



Wind Energy Operations & Maintenance Best Practices for Mobile Crane Safety

in Wind Energy Operations

These best practices provide the Canadian wind industry with a set of safety considerations and guidelines when performing lifting operations requiring external cranes of various sizes and capabilities.

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Introduction

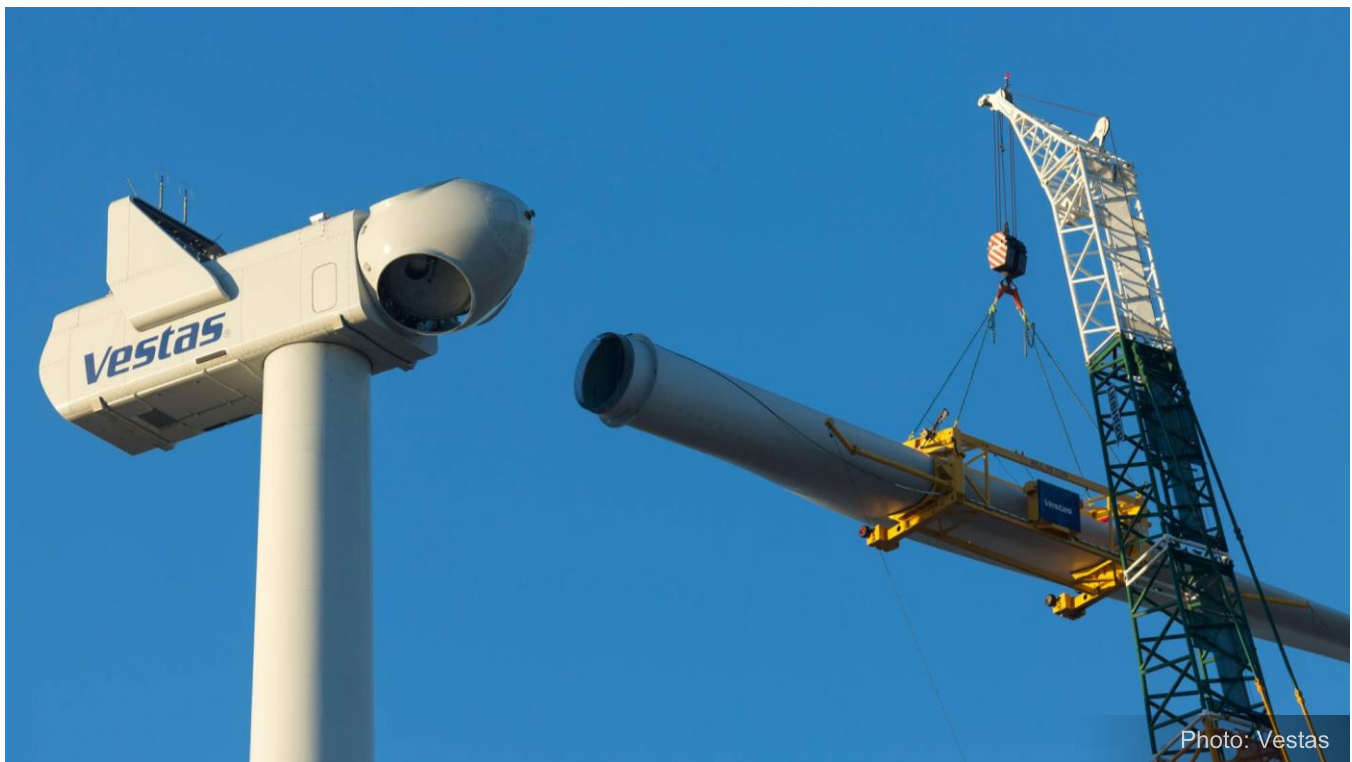
The CanREA EHS Committee has developed the following best practices to provide a wind industry resource addressing unique hazards and workforce arrangements for heavy lifting activities at a wind power facility.

The document targets wind energy site staff by focusing on information and practices that are relevant for direct employees and not necessarily all workers on site during lifting activities. The current state of the industry is for many wind site operators to contract a crane service for major repairs. The service provider will have their own practices, procedures, regulatory compliance programs, and qualifications. This document is not intended to replace these expectations but demonstrate that safety is everyone's responsibility. By enabling wind site staff with relevant information, everyone on the job can gain confidence in asking questions, promoting a safety culture, calling a stop-work action, and helping with injury prevention.

Recent advancements and adaptations in crane equipment have created a need for additional safety considerations. Self-climbing, nacelle mounted and internal cranes along with the use of tower cranes that are constructed at each turbine require special attention to ensure wind energy site staff are equipped with sufficient information to work around this equipment. This best practice document does not address these types of cranes but remains focused on large, mobile cranes.

- The first section provides site owners and staff with the roles typically needed to execute a major lift operation. This allows wind sites to inquire about any missing roles and verify if the personnel fulfilling a specific role is capable of meeting the basic functions of the role.
- The next section highlights pre-mobilization considerations to ensure efficiency of the job right from the beginning as well as an opportunity to team up for success with on-site safety by anticipating the needs of the lift plan.
- The subsequent sections walk through pre-lift activities, set-up, execution of the lift, and demobilization. At each stage of the job there are adjustments required to accommodate for changes such as weather and soil conditions or drop zone footprint. Remaining vigilant and aware throughout the project is important.
- Finally, the document provides a section listing regulatory considerations in the Canadian context. This is particularly important in a country like Canada with multiple authorities having jurisdiction between each province and territory.

For inquiries on this or any other CanREA resources and to find out how to get involved please contact info@renewablesassociation.ca.



Disclaimer

The Canadian Renewable Energy Association (“CanREA”) assumes no liability or responsibility for reliance on the contents of this Best Practices for Mobile Crane Safety in Wind Energy Operations (the “Guide”), which is intended for educational and informational purposes only. CanREA makes no representation or warranty about the suitability of the information offered in this Guide, including for legal compliance or any other purpose. The Guide is offered only as general guidance and does not constitute legal or professional advice. This guide is not intended as a substitute for the specific and expert advice required in areas such as crane operations, wind energy operations, or regulatory compliance.

