MODEL TOWER CRANE

PROCUREMENT GUIDELINE

For the Australian Construction Industry

June 2021

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- Lendlease Building Pty Limited
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1.0 FOREWARD

This Model Tower Crane Procurement Guideline (the Guideline) has been developed to assist the Australian Construction Industry and related clients or interested parties in the procurement of a Tower Crane for construction operations across Australia. The Guideline has been developed pursuant to an Enforceable Undertaking between Lendlease Building Pty Limited, ACN 000 098 162 and SafeWork New South Wales (NSW) dated 30th of March 2020.

The Enforceable Undertaking is the outcome of an incident event involving a Stiff Legged Derrick Crane (Derrick Crane) that was positioned on the level 51 roof of the Barangaroo South Tower One Construction Project (Tower One). On the 8th November 2016, workers engaged by Lendlease Building Pty Limited were directed to use the Derrick Crane to lift a 3.7 tonne elevating work platform from the level 51 roof of Tower One and lower it onto the roof of a plant room located on level 4 of the building's podium below. At approximately 1:20pm, while the lift was being performed the support grillage for the Derrick Crane buckled, causing the crane's mast and framing to distort.

The elevating work platform remained suspended from the Derrick Crane in mid-air at level 51, above the building's podium at level 4. A crane crew worker was standing at the podium level 4 below the suspended load of the Derrick Crane on level 51 above, when it's framing distorted. In addition, the commercial tenancy located below the podium on level 4 was also occupied. The load remained suspended by the damaged Derrick Crane at level 51 and was subsequently safely removed along with the damaged crane. There were no injuries caused by the incident.

1.1 Scope and Application

As a result of the above-mentioned incident, SafeWork NSW and Lendlease Building Pty Limited agreed the need to increase awareness of tower crane design and procurement and the safety of tower crane operations on construction projects. This Model Tower Crane Procurement Guideline developed as part of the Enforceable Undertaking applies to the construction industry and related construction projects, principal contractors, crane suppliers, clients and other interested parties (i.e. persons conducting a business or undertaking).

The scope of the Guideline relates to the design, procurement and supply of a used tower crane based on the Principal Contractor's scope of works, tower crane trade inclusions and trade requirements for a site specific construction project; together with prompts to assist the development of the optimum tower crane technical solution to be provided by the tower crane supplier to achieve the scope of works and other related requirements of a site specific construction project. This information is provided in Appendix 1.

The Guideline also outlines considerations in Appendix 1 required in relation to tower crane supplier responsibilities for the relevant design shop drawings and safety systems, which align with and compliment obligations under the Work Health & Safety Act and Work Health & Safety Regulation and relevant standards and codes; such as Australian Standard AS1418 Cranes, Hoists & Winches.

Appendix 2 of the Guideline provides additional optional technical solutions/operational aids that exist for tower cranes, which are in many cases non-standard. This information is provided to highlight to Clients and other key stakeholders such as Principal Contractors technical and operational aids, which can provide additional key benefits to tower crane operability, including safety. These are generally readily available and many are reasonably practicable to implement to improve tower crane operations and related safety outcomes.

Appendix 3 of the Guideline focuses on tower crane operator/driver familiarisation of the site specific tower crane and its key operating requirements, provided by the Crane Supplier. It addresses operator proficiency recognised as an important factor in tower crane safety by the research outlined in section 4 of this Guideline.

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2.0 INTRODUCTION

The provision of relevant and accurate information during the design and procurement of a used tower crane is an important factor in ensuring the adequacy of a tower crane technical solution supplied to a construction project. In particular, that the plant/equipment (tower crane) is fit for purpose and safe in its erection, operation, alteration and removal for the site specific construction project selected.

Due to the elevated location and the multitude of load shifting operations performed at height by typical tower crane operations, the overall safety of a construction site, its work areas and surrounding community/public areas of the site is heavily dependent on the design, procurement and safe operation of a tower crane. Currently, tower cranes procured in Australia should comply with Australian standards AS1418, AS2550, or a recognised equivalent, and must comply with applicable laws as detailed in brief in the next section.

It is important to note that the standards for tower cranes in Australia, in particular the design standard, AS1418.4 Cranes Hoist & Winches - Tower Cranes; was last updated in 2004 and its equivalent European Standard EN14439 Cranes – Safety – Tower Cranes; was last updated in 2006. In contrast, the dynamics of the construction industry in Australia have continued to change significantly, i.e. buildings are far more complex and modularised components such as facade elements, services risers and precast concrete require tower cranes to carry out an increased number of lifts; more complex and larger capacity lifts and on large developments operate in close proximity to other tower cranes. In contrast the tower crane design standards have not kept pace with such changes to the construction industry or technological innovation on tower cranes, which generally enhance safety in design and the safety of tower crane operations.

In addition, the standards have also not addressed inherent failures in tower cranes made apparent through significant incidents within Australia and other parts of the World. For example, in Australia in the past decade there has been two incidents of tower crane engine bay fires; one in Sydney (2012) and another in Melbourne (2016); which resulted in failure of the luffing rope due to heat resulting in the collapse of the tower crane jib. No revisions were made to the Australian standards following these incidents and currently engine fire suppression is not a mandatory requirement on such tower cranes but is readily available and a reasonably practicable control to minimise this risk.

Technically older tower cranes with minimal Category 3 Control Systems or no other notable 'operator/driver assist' operational aids such as anti-collision, zoning and real time data monitoring; may comply with the abovementioned design standard. However, the work health and safety (WHS) laws extend beyond the requirements of Australian or international standards and require that all risks are managed so far as reasonably practicable. This means if it is reasonably practicable to use a tower crane that is fitted with additional technical solutions or operational aids to improve safety, then such solutions must be used.

The cost of tower crane hire and operation is a major determining factor in procurement, and it is acknowledged that additional technical solutions / operational aids come at a cost at the time of procurement. However, the benefits in ensuring the safe operation of a tower crane are significantly greater than those costs at procurement.

The intended outcome of this Model Tower Crane Procurement Guideline is to better inform the procurement process for tower crane design, procurement and selection; and to promote the optimum technical solution over price. This includes identifying additions to the proposed technical solution such as operational aids, including available technology to raise awareness of such features that enable safer load shifting operations on construction projects and reduce the potential for tower crane incidents.

3.0 LEGAL REQUIREMENTS

Work health and safety laws assign duties to persons conducting a business or undertaking (PCBU) that import, manufacture, design, supply and operate plant at a workplace, to ensure so far as reasonably practicable that its manufacture and design is without risks to health and safety. That is, the plant is fit for purpose and erected, inspected and maintained to the manufacturer's requirements and related Australian standards; and that the plant is safe to use without risks to the health and safety of workers and others. This includes the base, tower structure and any supporting structure (grillage) which the tower crane relies on.

In addition, a person with management or control of a workplace, such as a Principal Contractor of a Construction Project must ensure, so far as reasonably practicable that the workplace, the means of entering and exiting the workplace and anything arising from the workplace, including the operation of plant such as a Tower Crane are without risks to the health and safety of any person.

In New South Wales, tower cranes including self-erecting tower cranes that were designed from 1 September 2001 require registration of the design. All tower cranes including self-erecting tower cranes also require item registration (Part 5.3 of the NSW Work Health and Safety (WHS) Regulation 2017). Plant registration requirements may differ across jurisdictions therefore confirmation should be sought from the corresponding regulator in other states or territories.

Design registration is a verification process which aims to ensure the design of the crane meets an acceptable level of safety. Item registration is an annual registration (in NSW) which serves to ensure the crane has been inspected by a Competent Person and is safe to operate. Both the Design Registration and Item Registration for a tower crane erected at a workplace/ construction project must be available on request.

Specific requirements regarding the major inspection of tower cranes is provided by clause 235 of the NSW WHS Regulation 2017. This includes, a major inspection carried out by, or under the supervision of, a Competent Person according to the manufacturer's recommendations, or if not available the advice of a competent person, or if neither of these are reasonably practicable every 10 years.

In addition, it is a legislative requirement for a tower crane operator, rigger and dogger to hold a High-Risk Work License (HRWL) related to their role and the capacity or type of crane. The HRWL provides fundamental skills and knowledge regarding tower cranes, rigging and dogging; and assesses the driver's skills in the operation of a particular crane. However, a HRWL should not be solely relied upon to verify the competency of a worker, noting there are fundamental design and operating differences between new and aged tower cranes and different makes, models and capacities. The WHS laws also require that workers are provided with the information, training, instruction or supervision necessary to ensure that workers are familiar with the tower crane type and can operate it safely.

The above brief overview of work health and safety laws and their applicable Australian standards regulate tower crane design, erection, commissioning, operation, alteration and removal. The comprehensive nature of these laws and related standards is indicative of the high risk nature of tower cranes and related load shifting operations.

4.0 CRANE INCIDENTS & STATISTICS

Tower cranes can expose persons to a risk of serious injury or death from a variety of hazards and related risks including:

- structural or mechanical failure and collapse;
- contact or collision with other plant, structures or people;
- arcing or flashover when a tower crane boom, hook or rope comes in close proximity to an energised overhead power line;
- lightning strike and damage to major components of the tower crane or its rigging equipment;
- falling materials/objects being load shifted by the tower crane;
- fall of objects used in the erection, alteration, dismantling, operations, service and maintenance of a tower crane;
- persons falling from height when accessing, inspecting or maintaining a tower crane;
- fires and related damage or collapse;
- extreme weather and related damage or collapse; and
- fatigue of those workers involved in tower crane operations or related slinging and lifting and load shifting operations.

Tower crane incidents and related risk factors such as those identified above can lead to serious injuries and fatalities on construction sites and have the potential to significantly damage neighbouring structures and impact the surrounding community and affect surrounding business continuity. During 2018, there were 60 incidents reported to SafeWork NSW where a tower crane was a significant factor in the incident with the majority occurring in the Sydney metropolitan area, and most being a classified as a dangerous occurrence and approximately twenty percent resulting in injuries[1]. Forty-seven workers were also killed in incidents involving cranes between 2003 and 2015.

Safe Work Australia reports that on average around two hundred and forty serious injury claims arise from crane incidents every year[2,3] . From 2014 to 2018, an average of nine percent of worker fatalities occurred from being hit by moving objects, which included plant such as a crane or a forklift[4].

In a study of one hundred and twenty seven crane related fatalities that occurred from 1997 to 2003 in the United States of America (USA) the most frequent accident types were identified as struck by a load (32 percent); electrocution due to contact with overhead power lines (27 percent); crushed during assembly/disassembly (12 percent), and failure of the boom/cable (12 percent)[5]. Another study in the USA analysed three hundred and twenty three fatalities across three hundred and seven crane incidents between 1992 and 2006. The most frequent causes of these fatalities was electrocution due to contact with overhead power lines (32 percent), collapse of a crane (21 percent) and being struck by the crane jib/boom (18 percent)[6].

A study examining crane related accidents identifies electrocution due to contact with power lines as exclusively involving mobile cranes[7]. Hence, statistics related to cranes should be regarded as generalised only due to the variety of different crane types and related risk factors, i.e. tower cranes, mobile cranes, and truck mounted cranes, all represent different risk profiles.

1. SafeWork - Tower Cranes: Project Findings Report from 1 June to 30 November 2019.
2. RMIT, Centre for Work Health and Safety, NSW Government - Preventing Crane Safety Incidents In The Construction Industry, May 2020.
3. Safe Work Australia - Work Related Traumatic Injury Fatalities, Australia 2015.
4. Safe Work Australia - Work Related Traumatic Injury Fatalities, Australia 2018.
5.Beavers, J.E., Moore, J.R., Rinehart, R. and Schriver, W.R., 2006. - Crane Related Fatalities in the Construction Industry. Journal of Construction Engineering and Management, 132(9), pp.901-10.
6. McCann, M., 2009. Crane Related Deaths in Construction and Recommendations for their Prevention.
Silver Spring, MD: The Centre for Construction Research and Training.
7. Beavers, J.E., Moore, J.R., Rinehart, R. and Schriver, W.R., 2006. - Crane Related Fatalities in the Construction Industry. Journal of Construction Engineering and Management, 132(9), pp.901-10.

Another study in 2009 identified factors affecting the safe use of tower cranes specifically and utilised an expert panel to judge the importance of the factors determined from which human factors or safety management were identified as 'highly affecting'. Operator proficiency was rated as the most important factor by the expert panel and among project conditions blind lifting was also rated as high in its ability to influence the safe operation of a tower crane[8].

Research by RMIT University funded by the New South Wales Government Centre for Work Health & Safety and SafeWork NSW identified causes related to fatalities involving a crane as predominantly:

- failure of the boom/cable;
- crane tip over;
- electrocution;
- struck by load – other than failure of boom/cable;
- falls;
- crushed during assembly/disassembly; and
- struck by cab/counterweight[9].

