CRANES

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1.0 SCOPE

This data sheet applies to fixed and rail-mounted cranes, including container cranes and other ship cargo-handling cranes, gantry and overhead travelling cranes, tower cranes, and similar hoisting machines, derricks, stackers/reclaimers, and ship loaders.

This data sheet also applies to remote-operated, automatic tracked, and GPS-located cranes of the same type described above.

This data sheet does not apply to mobile cranes, which are covered in Data Sheet 7-40, *Heavy-Duty Mobile Equipment*.

1.1 Hazard

Refer to the FM publication *Understanding the Hazard: Cranes* (P0243).

1.2 Changes

July 2023. Interim revision. Editorial changes were made for asset integrity and equipment contingency planning guidance to provide additional clarity.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

The recommendations in this data sheet are intended to supplement, not supersede, those of the manufacturer and the requirements of recognized standards on crane design, construction, operation, maintenance, inspection, and testing. For general reference, some of these standards are listed in Appendix D.

Refer to Table C-5 in Appendix E for additional information on limiting wind speeds for various modes of crane operation commonly used in the industry.

Refer to Appendix E for a checklist of information needed to assess crane stability and securement.

Refer to Appendix F for wind speed and wind load adjustments when crane wind loads and wind securement are based on FEM or ISO standards.

Unless noted otherwise, the following recommendations apply to all the types of cranes covered by this data sheet (see Section 1.0, Scope).

2.2 Construction and Location

2.2.1 Windstorm

2.2.1.1 For the windstorm-secured (stowed, out-of-service) condition, install crane securement designed to resist wind loads based on the appropriate design wind speed determined using Data Sheet 1-28, *Wind Design*.

2.2.1.2 Base wind load (wind force) calculations on appropriate industry consensus standards used in conjunction with the design wind speed from Data Sheet 1-28. Refer to Appendix D for list of appropriate, commonly used, industry consensus standards.

2.2.1.3 Assess crane stability and securement using the Checklist of Data Needed to Assess Crane Stability and Securement Documentation for Wind Loading in Appendix E.

2.2.1.4 Locate out-of-service windstorm securement (stowage) so cranes can be moved to secured locations within the amount of time specified in the windstorm emergency response plan (ERP) and CSPM (see Section 2.3.1).

2.2.2 Earthquake

2.2.2.1 In seismically active areas (FM 50-year through 500-year earthquake zones per Data Sheet 1-2, *Earthquakes*), design the crane, crane foundations, and crane securement (for the stowed condition) in accordance with the latest edition of the International Building Code or comparable nationally accepted consensus code, and the recommendations in Data Sheet 1-2.

2.2.3 Fire

2.2.3.1 Use noncombustible or FM Approved Class 1 materials in construction of cabs, machinery houses, diesel engine-driven generator rooms, control rooms, and similar areas.

2.2.3.2 Separate cranes from combustible buildings and/or combustible yard storage.

A. Rail-mounted cranes: Provide separation in accordance with Data Sheet 1-20, *Protection Against Exterior Fire Exposure*.

B. Fixed/stationary cranes: Provide separation in accordance with Data Sheet 1-20, *Protection Against Exterior Fire Exposure*.

2.2.3.3 Separate cranes from fuel tanks in accordance with Data Sheet 7-88, *Ignitable Liquid Storage Tanks*.

2.2.3.4 Lubrication and Control Oil Systems

2.2.3.4.1 For hydraulic fluid systems, follow the recommendations in Data Sheet 7-98, *Hydraulic Fluids*.

2.2.3.4.2 Use FM Approved industrial fluids, including lube oils, where possible.

2.2.3.4.3 Provide fluid system interlocks to minimize the fire hazard if the use of FM Approved industrial fluids is not practical.

2.2.3.5 Grouped Cables

2.2.3.5.1 Locate and arrange grouped cables, where practicable, in accordance with Data Sheet 5-31, *Cables and Bus Bars*.

2.2.3.5.2 Protect cables from fire exposure, where practicable, by enclosing it with noncombustible construction or providing FM Approved fire wrap.

2.2.3.6 Refer to Data Sheet 7-11, *Belt Conveyors*, for recommendations regarding the use of conveyor belts.

2.3 Protection

The recommendations in Section 2.3.1 cover all cranes unless noted otherwise. For overhead traveling cranes and overhead gantry cranes, also refer to Section 2.3.2; for tower cranes, also refer to Section 2.3.3.

