government authorities and relevant building or local laws.

8.7 GENERAL GUIDELINES FOR CRANES

8.7.1 Single Crane Multiple Winch Lifts:

Some single cranes are designed to lift a load using both the main and auxiliary winches. Single crane multiple winch lifts can be undertaken on these cranes in accordance with the manufacturer's instructions. This can occur for example, to rotate a prefabricated concrete panel into its vertical position from a horizontal storage or a position suitable for transport by using two hoist ropes. Even though the concrete panel will be suspended by two hoist ropes, each rope usually needs to support more than 50 per cent of the load during the rotation and one rope will have to support the full weight. Therefore unless each hoist is capable of supporting the full load it is important to use the main hoist to support the full load.

The actual load to be carried by each winch and rope should be calculated and documented by a competent person before the lift commences.

Where a single crane is used for mid-air rotation one should:

- use a crane designed and manufactured for simultaneous multiple winch use
- follow the crane manufacturer's instructions

- if needed, reconfigure the crane before it can be used in this way
- make sure the main winch and auxiliary winch drives are independent
- not exceed the rigging maximum design fleet angle
- rotate as near as possible in line with the plane of the boom to prevent side loading the sheaves
- monitor the load on the main and auxiliary winches separately and simultaneously to avoid overloading either rope and to make sure the combined load of both ropes does not exceed the rated capacity
- not exceed the included angle between the main hoist rope and auxiliary hoist rope by more than 10 degrees, or as determined by the manufacturer or a competent person, unless otherwise specified by the manufacturer, and rotate with enough clearance to make sure the load does not strike the ground, crane or other objects.
- A competent person, for example an engineer should confirm the minimum required capacity of each hoist rope, that is the maximum load placed on each rope during the rotation. Sometimes the auxiliary winch line passes over the 'rooster sheave', the sheave mounted on a short boom extension. Do not overload the rooster sheave as some are not rated for the full line pull of the auxiliary winch and are not suitable for this purpose. Rooster sheaves and the associated rigging on the boom head should be designed and certified by an engineer.

8.7.2 Multiple Crane Lifts

Lifting a load with two or more cranes requires detailed planning and supervision because the movement of the load between the cranes may create extra loadings on the cranes, the load and the lifting gear. The design capacity of a crane will not be the maximum rated capacity but the de-rated capacity relevant to the multi-crane lift to be carried out. The cranes to be used in the lift will need to be de-rated. No load should be lifted simultaneously by more than one crane unless a single crane lift is not practical and the multiple crane lifting method ensures the load placed on each crane does not exceed its de-rated design capacity. Where multi-crane lifts are carried out, a documented lift plan and procedure should be prepared by a competent person, for example an engineer, and followed. The crane de-ratings for each of the cranes used for the multi-crane lift should be identified in the plan. Where it is necessary to lift a load using more than one crane, the person in control of the lift must hold at least an intermediate rigging high risk work licence.

8.7.3 Cranes Used for Demolition

Cranes should not be used for demolition (or wrecking) ball work. If a crane is used for demolition ball work it should be thoroughly inspected and verified by a competent person after the work is complete as being in a satisfactory condition before it is used for general lifting. The results of the inspection must be recorded in the crane's service logbook. Cranes used for demolition work must be fitted with suitable operator protective devices, for example a FOPS, to protect the crane operator. The hoist rope should be prevented from leaving the boom point sheave. This may include fitting heavy duty rope guards to the sheave to control the slack rope condition that may occur as the ball falls—damage is likely where the demolition ball is attached to the hoist rope. Hoist ropes should not be fixed directly to the demolition ball. A length of chain

should be used to join the hoist rope to the demolition ball. The chain should be at least 16 mm and at least 2 metres in length.

8.7.4 Cranes not in Use

A crane may not be in use if it is unattended, parked or stored. You must make sure, so far as is reasonably practicable, a crane that is not in use is left in a state that does not create a risk to the health or safety of a person.

Except in an emergency due to fire or other life threatening reason, the crane operator should never leave the crane cabin or controls while a load is suspended from the crane. A crane should not be left unattended unless:

- loads are removed from the hook or lifting device
- the hook has been secured or raised to a position where it is clear of other operations
- the crane is properly stowed
- powered movements have been disabled, and
- the keys removed or the starting device locked out.