The research identified three levels of accident causes related to cranes depicted in Figure 1 the Crane Safety Incident Causation Model. These are: (i) immediate incident circumstances; (ii) shaping factors; and (iii) originating influences.

Figure 1: Crane Safety Incident Causation Model (RMIT University)

8. Shapira, A. and Lyachin, B., 2009. Identification and Analysis of Factors Affecting Safety on Construction Sites with Tower Cranes. Journal of Construction Engineering and Management, 135(1).
9. Ehsan, G., Lingard, H., Cooke, T., 2020 Causes of Fatal Accidents Involving Cranes in the Australian Construction Industry. Construction Economics and Building.

Job factors
- Fatigue
- Long working hours
- Shift work/roster schedule
- Unrealistic workload/work pace
- Working outside of standard working hours

Plant management factors
- Lack of maintenance of plant
- Lack of/poor safety in design
- Modifications made to the crane
- No specific requirements for cranes and their design for safe operations
- Poorly written/generic/poorly translated manufacturer's manuals

Worker factors
- Complacency/over confidence
- Inadequate on-boarding/induction of NTI and migrant workers
- Inexperience or insufficient skill of operator/dogman/lifting coordinator
- Pressures on crane operators to 'get the job done'
- Stress/mental ill-health
- Transient workforce

Immediate incident circumstances

Material/equipment factors
- Crane too small for tasks being performed
- Loads being carried too heavy
- Load transfer too far
- No lift plan/plan not reflective of situation
- Operating substandard crane
- Structural/electrical failure of crane

Site factors
- Changes to ground conditions
- Crane located above/below ground services
- Existing soil conditions
- Lighting/visibility
- Negative interaction between adjoining tasks/ activities on site
- Supporting structure not adequate
- Working in unsuitable weather

Worker factors
- Hazards not identified
- Lack of hazard awareness
- Lapse of concentration
- Not following manufacturer's instructions
- Not following procedures/SWMS
- Override safety technology
- Unfamiliar with plant being operated

Incident

According to the RMIT research the most prevalent immediate incident circumstances identified by the research in eighteen of the twenty two fatalities reviewed was layout of the site and restricted space in the vicinity of the crane (77.8 percent); unsafe actions taken by workers including the crane operator and workers in the vicinity of the crane (38.9 percent); and the crane itself (38.9 percent). Other immediate incident circumstances identified in the research and considered relevant in fatality cases were localised hazards in the vicinity of the crane, lack of personal protective equipment and prevailing weather conditions.

The most prevalent shaping factors identified by the RMIT research in sixteen of the twenty two fatalities reviewed was physical site constraints (56.2 percent); and design of the process of construction work (50 percent). Other shaping factors considered relevant in fatality cases were inadequate supervision of the work (25 percent); attitudes or motivation (12.5 per cent) and the scheduling of the construction work (6.3 percent).

The most prevalent originating influences identified from the RMIT research in thirteen of the twenty two fatalities reviewed was the quality of the risk management systems relating to the operation of the crane (69.2 percent); and the method of construction (61.5 percent). Other originating influences identified and considered relevant in fatality cases were aspects of prevailing safety culture (38.5 percent); design of the permanent structure under construction (38.5 percent); and failings in the management of the project (15.4 percent)[10].

In addition to the above immediate incident circumstances, shaping factors and originating influences identified as common by the research Figure 1 provides a definitive list of all causal factors identified by the research and its qualitative analysis of fatalities related to cranes. Many of these factors can be related back to decision making in the design and procurement of a tower crane, the detail of the technical solution developed and the willingness of the Principal Contractor to involve a specialist tower crane supplier(s) early in the tender stage of a construction project. This enables the supplier's specialist knowledge to be drawn upon in the development of the tower crane technical solution to meet the construction project's design and build requirements; its site specific location and relevant constraints; and the logistics required to meet the construction program.

Appendix 1 provides a model guideline for tower crane procurement to be used by the Principal Contractor and Crane Supplier to develop the optimum tower crane technical solution for a construction project. This addresses many of the causal factors (originating influences) associated with crane incident causation identified in the research outlined above and related to crane design, procurement, logistics scheduling, site specific parameters and other constraints.

The additional technical solutions/operational aids outlined in Appendix 2, including data monitoring now available on modern tower cranes, also provides for more detailed analysis and greater certainty over the operations of a tower crane and its operator/driver, e.g. loads lifted versus capacity of the crane; faults, servicing, anti-collision and zoning, load limit alarms, hook cameras for blind lifting and other operational aids such as computer aided modelling to provide greater certainty in building/structure design to inform the requirements of the tower crane technical solution. These additional and in many cases reasonably practicable aids, further address causal factors (originating influences and shaping factors) associated with crane incident causation including unsafe actions taken by workers including the crane operator and the operations of the crane itself and related logistics.

Appendix 3 focuses on tower crane operator/driver familiarisation of the site specific tower crane and its key operating requirements, provided by the Crane Supplier. It further addresses causal factors (immediate incident circumstances) such as operator proficiency recognised as an important factor in tower crane safety by the above research at Footnote 8.

10. Ehsan, G., Lingard, H., Cooke, T., 2020 Causes of Fatal Accidents Involving Cranes in the Australian Construction Industry, Construction Economics and Building.

5.0 FACTORS CONSIDERED IN TOWER CRANE PROCUREMENT

Tower crane procurement decisions are primarily based on tower crane design aligned with the type, design and layout of a building and construction project for which load shifting operations are required.

Early contractor involvement (ECI) between the Principal Contractor and the tower crane supplier is a key element in achieving industry leading practices for tower crane design, procurement and related safe operations. Involvement is highly recommended in the initial construction project 'concept' design and tender preparation to ensure that a tower crane design solution is determined in the tender submission at a concept level. Once the Tender is awarded and a detailed design concept is refined then prospective tower crane suppliers will tender on a further developed tower crane technical solution, using the information outlined in Appendix 1 and Appendix 2.

Alternatively, if the Tender relates to a detailed (completed) design then the ECI phase involving tower crane suppliers is condensed to include multiple tower crane tenders and the preferred optimum technical solution is selected based on the information outlined in Appendix 1 and Appendix 2. The tower crane supplier response to that information (Appendix 1 and Appendix 2) provided and determined in consultation with the Principal Contractor for the construction project, forms the basis on which the tower crane supplier and its related technical solution is selected.

A summary of factors to be considered in early contractor involvement and procurement of a tower crane technical solution in concept design is listed on the following page in brief and a more definitive list of prompts and questions is outlined in Appendix 1 to further inform the detail required of an optimum tower crane technical solution for a specific construction project. Depending on the type of delivery for the construction project, e.g. design and construct or traditional construct only as described above; the objective of Appendix 1 and Appendix 2 is to provide a definitive framework to assist with the development of an overall tower crane technical solution procurement specification specific to the construction project's detailed design, site constraints and related load shifting requirements. This will be provided by the tower crane suppliers as part of a tender process; or a single preferred or preselected tower crane supplier, in consultation with the Principal Contractor with management or control of the proposed construction project.

Selection of a tower crane(s) which is inherently safe by design and meets the most appropriate technical solution for a specific construction project is paramount to industry leading practice safety outcomes for tower crane operations. This typically includes a tower crane selected on the basis of the most appropriate technical solution, i.e. optimum operability; reach and capacity fitted with an advanced Category 3 Control System and any additions required to the overall technical solution in the form of operational aids such as a camera on the hook or jib to avoid blind lifts, anti-collision, zoning, real time data monitoring and other ancillary features that provide for safer design and operability outcomes.

Industry leading practice also includes independent third-party inspection of the tower crane and its major components at the supplier's premises, independent verification of the tower crane base design by a structural engineer and independent verification of the tower crane commissioning by a Competent Person.

Tower Crane Design and Procurement Considerations:

- Building design and the height of the structure to be erected;
- Adjacent properties/buildings or structures;
- Construction type and typical materials that require load shifting by the tower crane;
- Construction site layout, area and the foundation for the crane including inspection and test plans along with an independent structural engineer check to verify compliance of the foundation (crane base) to the original structural engineer's design standard;
- Site location and any adjoining constraints or no go areas;
- Adjacent construction sites and associated cranes, access, proximity, flyover or other hazards;
- No go areas over which load lifting should be prevented and related zoning;
- Crane freestanding and climbing/alteration requirements;
- Rated capacity and reach of the tower crane, logistics and the location of delivery zones and loading bays;
- Optimum crane location, crane base and crane ties;
- Maximum weight of the largest material/ loads to be lifted and crane lifting radius and capacity;
- Tower crane recovery at the completion of the construction of the building/structure;
- Crane type, rated capacity and lifting constraints – luffing or hammerhead or self erecting;
- The number of tower cranes and the provision of additions to the technical solution where multiple tower cranes are proposed, e.g. anti-collision and offsetting of crane heights where multiple tower cranes are to be used;
- Overhead powerlines or other obstructions in the vicinity of lifting operations;
- Tower crane fuel type, i.e. electricity supply availability or diesel and refuelling at height;
- Environmental factors including prevailing weather and lightning protection;
- Height and operating radius of the tower crane and any Obstacle Limitation Surfaces (airspace) factors or occupied building tenancies within the crane operational envelope;
- Crane out of service requirements (stow height, jib angle, weathervane, prevailing winds and storm buffers);
- Emergency retrieval access for the Operator/Driver or maintenance personnel;
- Safe access to the tower crane by the Operator/ Driver including low voltage tower lighting;
- Safe access to the tower crane for inspection and maintenance personnel;
- Independent third party inspection of the tower crane and its major components at the supplier's premises;
- Verification of the tower crane base design and inspection and test plan verification by an independent structural engineer; and
- Independent verification of the tower crane commissioning by a competent person.

Site Logistics / Load shifting in Delivery Considerations:

- Crane utilisation rate during construction versus construction schedule and real time data logging to track utilisation rate, maintenance and servicing, faults, loads lifted versus max lifting capacity, anti-collision and other features and operator/driver aids;
- Crane and counterweight location and distances from major plant or equipment like concrete placement booms or mast climbers, personnel and materials hoists or site amenities;
- Line of sight by the Operator/Driver for lifting operations and the required number of additional Doggers or Crane Coordinators, depending on the size and complexity of the construction project and its load shifting operations;
- Dry hire or wet hire and the skills and competency of the tower crane Operator/Driver and its supporting crane crew engaged in slinging and lifting specific to the tower crane supplied;
- Real time data logging and electronic alerts such as safe working load limits, anti-collision deactivation, maintenance or engine defects or other alerts;
- Tower crane security and protection against unauthorised access during and after working hours;
- Tower crane alteration/dismantling/removal and availability of exclusion zones or road closures and any need for a recovery crane to assist with removal; and
- Maintenance, service, and inspection requirements are included in the construction program schedule.

6.0 MODEL TOWER CRANE PROCUREMENT

The figure below represents the industry preferred model for tower crane procurement with early contractor involvement in the construction project tender to consider design and other procurement considerations related to load shifting logistics, the 'concept' design characteristics of the construction project to be built and additional custom tower crane operational aids that provide for safer lifting operations.

The preferred model contemplates a 'minimum technical solution' against which tower crane supply contractors are requested to develop their preferred technical solution for the construction project tender. Appendix 1 provides prompts and questions that enable the Principal Contactor to engage early with preferred tower crane supply contractors to assist in the development of an appropriate technical solution and to then competitively assess tower crane supply contractors to determine the best technical solution.