2.3.1 Wind Protection: All Cranes

2.3.1.1 Develop a detailed crane securement procedure manual (CSPM) and emergency response plan (ERP) for the crane securement procedures.

2.3.1.1.1 Include procedures for the various cranes, crane configurations, and all applicable operational and nonoperational conditions and associated wind speed limits.

2.3.1.2 Establish an in-house audit procedure to monitor the effectiveness of the manual securement and tie-down procedures in accordance with the CSPM.

2.3.1.2.1 Record and track the time needed to secure the cranes.

2.3.1.2.2 Test the ERP to prove cranes can be moved to their secured location prior to the onset of damaging winds.

2.3.1.3 Provide wind securement for all operational and non-operational modes, including the following:

A. Operational (in-service) wind speed limits

B. Maintenance or parked wind speed limits

C. Storm-secured (stowed, out-of-service) wind speeds

2.3.1.4 Obtain detailed calculations, prepared by a licensed engineer, for each of the above-mentioned operational modes and securement methods. Keep them on file and readily accessible for help in assessing the adequacy of the securement procedures. Refer to Appendix E for a checklist of technical information needed to assess crane stability and securement.

2.3.1.5 Base the maximum in-service wind velocity on the least-favorable wind effects associated with crane operations (e.g., hoisting and slewing).

2.3.1.6 Provide securement under operational conditions along the crane tracks, spaced so the cranes can be moved to the securement location in time to prevent damage or malfunction from winds in accordance with the ERP and CSPM.

2.3.1.7 Provide cranes with adequate means of motorized travel (e.g., gantry wheel motors) to allow the crane to move to its designated securement position within the allotted time per the CSPM and ERP. Provide the needed motor capacity based on the assumption that the crane will be travelling into a direct head wind.

2.3.1.8 For each crane, do the following:

A. Install a wind velocity-indicating device mounted at or near the top of the crane.

B. Install the velocity read-out of the indicating device in the operator’s cab.

C. Provide visible and audible alarms to the cab and to remote control stations when the maximum in-service wind velocity is exceeded.

D. Establish a program to check the calibration and accuracy of all wind velocity-indicating devices.

2.3.1.9 In yards where there are several cranes of high value, do the following:

A. Install a remote wind velocity-indicating device to sound an alarm, audible throughout the yard, when the maximum in-service wind is reached.

B. Mount the wind velocity-indicating device at a height at least as high as the top of the tallest crane on site.

C. In very large yards, where cranes could be separated 1 mile (1.6 km) or more, install more than one wind-velocity alarm.

2.3.1.10 If automatic storm brakes are installed, provide control logic for them so they will engage only when the crane is not in motion.

2.3.1.11 Equip the crane with wheel wedges or rail chocks. These are for use in a windstorm emergency, to provide additional wind resistance, or for use when carrying out repairs to the rail clamps.

A. Use wedges on idler wheels (non-drive) and preferably make them of hard wood, with a long tapering toe, and side frames to hold them on the rail.

B. Attach rail chocks of heavy steel casting to the rail head by using the proper bolts and nuts.

2.3.1.12 For cranes intended to weathervane (swing through a full 360 degree arc) when out-of-service, install the crane in a manner providing sufficient clearance to prevent the boom and superstructure from striking any fixed object or other crane. In order to weathervane properly, friction clutches on the slewing gears must be fully opened.

2.3.1.13 For crane securement such as stowage pins and manual tie-downs, install foundations or anchorages that are adequate to resist the necessary loads and are independent of the crane rails.

2.3.1.14 Minimum Safety Factors for Crane Stability and Strength

A. For resistance to wind-induced sliding or rolling based on motor brakes, wheel brakes, or storm brakes, use a safety factor of at least 1.25.

B. For resistance to wind-induced overturning based on only the self-weight (dead load) of the crane (i.e., tie-downs not engaged), use a safety factor of at least 1.25.

C. For the design strength of windstorm securement components such as stowage pins (sliding resistance) and tie-downs (uplift and overturning resistance), use a safety factor based on the applicable nationally accepted consensus code or industry standard, but not less than 1.5 unless noted otherwise in Section 2.3.

2.3.2 Wind Protection: Overhead Traveling and Rail-Mounted Gantry Cranes

This section applies to overhead and gantry cranes, including storage gantry cranes, traveling bridge cranes, and others having the same fundamental characteristics. These cranes are grouped together because they all have trolleys and similar travel features.

