Mobile crane

Code of Practice

2024

Workplace Health and Safety Queensland
worksafe.qld.gov.au

Queensland Government

This Queensland code of practice has been approved by the Minister for State Development and Infrastructure, Minister for Industrial Relations and Minister for Racing under section 274 of the *Work Health and Safety Act 2011* and section 44 of the *Electrical Safety Act 2002*.

This code commences on 23 September 2024.

PN13050

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Foreword

The *Mobile crane Code of Practice 2024* is an approved code of practice under section 274 of the *Work Health and Safety Act 2011* (the WHS Act).

An approved code of practice is a practical guide to achieving the standards of health, safety and welfare required under the WHS Act and the *Work Health and Safety Regulation 2011* (the WHS Regulation).

Under section 26A of the WHS Act, a person conducting a business or undertaking (PCBU) must:

- comply with an approved code of practice
- manage hazards and risks arising from the work carried out as part of the business or undertaking in a way that is different to the code but provides an equivalent or higher standard of work health and safety than the standard required in the code.

A code of practice applies to anyone who has a duty of care in the circumstances described in the code. In most cases, following an approved code of practice would achieve compliance with the health and safety duties in the WHS Act, in relation to the subject matter of the code. Like regulations, codes of practice deal with particular issues and do not cover all hazards or risks which may arise. The health and safety duties require duty holders to consider all risks associated with work, not only those for which regulations and codes of practice exist.

Codes of practice are admissible in court proceedings under the WHS Act and the WHS Regulation. Courts may regard a code of practice as evidence of what is known about a hazard, risk or control and may rely on the code in determining what is reasonably practicable in the circumstances to which the code relates.

An inspector may refer to an approved code of practice when issuing an improvement notice. This may include issuing an improvement notice for failure to comply with a code of practice where equivalent or higher standards of work health and safety have not been demonstrated.

Code terminology

This code includes references to the legal requirements under the WHS Act and WHS Regulation. These references are not exhaustive and are included for convenience only. They should not be relied on in place of the full text of the WHS Act or the WHS Regulation.

The words '**must'**, '**requires'** or '**mandatory'** indicate that a legal requirement exists that must be complied with.

The world '**should'** is used in this code to identify the standard required in this code. PCBUs can only manage the identified hazard or risk in a different way if doing so provides an equivalent or higher standard of work health and safety.

The word '**may**' is used to identify an optional course of action.

Scope and application

This code provides practical guidance to persons conducting a business or undertaking about how to manage risks associated with mobile cranes, vehicle-loading cranes and other mobile plant used as a mobile crane to raise or lower a freely suspended load.

1 Introduction

1.1 What are mobile cranes?

A mobile crane is a crane capable of travelling over a supporting surface without the need for fixed runways and relying only on gravity for stability.

There are four general types of mobile crane operating in Australia:

- hydraulic slewing cranes
- lattice boom cranes including crawler cranes
- non-slewing (pick-and-carry) cranes
- vehicle loading cranes.

A slewing mobile crane is a mobile crane incorporating a boom or jib that can be slewed but does not include earth moving equipment such as a front-end loader, backhoe, or excavator configured for crane operation.

A non-slewing mobile crane, also known as a pick and carry crane, is a mobile crane incorporating a boom or jib that cannot be slewed and includes:

- an articulated mobile crane
- a locomotive crane.

A vehicle tow truck is not considered to be a non-slewing mobile crane.

Mobile cranes can be set up in a range of locations and environmental conditions. Some mobile cranes, for example a non-slewing mobile crane, can also carry a load while moving (known as mobiling).

For the purpose of this code:

- a vehicle-loading crane means a crane mounted on a vehicle for the purpose of loading and unloading the vehicle
- ‘other mobile plant’ means a machine that is primarily used for activities other than raising or lowering a freely suspended load, and includes a backhoe, excavator, front-end loader, and telescopic handler.

1.2 Who has health and safety duties in relation to mobile cranes?

A **person conducting a business or undertaking** has the primary duty to ensure, so far as is reasonably practicable, workers and other people are not exposed to health and safety risks arising from the business or undertaking.

This duty requires the person to manage risks by eliminating health and safety risks so far as is reasonably practicable and, if it is not reasonably practicable, to minimise those risks so far as is reasonably practicable. It also includes ensuring so far as is reasonably practicable the:

- provision and maintenance of safe plant including mobile cranes
- safe use, handling, storage and transport of plant.

The WHS Regulation includes specific duties for a person conducting a business or undertaking with management or control of plant, powered mobile plant and plant that lifts or suspends loads.

If you own a mobile crane, you are the person with management or control of that plant.

With regards to hiring plant, both you (the person hiring the plant) and the person who supplies the plant in the hiring arrangement must ensure, so far as is reasonably practicable, the plant is safe to

use. During the time the plant is in your possession you will have control over the way the plant is used in the workplace.

A person who hires or leases plant to others will have duties as a supplier of plant and as a person with management or control of plant. This means they must ensure, so far as is reasonably practicable, the plant is safe to use and properly maintained. They must also provide specific information with the plant about how to operate it safely.

In most cases the supplier will be responsible for inspecting and maintaining the plant. However, if the plant is to be hired for an extended period of time, you and the supplier may develop arrangements to ensure the plant is properly inspected and maintained throughout the hire arrangement. This may involve the supplier coming to your workplace to maintain the plant, or you maintaining the plant while it is at your workplace.

The arrangements you make will depend on your ability to inspect and maintain the plant in accordance with the manufacturer's specifications. If you choose to maintain the plant yourself during the lease, you should provide all information and records about the maintenance to the crane owner at the end of the hire arrangement.

Designers, manufacturers, importers and suppliers (distributors) of plant must ensure, so far as is reasonably practicable, the plant they design, manufacture, import or supply is without risks to health and safety. This duty includes carrying out analysis, testing or an examination and providing specific information about the plant. Information must, so far as is reasonably practicable, be passed on from the designer through to the manufacturer and supplier to the end user.

Suppliers must provide a purchaser of a mobile crane which requires plant design registration with the design registration number.

Officers, such as company directors, have a duty to exercise due diligence to ensure the business or undertaking complies with the WHS Act and Regulation. This includes taking reasonable steps to ensure the business or undertaking has and uses appropriate resources and processes to eliminate or minimise risks from plant.

Workers and other people at the workplace must take reasonable care for their own health and safety, co-operate with reasonable policies, procedures and instructions and not adversely affect other people's health and safety.

1.3 What is involved in managing the risks associated with mobile cranes?

WHS Regulation sections 34-38: To manage risk, a person conducting a business or undertaking must:

- identify reasonably foreseeable hazards that could give rise to risks to health and safety
- eliminate risks to health and safety so far as is reasonably practicable
- if it is not reasonably practicable to eliminate risks to health and safety—minimise those risks so far as is reasonably practicable by implementing risk control measures according to the hierarchy of control in section 36 of the WHS Regulation
- ensure the control measure is, and is maintained so that it remains, effective, and
- review and as necessary revise control measures implemented to maintain, so far as is reasonably practicable, a work environment that is without risks to health or safety.

To properly manage risks, a person conducting a business or undertaking must:

- identify hazards, for example:
    - observe the workplace to identify areas where cranes operate and how they interact with other vehicles, pedestrians and fixed structures like overhead electric lines

    - ask the crane operator, crane crew, and others about problems they encounter at the workplace including with operation, inspection, maintenance, repair, transport, and storage requirements
    - review your inspection and maintenance records (e.g., logbooks, and incident and injury records including near misses).
- assess risks that may result because of the hazards (i.e. understand the nature of the harm that could be caused by the hazard, how serious the harm could be and the likelihood of it happening). Some of the risks when using a crane may include:
    - structural failure, overturning, or collapse of the crane
    - contact or collision of the crane or its load with people or other plant and structures
    - falling objects.
- decide on control measures to prevent, or minimise the level of, the risks and implement control measures
- monitor and review the effectiveness of the measures. Control measures need to be regularly reviewed to make sure they remain effective, taking into consideration changes, the nature and duration of work and that the system is working as planned.

Further information on the risk management process is in the *How to Manage Work Health and Safety Risks Code of Practice*.

1.3.1 Consulting workers

WHS Act section 47(1): The person conducting a business or undertaking must, so far as is reasonably practicable, consult with workers who carry out work for the business or undertaking who are, or are likely to be, directly affected by a matter relating to work health or safety.

WHS Act section 48(2): If the workers are represented by a health and safety representative, the consultation must involve that representative.

Consultation involves sharing of information, giving workers a reasonable opportunity to express views and taking those views into account before making decisions on health and safety matters.

Consultation with workers and their health and safety representatives is required at each step of the risk management process. By drawing on the experience, knowledge, and ideas of your workers you are more likely to identify hazards and choose effective control measures.

You should encourage your workers to report hazards and health and safety problems immediately so the risks can be managed before an incident occurs and you must consult your workers when proposing any changes to the work that may affect their health and safety.

1.3.2 Consulting, cooperating, and coordinating activities with other duty holders

WHS Act section 46: If more than one person has a duty in relation to the same matter, each person with the duty must, so far as is reasonably practicable, consult, co-operate and co-ordinate activities with all other persons who have a duty in relation to the same matter.

Sometimes you may share responsibility for a health and safety matter with other business operators who are involved in the same activities or who share the same workplace. In these situations, you should exchange information to find out who is doing what and work in a cooperative and coordinated way so that all risks are eliminated or minimised as far as reasonably practicable.

Further guidance on consulting, cooperating, and coordinating activities is available in the *Work Health and Safety Consultation, Coordination and Cooperation Code of Practice*.

1.4 Safe work method statements

WHS Regulation section 299: When carrying out high risk construction work, a PCBU must ensure that a safe work method statement is prepared or has already been prepared by another person.

When using a mobile crane for construction work, certain activities pose an increased risk and are therefore considered high risk construction work. These activities may include work:

- involving a risk of a person falling more than 2 metres
- carried out on a telecommunications tower
- involving demolition of an element of a structure that is a load bearing or otherwise related to the physical integrity of the structure
- involving or likely to involve the disturbance of asbestos
- involving structural alterations or repairs that require temporary support to prevent collapse
- carried out in or near a confined space
- carried out in or near:
  - a shaft or trench with an excavated depth greater than 1.5 metres
  - a tunnel
- involving use of explosives
- carried out on or near pressurised gas distribution mains or piping
- carried out on or near chemical, fuel, or refrigerant lines
- carried out on or near energised electrical installations or services
- carried out in an area that may have a contaminated or flammable atmosphere
- involving tilt-up or precast concrete
- carried out on, in or adjacent to a road, railway, shipping lane or other traffic corridor that is in use by traffic or pedestrians
- carried out at a workplace in which there is movement of powered mobile plant
- carried out in an area in which there are artificial extremes of temperature
- carried out in or near water or other liquid that involves the risk of drowning
- involving diving work.

Where the activity involves high risk construction work, a safe work method statement (SWMS) must be prepared before the work starts. Where the circumstances of the high-risk construction work is the same, or very similar, to work undertaken in the past, the SWMS can be based on a previously used SWMS, subject to the SWMS being reviewed and, as necessary, revised. However, where the high-risk construction work differs from work undertaken in the past (i.e. the type of lift is more unique and complicated), a new site-specific SWMS should be prepared. Examples of more unique and complex circumstances may include lifts involving:

- tilt-up and pre-cast concrete panel jobs
- multiple crane lifts
- lifting of workboxes with personnel in them
- installation of bridge beams
- working near power lines
- lifting large pressure vessels or tanks
- cranes used on barges
- mobile plant retrieval following an incident
- erection of tower cranes
- heavy lifts (such as bridge beams (10 tonnes or more) or other lifts where the load is 50 tonnes or more (see section 8.2.5 (performing heavy lifts)).

If it is not clear that a SWMS based on a previous SWMS is appropriate for the circumstances, a site-specific SWMS should be prepared.

Where a SWMS is required, the SWMS must:

- identify the type of high-risk construction work being done
- specify the health and safety hazards and risks arising from the work

- describe how the risks will be controlled
- describe how the control measures will be implemented, monitored and reviewed.

A SWMS must be developed in consultation with workers and their representatives who are carrying out the high-risk work.

Where a documented lifting procedure has been prepared, information required for a SWMS may be incorporated into the lifting procedure or vice versa. Information on documenting lifting procedures is provided in section 7.5 (documented lifting procedures).

1.5 Information, training, instruction and supervision

WHS Act section 19(3)(f): A person conducting a business or undertaking must ensure, so far as is reasonably practicable, the provision of any information, training, instruction or supervision that is necessary to protect all persons from risks to their health and safety arising from work carried out as part of the conduct of the business or undertaking.

WHS Regulation sections 39(2) and (3): A person conducting a business or undertaking must ensure that information, training and instruction provided to a worker is suitable and adequate having regard to:

- the nature of the work carried out by the worker
- the nature of the risks associated with the work at the time of the information, training and instruction, and
- the control measures implemented.

The person must ensure, so far as is reasonably practicable, that the information, training and instruction is provided in a way that is readily understandable by any person to whom it is provided.

WHS Regulation section 317(1): A person conducting a business or undertaking must not direct or allow a worker to carry out construction work unless the worker has successfully completed general construction induction training and if the worker completed the training more than 2 years previously—the worker has carried out construction work in the preceding 2 years.

All workers exposed to work health and safety risks should be provided with information about:

- work health and safety legislation
- their organisation's work health and safety policy or program
- work health and safety risk management processes
- which control measures are in place to minimise exposure to risks associated with workplace hazards
- correct use of risk control measures and how to ensure they are kept in working order
- any known residual risk
- safe work procedures
- how to use and maintain equipment
- any special safety information needs.

Adequate and appropriate training is a way of managing the risks associated with hazards. Training should be appropriate to the type of work to be performed. In some cases, formal training will be required, in others, on-the-job training may be more appropriate. The special needs of workers should be taken into account in deciding on the structure, content and delivery of training. This assessment should include literacy levels, work experience and specific skills required for a job.

Section 15 of this code provides further information on the training requirements for mobile crane operations.

2 Design and plant registration of mobile cranes

WHS Regulation section 243: The design of specified items of plant must be registered. Schedule 5, Part 1 lists the specific items of plant requiring design registration, which includes mobile cranes with a rated capacity of greater than 10t.

WHS Regulation section 244: An altered design of an item of plant must be registered if the alteration may affect health or safety.

WHS Regulation section 245: A design of an item of plant is not required to be registered if the design is registered under a corresponding WHS law.

Mobile cranes must be designed in accordance with acceptable engineering principles or relevant technical standards, to ensure the mobile crane is without risk to health and safety.

An application for registration of the design of a mobile crane must be accompanied by:

- a statement signed by the designer of the mobile crane stating:
  - the designer has complied with their obligations under section 22 of the WHS Act
  - the published technical standards and engineering principles used in the design
- a design verification statement
- representational drawings of the crane
- the relevant fee.

A person must not make a design verification statement for any part of a design of plant that the person was involved in designing.

A certificate of registrable plant design stops having effect if the design is changed in a way that may affect the health or safety of operators or nearby workers.

An example of a change in design **causing** a certificate to stop having effect:
A certificate of registrable plant design is in force for the design of a mobile crane. The number of counterweights on the mobile crane is increased so that the rated capacity of the crane can be increased. This may increase the risk of structural failure of the crane or the risk of the crane overturning. The certificate stops being in force because of the change.

*An example of a change in design **not causing** a certificate to stop having effect:*
A certificate of registrable plant design is in force for the design of a mobile crane. The mobile crane's hoist rope is replaced with a steel wire rope of a different construction (e.g. number of strands) than that listed in the original design registration submission, and the crane manufacturer specifies that the new type of rope may be used. The certificate does not stop being in force because of the change.

3 Risks associated with mobile crane operations

Mobile crane operations may present a risk of injury to workers and other people from:

- structural failure
- crane overturning
- contact or collision with other plant and structures, and
- falling objects.

Structural failure may include the failure of any crane component, such as the boom, jib, hydraulic rams or wire rope. A mobile crane may suffer structural failure if the crane has been overloaded in the structural area of its load chart. Structural failure may occur without warning.

A mobile crane is likely to **overturn** if the crane has been overloaded in the stability area of its load chart. This may be influenced by a number of factors including:

- poor ground conditions such as unstable ground
- failure to use or fully extend outriggers or stabilisers
- failure to level the crane

- rapid slewing, and
- high wind conditions.

Contact or **collision** with other plant and structures may occur where sufficient clearances are not maintained between the mobile crane and other plant and structures, such as other cranes, buildings and overhead powerlines.

Falling objects may result from erecting and dismantling activities, and the way loads are secured during lifting operations. Falling objects may present a risk of injury to workers and members of the public.

4 Limiting and indicating devices

Limiting and indicating devices should be fitted to mobile cranes as required by the version of *AS 1418.5: Cranes, hoists and winches – Mobile cranes* under which they have been design registered to, unless otherwise required by this code. The purpose of limiting devices is to stop a specific crane motion before the crane moves out of its limits into an unsafe situation. Indicating devices are used to visually or audibly warn the crane operator that the crane may be approaching its set limits or an unsafe situation. These devices may be used individually, or together, for specific crane motions.

4.1 Reliability of devices

Limiting and indicating devices are safety functions to assist in ensuring the crane remains in a safe state. However, the responsibility still remains with the crane operator to operate the crane in accordance with the instructions provided by the crane manufacturer, including the load charts.

The design and selection of limit systems should be completed in accordance with appropriate technical standards for safety related parts of control systems or for functional safety of machinery.

To ensure ongoing reliability and safe operation of the crane, the calibration of limiting and indicating devices should be checked at periodic intervals by a qualified person in accordance with the crane manufacturer's instructions.

4.2 Rated capacity limiters

A rated capacity limiter prevents overloading of the crane by stopping all relevant crane functions when an overload is detected. Rated capacity means the maximum load that may be attached and handled by the crane and may not include the weight of the hook block, falls of rope, slings and rigging hardware. The load to be raised should include the weight of all lifting appliances. The crane's load chart will provide guidance on any deductions that may need to be made.

Rated capacity limiters should be provided on all mobile cranes manufactured between 2002 and 2013 with a maximum safe working load of more than three tonnes. For cranes manufactured since 2013, cranes with a maximum rated capacity of 1000kg or 40,000Nm or greater should be fitted with a rated capacity limiter. The limiter should prevent:

- hoisting of a load greater than 110 per cent of the rated capacity
- the radius being increased greater than 110 per cent at the particular radius.

4.3 Motion limiting devices

Motion limiting devices are used to prevent physical damage to the crane or part of the crane due to movement of the crane or part of the crane past its designed range of motion.

Motion limiting devices should be fitted to a mobile crane to prevent motion out of its service limits. These devices cause braking, including deceleration where appropriate and stopping, when the following extreme permissible positions have been reached:

- the highest position of the hook (this is generally known as 'anti-two block')
- the extreme permissible operating positions of the jib (luff limiter)
- the end positions of horizontally telescoping or movable jibs.

4.4 Working radius indicator

A radius indicator displays the radius of the suspended load generally measured from the centre of the slew ring, or centre of the front axle for pick-and-carry cranes. A radius indicator should be fitted on all mobile cranes that were originally designed with this feature.

4.5 Load indicators

Load indicators should be fitted to all mobile cranes with a maximum rated capacity of 1000kg or 40,000Nm or greater. Load indicators measure and display the mass of the load being lifted. This indicator assists the crane operator to stay within the load chart and safe working limit of the crane. The load indicator should be capable of displaying the mass of the suspended load at all times.

4.6 Free fall lock-out

Hoist winches on some mobile cranes are fitted with a free fall feature that allows the hook and load to fall under gravity in an uncontrolled manner. This feature has been traditionally provided on cranes for activities such as clam-shell dredging and dynamic compaction. However, the risk associated with an inadvertent activation of the free fall feature can be high and the risk to workers from falling loads and potential damage to the crane and crane operator is too great.

Owners of any crane with free fall capabilities should de-activate the free fall facility permanently unless there are no alternatives for this type of operation. This de-activation of the free fall should include removal of free fall switches on the crane and a certificate from the crane manufacturer or a competent person (preferably a professional engineer) to state that the free fall function has been permanently removed. Where free fall switches cannot be removed, the free fall function is to be positively locked-out and a certificate should be signed by a competent person to verify that the lock-out feature has been correctly installed.

In the limited circumstance where free fall capabilities need to be used, a documented risk assessment should be prepared.

Where the free fall feature is used on a crane this may subject the crane to shock loading. Preferably cranes used for free fall activities should not be used for general lifting. However, if they are used for general lifting a competent person should undertake a safety inspection when work operations change (i.e. after the free fall activity is finished and prior to commencing general lifting operations).

5 Ergonomic issues

5.1 Safe means of access

Mobile cranes should be fitted with safe means of access that allow the crane operator to safely access the crane cabin and other frequently accessed areas of the crane. Safe access includes the provision of:

- ladders
- footholds
- steps
- grab rails.

Access provisions provided by the crane manufacturer should not be removed or modified unless a qualified person (e.g. an ergonomist) specifies otherwise. Where there is a risk of slips, trips and falls, it may be necessary to modify the walking surfaces with an anti-slip product (e.g. treads, paint).

5.2 Seating

The design of the seating in mobile cranes should take account of the extensive periods of time the crane operator spends in the seat. The seating should be comfortable, have adequate back support and be height adjustable.

5.3 Windows and windscreens

Clear vision should be provided in the operator's cabin at all times. Access should be provided to enable windows and windscreens to be regularly cleaned. Cracked glass in windows and windscreens should be replaced.

6 Crane documentation and markings

6.1 Load charts

Load charts, also called rated capacity charts, identify what a crane is designed to lift safely.

The person with management or control of the crane must ensure that the lifting and suspending is carried out within the safe working limits of the crane. This includes the provision of a load chart (also known as a rated capacity chart) that:

- includes the information specified in *AS 1418.5: Cranes, hoists and winches – Mobile cranes*
- is written in English
- uses metric units.

Where the crane has one main load chart, this should be fixed in the operator's cabin in a clearly visible location. Where the crane has numerous load charts (e.g., for different boom and fly jib configurations), a hard copy of or digital format of the relevant configuration load charts should be kept in the operator's cabin. Lifting should not take place unless an operator has access to a load chart (hard copy or electronic). Numerous load charts may also be able to be accessed within the computer in the operator cabin for the relevant configuration. Although the crane's load moment system may appear to be operating correctly, the load charts will verify that the crane is not being overloaded.

The lifting capacity of a crane is limited by structural strength and/or stability.

The lifting capacities specified on a load chart must never be exceeded, except during testing of the crane by a competent person under controlled conditions or as documented and approved by the crane manufacturer.

On some mobile cranes, there may be numerous load charts for differing boom and counterweight configurations. The load charts may be complex and include numerous conditions that will ensure the crane can safely lift a load. Two important factors that are often overlooked when reading load charts are:

- The need to subtract the mass of the hook block, lifting slings and other lifting gear from the capacity of the crane at the particular radius. Load chart notes should also be consulted to ensure all reductions are considered. 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 one tonne, the load to be lifted cannot be greater than 19 tonnes. This issue becomes critical for heavier hook blocks and lifting gear (e.g. spreader beams).
- The need to subtract the mass of the fly jib 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, unless this is allowed for and noted on the load chart. Capacities of the main boom are generally based on the fly jib being removed. If this issue is ignored, the likelihood of the crane overturning can be very high.

6.2 Crane operator's manual

The crane operator's manual is to be supplied with the mobile crane. The manual should be:

- written in English
- kept on the crane at all times, in either hard copy or digital format.

6.3 Crane markings

A mobile crane and its lifting components should be marked permanently and legibly in accordance with the requirements specified in *AS 1418.5 – Cranes, hoists and winches – Mobile cranes*. The markings should be in English, with values in SI units.

All operator controls must be suitably marked to indicate their function and operation. The markings on the controls should be either in English or international code. The crane's computer is to be compatible with these requirements.

7 Planning and coordinating mobile crane operations

Planning is the first step in ensuring that work is done safely. The planning for mobile crane operations should start as early as possible to help eliminate many of the associated health and safety risks. In order for this to be successful, it should involve consultation with everyone engaged in the work. These people may include the principal contractor or crane hirer, crane supplier, electricity entity, engineer, PCBU and crane operator.

Effective planning will help identify ways to protect people who are:

- erecting and dismantling mobile cranes
- directly involved in the lifting operation, such as the crane operator and dogger
- performing other work activities at the workplace
- in an area adjacent to a mobile crane, including a public area.

Some of the issues to be considered when planning for mobile crane operations include:

- determining crane requirements appropriate for the work to be undertaken
- ensuring there is adequate workplace access
- identifying the most appropriate location to site the mobile crane in relation to other buildings, structures and plant at the workplace
- liaising with electricity entities regarding control measures for working around overhead powerlines
- ensuring that the ground conditions are adequate to support the mobile crane, including consideration of the location of underground services such as power, water, gas, sewers and phone/data cabling
- ensuring that the appropriate number of people is available to support safe mobile crane operations.