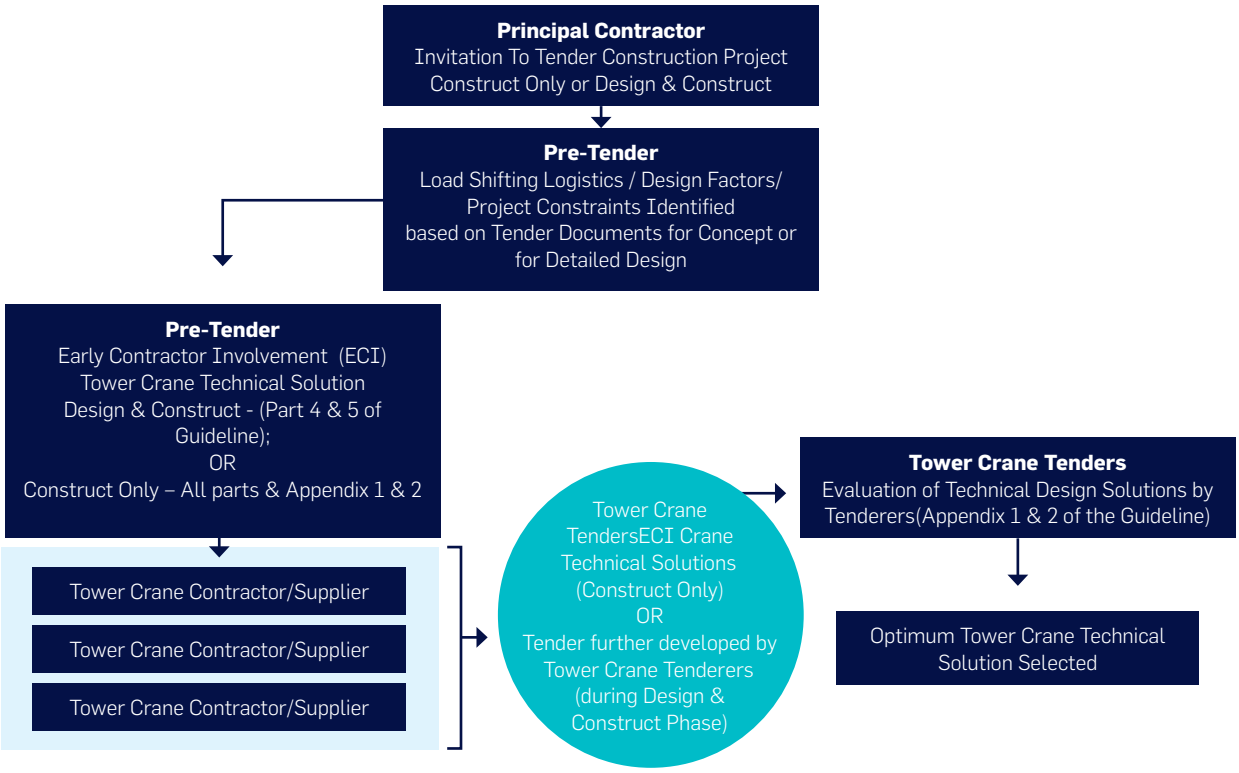

Figure 2: Model Tower Crane Procurement

Appendix 1 detailed prompts and questions are outlined in ten key areas:

- Scope of works;
- Technical Design Solution based on Scope of Works Overview;
- Program and Key Dates & Milestones;
- Trade Inclusions;
- Trade Requirements;
- Detailed Design Responsibilities;
- Shop Drawings and Documentation;
- Safety Systems; and
- Additional Safety Features

6.1 Early Contractor Involvement

The previously listed key areas and related questions and prompts have the capacity to influence tower crane design and procurement decisions and the adequacy of the technical solution required, hence early contractor involvement is strongly recommended. Many are implicated in the originating influences; shaping factors and immediate incident circumstances outlined in Figure 1 of the RMIT research, that can lead to crane incidents if not considered in early design and procurement and related design of a tower crane technical solution for a construction project and its site specific conditions.

Although major buy/hire decisions are governed by tower crane design standards followed by factors associated with a specific construction site requirements, additions to the technical solution or operation of the crane such as hook/jib tip cameras, anti-collision, zoning, real time data monitoring and other operator/driver assist features must also be considered in procurement of the appropriate technical solution to enhance driver operability and machine safety; as they are readily available and reasonably practicable to implement.

Principal contractors in conjunction with the crane supplier must consider such additions in the tower crane procurement design based on the risks determined for the construction project and its logistics and operations, for which a tower crane is a key plant procurement item. For example, on a construction project where two tower cranes are required to operate in close proximity with overlapping radii it is reasonably practicable to include the fitment of an anti-collision system to prevent collision due to operator/driver error, or where the potential exists for a tower crane to slew over a no-go area such as a light rail corridor or public area, it is reasonably practicable to include the fitment of zoning technology to prevent the tower crane operator from slewing the tower crane or its load over such an area. Similarly, real time data monitoring can monitor the efficiency of a tower crane, provide early warning of faults and therefore decrease downtime, servicing and maintenance costs; monitor the weight of loads versus the lifting capacity of the tower crane and provide an external alert to others when safety features may be deactivated or faulty.

In addition, regular inspection of a tower crane and its supporting structures at pre-erection, climbing, maintenance, after repair, dismantling or after a severe weather event is also paramount to achieve tower crane safety. This includes oversight of design and commissioning by a Third Party Specialist, which is highly recommended to achieve a complete technical solution. Leading industry practice in design, procurement and commissioning involves the inspection of the tower crane and its major components:

- at the supplier's facility by a Third Party Specialist;
- as part of a review and independent verification of the tower crane base by an Independent Structural Engineer; and
- as part of a review and independent verification of the tower crane commissioning process by a Competent Person.

Finally, the crane crew remains another significant factor in achieving safe operations for a tower crane. The RMIT Research outlined in part four of this Guideline identified labour related factors (under Originating Influences), i.e. crane contractor's experience and shortage of skilled workers; worker factors (under Shaping Factors); i.e. inexperience or insufficient skill of the operator, dogman/lifting coordinator; and worker factors (under Immediate Incident Circumstances), i.e. not following the procedure or safe work method statement, overriding safety technology and a lack of familiarity of the plant being operated; all as causal factors of crane incidents and related fatalities.

Overall, procurement of tower cranes designed with additional operator/driver aids features such as those described above and outlined in Appendix 2 of this Guideline, including real time data monitoring would in most cases eliminate the 'worker factors' identified by the RMIT research, provide for safer operation, load shifting and maintenance, which together greatly assist in preventing tower crane incidents on a construction site. Therefore, it is paramount that the crane crew is adequately trained, experienced and competent in the safe use of a specific tower crane type and its load shifting operations.

Appendix 3 of the Guideline provides a standardised tower crane operator/driver familiarisation that can be tailored to meet the needs of a tower crane manufacturer/supplier. The objective of the document is to formally familiarise a proposed operator/driver of a tower crane in its specific key features.

It is anticipated that this familiarisation would be provided by a crane supplier technician as part of the Supply Agreement.

7.0 KEY DEFINITIONS

Category 3 Control System – means limiting and indicating devices intended as an aid to crane operators. The devices should not be relied upon to replace the use of the crane's load chart and operating instructions under any circumstances. Sole reliance on these devices in place of good operating practices may cause an incident. Where limiting and indicating devices are to be installed on a tower crane, the safety circuits of these devices should generally meet either:

- a reliability level of Category 4 under AS 4024: Safety of machinery
- a safety integrity level of Category 3 under AS 62061: Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems.

These categories of reliability level and safety integrity level are related to the concept of 'fail-safe'.

Hazard – means a source or a situation with a potential for harm in terms of human injury or ill-health, damage to property, damage to the environment or a combination of these, i.e. anything that can cause harm to people, plant, equipment and property.

Hierarchy of Control – means an approach used to identify the most effective control measures for minimising risk, which must be used where it is not reasonably practicable to eliminate a hazard or its associated risks. The hierarchy in order of decreasing effectiveness is:

- Substitution/ Isolation /Engineering controls (equally effective) where the effectiveness of the control does not rely on human behaviour;
- Administrative where the effectiveness of the control does rely on human behaviour; and iii) personal protective equipment.

Independent Structural Engineer – means an engineer that holds relevant tertiary qualifications experience and is employed or contracted separate to the entity seeking the independent review (and any of its subsidiary companies) so that the engineer cannot be influenced or controlled by others in the matters of their requested opinion, review, conduct or other outcomes.

Limiting and indicating devices – see Category 3 Control System.

Person Conducting a Business or Undertaking – A PCBU conducts a business or undertaking alone or with others and is a specific duty holder under work health and safety laws.

Reasonably practicable – in relation to a duty to ensure health and safety, means that which is, or was at a particular time, reasonably able to be done to ensure health and safety, taking into account and weighing up all relevant matters including:

- The likelihood of the hazard or the risk concerned occurring; and
- The degree of harm that might result from the hazard or risk; and
- What the person concerned knows, or ought reasonably to know, about the hazard or risk, and about the ways of eliminating or minimising the risk; and
- the availability and suitability of ways to eliminate or minimise the risk; and
- after assessing the extent off the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk.

Reliability level – means a category of reliability covered in Australian Standard 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 must either bring the tower crane motion to a safe condition after the occurrence of the first fault or, in the event of additional foreseeable faults, must not cause the designed safety function of the control circuit to be lost.

Risk – understanding the nature of the harm that could be caused by a hazard, how serious the harm could be and the likelihood of it happening.

'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.

Self Erecting Tower Crane - means a crane that is not disassembled into a tower element and a boom or jib element in the normal course of use, and where the erection and dismantling processes are an inherent part of the crane's function.

Third Party - means a person who is not a party to the works contract or its transactions.

Tower Crane – means a boom crane or a jib (horizontal or luffing) crane mounted on a tower structure which may be demountable or permanent.

8.0 BIBLIOGRAPHY

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Related Documents

- Australian Standard AS1418 – the set of Standards relating to Design, Manufacture and Testing of Cranes, Hoists and Winches.
- Australian Standard AS2550 Series which focuses on Safe Use of Cranes, Hoists and Winches.
- Australian Standard AS4024.1 Safety of Machinery Series.
- Work Health and Safety ACT 2011 (NSW).
- Workplace Health and Safety Regulation 2017 (NSW).

APPENDIX 1
MODEL TOWER CRANE TECHNICAL SOLUTION SCOPE DEVELOPMENT

Package Ref:		Revision:		Date:	

To be used by the Tower Crane Supplier to develop an optimum tower crane technical solution for Tender on a construction project in the detailed design stage, in conjunction with the Principal Contractor for the Construction Project.

1.0 SCOPE OF WORKS	
Is the scope of works adequately defined by the Principal Contractor appointed for the Construction Project, e.g. the design, supply, installation and certification in its entirety for the Tower Crane(s) at the nominated project construction site? Is the project name and the land parcel where the construction project is located outlined, including street location and adjoining streets and vehicular access points? Is a description of the proposed construction project provided including for example: height (no. of floors); single or multiple towers, low rise/high rise, concrete framed construction with glazed curtain wall and other relevant general description characteristics such as site constraints or latent conditions? Are Subcontract Terms and Conditions or other contract information provided including relevant drawings, specifications and other relevant information to ascertain the total works for the Tower Crane Supply Agreement (TCSA) to facilitate the development of an appropriate technical tower crane solution?	
Likely descriptions for standard terms that would appear in the procurement process should include:	
"Principal Contractor"	means the Pty Limited entity name, Australian Business Number and address appointed with management or control of the Construction Project under the Work Health & Safety Regulation 2017.
"Approved"	means as approved in writing by the Principal Contractor.
"Supply"	means the supply of plant, equipment, materials and associated accessories to meet the requirements of the TCSA.
This will include people also in the case of a wet hire arrangement.	means the carrying out of all works under contract to place, install and secure in position the tower crane(s) and includes for making related connections like electrical or other supply.
"Install"	means the carrying out of all works under contract to place, install and secure in position the tower crane(s) and includes for making related connections like electrical or other supply.
"Project"	means the Construction Project by name to which the TCSA applies.
"Tender"	Means the Tender or Subcontract.
"Tenderer"	Means the Subcontractor or Supplier of the goods and services specified.
"Principal"	means the Client for the Construction Project that has appointed the Principal Contractor.
"Scope of Works"	means the Scope of Works in the TCSA.

2.0 TECHNICAL DESIGN SOLUTION BASED ON SCOPE OF WORKS OVERVIEW

2.1 Works Overview

	(a) Outline the nature of the works and what the Tower Crane Supply Agreement (TCSA) includes, e.g. the provision of all design, supply, delivery, materials handling, installation, commissioning, maintenance and servicing, jumping/alteration and dismantling health and safety, consumables, supervision, labour, materials and plant and equipment necessary to complete the Tower Crane(s) works. (b) Will the tower crane Supply be with a crane crew or operator/driver (wet hire) or without a crane crew or operator/driver (dry hire)? (c) Identify what drawings specifications or other contract conditions / requirements that will be included to inform the required technical solution and achieve compliance with relevant Regulatory Authority(s), Australian standards, codes of practice/compliance codes and the Principal Contractor.

2.2 Project Visit & Verification of Tower Crane Requirements

Have the Tower Crane supply tenderers visited the Construction Project to determine all conditions present relating to access/egress, surface conditions, underground services, overhead services or other overhead restrictions, logistics and deliveries or other characteristics associated with the Construction Project and the required works?

2.3 Tower Crane Technical Solution Design Considerations		**Yes**	**No**	**N/A**
Tower crane design considerations to achieve the most appropriate technical solution should consider the following:				
2.3.1	Building design and the height of the structure to be erected.			
2.3.2	Adjacent properties/buildings or structures.			
2.3.3	Construction type and typical materials that require load shifting.			
2.3.4	Construction site layout, area and the foundation for the crane including inspection and test plans to ensure compliance of the foundation to the Structural Engineer's Design Standard.			
2.3.5	Site location and any adjoining constraints or no go areas.			
2.3.6	Access to the site location including roads, bridges with maximum load ratings, turning and vehicle length restrictions, sufficient laydown areas and permits of other road access/closure requirements for erection or dismantle of the tower crane.			
2.3.7	Zoning to prevent lifting over any no go areas.			
2.3.8	Crane freestanding and climbing requirements.			
2.3.9	Rated capacity and reach of the tower crane, logistics and the location of delivery zones and loading bays.			
2.3.10	Crane location, crane base and crane ties.			
2.3.11	Maximum weight of largest material/ loads to be lifted and crane lifting radius and capacity. Load list detailing pick and place locations for each load.			
2.3.12	Construction sequence provided and any potential options for changes to the sequence that may affect crane positioning, capacity and other equipment required. For example, acceleration of works which may lead to the requirement for installing facade panels under overhanging obstructions, early access to tenancies or other options.			
2.3.13	Tower crane recovery at the completion of the building/structure.			