Acknowledgements

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Table of Contents

Definitions	4
Qualified Person (ASME B30.5)	4
Competent Worker (ASME B30.5)	4
Competent Person (CSA Z150-16)	4
Classification of Critical/Serious/Complex/Special Lifts	4
Personnel Considerations.....	5
Crane Operator	5
Crane Owner	5
Crane User	6
Lift Supervisor/Lift Director	6
Rigger	7
Tag Line Operators	8
Signal/Flag Person/Spotter	8
Third Party Inspector.....	9
Additional Personnel on Site	9
Dedicated Safety Personnel	9
Site Lead/Supervisor.....	9
Safety Lead.....	10
Authority to Act and Decisions to Stop Work	10
Pre-Mobilization	10
Pre-Mobilization Checklist	10
Pre-Lift.....	12
Communication	12
On-Site Assessment.....	13
Setup and During Work	14
Exclusion Zones	14
Communication	14
Personal Protective Equipment (PPE) and Training	15
Physical Awareness	15
Contingencies	15
Weather Conditions.....	16
Soil Considerations	16
Environmental Responsibility Considerations	17
De-mobilization	18
Regulatory Compliance.....	18
Canadian Standards, Legislation and Regulations - General.....	18
Resources and International Standards.....	19
Exhibit A	20
Pre-lift Job Briefing	20
Job Information	20
Personnel Positions.....	20
General Checklist	20
Job Specific Process Questions	21
Potential Hazards Observed.....	21
Hazard Control	22

Definitions

Qualified Person (ASME B30.5)

A person who, by possession of a recognized degree in an applicable field or certificate of professional standing, or who, by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter and work.

Competent Worker (ASME B30.5)

A worker who is adequately qualified, suitably trained, and with sufficient experience to safely perform work without supervision or with only a minimal degree of supervision.

Competent Person (CSA Z150-16)

A person who, by possession of a recognized degree or certificate of professional standing, or by extensive knowledge, training, and experience, has successfully demonstrated the ability to resolve or solve problems relating to the subject matter, and who is familiar with the provisions of this Standard (CSA Z150-16) that apply to the subject matter and their applications.

Classification of Critical/Serious/Complex/Special Lifts

Certain conditions may require additional considerations for a lift from a safety perspective. There may also be specific regulatory requirements in certain jurisdictions to specify a lift in a certain way such as “critical” or “complex.” Individual organizations may classify in different ways to trigger certain policies and procedures based on the specifications of the lift. In many cases a lift may be classified in this manner for any of the following conditions:

- Lifts over 75 per cent of rated crane capacity.
- Lifting over live process equipment or that endangers existing facilities.
- Lift is within the limits of approach to high voltage electrical or high-pressure gas lines.
- Hazardous substances are involved.
- There is a load transfer required.
- Load exceeds 4.5 meters / 15 feet.
- Wind speed exceeds 10 m/s / 22 mph / 35 Kph (engineering may be required).
- Temperatures are lower than -30o C / -22o F (engineering may be required); or
- Local/state/national regulations and/or standards may also define; or
- Any other environmental, ground or high-risk condition as determined by the site supervisor or the lift engineer.
- Any tailing crane operation where the weight of the load exceeds 85 per cent of the capacity of the tail crane.
- Any lift involving two or more cranes lifting the same load simultaneously, where the load on any one crane may exceed more than 85 per cent of that crane’s lifting capacity as measured on the lifting chart.
- Any load where special lifting or rigging equipment such as tuggers, chainfalls, leaver hoist, jack and slide operations, lift and lock, strand jacking, magnets, or non-standard crane configurations (as determined by lift supervisor or other qualified person) are used.
- Any crane lift where the crane is set up over any underground installations requiring additional protections such as over manholes, catch basins, sewers, sinkholes, new excavations, bitumen, underground gas lines, underground springs, firewater lines or other known surface, or sub-surface interferences.

- Any use of the crane to lift of a person by any means.
- Involve special risks due to the type of load (unknown center of gravity, seriously damaged components, etc.) and/or complex environment.

Personnel Considerations

It takes significant forethought to assemble the right experience and team to prevent injury and near misses. The following personnel considerations provide the minimum expectations for qualified persons to assist wind farm staff in identifying if the right skills are present for the job. It is incumbent upon the team as a whole to inquire of each other if tasks are not performed adequately or are missed completely.

Crane Operator

A crane operator can be expected to perform the following tasks competently:

- Provide proof of competency and qualifications to safely operate equipment.
- Comply with all governing regulations for the jurisdiction in which the work is being performed.
- Safe operation of the crane in compliance with the crane manufacturer's instructions. The operator should notify the person in charge immediately of any concerns over non-compliance or other safety concerns.
- Inspect the assembled crane and rigging prior to lifting. The operator should never lift a load that is not safely rigged.
- Verify that the load weight does not exceed the safe lifting capacity of the crane and environmental conditions.
- Plan for emergency conditions including the set-down area.
- Check that the black box data recorder is available and operational when applicable.
- Assess the site for suitability of the lift as prescribed on the approved lift plan(s). This includes crane pad preparation including matting.
- Follow the approved lift plan as specified.
- Check the communication system for clear and simple, hands-free communication throughout.
- Communicate before, during and after the lift with the team as agreed upon during the pre-lift checks.
- Inspect the assembled crane after the lift operation.
- Manage personal fatigue, mental and physical requirements appropriately.
- Call "stop-work" on a job at any time that they perceive a safety risk or potential risk to equipment. The operator should also vocalize with the site manager if there are concerns over sub-optimal conditions for the lift.

Refer to the section below on Regulatory Compliance for certifications and qualifications as well as maintenance of qualifications required of crane operators.