Other matters to be considered during the planning stage are listed in *AS 2550.5: Cranes, hoists and winches – Safe use – Mobile cranes*.

7.1 Selecting the crane

Matters to be considered in the selection of mobile cranes are outlined in *AS 2550.5: Cranes, hoists and winches – Safe use – Mobile cranes*.

Select the type and number of mobile cranes to suit the particular needs of a workplace. If crane characteristics do not match job requirements, then unsafe conditions are created before any work is done.

When selecting a mobile crane for a job, the size and characteristics of the crane should be assessed against the following criteria:

- the weights, dimensions and lift radii of the heaviest and largest loads to be lifted
- the maximum lift height and radius, and the weight of the loads to be handled at these points
- the number and frequency of lifts to be made
- how long the crane will be required at the workplace
- the type of lifting to be done (e.g., precise placement of loads)

- the type of carrier required—this depends on ground conditions and machine capacity in its various operating quadrants
- whether loads are to be walked or carried
- the gradient of the supporting surface
- whether loads are to be suspended for lengthy periods of time
- the workplace conditions, including the ground on which the crane is to be set up, access roads and ramps it will travel on, space for erection, and any obstacles that may impede access or operation.

There are generally four types of mobile cranes operating in Queensland—hydraulic slewing cranes (see Figure 1), lattice boom cranes (including crawler cranes), non-slewing (pick-and-carry) cranes and vehicle-loading cranes. Each of the basic mobile crane types has advantages and disadvantages, and the best crane type should be selected for the job to be undertaken.

Hydraulic slewing mobile crane

Lattice boom crane

Non-slewing (pick-and-carry) crane

Vehicle-loading crane

Figure 1 – Types of mobile cranes

7.2 Crane crew

The number of people in the crane crew should be determined by a risk assessment and be appropriate to ensure the safe operation of the mobile crane at a workplace.

The risk assessment should address the following risks:

- collision between cranes and other plant, and coordination of multiple cranes
- loads contacting structures (including neighboring property and temporary structures such as scaffolding) or obstructing walkways and other workers
- overhead powerlines
- ability of the crane crew to maintain visibility of the load, safely load and unload materials, and assess work areas before unloading deliveries.

If a risk assessment identifies that the crane crew cannot maintain visibility of the load at any point in time during the lift process due to one or more of the following risk factors, then additional control measures may be required during the lift process:

- positioning of the proposed crane crew
- size or complexity of the site or structure
- proximity of collision hazards
- the lift process or procedure.

Examples of additional control measures may include (but are not limited to):

- re-design of the proposed lift or alternative crane
- isolation of area during the lift
- anti-collision devices and systems
- flagging and insulated covers on suspended powerlines
- use of a safety observer or ‘spotter’
- use of an additional dogger (e.g. where a single dogger could lose sight of a suspended load)
- cameras fitted to the crane, crane hook or structure.

In instances where additional control measures are required, any re-design of the lift process, use of additional personnel, or inclusion of new technology that has not already been identified at the start of the project should be undertaken in consultation with the principal contractor or person in control of the workplace, the relevant PCBU and the crane crew.

If the person responsible for slinging a load is required to exercise judgement in relation to the suitability and condition of lifting gear and the method of attaching the sling (including sling accessories) to the load or crane, then this person must hold a dogging license or be training to be dogger and be supervised by a licensed dogger. A crane operator should not undertake their own dogging work or supervise a trainee dogger, even if the operator is also a licensed dogger.

7.3 Crane siting

The siting of a mobile crane may present a risk of injury to workers and members of the public in the vicinity of the crane from:

- the crane overturning due to failure of the crane to withstand the forces likely to be imposed on it
- collision between the crane with other plant and structures at the workplace.

The siting of mobile cranes should occur after careful consideration of the above factors.

7.3.1 Collision between the crane and other plant or structures

When siting a mobile crane, the following hazards must be considered:

- overhead powerlines and other services
- nearby structures
- other cranes or high obstructions, including those on adjacent workplaces (e.g. concrete placement booms)
- other mobile equipment moving within the crane working area, and
- the vicinity of aerodromes and aircraft flight paths for ‘high’ cranes.

Mobile cranes should be positioned so that the risk of injury from collision with other plant is minimised. This issue is particularly important where mobile cranes are set up on public roads. In this situation, the traffic control procedures of the road controlling authority must be complied with.

Another way to minimise the risk of injury from collision with other mobile plant and vehicles is to increase the visibility of mobile cranes. One way to increase the visibility of a crane is to permanently mark the crane's outriggers and stabilisers with hazard striping (i.e. 'zebra striping' – see Figure 2). The outrigger beams or hydraulic cylinders should be marked with the hazard striping. The striping should:

- be at an angle 30-60 degrees to the horizontal
- be 40-150mm wide
- consist of two contrasting colours, one of which is red, yellow or white.

Figure 2 – Hazard striping on a mobile crane

Note: If there is inadequate room on the stabilisers and outriggers of mobile cranes (including vehicle-loading cranes), the dimensions of the hazard striping may be decreased.

Where mobile cranes are set up in flight paths (e.g. near aerodromes), the local aerodrome operator must be contacted to ensure the requirements of the Civil Aviation Safety Authority (CASA) are met (see www.casa.gov.au). Where necessary, aircraft warning lights should be fitted to the highest part of the crane.

For further information on control measures to avoid the risk of injury from collision, refer to section 9 of this code.

7.4 Communication

A reliable method of signaling between the crane operator and dogger, or multiple crane operators and/or doggers during a multiple crane lift, is essential for safe crane operation. Failure to implement a reliable method of communication may lead to unsafe crane operations and contribute to injury to workers and other people from:

- dropped loads
- collision with other plant and structures.

An effective means of communication is particularly important where:

- the crane operator cannot see the load
- the crane operator cannot see the load's landing area
- the crane operator cannot see the path of travel of the load or the crane
- the crane operator cannot see the dogger
- for multiple crane lifts, the crane operator cannot see the dogger or the alternate crane operator is out of sight
- the crane operator is not in a position to make an accurate judgement of distance
- it is possible for the crane to come into contact with overhead powerlines.

People using radio equipment should be familiar with the manufacturer's operating instructions. A fixed channel radio frequency should be selected for the duration of the crane operations to prevent interference to or from other radio equipment being used in the vicinity of the crane. Everyone using the radios should be aware of the risk of interference and signals from other radio equipment. Work should stop immediately if there is a loss of radio communication.

Analog radios are recommended over digital radios due to the risk of delay with digital radios which could result in confusion and miscommunication (i.e. verbal commands being cut off and misinterpreted).

The safe use of radio communication usually involves:

- the crane operator and dogger performing an operating safety check to ensure the radios are performing satisfactorily, and a fully charged battery and spare are available

- ensuring operators are familiar with the specific procedures for using radio communication for that workplace
- adopting a constant talk method between radio users so that all involved people are aware of the progress of the lifting operations at all times
- ensuring the crane operator normally takes radio instructions from one person only, unless special circumstances exist that require specific arrangements to be in place for the use of more than two radios.

Where radio communication is not or cannot be used, other forms of communication, such as hand signals, verbal communication or whistle signals should be used. These forms of communication should comply with *AS 2550.1: Cranes, hoists and winches – Safe use – General requirements*.

Mobile phones should not be used for directing mobile crane operations as the use of mobile phones can cause those involved in the lift to become distracted (e.g. via an incoming call or other notifications).

7.5 Documented lifting procedures

The use of a mobile crane can be hazardous particularly as the complexity of the lift increases. Documented lifting procedures are important for the planning and coordination of mobile crane operations and should be prepared for all mobile crane lifting operations. Where the type of lift is straight forward and has been previously undertaken, generic lifting procedures for that type of operation can be used (i.e. a pick-and-carry mobile crane has been hired to carry out general lifting on a construction site. It is being used to lift relatively small loads on the site, including rubbish skips and steel reinforcement. The loads are well within the capacity of the crane, the ground is flat, and the loads can be easily slung). Where the type of lift is more complex and unique, and therefore higher risk, the documented lifting procedures need to be site specific and comprehensive.

Note: Where the lift being carried out involves high risk construction work, to reduce duplication, the information required for a safe work method statement (see section 1.4 – Safe Work Method Statements) may be incorporated into documented lifting procedures. Where this approach is taken, all requirements for a SWMS should be included in the lifting procedures.

Comprehensive documented lifting procedures should be prepared in the following situations:

- tilt-up or spin-up panel jobs
- plant recovery (e.g. overturned plant)
- multiple crane lifts, where more than one crane is used to lift a load at any one time
- lifting of workboxes with people in the boxes
- installation of bridge beams during bridge installation work
- working near live overhead powerlines
- lifting large pressure vessels or tanks
- using a crane for demolition
- complex rigging arrangements (e.g. where additional chain blocks are attached to lifting gear so the load can be rotated or maneuvered while it is suspended on the crane hook - see Figure 3)
- the use of mobile cranes on barges
- erection of tower cranes
- heavy lifts where the load is 50 tonnes or more.

Figure 3 - Complex rigging example

Documented lifting procedures for the lift types mentioned above should include the following:

- maximum load radius to be used for the cranes

- where spotter duties are required (e.g. for preventing collision or contact with powerlines), what the duty is and who is responsible for performing the duty
- position of the load to be lifted and the final position to which it is to be lifted, where practicable (a diagram that shows a plan view of the site may assist)
- maximum wind speed where the load has a large surface area
- verification of the maximum allowable ground bearing pressure (this should be carried out for heavy lifts—see section 8.2.5)
- any proximity hazards including but not limited to underground service, retaining walls, embankments, crane clearance to structures and power lines (these hazards are best represented in a plan or elevation drawings as practicable)
- allowance for any factors that require an increase of crane capacity (e.g. for multiple crane lifts or lifting products of demolition)
- rigging requirements of the job.

The lifting procedure may need to be a live document that allows for changes to be made before and during the lifting procedure.

For more information on issues that should be considered when planning and undertaking mobile crane operations see Appendix 3.

8 Crane stability

Stability is one of the most important safety issues relating to mobile cranes. Failure to maintain stability is one of the key factors associated with serious crane incidents. The main issues relating to crane stability are:

- the stabilising moment of the crane—the crane counterweight generally provides the primary stabilising moment
- the overturning moment applied by the suspended load, the part of the crane boom that is outside the tipping point of the crane, and the wind
- the ground conditions and means of supporting the outrigger pads or the crane tyres
- the slope of the ground—both side slope and slope in direction of crane travel (this particularly applies to pick-and-carry cranes)
- wind conditions—this will vary depending on the size and shape of the suspended load and crane boom.

To ensure the crane does not overturn, the above factors should be addressed.

8.1 Stabilising and overturning moments

8.1.1 Stability function of load charts

The stability factors specified by *AS 1418.5: Cranes, hoists and winches – Mobile cranes* allow for variables such as:

- dynamic factors caused by the crane motion and the load (e.g. for boom movement, application of brakes, swaying of the load)
- wind effects on the load and boom.

Some overseas crane standards, such as those commonly used in the USA, specify stability factors that are less conservative than those in AS 1418.5. If a crane operator unknowingly operates a crane that is set up to comply with a less conservative standard, the risk of overturning the crane is increased.

All mobile cranes are to comply with the stability factors specified in AS 1418.5 and load charts should be marked as complying with this standard.

8.1.2 Counterweights

The crane counterweight is critical in ensuring crane stability. A counterweight that is too light for a load and boom configuration will cause the crane to overturn in the direction of the suspended load. Additionally, a crane can fall over backwards due to the effect of the counterweight in situations when:

- the counterweight is too heavy for the boom configuration
- the crane is travelling up a slope with the boom luffed up
- inadequate timbers are placed under the outrigger pads below the counterweight when the crane is positioned on soft ground
- outriggers are not extended or lowered into position.

On the majority of smaller mobile cranes, the counterweight is fixed and cannot be easily removed. However, on an increasing number of larger cranes, some of the counterweights are designed to be removed for road travel, or when smaller boom and lifting configurations are required. In this situation, it is particularly important to attach the correct type and number of counterweights to the crane for the particular lift to be undertaken.

Counterweights should be secured to the crane in the manner specified by the crane manufacturer. Where counterweights are removable, each counterweight should be clearly and permanently identified with the crane manufacturer's name or trademark and the mass of the counterweight (preferably in tonnes).

Where the crane is fitted with a rated capacity limiter, the data input into the computer should be correct for the counterweight configuration on the crane and related to that shown on the appropriate load chart. This also applies to the boom configuration being used on the crane.

In some unusual circumstances, additional counterweights are attached to the crane to increase its capacity. If this is done, an engineer is to check the complete crane design and certify that the amended design complies with *AS 1418.5: Cranes, hoists and winches – Mobile cranes*.

8.2 Ground conditions and crane support

Ground conditions can vary dramatically from one workplace to another, and even within the one workplace. Failure to address poor ground conditions to ensure crane stability may cause the crane to overturn resulting in serious injury to the crane operator and other people in the vicinity of the crane.

8.2.1 Ground factors

Factors that will affect the ability of the ground to provide adequate support include:

- the presence of water, including when it is mixed with the soil as mud, and where it is present under the surface (e.g. underground springs or streams)
- the type of ground (e.g. clay, sand, rock or a mixture of these)
- backfilled ground that was previously an excavation or trench
- cavities or penetrations in the ground that have been covered but still exist
- continued operation of the crane in one location (e.g. the outrigger pads may sink).

When a mobile crane is being set up, the crane operator can only make a decision based on the surface of the ground. Generally, rock provides the most stable supporting surface for a mobile crane. However, although rock may be present on the surface, it may not extend far below the surface. One way to establish how far rock may extend below the surface is to examine nearby excavations or trenches at the workplace. Rock that extends far below the surface provides a good indication of the ground's integrity. However, this will only provide a reasonable indication of the ground's strength when the excavation is not too far from the crane. Additional risks must be managed when outriggers are positioned too close to an excavation. See section 8.2.3 of this code for further information.

Care also needs to be taken with ground that has a 'crust' on its surface. The surface of this type of ground is usually firmer than the ground underneath. The firm surface may give the perception that

the ground is more stable than it actually is. If the ground is punctured by an outrigger, or the end of a crawler track, the softer ground will be exposed, which may cause the crane to overturn.

Where a mobile crane is continuously operated in one location, the ground underneath the supporting surface may compact. Additional care needs to be taken to ensure that the crane has not compacted the ground to the extent that the minimum overturning moment of the crane is reduced (i.e., the crane is more likely to overturn).

8.2.2 Geotechnical report as part of the building activity

Where a geotechnical report is prepared by a geotechnical engineer on behalf of a principal contractor or PCBU as part of the building activity (e.g. for building foundations), the geotechnical report should be provided to the supplier of the mobile crane to assist the crane operator with the assessment of the ground conditions where the crane will operate.

The geotechnical report should only be relied upon if it applies to the area where the crane is to be set up (in the case of a crane set up on outriggers) or the area where the crane will be driven with a suspended load (in case of a pick and carry crane).

For certain types of lifting, including bridge beams (10 tonnes or more) and other heavy lifts where the load is 50 tonnes or more, a specific geotechnical report for the lifting activity should be prepared (see section 8.2.5 – performing heavy lifts). The principal contractor or PCBU in control of the site is responsible for engaging the geotechnical engineer.

Note: Where it has rained on the site or the ground has been disturbed (e.g. by trenching operations), the geotechnical report may no longer be relevant.

8.2.3 Crane proximity to excavations and trenches

When cranes are set up close to excavations or trenches, there may be an increased risk of the sides of the excavation or trench wall collapsing, causing the crane to overturn. This risk increases with softer ground, and the presence of groundwater. Additionally, the risk of collapse is greater for vertical cuts in the excavation wall in comparison to walls that have been battered back at an angle. The presence of ‘slippery back’, where there is a naturally occurring slip plain such as a fracture in the ground, can also increase the risk of excavation or trench collapse.

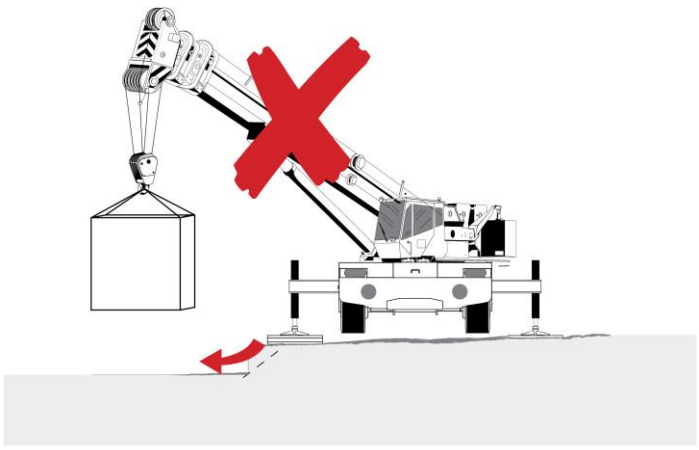


Figure 4 – Where cranes are set up close to excavations or trenches, there is an increased risk of the crane overturning.

Generally, the following principles should be applied when setting up mobile cranes near excavations:

(a) Where the ground is compact and non-friable (i.e. not crumbling), the distance of any part of the crane support timbers from the excavation should be at least equal to the depth of the excavation (1H:1V rule).

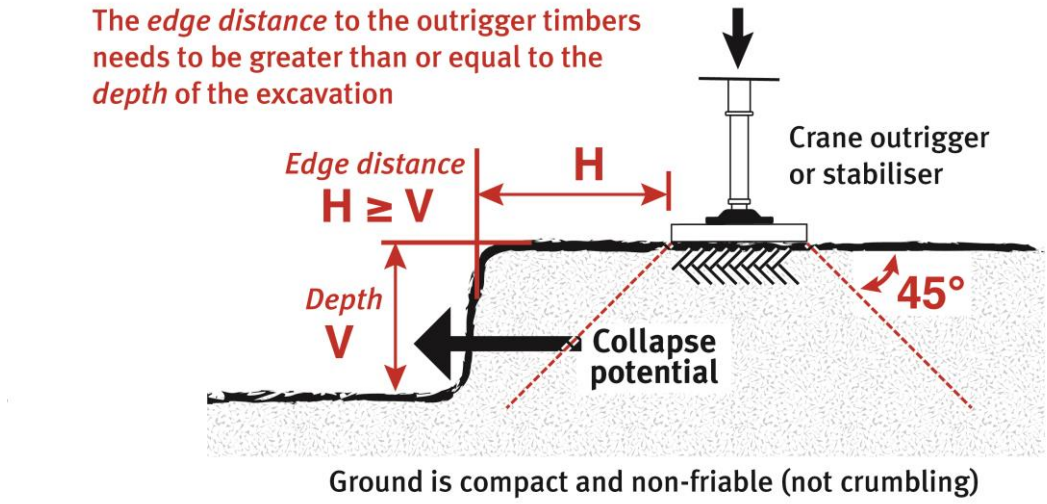


Figure 5 – A three-metre deep excavation in compact ground, the outrigger timbers or pads should be a horizontal distance of at least three metres away from the closest edge of the trench wall.

(b) Where the ground is loose or backfilled (i.e. crumbling), the distance of any part of the crane support timbers from the excavation should be at least twice the depth of the excavation (2H:1V rule).

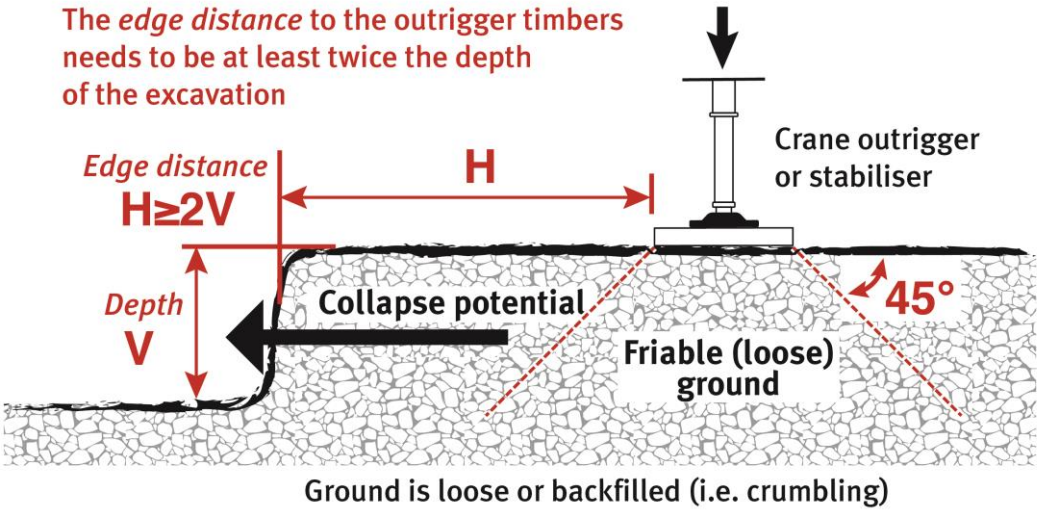


Figure 6 – A three-metre-deep excavation in backfilled ground, the outrigger timbers or pads should be a horizontal distance of at least six metres away from the closest face of the excavation wall.

8.2.4 Timbers, pads and bog mats

A variety of materials can be used to distribute the mass of the mobile crane, and the suspended load to the ground. Lengths of timber (timbers) with rectangular cross sections (see Figure 7) are the most common form. However, timber and plastic pads are also provided for some cranes. For heavier lifts, bog mats (see Figure 8), usually consisting of steel plate, are often used under mobile cranes. Timbers and pads are usually provided under outrigger feet, while bog mats may be used under the tracks of crawler cranes or where larger lifts are carried out.

Figure 7 - Crane outrigger foot on timbers

Figure 8 - Crane outrigger foot on bog mat

Crawler cranes will generally apply considerably less point load to the ground than a crane on outriggers with no timbers. This is because of the large area of tracks in contact with the ground, in comparison with the smaller contact area of the outriggers, on cranes of similar capacity. However, for heavy lifts, and where the ground has poor bearing capacity, bog mats or other supporting materials may be required.

This includes ensuring timbers, pads and bog mats are of dimensions and materials as specified by the crane manufacturer. If the manufacturer has not provided this information, a competent person, such as an engineer, should specify the minimum size of the material to be used.

Generally, the following principles should be applied to timbers, pads, steel plates and bog mats:

- Timbers should have a minimum width of 200mm and minimum thickness of 75mm
- Timbers should be laid together so that the width of the timber pad is wider than the outrigger foot
- The gap between timbers is not to exceed 25mm on the bottom and top layers and 100mm on the intermediate layers
- The risk of outrigger feet sliding off plastic pads or steel should be identified and controlled (i.e. when the crane is set up on a sloping road and a level pad cannot be created).

8.2.5 Performing heavy lifts

The likelihood of a mobile crane overturning is greater when the crane is used to lift heavy loads and additional risk control measures are not implemented. It is extremely important to ensure the ground has adequate bearing capacity to support the crane when performing the following lifts:

- bridge beams (10 tonnes or more)
- tilt-up panels
- other heavy lifts where the load is 50 tonnes or more.

The bearing capacity of the ground is usually estimated by the crane operator when lifting smaller loads. However, certification of the ground bearing capacity should be obtained from a geo-technical engineer before performing a heavy lift (see sections 8.2.2 and 8.2.7 for further information).

The crane operator should compare the ground bearing capacity with the maximum pressure the crane will apply to the ground for the lift. The maximum pressure applied by a crane is a function of the crane mass, crane configuration (i.e. boom length and centre of gravity) and the mass of load on the hook. The ground bearing capacity must be greater than the maximum pressure applied by the crane to the ground to ensure adequate crane support. A way to reduce the pressure exerted onto the ground is to use control measures, such as bog mats, which help to distribute the load applied by the crane.

8.2.6 Cranes on outriggers (or stabilisers) and short-legging

The use of outriggers on mobile cranes helps to provide greater stability to the crane when lifting loads. Irrespective of the ground conditions, timbers or other means of distributing the load should always be placed under the outriggers. Generally, outriggers lift the mobile crane's wheels off the ground, stabilisers do not.

Outriggers should be set according to the manufacturer's operating instructions for the specific type of mobile crane. The outriggers should also be used to help level the crane.

Some cranes are not designed for lifting with partially extended outriggers. If one or more outriggers are not fully extended, the crane may become unstable during lifting operations. In some instances, it may not be possible to fully extend all outriggers. Only cranes that have the manufacturer's approval to lift with partially extended outriggers should be used this way. If a lift is to be undertaken with partially extended outriggers, the correct outrigger configuration, according to the appropriate load chart, must be used. Where the manufacturer specifies the use of pins to lock the extended outrigger in place, these pins must be used. This is particularly important for two stage outriggers in ensuring structural stability.