2.0 TECHNICAL DESIGN SOLUTION BASED ON SCOPE OF WORKS OVERVIEW				
2.3 Tower Crane Technical Solution Design Considerations		**Yes**	**No**	**N/A**
2.3.14	Crane type, rated capacity and lifting constraints – luffing or hammerhead or self erecting.			
2.3.15	The number of tower cranes and the provision of additional safety features where multiple tower cranes are proposed, e.g. anti-collision and offsetting of crane heights.			
2.3.16	The same anti-collision system is used across all cranes or compatibility is confirmed. Where the anti-collision system has been retrofitted the system works without introducing new risks such as smooth deceleration zones and motion cut does not lead to loss of control if external forces such as wind is applied.			
2.3.17	Overhead powerlines in the vicinity of lifting operations.			
2.3.18	Tower crane fuel type – electrical supply availability or diesel and refuelling at height.			
2.3.19	Environmental factors including prevailing weather and lightning protection.			
2.3.20	Height and operating radius of the tower crane and any Obstacle Limitation Surfaces (airspace) factors or occupied building tenancies within the crane operational envelop.			
2.3.21	Crane out of service requirements (stow height, jib angle, prevailing winds and storm buffers).			
2.3.22	Emergency retrieval access for the Operator/Driver or maintenance personnel.			
2.3.23	Safe access to the tower crane by the Operator/Driver including tower lighting.			
2.3.24	Safe access to the tower crane for inspection and maintenance personnel.			
2.3.25	Reverse cycle air conditioning (heating & cooling), lighting, and a refrigerator included in the Tower Crane cabin.			
2.3.26	Tower Crane internal cabin noise below 70dB(A) at all times in operation.			
2.3.27	Tower Crane jib paint colouration and compliance with any local Authorities, e.g. flight path colour requirements.			
2.3.28	Real time data logging and electronic alerts such as safe working load limits, anti-collision deactivation, maintenance or engine defects or other alerts.			
2.3.29	Wind speed meter(s) fitted.			
2.3.30	The tower crane design has secondary independent braking measures in the event of a gearbox/primary luff winch or hoist winch failure, where loads or people are suspended; or alternative technology has fail to safe to prevent free-fall of a Work Box or other load.			
2.4 Site Logistics / Load shifting in Delivery Considerations		**Yes**	**No**	**N/A**
2.4.1	Crane utilisation rate during construction versus construction schedule and availability of real time data logging to track utilisation rate.			
2.4.2	Crane and counterweight location and distances from major plant and equipment like concrete placement booms, mast climbers, personnel and materials hoists or site amenities.			
2.4.3	Line of sight by the Operator/Driver for lifting operations and required additional Crane Coordinators, depending on the size and complexity of the load shifting operations.			

2.0 TECHNICAL DESIGN SOLUTION BASED ON SCOPE OF WORKS OVERVIEW					
2.4 Site Logistics / Load shifting in Delivery Considerations				**Yes**	**No**	**N/A**
2.4.4	Dry hire or wet hire and the skills and competency of the tower crane operator(s)/driver(s) and familiarisation in the specific crane type and its operation and operator/driver assist features (refer Appendix 3)					
2.4.5	Skills and competency of the supporting crane crew engaged in slinging and lifting, i.e. High Risk Work Licence and related experience.					
2.4.6	Tower crane security and protection against unauthorised access.					
2.4.7	Tower crane alteration/dismantling/removal and the availability of exclusion zones and any need for a recovery crane to assist with removal.					
2.4.8	Maintenance, service, and inspection requirements are included in the construction program.					
3.0 PROGRAM AND KEY DATES & MILESTONES					
3.1	Have construction program key dates and milestones been provided including date for commencement of the Tower Crane Supply Agreement (TCSA) works and date of completion?			**Yes**	**No**	**N/A**
3.2	Outline proposed tower crane hire durations below:					
	Tower Crane	Commencement Date	Completion Date	No. of Weeks		
				Yes	**No**	**N/A**
3.3	Is the TCSA price subject to rise and fall related to market rates or other price fluctuations?					
3.4	Does the TCSA allow for sufficient resources in labour and supervision (including any disputes) to achieve or better the Principal Contractor's Program; including any overtime required to meet the program requirements?					
3.5	Does construction schedule allocate appropriate time to install, commission, alter, dismantle and perform routine maintenance to the tower crane(s)?					
3.6	Does the TCSA make allowance for coordination with other trades or activities required to meet the objectives of the Principal Contractor's Program, including any out of hours work necessary to complete the works under the Supply?					
3.7	Has the Tenderer investigated all information relevant to the risk, contingencies and other circumstances having an effect on the Works Subcontract by making reasonable enquiry?					
3.8	Does the TCSA consider options where one crane can be used to modify another and are any related assumptions outlined in the proposed Technical Solution to the Principal Contractor?					
3.9	Will the Tenderer in turn subcontract any works under the TCSA and has provision been made to obtain copies of relevant insurances, workers' compensation and health and safety information?					
3.10	Does the TCSA consider the due date for any major inspections and ensuring these are completed prior to the commencement of the project; i.e. if there is a possibility of the project schedule being extended preventing the completion of a major inspection prior to that date required?					

4.0 TRADE INCLUSIONS				
		Yes	**No**	**N/A**
4.1	Trade Inclusions are those additional items that must be allowed for by the Supplier to support the tower crane installation and its initial operation. Check that Trade Inclusions have been outlined as part of the proposed Technical Solution and related Tower Crane Supply Agreement (TCSA). For example:			
	(a) Tower crane serial no. XXX and location as required.			
	(b) Transportation, Erection, Alteration (incl third party inspection for every alteration/ modification) of the Tower Crane.			
	(c) Commissioning of the Tower Crane.			
	(d) Design of the Tower Crane Base, including independent third party verification of the tower crane base design by a structural engineer.			
	e) Independent third Party Inspection of the Tower Crane arranged by the Principal Contractor for the Project including i) independent third party engineering inspection of the tower crane and its major components at the supplier's premises by a Third Party Specialist, and ii) independent verification of the tower crane commissioning by a Competent Person.			
	(f) Maintenance & Servicing.			
	(g) Dismantling and transportation of the Tower Crane.			
	(h) Supply and maintenance of ancillary equipment.			
4.2	If the proposed Tower Crane is diesel powered or electric with diesel generator supply has the consumption of fuel and related costs for either option been included in the Technical Solution and related TCSA along with an estimate of usage provided; OR Where an electric Tower Crane 'mains fed' option is to be provided has electricity power requirements and related costs been included in the Technical Solution and related TCSA?			
4.3	Is energy usage overall (diesel or electricity) included as part of the Tower Crane Supply Agreement to facilitate environmental reporting by the Principal Contractor?			
4.4	Does the Tower Crane Supply Agreement allow for the following information to be provided and be kept up to date: model, jib length, erection radius, alteration climbing /descending sequence, dismantle strategy including radii, base Reduced Level (RL), highest point RL, rope speed related to the Tower Crane base design requirements?			
4.5	Does the Technical Solution and related TCSA provide a clear plan of how the Supplier will install and dismantle the Tower Crane including the manufacturer's specification and any other information on any other cranes proposed for use together with a plan of the project site clearly showing the location where the boom, machine deck and other major components will be placed down?			
4.6	Are historical inspection, test and maintenance records of the tower crane(s) available for the Tower Crane to be supplied?			
4.7	Does the Technical Solution and related TCSA include an up to date 3D AutoCAD model file (editable) of the tower crane(s) supplied to the Project at each height clearly showing the operating radius and lifting weights at 10m increments?			

4.0 TRADE INCLUSIONS				
		Yes	**No**	**N/A**
4.8	Does the Technical Solution and related TCSA include the installation and dismantling methodologies for the Tower Crane provided?			
4.9	Has navigation (airspace) lighting if required by a statutory authority been allowed for in the Tower Crane Supply Agreement?			
4.10	Does the Technical Solution and related TCSA allow for coordination with any Jump Form, permanent or temporary vertical transport (hoist/lift), construction methodology and tower crane removal strategy?			
4.11	Does the Technical Solution and related TCSA allow for floor ties affixed to the slab surface and removal of the ties as required to complete the Works; including making good the tie locations so that all surfaces are flush with the surrounding finishes?			
4.12	Does the Technical Solution and related TCSA allow to supply and check the installation of all cast-in items required for the Tower Crane's systems and any Installation of cast-in items by others, e.g. formwork subcontractor?			
4.13	Does the Technical Solution and related TCSA allow to provide complete documentation to enable others, e.g. the Formwork Subcontractor to correctly install the cast-in brackets?			
4.14	Has the Tenderer satisfied itself that all prevailing conditions relating to access/egress, surface conditions, underground services, overhead services or other overhead restrictions, logistics and deliveries or other limitations associated with the Project and the required works and allowed for these conditions in the Technical Solution?			
4.15	Does the Technical Solution and related TCSA include a Loading Plan for temporary storage or part assembly of tower crane components on floors or other areas, approved by a Structural Engineer, including any temporary works design, supply, install and maintenance required to facilitate the TCSA?			
4.16	Does the Technical Solution and related TCSA allow for the design of the Tower Crane base location? This should include supply and installation of formwork, reinforcement, concrete, piles, steel or other structural elements for the base to be carried out by Others.			
4.17	Does the Technical Solution and related TCSA allow for design of temporary works as required to install and operate the Tower Crane(s), including storage of equipment, installation of equipment and movement of plant and equipment and an Engineer to check the base building design and confirm it capabilities?			
4.18	Does the Technical Solution and related TCSA allow for any requirements of a relevant Airport Authority or any other regulatory requirements for the tower crane Technical Solution, e.g. painting of the crane if required by an Authority?			
4.19	Does the Technical Solution and related TCSA allow for Engineering Certification of the base design along with certification of the installation of each of the base components, e.g. welded steel reinforcement verification before the concrete placement, to the design specification?			
4.20	Does the Technical Solution and related TCSA allow for the crane manufacturers wind load chart and base reaction source data to be supplied to enable checking by a third party?			

4.0 TRADE INCLUSIONS				
		Yes	**No**	**N/A**
4.21	Has the Principal Contractor engaged a third party structural engineer to review the crane base design?			
4.22	Does the Engineer providing the design review of the base design meet the Principal Contractor's minimum requirements for qualifications and experience?			
4.23	Does the Technical Solution and related TCSA include for any third party engineering inspections of the tower crane to be provided to the Project, e.g. at the supplier's storage yard; and at installation and commissioning?			
4.24	Does the Technical Solution and related TCSA allow to coordinate with the radio communication supplier at the project to enable sufficient time for the installation of radios, security cameras or other equipment as required?			
4.25	Does the Technical Solution and related TCSA allow to make available all plant and equipment for inspection prior to delivery to Site?			
4.26	Has the crane design been confirmed as having secondary independent braking measures in the event of a gearbox/primary luff winch or hoist winch failure, where loads or people are suspended?			
4.27	Does the Technical Solution and related TCSA allow to perform all testing and commissioning of the Tower Crane after its erection/installation and all completed permits to work, certification, testing and commissioning results provided to the Principal Contractor at the completion of the installation and commissioning?			
4.28	Does the Technical Solution and related TCSA include notification to the Principal Contractor of what crane inspections are required to satisfy the manufacturer's requirements and Australian standards; including a schedule for each specific Tower Crane?			
4.29	Does the Technical Solution and related TCSA allow for supply of all labour, cranage, loading, transport, equipment, materials and test weights required for the erection/installation and commissioning of the tower crane?			
4.30	Does the Technical Solution and related TCSA allow to attend and inspect the Project site a minimum of two weeks prior to the installation of the Tower Crane to verify access and egress, temporary areas for placement of crane components and that the erection and commissioning process can be completed successfully?			
4.31	Does the Technical Solution and related TCSA allow for reverse cycle air conditioning (heating & cooling), lighting, and a refrigerator to any Tower Crane cabin?			
4.32	Does the Technical Solution and related TCSA allow for any Tower Crane provided to operate below 70dB(A) within the internal cabin at all times during operation?			
4.33	Does the Technical Solution and related TCSA allow for any tower crane ties and their specific location?			
4.34	Does the Technical Solution and related TCSA allow to provide a documented procedure for placement of the tower crane and stow of the jib and hook in weathervane mode?			