Crane Owner

There are specific requirements for the owner of the crane. Some of these responsibilities of the equipment owner include:

- Ensure crane meets the requirements defined by the end user.
- Ensure the crane and all necessary components specified by the manufacture meet the users requested configuration and capacity.

- Provide all applicable load rating charts and diagrams.
- Provide any additional technical information pertaining to the crane necessary for operation when requested.
- Provide any expertise on the crane or lifting if required.
- Provide an equipment certification prior to the lift.
- Ensure all daily maintenance checklist/logs are completed and up to date.
- Ensure the operator is aware of any modifications to the crane or components such as documenting the rope information currently installed on each drum.

Crane User

The crane user may be a different person than the operator or owner. Depending on the contract being executed, the user could be the one who has purchased the crane services, the owner of the crane who is using the crane for an internal contract or a sub-contractor to the site owner that has purchased the crane services. In brief, the crane user is the individual or organization that is contracting for services. Some basic responsibilities of the crane user include:

- Review and comply to the lift plan.
- Is well versed in the emergency plan, set down area, and avenues of escape.
- Compliance with any requirements as per the manufacture and applicable regulations at the work site.
- Ensure the crane is in proper operating condition prior to initial use.
- Verify that the required frequency of inspections has been and is being performed.
- File the lift plan with any regulatory authorities informing them of the lift plan where applicable.
- Ensure the crane operators are qualified.
- Inform the crane owner if any rope on the crane is replaced or shortened.

Lift Supervisor/Lift Director

The lift supervisor can be a direct wind farm employee or contracted worker; however, it must be clear to everyone on the project who this single-point person is. This person should have the following competencies and responsibilities based on industry expectations:

- Will be present during lifting operations.
- Stop all operations if alerted to unsafe conditions.
- Ensure traffic controls are in place to restrict unauthorised access and unnecessary traffic.
- Appoint signal personnel and ensure they are competent and qualified for the role.
- Ensure all requirements from the site supervisor have been met.
- Approve all lifting plans and engineered drawings before lift is executed.
- Prepare comprehensive lift plans and interpret plans.
- Is able to evaluate a lift plan against site conditions and account for deviations between planned conditions and actual conditions.
- Can assess the emergency planning necessary ahead of time for issues during the lift. Is well versed in the emergency plan, set down area, and avenues of escape.
- Involved in selecting or at least approving the appropriate crane and conditions to perform the lift including rigging requirements and other hardware needed.
- Provide the Ground Bearing Capacity data to the crane operator and/or crane owner.

- Perform inspections, complete checklists, etc. including verification of load weights, rigging capacity, crane inspections and other equipment being used. This also includes tracking and approval of changes to the plan throughout the job.
- Ensure the lifting team is trained, qualified and equipped with appropriate Personal Protective Equipment (PPE) and all communication necessary has been completed clearly and received by the team.
- Is capable of communicating and using the appropriate signals, language, etc. necessary for the lifting activities.



Photo: Vestas

Rigger

Workers involved in rigging throughout the lift operation should be familiar with the following information and competent in the skills listed:

- Can properly attach rigging equipment to the hook, shackle, or load handling device.
- Is able to identify the crane type and capacity and read the lift chart.
- Is well versed with the lift plan, set up area, and lift points.
- Able to verify that rated capacities are not exceeded for the rigging equipment.
- Trained on using appropriate lift angles and identification of the swing radius and potential hazards.
- Experienced with proper rigging of taglines, guide ropes, connection points for lines, body positioning during the operation, and limitations of the prescribed rigging.
- Can apply load balancing techniques using chain falls or other devices.
- Capable of accounting for reasonable wind and environmental variations, overhead obstacles, and minimum distances from electrical sources.
- Able to identify when environmental conditions are sub-optimal.

- Can properly inspect the rigging and lifting equipment.
- Can ensure rigging equipment is adequately protected from cuts, abrasion, or other damage during load handling activities.
- Is well versed in the emergency plan, set down area, and avenues of escape.
- Proficient in language used for communication including hand signals.
- Confident to call “stop-work” at any point during the lift activities if a safety risk or potential risk to equipment is perceived.
- Capable of identifying sub-optimal conditions for the lift and communicating this to the site manager and/or lift supervisor.
- Is capable of completing the role of tag line operator below.

Tag Line Operators

A tag line operator will have less expectations than the rigger as the role is focused on operating the tag lines and less on the setup, attachment points and inspection. However, the rigger and a tag line operator may be the same person. The following expectations are provided for reference:

- Has been briefed on and understands the lift plan.
- Knows the set-down areas both planned and in case of emergency.
- Understands the proper equipment needed such as winches, chains, slings, hooks and clevises, shackles, wire ropes, chain falls, taglines, spreader bars and similar equipment.
- Has awareness of the tag line positioning at all times. Is able to prevent being caught by the line as the lift commences.
- Can identify the restricted area under the load.
- Has a method of hands-free communication such as a hands-free radio or another person nearby to communicate with the lift team on their behalf. Can demonstrate hand signals used for the lift.
- Is capable of identifying when conditions are sub-optimal.
- Is well versed in the emergency plan, set down area, and avenues of escape.
- Will call “stop-work” on a job at any time that they perceive a safety risk or potential risk to equipment. The operator should also communicate with the site manager if there are concerns over sub-optimal conditions for the lift.

Signal/Flag Person/Spotter

Another important role is the signaler or flag person. This person will be capable of communicating using the appropriate signals, flags, radio communications, etc. throughout the lift operation/crane movements. This role can be combined with that of the Rigger or Tag Line Operator. It is important to ensure that there are enough people to complete all of the roles safely and to avoid too much responsibility for one individual. Some key competencies include:

- Knows how to keep the line of sight open with the load, crane operator and tag line operators.
- Is fully versed in the signalling system agreed to for the operation and is capable of communicating effectively to the team.
- Knows the contingency plans if changes are needed to the primary lift plan and is able to identify sub-optimal conditions.
- Is capable of guiding the crane safely during movement of the crane such as reversing or forward crawling.
- Is well versed in the emergency plan, set down area, and avenues of escape.