For cranes not fitted with a slew and outrigger sensing device that limits the lifting capacity of the crane:

On these mobile cranes, short legging is only permitted where the load charts are provided for partial extension of the outriggers. The outriggers should be permanently marked so that the amount which the outriggers are extended can be clearly seen and this corresponds to information on the correct load chart (i.e. if the load chart specifies that half extension can be used then the half mark is provided on all outriggers). Even if only one outrigger is partially extended and the remaining outriggers are fully extended, the capacity of the crane for the complete 360 degrees of slew is not to exceed the rated capacities specified on the load chart for partial outrigger extension.

For cranes fitted with a slew and outrigger sensing device that limits the lifting capacity of the crane:

Mobile cranes fitted with these devices automatically limit the lifting capacity of the crane based on the outrigger configuration. These cranes may have sensors or operator programmable positioning. On these cranes different rated capacities can be used through the 360-degree rating of the crane, irrespective of how many outriggers are short legged. However, information that describes this operating feature is to be kept on the crane at all times (e.g. in the operator's manual).

8.2.7 Calculating pressure applied by outriggers

Ground bearing capacity must be greater than the maximum pressure applied by a mobile crane to the ground to ensure the crane does not sink and/or overturn. If not, then appropriate control measures, such as increasing the area of the outrigger pads or carrying out earthworks to increase the ground bearing capacity, are to be implemented.

A number of crane manufacturers provide information on the force applied by outriggers and the minimum number of outrigger pads to be used. Some manufacturers provide a digital read out on the force applied for different crane configurations based on the operating radius, amount of counterweight and suspended load. The peak outrigger pressure may occur when the hook is empty and should be checked due to high boom angles and counterweight.

Different ground types will have different ground bearing capacities. Generally, harder ground, such as rock, is capable of withstanding higher ground pressures than softer ground, such as dry sand. Where the ground consists of a combination of ground types, the poorer ground type should be used for determining the maximum ground pressure that can be applied to the ground when the crane is set up on outriggers.

The force applied by outrigger feet is often expressed as kilonewtons (kN) and pressure as kilonewtons per square metre (kN/m^2). However, for simplicity, the force applied by the outrigger feet can be expressed as tonnes (t) and the associated pressure applied to the ground as tonnes per square metre (t/m^2).

Table 1 identifies the maximum permissible ground pressure according to the ground type.

Table 1: Maximum permissible ground pressures for various ground conditions

Ground type	**Maximum permissible ground pressure, P_{MAX} (Tonnes per m^2)**
Hard rock	200
Shale rock and sandstone	80
Compacted gravel (with up to 20% sand)	40
Asphalt	20
Compacted sand	20
Stiff clay (dry)	20
Soft clay (dry)	10
Loose sand	10
Wet clay	Less than 10

The greatest force applied by any outrigger to the ground will be:
- at the point of tipping, just as the crane is about to overturn
- high boom angle and maximum counterweight with empty hook, or
- when the crane boom is located directly above an outrigger pad.

Below are two options to assist with calculating the pressure applied by outriggers. The most appropriate option to use will depend on whether the outrigger force is known or unknown.

Option 1 – Outrigger force unknown

A reasonable approximation for maximum ground pressure applied by the outriggers is detailed below.

Pressure (tonnes per m^2) applied by outrigger feet

$$P_{out} = \frac{0.65 \times (\text{total crane mass} + \text{lifted load})}{\text{individual outrigger area}}$$

$$P_{out} = \frac{0.65 \times (C_M + L)}{\text{area}}$$

When the maximum permissible ground pressure is known, the minimum area required under the outrigger feet can be calculated as follows:

Minimum area required under outrigger foot

$$\text{area} = \frac{0.65 \times (\text{total crane mass} + \text{lifted load})}{\text{maximum permissible ground pressure}}$$

$$\text{area} = \frac{0.65 \times (C_M + L)}{P_{MAX}}$$

To find the length and width dimensions for square outrigger timbers configurations, find the square root of the area (√area).

The following examples demonstrate the practical application of the above formulae.

Worked example 1

A mobile crane with a total mass of 40 tonnes is lifting a 20-tonne load—20 tonnes is the maximum the crane can lift in the stability range of the load chart. Each of the four outrigger feet on the crane are provided with timbers that are 0.8 m long by 0.8m wide. Calculate the maximum ground pressure that will be applied to the ground when lifting directly above an outrigger foot.

Lifted load (L) = 20 tonnes
Total crane mass (C_M) = 40 tonnes

Alt 1: Timber area in contact with the ground = 0.8 m x 0.8 m
= 0.64 m^2

Alt 2: Timber area in contact with the ground = 0.71 m x 0.9 m
= 0.64 m^2

Pressure applied by outrigger feet

$$P_{out} = \frac{0.65 \times (C_M + L)}{area}$$

$$P_{out} = \frac{0.65 \times (40 \text{ tonnes} + 20 \text{ tonnes})}{0.64\ m^2}$$

$$P_{out} = \frac{39 \text{ tonnes}}{0.64\ m^2}$$

$$P_{out} = 60.9 \text{ tonnes per } m^2$$

Worked example 2

A mobile crane is to be set up on its outriggers on compacted gravel. The crane has a total mass of 25 tonnes and is to lift a 10-tonne load—10 tonnes is the maximum the crane can lift in the stability range of the load chart. The lift plan requires the load to be slewed above each outrigger foot. Calculate the minimum required area of the timbers to be placed under each outrigger when lifting directly above an outrigger foot.

Lifted load (L) = 10 tonnes
Total crane mass (C_M) = 25 tonnes
Maximum **permissible** *ground pressure (P_{MAX}) for compacted gravel = 40 tonnes per m^2*

$$area = \frac{0.65 \times (C_M + L)}{P_{MAX}}$$

$$area = \frac{0.65 \times (25 \text{ tonnes} + 10 \text{ tonnes})}{40 \text{ tonnes per } m^2}$$

$$area = \frac{22.75 \text{ tonnes}}{40 \text{ tonnes per } m^2}$$

$$area = 0.569 m^2$$

Dimensions of square outrigger timbers:
$\sqrt{0.569 m^2} = 0.754m$

Therefore, the minimum length x width of timbers required = 755mm x 755mm.

Option 2 – Outrigger force known

Where the outrigger force is known, the following three formulae can be used:

Pressure applied by outrigger, P_{out} = Force/Area

Force applied by outrigger, $F = P_{out} \times$ Area

Minimum area of timbers, Area = F/P_{out}

Example 1
The outrigger leg of a particular mobile crane can apply a maximum downwards load of 25 tonnes. If the timbers under the outrigger foot have a length of 0.4 m (400 mm) and a width of 0.5 m (500 mm), calculate the pressure applied by the outrigger leg. What type of ground can this set-up be used on?

To calculate the greatest force applied by any outrigger to the ground:

First of all, calculate the area of the timbers in contact with the ground,

Area, $A = 0.4 \times 0.5 = 0.2$ m^2

Pressure applied by outrigger, P_{out} = Force/Area

$P_{out} = 25 / 0.2$

$P_{out} = 125$ tonne/m^2

After referring to Table 1, the unit is be set up on hard rock unless the area of the timbers under the outrigger feet is increased.

Example 2
The outrigger leg of a particular mobile crane can apply a maximum downwards load of 25 tonnes. The unit is to be set up on compacted gravel. What are the minimum area and length by width dimensions of the timbers to be set up under the outrigger feet?

From Table 1, maximum permissible ground pressure, P_{MAX} is 40 t/m^2

Minimum area of timbers Area = F/P_{MAX}

Area = 25/40

Area = 0.625 m^2

To find the length and width dimensions for square outrigger timbers configurations, find the square root of the area.
Length and width = $\sqrt{}$ 0.625
= 0.79 m

The length and width of the timbers are each to be at least 0.79 m (790 mm) long.

8.2.8 Crawler cranes

The ground pressure applied by crawler cranes is different to that applied by a crane on outriggers. It is sometimes assumed that the ground pressure will be the same at any place where the track is in contact with the ground. However, in practice this is rarely the case.

When the crawler crane is being used with a suspended load, the ground pressure will be greater towards the front of the crane. If there is no load suspended on the crane, the ground pressure will be greater towards the rear of the crane at high boom angles.

The distribution of ground pressure applied by a crawler crane will vary according to the working radius, angle of slew, load mass and counterweight mass (see Figure 9).

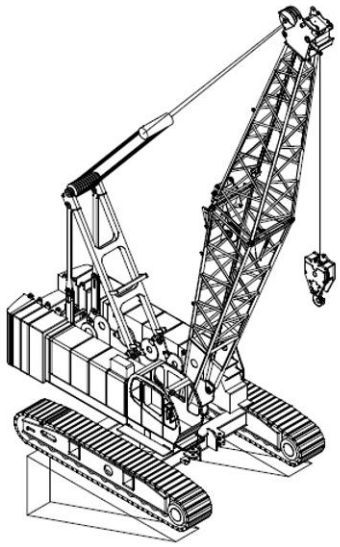
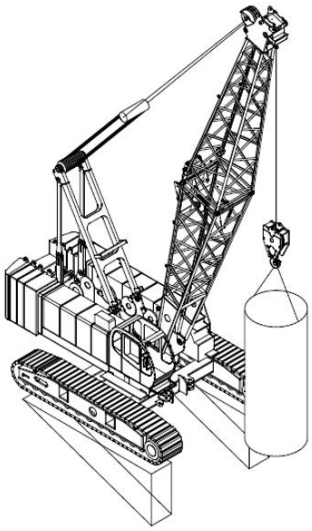
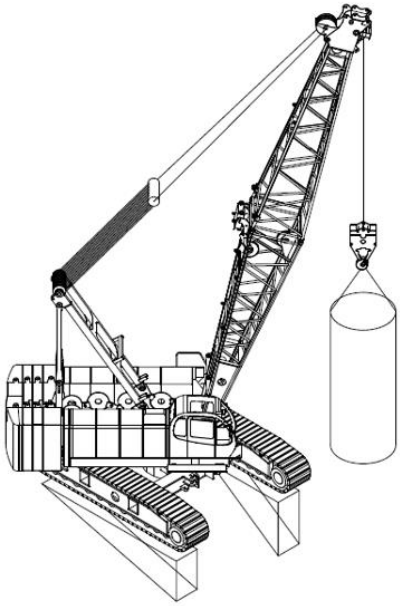
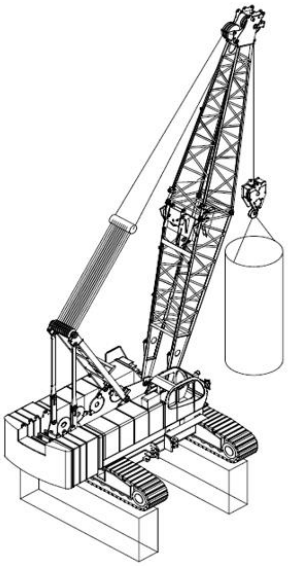
	
With no load on the hook the pressure is at highest under the rear of the tracks due to the counterweight.	With the jib in line with the tracks and a load on the hook there will be an equal triangular or trapezoidal loading under each track.
	
As the jib is slewed around until it is over the end of one track, the pressure increases under that track.	If the jib is slewed until it is at a right angle to the tracks the pressure becomes a rectangular distribution with the track nearest the load having the greatest pressure.

Figure 9 - Crawler Track Pressure Change due to Different Load Cases

8.3 Uneven and sloping ground—pick-and-carry cranes

Many crane roll overs occur when pick-and-carry cranes travel with a load along a side slope. This may also occur to telescopic handlers and other mobile plant when travelling with a suspended load. Working on a slope has the effect of either increasing or decreasing the working radius of the crane, which may in turn affect the stability of the crane, and cause the crane to overturn either forwards, backwards or sideways.

Where the combined centre of gravity of the mobile crane and load is high above the ground, a minimal ground slope can be a major factor in causing the crane to overturn. This particularly applies when:

- the boom has a high luff angle
- the boom is telescoped out
- the centre of gravity of the suspended load is high.

A side slope of only two or three degrees can have a drastic effect on the stability of the crane. Gutters, potholes, soft ground, pneumatic tyres, suspension movement, machine articulation and load swing will also tend to increase the side angle of the crane and make the risk of overturning greater.

Most manufacturers of pick-and-carry mobile cranes specify the cranes are to be operated on firm level ground. *AS 1418.5: Cranes, hoists and winches – Mobile cranes* does not require that mobile cranes be tested on gradients unless the crane is rated to operate on a gradient exceeding one per cent (0.57 degrees).

In practice, it can be very difficult to ensure the supporting surface for a pick-and-carry crane does not exceed a side gradient of one per cent. This is particularly the case at a workplace where construction work is being performed where the ground condition and slope may be constantly changing. A gutter or pothole in the ground will have the same effect as a gradient if the crane's wheel enters the hole.

Where possible, avoid working or travelling on sloping ground. If working or travelling on a slope is unavoidable, consider carrying the load on the uphill side of the crane, regardless of the direction of travel. Travel on a slope should be up or down the slope, not across the slope. Reference should be made to side de-ration charts prior to carrying out this work.

Newer generation mobile cranes are fitted with load moment indictors which will reduce the rated capacity of the crane as it travels over uneven ground with a suspended load. Operators should be familiarised with the behaviour of the load moment indictors fitted to the crane prior to commencing work that requires operation on uneven or sloping ground.

8.3.1 Additional precautions with non-articulating cranes in pick-and-carry mode

Manufacturer's instructions should be followed for a slewing crane operating in pick-and-carry mode.

When moving a load in the pick-and-carry mode, the dogger should remain in sight of the crane operator, and not walk in the path of the crane, or between the crane and the load. This will control the risk of the dogger being run over by the crane or crushed between the crane and the load. When travelling and maneuvering with a load, the crane operator should ensure that:

- the dogger maintains control of the load with appropriate use of tag lines
- travel speed is adjusted accordingly to allow the dogger to maintain control of the load
- the slew brake is applied at all times other than when the slew motion is being used
- precautions are taken on uneven road surfaces when loaded or unloaded, as an undulation in the road surface may move the crane into an unstable zone
- the slewing brake or lock is applied when travelling with a load
- the crane is not moved uphill with an unloaded boom in the near vertical position.

Always travel slowly to prevent excessive swinging of the load. The load should be carried as close to the ground as possible and should not lift higher until it is almost in position.

Where possible, avoid travelling the mobile crane across slopes or over potholes, depressions, soft ground, road cambers or shoulders, rail tracks, dunnage wood or any objects, as these could destabilise the crane or load.

8.4 Wind effect on mobile crane operations

The wind effect on mobile crane lifting operations has become a greater issue with higher booms and lifted loads that have a large frontal area but are relatively light. This has been illustrated in the wind farm industry where wind turbine components are lifted to heights in excess of 100 metres. However, wind speed and direction can affect all types and sizes of mobile cranes.

This risk of a mobile crane overturning or being damaged due to wind increases with increasing load radius, crane boom extension, boom height and frontal area of the load. Loads that are relatively light but have a large surface area are the most adversely affected by wind. For example, the risk of a mobile crane overturning will be higher when a fibreglass swimming pool shell is lifted in windy conditions in comparison to a heavier load with a smaller frontal area.

The maximum allowable wind speed should be stated by the crane manufacturer and be provided in the crane manual. A maximum permissible wind speed of 10 m/second (36 km/hour) is specified by a number of mobile crane manufacturers for some loads.

It is important to note that the maximum allowable wind load specified by the crane manufacturer is usually based on the maximum wind speed gusts and not the average maximum wind speed (e.g. according to the EN 13000 crane design standard, the wind speed listed in the capacity tables is the "3-second wind gust", measured at the highest point of the boom). It is therefore important that there is an accurate method for the crane operator to determine the actual speed of wind gusts.

Although 10 m/second is generally recognised as the maximum allowable wind speed for a mobile crane to operate, the maximum allowable wind speed may be considerably less depending on the characteristics of the suspended load and the configuration of the lift.

It is important to note that when the wind speed doubles, the applied wind load is increased by a factor of four.

8.4.1 Wind direction

Wind direction is categorised in three main orientations: (1) Wind from front, (2) Wind from side and (3) Wind from rear. Each direction has a different impact on crane operations.

(1) Wind from the front can push against the boom and cause the load indicator on the load moment system (LMS) to display a hoisted load less than the actual load. The actual hoisted load has not changed, but the wind pushing against the boom will make the load indicator read lighter. The safety cut-off functions will also not engage correctly, and the load might cause damage to the crane.

(2) Wind from the side does not change the LMS reading like wind from front, but it does cause side loading on the boom and hoisting system that can cause damage to the crane components. Additionally, wind from the side can also push the load outside the stability limit of the crane.

(3) Wind from the rear has the effect of pushing against the back of the boom so that the load indicator displays a hoisted load greater than the actual load. In addition, the wind pushes against the load to increase the radius, reducing the capacity of the crane.

The orientation of the crane and the orientation of the load can minimise the impact the wind direction has on the lifting operations.

8.4.2 Calculating the maximum allowable wind speed

A number of mobile crane manufacturers provide information on how to calculate the maximum allowable wind speed for a specific load and lifting configuration on the crane. This may be in the form of calculating the *maximum wind surface area* of a lifted load, to determine maximum winds that the mobile crane can safely withstand. The *wind surface area* is the area of the lifted load against which the wind applies pressure when the load is suspended from a crane hook. This information is typically used by a professional engineer to determine the maximum allowable wind speed for a specific situation. A mobile crane operator should not be expected to be able to calculate the maximum allowable wind speed for a particular load and crane configuration[1].

To determine whether the maximum allowable wind speed for a mobile crane needs to be reduced below the maximum wind speed specified by the crane manufacturer, a professional engineer considers factors including the following:

- The crane manufacturer's information on the specific model of the mobile crane, including the design standard to which the crane is manufactured.
- The crane configuration being used for the lift.
- The wind surface area of the load.
- The shape and the associated drag co-efficient of the load to be lifted (this is based on the shape of the load – as an example, a flat surface perpendicular to the wind will have a higher drag co-efficient than a cylindrical load)
- The maximum radius at which the mobile crane will operate.
- The capacity of the mobile crane at the maximum radius at which the concrete element is to be placed and how much this exceeds the actual load on the crane (e.g. the greater margin the higher wind the crane will be able to withstand).

The decision on whether a professional engineer is to be engaged to calculate a reduced maximum allowable wind speed is be made as part of the consultation process between the mobile crane supplier and the crane hirer. Where the mobile crane is supplied to a construction site where a principal contractor exists, the principal contractor should also be involved in the process. After a specific make and model of mobile crane has been supplied for a number of different lifts for loads of varying shapes and sizes, the crane supplier should be in a better position to comment on when an engineer will need to be engaged.

Note: in Queensland, persons carrying out an ***engineering service*** are required to be registered as professional engineers in Queensland. For more information refer to the Professional Engineers Act 2002. When a reduced maximum wind speed has been calculated and provided to the crane operator, it is the responsibility of the operator to immediately cease and place the crane out of service lifting when the wind speed is exceeded.

8.4.3 Anemometers and methods used to determine wind speed

Crane operators are to be provided with the ability to accurately determine the maximum wind speed before and during lifting. Approximations of the wind speed made by observing the wind effects (e.g. the Beaufort Scale) are only approximate and can be inaccurate. In addition, a crane operator may not be in a position where he or she is able to make a comprehensive assessment of wind conditions by observing wind effects as there is a need to focus on the lift itself.

Prior to a lift taking place, where wind is considered to be a key safety factor, an assessment of the weather forecast (i.e., from the Bureau of Metrology) for the lifting period is to take place. However, metrological data on wind speed may not be able to be directly applied to a crane lift as the predicted wind speeds are normally close to sea level (i.e. typically at 10 m above sea level). It should also be remembered that the actual wind gust speeds may exceed the forecast and persons planning a critical lift should allow for a safety margin so that the lift will be safe.

One of the best ways to monitor wind speed during a lift is to fit anemometers to crane booms. Anemometers should be provided on all slewing mobile cranes with a maximum rated capacity of 45

tonnes or more. The wind speed measuring device should be provided on the tip of the main boom, unless otherwise specified by the crane manufacturer. Anemometers must be fitted on all cranes by 2 September 2025.

Roles and responsibilities regarding crane stability
While the crane operator is primarily responsible for crane stability to ensure a crane will not overturn, other people who also have responsibilities in relation to the stability of a crane include:

- the crane manufacturer and supplier
- the principal contractor or PCBU
- the crane owner (PCBU)
- doggers.

Refer to section 11.1 of this code for information on the roles and responsibilities associated with safety issues other than crane stability.

8.4.4 The crane operator

Crane operators must operate the crane within its capabilities to ensure the crane does not overturn. The operator should have the final say about whether a lift should proceed and should be satisfied that:

- the crane is adequately supported on the ground and the crane is level to within the tolerance specified by the crane manufacturer
- materials placed under the outrigger feet or crawler tracks, to help ensure the crane does not overturn, are set up to comply with the crane manufacturer's specifications, or the crane owner's specifications if the former do not exist (see section 8.2.6)
- the suspended load will remain within the rated capacity of the load chart
- the functions of the crane are operating properly, including all crane motions, brakes, load moment systems and indicators
- the wind is not excessive for the load being lifted, particularly for loads with a large surface area, and when the load is high above the ground.

Crane operators should also regularly inspect the ground to ensure that continuous operation of the crane has not compressed the ground to the extent that further operation of the crane will be unsafe.

An operator should not operate a pick-and-carry crane on gradients exceeding those specified by the manufacturer. Operators should not be expected to calculate how much to de-rate the capacity of the crane where the crane manufacturer does not provide written guidance on this issue. **Note**: a crane operator is not expected to be able to calculate the reduced wind speed for loads with large surface areas. This should be done by an engineer. Refer to section 8.4.2 for guidance.

Operators of mobile cranes should exercise proper diligence and ensure that the crane is operated in accordance with the crane manufacturer's instructions.

8.4.5 The crane manufacturer and supplier (distributor)

The crane manufacturer should ensure that the crane complies with the strength and stability requirements of the design standard to which the crane has been manufactured. The crane manufacturer is to carry out testing to be able to demonstrate that the stability of the crane is based on *AS 1418.5: Cranes, hoists and winches – Mobile cranes* with reference to the design standard marked on the load chart.

Cranes on outriggers

Crane manufacturers should provide information on the maximum load applied by the outrigger feet to the ground. This information should preferably be in the form of a range of loads for various crane and load configurations.

This information can either be provided in the crane operating manual or as an output from lift planning software.

Cranes on crawler tracks
Crane manufacturers should provide information on the maximum load applied across the crawler tracks to the ground applicable to the crane and load configuration.

This information can either be provided in the crane operating manual or as an output from lift planning software.

Pick-and-carry cranes (including crawler cranes)

Side slope: manufacturers and suppliers of pick-and-carry mobile cranes (see figure 10) should provide clear information on the maximum side slope the crane may be safely operated on. For example, specifying the maximum allowable side gradient will provide more specific information to the operator compared to the term 'firm level ground', which may be open to some interpretation (e.g. tolerance). This information can either be provided in the crane operating manual or as an output from lift planning software.

Figure 10 – Pick-and-carry mobile cranes (non-slewing hydraulic cranes)

A pick-and-carry crane cannot consistently remain within an operational slope of less than one degree at a workplace where construction work is being performed. It is recommended that crane manufacturers and suppliers provide details on the amount of de-ration that should be applied on side slopes with a gradient of up to five degrees.

Ground pressure: crane manufacturers and suppliers of pick-and-carry cranes should provide documented information on the maximum pressure applied by the crane's tyres or tracks to the supporting surface.

8.4.6 A principal contractor or PCBU

A principal contractor or PCBU in control of the site where the crane is being set up should supply to the crane crew all information on the location of trenches, backfilled excavations and covered penetrations at the workplace. Where current information on underground essential services information has been obtained by the principal contractor or PCBU (e.g, if obtained prior to excavation work), this information should also be provided to the crane crew.

In some situations, it will not be obvious that the ground will support the crane by simply looking at the ground surface. Where documentation is available to the principal contractor or the PCBU on ground bearing capacity, this information should be made available to the crane operator (also see section 8.2.2 – Geotechnical report as part of the building activity).

However, the principal contractor or PCBU should obtain documented information about the ground bearing pressure from a geo-technical engineer when a mobile crane is required to perform the following lifts:

- bridge beams (10 tonnes or more)
- tilt-up panels
- other heavy lifts where the load is 50 tonnes or more.

A principal contractor or PCBU should provide geotechnical documentation and information about the location of trenches, backfilled excavations, covered penetrations and ground conditions as described above to the crane owner to ensure the crane owner can verify that the mobile crane will have adequate support to carry out the lift.

8.4.7 The crane owner (PCBU)

The crane owner should ensure that the timbers or pads supplied with the crane will adequately support the crane. The crane owner may need to seek the advice of a competent person when selecting appropriate materials to support the outrigger feet.