2.3.2.1 For overhead traveling cranes, provide locking bars, automatic latches, or crane traps to secure the crane. Provide these safeguards at one end of the crane at a minimum, and in additional locations as needed per the CSPM.

2.3.2.2 Provide skew-limit switches wired to cut off power automatically when the bridge of an outdoor storage gantry crane has skewed a predetermined distance.

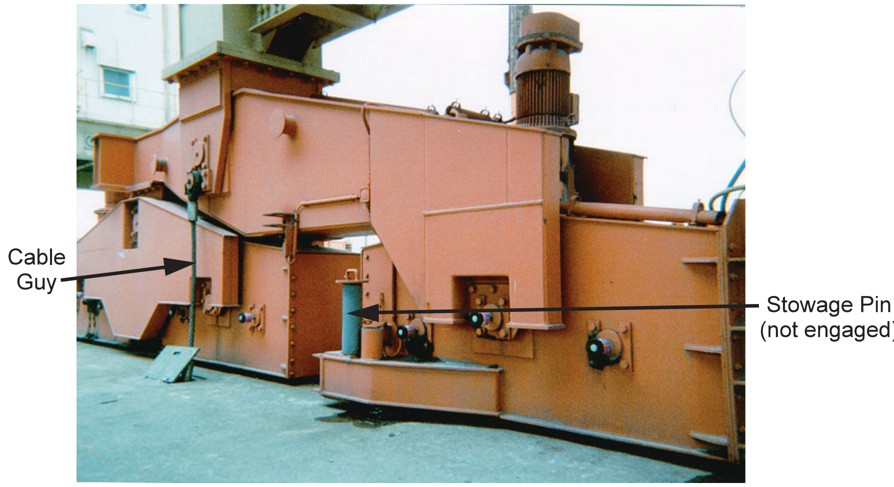

Fig. 1. Gantry crane cable guy (tie-down) and stowage pin

2.3.3 Tower Cranes

2.3.3.1 For tower cranes intended to weathervane when out of service, install the crane in a manner providing sufficient clearance to prevent the boom and superstructure from striking any fixed object or other crane. In order to weathervane properly, friction clutches on the slewing gears must be fully opened.

2.3.3.2 Position the trolley of hammerhead tower cranes near the tower at a minimum radius, and raise the hook to its highest position.

2.3.3.3 For climbing or self-climbing tower cranes, where collars and tie beams are used to laterally support the crane tower to the building structure, refer to Section 2.5.1 for rigging recommendations for slings used for temporary support of collars or similar support members.

2.3.4 Collapse and Toppling Protection

This section applies to failure protection for normal crane operations such as hoisting. Its applicability will depend on the type of crane. Refer to Section 2.5.1 for recommendations specific to rigging.

2.3.4.1 Provide a durable rating chart visible to the crane operator. Include a full and complete range of load ratings for each permitted tower height (if applicable) and all stated operating radii for each permitted boom length, jib length, and combination of boom and jib (as applicable).

2.3.4.2 Equip cranes with load indicators to protect against overrated load lifts caused by erroneous load weights.

2.3.4.3 Load-moment indicators need to be calibrated for each actual use to ensure accuracy.

2.3.4.4 Use an independent means to measure loads prior to lifting. Do not rely solely on the load indicator to determine that an unknown load weight is within the rated load of the crane.

2.3.4.5 Install bumpers on both the bridge and trolley, for travel with power off in either direction, with the following features:

A. Sufficient energy-absorbing capacity to stop the bridge and trolley when traveling at a speed of at least 40% and 50% of rated load speed, respectively.

B. The ability to stop the bridge and trolley (not including the load block and lifted load unless guided vertically) at the rate of deceleration as specified by the manufacturer for the given travel speeds (as a percentage of the rated speed).

2.3.4.6 Install contact bumpers, meeting the guidelines of Recommendation 2.3.4.3, on multiple cranes operating on the same runway and multiple trolleys operating on the same bridge.

2.3.4.6.1 Install proximity limit switches and an alarm when two or more cranes use the same rails.

2.3.4.7 Equip each independent hoisting unit of a crane with at least one self-setting brake applied directly to the motor shaft or some part of the gear train.

2.3.4.8 Provide a means to apply brakes automatically when power is removed and to provide service and parking brake functions for the bridge and trolley.

2.3.4.9 Install a slewing brake with the following capabilities:

A. Sufficient holding power in both directions to prevent movement of any rotating superstructure during normal operation.