- Confident to call “stop-work” at any point during the lift activities if a safety risk or potential risk to equipment is perceived.
- Capable of identifying sub-optimal conditions for the lift and communicating this to the site manager and/or lift supervisor.

Third Party Inspector

For cranes assembled on site a third-party inspector may be required. This person will perform load testing before any lifts take place. They will ensure there is a reporting mechanism during the assembly of the crane, ensuring all of the proper procedures are followed. In addition, daily inspections and documentation can be supplied through this role enabling full transparency, compliance and safety from start to finish.

Additional Personnel on Site

Anyone involved with crane lifting activities or who will be exposed to the site while lifting activities are taking place should receive training to ensure competency in their role and awareness of hazards. At a minimum, this training should include:

- Reporting of any unsafe conditions.
- Awareness and compliance with all signs and barricades.
- Ensure all established communication methods are clearly understood.
- Situationally aware and never stands or passes under a suspended load.
- Is well versed in the emergency plan, set down area, and avenues of escape.

Dedicated Safety Personnel

Safety is everyone’s responsibility. This should be reinforced by management at every opportunity. There are certain roles that are safety related that need to be specified to enable all workers in safety actions. Without an avenue for everyone involved to stop-work, communicate an anticipated hazard or ask questions, a safety-first culture cannot be achieved. Some of these enabling roles that should be established well in advance of the lift include the following:

Site Lead/Supervisor

As the responsible representative of the wind farm owner/operator the site lead is an important role in ensuring the overall safety of on-site activities. While the site lead may not engage with all workers present, they will maintain the overall coordination of work. Some of the specific responsibilities include:

- Ensure that only authorized persons are permitted on site.
- Assign a person in charge for each operation on site.
- Provide training opportunities for all personnel in the tasks required including the safety lead.
- Ensure the crane meets all requirements prior to initial site usage.
- Determine if any other regulations are applicable to crane operations.
- Ensure a qualified person is designated as the lift director.
- Coordinate with all other site activities that may be affected by crane operations.
- Ensure Crane operator, signal person, and riggers meet requirements for competency and qualifications.
- Identify hazards and mitigation opportunities specific to lifting operations (wind, fog, poor soil, extreme cold and heavy rains).
- Follow all specific overhead powerline regulations based on work location.

- Ensure all crane maintenance is done by personnel that meet the competence requirements.
- Approves all lifting plans and engineered drawings before lift is executed.

Safety Lead

The safety lead for a site is tasked with enabling the company safety policies and procedures are effective. Adherence to the policies and procedures is important and must be monitored. However, ensuring everyone involved understands and can execute the systems and programs is equally as important. Another important activity involves review of third-party contractor safety policies and procedures while coordinating between the different organizational groups on site. The site safety lead will work directly with the workforce completing the crane operation.

For each of the roles specified it is important for all organizations involved in the job to understand who will fill each role. If multiple organizations specify their own representative to fill the role, communication should take place as to who has the final authority to act.

Authority to Act and Decisions to Stop Work

Some additional considerations include an agreement with the contractor defining who has authority to stop work and what happens when someone calls a stop work situation for safety concerns. Who will pay for expenses incurred during a stop work situation? It should be acknowledged that the understanding of how a safety decision will be treated by a worker will impact their readiness to make the call in the moment. Even a brief hesitation by a worker operating a tagline could mean the difference between an injury or a delayed lift with no injury. Therefore, workers must understand clearly that a stop-work action is not going to be perceived negatively or result in penalization.

Pre-Mobilization

Pre-mobilization refers to the period of time prior to the execution of any work necessary to move a crane from its current location to the lift site. This is before rigging equipment is packed into bags, booms are disassembled or moved for relocation, transportation trucks are dispatched, etc. During this stage the lift plan is designed and communicated with all necessary specifications provided by the customer to the crane company and agreements formalized for the lift plan, scheduling, payment, etc. Once activities have begun for mobilizing the necessary equipment and personnel, the project has moved into deployment and out of the “pre-mob” stage.

Pre-Mobilization Checklist

- Ensure the crane meets the job specifications – During the pre-mobilization period there may be several iterations of the lift plan and requests made to the crane company. For this reason and to reduce incidents through human error, it is important that the lift supervisor checks that the crane capacity and configuration is adequate for the specified lift.
- Review the lift plan including load and capacity charts accompanied by the necessary approvals – There may be multiple lift plans considered and revised, as well as more than one plan needed for the specified lift, making it important for the lift supervisor to review the final documents prior to mobilization. Catching errors or miscommunication at this stage can prevent additional expenses and manoeuvres from a mobilized crane operation. In the planning stage, be sure to capture any walking/mobilization of the crane and partial disassembly for movement of the equipment. Refer to the Regulator Compliance section for provincial regulations regarding lift plan approval.