Where the timbers or pads supplied by the crane owner will not ensure adequate crane support on soft ground with a bearing capacity of less than 10 tonnes per m^2, the crane owner is to clearly state the minimum ground bearing capacity.

The crane owner should be given information about the ground bearing capacity from the principal contractor or PCBU before a mobile crane can be supplied to perform the following lifts:

- bridge beams (10 tonnes or more)
- tilt-up panels
- other heavy lifts where the load is 50 tonnes or more.

Once this information is obtained, the crane owner can ensure that adequate control measures are available to ensure the crane has adequate support to carry out the heavy lift.

8.4.8 The dogger

The dogger is responsible for safely slinging the load and providing accurate directions to the crane operator on load movement to ensure crane stability. This includes:

- communicating the weight of the load to the crane operator, where this is known, to help ensure the rated capacity of the crane for a given radius is not exceeded
- calculating the working load limit of the ropes, slings, chains and other lifting accessories to be used in the lift
- taking adequate precautions when directing a pick-and-carry crane across rough surfaces and checking the area for other hazards
- providing the crane operator with clear and accurate directions.

9 Minimising risk of injury from collision

Failure to maintain sufficient clearance between a mobile crane and other plant and structures may result in a collision between the crane, or its load, with other plant or structures. The possible outcomes from this collision include:

- damage to crane components, such as the boom, which may seriously weaken the component, leading to structural collapse
- injury to people in the vicinity of the crane, including workers and members of the public.

9.1 Working near overhead powerlines

ES Act section 30: A PCBU must ensure its business is conducted in a way that is electrically safe. If the work involves working near overhead powerlines the PCBU must ensure persons performing the work are electrically safe. This includes potential contact with overhead powerlines when operating a mobile crane.

9.1.1 Planning for work near overhead powerlines

Contact with overhead powerlines can pose a risk of electrocution when operating a mobile crane. It can be extremely difficult for crane operators to see powerlines and to judge distances from them.

Before setting up or operating a mobile crane near overhead powerlines, PCBUs should conduct an inspection to identify the presence of overhead power lines that may pose a risk during crane operation. Consultation regarding risks of the work should occur between all relevant parties involved in the work. Once the risks associated with overhead powerlines have been identified and assessed, appropriate control measures must be put in place.

The most effective way to eliminate the risk of electric shock from working near energised overhead powerlines is to arrange for the power to be de-energised or re-routed. The PCBU, principal contractor, or the crane owner should discuss options for de-energising or re-routing the electricity

supply with the relevant electricity entity. These options are the most effective control measures and should be considered before anything else. The PCBU, principal contractor and crane owner should also consult with each other to ensure the electricity entity has been contacted.

De-energising or re-routing powerlines should be arranged with the electricity entity as quickly as possible as this can take some time to arrange. Where overhead powerlines have been de-energised, written confirmation should be sought from the person in control of the powerline before undertaking any work.

If it is not reasonably practicable to de-energise the power or re-route the overhead powerline, the most effective control measure to reduce risk is to establish an exclusion zone (see section 9.1.2).

9.1.2 Exclusion zones for operating a mobile crane near overhead powerlines

ES Regulation 68: A PCBU must ensure, so far as is reasonably practicable, that no person, plant or thing at the workplace comes within an unsafe distance of an overhead or underground electric line. If it is not reasonably practicable to ensure a safe distance, the person must ensure that a risk assessment is conducted for the proposed work and control measures implemented are consistent with:

- the risk assessment
- if an electrical entity is responsible for the electric line, any requirements of the electrical entity

ES Regulation 69: A person or operating plant comes within an unsafe distance of an overhead electric line if the person or plant is within the exclusion zone for the person or operating plant for the line.

If it is not reasonably practicable to de-energise or re-route an overhead powerline, the most effective control measure to reduce risk is to maintain “exclusion zones” that prevent people, plant, equipment and materials from coming close enough to energised overhead powerlines for direct contact or flash-over to occur.

A PCBU must ensure, so far as is reasonably practicable, that any person, part of the crane, or the crane’s load does not enter the exclusion zone.

PCBUs should ensure that workers, the mobile crane, and the load stay at least three metres away from overhead powerlines, for voltages up to 132kV, with greater distances applying for voltages above that. These distances apply to any part of the crane including the load it is lifting. This may be achieved in several ways, including:

- setting up or operating the crane in an area that keeps it outside the exclusion zone
- engineering controls such as mechanical stops or constraints to prevent the crane entering the exclusion zone.

A number of factors should be considered when implementing a system to maintain an exclusion zone, these include:

- identifying the minimum clearance distance from the closest part of the crane and its suspended load to the powerline, such as:
  - the maximum travel distance of the crane boom
  - the size and shape of any load to be lifted
  - the possibility of load swing after the crane boom comes to rest
- allowing for sway or sag of the powerlines (sway is usually caused by wind, while sag may vary as the temperature of the line varies)
- using a safety observer (commonly known as a ‘spotter’) who observes the operation of the mobile crane and advises the operator if it is likely the crane will enter the exclusion zone.

The identified minimum clearance distance may need to be greater than the prescribed exclusion zone distance to ensure there is no breach of the exclusion zone (e.g., to take into account the load

swinging once the crane stops moving). Additionally, electricity entities may also specify a greater distance than the exclusion zones provided in Schedule 2 of the ES Regulation, if they consider the risk warrants it.

Safety observers or 'spotters'

A safety observer or 'spotter' is a person who is trained and competent to observe and advise the crane operator if the crane or any part of the load it is carrying is likely to come within the exclusion zone of an overhead powerline. Safety observers should not carry out other tasks, such as dogging duties, at the time of observing crane operations.

The safety observer or 'spotter' should:

- have knowledge about working safely around moving plant, including an understanding of escape routes and maintaining visibility
- understand the relevant traffic management guidelines for the site
- have and understanding of exclusion zones and knowledge about how mobile cranes operate, and the limits of their movements and extensions, in order to understand the potential for the crane to encroach on an exclusion zone.

Training appropriate for those acting as a safety observer or spotter includes:

- RIIRTM203E – Work as a safety observer/spotter
- T0911 Introduction to Electrical Network Infrastructure for Authorised Persons
- UETDREL006 – Work safely in the vicinity of live electrical apparatus as a non-electrical worker.

Devices to minimise the risk from contact with overhead powerlines

Lower order administrative controls should only be considered when other higher order control measures are not reasonably practicable, or to increase protection from a hazard. There are several devices available that assist in preventing contact with overhead powerlines. These include:

- warning signs to indicate the location of overhead powerlines
- tiger tails or line markers on overhead powerlines to act as a visual aid to highlight the location of the powerline. (Note: tiger tails **do not** insulate wires)
- warning devices to warn the crane operator before the boom enters the exclusion zone.

The use of tiger tails on powerlines acts as a visual aid to highlight the location of the overhead powerline. Only low voltage lines (under 1000 volts) can be continuously covered with tiger tails, which leaves the higher voltage lines on power poles (usually at least 11 000 volts) exposed.

Limiting or warning devices may be used to prevent the crane boom or load from entering the exclusion zone, or to warn the crane operator before the boom enters the exclusion zone. If a limiting device is used, the system should be designed to 'fail-safe' and comply with appropriate technical standards for safety related parts of control systems or for functional safety of machinery.
Regardless of whether safety devices are used, the exclusion zone must not be encroached.

Further information on requirements for operating plant near overhead powerlines may be obtained in the ES Regulation and the *Electrical Safety Code of Practice – Working near overhead and underground electric lines* or at https://www.worksafe.qld.gov.au/electricalsafety.

9.2 Working near other plant and structures

A collision between a mobile crane and other plant (e.g., other cranes and mobile plant) and structures (e.g. buildings) may cause injury to workers and other people present in the vicinity of the crane from:

- dropped loads
- overturning cranes
- broken crane components, such as boom sections.

Where two or more cranes or other mobile plant work within a workplace, or share the same airspace, a documented procedure, such as a safe work method statement for construction work, must be established to ensure sufficient clearances are maintained between the cranes, their loads and the mobile plant.

When cranes operate in adjacent areas, they may share the same airspace. Systems of work should be negotiated between the people in control from each work area to ensure sufficient clearances are maintained between the cranes. Each work area should nominate a person who has a responsibility to implement a correctly documented system to control the risk of injury from a collision.

10 Erecting and dismantling mobile cranes

Failure to erect or dismantle mobile cranes in accordance with the crane designer's or crane manufacturer's instructions may result in injury to persons from crane collapse or falling objects.

10.1 Responsibilities for persons erecting and dismantling mobile cranes

A person with management or control of a mobile crane at a workplace must manage risks to health and safety. They must also ensure that a person who erects or dismantles the mobile crane is a competent person (e.g. a rigger) and has been provided the available information for eliminating or minimizing risks to health or safety.

Plant must not be commissioned or dismantled unless the person with management or control of the plant believes so far as is reasonably practicable it is without risks to the health and safety or any person.

A PCBU should ensure there is a documented work procedure that follows the crane manufacturer's specifications for the erecting and dismantling process. Following the information outlined in the work procedure should ensure that:

- the crane is erected or dismantled in accordance with the crane designer's or manufacturer's instructions
- access to and egress from the crane complies with relevant technical standards
- the crane is stable during erecting and dismantling
- the proposed method for erecting or dismantling the crane will not adversely affect other plant and structures
- approved special tools, jigs and appliances necessary to control any risk of injury during erecting and dismantling are used
- the interaction of the crane with other plant is considered
- environmental factors, such as wet or windy conditions, are considered; and
- workers are provided with suitable fall protection when working at a height.

10.2 Minimising risk of injury during erecting and dismantling processes

10.2.1 Crane collapse

Written instructions for erecting and dismantling a mobile crane should be available with the crane. The PCBU should engage a competent person (e.g.. a rigger) to oversee all erecting and dismantling activities. Only parts and components that meet the specifications of either the crane manufacturer or a competent person should be used when erecting a mobile crane. The crane components should be assembled in the correct sequence, using appropriate tools and equipment according to the prescribed assembly procedures.

When changing boom sections on lattice boom cranes (see Figure 11), the competent person should take special care to prevent the collapse of the boom. Adequate support should be provided under each section before removing the joint pins or bolts. When joint pins or bolts are replaced, they should be provided with properly fitted split pins or a locking device.

Figure 11 – Lattice boom crawler crane

Where required, the crane manufacturer's counterweight is to be attached to the crane at the appropriate location before the boom or jib is fitted or removed. Crane manufacturers may require sequential installation or removal of the fly jib, counterweights and boom components.

10.2.2 Falling objects

WHS Regulation section 54: A person conducting a business or undertaking at a workplace must manage risks to health and safety associated with an object falling on a person if the falling object is reasonably likely to injure the person.

WHS Regulation section 55: If it is not reasonably practicable to eliminate the risk of falling objects, a person conducting a business or undertaking must control the risk of an object falling on a person by providing adequate protection against the risk.

The person provides adequate protection against the risk if the person provides and maintains a safe system of work including:

- preventing an object from falling freely, so far as is reasonably practicable, or
- if it is not reasonably practicable to prevent an object from falling freely, providing, so far as is reasonably practicable, a system to arrest the fall of the falling object.

To control the risk of workers and other people being hit by falling objects during erecting and dismantling mobile cranes, control measures based on a risk assessment should be implemented. For example:

- erect and maintain effective barricades at an appropriate distance around the mobile crane. Only persons who are directly involved in erecting and dismantling activities are to be allowed inside this area.
- schedule the erecting and dismantling of the crane to occur when the movement of other persons and mobile plant at the workplace is at a minimum.

11 Operational issues

11.1 Roles and responsibilities associated with mobile crane operations

All persons involved in mobile crane operations should have a clear understanding of their responsibilities. Such persons should understand their role and responsibility for the safety of each lift. Refer to section 8.5 of this code for specific information on the roles and responsibilities associated with crane stability.

11.1.1 Crane owner

A crane owner must ensure that only persons with the appropriate mobile crane licence class operate the mobile crane (unless the crane has been supplied without an operator in a hire arrangement). If persons operating the mobile crane will be required to drive the vehicle on a public or private road, the crane owner must ensure that the persons are competent to manage the unique handling characteristics of mobile articulated cranes and undertake emergency procedures in the event of a loss of control.

Additionally, the crane owner who employs crane operators, riggers and doggers should ensure that the operators, riggers and doggers have undergone familiarisation and refresher training as required under this code.

A crane owner should ensure that the crane manufacturer's operating manual is kept on the crane and maintain all of the other crane manufacturer's manuals and instructions. Instruction and training based on the manuals and instructions should be provided to all persons involved in mobile crane operations. Crane maintenance manuals should also be made available to all maintenance staff.

A crane owner's responsibilities also include:

- defining roles and responsibilities for all persons involved with the crane operation
- ensuring a thorough equipment maintenance and inspection program is in place
- ensuring equipment is maintained and inspected in accordance with the crane manufacturer's requirements and the requirements of this code and other relevant technical standards
- not allowing a person in charge of and/or operating a crane to also undertake their own dogging work or supervise a trainee dogger, even if the operator is also a licensed dogger
- ensuring work crews are instructed to perform lifts in accordance with agreed lifting procedures.

11.1.2 Principal contractor

A principal contractor has a duty to ensure the overall coordination of the lifting operations at a workplace where construction work is being performed. This includes ensuring systems are in place to facilitate communication between all PCBUs and workers at the workplace, for overlapping work areas.

A principal contractor's responsibilities also include:

- ensuring the workplace is adequately prepared for the incoming mobile crane, including current ground conditions that may impact crane stability
- consulting with the crane operator once the crane arrives at the workplace
- ensuring all persons have been provided with site-specific induction where required, before they start work at the workplace
- sighting general induction evidence for all PCBUs and workers before they start construction work at the workplace
- ensuring crane operators and doggers hold the appropriate licence to perform a class of high-risk work
- traffic management

- being aware of the location of powerlines and whether they have been de-energised before work commences in their proximity.

Where a lift involves the use of steel reinforcement cages, principal contractors should ensure that there are engineered lifting points. More information on control measures to minimise the risk of injury from unsecured and dropped loads can be found in section 11.2.3.

A principal contractor should not attempt to influence a crane crew to perform a lift that the crane crew considers to be unsafe.

11.1.3 Crane operator

The primary role of the crane operator is to perform the function of the crane operation in a safe manner. The crane operator must always exercise proper diligence and operate the crane safely. If the crane operator has reason to believe that a lift may be dangerous or unsafe, the operator must not proceed until the concern has been reported, relevant risks have been managed, and safe conditions have been confirmed. If the crane operator is required to drive the mobile crane on a public or private road, they must ensure they are competent to manage the unique handling characteristics of mobile articulated cranes and undertake emergency procedures in the event of a loss of control.

Crane operators are required to know:

- the particular model of crane to be operated, its characteristics, functions and limitations
- the information in the crane's operating manual
- the crane's load chart, including all notes and warnings, and how to calculate or determine the crane's actual net capacity in the configuration required for the lift(s)
- the adjustment of load limiting settings required for the configuration
- inspection and maintenance procedures to be followed in accordance with the guidelines of the manufacturer and owner
- any workplace conditions that may affect crane operation, including the presence of overhead powerlines, nearby structures, cranes and concrete placement booms
- whistle, hand and radio signals
- basic slinging techniques.

Before and during crane operation, the crane operator should

- set up the crane in accordance with the manufacturer's instructions
- complete the daily inspection checklist, including filling out the crane logbook.
- check no unauthorised persons are present on the crane
- inspect the area, including the ground condition
- monitor the ground condition during repetitive crane lifts in one location
- have a clear understanding of the agreed lift procedure
- check each motion performed is safe.

While operating the crane, the crane operator should not:

- supervise and/or direct a trainee dogger, or
- leave the crane operator controls unless in an emergency or after the following actions have been taken:
    - removed all loads and lifting slings from the hook or dedicated lifting device
    - raised the crane hook to a position where it is clear of other operations namely loads and slings
    - disabled all powered crane motions
- leave the crane to sling their own load.

These requirements apply regardless of whether the mobile crane operator holds the appropriate licence to perform high risk work as a dogger or rigger.

11.1.4 Dogger

A dogger must hold a high-risk work licence for dogging work, as specified under Schedule 3 of the WHS Regulation.

The primary role of a dogger is to assist the crane operator in the safe and efficient operation of the crane. This includes the application of slinging techniques, including the selection and inspection of lifting gear, and the directing of the crane operator when a load is out of the operator's view. The use of a dogger is crucial when the crane operator's vision is obscured, or when operating in high-risk areas. Dogger's should be positioned to safely observe the entire lifting operation that they are responsible for. However, a dogger should not be used concurrently to also perform the role of a 'spotter' when the crane is operating close to overhead powerlines.

A dogger should be in control of the load from the time it is slung until it is securely placed in its final position. If a load is being controlled by more than one dogger, the different doggers should know what part of the lifting operation they are responsible for.

Doggers are required to know how to:

- use the various types of ropes, slings, chains and accessories
- determine the safe working loads of any rope, sling, or chain to be used for lifting
- assess the weight of loads to be lifted
- sling loads of different weights and sizes safely
- direct a crane operator in the movement of a load (this is particularly important when the load is out of the operator's view)
- give appropriate hand and whistle signals used for directing loads.

Before signaling the crane operator to raise a load, the dogger should ensure:

- each lifting attachment, sling and shackle has a safe working load, or working load limit greater than or equal to that of the load. These attachments should be suitable for safely handling the load
- the lifting gear is correctly applied to the load and the crane hook
- the load is secured
- the load is properly balanced
- the load is free, not snagged
- the load, when it is lifted, will not contact any object or constitute a hazard to any person.

Doggers should remain outside the crush zone while a load is being lifted.

11.2 Minimising risk of injury from lifting loads

WHS Regulation sections 315L: A principal contractor must ensure that, before construction work starts, adjoining areas where loads are being lifted over are closed under section 315M at least to the extent necessary to prevent objects falling on or hitting persons in the adjoining area. Alternatively, a principal contractor must ensure a gantry is erected that provides adequate protection to persons in the adjoining area against falling objects if the load were to fall.

WHS Regulation section 315M: A principal contractor must, before construction work starts, ensure written approval is obtained from the relevant authority or person who controls the adjoining area, and if an authority controls the area, use any measures for the closure required by the authority (such as physical barriers, signs, traffic controllers etc.).

Lifting of loads may present a risk to the health and safety of workers and others in the vicinity of the mobile crane from:

- damaged lifting gear
- crane overload
- unsecured and dropped loads (falling objects).

11.2.1 Control measures to maintain the integrity of lifting gear

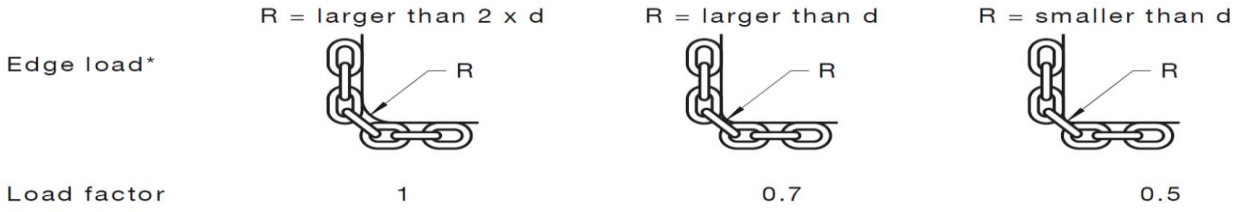
Guidance on the use and inspection of chains, wire ropes and synthetic slings is provided in the following publications:

- *AS 2759: Steel wire rope – Use, operation and guidance*
- *AS 3775.2: Chain slings – Grade T – Care and use*
- *AS 2321: Short-link chain for lifting purposes*
- *AS 4497: Round slings – Synthetic fibre*
- *AS 1353.2: Flat synthetic-webbing slings – Care and use*
- *AS 4991: Lifting devices*
- *AS 2741: Shackles*

Basic items that should be checked include:

- the lifting gear is tagged and all relevant information listed (e.g. relevant information for a chain sling includes grade of chain, WLL, manufacturer, chain size and Australian Standard marking)
- lifting hooks are provided with operable safety latches
- permanently fixed shackles are prevented from unscrewing (e.g. mousing or similar, refer to Figure 12)
- lifting eyes and inserts are compatible and the same proprietary brand
- lifting slings are not damaged (e.g. excessive wear, damaged strands, cracks, deformation or severe corrosion)
- the sling is appropriate for loads being lifted, including adequate capacity and protection from sharp edges; and
- Apply load reduction factors where the radius (R) of the corner of the load is less than twice the link diameter (d) of the lifting chain (refer Figure 13).

Figure 12: Moused shackle



Chain size, d (mm)	Reeved WLL (tonnes)	Revised WLL due to edge factor (tonnes)	Revised WLL due to edge factor (tonnes)	Revised WLL due to edge factor (tonnes)
13	4.0	Load Factor =1 WLL = 1 x 4.0 = 4.0	Load Factor = 0.7 WLL = 0.7 x 4.0 = 2.8	Load Factor = 0.5 WLL = 0.5 x 4.0 = 2.0
19	8.4	Load Factor =1 WLL = 1 x 8.4 = 8.4	Load Factor = 0.7 WLL = 0.7 x 8.4 = 6.1	Load Factor = 0.5 WLL = 0.5 x 8.4 = 4.2
26	15.9	Load Factor =1 WLL = 1 x 15.9 = 15.9	Load Factor = 0.7 WLL = 0.7 x 15.9 = 11.1	Load Factor = 0.5 WLL = 0.5 x 15.9 = 7.9

Figure 13: Load deration factors relating to corner profiles.

The manufacturer's requirements for lifting gear should be followed including using protective sleeves and corner pieces. Although the edges of a load may not appear to be sharp, a sling may become damaged when it is placed under tension.

Slings should be placed around a load so that the sling is not crossed or twisted to ensure that the load is balanced and stable. If possible, the point of the lift should be located directly above the centre of gravity of the load. This will prevent the loads from toppling or falling out during the lift.

Synthetic slings should only be used for appropriate lifts. For example, it is recommended that round

(sausage) slings only be used for round loads (or other shaped loads if protective sleeves are used) as sharp-edged loads may damage or tear this type of sling.

The following photographs provide examples of **correct** use of slinging techniques:

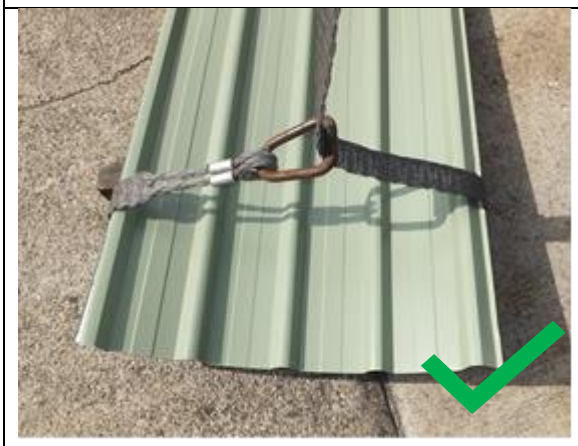
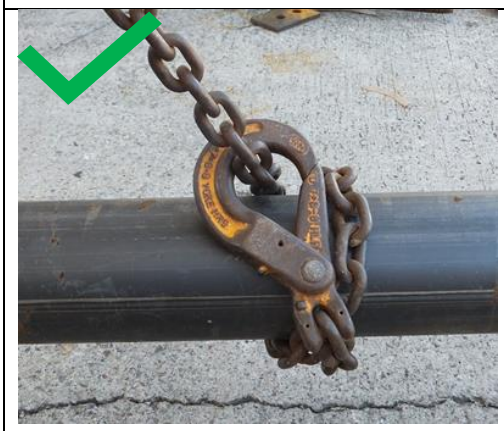
Photograph	Description
	*Figure 14: A steel webbing sling being used to lift roof sheeting – edges will not damage this type of sling.*
	*Figure 15: Round webbing sling with double wrap choke around steel pipe – large radius so sling protection not required.*
	*Figure 16: Chain sling with double wrap choke around steel pipe – helps to prevent any slippage.*

 Photo courtesy LCR Group	*Figure 17: round webbing sling with plastic protection on beam edges.* **Note:** rigid sling protection should have a corner radius of at least three times the compressed thickness of the sling or meet the sling manufacturer's recommendations (refer to AS 4497 for further information).
 Photo courtesy LCR Group	*Figure 18: round webbing sling with rubber mat around edges.* (Refer to AS 4497 for further information).
 Photo courtesy LCR Group	*Figure 19: round webbing sling with fabric protection around beam edges.* (Refer to AS 4497 for further information).

 Photo courtesy LCR Group	*Figure 20: round webbing sling with plastic protection around outrigger box edges.* **Note:** rigid sling protection should have a corner radius of at least three times the compressed thickness of the sling or meet the sling manufacturer's recommendations (refer to AS 4497 for further information).