B. The ability to be set in the holding position and remain so without attention from the operator.

2.3.4.10 Provide a positive locking device, designed to prevent accidental engagement or disengagement, for any rotating crane superstructure that may be left unattended. Exception: Booms designed to weathervane when left unattended do not need positive locking devices.

2.3.4.11 Provide the boom hoisting mechanism with an auxiliary ratchet and pawl (pivoted tongue) or another positive-locking device to prevent unintentional lowering of the boom.

2.3.4.12 Provide automatic devices to stop the boom drum motion when the maximum permissible boom angle is reached.

2.3.4.13 Do not use shop-made or makeshift rigging attachments.

2.3.4.14 Use specially designed rigging attachments only if they meet **both** of the following criteria:

A. The rigging attachment is fabricated by a qualified manufacturer of rigging devices.

B. The rigging attachment is proof-tested at twice the rated load.

2.3.4.15 For sheaves carrying ropes that can become momentarily unloaded, install close-fitting guards or devices that will guide the rope back into sheave grooves upon reapplication of load.

2.3.4.16 Install boom stops on luffing booms.

2.3.4.17 Use only below-the-hook lifting devices manufactured in accordance with the applicable nationally recognized standard.

2.3.5 Fire Protection

2.3.5.1 Install an automatic gaseous fire protection system in the control room, cable room and cabinets, switchgear cabinets, and other areas of similar importance. Select and design the system in accordance with Data Sheet 4-0, *Special Protection Systems*.

2.3.5.2 Install automatic sprinkler protection in accordance with the specific hazard or occupancy data sheet and Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*.

2.3.5.3 Provide the sprinkler water supply from a pressure tank or, for fixed cranes, from private or public water supplies in accordance with the applicable FM data sheets.

2.3.5.4 Refer to Data Sheet 7-11, *Belt Conveyors*, for recommendations regarding fire protection for conveyor belts.

2.3.5.5 Install FM Approved smoke detectors in the battery room, machinery room, elevator shaft, elevator machine room, transformer room, transformer blower room, near main electrical disconnect and grouped cable trays, and in any similar areas not having fixed protection.

2.3.5.5.1 Arrange the smoke alarm system to signal in the control cab and at the base of the crane.

2.3.5.5.2 Design the smoke alarm system in accordance with Data Sheet 5-48, *Automatic Fire Detection*, the appropriate occupancy-specific data sheet, and the *Approval Guide*.

2.3.5.5.3 Refer to Data Sheet 5-4, *Transformers*, for more detailed recommendations for transformer rooms.

2.3.5.6 Provide portable fire extinguishers in the operator's cab and other rooms in accordance with Data Sheet 4-5, *Portable Extinguishers*.

2.3.6 Lightning Protection

2.3.6.1 Provide lightning protection to the crane structure and moving surfaces.

2.3.6.2 Provide brushes on each gantry crane truck to complete the electrical connection to the earth.

2.4 Equipment and Processes

2.4.1 For electric motor-operated cranes not equipped with spring-return controllers or momentary contact pushbuttons, install a device that will disconnect all motors from their power source in the event of a power failure. Select a device that will not permit any motor to be restarted until the controller handle is brought to the "off" position, or a reset switch or button is operated.

2.4.2 Install new or replacement electric motors with minimum class F insulation.

2.4.3 Arrange power supplies to cranes so they can be locked in the off position whenever the crane is idle or unattended.

2.4.4 Install an over-travel limit switch in the hoisting direction for electric-driven crane booms or load hoists to prevent the equipment from traveling beyond the safe limit.

2.4.5 In addition to rail stops, for all rail-mounted cranes and trolleys, install travel limit switches to cut off the power to the travel motors and apply the brakes.

2.4.6 Install limit sensors to shut down any drive mechanism when overspeed is sensed in any axis of motion.

2.4.7 Install a warning device that will activate when the following faults are sensed on a crane:

A. Travel beyond set limits in any axis of motion when such motion is physically possible

B. Loss of support of a load

C. Activation of any emergency stop switch

D. Electrical or mechanical overload or electrical power failure

2.4.8 Ensure crane faults will cause drive motors to be disconnected from their power source and the brakes to be set.

2.4.9 Refer to Data Sheet 5-4, *Transformers*, for detailed recommendations.

2.5 Operation and Maintenance

2.5.1 Operations: General

2.5.1.1 Ensure all cranes are operated only by trained, experienced, and qualified personnel who meet the owner's operating and physical qualifications.