- Check the crane pad – Re-visit the crane pad and perform measurements to ensure the usable area remains true to the drawings and the surrounding growth will allow for maneuvering of the load. Erosion, sloping, high vegetation, etc. can all affect the original assumptions made during construction of the site.
- Soil condition measurements – If relevant records do not exist, perform a soil condition and weight bearing capacity analysis. Be sure to communicate these to the crane company/operator. Check for road weight restrictions during the entire lift operation window including mobilization, de-mobilization and contingency dates. Be cautious during shoulder season to prevent equipment from being trapped onsite if road restrictions are enforced after the mobilization effort.
- Ensure crane maintenance records are up to date with manufacturers requirements – It is appropriate to request maintenance records and to compare these records with manufacturer recommended practices for maintenance. Out of date maintenance activity is an indicator to further investigate the safety of using the equipment and the crane service provider.
- Crane and operator certifications – The crane organization should be able to provide certification for the crane operator designated for the job along with an operator certification indicating the organization is certified to conduct the work. The crane operator may not be selected until closer to the lift date, however, this documentation should be marked as outstanding until presented.
- Should maintenance records or certifications be out-of-date, and the inspection or recertification is planned as part of the assemble, provide sufficient time in the schedule for corrective actions such as wire rope restringing, hydraulic hose replacement, and software updates.
- Rigging and lifting equipment must be clearly marked with their rated capacity and inspected – A qualified person should be tasked with visually inspecting all rigging and lifting equipment for defects including certification markings and rated capacities. Confirmation of the completion of this task should be documented for future reference and to allow the mobilization process to continue.
- Limit switch, rated capacity indicator, load movement indicator testing – Safety devices used to either indicate when limits are exceeded or shut down lifts if operational conditions are unsafe should be tested prior to deployment. Timing, weather, financial and other pressures may cause inappropriate continuation of work if these devices are tested on site and shown to be dysfunctional. Testing during pre-mobilization (as well as immediately prior to use) reduces the pressure to repair or replace the device before the lift proceeds. Types of devices to consider include (but are not limited to):
 - Limit switch (anti-two blocking device) to shut off power to the hoist mechanism when the lower load block or overhaul ball is hoisted to near the hoist mechanism. For example, a load movement limiter that is tied to the cranes control system that will automatically shut off power and set the brakes if an overload condition is reached (also known as a rated capacity limiter).
 - Rated capacity indicator which displays to the crane operator the percentage of rated capacity on the hook.
 - Load movement indicator (LMI), which displays to the crane operator the weight on the hook, radius, etc.
- Ensure local stakeholders are aware of the operation – This includes environmental and labour regulators as well as landowners and aerial applicators. Ensure no major land activities or crop spraying is scheduled during this time.

Pre-Lift

Communication

Maintaining clear and open lines of communication is a critical component of any lift plan. Communication protocol should be agreed upon before any load is affixed to the hook. In addition, communication of plans, certification, and other important details should be a priority prior to the start of any work. Apart from the lift plan and crane operation health and safety policies, this includes communication of other environmental, health, and safety policies such as spill management, lock out/tag out, etc. This requires organization of written and verbal communication to not only ensure that the communications have been provided but that they have been provided to the right people at the right time. Incidents can take place even when all the correct information has been communicated but a selection of people who needed it were not included in the process.

Designated channels and responsibilities for communication – Designation of proper communication channels reduces confusion and gives the parties involved the tools they need to have their voice heard. This includes radios and cellphones during staging and setup, email communications in the days leading up to the job, physical documentation shared on site or any other method specified. What is important is that the communication channels are specified and agreed to ahead of time to prevent missed messages and frustrations. Agreement on clear, concise dialogue through the designated channels can empower involved personnel to speak up about safety concerns or unclear workflows. Also, by designating responsible persons in the communications chain, important details are more likely to be shared using any of the methods agreed upon and increases efficiency in the chain.

Communication with local authorities having jurisdiction (AHJ) – Awareness of local regulations and authorities is the responsibility of both the organization conducting the lift and the property owner or lease holder. Contact the local AHJ and be intentional about keeping communication open even if the information flow is one-sided. Regular updates to the AHJ demonstrates a willingness to comply with regulation and a priority on the health and safety of the workforce on site. A local authority may not have the internal resources to respond to all communications even if they are monitoring and recording all inbound messages.

Lift and site safety plans communicated – Remaining focused on communication of the lift plans and site safety plans is critical from start to finish. Changes may be driven by many legitimate reasons and a methodology to both agree to and widely communicate the changes must be established up front. Attempting to communicate changes a few days ahead or even the day of the lift can be a challenge for a multi-disciplinary and multi-organization crew. Settling on the communication chain and responsible point persons can make the difference between a worker being in a safe position or compromised.

The main components of a lift plan include the following:

- Elevation view drawing.
- Plan view drawing.
- Lift analysis.
- Identification of a critical or serious lift.

It is important to identify if the lift is considered special, complex, or critical. A pre-established set of criteria can help to identify a lift that is outside of a standard definition. This may vary between organizations, so it is useful to establish consistent language.

Crane and operator certifications – Following on the pre-mobilization checklist, it is important to revisit this requirement and ensure certifications have been provided. At this stage it is also important to

identify any necessary recalls, upgrades, changes in crane operator assigned or other updates necessary for validation and documentation.

Rigging inspection, testing and certification documentation provided – As above, the pre-mobilization checklist requests the rigging equipment by certified and adequately specified for the job. Additional testing and inspection are warranted on site prior to this equipment becoming a critical element during the lift. Once the load is in the air, rigging equipment will be depended upon for safety and preserving the payload as well as surrounding assets. It is important to ensure an inspection take place after partial disassembly/reassembly and movement of the crane.

Radios – While having radio communication may be an inherent expectation, there are some detailed requirements that are important to consider. Pre-checks of the radios and clear lines of communication (as specified above) are important. Equipment should be fully functional, and the team involved in the lift should be comfortable with the channel selection and the roles of those using the system (see below). A hands-free microphone style radio for the crane operator is required to keep the operator's hands on the controls at all times. Spare batteries, dropped-object tethers, and hands-free radios for other roles (especially tag line operators) are also important considerations.

On-Site Assessment

Before equipment and the lift teams arrive, an on-site assessment should take place. The assessment should consider the following points as a method to prevent lost time reworking site elements once the crew arrives and the danger associated with “making-due” with the site as-is because of time constraints.