4.0 TRADE INCLUSIONS				
		Yes	**No**	**N/A**
4.35	Does the Technical Solution and related TCSA allow to coordinate the location of the power cable with the jump alterations/ lifts or similar being used below the Tower Crane?			
4.36	Does the Technical Solution and related TCSA allow for the provision of Original Equipment Manufacturer climbing frames for the Tower Crane to be supplied?			
4.37	Does the Technical Solution and related TCSA allow for an Original Equipment Manufacturer engineered solution for a jib stop / storm brace for the Tower Crane to be supplied?			
4.38	Does the Technical Solution and related TCSA consider the location of any crane signage and its approval by the Original Equipment Manufacturer or requirement to downgrade the capacity of the crane?			

5.0 TRADE REQUIREMENTS				
Trade Requirements are those additional items that must be allowed for by the Supplier to support the ongoing operations of the Tower Crane. Check that Trade Requirements have been outlined as part of the proposed Technical Solution and related TCSA. For example:		**Yes**	**No**	**N/A**
5.1	Does the Technical Solution and related Tower Crane Supply Agreement allow for all ongoing Works undertaken as part of the Supply Agreement to be in accordance with all Regulatory Authority requirements, codes of practice/ compliance standards and relevant Australian standards?			
5.2	Does the Technical Solution and related TCSA specify Tower Crane component deliveries to meet the Subcontract Programme outlined by the Principal Contractor and has a storage location on the site been determined?			
5.3	Does the Technical Solution and related TCSA allow for safe Operator/Driver access from the leading deck to the Tower Crane?			
5.4	Does the Technical Solution and related TCSA list ancillary equipment that will be provided with the Tower Crane for the duration of the Supply Agreement? An example list is outlined below: • 1 x work box • 1 x first aid cage • 1 x 1.5m3 concrete kibble • 1 x large concrete kibble • 1 x block cage (5 blocks high) • 4 x 10m, 10mm, grade 100, chains (2 leg) • 4 x 10m, 13mm, grade 100 chains (2 leg) • 4 x 10m, 16mm, grade 100 chains (2 leg) • 2 x 10m, 20mm, grade 100 chains (2 leg) • 6 x 6m long 4t nylon slings • 4 x 6m long 2t nylon slings • 2 x 4t flat slings 6m long • 2 x 5t flat slings 6m long • 1 x set of 4, 4t shackles • 1 x set of 4, 6t shackles • 1 x set of 4, 8.5t shackles • 1 x set of 4, 12t shackles • 1 x set of all sizes of swift lifting equipment (clutch shall match brand of lifting insert used on the project) • 10 x 3m3 crane rubbish bins that can be lifted by crane • 2 x chain block, 3t and 5t • 2 x 3t ratchet lever blocks • 2 x lock boxes			
5.5	Does the Technical Solution and related TCSA allow for all lifting sundries/ ancillary equipment supplied to the Project to be fit for purpose, detailed on a lifting gear/equipment register with relevant inspection and test records to the manufacturer's requirements and Australian standards; and include maintenance and repairs for all lifting sundries/ancillary equipment supplied to be included for the duration of the works?			

5.0 TRADE REQUIREMENTS				
		Yes	**No**	**N/A**
5.6	Does the Technical Solution and related TCSA allow for all crane servicing and maintenance as required and in accordance with the manufacturer's recommendations and Australian standards?			
5.7	Does the Technical Solution and related TCSA outline a schedule of all maintenance and repair works to be undertaken and are these activities?			
5.8	Does the Technical Solution and related TCSA allow for all labour and parts required for servicing and maintenance of the Tower Crane?			
5.9	Does the Technical Solution and related TCSA allow for the cost of servicing, inspections and maintenance from the time and date when the Tower Crane is commissioned and ends on the removal date agreed with the Principal Contractor to the frequencies required by the Original Equipment Manufacturer, e.g. jib walk inspection?			
5.10	Does the Technical Solution and related TCSA allow for annual registration of all scheduled plant and equipment (i.e. tower crane Design Registration and tower crane plant Item Registration) in accordance with Regulatory requirements?			
5.11	Does the Technical Solution and related TCSA allow for the use of a Work Box for the purpose of servicing the tower crane where no other alternative safe access/egress is reasonably practicable? The Work Box must also be suitable for lifting persons for the purposes of construction work as well as servicing where no other alternative safe access/egress is reasonably practicable.			
5.12	Does the Technical Solution and related TCSA allow to inspect and where required test all lifting chains or other lifting gear provided with the Tower Crane in accordance with relevant Australian standards using a National Association of Testing Authorities (NATA) certified laboratory before erection/ installation and provide evidence?			
5.13	Does the Technical Solution and related TCSA allow for all testing and commissioning of chains as supplied new, including monthly inspections by a competent person for the duration of the Supply Agreement?			
5.14	Does the Technical Solution and related TCSA allow for all visual inspection of all lifting gear or equipment on a monthly basis and inspection and testing as required by Australian standards?			
5.15	Does the Technical Solution and related TCSA allow for the supply of all labour resources for the installation and dismantling/removal of the Tower Crane other than minimum project personnel provided for first aid and other general duties such as traffic control?			
5.16	Does the Technical Solution and related TCSA allow to obtain and pay for any permits and related costs required that are specific to the TCSA for its defined duration such as a part road closure and traffic control?			
5.17	Does the Technical Solution and related TCSA allow to provide, maintain and supervise a robust exclusion zone during the erection/installation, alteration and dismantling/removal activities for the tower crane; in coordination with the Principal Contractor?			
5.18	Does the Technical Solution and related TCSA provide for an agreed written notice period with the Principal Contractor to remove the Tower Crane from the Project?			

5.0 TRADE REQUIREMENTS				
		Yes	**No**	**N/A**
5.19	Does the Technical Solution and related TCSA allow for plant or equipment breakdown and a suitable response time for its personnel to attend the Project following any reported breakdown; e.g. four hours?			
5.20	Does the Technical Solution and related TCSA allow for the delivery by a competent person of training to any Operator/Driver in the specific Tower Crane supplied and for more than one operator to be trained?			
5.21	Does the Technical Solution and related TCSA allow to coordinate with any Jump Form, perimeter screens, personnel and material hoists and the timing for alteration/climbing of the Tower Crane to prevent delay of the structure?			
5.22	Does the Technical Solution and related TCSA allow to provide as part of its tender submission a winch cable management scheme for each Tower Crane to be provided?			
5.23	Does the Technical Solution and related TCSA allow for inspections of the Tower Crane and its related components to the manufacturer's requirements and applicable Australian standards?			
6.0 DETAILED DESIGN RESPONSIBILITIES				
		Yes	**No**	**N/A**
6.1	Does the Technical Solution and related TCSA allow to provide fully detailed engineering drawings and editable 3D Model in Industry Foundation Classes 2x3 or 4.0 format (preferred), or other file format as acceptable by the receiving party for the Tower Crane, piers, jumping system, base and bolting configuration as required? All design is to be carried out by a suitably qualified and experienced Engineer agreed with the Principal Contractor.			
6.2	Does the Technical Solution and related TCSA allow for the supply, delivery and installation of all necessary cast-ins, fixings rods, angles and templates required for the tower crane pads; including all tensioning required to the tower crane base fixing, and the provision of tensioning records supplied to the Principal Contractor?			
6.3	Does the Technical Solution and related TCSA allow for a suitably qualified and experienced Structural Engineer to inspect the Tower Crane base footings and related welding or other component design conformity prior to the concrete placement?			
6.4	Does the Technical Solution and related TCSA allow for any movement induced by the axial shortening of the building or other complexity to the slope or form of the building and any potential impacts on the Tower Crane operations?			
6.5	Does the Technical Solution and related TCSA allow for all building movement in the construction phase and permanent (completed) phase?			
6.6	Does the Technical Solution and related TCSA allow for in design (temporary and final conditions) and impacts from any climatic conditions due to the location of the Project such as ocean, high / low temperatures, wind, fog or other?			
6.7	Does the Technical Solution and related TCSA allow for the movement of the crane and the tolerances of the building within its design, e.g. sway of the building?			
6.8	Does the Technical Solution and related TCSA allow for all temporary engineering including the tower cranes base, e.g. the tower crane should not be founded below ground floor or change the permanent concrete outline?			

6.9	Does the TCSA consider the due date for any major inspections and ensuring these are completed prior to the commencement of the project; if there is a possibility of the project schedule being extended preventing the completion of a major inspection prior to that date required?			
7.0 SHOP DRAWINGS AND DOCUMENTATION				
		Yes	**No**	**N/A**
7.1	Does the Technical Solution and related TCSA allow for replies to be provided within an agreed timeframe, e.g. maximum of 3 working days for general correspondence; or requests for information and following comments on drawing submissions an agreed timeframe to make all necessary changes required, e.g. 5 working days; and the drawing to be submitted again to the Principal Contractor for acceptance of changes before any formal upload or transmittal to other parties?			
7.2	Does the Technical Solution and related TCSA allow for all drawings to be submitted to a standard and electronic format agreed with the Principal Contractor? For example, drawings will be provided in editable 3D Model in Industry Foundation Classes 2x3 or 4.0 format (preferred), or if necessary other file format and in pdf format to the standard approved by the Principal Contractor. The Tenderer must ensure that they have the latest version of Software at all times, upgrade timing to be agreed with the Principal Contractor. This must be completed for all stages of the tower crane(s) supplied.			
7.3	Does the Technical Solution and related TCSA allow for all drawing legend pages and schematics to remain updated, upon any changes to lay out details necessary changes are to also be made to all general arrangement plans at the same time?			
7.4	Does the Technical Solution and related TCSA allow for production of workshop drawings based at a given time on the latest Architectural / Structural layouts, and drawings Approved For Construction (AFC) status?			
7.5	Does the Technical Solution and related TCSA allow to produce shop drawings as required to achieve design intent and structural engineering requirements and coordination with other related consultants and Tenderers; including the provision of all required structural calculations at the time of submitting the Tower Crane shop drawings?			
7.6	Does the Technical Solution and related TCSA allow for sufficient competent staff to ensure that deadlines of documentation such as drawings, inspection and test plans, commissioning methodologies, commissioning results are provided to a standard agreed as acceptable, rejection of submissions and requests for changes and resubmissions as and when required by the Principal Contractor?			
7.7	Does the Technical Solution and related TCSA allow for the provision of diagrams for all stages of the tower crane including coordination with other impacted Trades on the Project such as Jump Form, facade, screens and formwork?			

8.0 SAFETY SYSTEMS				
		Yes	**No**	**N/A**
8.1	Does the Technical Solution and related Tower Crane Supply Agreement (TCSA) verify the tower crane is compliant with the Australian standards listed including all components and subcomponents of the tower crane? AS1418 - All AS2550 - All AS3000 AS3012 AS1170 AS4024 – series AS3777			
8.2	Does the Technical Solution and related TCSA verify that the Tower Crane(s) provided to the Project is Design Registered by the WHS Regulator and Item Registered by the WHS Regulator?			
8.3	Does the Technical Solution and related TCSA verify that adequate guarding is provided to rotating equipment to the requirements of AS 4024 Safety of Machinery?			
8.4	Does the Technical Solution and related TCSA include Non-Destructive Testing (NDT) as a minimum by an approved/ accredited testing laboratory, and copies of all test reports show a unique number that can be traced to the item tested, which must include: • 100% of boom welds • All pendant welds • All bridal welds • All slew ring mount welds • All boom connection points • All mast connection points • Slew ring bearing mount • Trolley welds • 100% of all slew ring bolts			
8.5	Does the Technical Solution and related TCSA specify that the Tower Crane(s) to be provided to the Project operates below 75dB(A) at all times and internal Cabin noise does not to exceed 70dB(A) over an 8 hour period?			
8.6	Does the Technical Solution and related TCSA include an anti-collision system where two or more tower cranes are to be provided to the Project and operate in close proximity and clearly demonstrate the system and its operation?			
8.7	Does the Technical Solution and related TCSA include a zoning system where the tower crane(s) provided to the Project will interface directly with public or other no go zones/ spaces, e.g. adjacent overhead power lines, school, light rail corridor or other; and clearly demonstrate the system and its operation to prevent lifting over no go zones/ spaces?			
8.8	Does the Technical Solution and related TCSA allow for an Original Equipment Manufacturer engineered solution for a jib stop / storm brace for the Tower Crane to be supplied?			