2.5.1.2 For remote-operated, automatic tracked, and GPS-located cranes, ensure associated servers are redundant or backed up to a secure location.

2.5.1.3 Ensure lifted loads are within the rated load of the crane in its existing and planned configurations.

2.5.1.3.1 Ensure loads do not exceed the crane rating at the radius at which the load is to be lifted and set down.

2.5.1.3.2 Do not test crane stability using methods not approved by the manufacturer or applicable nationally accepted consensus code (one example of an unacceptable test for crane stability is a visual check for wheel contact with tracks for lifting unknown loads).

2.5.1.4 Have planning and supervision of major rigging operations performed by qualified personnel to ensure the best methods and the most suitable equipment are used.

2.5.1.5 If any equipment becomes damaged, remove the crane from service until the necessary repairs have been made.

2.5.1.6 Avoid sudden movements during any portion of a lifting operation. Sudden movements can produce forces well in excess of the weight being handled, resulting in potential failure of the hoist cable, pendants, tower, boom, or other load supporting components.

2.5.1.7 Avoid luffing booms at high angles (this could make the boom topple backward over the top of the machine).

2.5.1.8 Take the following precautions when using rigging equipment:

A. Avoid dragging the rope slings from beneath the load.

B. Avoid dragging the hoisting rope through dirt or around objects that will scrape, nick, or crush it, or induce sharp bends.

C. Keep rope away from flame cutting and electric welding operations.

D. Avoid contact with solvents and chemicals.

E. Discard knotted, kinked, or stretched slings since this indicates permanent damage.

F. Avoid wrapping wire rope completely around a hook.

G. Avoid bending the eye section of wire rope slings around corners (the bend will weaken the splice or swagging). There should be no bending near any attached fitting.

H. Ensure the sling angle (from horizontal) is not less than that specified by the manufacturer or crane safety standard (in general, not less than 45 degrees).

I. For synthetic slings, in addition to the applicable recommendations above, do the following:

1. Avoid using slings made of polyester.

2. Use a safety factor of at least 5.0 against sling failure.

3. Only use slings that are new or have no visible signs of wear (fraying, abrasion, chaffing, etc.), aging (including bleaching or discoloration from ultraviolet light exposure), stretching, or other degradation or overload.

4. At connection or support points, use rigid metal shoes, sleeves, or other devices to ensure the minimum radius of curvature is met or exceeded per the specifications of the manufacturer or the applicable national safety standard.

5. Provide protection of the slings from fraying, abrasion, chaffing, and similar wear and damage during use.

2.5.1.9 Follow the procedures in the CSPM and ERP whenever a crane is to be left overnight, stowed, or placed out of service.

2.5.1.10 Apply stowage pins, wheel wedges, rail chocks, or other wind-resisting devices in accordance with the CSPM when the crane is not in service.

2.5.1.11 When winds in excess of the maximum in-service wind are forecast within the next 24 hours, secure cranes before the wind velocity reaches the maximum in-service wind speed.

2.5.1.12 Secure booms and cabs of revolving tower cranes against rotation (unless required to weathervane) when high winds are forecast or when the crane is idle. Do not secure booms to the ground.

2.5.1.13 For each crane, ensure the operator and at least two other individuals are assigned primary responsibility for windstorm securement of the crane. If the crane is operated remotely, ensure the remote operator is actively involved in the windstorm securement of the crane per the CSPM.

2.5.2 Traveling With Load

Establish traveling procedures that meet the manufacturer's instructions in addition to the following minimum recommendations:

A. Keep the travel load within the recommended maximum (never travel with a capacity load).

B. Keep travel speeds low and avoid sudden starts and stops.

C. Keep the boom in line with the direction of travel unless otherwise permitted by the manufacturer.

D. Keep the load as close to the ground as possible (to increase the length of hoisting cable between the boom and load) and use tag lines to control the load.

E. Avoid carrying the boom at its highest angle (many accidents occur when the boom topples backward over the machine).

F. Keep the travel path clear of obstructions.

2.5.3 Inspection

2.5.3.1 Develop a written, comprehensive inspection, testing, and maintenance (ITM) program for cranes and associated hoisting and rigging equipment. Base the program on the manufacturers' operation and maintenance manuals and nationally recognized standards for cranes and associated equipment.

2.5.3.2 Prepare written, dated, and signed periodic inspection and testing reports and maintenance records, as applicable, for cranes and associated equipment. Keep this documentation readily available onsite.