- Check for obstructions on route including erosion, icing, fallen trees, dumping, snow and ice (if applicable) and other hazards.
- Check that the turbine is safe to enter, look for potential vandalism, damage to equipment, broken locks, grounding straps, stairs, blades, tower, crane pad, animal entry, carcasses and feces, etc.
- Check for any unforeseen landowner activities that could interfere with the operation such as tile-bed repairs, forest clearing, plowing, etc.
- Ensure there is sufficient room to assemble the crane and move it into position.
- Review the site staff work schedule. Ensure that the right roles and responsible persons will be represented on site and there are no details overlooked such as vacations, personal time or travel.
- Mats and ground support systems require evaluation prior to onsite setup. This is true for safety reasons, damage to fields, natural habitat considerations and equipment damage. Matting should be in the crane owner, engineer and manufacturers recommendations after the crane user has identified the Ground Bearing Pressure (GBP) and exclusion zones.
- Perform a risk assessment on-site with all parties involved. The assessment should be agreed upon and signed off by all parties.

Setup and During Work

Exclusion Zones

An exclusion zone is set up to barricade the immediate work zone where the lifting activities are taking place. This clearly marks the perimeter that all workers and equipment are required to remain outside of unless they are directly involved in the lifting activities. The exclusion zone should be set to account for the direct lift zone, potential drop zone, crane swing radius, and set-down areas. Barriers are used to mark the exclusion zone along with signage.

- A typical exclusion zone stretches from the crane, out to the length of the lifting crane's boom plus an additional 40 meters.
- An area should be designated and clearly marked as an emergency set down area. It is important to keep this area clear if the load has to be set down unexpectedly. Any personnel or equipment should be removed from this area to provide the crane operator with a safe place to deposit the load if needed.
- Tag line operators should also be provided with a designated zone within which to operate. Tag line operators should stay within this zone to remain out of harms way according to the lift plan.
- It is important to never allow anyone to ride on a load as it is lifted and that loads are never lifted over personnel.



Photo: Vestas

Communication

Before a lift commences, a pre-lift communication verification is performed to ensure all communication channels and methods are functioning. Commands should be agreed upon well in advance for the anticipated activities and contingencies. In addition, if one or more communication methods are lost, a plan should be in place to accommodate. This may include a pre-arranged sequence of events that are triggered if there is a loss of communication. Separate emergency communication protocols may be put in place in advance as well. In the event of an emergency, it must be clear what the best way to communicate within the team and contact first responders.

Personal Protective Equipment (PPE) and Training

Work on wind turbines requires a full set of personal protective equipment (PPE) and training for and work inside and up tower. PPE and training should not be neglected outside of the tower and on the crane. Each jurisdiction in Canada will require different safety equipment for the various activities, however, it is important to note that fall protection is required when climbing/assembling cranes where the worker is required to leave the ground to complete the task. Awareness of walking surfaces, ladders, work platforms, etc. is important and wind farm workers should be prepared to hold all team members accountable for wearing the proper PPE for the jurisdiction in which they are operating.

Hard hats, eye protection, re-enforced footwear, hearing protection, cold climate clothing, etc. are examples of other PPE that may be required along with training on when and where to use this equipment. Safety is everyone's responsibility and establishing a safe work culture requires awareness and training for everyone on site.

Physical Awareness

The following are examples of physical hazards to be aware of during setup and throughout the duration of the lifting activities. Physical awareness may seem obvious, however, with the coordination of all the activities taking place on site during a major lift, workers can lose sight of all moving pieces and hazards if they are not adequately prepared.

- Watch for overhead powerlines and know what to do if contact is made.
- Inspect the rigging and backup lines, assess the physical location of each to ensure a worker doesn't become entangled in the lines.
- Be aware of buried gas lines, power lines, water mains, drainage tiles, and communication cables.
- Know the location and be aware of driveways, driving paths, etc. to prevent damage while moving large equipment.
- Always position the hook directly over the load before lifting.
- A test of the brakes should be made every lift by performing a short lift to ensure proper operation.
- Remain aware of lighting during dawn/dusk, sunrise/sunset and low light or intense sun conditions.
- Be diligent in preventing hand injuries, avoiding pinch points, never wearing loose clothing or jewelry, and the hazard of being caught between objects.
- Do not neglect fatigue management for the individual worker and the team. There may be a temptation to underestimate or dismiss fatigue under tight deadlines or narrow weather windows, but it is a major source of concern for all the other hazards listed.

Contingencies

Planning for contingencies alongside a perfect lift is very important. A walk through of all planned and contingency scenarios should be part of the pre-lift meeting and part of the emergency action plan as discussed above. All affected crew members should participate in this meeting and a refresher of the plan and contingencies should be conducted with the team prior to recommencing work if a pause in work is required or the lifting activities span multiple days. Keep in mind the following possibilities when planning lifting activities:

- Loss of ground stability while lifting or in transit.
- Contact with an electrical power source.
- A sudden or gradual increase in wind speed.

- Loss of tagline control.
- Contact with the boom by the load.
- Loss of computer control.
- A rigging failure.

Finally, documentation of all plans, contingencies and recordings of actions taken after an activity is very important. It is important not to neglect record keeping for many reasons, including transparency with the team and explanation of activities after the event has taken place.

Weather Conditions

While weather conditions play an important role in all crane activities, wind energy sites are especially vulnerable to the environment. Wind sites are typically positioned in high wind speed areas that can drive the need for constant monitoring of the environment. There may be an absence of any substantial shelter at the lift site. This should be planned for and awareness of weather event plans need to be communicated. Below are a few considerations to make while working on a wind energy site.

Weather Systems – Knowledge of the terrain and its effect on wind speeds is particularly important. Mountains, fields, forests, lakes, ocean, etc. will all have an impact on what kind of weather can be expected and how quickly the weather can change. An understanding of the typical times for weather to change within the season that the lifting activities are taking place can set the expectations for contingencies and make for a more robust lift plan. The wind farm staff are typically the most knowledgeable of these weather systems and how quickly they can change. Be sure not to discount this local knowledge when planning.

Wind – The crane operator should be able to use a wind speed indicator appropriately to conduct the lift. This includes having a calibrated sensor with the appropriate documentation to demonstrate this. Additional wind speed sensors can provide awareness to the team to check against what the crane operator is seeing.