8.0 SAFETY SYSTEMS				
		Yes	**No**	**N/A**
8.9	Does the Technical Solution and related TCSA allow for Tower Crane jib paint colouration to comply with any local Authorities, e.g. flight path colour requirements?			
8.10	Are Wind speed meter(s) fitted to the Tower Crane as part of the Technical Solution and related TCSA?			
8.11	Does the Technical Solution and related TCSA allow for height and operating radius of the tower crane and any Obstacle Limitation Surfaces (airspace) factors or occupied building tenancies within the crane operational envelope?			
8.12	Does the Technical Solution and related TCSA allow for navigation (airspace) lighting if required by a statutory authority including an alert should the lighting cease to function?			
8.13	Does the Technical Solution and related TCSA allow for the skills and competencies of all personnel involved in the Supply Agreement to be provided for verification of high risk work licencing and other competency tickets for Crane Crew; Crane Operators relevant to the crane type and capacity, Riggers, Doggers, fitter/mechanic or others involved with work at heights in the tower crane erection, alteration, dismantling, removal, operations and service and maintenance.			
8.14	Does the Technical Solution and related TCSA include familiarisation for the operator(s)/driver(s) by the Supplier in the specific crane type and its operation and operator/driver assist features regardless of years of experience or qualifications/competency held? (refer Appendix 3)			
	Does the Technical Solution and related Tower Crane Supply Agreement allow for third party inspections of the tower crane to be provided to the Project, e.g. at the supplier's storage yard; and at installation and commissioning?			
8.15	Does the Technical Solution and related TCSA allow for third party inspections of the tower crane to be provided to the Project, e.g. at the supplier's storage yard; and at installation and commissioning?			
8.16	Does the Technical Solution and related TCSA allow for verification of registration of all 'scheduled plant and equipment' (i.e. tower crane Design Registration and tower crane plant Item Registration) in accordance with Regulatory requirements?			
8.17	Does the Technical Solution and related TCSA provide for separate itemised pricing for additional safety features selected in section 8 or section 9 where these features are not supplied as standard by the Original Equipment Manufacturer?			
8.18	Does the Technical Solution and related TCSA verify the crane design been confirmed as having secondary independent braking measures in the event of a gearbox/primary luff winch or hoist winch failure, where loads or people are suspended or alternative technology is fitted that has fail to safe to prevent free-fall of the Work Box/load?			
8.19	Does the Technical Solution and related TCSA verify the crane design includes for adequate walkways along the jib length to allow for routine inspection and a fall arrest system verified as meeting the requirements of AS1891.4.			

APPENDIX 2
ADDITIONAL TECHNICAL SOLUTION /OPERATIONAL AIDS

To be used by the Tower Crane Supplier to develop an optimum tower crane technical solution for a construction project in the detailed design stage, in consultation and with input from the Principal Contractor for the Construction Project. Additional technical solutions/operational aids that exist for tower cranes are in many cases non-standard. The information is provided to highlight to Clients and other key stakeholders technical and operational aids which provide key benefits to tower crane operability, including safety. These are generally readily available and in many cases are considered reasonable practicable to implement.

Each feature listed below is further outlined in in Appendix 2 of this Guideline.

Additional feature/ operational aid	**Procurement Requirement**	**Rationale for Selection**
Anti-collision		Two or more cranes operating in close proximity (i.e. within radius) and the potential for clash of jibs/loads and fall of materials. SMIE and Ascorel remain the two major suppliers. Fitment of a visible (white) strobe light to the external underside of the crane cabin and real time data monitoring alert if the system is deactivated by the Tower Crane Operator.
Zoning		Normally a supplementary component of the Anti-Collision system. Areas exist that are to be precluded from lifting over, e.g. public space, rail corridor, school or other 'no go' area.
Building Information Modelling		Use of BIM or equivalent technology in the development of a tower crane technical solution and modelling of tower crane operations in relation to the structure in design and as it is built.
Data Monitoring		Real time automatic monitoring can be optimised across a wide range of parameters and presented in easy to read graphs, reports or interactive maps that can be viewed by web-based software or mobile phone.
Fire Suppression System		Engine fire and failure of major components such as the luffing rope and related jib collapse.
Jib Tip Hook Camera Assist		Additional visual aid to Tower Crane Operator/Driver where the crane hook is out of sight (Blind Lift) for load shifting.
Luff Winch Slack Rope Limit		Detects loose wire rope on the luffing drum if the operator continues to luff down and prevents the luffing drum from releasing anymore wire rope and therefore unexpected lowering of a load.
Machine deck mesh handrail system		Increased protection from falling objects from the machine deck with perforation gaps not exceeding 25mm in any direction.
Self Actuated/Closing Hook Latch		Prevents inadvertent release of the chains off the hook if the hook becomes snagged and upturns.

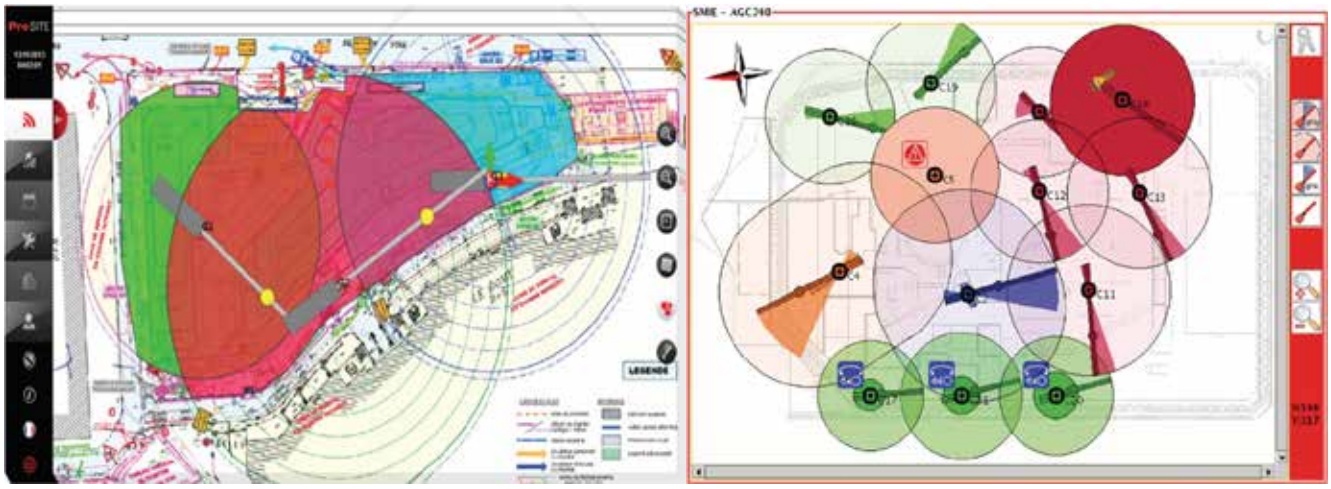
Tower Crane Security		Increased advent of unauthorised entry to tower cranes and risk of fall from height by an inexperienced person. Lockable hatch to restrict access to the crane cabin when crane is not in use. Anti-climb screen mesh around the base of tower crane and a security gate to restrict unauthorised access. Fitment of movement detectors, a security camera and intruder (back to base) alerts to the Tower Crane(s) access points to provide early warning of unauthorised access.
Weathervane/ Jib Stow		Warning light visible for up to 60m, that confirms the crane has been placed in weathervane (free slewing) mode and additional warning light to verify that the jib has been stowed and the angle (radius) recommended by the commissioning engineer or the manufacturer has been implemented. Back up text messaging alerts are also available.
Winch Down Overspeed Protection		Prevents free fall of loads/ Work Box due to hydraulic failure or operator/ driver error.

Anti-Collision

Anti-collision technology prevents collision between crane jibs where multiple tower cranes are in operation on a construction project. The system allows tower cranes to track each other automatically at an optimum speed and maintain a pre-set separation by calculating in real time the risk of collision with regard to the breaking capacity of the crane; thereby eliminating potential for tower crane jib clashes and increasing the productivity of tower crane operations.

Key Features:

- load parameters, hook height;
- automatic clash detection and braking;
- communications between tower crane systems and operators;
- override by-pass/deactivation real time detection; and
- real time operator/driver assist graphic design.



Typical screenshots of anti-collision software.

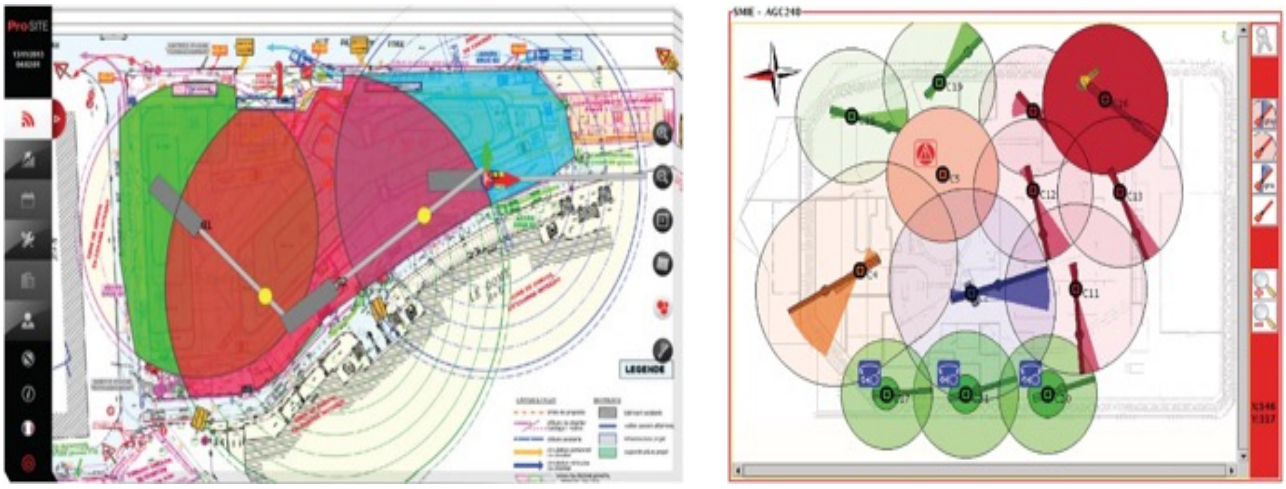
Zoning

Zoning prevents oversailing by the tower crane of critical exclusion zones such as public areas/ rail corridor interfaces / site boundaries or schools that are pre-coded into the tower crane's computer. The tower crane can therefore work in proximity of the zone or follow its boundary in complete safety.

Zoning technology is normally a component of the anti-collision system of a tower crane.

Key Features:

- load parameters, hook height;
- protection and monitoring of zoned areas;
- override by-pass real time detection;
- communications between tower crane operators; and
- real time operator/driver assist graphic design.



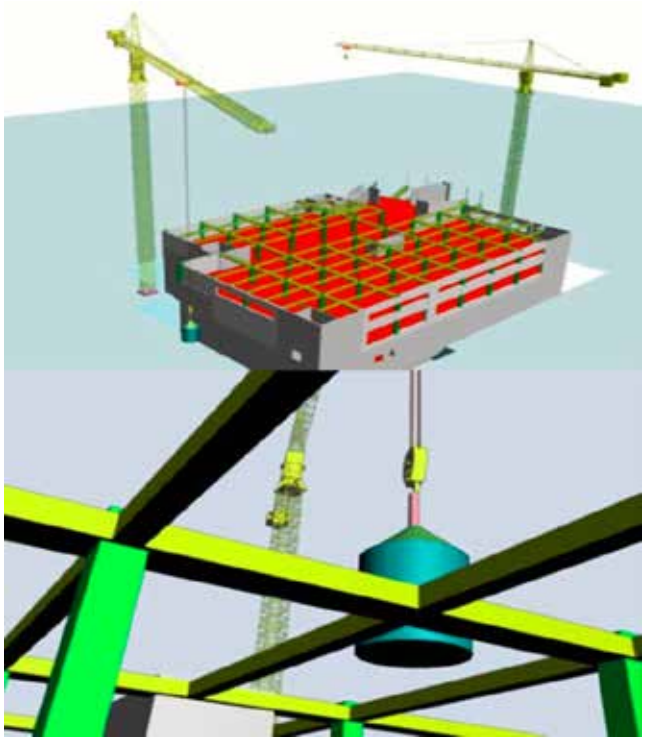
Typical screenshots of anti-collision software.

Building Information Modelling

Most high rise or large scale building and construction projects rely on tower cranes to carry out lifting activities. In practice, tower cranes are managed based on demand, urgency, and prioritised work tasks that must be performed within a timeframe established by the construction project team and the project schedule of critical path activities and related sub-activities.

Effective modelling of complex construction projects and related building and logistics operations using three dimensional (3D) Building Information Modelling (BIM) can significantly assist construction planning and scheduling. This can include the identification of the optimum location for the placement of a tower crane(s) with related elements and inputs such as building type and configuration, work hours, no go zones, delivery and unloading zones, crane capacity and type, landing platforms, construction scheduling of major components and sub component activities and vertical building complexities. These parameters can be evaluated by the 3D BIM model to assist with the development of the tower crane technical solution.