The following photographs provide examples of **incorrect** use of slinging techniques:

Photograph	**Description**
	*Figure 21: Unsafe use. Edges of metal sheet may cut sling.*
	*Figure 22: Unsafe use. Edges of I-Beam may cut sling.*
	*Figure 23: Unsafe use. Chain sling with single wrap choke around steel pipe and has a greater than 90-degree inclusion angle – does not prevent slippage.*

	*Figure 24: Unsafe use. Sling hook inserted into pipe.*
	*Figure 25: Chain sling with chain bearing against latch.*

All lifting gear, including slings, hooks and material boxes, should be periodically inspected for damage and wear by a competent person. The period between inspections will depend on the severity of use but should not exceed 12 months. The inspection of synthetic slings should be carried out at three-monthly intervals (see *AS 1353.2: Flat synthetic-webbing slings – Care and use* and *AS 4497: Round slings – Synthetic fibre* for further information). All lifting gear should be tagged to identify the date of the lifting gear's last inspection (e.g. colour coding is often used). Documented maintenance records for the lifting gear should be available at the workplace.

In addition, before each lift, the dogger should inspect the lifting gear for any damage or wear.

11.2.2 Control measures to minimise risk of injury from crane overload

A mobile crane should be operated within its rated capacity.

Before hoisting a load, the dogger should make sure that the hoist rope hangs vertically over the load. Care should be taken to ensure the load does not swing once lifted. The crane operator should ensure the load is always under control. When handling maximum or near maximum loads, the crane operator should take the following precautions after the load has been lifted a few centimetres:

- smoothly stop raising the load
- check the mass recorded on the load indicator
- recheck the load chart.

Except in an emergency, the crane operator should not leave the cabin or control room while a load is suspended from the crane.

11.2.3 Control measures to minimise risk of injury from unsecured and dropped loads

WHS Regulation section 55: A PCBU must minimise the risk of an object falling on a person by providing adequate protection against the risk. Adequate protection includes preventing an object from falling freely, so far as is reasonably practicable, or providing a system to arrest the fall of a falling object if it is not reasonably practicable to prevent an object from falling. Examples of systems include secure barriers, providing a safe means of raising and lowering objects, and providing an exclusion zone persons are prohibited from entering.

WHS Regulation section 219: The person with management or control of plant must ensure, so far as is reasonably practicable, that no loads are suspended or travel over a person unless the plant is specifically designed for that purpose. The person must also ensure that loads are lifted or suspended in a way that ensures the load remains under control during the activity.

WHS Regulation section 315L: A principal contractor must ensure that, before the work starts, the adjoining area is closed at least to the extent necessary to prevent objects falling on, or otherwise hitting, persons in the adjoining area, or, a gantry is erected that provides adequate protection to persons in the adjoining area against falling objects if the load were to fall.

Extreme care should be exercised when lifting loads in the vicinity of other persons, including other workers and members of the public.

Where possible, handling loads over public access areas, such as footpaths, roads, highways, railways, waterways and buildings, should be avoided. Where this is necessary, control measures must be implemented to prevent or minimise the risk of injury from falling objects.

Exclusion zones

Exclusion zones should be established around mobile cranes and adjoining areas to prevent persons from entering the area. The size of the exclusion zone should be based on a written risk assessment.

Where the exclusion zone requires closure of a public footpath or roadway, approval must be obtained from the relevant authority and pedestrians should be safely directed to an alternative footpath. Lane closures and other operations that require the erection of barricades and signs should comply with the requirements of the Department of Transport and Main Roads, local government authorities and any relevant building or local Acts.

Lifting materials

Crane-lifted loads should be slung and secured so that the load (or any part of it) cannot fall. To ensure the safe lifting of loads, the following should occur:

- **Material boxes**
    - The tare mass and SWL should be clearly marked on all material boxes. A distinct identification number on the box that can be cross referenced to the design drawing or certificate for the box will assist to verify this.
    - Material boxes should be appropriate for the material being lifted and be engineer-designed and certified.
    - Four chains (one in each corner) should be attached to material boxes during lifting.
    - Specifically designed material boxes should be used to lift smaller components. Boxes should have enclosed sides or robust mesh, with openings less than the minimum size of materials being lifted.
    - Material boxes should be inspected and maintained, and inspection records kept.
    - Loads within material boxes should be secured against movement.
    - Materials should not be stacked higher than the side of the material box unless they are adequately secured, but at no time should the material box become top heavy.

- **General lifting**
    - Formwork frames should be either tied together or lifting slings should be wrapped around the load.
    - Loads of joists or bearers should be strapped together before lifting.
    - Timber sheeting should be strapped together and lifted in a flat position.
    - Sheets of plasterboard may be lifted in a specifically designed material box. If a material box is not used, then the lifting system should :
        (i) be certified by an engineer
        (ii) specify the minimum and maximum number of sheets
        (iii) specify the number and locations of lifting slings
        (iv) specify the capacity of lifting slings.
    - Tag lines should be used as required to control loads.
    - All loads should be supported where possible with dunnage, with the load uniformly distributed over the supporting surface.
    - Basket hitches should not be used wherever persons may be located near a lifted load, unless the sling is positively restrained from sliding along the load.
    - Lifting multiple loads at the same time (commonly known as high/low loads) should be avoided due to the difficulty in ensuring the dogger is not underneath the loads.

Reinforcement cages

Where there is any risk of workers being struck by a falling reinforcement cage, the design of the steel reinforcement cage and the lifting method used should be certified by an engineer. The engineer is to take into consideration the lifting loads applied over the full range of motion and orientation of the cage during the lift.

The loads applied to the lifting points, connections, tie wire, localised stress in the bars and overall stability of the cage or mat should also be considered. The lifting points, number of slings and the lifting method should be clearly shown on a drawing supplied to the site, specifically to the personnel involved in the lifting process and lifting points clearly marked on the cage.

Bulker bags
Flexible intermediate bulk containers (e.g. “bulker bags”) with sewn in lifting slings with sewn in lifting slings are sometimes used to transport bulk materials (e.g. sand).

Australian Standard AS3668 relates to the design and use of bulker bags and specifies that bulker bags can be of two types: the single-trip type and the multi-trip type. Bulker bags are primarily designed for lifting by forklift so that, in the case of a bag with four lifting loops, the loops hang vertically from the forklift tines.

When lifted by crane hook, the lifting method should comply with the instructions of the bulker bag manufacturer.

AS3668 specifies that personnel are not to be underneath bulker bags.

For this reason, the slings on these bags should only be used for lifting the bag when an exclusion zone is used and there is no possibility of any person being under the load. If these bags are to be lifted (except for lifting from the back of a truck to ground level or from ground level to ground level), where an exclusion zone is not used, bulker bags should only be lifted in brick cages or material boxes.

11.3 Multiple crane lifts

Lifting a load with two or more cranes is a higher risk lift that requires greater attention to planning and supervision, because the effects of the relative motion between the cranes may create additional

loadings on the cranes, the load and the lifting gear in place. A lift plan should be developed for these types of lifts (see sections 1.4 and 7.5).

11.3.1 Safety measures for multiple crane lifts

Loads are ideally lifted by a single crane. However, where the load is large and capacity of the mobile crane is limited, it may be necessary to lift the load using two or more mobile cranes. Prior to carrying out a lift for multiple cranes:

- A documented lifting procedure should be prepared (see Section 7.5), preferably with diagrams showing the relative crane and load positions.
- Ensure the person who is directly supervising the lift holds a High Risk Work License in Intermediate or Advanced Rigging.
- Make an accurate assessment of:
  - the share of the load which is to be carried by each crane; and
  - how the share of the load is going to be maintained.
- Make sure the instructions to each crane operator and other persons involved are clear and responsibilities are understood by each person involved.
- Select cranes of similar capacity and characteristics, where practicable.
- Ensure all cranes involved have load indicators that are correctly calibrated (i.e. reading correctly).

The most common type of multiple crane lifts are dual lifts using pick and carry cranes. Some safety principles that apply to this situation include:

- Where the cranes are operating in areas where there are no physical obstructions and the travel paths of the cranes are not restricted, aim to position the cranes either side by side or in line with one another.
- Choose a travel path where sharp turns are avoided.
- Aim to keep the load as close to the ground as possible while making sure the load always remains clear of the ground.
- Aim to drive both cranes at the same slow travel speed and avoid rapid brake application.
- When one crane is behind the other, designate a lead crane to control the pace of travel and the following crane (second crane) to adjust speed to keep the hoist ropes vertical.
- Avoid two blocking crane hooks but allow an adequate length of hoist rope so that the crane operators can see if the hoist rope is not hanging close to vertical.
- When moving the load around a corner with one crane in front and one behind the load, the operator in the first crane needs to avoid pulling the second crane over. This can become a greater hazard if the second crane is articulated (refer Figure 26).

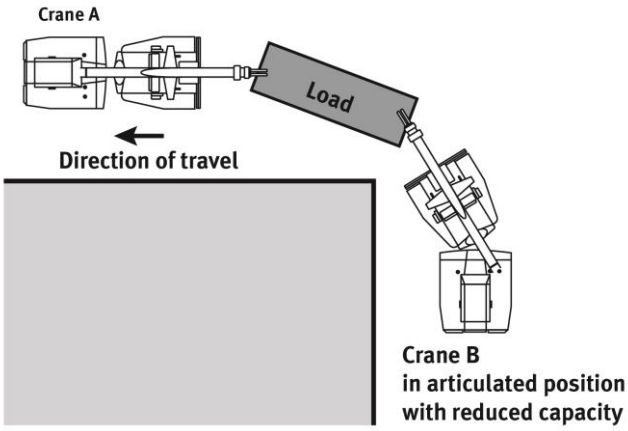


Figure 26: Example of two articulated cranes travelling around a corner.

11.3.2 Calculated share of the load

Where multiple hoisting operations are carried out, the following minimum capacity requirements for each crane will apply:

- for two cranes—20 per cent greater than the calculated share of the load
- for three cranes—33 per cent greater than the calculated share of the load
- for four or more cranes—50 per cent greater than the calculated share of the load.

If it is not possible to comply with the minimum capacity requirements stated above, then an engineer should check and certify the lifting procedure. The lifting procedure must be documented.

11.3.3 Principles for multiple-crane lifting

The following factors are to be considered when planning for multiple crane lifts:

- mass of the load
- position of the centre of gravity of the load
- mass of the lifting gear
- working load limit of the lifting gear
- synchronisation of crane motions
- communication method.

Load spiking can occur during a multiple crane lift when the load is lowered to the ground by one crane faster than other crane(s). For example, in the case of a long load being lifted by two cranes, if the load is lowered at an angle so that one end of the load contacts the ground before the other, the momentary load on the crane suspending the opposite end of the load can be momentarily 33 per cent higher than the calculated share of the load. For this reason, it is important that both ends or corners of the load are lowered at the same time.

Mass of the load

Ensure the total mass of the load and its distribution is either known or calculated. Where the information is taken from a technical drawing, ensure allowances are made for manufacturing tolerances.

Position of the centre of gravity

Due to the variable effect of manufacturing tolerances and rolling margins, the position of the centre of gravity may not be accurately known. Accordingly, the proportion of the load being carried by each crane may therefore be uncertain.

Mass of the lifting gear

Ensure the mass of the lifting gear and its distribution are accurately known and included as part of the calculated load on the cranes. Where heavy or awkwardly shaped loads are handled, the deduction from the safe working loads of the cranes to allow for the weight of the lifting gear may be quite significant.

Working load limit of the lifting gear

Ensure the distribution of the forces within the lifting gear which will arise during the lifting operation is established. The lifting gear should have a safe working capacity margin in excess of that needed for its proportioned load. Determine whether special lifting gear is required to suit the maximum variation in distribution and direction of applied loads and forces which may occur during multiple lifting.

Synchronisation of crane motions

Minimise the variation in the direction and magnitude of forces acting on the cranes by operators synchronising the cranes' motions. Where possible, ensure cranes of similar capacity and operating characteristics are used. However, in practice, there will always be some variation due to differences in response to the activation of the motion controller and the setting and efficiency of the braking system.

As it is unlikely that the motions of the cranes will be accurately synchronised, ensure that an assessment of the effect of variation in plumb of the hoist ropes, which may arise from inequalities of speed, and the means for keeping such inequalities to a minimum, is made. To allow for these inequalities, the lifting operation should be performed at low speeds with extreme care to ensure the hoist ropes are kept as close as possible to vertical.

The rated capacity of a crane is calculated on the assumption that the load will be raised and lowered in a vertical plane. The crane boom has limited strength in the lateral plane.

Communication method

A reliable method of communication between crane operators and the rigger in charge of the lift should be established and recorded in the lift plan and/or SWMS prior to a multiple crane lift being undertaken. If the circumstances of the lift result in a crane operator not being visible during the lift, then two-way radios should be used.

Further information on communication methods for planning and coordinating mobile crane lifts is provided in section 7.4 Communication.

11.4 Leaving the crane unattended

Failure to take adequate safety precautions to secure an unattended mobile crane for a period of time may encourage unauthorised use of the crane by persons who are not competent crane operators.

11.4.1 Ways to secure an unattended crane

A mobile crane should not be left unattended unless the following actions have been taken:

- all loads are removed from the hook
- the hook has been raised to a position where it is safely clear of other operations
- all powered motions have been disabled
- the keys have been removed from the crane, and
- the cabin has been locked.

When leaving a mobile crane unattended for a longer period of time, ensure the crane is configured in an out-of-service condition as specified by the manufacturer's instructions.

11.5 Mobile cranes and road travel

Failure to follow proper precautions before and during road travel may increase the risk of injury to the crane operator and other people, such as pedestrians and other road users.

11.5.1 Preparation for road travel

The crane manufacturer's instructions should be followed when preparing a mobile crane for road travel.

Precautions for road travel include:

- securing outriggers (both hydraulic and manual) with a locking device specified by the crane manufacturer, and stowing them in a travelling position to ensure that there is no lateral movement
- storing loose components in appropriate storage areas in accordance with the crane manufacturer's instructions or any other relevant published guidelines for the safe carriage of loads on road vehicles (e.g. *Load Restraint Guide* ISBN 978-0-6480157-5-8)
- disengaging all drives to hydraulic pumps, booms and outriggers, and putting the controls in the OFF position
- restraining the boom in accordance with the crane manufacturer's instructions to ensure there is no unintended movement of the boom.
- restraining the hook block in accordance with the crane manufacturer's instructions to ensure there is no unintended movement
- for mobile cranes which require dollies, ensure the slew brake is disengaged, the dolly is securely fastened to the crane connection points and the luff cylinder is energised/de-energised as per the manufacturer's instructions (refer to Figure 27)
- checking fluid levels and tyre pressures, and
- for mobile cranes with hydraulic suspension, ensure understanding of the maximum suspension system pressures allowed by the manufacturer.

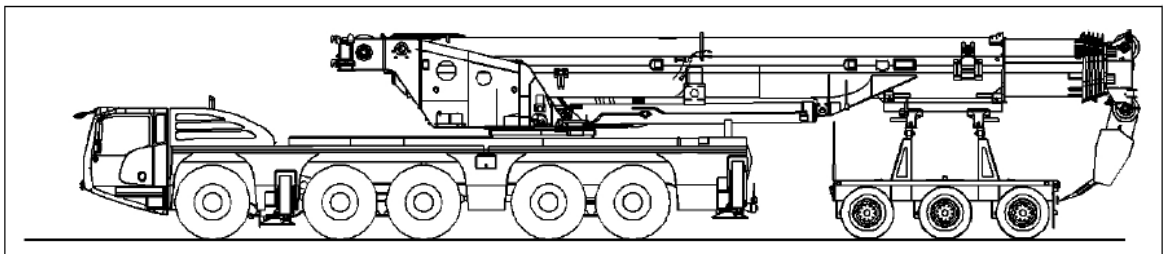


Figure 27: Mobile crane with a securely fastened dolly.

11.5.2 Considerations for road travel

If the crane operator is required to drive the mobile crane on a public or private road, they must be competent to manage the unique handling characteristics of the mobile crane and undertake emergency procedures in the event of the crane driving in an unexpected way. The amount of operator skills needed to safety drive a mobile crane increases for mobile cranes with articulated steering, mobile cranes towing dollies and mobile cranes with more than one steering axle.

Persons driving a mobile crane on a public or private road must be competent to ensure:

- The mobile crane is started, steered, manoeuvred, positioned and stopped in accordance with traffic regulations, manufacturer instructions and relevant vehicle handling procedures and in a manner that allows for the forward overhang of the boom
- The braking system of the mobile crane is managed and operated efficiently to ensure effective control of the crane under all conditions and to allow for the greater stopping distance necessitated by the size and weight of the crane and the forward projection of the boom
- Driving hazards are identified so they may be anticipated and avoided or controlled through defensive driving
- The mobile crane is parked, shut down and safely secured according to traffic regulations
- Crash avoidance space is maintained
- The crane is driven to conditions including rain, winding roads, unsealed.

11.5.3 Mobile cranes with articulated steering

Mobile cranes with articulated steering have unique handling characteristics that are unlike any other crane. These vehicles respond differently to driver inputs including how the driver steers, accelerates and brakes. These cranes are usually fitted with emergency steering systems that include a back-up electric motor that powers a hydraulic pump for the steering cylinders. In addition, the steering geometry on articulated steering cranes generally does not self-centre like traditional steering. Persons driving mobile cranes with articulated steering need to:

- Be able to test the emergency steering system is operating
- Be aware that an articulated crane may need to be driven at a slower speeds, especially on winding roads or roads in poor condition
- Know how to avoid losing control of the crane and what action to take if the steering starts to malfunction
- Allow for the increased boom overhang at the front of the crane when stopping at intersections.

11.5.4 Licensing requirements

Drivers of mobile cranes are required under the *Transport Operations (Road Use Management) Act 1995* to hold the appropriate class of heavy vehicle driver licence before driving the crane on a road. This means that a person who has been granted a high risk work licence to operate a mobile crane must **also** hold the appropriate heavy vehicle class of driver licence to drive that mobile crane on a road to or from a workplace.

Queensland's driver licensing system reflects the National Driver Licence Scheme for licence classifications. It allows for a graduated driver licence classification system based on the gross

vehicle mass (GVM) of each type of vehicle. Refer to Appendix 4 for a description of the driver licence classes appropriate for mobile cranes.

11.6 Workboxes and first aid boxes

11.6.1 Features and use of work boxes

A work box is a personnel carrying device designed to be suspended from a crane to provide a working area for a person elevated by and working from the device.

Crane-lifted workboxes may be used by workers to gain access to elevated work areas that are otherwise difficult to reach to perform minor work of short duration. Generally, crane-lifted workboxes do not provide a level of safety equivalent to properly erected scaffolding, elevating work platforms and other specifically designed access systems. A crane-lifted workbox can, however, provide a higher level of safety than fall-arrest harness systems.

Before workboxes are selected as a means of access, a risk assessment should be undertaken and recorded demonstrating that the use of other means of access, such as scaffolding or elevating work platforms, is impractical.

Crane-lifted workboxes should meet the following criteria:

- the work box is to be design registered
- correctly tagged lifting slings should be supplied with the work box and attached to lifting points by means of hammerlocks or moused shackles
- the factor of safety for each suspension sling should be at least eight for chains and ten for wire rope
- have fall-arrest anchorage points
- the SWL, tare mass and design registration number of the workbox should be clearly marked (e.g. on a data plate)
- if the workbox is provided with a door, this should be inward opening only, self-closing and provided with a latch to prevent accidental opening
- the sides of the work box should be at least one metre high
- a handrail should be provided that runs around the inside of the box perimeter. This handrail helps to prevent injury to occupants' hands in the event of the box contacting other obstructions
- if there is a risk of a person falling from a height, a fall-arrest harness must be provided and worn by the person. Harnesses should be attached to fall-arrest anchorage points in the work box or to the main sling ring above the workers' heads. Energy absorbers must be provided on the lanyards (see *AS/NZS 1891 Series: Industrial fall-arrest systems and devices* for further information), and
- at least one person in the work box should hold a doggers or riggers licence class to ensure correct directions are communicated to and from the crane operator.
    - *N.B. In very unusual circumstances, such as where a one person box is being used to inspect sewerage (where the shaft is too small for a two person box), a risk assessment to not include a dogger in the box can be undertaken. The box must be in clear view of the dogger and watched at all times.*

Further guidance on the design and safe use of work boxes and cranes is provided in:

- *AS 1418.17: Cranes (including hoists and winches) – Design and construction of workboxes* and
- *AS 2550.1: Cranes, hoists and winches – Safe use – General requirements*.

11.6.2 Features and use of first aid boxes

First aid boxes are a type of crane-lifted work box and should only be used for the retrieval of injured persons.

A crane-lifted first aid box may be required in emergency response and retrieval situations. First aid boxes should be readily accessible on the site to ensure that an effective emergency response can be initiated if they are required.

Crane-lifted first aid boxes should meet the following criteria:

- the first aid box is to be design registered
- first aid boxes should be clearly identified and marked as first aid boxes
- boxes are to be provided with sides and a roof except that a horizontal gap may be provided around all sides of the box
- the sides of the box are to be at least 1 metre high, up to a horizontal gap which is not to exceed 250 millimetres in vertical distance
- the minimum internal height of the box is to be 2.2 metres
- the minimum internal width of the box is to be 1.2 metres, measured internally from face to face (not including the grab rail)
- the minimum internal length of the box is to be 2.8 metres
- the maximum mesh size of the box is not to exceed 50 millimetres x 50 millimetres (i.e. openings which exceed 0.0025 metres^2)
- a grab rail is to be provided along the longer sides of the box and fitted internally to minimise the risk of crush injuries
- if the first aid box is provided with a door, the door may be outward opening but must be lockable to help prevent inadvertent opening
- persons in the first aid box are not required to use fall-arrest harnesses as the first aid box is enclosed
- correctly tagged lifting slings should be supplied with the first aid box and attached to lifting points by means of hammerlocks or moused shackles
- the factor of safety for each suspension sling should be at least eight for chains and ten for wire rope, and
- the SWL, tare mass and design registration number of the first aid box should be marked on the first aid box.

Figure 28 is an example of a compliant first aid box.

At least one person in the first aid box should hold a doggers or riggers licence class to ensure correct directions are communicated to and from the crane operator.

Strong winds may affect the safe use of first aid boxes in emergency situations. First aid boxes should not be used when wind speeds exceed those specified by the crane manufacturer or in adverse weather conditions such as electrical storms. The use of first aid boxes is more suitable in locations which are less susceptible to windy conditions, such as the side of a building structure which is not as exposed to high winds.

First aid boxes should be lifted away from structures to avoid collision.

Figure 28 – Compliant first aid box

11.6.3 Features of a crane when using work boxes and first aid boxes

When using a crane-lifted work box or a first aid box, the crane should meet the following criteria:

- the crane should have a rated capacity of at least twice the total load of the workbox and its contents, at the maximum radius for the task to be performed and not less than 1000 kilograms
- the crane should be fitted with an upper hoist limit that stops operation of the hoist and luff functions of the crane
- the crane's levers and foot pedals should be fitted with a constant pressure system that stops the crane's motions when the operator removes pressure from the controls
- the crane should not be capable of free fall.

11.7 Fatigue

PCBUs must ensure, so far as is reasonably practicable, workers are not exposed to health and safety risks. This includes ensuring that the risk of fatigue is managed.

Factors that may increase the risk of fatigue include:

- early shift starts
- late finishes
- short breaks between shifts
- long hours
- work requiring continued physical effort
- environmental conditions such as working in hot climates.

Fatigue can adversely affect safety at the workplace through reduced alertness and may lead to errors and an increase in incidents and injuries. The following are signs or symptoms that may indicate a worker is fatigued:

- excessive yawning or falling asleep at work
- short term memory problems and an inability to concentrate
- noticeably reduced capacity to engage in effective interpersonal communication
- impaired decision-making and judgment
- reduced hand-eye coordination or slow reflexes
- other changes in behaviour (e.g. repeatedly arriving late for work)
- increased rates of unplanned absence.

The best way to control the risk of fatigue is to eliminate factors causing fatigue. However, if elimination is not reasonably practicable, the risks must be minimised. Control measures to minimise the risk of fatigue include:

- developing a working-hours policy including maximum daily work hours, maximum average weekly hours, maximum hours over a selected period (e.g. three months) and policies for on-call work and work-related travel including consideration of the impact of long travel requirements (e.g. fly-in fly-out flight times) on worker fatigue
- developing procedures to manage and limit excessive working hours (e.g. requiring minimum breaks on a regular basis, especially during longer shifts)
- avoiding work arrangements which provide incentives to work excessive hours
- considering if night work is necessary and rearranging schedules so non-essential work is not carried out at night
- encouraging workers to report work-related fatigue concerns
- developing contingency plans for situations where workers unexpectedly need to work longer hours, more shifts or a long sequence of shifts
- avoiding work during periods of extreme temperature or minimise exposure time through job rotation
- developing a fatigue policy for all workers including managers and supervisors.