Once again, local knowledge of the average wind speeds and ability for the climate to change on site is important. If there is a risk of rapid wind speed changes based on the topography and season this information should be made available and discussed prior to the lifting activities.

It should be communicated what the maximum wind speed is for lift operations, difference between the types of cranes, and what type of cranes will be appropriate for the environment.

Lightning – As with day-to-day wind farm operations, lightning warning systems and tracking should be in place during a lift. Communicate and agree ahead of time what rule will be used in the presence of lightning. What distance is appropriate to stop work and how will the stop work order be executed. Who will be responsible for monitoring and reporting. The farther advanced the warning is, the more time there will be to put a plan in place and keep everyone safe, so be clear on what measurement system will be used and what is the range capability.

Temperature – Be sure to not discount temperature effects including extreme heat and extreme cold. Agree on temperature limits for stopping work or increased breaks. Account for wind chill, solar intensity and humidity effects, and the potential for heat stroke.

Soil Considerations

More than many other worksites, soil conditions are particularly important on a wind farm. The amount of mobilization and the dispersed nature of the wind turbines may require the crane to move across a wide variety of ground types and lift on a pad that is infrequently used. Soil testing is an essential part to any lift and is a dynamic activity as moisture content, weather and other conditions change. It may

not be sufficient to use previous soil test results depending on these factors. Multiple options exist - from simple tests to more involved studies.

For operational guidelines and a review of soil test methods, refer to the American Wind Energy Association (AWEA) whitepaper, *Guidance for Determining Ground Bearing Capacities for Crane Travel in the Wind Industry* (February 2020).

Here are a few more things to consider for safe mobilization and lifting activities:

- Ensure the crane operator understands the site. Is the lift taking place in a farm field, mountainous region, forested area or near water (above or below the surface)?
- Know the road restriction time frames and if any will be in place or if there will be restrictions imposed after the work has started.
- Be aware of any regulations for soil testing, be sure to document any test results and keep them accessible/traceable, and repeat measurements as necessary.
- Inspect the crane pad(s), walk paths. Refer to the On-Site Assessment section for more details on matting and preventing soil and underground infrastructure damage.
- When reviewing soil conditions be sure to flag areas to avoid in order to prevent damage.

Environmental Responsibility Considerations

The wind energy industry is a significant enabler of clean energy solutions for Canada. Special considerations should be made when performing lifting activities on a wind energy site to ensure environmental protection. This is particularly true because of the distributed nature of wind in the natural environment. The following considerations provide minimum expectations to accommodate for:

- A plan should be in place to contain and clean up any accidental spills.
- Waste should all be managed and removed to leave the site waste free.
- Protected areas should be communicated to the entire team involved in the lifting activities for special consideration to prevent damage to important habitat.
- Tile beds and drainage systems in farm fields are a particularly important part of the local environment in maintaining water management systems. A plan should be in place to prevent damage and recover from any accidents.



De-mobilization

Remaining vigilant until the end of the job requires attention until all equipment has been removed from the site and operations have resumed. All the details provided above apply until the project is fully completed, including documentation.

Be sure to remain aware of environmental conditions and changes in weather patterns from the beginning of the project. Track and communicate changes to plans, extraction routes, scope of work etc., and ensure the full team remains aware of all pertinent information.

Fatigue management should be heightened as the actual lifting activities cease and de-mobilization begins. Help the team remain aware of their own physical condition and mental health while timing constraints increase and the desire to complete the job grows.

Regulatory Compliance

The following resources are provided as a starting point for compliance expectation in Canadian jurisdictions. Due to the changing nature of regulations, industry solutions offered and industry best practices, it is important to pursue the most up to date information. The resource identified below are not exhaustive.

Canadian Standards, Legislation and Regulations - General

Jurisdiction	Reference
National	CSA Z150-16 Safety Code on Mobile Cranes
British Columbia	https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-14-cranes-and-hoists https://bccranesafety.ca/
Alberta	https://search-ohs-laws.alberta.ca/legislation/occupational-health-and-safety-code/part-6-cranes-hoists-and-lifting-devices/
Saskatchewan	https://publications.saskatchewan.ca/#/products/112399
Manitoba	https://www.gov.mb.ca/labour/safety/pdf/1_2016_wsh_ar_oc.pdf#page=225 https://www.wcb.mb.ca/topics/cranes/
Ontario	https://www.ontario.ca/page/achieve-compliance-construction-sites-equipment-and-vehicles-cranes-hoisting-and-rigging
Québec	http://legisquebec.gouv.qc.ca/en/showdoc/cr/S-2.1,%20r.%2013
New Brunswick	https://ohsguide.worksafenb.ca/topic/mobilecranes.html
Nova Scotia	https://novascotia.ca/just/regulations/regs/tscrane.htm
Prince Edward Island	https://www.princeedwardisland.ca/sites/default/files/legislation/o1-01g-occupational health and safety act general regulations.pdf
Newfoundland	https://www.assembly.nl.ca/Legislation/sr/Regulations/rc120005.htm

Resources and International Standards

United States of America

- AWEA Micro Credentials, contact workforcedev@awea.org for details and to obtain a copy.
 - Basic Crane Awareness
 - Crane Lift Plans
 - Crane Rigging Usage and Inspection
- AWEA Crane Task Force, Guidance for Determining Ground Bearing Capacities for Crane Travel in the Wind Industry (February 2020)
- National Commission for the Certification of Crane Operators (NCCCO) - <http://www.nccco.org/>
- US 29 CFR 1926 sub CC. soil compaction - <https://www.osha.gov/laws-regs/regulations/standardnumber/1926>
- OSHA – 29 CFR 1926.179 – Overhead and Gantry Cranes
- OSHA – 29 CFR 1926.180 – General Industry Crawler/Locomotive/Truck Cranes
- OSHA – 29 CFR 1926.1400 Construction Cranes & Derricks
- OSHA - 29 CFR 1903.1 (The General Duty Clause)
- CMAA (Crane Manufacturers Association of America) - Spec. No. 70 and 74 Crane Operator's Manual
- ASME B30 Construction Package (Slings, Hooks, Rigging)
 - B- 30 series Cranes, Derricks, Hoists,
 - B- 30.2 Overhead and Gantry Cranes (Top Running Hoist)
 - B- 30.10 Hooks
 - B- 30.11 Monorail and Underhung Cranes
 - B- 30.16 Overhead Hoists (Underhung)
 - B- 30.17 Overhead & Gantry Cranes (Underhung Hoists)
 - B- 30.18 Stacker Cranes
 - B- 30.21 Manually Lever Operated Hoists
 - B- 30.5 Mobile Cranes