When leaving a mobile crane unattended for a period of time ensure the crane's boom is retracted and lowered as far as possible.

Where there is no risk of a tower crane boom contacting other structures, the crane should be left to weathervane when unattended according to the crane manufacturer's instructions. Where it is necessary to restrict the movement of the boom of a tower crane the method of tethering, that is securing the boom to prevent slewing, should be according to the crane manufacturer's instructions or as determined by an engineer. If a crane is to be stored, it should be prepared to be left unattended and:

- the manufacturer's storage instructions followed
- remote control equipment isolated
- the power supply and controls isolated and locked off
- storm anchors applied, if fitted, and
- doors and windows locked to prevent unauthorised access.

8.7.5 Decommissioning and Dismantling

A crane must be decommissioned or dismantled by a competent person and inspections must be undertaken during the process. A crane should be decommissioned and dismantled according to the manufacturer's instructions.

SAQ 3

a) Briefly state the check points to ensure safe loading of a crane.
b) What precautions are needed when loads are lifted with multiple cranes?
c) Explain the safety measures to be taken when a crane is not in use.

8.8 LET US SUM UP

We have touched upon safety requirements in mechanical operation in general and studied the safe operations of cranes in detail.

We have learnt that:

- Commonly 7 types of cranes are used in the industry, namely,
  - Mobile cranes
  - Telescopic crane
  - Tower crane
  - Truck mounted crane (also known as boom truck or picker truck)
  - Rough terrain crane
  - Loader crane (also known as a folding boom crane)
  - Overhead crane
- The usual hazards of working with cranes are,

  Falling Loads can be caused by,

  - Operator incompetency
  - Slipping
  - Mechanical failure
  - Two blocking

  Crane Overload

  - Swing or suddenly drop loads
  - Hoist loads beyond the cranes capacity
  - Use defective components
  - Dragging or side-pulling. Do not pay enough attention to the loading chart provided on the body of the crane
  - Not following the cranes' rated capacity/loading chart

  Electrical Hazards
- The safety precautions to be taken during crane operations can be summed up as,
  - Have a certified operator
  - Know what's below
  - Plan for swing
  - Use cranes within rated capacity
  - Stay in touch
  - Avoid man-baskets
  - Start with a plan
- How to safely load and operate cranes

  To ensure safe loading of cranes various factors to be considered are,

  - the safe working zone
  - the counterweight mass
  - whether a fly jib is fitted, in use, in place or stowed and the increased mass and maximum working radius that may result when using a fly jib.
  - outrigger extension or pick-and-carry mode
  - maximum speed for mobiling a load
  - rope and reeving details, including number of falls of rope in the hook block

- main or auxiliary hoist in use, and
- whether the hook block is included or excluded.
- limiting and indicating devices in working condition
- suitable operator protective devices
- crane positioned in right location
- crane standing area
- electric lines near operation area
- working at a height
- wind conditions
- communication between operator and ground staff

8.9 KEY WORDS

Crane Hazards: while with cranes poses many hazards, and unsafe working pratices can result in injuries, fatalities and costly damage to buildings, equpment and materials.

Falling Loads: while working with overhead cranes, falling loads are one of the most comon, and most dangerous, hazards.

Electric Overhead Traction (EOT) : an overhead crane, also referred as an crane, is normally used in factory, with some of them being able to lift very heavy loads.

Crane overload: the majority of crane structural failures and upsets are the result of somebody overloading a crane.

Mobile crane: the most standar and versatile type of cranes used in construction and other industries.

Telescopic cranes: offer a boom that consists of a number of tubes fitted one insdie the other.

Tower crane: it is a modern form of a balance crane.

Boomtrucks or picker trucks: these are cranes mounted on a truck with rubber tires and provide great mobility.

Rough terrain crane: it is crane that is mounted on an undercarriage with rubber tires, designed for operations off road.

Loader crane: a folding boom crane is a hydraulic powered articulated arm fitted to a trailer, used to load equipment onto a trailer.

Overhead crane: referred to as an Electric Overhead Traction (EOT) crane, is normally used in a factory, with some of them being able to lift very heavy loads.