Further guidance is provided in the Workplace Health and Safety Queensland Preventing and managing fatigue-related risk in the workplace guide, and the Safe Work Australia Guide for managing the risk of fatigue at work and Fatigue management - a guide for workers.

12 Requirements for mobile cranes used in specific applications

12.1 Vessel-mounted cranes

12.1.1 Characteristics of vessel-mounted cranes

Vessel-mounted cranes include cranes that may be operated on a barge, pontoon or vessel. The combined mass is to be considered as a vessel-mounted crane. The vessel should be anchored during crane operation. If this is not possible, then the vessel should be anchored to a craft alongside it.

When positioning the crane on a barge, pontoon or vessel in either loaded or unloaded conditions, the following should be considered:

- effect on freeboard (i.e. distance between the vessel's deck and the water)
- strength of the vessel to support the crane structure
- installation of stops to prevent the crane driving off the vessel's side, and
- method of securing the crane when working outside of smooth water limits.

A competent person should determine the list (i.e. deck tilt) and freeboard allowable with the rated capacity and test load conditions of the crane. An Australian Maritime Safety Authority (AMSA accredited Surveyor with Stability Category must be experienced in crane design and stability of waterborne vessels. The vessel and crane combination is to be certified by a marine surveyor in accordance with AMSA) requirements.

As a general guide, the maximum list of the vessel under rated capacity conditions should not exceed ± 5 degrees, with one half of the freeboard remaining. Confirmation should be obtained from the crane manufacturer on the de-rating of the crane from land-based ratings when on the barge, pontoon or vessel. Note that generally, the manufacturer's rated capacities for cranes mounted on vessels are frequently not greater than 70 per cent of the land-based rated capacity.

Where the crane can move along the deck of the vessel, lifting should only take place when the crane is secured to the deck (e.g., by chains of adequate strength).

12.1.2 Testing before use

The crane and vessel combination should be inspected after erection and before the application of any loads to ensure:

- All ties, anchorages and ballast are in place and correctly secured.
- The crane configuration is in accordance with the crane manufacturers or a competent person's specifications.
- The crane configuration is free from any defects that would preclude the vessel-mounted crane from handling the test load safely.

The crane should undergo testing of its stability, functions and brakes as outlined in *AS 2550.1: Cranes, hoists and winches – Safe use – General requirements*. After these tests have been completed, a competent person should complete a full assessment to ensure the vessel and crane combination has withstood the test loadings without structural damage, and the mechanisms function free of any defect that will affect the safety of the crane.

12.2 Mobile cranes on suspended structure

Mobile cranes are sometimes lifted or driven onto a suspended structure (e.g. a suspended floor or slab) or other elevated parts of a building for either construction or demolition activities. It should be noted that a suspended structure may not originally be intended to support mobile plant and there may be a risk of the floor or structure collapsing. Prior to accessing and operating on the elevated area, written documentation is to be provided that demonstrates the design floor loading of the

building is not being exceeded for point and distributed loads. Where the floor requires strengthening (e.g., by propping), an engineer is to provide written instructions that detail the dimensions, locations and other specifications of the propping to be used.

If the crane can only be used in particular areas of the building, due to inadequate strength in other areas, access to such areas is to be prevented by the use of barricades or other types of barriers. The lift plan should also consider if and where other plant and material can be put on the suspended structure while the crane is being operated. This should include information on appropriate distances between other plant/material while the crane is in operation.

12.3 Use of mobile cranes for demolition

Mobile cranes may be used to demolish a structure where the demolition involves systematically removing parts of a structure piece by piece with the crane. Demolition with a wrecking ball attached to a mobile crane should not be undertaken due to the high risk and likelihood of damaging the crane.

The use of mobile cranes for demolition work requires the preparation of a SWMS before work commences (see section 1.4).

Where a crane is used for demolition work, additional safety precautions may be required to allow for safety factors such as:

- not knowing the exact mass of parts of the structure to be removed
- additional shock loading that may occur when the part of the structure to be removed is disconnected from the structure (i.e. when unbolted or cut with an oxy torch)
- the part of the structure being removed is not balanced properly (i.e. the load to be lifted is an unusual shape), and
- the load to be lifted gets stuck even though it appears that all the restraint has been removed.

Due to these factors, additional crane rated capacity is required. Mobile cranes used for demolition should have a rated capacity not less than 1.5 times the assessed load. For example, for a given load radius, a 4t load will require a rated capacity of 6t, plus hook block and rigging.

Traffic management arrangements should be implemented to prevent collision with pedestrians or other mobile plant during demolition work.

Further guidance on undertaking demolition work is available in the *Demolition Work Code of Practice*.

12.4 Use of mobile cranes for tree lopping

It is recommended that mobile cranes not be used for tree lopping. Tree lopping is the activity of removing or pruning a tree by the systematic removal of the tree limbs, foliage and trunk. During tree lopping, the tree is connected to the crane hook prior to cutting and it is intended that the crane will be able to assist to lower the tree parts in a controlled manner to designated areas. Cranes have been used for tree lopping; particularly where parts of the tree are above buildings and other structures.

Tree lopping with cranes is considered to be of very high risk due to the increased risk of the crane overturning or structural failure of the boom. During the activity, it is difficult to determine both the mass of the part of the tree being cut and the direction in which the timber will fall. In addition, it is extremely difficult to eliminate shock loading that will be applied to the crane. These issues will either cause the load radius to increase or apply a side loading to the boom. Safe crane operation requires that only vertical loads be applied to the hoist rope and the loads be applied gradually. This requirement is generally stated in crane manufacturer's instructions.

Mobile cranes should not be used for tree lopping unless the following can be ensured:

- the crane operator does not perform the role of a dogger
- a dogger is present during all lifting activities
- the arborist, crane operator and dogger consult with each other
- side loading will not be applied to the crane boom
- any loading to the crane is less than 50 per cent of the crane's rated capacity
- the crane will not be shock-loaded

- wind will not adversely affect the safe use of the crane
- only vertical loads will be applied to the hoist rope and crane hook
- at completion of the saw cut, the radius of the load will not increase.

If the above can be ensured, and there is no other practicable alternative, a mobile crane may be used for this activity in very limited situations. However, the work procedure should be documented and hazard control measures listed in the procedure. The tree arborist and crane operator are to participate in, and be satisfied with, the documented procedure.

12.4.1 Tree trimming and removal work – crane access method

The crane access method involves workers wearing a harness, attaching themselves to a crane and the crane then lifting the worker into a tree. This process potentially exposes workers to the risk of falls from height, being struck by falling objects, contact with energised electric lines and biting or stinging hazards including ants, bees, wasps and snakes.

Risks associated with the using the crane access method to access trees for tree trimming and removal work must be managed. Guidance on potential risks associated with this work, and how they can be managed, can be found in the *Guide for tree trimming and removal work – crane access method*.

12.5 Lifting and landing pre-cast bridge beams

Pre-cast bridge beams (e.g. “Super T’s”) are large loads that require comprehensive lifting and installation procedures to ensure they are landed safely. While bridge beams are sometimes landed with a single mobile crane, they are often lifted into position using two mobile cranes which require careful co-ordination between crane operators. Where a dual crane lift is carried out, an Intermediate Rigger (as a minimum) will be required to oversee the lifting operation. In some cases, the outside beams on the bridge may not be symmetrical but may have additional concrete or steelwork on one side (e.g., as the edge protection or barriers on the completed bridge). Under these circumstances, both the position of the lifting inserts and slings should be calculated so that the beams hang in a way that facilitates easy installation.

In addition, asymmetrical beams can become unstable when landed and the load is taken off the crane hook. The PCBUs should supply a method of securing the beam to prevent the beam from rotating or falling over after the lift is completed. This methodology is in addition to the lift procedure. The use of side bracing is not considered to be the best method due to the risk.

A safer alternative is for the attachments of the tops of non-symmetrical beams to the adjacent bridge beams by means of steel bars with welded connections or by means of load rated rigging gear, while the crane(s) are still holding the beams in place.

The method used to temporarily secure precast bridge beams into position is to be documented and approved by an engineer, experienced in rigging practices associated with bridge construction. Consultation with the rigging crew is advised.

13 Use of other mobile plant as a mobile crane

WHS Regulation section 219(2) and 219(3): The person with management or control of plant at a workplace must ensure, so far as is reasonably practicable, that the plant used is specifically designed to lift or suspend the load. If this is not reasonably practicable, the person must ensure that the plant does not cause greater risk to health and safety than if specifically designed plant were used.

If it is not reasonably practicable to use a mobile crane, other mobile plant may be used as a mobile crane to lift or lower freely suspended loads where it does not cause greater risk to health and safety

than if a mobile crane were used. Other mobile plant that is sometimes used in this way includes backhoes, front-end loaders, excavators and telescopic handlers (also known as ‘load-alls’ and ‘tool carriers’).

Where alternative plant is used in crane mode (i.e., to lift a suspended load), operators should be provided with documented familiarisation training for the specific make and model of plant being used.

13.1 Use of earthmoving plant as a mobile crane

The primary intended use for earthmoving plant is in earthmoving applications where workers are not required to be in close proximity to the plant. However, some earthmoving plant (in particular excavators) can be used for lifting loads incidental to their primary application. One advantage of a tracked excavator in comparison to a rubber tired mobile crane is that the excavator will have greater stability over muddy or uneven ground.

As an example, earthmoving plant such as excavators are often used for lifting pipes or shoring boxes and other objects associated with drainage such as small stormwater pits, or for unloading construction equipment or maneuvering accessories associated with the equipment. This is common practice within the earthmoving industry. However, where the lifted objects become larger and taller (e.g. a formwork shutter) and where the objects being lifted are not inherently stable when placed on level ground, the use of earthmoving plant to lift the load is not appropriate. This is due to the load not being able to remain stable on its own and workers often being required to attach the object to a brace(s) or another member while still attached to the earthmoving plant. Earthmoving plant should not be used to lift personnel unless specifically designed to do so

Mobile cranes are generally preferred for complex lifting activities for the following reasons:

- unless specifically designed to do so, earthmoving plant do not generally lift in a purely vertical motion but instead lift in a series of arc motions. In comparison, mobile cranes fitted with a hoist can lift vertically
- Earthmoving plant is often designed for more rapid movement in comparison to a mobile crane (however, some modern excavators do include features such as a crane mode to reduce or control speed of movement)
- mobile cranes of more than 1 tonne rated capacity will be fitted with a load indicator as standard equipment and are often fitted with a rated capacity limiter. These operator aids assist in preventing overload to the crane and lifting gear and the associated risks to persons who may be in the immediate area of the mobile crane (i.e. doggers and riggers). Some earthmoving plant are also fitted with load indicators and rated capacity limiters
- operators of earthmoving machinery sometimes do not have the same level of training in lifting loads as mobile crane operators (i.e. they are not required to obtain a high risk work licence); and
- there are usually no motion limiting devices to restrict lifting at greater side slopes angles than specified by the manufacturer and operators are not trained in the reduction of capacity due to side slope.

Based on these factors, and the design and nature of the operating functions of earthmoving plant, except where these issues have been addressed, using earthmoving plant to lift loads will generally present a higher risk to workers and others than if a mobile crane was used. As such, using earthmoving plant for complex loads should not be performed unless equal to or better than safety standards can be demonstrated. Typically, earthmoving plant is suitable for lifting loads associated with earthmoving activities including pipes, trench shields, small storm water pits and culverts. In these circumstances, the correct lifting equipment, as selected by appropriate personnel, should be used to safely secure and place the load.

Backhoes are not suitable to move a suspended load in pick and carry mode due to excessive load swing. This is exacerbated by the wheels of backhoes which cause excessive movement when being driven over rough ground.

13.2 Rated capacity of other mobile plant

The rated capacity of other mobile plant is the maximum mass that may be handled at the maximum lift point radius, or reach, for each lift point, without the strength and stability requirements being exceeded. When determining the allowable load to be lifted, the mass of any attachments should be deducted, unless the rated capacity chart allows otherwise.

The rated capacity of other mobile plant is the maximum mass that may be handled at the maximum lift point radius, or reach, for each lift point, without the strength and stability requirements being exceeded. When determining the allowable load to be lifted, the mass of any attachments, such as buckets or quick-hitch, must be deducted, unless the rated capacity chart allows otherwise.

When used in crane mode earthmoving plant is to comply with the stability criteria specified in Australian Standard AS 1418.8 *Cranes, hoists and winches Part 8: Special purpose appliances*. This includes ensuring the rated capacity of the plant is not greater than:

- 75 per cent of tipping load in the stationary mode
- 66 per cent of tipping load in the pick-and-carry mode; or
- 50 per cent of tipping for articulated wheel loaders and tool carriers.

13.3 Load chart

The load chart for the mobile plant should identify each lift point location, and the corresponding rated capacity for each position. The appropriate load chart should be fixed inside the operator's cab and show the following information:

- manufacturer's name and model
- boom and dipper arm identification and length, particularly where different boom configurations may be used
- track width, where this is variable
- deductions for attachments, such quick-hitch devices, so that the net allowable load to be lifted can be determined, and
- one of the following:
  - the rated load at the least stable position; or
  - where variable load rating is provided for, means to clearly determine the load position in accordance with the rated capacity chart or rating capacity limits
- any reduction in capacity due to structural or stability issues when operating out of level or driving the crane while carrying a load.

13.4 Lifting points on earthmoving plant

Lifting attachments on earthmoving plant are sometimes supplied by the plant manufacturer. If this is not the case, the attachments should be designed by a suitably qualified engineer. Lifting attachments often consist of a welded assembly that fits onto the end of the dipper arm when the bucket is removed. All lifting points on earthmoving plant should form a closed eye, to which a load rated shackle may be attached. Figure 29 shows an example of a lifting attachment with a closed eye.

The provision of load rated swivels on earth moving plant will allow the load to be more easily rotated during load placement.

AS 1418.8 specifies that a static strength test at 200 per cent of the rated capacity of each lift point is to be carried out. The lift points should not show any permanent deformation after testing. The test may be performed with the component dismantled from the machine. This should be done if application of the test load could result in damage to the earthmoving plant.

Figure 29 – A swivel between the lifting point and load

Hooks should not be used on the dipper arm or other attachments of earthmoving plant, because the load may become unintentionally disengaged as the arm rotates. This can even occur when the hook is fitted with a latch, because the latch may be damaged (e.g. with a mobile crane, the hook hangs vertical, with an excavator, the lifting point rotates).

When lifting lugs are welded to attachments or other parts of the earthmoving plant, the material specifications for the two different components are to be compatible for welding, and the appropriate welding procedures should be followed.

Lifting lugs should not be attached to buckets for the following reasons:

- Application of the lifted load to the outside of the bucket can load the pins and linkages in a way other than the designer intended
- It is easier for the operator to unintentionally overload the plant by not allowing for the dead weight of the bucket or because the bucket has earth stuck to the inside
- The lifting chain or sling can be damaged when a bucket is fitted because it may pass over the front edge of the bucket
- Lifting lugs on buckets may be damaged when the bucket is used for digging activities
- Slinging rigging equipment around the bucket does not constitute a lifting point.

13.5 Quick hitches

A quick hitch is a latching device that enables attachments on earthmoving plant to be rapidly connected to the dipper arm of the plant. While the device saves time and effort, a number of fatalities have occurred in Australia when excavator attachments have fallen off the quick-hitch due to loss of hydraulic pressure.

Quick hitches are fitted with a fixed latch and a moving latch. The moving latch either slides or pivots into position underneath the pin on the attachment, after the fixed latch has already been engaged under the other pin. If hydraulic pressure is lost the moving latch will disengage unless there is an effective locking system to prevent this occurring.

The more basic quick hitches rely on manual Locking. Locking pins are generally used on quick hitches to ensure the attachment is correctly engaged and remains locked in position on the dipper arm. These require the conscious action of the plant operator to get out of the cabin and fit the pin.

A number of different designs of quick hitch incorporate an automatic back up locking system that prevents the quick hitch inadvertently disengaging. The backup locking system requires an indicator that the operator can see while seated in the cabin. Irrespective of whether the quick hitch has a manual locking pin or automatic locking system it must be remembered that continuing safe operation can only be ensured when the quick hitch and attachment are compatible and wear does not exceed that permitted by the quick hitch manufacturer. Quick-hitches should comply with the safety system specifications included in *AS 4772 Earthmoving machinery – Quickhitches for excavators and backhoe loaders or ISO 13031 Earthmoving machinery – Quick Couplers used on earth-moving*

machinery. If the quick-hitch does not comply with either of these standards, it is to be fitted with a manual locking pin.

Where the quick-hitch supplier claims a quick-hitch complies with AS 4772 or ISO 13031, a certification document stating this should be provided by the supplier upon request.

The following applies to the design and use of quick-hitches:

- The quick hitch is compatible with the mobile plant it is fitted to (pin size, rating etc)
- Where the quick hitch is designed for lifting, the lifting point is designed is to be in the form of a closed eye with an identification plate that states the maximum rated lifting capacity of the lifting point (note: this is not to be confused with the maximum rated lifting of the plant – the latter information should be more visible than the lifting lug capacity to help prevent over loading of the earthmoving plant).
- Quick hitch manufacturer's instructions are available to the operator and kept in the cabin.
- The operator has received training for the type and model of quick hitch fitted to the machine.
- The lifting point is inspected for condition and serviceability prior to lifting .
- Where the quick hitch has a lifting lug, a swivel is provided between the lifting hook and shackle attached to the lifting lug (refer Figure 28).
- Where manual locking pin quick-hitches are used the head of the pin should be painted red with a lynch pin or similar restraint at the opposite end to help keep the pin in position.
- The quick hitch should be inspected in accordance with the manufacturer's instructions and by a competent person. This inspection should include tolerance checking of all critical components.

13.6 Burst protection and rated lifting capacities

Burst protection is to be fitted on all earthmoving plant used as a crane, where the rated capacity exceeds 1 tonne. The burst protection is to be fitted to both the boom and dipper arm of the plant. Burst protection fitted to excavators and the hoe arm of backhoes is to comply with the performance requirements of *ISO 8643: Earthmoving machinery – Hydraulic excavator and backhoe loader boom-lowering control device – Requirements and tests.*

The following additional conditions are to be applied:

- The maximum rated capacity is to be in accordance with the manufacturer's specifications for the plant. Plant should not be de-rated to avoid fitting burst protection.
- **Single rated capacity:** Where the decision is made to rate the lifting capacity of the plant at its maximum lifting radius, this becomes the rated capacity[1] and is to be marked on the boom or dipper arm. The rated capacity should then be strictly observed at all times, irrespective of the radius of the load. Information should be available on site to confirm that the rated capacity marked on the unit is the same as that specified by the manufacturer.
- **Variable rated capacities:** Where the plant has variable lifting capacities, the manufacturer's rated capacity chart (i.e. load chart) is to be fixed to the inside of the operator's cabin. For plant with variable rated capacity, the lifting capacity at minimum radius is to be used to decide whether burst protection is required.
- Where practicable the burst protection device should not be provided with the ability for the operator to switch the device off (in case the operator forgets to switch the burst protection on when the plant is operated as a crane).
- Where the rated capacity of the plant is one tonne or less, and the decision is made not to fit burst protection, the plant should not be used to lift loads where this presents a risk to workers.

Earthmoving plant owners should seek advice on fitting of burst protection from original plant manufacturers, to help avoid fitting faulty or unsafe systems.
Note: Safe Working Load abbreviated to 'SWL' may be used to indicate the rated capacity on older earthmoving plant. Working Load Limit (WLL) or Rated Capacity may also be used.

13.7 Maintaining earthmoving plant in safe condition

Earthmoving plant is frequently used in a harsh environment where the plant may be exposed to damage or wear during use. This can include structural damage to lifting points, the boom, dipper arm and quick hitch, damage to hydraulic lines and hoses, and wear on pins, bushes and hydraulic cylinders. Earthmoving plant is to be serviced and inspected in accordance with the manufacturer's instructions. An inspection program is to be implemented to ensure that the plant is safe before it is used to lift loads. When the plant is used in crane mode a pre-start inspection of the plant should also take place. Particular care and attention is required where the earthmoving plant is exposed to a severe working environment (e.g. demolition work, rock breaking). Earthmoving plant owners should seek advice on safety inspections required (e.g. nondestructive testing of the boom and dipper arm and any other high stress areas) for earthmoving plant exposed to a severe environment.

However, irrespective of the working environment a safety inspection should be carried out at intervals not exceeding 12 months. Safety inspections should include:

- Any items specified by the manufacturer of the earthmoving plant.
- Inspecting for hydraulic fluid leaks on hoses, cylinders and pumps.
- Function testing of the plant to verify the plant is operating in accordance with the manufacturer's specifications.
- Removal of grime and inspection of welds, pins and linkages on the boom, dipper arm, crowd mechanism, hydraulic cylinder mounts and lugs for cracking, deformation and excessive play.
- Inspection of pin retainers and locking systems to determine that they are provided and in good condition.
- Where cracking has been identified replacement or repair of the damaged parts. Where a repair is made the repair should be certified by a professional engineer or the manufacturer of the earthmoving plant.
- Where a quick-hitch is fitted, function and tolerance checking of the quick-hitch to verify it complies with the manufacturer's instructions.

14 Vehicle-loading cranes

14.1 General use

Vehicle-loading cranes (see Figure 30) are intended to be mounted on a broad range of vehicles including tray trucks and prime movers. When originally introduced, vehicle-loading cranes were used for loading the truck on which they were mounted. However, with the introduction of larger capacity vehicle-loading cranes, these types of cranes are also used for traditional crane operations where either:

- the load is lifted from the vehicle tray to an elevated area at a workplace (e.g. lifting packs of timber from the vehicle directly to a building floor)
  or
- the load is lifted both to and from locations, remote from the vehicle on which the crane is mounted.

Figure 30: Vehicle-loading crane

14.2 Crane and vehicle suitability

Vehicle-loading cranes should only be mounted on vehicle types and models specified by the crane manufacturer. Failure to comply with this could lead to structural failure of the crane or vehicle or make the crane combination unstable. Where second-hand vehicle-loading cranes are imported from overseas and introduced into Queensland, the crane and vehicle combination is to be provided with a compliance plate that has been attached by an authorised person in compliance with Department of Transport and Main Roads requirements.

The method of mounting the crane to the vehicle should be in accordance with the crane manufacturer's specifications or the recommendations of a competent person. Any adverse effects to both the vehicle and crane are to be taken into consideration. Welding the crane to the vehicle chassis is generally unacceptable because it can damage the chassis, and also lead to fatigue failure of the connection.

14.3 Design of controls on vehicle-loading cranes

Controls on vehicle-loading cranes should be of the constant pressure (deadman) type, and permanently marked with clearly visible symbols in accordance with *AS 1418.11: Cranes, hoists and winches – Vehicle-loading cranes*.

The position and layout of controls on vehicle-loading cranes should be designed so that the risk of the operator being crushed against the controls by inadvertent operation of the crane is minimised. If administrative controls are provided to prevent injury, training must be provided for operators on this issue.

An emergency stopping device should be provided at every control station on the vehicle-loading crane. The emergency stopping device should:

- remove the energy supply to the crane, and bring the crane to a complete stop when activated
- be readily visible and coloured red
- be arranged for easy access, and located so that the operator will not be exposed to other hazards when activating the device
- lock in the 'stop' position when activated.

14.4 Rated capacity limiters

Rated capacity limiters should be provided on all vehicle loading cranes with:

- a maximum rated capacity of one tonne or greater; or
- a gross lifting moment of 40 kNm (kilonewton metres) or greater.

The purpose of the rated capacity limiter is to prevent movements that may increase load moment in excess of the rated capacity, and to also prevent an increase of the load radius or permissible stresses in the structure.

Where smaller vehicle-loading cranes are not fitted with a rated capacity limiter, relief valves and fittings should be used to provide overload protection.

14.5 Rated capacity indicators

All vehicle-loading cranes manufactured after 2003 should be fitted with a rated capacity indicator. The rated capacity indicator should warn the crane operator when the load exceeds 90 per cent of the rated capacity. The rated capacity indicator should give a separate warning to the operator and persons in the vicinity of the crane if the rated capacity is being exceeded.

The warning for approach to rated capacity should be clearly distinguishable from the warning for exceeding the rated capacity by all persons while the crane is being operated. Both warnings should be continuous.

14.6 Stabiliser locking

Stabilisers on vehicle loading cranes are typically manually operated and rely on the operator to push them back into their locked position after use. If the stabiliser is not pushed back into its locked position, there is a risk the stabiliser will extend during transportation (e.g. when the vehicle turns a corner).

The locking mechanism for manually extended vehicle loading crane lateral stabilisers should include two separate latching devices for each stabiliser and at least one of these should be automatically operated (e.g., a manually operated securing pin and an automatic spring latch).

PCBUs must also ensure workers who drive/operate the vehicles are provided with appropriate instruction, training and supervision regarding the use of the stabiliser and their lateral locking mechanisms. The training should relate to the specific make and model of plant and be documented.