Europe

- UK Lifting Operations and Lifting Equipment Regulations (1998)
- Federation European Manutention (FEM) 5.016 – “Guideline – Safety Issues in Wind Turbine Installation and Transportation”

China

- INS BEI 01.01.31 Lifting and Rigging Operation Safety (ASP – China)

Australia

- Mobile crane – Code of Practice 2006 (Queensland)
- AS 1418.5 – Cranes, Hoists and Winches – Mobile Cranes
- AS 2550.5 – Cranes, Hoists and Winches – Safe use – Mobile Cranes
- AS 4991 – Lifting Devices
- AS 4024 (series) – Safety of Machinery
- AS 2759 – Steel Wire Rope – Use, Operation and Maintenance
- AS 1353.2 – Flat Synthetic Webbing Slings – Care and Use
- AS 2550 – Cranes, Safe Use

Exhibit A

Pre-lift Job Briefing

This Exhibit provides some of the key considerations recommended prior to a crane lift operation. It serves as a compiled checklist from multiple organizations to allow wind site operations staff to compare and contrast against their existing knowledge and processes. It is not a substitute for a comprehensive pre-lift checklist or Job Hazard Analysis (JHA). Please refer to company internal policies and approvals prior to any crane operations.

Job Information

- Site Name
- Job Location
- Date and Time
- Weather
- Temperature
- Wind Speed
- Wind Gusts - Min and Max
- Maximum Work Radius
- Load Description
- Load Weight

Personnel Positions

- Up Tower Lead
- Down Tower Lead
- Crane Caller
- Tagline Root End
- Tagline Tip End
- Spotter 1
- Spotter 2

General Checklist

- Equipment certification current/available: Expiry date:
- Operator certification current/available: Expiry date:
- Signal person
- Signals by hand/radio/phone
- Hoist cable condition verified
- Rigging and lifting devices inspected (slings, straps, wire rope chokers, spreader bars, etc.)
- Ball and safety latch condition verified
- Load limits verified
- Fuel level sufficient
- Weather conditions are suitable for the lift
- Work area has been identified and secured
- The activity has been discussed with the crew including any revisions and updates
- The appropriate team members are present for the pre-lift meeting
- Emergency actions and set down area specified and understood
- Clear direction to commence the lift provided
- Job Hazard Analysis has been reviewed and signed by participants in the lift
- Multiple lift activities have been specified where applicable

Job Specific Process Questions

- Does the setup match the lift plan?
- Are all required permits in place/signed off?
- Is LOTO required?
- Are ground conditions suitable (slopes, buried utilities, soil type, compaction, etc.)?
- Does this activity require the installation of a jib or other attachments?
- Are there power lines nearby and if so, has the minimum distance been identified?
- Is this an engineered lift and if so, has the plan been reviewed and are the proper approvals in place?
- Have the most up to date lift plans been shared with the crew?
- Does the task involve lifting personnel and if so, are the proper measures in place including the test lift?
- Structural condition visually verified?
- Are proper attachments present and verified?
- Has the proper PPE been specified and verified, including safety harnesses?
- Have the appropriate road closures been implemented?

Potential Hazards Observed

- | | |
|--|---|
| ☐ Slip/Trip/Fall | ☐ Moving Machinery |
| ☐ Ladder | ☐ Working Over Water |
| ☐ Heat/Cold | ☐ Electrical Hazards |
| ☐ Noise | ☐ Tools/Rigging |
| ☐ Particle in Eye | ☐ Ground Conditions |
| ☐ Overhead Work | ☐ Load Control |
| ☐ Heavy Lifting | ☐ Spill/Leaks |
| ☐ Overexertion | ☐ Communication |
| ☐ Cuts, Sharp Edges | ☐ Hot Work |
| ☐ Pinch Points | ☐ Authorized Work Area |
| ☐ Repetitive Motion | ☐ Traffic Control |
| ☐ Inadequate Lighting | ☐ Cold Climate Hazards |
| ☐ Working at Heights | ☐ High Temperature Hazards |

Hazard Control

PPE:

- ☐ Gloves
- ☐ Safety Glasses
- ☐ Hard Hat
- ☐ Work Boots
- ☐ Hearing Protection
- ☐ Harness
- ☐ Fall Protection
- ☐ Life Jacket
- ☐ FR Coveralls

Ladder:

- ☐ Inspected
- ☐ Firm Footing

Communication:

- ☐ Mobile Phone
- ☐ Sat Phone
- ☐ Radios
- ☐ Hand Signals
- ☐ Hands Free Radios

Tools and Rigging:

- ☐ Inspected
- ☐ Appropriate for the Task
- ☐ Accounted for

General:

- ☐ Barricading/Secure Site
- ☐ Tag Lines
- ☐ Air Horn
- ☐ 3 Point Contact
- ☐ Hydration
- ☐ Buddy System
- ☐ Aux. Lighting
- ☐ Spotter
- ☐ Fire Extinguisher
- ☐ Spill Kit
- ☐ Mats/Blocking
- ☐ MSAD
- ☐ Operator Knows My Location
- ☐ First Aid Kit