8.10 ANSWERS TO SAQs

SAQ 1

a) Key risk areas in mechanical operations and safety measures needed for them can be broadly categorised as below;

- Winding equipment – Safety precautions include suitable guards covering high speed rotating parts and general electrical safety.
- Diesel engine systems – Safety measures against toxic fumes, heated pipes and parts, high speed rotating parts need to be taken.

- Welding – Wearing protective gloves and clothing, using proper screen and protection from electrical hazards is required for safe operations.
- High pressure hydraulic equipment – Making sure that safety valves in the system are always in working order, few routine checks like oil level, leak, clogging filters, hoses defects, hydraulic piping and connections, abnormal noise pump etc. should be the primary safety measures.
- Metal cutting operations - To ensure safety avoid wearing loose garments and using rags near running machines, wear goggles to avoid flying metal chips, stop machine before cleaning chips or when you are away and never try to free a stalled cutter without turning the power off first.
- Mobile and transportable equipment – We shall discuss the safety measures for this type of mechanical operation in detail below taking the example of cranes.

b) The usual hazards of working with cranes are,

Falling Loads can be caused by,

- Operator incompetency
- Slipping
- Mechanical failure
- Two blocking

Crane Overload

- Swing or suddenly drop loads
- Hoist loads beyond the cranes capacity
- Use defective components
- Dragging or side-pulling Do not pay enough attention to the loading chart provided on the body of the crane
- Not following the cranes' rated capacity/loading chart

SAQ 2

a) Commonly 7 types of cranes are used in the industry, namely,

- Mobile cranes
- Telescopic crane
- Tower crane
- Truck mounted crane (also known as boom truck or picker truck)
- Rough terrain crane
- Loader crane (also known as a folding boom crane)
- Overhead crane

b) The safety precautions to be taken during crane operations can be summed up as,

- Have a certified operator
- Know what's below
- Plan for swing
- Use cranes within rated capacity
- Stay in touch
- Avoid man-baskets
- Start with a plan

SAQ 3

a) To ensure safe loading of cranes various factors to be considered are,

- the safe working zone
- the counterweight mass
- whether a fly jib is fitted, in use, in place or stowed and the increased mass and maximum working radius that may result when using a fly jib.
- outrigger extension or pick-and-carry mode
- maximum speed for mobiling a load
- rope and reeving details, including number of falls of rope in the hook block
- main or auxiliary hoist in use, and
- whether the hook block is included or excluded.
- limiting and indicating devices in working condition
- suitable operator protective devices
- crane positioned in right location
- crane standing area
- electric lines near operation area
- working at a height
- wind conditions
- communication between operator and ground staff

c) Lifting a load with two or more cranes requires detailed planning and supervision because the movement of the load between the cranes may create extra loadings on the cranes, the load and the lifting gear. The design capacity of a crane will not be the maximum rated capacity but the de-rated capacity relevant to the multi-crane lift to be carried out. The cranes to be used in the lift will need to be de-rated.

Where multi-crane lifts are carried out, a documented lift plan and procedure should be prepared by a competent person, for example an engineer, and followed. The crane de-ratings for each of the cranes used for the multi-crane lift should be identified in the plan. Where it is necessary to lift a load using more than one crane the person in control of the lift must hold at least an intermediate rigging high risk work licence.

c) If a crane is to be stored it should be prepared to be left unattended and:

- the manufacturer's storage instructions followed
- remote control equipment isolated
- the power supply and controls isolated and locked off
- storm anchors applied, if fitted, and
- doors and windows locked to prevent unauthorised access.

Except in an emergency due to fire or other life threatening reason, the crane operator should never leave the crane cabin or controls while a load is suspended from the crane. A crane should not be left unattended unless:

- loads are removed from the hook or lifting device
- the hook has been secured or raised to a position where it is clear of other operations
- the crane is properly stowed
- powered movements have been disabled, and

- the keys removed or the starting device locked out.

8.11 READINGS AND FURTHER READINGS

[1] https://www.ccohs.ca/oshanswers/safety_haz/safeguarding/general.html

[2]https://books.google.co.in/books?id=91mBNcrrX3AC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

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