Owners of vehicle loading cranes should assess the on-going safety of the current stabilizer lateral locking mechanisms. It may be necessary for an engineer or the manufacturer to redesign, modify or select another locking mechanism that, eliminates or minimises the risk of a stabiliser inadvertently extending while travelling on public roads.

Where a vehicle loading crane does not have a warning system to indicate when the stabilisers are not locked laterally in the transport position, owners of vehicle loading cranes should retrofit a warning system. Australian Standard *AS1418.11: Vehicle-loading cranes* specifies the provision of an indicator to show that the stabilisers are not locked in the transport position. Cranes manufactured to comply with the AS 1418.11 should include a warning system visible and audible to the driver (i.e. a warning light with a buzzer in the truck cabin).

The feasibility of fitting an upgraded warning and indicating system to older vehicle loading cranes should be addressed during the annual inspection and maintenance program for the crane.

14.7 Operational issues for vehicle-loading cranes

The vehicle-loading crane should be operated in accordance with the operator's instruction manual provided by the crane manufacturer. Additionally, the following points should be complied with:

- Operators should be provided with familiarisation training on the specific make and model of the particular vehicle-loading crane (refer to Appendix 5 for an example of a checklist that can be used).
- Operators of vehicle-loading cranes with a maximum load moment capacity of 10 metre tonnes or more must hold the appropriate high risk work licence class (CV) to operate a vehicle-loading crane.
- A person operating a VLC, with a maximum rated capacity under 10 metre tonnes, is able to sling loads, without holding a dogging HRW licence, when there is no judgment required for slinging techniques or inspecting and selecting the suitability and the condition of lifting gear. This requires the weight of the load, the slings and slinging technique to be predetermined by a licensed dogger or rigger or an appropriately qualified engineer. The PCBU must provide comprehensive documented training relevant to slinging loads, including the above factors, and evidence of this training needs to be available on request.
- If the load is out of the operator's view at any stage during the lifting process, the movement of the load should be directed by a qualified dogger or rigger.
- When the vehicle loading crane is used for precision placement of a load, a dogger should be used. For example, lifting a sign into position where fixing alignment is required would require the assistance of a dogger. Conversely, placing a pallet of blocks in view of the operator would not be considered precision placement.
- An operator holding a DG (for VLC under 10 metre tonnes) or CV Class HRW licence may also apply slinging techniques and select/inspect slings whilst in control of or operating a VLC.
- The crane may only be used with all stabilisers extended in accordance with the crane manufacturer's instructions. Where multiple positions can be used on stabiliser legs, the legs should be set up in compliance with the manufacturer's load chart.
- The crane should only be used so that it is level in accordance with the crane manufacturer's specifications (usually not exceeding one degree or less).
- Timbers or other pads specified by the crane manufacturer are to be provided under the stabiliser feet.
- Hooks should be provided with spring-loaded safety latches and should be adequately maintained.
- Where it is possible to apply a side load to the crane hook, the hook should be provided with an appropriate swivel.
- The crane should never be used in pick-and-carry mode.

- Where vehicle loading cranes are used to lift persons the unit should comply with *AS 1418.10 – Cranes, hoists and winches – Part 10: Mobile Elevating Work Platforms*.
- Where provided, spring lock-outs on the vehicle are to be activated during crane operation.
- The crane should only be used with a load suspended vertically from the hook. The crane is not to be used to drag a load across a supporting surface.
- The stabiliser legs should be clearly marked with 'zebra striping' to improve visibility. Section 7.3.1 of this code provides further information on the dimensions of the zebra striping.

15 Training

15.1 Responsibilities for training

The duties for providing information, instruction and training are outlined in section 1.5 of this code.

Information, training and instruction for mobile crane operations should cover at least:

- documented work procedures to be used in the setting up and safe operation of mobile crane activities
- method for inspection and maintenance of mobile cranes
- knowledge of the crane manufacturer's operation and service manuals
- correct use, care and storage of personal protective equipment
- correct use, care and storage of tools and equipment to be used
- observance of electrical safety practices
- procedures to be adopted in the event of incident or injury
- driving techniques for an articulated mobile crane.

PCBUs should ensure that management systems are in place to:

- ensure only those workers who have received training and instruction are authorised to carry out that work, and
- sufficiently monitor all work to ensure that agreed safe work practices are being adhered to, including the use of all safety procedures and systems and personal protective equipment.

15.2 Familiarisation training

Mobile cranes can be fundamentally different in their design, mode of operation, control layout and configuration. Before a person is allowed to work as a crane operator, the PCBU of the person should either:

- assess the person's knowledge and understanding of safe crane operation
- seek further evidence of the person's competence, or
- provide additional training, prior to allowing the person to work.

Familiarisation training provides crane operators with an opportunity to become familiar with the design, layout and operating functions of a specific mobile crane. This should be provided to crane operators prior to commencing work for a new PCBU or operating a crane that has been newly acquired by their PCBU. This process may require the presence of a representative from the mobile crane supplier or manufacturer, particularly when the crane is new. The representative from the mobile crane supplier or manufacturer should have detailed knowledge of the operational and safety features of the crane in question. The representative from the mobile crane supplier or manufacturer should also be endorsed by the crane supplier or manufacturer as being competent to provide the familiarisation training.

A record of the familiarisation training should be made and kept by the PCBU of the crane operator. A copy of the training record is also to be given to and kept by the crane operator. The record should be signed by both the crane operator and the PCBU, or a representative of the PCBU.

The record of the familiarisation training should take the format of a checklist. Crane operators should demonstrate that they understand how to undertake safe crane operations based on this checklist.

Sample checklists for familiarisation training are provided in Appendix 4 of this code.

15.3 Refresher training

PCBUs should ensure that persons who work as part of a crane crew (crane operators, doggers and riggers) receive refresher training. Refresher training may be provided by the PCBU or an independent consultant or third party (e.g., registered training authority).

Refresher training should be made available to these persons on an ongoing basis. The purpose of refresher training is to ensure that crane operators, doggers and riggers maintain the competencies originally achieved in the relevant licence class for performing high risk work and to keep up to date with current industry practices and innovations. It is particularly relevant for persons who have not continuously performed work in a class of high risk work.

The person providing the refresher training should be endorsed by the crane company as competent to provide this training.

Refresher training should reflect issues such as:

- the application of new technology, particularly for those persons who obtained their licence class while working on more basic cranes
- information in this code
- any relevant changes to workplace health and safety legislation and Australian Standards which may have an impact on safe crane operations
- safe crane operation.

Refresher training may include:

- conducting a training needs analysis to identify the particular training needs of individual workers
- providing theoretical information, where required
- providing practical demonstration and supervision.

Refresher training requirements apply to any type of mobile crane and plant that is used as a mobile crane (e.g. an excavator).

For earthmoving plant that may be used for lifting incidental to their primary purpose, appropriate training including consideration of all of the aspects above where appropriate, should be provided.

15.3.1 Frequency of refresher training

The interval between refresher training courses should not exceed three years. Crane operators, doggers and riggers should undergo refresher training between two and a half and three years after either being issued with their initial licence for a class of high-risk work, or since attending their most recent refresher training, whichever is the shorter time frame.

15.3.2 Record of refresher training

Crane operators, doggers and riggers should keep a documented record of refresher training they have undertaken.

Each training record should be verified and signed by the PCBU, or a representative of the PCBU. The PCBU should also keep a copy of the training record.

The record should consist of the following information:

- the person’s full name and signature
- the relevant classes of high-risk work licences held by the person and the licence numbers
- the name and signature of the person conducting the training
- the dates and times of the training
- details of the training, including where appropriate, the type of equipment used or operated, and the outcomes achieved.

16 Inspecting, testing, maintenance and repair of mobile cranes

Failure to carry out appropriate planned inspections and preventative maintenance programs may lead to structural or mechanical failure and collapse of the mobile crane.

Inspecting and appropriate testing should be carried out frequently to ensure the:

- Parts of the crane subject to deterioration through corrosion, damage, wear or abrasion are replaced or repaired before they become unserviceable.
- Crane is maintained in a safe and serviceable condition (e.g. all windows and windscreens should be regularly cleaned and cracked windows and windscreens should be replaced to ensure vision is not obscured).

Inspecting and testing of mobile cranes should also include:

- pre-operational inspection
- routine inspection and maintenance
- annual inspections
- major inspections.

16.1 ‘Competent person’ for inspecting mobile cranes

The *Work Health and Safety Act 2011* includes duties for persons conducting a business or undertaking, owners and suppliers of plant. A duty holder who owns a crane may engage a competent person to inspect the crane to determine whether the condition of the crane poses a risk to safety.

A competent person can be:

- the owner of the crane
- a person employed by the owner of the crane (i.e., where the owner is also a PCBU); or
- an independent consultant or third party.

16.1.1 Inspecting specific parts of a crane

A competent person who has been engaged to inspect a specific part of a crane should have suitable experience and knowledge in the inspection of that part of the crane. This person may not necessarily need experience in inspecting the complete crane.

For example:

- A competent person inspecting welding on a crane should have suitable knowledge and experience in the inspection and testing of welds. This should include knowledge of non-destructive testing methods and *AS/NZS 1554: Structural steel welding*.
- A competent person inspecting hydraulic systems and circuitry on the crane should have suitable knowledge and experience in the inspection and testing of hydraulic systems.
- A competent person inspecting electrical systems on the crane should have suitable knowledge and experience in electrical systems, including the ability to read circuit diagrams and understand relevant technical standards. This person must be a qualified and licensed electrician where the voltage of the electrical system is greater than 50 volts alternating current, or 115 volts direct current.
- A competent person carrying out non-destructive testing on mobile crane components should have suitable knowledge and experience in non-destructive testing methods. This person should be accredited by the National Association of Testing Authorities (NATA).

In these instances, the competent person would verify that the welding, hydraulic system or electrical system complies with the relevant technical standards. It would not be appropriate for this person to verify that the complete crane complies with a relevant technical standard or is in a safe condition.

16.1.2 Inspecting a complete crane

A competent person who has been engaged to inspect the **complete crane** should have suitable knowledge of and experience in the inspection of cranes. Although this person would not necessarily need to be an engineer for inspections other than the major inspection, it is advisable that the person have a qualification in a mechanically associated trade. This person should be able to make a judgement about the maximum allowable amount of wear and deformation in mechanical and structural components, and the associated pass/fail criteria.

The person should also be able to demonstrate experience in the inspection of the specific crane type.

The decisions of the competent person should be based on information contained in the crane manufacturer's instructions, relevant technical standards, sound engineering principles or a combination of all these.

16.1.3 Crane alterations

WHS Regulation, section 244

If the design of an item of plant that is registrable is altered, the altered design must be registered if the alteration may affect health or safety.

WHS Regulation, section 282

Registration holders must notify the WHS Regulator in writing of changes to information provided to the regulator in relation to a registered item of plant, including when plant is altered in a way that requires the plant to be subject to new control measures.

Where an alteration has been made to the design of a crane, the competent person must be an engineer with suitable knowledge and experience. It is likely that the competent person will need to perform engineering calculations on the crane design to determine that it complies with relevant technical standards.

Proposed alterations to the design of a mobile crane should not be considered in isolation but assessed in relation to the whole device and how it operates to ensure the proposed alteration will achieve the desired safety outcome and not lead to other adverse consequences.

Before making alterations to a mobile crane, the person with management or control of the mobile crane should consult with the designer and manufacturer to ensure all relevant safety issues have been considered. If the original designer and manufacturer of the plant design implement alterations, then relevant obligations imposed by the WHS Regulation still apply. If the original designer or manufacturer cannot be contacted, alterations should be carried out by, or under the supervision of, a competent person based on relevant technical standards or engineering principles. The scope of this work is likely to be a professional engineering service which must be carried out or supervised by a registered professional engineer under the *Professional Engineers Act*.
The WHS Regulation requires that registrable plant design alterations, which may affect health or safety must be registered.

The mobile crane should be isolated from power sources and be unable to be switched on or activated accidentally before alterations begin or while alterations are being carried out.
Before returning an altered mobile crane to service you should:

- have control measures in place to eliminate or, where that is not reasonably practicable, minimise risks created by the alteration including providing information and training for users and supervisors about the changes; and
- inspect and test the plant, having regard to the altered design specifications and relevant technical standards.

16.2 Non-destructive testing

Non-destructive testing (NDT) is the testing of materials to detect internal, surface and concealed defects or discontinuities, using methods which do not damage or destroy the material under test. NDT of specific mobile crane components is to take place at set intervals (e.g. a major inspection).

All NDT should be carried out by a competent person who has been accredited by NATA. Technicians performing NDT independently should be AiNDT Cert II in the NDT method performed or a competent person should provide a procedure to an AiNDT Cert I. The results of NDT must be available at the crane yard.

When NDT is used for the detection of surface discontinuities (cracks) in metals and weldments, the recommended surface preparation must be completed according to the capabilities of the NDT method.

16.3 Pre-operational inspection

The crane operator should carry out a visual inspection and functional test before the commencement of each work shift, including inspecting and testing the following:

- all relevant items indicated in the operator's manual
- operating and emergency controls
- brakes
- safety switches and interlocks, including limiting and indicating devices
- visual inspection of the structure
- wire ropes to ensure they are on the drum and correctly reeved on the sheave.

The results of the inspection should be entered into a logbook and accessible with the crane.

All personal protective equipment should also be inspected to ensure it is functioning correctly. All safety-related problems must be corrected before the crane is used and recorded at an appropriate time.

16.4 Routine inspection and maintenance

Routine inspection and maintenance must be carried out in accordance with the crane manufacturer's instructions. These inspections may include a program of weekly, monthly and quarterly inspections, or alternatively be scheduled based on hours of operation and should include:

- all functions and their controls for speed and smoothness of operation for the full extent of that motion (e.g. full telescope, full 360 degree slew)
- all emergency and safety switches and interlocks, including limiting and indicating devices
- lubrication of all moving parts
- inspection of filter elements and fluid levels
- visual inspection and measurements as necessary of structural members and other critical components such as brakes, gears, rims, tyres, fasteners, pins, shafts, wire ropes, sheaves, locking devices
- signage, including warning signs and control markings
- additional items nominated in the crane manufacturer's instructions.

All replacement parts should be identical or equivalent to the original parts or components. A written report should be supplied upon completion of the inspection. Electronic service reminders should not supersede written evidence of completed maintenance, as it is not always possible to clear service reminders should the inspection and maintenance be completed prior to the reminder activating.

16.5 Annual inspections

An annual inspection should include all items specified by the crane manufacturer for annual inspection, as well as all items included in the routine inspection and maintenance programs.

Annual inspections include:

- the effective functioning and calibration of all limiting and indicating devices
- detailed visual inspection and tolerance checking of all structural and wear components
- checking of tolerances for wear limit
- a detailed check for corrosion
- a detailed examination of critical areas for evidence of cracking.

An example of an Annual Crane Safety Certificate is provided in Appendix 6. This document may be used as evidence that the crane has received an annual safety inspection by a competent person.

16.6 Major inspection

WHS Regulation section 235(1) and (2): The person with management or control of a registered mobile crane at a workplace must ensure that a major inspection of the crane is carried out by, or under the supervision of, a competent person;

(a) at the end of the design life recommended by the manufacturer for the crane; or

(b) if there are no manufacturer's recommendations- in accordance with the recommendations, of a competent person; or

(c) if it is not reasonably practicable to comply with paragraph (a) or (b) – every 10 years from the date that the crane was first commissioned or first registered, which ever occurred first.

A major inspection must be completed for a registered mobile crane (i.e. where the maximum MRC is greater than 10 tonnes). Although not a mandatory requirement, non-registrable mobile cranes (i.e. where the maximum MRC is 10 tonnes and less) should have a 'major' inspection completed so that they continue to be safe to operate.

Major inspections must be carried out at the end of the crane's design life, as determined by the manufacturer's instructions, or if this is unknown or unavailable, as determined by a competent person to meet the same minimum requirements established by relevant technical standards.

If it is not reasonably practicable to inspect a crane according to either of these, the crane is to be inspected at least every 10 years from the date the crane was first commissioned or registered, whichever was first. This must include inspection of the structure as well as mechanical components.

Major inspections must be carried out by, or under the supervision of, a competent person who:

- has acquired through training, qualifications or experience the knowledge and skills to carry out a major inspection of the plant and is registered under a law that provides for the registration of professional engineers, or
- is determined by the regulator to be a competent person.

Section 16.6.1 lists some items to be inspected during a major inspection of a mobile cranes. The full list of items to be inspected must be determined by a competent person.

Completion of a major inspection does not indicate that the components inspected will have a further 10 year design life. It should not be assumed that the items included in the list only require inspection at 10 yearly intervals. Items will require some type of inspection and maintenance at more frequent intervals, for example at annual and other inspection intervals, according to the crane manufacturer's instructions.

Where there is documented evidence that inspection and testing has been carried out on certain items, for example slew ring bolts, drive systems and braking systems, within a reasonable preceding period as determined by a competent person, the item may not have to be stripped down in the major inspection. The competent person should still inspect the safe operation of the item to certify it is operating safely and document the reasons for the decision.

The design working period (DWP) method is a method sometimes used to help determine the degree of maintenance and inspection on a crane based on comparing its actual use to its design criteria. Some engineers use the DWP method to help justify not dismantling parts of a mobile crane. It is to be noted that this method does not consider corrosion based on environmental factors, hidden damage due to misuse of the crane or load cycles experienced by a mobile crane when being driven. In addition, in the absence of data loggers that can be downloaded, it can be difficult to verify how much use the crane has had. Where the manufacturer specifies inspection criteria for the major inspection, the engineer should follow this criteria as a minimum. The DWP method should not be relied upon as the only method to determine the scope of the major inspection. The competent person needs to consider environmental factors, how the crane has been stored and whether the crane has any hidden damage.

Prior to listing the key inspection items, the following is to be noted:

- Where the crane manufacturer specifies instructions for the major inspection, these instructions are to be followed and take precedence over the list below.
- The list only specifies some of the generic items requiring inspection. The actual list of items inspected will be considerably larger and will be based on the requirements of the crane manufacturer, or, if these do not exist, the instructions of a competent person.
- Items included in the list may require more frequent inspection. All items will require some type of inspection and maintenance at more frequent intervals (i.e. at annual and other inspection intervals) in accordance with the crane manufacturer's instructions.

16.6.1 Key items requiring inspection

The key items which are to form part of the major inspection are detailed below.

Slew ring

The amount of clearance in the slew ring is to be quantitatively measured and compared to the maximum clearance specified by the crane manufacturer. The clearance should be measured at a minimum of four locations around the slew ring. If the clearance exceeds that specified by the manufacturer, the slew ring should be split. Where the slew ring is split, all components should be examined and replaced where they are damaged or worn. The backlash and teeth width in both the pinion drives and ring drive are to be measured and are to be within the crane manufacturer's specification.

Slew ring bolts

One of the following alternatives should be followed:

- Remove all bolts and replace with new bolts of the type specified by the manufacturer, installed in accordance with the crane manufacturer's instructions (i.e. torque and tightening sequence).
- Re-torque slew ring bolts to the crane manufacturer's specifications. Where any bolts fail, all bolts are to be removed and non-destructively tested and reinstalled, or replaced with new bolts. **Note:** this alternative may only be selected where the crane manufacturer states that the procedure is an acceptable method of testing integrity of the slew ring bolts.
- Remove all bolts and non-destructively test for cracking or other imperfections. Reinstall undamaged bolts in accordance with the crane manufacturer's instructions (i.e. torque and tightening sequence). **Note:** this alternative may only be selected where the crane manufacturer states that the procedure is an acceptable method of testing integrity of the slew ring bolts.
- Remove a percentage of slew bolts in accordance with the crane manufacturer's instructions. Non-destructively test removed bolts. If any damage is found, all bolts are to be removed and non-destructively tested or replaced with new bolts. **Note:** this alternative may only be selected where the crane manufacturer states that the procedure is an acceptable method of testing integrity of the slew ring bolts.

Drive systems (including hydraulic motors, gearboxes and drive shafts)

Where catastrophic failure of the drive system can result in the load or boom dropping in an uncontrolled manner, carry out the following:

- Remove and strip down all parts of the drive system. Ensure all components are within manufacturer's tolerance. Replace worn components including valves, shafts and bearings.
- Non-destructively test parts of the drive system that may be prone to cracking. Particular attention should be given to components, the failure of which will have a catastrophic effect. Since significant fatigue damage can occur in the microstructure of these components without evidence in non-destructive testing, the competent person should consider the replacement of such components.
- Hydraulic motors and valves are to be pressure and performance tested prior to re-entering service.

Where catastrophic failure of the drive system will not result in the load or boom dropping in an uncontrolled manner, carry out the following:

- inspect the drive system for vibration, fluid leakage and correct operation, and
- where damage or malfunction can be observed, remove and repair or replace defective part.

Braking systems

- Hoist and luff brakes are to be removed from the crane and dismantled. Pins, springs, valves and bearings are to be checked for correct tolerance. Rubber seals are to be replaced and pistons checked for correct operation.
- Any welds in braking systems, including band brake weld terminations, are to be crack tested by NDT. Non-destructively test parts of the braking system that may be prone to cracking. Particular attention should be given to components that will have a catastrophic effect if they fail.
- Since significant fatigue damage can occur in the microstructure of these components without evidence in non-destructive testing, the competent person should consider the replacement of such components.
- Hydraulic systems are to be checked for leaks prior to reattachment to the crane.
- Brake linings are to be checked for wear limits.
- After reinstallation brakes are to be adjusted and actuated a number of times to ensure correct operation.

Hydraulic cylinders (all cylinders, including outrigger cylinders)

- Hydraulic cylinders are to be checked for external leakage and creep. Where leakage is observed, or creep exceeds manufacturer's specifications, hydraulic cylinders are to be removed and stripped down.
- Seals are to be replaced and rams rechromed where necessary.
- NDT crack test welds on rod ends and caps.
- Reassembled cylinders are to be pressure tested and checked for operation and leaks.

Booms (hydraulic cranes)

On all hydraulic booms:

- Perform creep test on telescopic function with boom extended and raised to maximum amount permitted on load chart. Where creep exceeds the crane manufacturer's specifications and this is caused by leakage in telescoping cylinder, disassemble boom and remove hydraulic cylinder for repair or replacement.
- Check boom straightness in both planes to manufacturer's specifications. Where boom deflection exceeds manufacturer's tolerances, remove and dismantle boom and repair or replace.
- Check wear pad clearance and replace worn wear pads.
- Check boom condition for corrosion and damage. Non-destructively test accessible welds on both boom sections and slew ring upper.
- Where pin type locks are used (i.e., instead of rope or chain type extensions), the effective operation of the locking mechanism is to be inspected. **Note**: in some cases, manufacturers of these boom types may require disassembly of the boom at pre-determined intervals.

There are additional requirements where the boom has internal boom extension wire ropes or chains, or where boom extension is activated by screw drive:

- Remove and disassemble boom. Inspect wire ropes to *AS 2759: Steel wire rope – Use application and maintenance*, and chains to manufacturer's tolerance. Replace worn ropes and chains.
- Inspect wire rope and chain anchorages and non-destructively test welds on anchorages.
- Where screw drives are used, measure all screw threads and non-destructively test any welds on assembly.

Booms (lattice boom cranes)

- Boom NDT for cracks:
  - all welds connecting male and female clevises (on the ends of every boom section)
  - welds on boom butt section
  - welds on boom head, and
  - minimum of 10 per cent of lacing welds (all welds if cracks are found).
- Chord thickness testing (ultrasonics)—all chords on boom sections.
- Thickness testing of plate used on butt section (i.e., near water drain holes).
- Check boom for straightness, damage and corrosion.

Rated capacity limiters and load indicators

Rated capacity limiters and load indicators are to be checked and calibrated for correct operation. The accuracy of these systems is to be within the tolerance specified by the crane manufacturer or *AS 1418.5: Cranes, hoists and winches – Mobile cranes*. A calibration certificate is to be completed by the competent person testing the equipment. However, it should be noted that rated capacity limiters and load indicators are to be calibrated at much more frequent intervals than at the 10-year major inspection.

Steel wire ropes

All hoist, luff, pendant, trolley and counterweight ropes should be inspected for wear to ensure they do not exceed the discard criteria specified in *AS 2759: Steel wire rope – Use application and maintenance*. If the competent person considers that the rope will require replacing within the next three months, the rope should be replaced with one that passes the inspection criteria of *AS 2759: Steel wire rope – Use, application and maintenance*. Ropes should only be replaced with the type of rope specified by the crane manufacturer unless a professional engineer specifies otherwise.

The pins and terminations on pendant ropes should also be inspected.