BIM Modelling



Source: Automation in Construction 15 (2006) 554 – 562

Data Monitoring

Modern tower cranes have remote data communication via radio, cellular or satellite networks which enable log of fleet or individual tower crane operations to maintain oversight of key parameters related to operations, including safety and optimise productive use of the tower crane asset.

Real time automatic monitoring can be optimised across a wide range of parameters and presented in easy to read graphs (example below), reports or interactive maps that can be viewed remotely by web-based software or even a mobile phone.

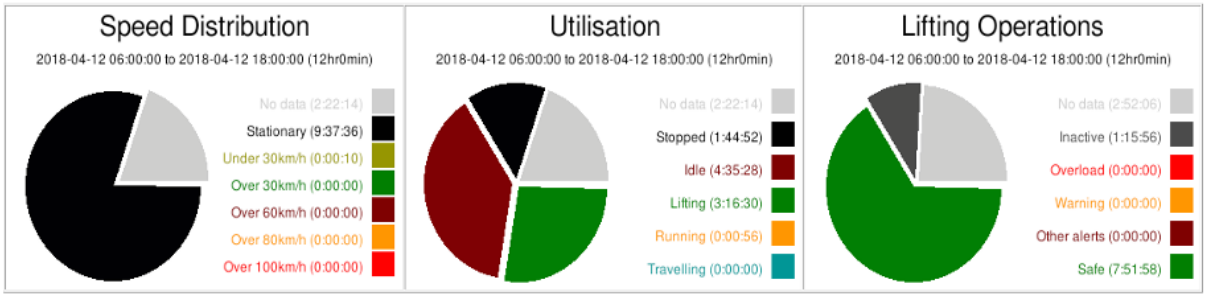
Standard features can include:

- equipment tracing;
- engine monitoring and alerts;
- service intervals and scheduling alerts;
- lift configurations and loadings;
- safe working load parameters and related alerts;
- wind speed and related alerts; and
- anti-collision or zoning deactivation alerts;

Typical screenshots of data logging phone and computer

Report type: Summary
Period: 2018-04-12 06:00:00 to 18:00:00 (timezone Australia/Victoria)
Equipment: Favelle Favco M220DX Tower
Branch/Project: On-Site
Fleet ID: 2241
Registration: 2241
Engine hours: 1755.10

Pie charts:



Largest lift recorded:

From	To	Duration	ATB	O'ride	Main Hook SWL (%)	Main Hook Load (t)	Main Hook SWL (t)
2018-04-12 10:40:28	10:40:33	0:00:05	OFF	OFF	65.22	3.00	4.60

Lifts:

SWL %	Count	Duration	Count (%)	Duration (%)
No data	3	2:52:06	6.82	26.72
0 to 20%	14	7:17:20	31.82	67.90
21 to 40%	11	0:18:24	25.00	2.86
41 to 60%	11	0:13:43	25.00	2.13
61 to 80%	5	0:02:31	11.36	0.39
81 to 100%	0	0:00:00	0.00	0.00
> 101%	0	0:00:00	0.00	0.00
Totals	44	7:51:58	100%	100%

Equipment alerts:

Lift errors	Engine alerts	Speed > 100 km/h	Service due (hh:mm)
0	1	0	244:08

Fire Suppression System (Diesel Tower Cranes)

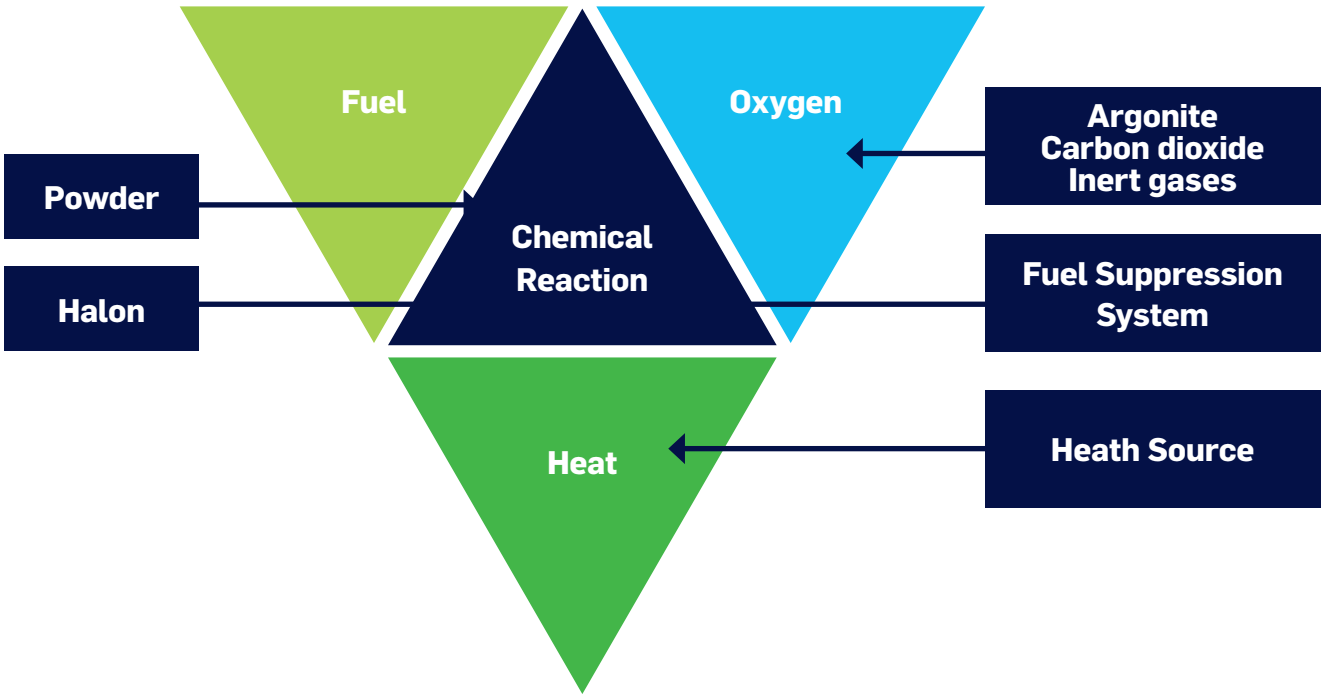
A fire suppression system is an engineered group of dispersal units designed to extinguish or prevent the spread of fire through the application of a suppression agent and mounted in the tower crane engine compartment. There are several fire suppression systems available on the market.

The systems operate in auto mode with ignition off and in the manual mode when the tower crane is in operation. The dashboard alarm detects fire and the Operator/Driver can activate the fire system discharge, which shuts down the engine and seconds later discharges the suppression agent. In auto mode the system can discharge immediately.

The suppression agent is an ultrafine particle sized (less than 2 microns) potassium or other based aerosol. The aerosol is discharged at low pressures (less than 350 kPa) and a chemical reaction takes place between the aerosol and the free radicals (reactive atoms and molecules) that exist in the flames of a fire. This reaction helps in suppressing and extinguishing an engine fire.

In addition, the fire suppression system must include fire rated engine hoses and external (outside the engine bay) battery placement to prevent the risk of reignition and fire spread.

Typical fire suppression system



Jib Tip Hook Camera Assist

Cameras can be attached either to the jib tip hook and/or the winch drums for viewing the load in flight, lift/landing of the load, winches and the work site. This feature helps the tower crane operator/driver to eliminate blind spots and view areas clear of obstruction. It assists the operator/driver to verify that the load is properly attached to the hook.

On hammerhead tower cranes, the camera travels on the trolley. Adjustments to the installation can cater for the use of fly jibs, so that the camera view continues to cover the hook.

Additional advantages of the cameras on tower cranes includes:

- Improved communication with the crane operator and rigger/dogger slinging the load;
- Increased accuracy of load placements;
- Increased vision of the load lifting or load landing zone;
- Increased vision of the stability of the load in flight and related winch speed;
- Increased productivity on the job site;
- Remote monitoring of the job site with an aerial view ; and
- Additional camera to monitor winch drum.

Typical job/hook camera assist view

Actual vision of crane operations

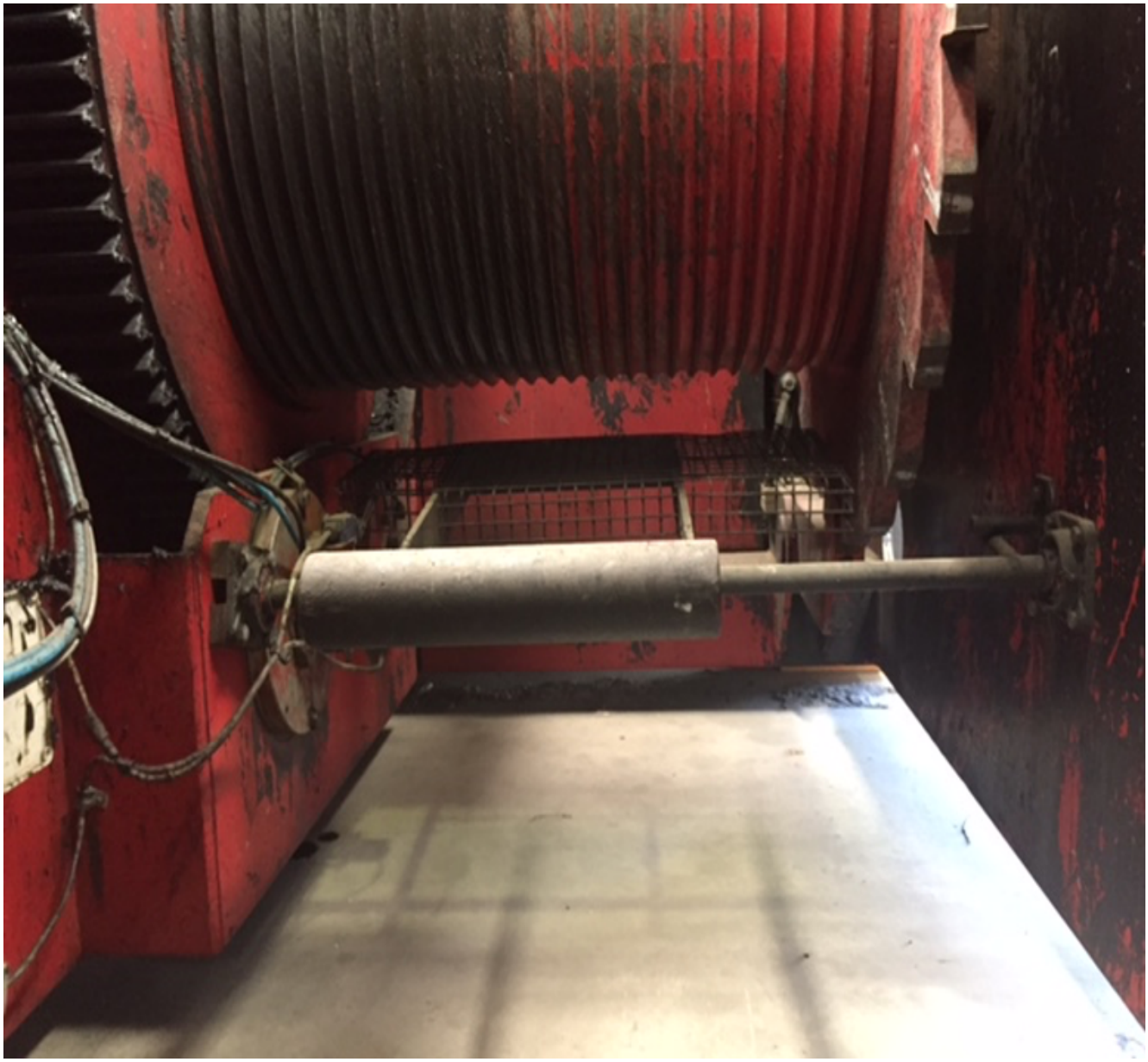
Camera installed on a crane hook
(photo for representation purposes only)

Luff Winch – Slack Rope Limit

The jib on luffing cranes can be held up by the wind if the operator rotates the tower crane with the jib near minimum radius (i.e. luffed up) when facing into the oncoming wind direction.

The Slack Rope Limit detects loose wire rope on the luffing drum if the operator continues to luff down and prevents the luffing drum from releasing anymore wire rope and therefore unexpected lowering of a load.

Typical slack rope limit detection



Machine Deck Mesh Handrail System

Tower cranes are provided with perimeter edge protection that extends around the machine deck to prevent a fall from height. The edge protection should consist of a top rail, a mid-rail and a toe board.

In addition, the installation of infill mesh to the handrail system also prevents the potential for fall off materials from the machine deck, e.g. dropped tool or component when carrying out maintenance or other work.

Installation of 25mm aperture mesh to prevent the fall of dropped tools or materials off the machine deck. The crane supplier/original equipment manufacturer should be consulted to determine if the mesh could create additional wind loads on the crane.