Rope sheaves

Regular inspection and service of all rope sheaves should be carried out in accordance with the crane manufacturer's instructions during the crane's periodic safety inspections. All sheaves should freely rotate without excessive end play. Damaged and worn sheaves are to be replaced. At the major inspection, all rope sheaves should be removed from the crane and closely inspected for both their condition and operation. Sheaves should not be painted. Information on ways to identify worn, damaged or otherwise degraded plastic rope sheaves should be requested from the crane manufacturer.

16.7 Records of inspections and maintenance

A crane service record, such as a maintenance logbook, of the significant events concerning the safety and operation of the crane should be kept and readily available. The records should be easily understood and written in plain English. Records may be kept in any suitable format and should be transferred with ownership of the crane. All entries in the maintenance logbook are to:

- clearly describe the work undertaken and parts replaced
- be dated
- note the name of the person carrying out the work
- be signed by the person carrying out the work.

Documentation stating that the crane has been inspected by a competent person, and is in a safe and satisfactory condition, should be readily available.

The checks, adjustments, replacement of parts, repairs and inspections performed, and all irregularities or damage concerning the crane's safe use, should be recorded.

Additionally, all complete routine, annual and major inspection reports should be maintained and made available for examination as required.

A mobile crane preventative maintenance program should be established based on the working environment and the frequency and severity of use of the mobile crane. The following items should form part of an effective maintenance program:

- Replacement parts and components should be identical or equivalent to the original equipment parts and components.
- A specific rectification program should be carried out where past experience has shown particular problems with a crane.
- All safety-related malfunctions and problems should be corrected before the crane is returned to service.

The owner of the mobile crane should ensure that:

- The necessary facilities and systems of work are provided and maintained so as to minimise the risks to health and safety of persons maintaining, inspecting, repairing or cleaning the crane.
- Inspections, maintenance and cleaning are carried out having regard to procedures recommended by the crane designer and manufacturer, or the relevant Australian Standard, or as recommended by a competent person.
- Repair, inspection and, where necessary, testing is carried out by a competent person.
- All safety features and warning devices of the crane are maintained and tested.
- When the crane has been damaged to the extent that its function or condition is impaired, resulting in increased risk to health or safety, a competent person assesses the damage and advises the owner of:
    - the nature of the damage; and
    - whether the crane is able to be repaired, and if so, what repairs should be carried out to minimise risks to health and safety.
- Repairs to the crane are carried out so as to retain the crane within its design limits.
- Annual maintenance, repair and inspection records are kept for the crane.

16.8 Mobile crane repair

All worn or damaged parts of a crane that constitute a hazard or impair the operation of the crane or may constitute a hazard before the next routine inspection, should be repaired or replaced. All repaired or new parts must comply with the crane manufacturer's instructions. Where these are not available, the repaired or new parts must comply with the recommendations of a competent person, taking into account the requirements of this code and appropriate Australian Standards or any other relevant technical standard.

16.9 Second-hand imported (overseas) mobile cranes

The importance of the maintenance history of second-hand imported mobile cranes from overseas cannot be underestimated. Before a second-hand imported mobile crane can be operated for the first time, the owner of the crane must, if the crane is at least 10 years old, ensure a major inspection of the crane, or, if the crane is less than 10 years old, it should undergo an annual inspection.

Appendix 1: Dictionary

‘Anemometer’ means an instrument for measuring wind speed.

‘Competent person’ means a person who:

- (a) For major inspections
  - has acquired through training, qualification or experience the knowledge and skills to carry out a major inspection of the crane; and
  - is registered under a law that provides for the registration of professional engineers; or
  - is determined by the regulator to be a competent person.

- For any other case – a person who has acquired through training, qualification or experience the knowledge and skills to carry out the task.

‘Dedicated radio frequency’ means a specific radio frequency that has been provided by the Spectrum Management Agency.

‘Design verification statement’ means a statement that:
- is written and signed by a person who is eligible to be a design verifier for the design; and
- states that the design was produced in accordance with published technical standards or engineering principles specified in the statement; and
- includes:
  (i) the name, business address and qualifications (if applicable) of the design verifier; and
  (ii) if applicable, the name and business address of the organisation for which the design verifier works.

‘Design verifier’ for a design of plant, means a person who has the skills, qualifications, competence and experience to design the plant or verify the design.

‘Dogger’ means a person who carries out dogging work.

‘Dogging work’ means the application of slinging techniques including the selection and inspection of lifting gear to safely sling a load or the directing of a plant operator in the movement of a load when the load is out of the operator’s view.

‘Engineer’, in relation to the performance of a task means a person who:
- is a registered professional engineer under the *Professional Engineers Act 2002*; and
- is competent to perform the task.

‘Engineering principles’ means principles stated or outlined in an engineering, mathematical or scientific text, relevant to safe plant design, commonly used in professional engineering practice.

‘Fail-safe’ means that when partial or total failure of plant occurs, the plant fails in a manner which leaves the plant in a safe condition and which does not introduce any additional condition which is unsafe.

‘Geo-technical engineer’ means an engineer who holds an engineering qualification relevant to geo-technology.

‘Load chart’ means a notice fitted on a crane or hoist specifying the rated capacities as supplied by the manufacturer.

‘Outriggers’ structural members that, when deployed, increase the footprint of the crane and lift the vehicles wheels off the ground.

‘Reliability level’ means a category of reliability covered in *AS 4024: Safety of machinery*, and is a measure of the ability of the safety-related control circuit to provide a safety mechanism (e.g. electronic cut-off of power) even if the safety circuit itself is damaged. For example, a category 4

safety-related control circuit should either bring the crane motion to a safe condition after the occurrence of the first fault or, in the event of additional foreseeable faults, should not cause the designed safety function of the control circuit to be lost.

'Representational drawing' means a general arrangement drawing showing leading dimensions and material specifications.

'Safety integrity level' (SIL) means a safety integrity level covered in *AS 61508: Functional safety of electrical/electronic/programmable electronic safety-related systems* and is used where a control circuit employs programmable electronics. For example, a SIL 3 microprocessor-based system will provide an equivalent level of reliability to Category 4 under *AS 4024: Safety of machinery*, however due to the complexity of the circuits involved in programmable electronics, the SIL is determined based on the probability of component failure, software errors and external influences rather than foreseeable fault conditions.

'Side de-ration chart' means a load chart that reduces the allowable lifting capacity of a crane in relation to the degree of side slope that the crane is to travel on with a suspended load. These charts must be read in conjunction with the crane's normal load chart.

'Stabilisers' structural members that, when deployed, increase the footprint of the crane and do not lift the vehicles wheels off the ground.

'Stabilising moment' is the moment that tends to keep the crane upright. Overturning moment is the moment that tends to tip the crane over. When the overturning moment exceeds the stabilising moment, the crane will overturn. 'Moment' is the engineering calculation of force multiplied by the perpendicular distance between the force and the turning point.

'Technical standard' for a design of plant, means a standard published by:

(a) the chief executive
or
(b) Standards Australia
or
(c) another organisation that publishes standard(s) about the design of plant.

Examples of paragraph (c):

- *American National Standards Institute*
- *American Society of Mechanical Engineers*
- *Canadian Standards Association*
- *International Standards Organisation*
- *Europaische Norm (European Standard).*

'Two-blocking' means contact of the hook block with any part of the boom head or sheaves.

'Workbox' means a personnel-carrying device, designed to be suspended from a crane, to provide a working area for persons conveyed by and working from the box.

Appendix 2: Referenced technical standards

Technical standard	Title
AS 1353.2	Flat synthetic-webbing slings – Care and use
AS 1418.1	Cranes, hoists and winches – General requirements
AS 1418.5	Cranes, hoists and winches – Mobile cranes
AS 1418.8	Cranes, hoists and winches – Special purpose appliances
AS 1418.10	Cranes, hoists and winches – Mobile Elevating Work Platforms
AS 1418.11	Cranes, hoists and winches – Vehicle-loading cranes
AS 1418.17	Cranes (including hoists and winches) – Design and construction of workboxes
AS/NZS 1554 (Series)	Structural steel welding
AS 1657	Fixed platforms, walkways, stairways and ladders – Design, construction and installation
AS 1891 (Series)	Industrial fall-arrest systems and devices
AS 2550.1	Cranes, hoists and winches – Safe use – General requirements
AS 2550.5	Cranes, hoists and winches – Safe use – Mobile cranes
AS 2550.11	Cranes, hoists and winches – Safe use – Vehicle-loading cranes
AS 2759	Steel wire rope – Use, operation and maintenance
AS/NZS 3000	Electrical installations (Australian/New Zealand Wiring Rules)
AS 3775.2	Chain slings – Grade T – Care and use
AS 4024 (Series)	Safety of machinery
AS 4497	Round slings – Synthetic fibre
AS 4991	Lifting devices
AS 61508 (Series)	Functional safety of electrical/electronic/programmable electronic safety-related systems

Appendix 3: Matters to consider when planning and undertaking mobile crane operations

The following questions are provided as prompts or reminders of some of the key matters to consider when planning and undertaking mobile crane operations. The content below should be read in conjunction with the requirements in this code of practice, other relevant codes of practice (e.g. the *Tilt-up and pre-cast construction Code of Practice* and the *Steel construction Code of Practice*), and relevant health and safety legislation.

Crane selection

- Does the crane have adequate lifting capacity to perform the lift safely?
- Is the crane type suitable for the lift (e.g. adequate space, ground conditions, accessibility, visibility, etc)?
- Does the actual site layout match the layout information provided when the crane was ordered?
- Does the crane have the correct number of counterweights fitted?
- Is the crane rigged with the correct number of rope falls?
- Is there a diagram that shows the position of the crane and load to be lifted? **Note:** this is particularly important with heavy and complex lifts including tilt-up and dual lifts, etc.
- If tilt-up panels are to be lifted, has allowance in the crane's capacity been made for the panel tilt?
- Have clearances for the crane's counterweight been considered when operating around tilt-up panel braces?

Crane condition

- Is the crane in good condition?
- Has a pre-start safety check been performed? **Note:** particularly important in day/night shift operations
- Are all features on the crane operating correctly?
- Has the crane received an annual safety inspection?
- If more than 10 years old, has the crane received its major inspection?

Load chart issues

- Is the correct load chart provided in the crane operator's cabin? **Note:** The computer display is not enough on its own.
- Does the load chart verify the crane has adequate capacity?
- Is the load chart written in English?
- Is the load chart and rated capacity limiter based on Australian Standards?
- Does the crane have the same load rating for the full 360 degrees of slew?
- Have the correct deductions been made to the rated capacity of the crane based on the load chart notes (e.g. hook block mass, fly jib deduction, etc)?

Crane safety features

- Are the load, radius, boom angle and boom extension indicators operating and are they correctly calibrated?
- Has the operator been adequately trained to operate the safety system on the crane?
- Has the rated capacity limiter (computer) been set correctly for the crane rigging configuration?
- Is the anti-two block and luff limit (where fitted by the manufacturer) operating?
- Have the crane's rated capacity limiter and motion limiters been checked for correct operation?

Ground conditions

- Have enough timbers been placed under the outrigger feet? (See Photograph 1 and 2)
- If the crane is being used in pick-and-carry mode, is the ground hard enough or is the ground slope less than that allowed by the crane manufacturer?

- If the ground has been recently excavated or if there is a likelihood of underground services, have precautions been taken?
- Is the ground dry enough to prevent slipping of pick and carry cranes or to prevent outriggers slipping?
- If it has rained since the last lift, is the ground still firm enough?
- Are the ground conditions being monitored as lifting continues to ensure that outrigger feet are not sinking?
- Has the ground bearing capacity been calculated for heavy lifts?
- Has the pressure applied by the crane to the ground been calculated for heavy lifts?

Photograph 1:Example of good outrigger support.

Photograph 2:Example of consequences of poor ground and inadequate support

Other environment issues

- Is the wind speed within the range nominated by the crane manufacturer or an engineer? **Note:** an engineer may be required in circumstances where the load has a large surface area, or high coefficient of drag, and the wind is likely to make the lift hazardous.
- In the event of strong winds, can it be assured that it is still safe to carry out the lift? If so, have the correct precautions been taken?
- If there are live power lines within the operating radius of the crane, have the correct precautions been taken to prevent contact?
- If it is claimed that power lines are de-energised, is there signed and dated permit on site verifying this is the case?
- If there is other mobile plant within the operating radius of the crane, have correct precautions been taken to prevent collision?
- Have precautions been taken to minimise suction forces as the load is lifted (e.g. muddy conditions, tilt-up panel work)?
- If there are additional factors making the load heavier, does the crane still have adequate capacity in accordance with the load chart to safely lift the load?

Load type issues

- Has the load mass been clearly marked on the load or noted on the work method statement?
- Does the marked load seem reasonable based on the material type?
- If the mass of the load is unknown, has its mass been estimated by calculation?
- If the exact mass of the load is unknown, does the crane have more than adequate capacity for the lift?

- If the load is of a large surface area that will easily be affected by the wind, have precautions been taken?
- If the lift is with more than one crane, have appropriate deductions been made to the rated capacity of each crane?
- If more than one crane is lifting the load, is an intermediate rigger supervising the lift?
- If a workbox is to be lifted are the crane and workbox suitable for this type of lift?

Load securing

- Is the sling type and configuration suitable for the load?
- Are the slings in good condition and marked with their working load limit in different configurations?
- Have slings been periodically inspected and marked with the inspection date?
- Has the load been firmly secured so that it cannot move once it is lifted?
- Will the slinging technique effectively secure the load? **Note:** Basket hitch should not be used anywhere near people.
- Have synthetic slings been protected around corners of hard materials?

Personnel issues

- Does each person involved in the lift understand his or her responsibilities? **Note:** This is very important where there are multiple doggers or riggers or where it is a multiple crane lift.
- Do all persons involved in the lift hold the appropriate high-risk work licence?
- Has the crane operator received documented familiarisation training for the crane?
- Is there an agreed communication method between all persons involved in the lift?

Appendix 4: Queensland driver licence classes

Queensland driver licence classes are listed in the *Transport Operations (Road Use Management—Driver Licensing) Regulation 2021*. Further information about driver licensing can be found on the Department of Transport and Main Roads website.

Vehicle description	Licence class
A motor vehicle (with or without a trailer), other than a motorcycle, that: 1. has a maximum weight of 4.5 tonne (t) gross vehicle mass (GVM) 2. is built or fitted to carry no more than 12 adults, including the driver. A moped—fitted with an electric motor or an internal combustion engine (with a maximum capacity of 50mL) with a maximum manufacturer's top rated speed of 50km/h that is not a bicycle. A specially constructed vehicle with or without a trailer	Class C
A class C vehicle. A bus or truck (including a prime mover or a mobile crane) not more than 8t GVM. **Note:** You may also tow a trailer with a maximum weight of 9t GVM.	Class LR
A class LR vehicle. A bus or truck (including a prime mover or a mobile crane) over 8t GVM with a maximum of 2 axles. Note: You may also tow a trailer with a maximum weight of 9t GVM.	Class MR
A class MR vehicle. A bus or truck (including a prime mover or a mobile crane) over 8t GVM with more than 2 axles. **Note:** You may also tow a trailer with maximum weight of 9t GVM. An articulated bus (a bus that can bend in the middle).	Class HR
A class HR vehicle. A truck (including a prime mover or mobile crane) over 8t GVM with a trailer of more than 9t GVM.	Class HC
A class HC vehicle. A B-double (prime mover towing 2 semitrailers, with 1 semitrailer supported at the front and connected to the other semitrailer). A road train (motor vehicle, other than a B-double, towing 2 or more trailers).	Class MC

Class of licence required to drive mobile cranes on a road

Vehicle description	Licence class
Mobile crane of not more than 8 tonnes GVM, with or without a trailer of not more than 9 tonnes GVM	Class LR
Mobile crane over 8 tonnes GVM with a maximum of two axles, with or without a trailer of not more than 9 tonnes GVM	Class MR
Mobile crane over 8 tonnes GVM with more than two axles, with or without a trailer of not more than 9 tonnes GVM	Class HR
Mobile cranes over 8 tonnes GVM with more than two axles, with a trailer (no GVM restriction)	Class HC
All mobile cranes, with or without trailers.	Class MC

Appendix 5: Familiarisation training checklists

Hydraulic slewing crane

Crane model training performed on:_____

The operator demonstrated the ability to correctly perform the following on the first or on the second (or follow up) occasion:

	1st	2nd		1st	2nd
Seat adjustment			Ground inspection		
Gauge and indicator function			Crane levelling (for crane set-up)		
Control identification (levers and switches)			Outrigger extension/retraction		
Warning devices (including horn)			Outrigger feet support (timber placement)		
Park brake			Outrigger lock pins		
Load chart (capacity at radius)			Maximum wind speed		
Load chart (deductions from capacity)					
Load chart - 360^0 ratings			Fly jib (rigging and de-rigging)		
Load chart - fly jibs					
Load chart - outrigger extension/on rubber			Safety inspection: • ropes • rams • wear pads • boom • grease points • fluid leaks • fluid levels • brakes • cabin visibility • tyre pressure • lights		
Winch line pull					
Rope full configurations					
Load moment system features					
LMS - set up and operation					
LMS - relationship to load chart					
LMS - override procedures					
Slew function					
Luff function					
Telescoping function					
Boom extension sequence					
Hoist function			Crane preparation for road travel		
Slew brake					
Slew lock pin					
Anti-two block					

Worker statement

- I have received instruction in the operation, maintenance, inspection and safe use of this crane.
- I understand its safety features and how to carry out pre-operation, daily routine and logbook checks.
- I understand the manufacturer's instructions and guidelines for the safe operation and driving of this crane.
- I confirm I am able to safely operate this crane and I agree to comply with safety instructions.
- In the event of being unsure of a task, I will request further training or instruction before performing the task.

Worker name: _____ Date:_____
Worker signature: _____
PCBU representative name: _____
Signature: _____ Date: _____

Non-slewing hydraulic (pick-and-carry) crane
Crane model training performed on:_____

The operator demonstrated the ability to correctly perform the following on the first or on the second (or follow up) occasion:

	1st	2nd		1st	2nd
Seat adjustment			Safety inspection: • ropes • rams • wear pads • boom • grease points • fluid leaks • fluid levels • brakes • cabin visibility • tyre pressure • lights		
Gauge and indicator function					
Control identification (levers and switches)					
Warning devices (including horn)					
Load chart (capacity at radius)					
Measure radius					
Load chart (deductions from capacity)					
Load chart (fly jib)					
Load chart (articulated capacities)					
Load chart (effect moveable counterweight)					
Side alteration load chart					
Winch line pull					
Rope full configurations			Crane preparation for road travel		
Load moment system features			Emergency steering		
LMS - set up and operation			Park brake		
LMS - relationship to load chart			Holding brake		
LMS - over ride procedures					
Load indicator (where LMS not fitted)					
Articulate function					
Luff function					
Telescoping function					
Hoist function					
Anti-two block (where fitted)					
Manual boom extension procedure					
Ground inspection					
Fly jib (rigging and de-rigging)					
Spreader bar use (where provided)					

Worker statement

- I have received instruction in the operation, maintenance, inspection and safe use of this crane.
- I understand its safety features and how to carry out pre-operation, daily routine and logbook checks.
- I understand the manufacturer's instructions and guidelines for the safe operation and driving of this crane.
- I confirm I am able to safely operate this crane and I agree to comply with safety instructions.
- In the event of being unsure of a task, I will request further training or instruction before performing the task.

Worker name: _____ Date:_____
Worker signature: _____
PCBU representative name: _____
Signature: _____ Date:_____

Lattice boom crane

Crane model training performed on:_____
The operator demonstrated the ability to correctly perform the following on the first or on the second (or follow up) occasion:

	1st	2nd		1st	2nd
Seat adjustment			Load chart (capacity at radius)		
Gauge and indicator function			Load chart (deductions from capacity)		
Control identification (levers and switches)			Load chart - 360^0 ratings		
Warning devices (including horn)			Load chart - fly jibs		
Crane set–up (where applicable)			Winch line pull		
Track attachment			Rope full configurations		
Counterweight attachment					
Boom assembly			Safety inspection: • ropes • boom • sheaves • grease points • drive systems • fluid leaks • fluid levels • brakes • cabin visibility • tracks/tyres • lights		
Boom rigging					
Limit set-up					
A-frame erection					
Fly jib (rigging and de-rigging)					
Load moment system features					
LMS - set up and operation					
LMS - relationship to load chart					
LMS - override procedures					
Load indicator (where LMS not fitted)					
Slew function					
Luff function					
Luff limit					
Hoist function					
Hoist brake					
Slew brake					
Slew lock pin					
Anti-two block					
Driving crane with load (speed, load and boom position)					
Ground inspection					
Crane levelling					

Worker statement

- I have received instruction in the operation, maintenance, inspection and safe use of this crane.
- I understand its safety features and how to carry out pre-operation, daily routine and logbook checks.
- I understand the manufacturer's instructions and guidelines for the safe operation and driving of this crane.
- I confirm I am able to safely operate this crane and I agree to comply with safety instructions.
- In the event of being unsure of a task, I will request further training or instruction before performing the task.

Worker name: _____ Date: _____
Worker signature: _____
PCBU representative name: _____
Signature: _____ Date: _____

Vehicle loading crane (VLC)

VLC make / model training performed on:_____
Truck make / model crane mounted on:_____
Crane installation location on truck (circle one): front / rear

The operator demonstrated the ability to correctly understand and/or perform the following on the first or on the second (or follow up) occasion:

Subject	1st	2nd	Subject	1st	2nd
Rated capacity chart			Load moment system features:		
Identifies danger zones			• LMS - set up and operation		
Anti-crush safety devices			• LMS - relationship to load chart		
Identifies maximum operating slope and how to measure			• LMS - override procedures		
Truck parking (location, park brake)			• Identifies slew restriction zones		
PTO engage/disengage			• Identifies operating controls and crane motion symbols		
			• Warning devices & fault codes		
Crane safety inspection (basic):					
• boom			Attachment fitting and use		
• wear Pads			Operate crane functions correctly:		
• hydraulic cylinders & hoses			• Stabiliser deployment		
• controls & marking			• Level crane		
• fluid levels & grease points			• Unpack crane from transport position		
• hoist drum and rope (where fitted)			• Slew function		
• stabiliser feet pads			• Lift and lower functions		
• stabiliser extension warning system			• Telescoping function (Boom extension sequence)		
• stabiliser locking system			• Winch function (where fitted)		
			• Pack crane in transport position		
Discuss Boom unlock method					
Discuss Boom pack up & lock method			Slinging and moving a load:		
E-stop location & operation			• Lifting equipment inspection		
Remote control explanation			• Load slinging		
Remote control operation			• Load movement (doesn't drag load)		
How to operate crane in event of remote control malfunction			• Load placement on vehicle		

Worker statement

- I have received instruction in the operation, maintenance, inspection and safe use of this crane.
- I understand its safety features and how to carry out pre-operation, daily routine and logbook checks.
- I understand the manufacturer's instructions and guidelines for the safe operation of this crane.
- I confirm I am able to safely operate this crane and I agree to comply with safety instructions.
- In the event of being unsure of a task, I will request further training or instruction before performing the task.

Worker name: _____ Date: _____

Appendix 6: Example of crane safety certificate – annual inspection

Certificate no.: _____

Crane type: _____ Crane manufacturer: _____

Crane serial no: _____ Design registration no.: _____

WHSQ plant registration no.: _____ Manufacture date: _____

Owner's name: _____

Address: _____

Inspection date: _____

Name of competent person: _____

Address of competent person: _____

Telephone number: _____

Qualifications of competent person (tick one box)**:**

☐ Professional engineering qualification, membership of professional organisation and crane industry experience

☐ Professional engineering qualification and crane industry experience

☐ Other tertiary qualification and crane industry experience

☐ Trade qualification and crane industry experience

☐ Other (state): _____

Competent person statement:
I hereby certify that the crane, serial number: _____, has received its annual safety inspection in accordance with the instructions of the crane designer and manufacturer, and with relevant Australian Standards and the Mobile Crane Code of Practice, and is safe to use.

Competent person signature: _____**Date:** _____

Comments:_____

Appendix 7: Example of crane safety certificate – major inspection

Certificate no.: _____

Crane type: _____ Crane manufacturer: _____

Crane serial no.: _____ Design registration no.: _____

WHSQ plant registration no.: _____ Manufacture date: _____

Owner's name: _____

Address: _____

Inspection date: _____

Name of competent person: _____

Address of competent person: _____

Telephone number: _____

Qualifications of competent person:

The competent person undertaking the major inspection must have acquired through training, qualification or experience the knowledge and skills to carry out a major inspection of the crane and be registered under a law that provides for the registration of professional engineers (i.e. Registered Professional Engineer of Queensland.

_____

Competent person statement:
I hereby certify that the crane, serial number: _____, has received its major safety inspection in accordance with the instructions of the crane designer and manufacturer and the Mobile Crane Code of Practice and is safe to use. This inspection includes mechanical, structural and electrical items of the crane.

Competent person signature: _____ **Date:**_____

Comments:_____