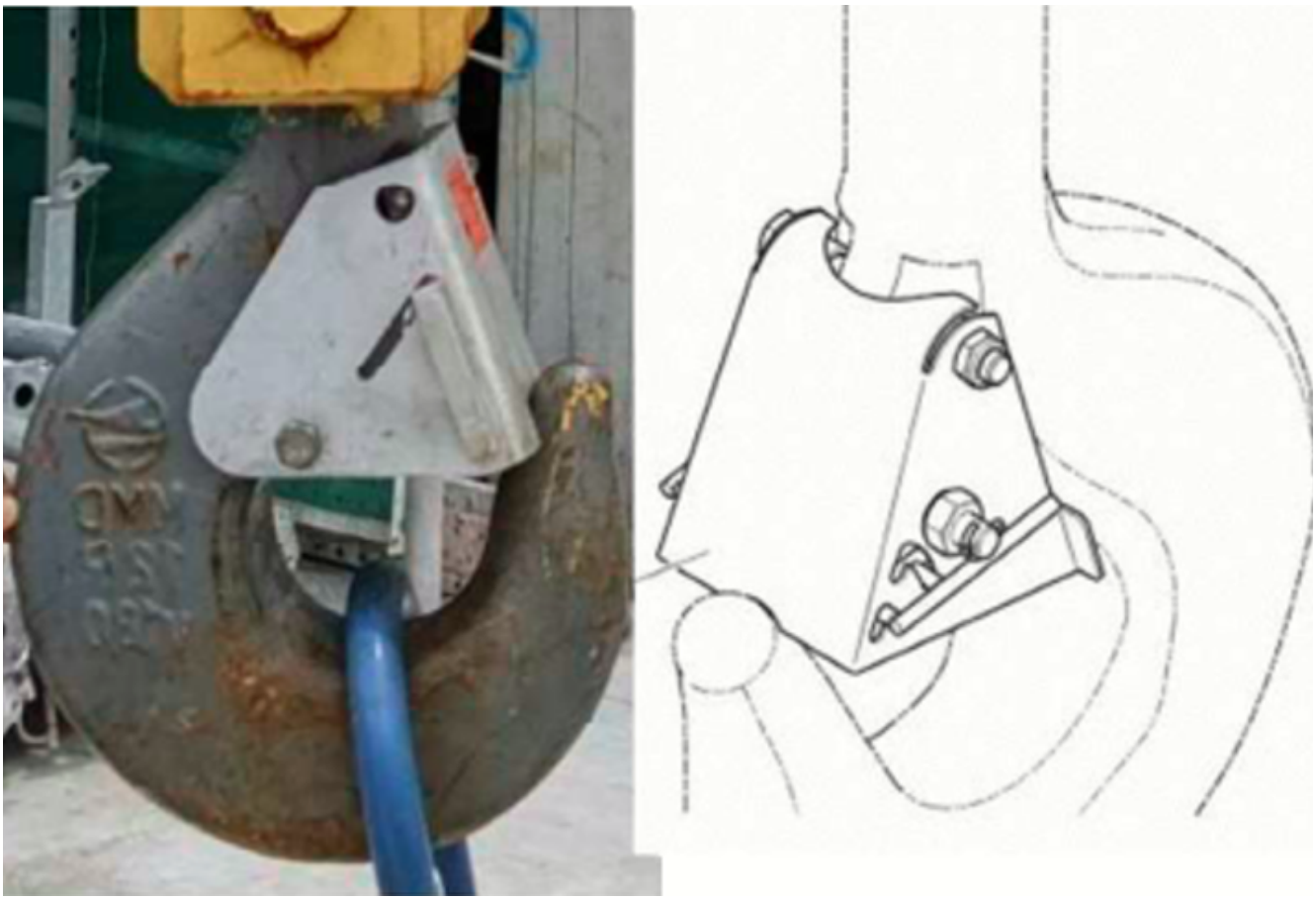
Self Actuated Hook Latch

Tower cranes are provided with an operable (spring loaded) safety latches to the crane hook, a requirement of Australian Standard AS3776. Latches are intended to retain on the crane hook any loose sling or devices under slack conditions.

Using an open hook or a hook with a damaged or gravity hook latch can allow a load on the hook to come free and fall, for example if the load or the hook was snared causing the hook to rotate and invert. This type of incident occurred on a construction project in Malaysia in 2019 causing the lifting chains to detach from the hook and fall a number of floors and strike a worker on the head, causing significant injury and death due to complications in hospital. The hook latch, a spring loaded mechanism was defective and it fell open due to gravity conditions when the hook inverted, enabling the chains to fall free when the crane load snagged on a perimeter protection screen.

Whilst the use of a hook with a latch does not preclude the inadvertent detachment of a load from the hook, it does provide an additional barrier to prevent detachment, but in all cases correct hook engagement is required.

Self Actuated /self-locking hook latch mechanism



Tower Crane Security

Social media and the increasing advent of unauthorised out of hours access to construction sites by trespassers means that security to partly constructed structures and temporary structures such as tower cranes is important. Tower crane risks could include fall from height, damage to the plant or its equipment or even unauthorised operation of a tower crane by an inexperienced intruder.

A lockable hatch to the machine deck and cabin is standard to restrict normal access to the crane cabin when the tower crane is not in use. Any padlock used to lock a ladder access hatch should be tethered to prevent the potential for a fall of the padlock when it is removed to gain access to a tower crane ladder or cabin. Additional security features can typically include:

- anti-climb mesh or plywood to a minimum height of 3m (with no handholds/footholds) around the base of crane access towers or ramps and a security gate to restrict unauthorised access;
- a door or gate access combination or other security lock to prevent unauthorised access with minimal gaps to the access frame surround to prevent levering and compromising of the locking mechanism at the tower crane base or other intermediate access locations. The door or gate must remain operable from the inside without a key to enable safe egress in an emergency; and
- security cameras and sensors within and outside the crane tower sections and access points with (back to base) alerts and strobe lights to attract attention, basement, or floor levels where a tower crane penetration exists includes floor to soffit protection of areas where unauthorised access could be gained.

Tower cane security at the bases with minimum 2,400mm high plywood sheet and anti- climb mesh to the tower frames minimum two frames high, and locked ladder access hatch.

Weathervane / Jib Stow

It is important to ensure that tower cranes are correctly configured every time they are placed out of service to reduce the risk of structural damage due to an extreme weather event. Incidents of tower crane jib failure due to an extreme weather have occurred in Australia and globally.

At the end of each shift and prior to a forecast weather event the tower crane should be correctly stowed. This means

- the crane boom, rope and hook are placed clear of all adjacent structures (in a 360 degree radius);
- there is no load on the crane hook, including chains if there is a risk of the chains contacting a structure or the chains being struck by lightning;
- the crane hook is raised, so it is close to the boom tip;
- the trolley on a hammerhead crane is positioned in close proximity to the mast/tower (minimum radius);
- the boom of a luffing crane is positioned at the recommended radius for weathervane;
- the crane is placed in weathervane (free slewing) mode by the operator/driver before descending the access ladder; and
- the crane is slewed so the boom is away from the wind (pointing downwind).

In addition to the above precautions, a warning light that is visible for up to 60m can be installed on some crane types that confirms the crane has been placed in weathervane (free slewing) mode and an additional warning light installed to verify that the jib has been stowed at the angle (radius) recommended by the commissioning engineer or the manufacturer. Other crane suppliers may have alternative alert systems.

Tower Crane damaged during an extreme storm event and weather-vane not actuated.

Winch Down Overspeed Protection

Winch down overspeed protection is a safety feature which prevents free fall of loads including a Work Box due to hydraulic failure or driver error. While setting the operational parameters of the tower crane the maximum speed of the hoist/luff winch motor can be entered into the system.

Whenever this speed limit is exceeded a brake is applied and free slip off the hook is prevented. A visualisation dashboard is available to the Commissioning Engineer or Technician to pre-set the overspeed protection. This dashboard enables the Engineer or Technician to troubleshoot and set up the tower crane system and is available using selective software.

APPENDIX 3
TOWER CRANE DRIVER/OPERATOR FAMILIARISATION

To be used by the Tower Crane Supplier Technician or other Competent Person to familiarise the proposed Tower Crane Operator/Driver of the specific tower crane and related crane crew in the operations of the tower crane and its features. The tower crane Operator/Driver and related crane crew must also hold a tower crane High Risk Work Licence specific to the tower crane capacity or type of crane, e.g. Derrick Crane, or type of high risk work undertaken, e.g. rigging.

NOTE: The example below co-mingles elements of diesel and electric tower cranes. The proforma should be adapted to suit the specific type, make, model and capacity of the tower crane which is the subject of the Tower Crane Supply Agreement and its related Operator/Driver familiarisation.

TOWER CRANE DRIVER/OPERATOR FAMILIARISATION	
Client Name	
Construction Project/ Crane Location	
Crane Make & Model	
Crane Serial Number:	
Crane Operator/Driver Name	
Crane Operator/Driver Licence **(Ticket type/ Crane Capacity/ Expiry Date)**	
Employer:	
Signature:	
Name of Person conducting the familiarisation session:	
Qualifications:	
Employer:	
Signature:	
Date and time of familiarisation start:	
Duration of familiarisation session:	

(to be completed by the person conducting the familiarisation session)	**Yes**	**No**
Pre Start Procedure		
Can the Operator/ Driver explain and demonstrate the pre-start checks for the Tower Crane including requirements for pre-heating and energisation?		
Start-up Procedure		
Can the Operator/ Driver explain and demonstrate the start-up procedure including preheating and warm up?		

Use of Tower Crane control computer in conjunction with load chart book, and other associated systems (e.g. Robway Anti-collision, zoning, Load Shifting International System - LSI)		
Can the Operator/ Driver explain and demonstrate where to find and how to adjust and enter a load chart, boom length in metres, lifting capacity in kg, boom configuration – correct duty, counterweight configurations, attachments, change screen, configurations and all selections and enter the work screen?		
Use of Tower Crane control computer Working Program and other associated systems (e.g. Robway Anti-collision, hook camera, LSI System, zoning, communications)		
Can the Operator/ Driver explain and demonstrate where to find and the meaning of: radius in metres, rated workload, actual load, boom length and configuration, wind speed, winch rope measurement, boom angle, slew braking, error code location and audible alarm cancelling, error symbols and communication systems?		
Use of engine/motor management annunciator		
Can the Operator/ Driver explain and demonstrate how to access the program from another screen (working screen), where to find and meaning of symbols add data, what to do in the event of: low fluid level or high temperature, the engine/motor management annunciator panel, loss of power?		
Where fitted identification of anti-cavitation switches & emergency lowering valves /pump		
Can the Operator/ Driver explain and demonstrate where to find anti-cavitation switches, how to test anti-cavitation switches, where to find the emergency lowering assembly including valves and pump?		

Operation of tower crane controls	**Yes**	**No**
Can the Operator/ Driver explain and demonstrate winch #1 up and winch down, winch #2 up and down, slew right, luffing up, luffing down?		
Use and operation of cabin controls including any fire suppression system		
Can the Operator/ Driver explain and demonstrate adjustment of the seat angle, height of the seat, pneumatic lumbar support lower back, pneumatic lumbar support upper back, horizontal seat position, inclination of backrest, fan, air conditioning, heating controls, cabin and boom lights (if fitted), sound the horn, set engine revs, windscreen wiper and washer controls, operate sunshade top and front, locate and collect data from the hour meter, location and activation of any fire suppression system and location of fire extinguishers?		
Using attachments, reeving hooks, using wire rope connections		
Can the Operator/ Driver explain and demonstrate how to inspect ropes, inspect the hook, and greasing requirements for the hook?		
Shutdown Procedure		
Can the Operator/ Driver explain cool down period for motors and engine turbos after crane usage?		
Weathervane radius: To be stored on cradle and tied downs as instructed		
Can the Operator/ Driver explain and demonstrate how to: correctly put the tower crane into weathervane mode, check that the crane is in weathervane mode with engine running by use of slew brake switch? store the tower crane jib against the storm brace? stow the tower crane to the correct weathervane radius and hook height set by the engineer's drawings?		

Crane Maintenance		
Can the Operator/ Driver explain and demonstrate how to check fluid levels, check and grease all points accepting grease, check and grease open gear grease, if fitted with auto lube check and ensure it is functioning correctly and has a suitable grease level?		
Crane serviceability and logbook procedures		
Can the Operator/ Driver explain and demonstrate how to locate and maintain the central lubrication system, inform the crane operator and supervisor of crane hours and service intervals at 200-250 hours, inform supervisor of any faults / problems, use the daily inspection logbook/ sheets and input all relevant information, any requirements to provide the completed logbook/ sheets to whom and when; and who to report faults or defects to immediately on becoming aware of a fault or defect?		
List any additional comments or familiarisation requirements		