2.5.3.3 Conduct frequent and periodic inspections. Base the intervals between inspections on severity of crane service (e.g., light, normal, or heavy.)

2.5.3.4 Establish a schedule of frequent and periodic inspections that includes, at a minimum, the inspections listed in Table 1.

Table 1. Typical Crane Maintenance Schedule

Frequent Inspections		*Periodic Inspections*
*Daily or each shift**	*Weekly or Monthly**	*Quarterly, Semi-Annually, or Annually**
1. All wire ropes (including standing ropes, sheaves, drums, rigging devices and attachments, slings, hooks,** etc.) for excessive wear, damage, and proper operation.	1. All wire ropes subject to thorough inspection for excessive wear, damage and proper operation.**	1. Entire crane for structural damage, such as distortion or cracks in the slewing ring area and in the tower and boom assemblies.**
2. Lines, tanks, valves, drain pumps, and other parts of air or hydraulic systems, for deterioration or leakage. Check hydraulic oil level.	2. Functional operating mechanisms and sensors for wear and maladjustment interfering with proper operation.	2. Welded connections, main chords, lacings, and other structural members for cracks, paint flaking, dents, bends, abrasions, and corrosion indicating potential failure.**
3. Warning devices for proper operation.	3. Brakes and clutches for proper adjustment, operation and wear.	3. Sheaves, drums, pins, bearings, shafts, gears and rollers for evidence of wear, cracks or distortion.** Check for metal in oil lube systems.
4. Overspeed, overtravel, skew limit sensing and stopping mechanisms for wear and maladjustment interfering with proper operation.	4. Fire protection equipment for adequate operating conditions.	4. Brakes, clutch system linings, pawls and ratchets for wear.
5. Automatic/manual rail clamps for adequate operating conditions.	5. Tracks and base of crane rails for loose connections and gaps between rails, cleanliness, improper electrical bonding and grounding, inadequate drainage, subsidence and uneven tracks, bogie and rail wear, inoperative travel limit switches, loose rail stops, adequacy of rail clamps.	5. All electrical equipment and controls for proper operation and adequate condition. Conduct infrared inspections of power and control cables.
6. Maintain adequate housekeeping.	6. Gasoline, diesel, electrical, or other power plant for proper performance and compliance with established loss prevention procedures.	6. Control mechanisms for wear and contamination by lubricants or other foreign matter.
7. Inspect main electrical control cabinet.	7. Hydraulic and pneumatic hoses for leaks, and together with electrical cables for abrasive wear.	

*Inspection intervals depend upon severity of crane service.

**Inspection by nondestructive examination (NDE) methods (See Section 2.5.4.4) when determined appropriate to determine crane component integrity.

2.5.4 Testing

2.5.4.1 Check all functions, ensuring compliance with the manufacturer's specification, including all functional motions, limiting switches, locking and safety devices, and brakes prior to use for the following situations:

A. New and altered cranes

B. Associated crane equipment

C. Cranes idle for a duration exceeding six months

2.5.4.2 Load test all new and altered cranes prior to initial use. Do not exceed 125% of the rated load unless otherwise recommended by the manufacturer.

2.5.4.3 Examine crane hoisting cables and hooks by eddy current and magnetic particle or dye penetrant methods, respectively, prior to performing any of the following:

A. Heavy lifts equal to or exceeding 80% of rated load.

B. Lifts with severe loss exposure.

C. Operation of cranes idle for a duration exceeding six months.

2.5.4.4 Use nondestructive examination (NDE) methods to conduct detailed examinations of the structure, functional mechanisms, rails, hoist cables, and hooks when conditions are found during routine visual inspections that require additional evaluation to determine crane component integrity. NDE can include radiographic, ultrasonic, magnetic particle and/or penetrant testing methods, depending on the nature of the conditions.

2.5.4.5 Correct any unsafe condition disclosed by inspections before operation of the crane is resumed.

2.5.5 Maintenance

2.5.5.1 Establish and implement a crane inspection, testing and maintenance program as part of an asset integrity program based on the manufacturer's recommendations. See Data Sheet 9-0, *Asset Integrity*, for guidance on developing an asset integrity program.

2.5.5.2 Establish an inspection, testing and maintenance program for wire rope and wire rope slings.

A. Record any deterioration resulting in appreciable loss of a wire rope or wire rope sling original strength as disclosed during inspection by a designated person.

B. Determine whether further use would constitute a hazard.

2.5.5.3 See Appendix G for a list of actions to include (as applicable) in the inspection, testing and maintenance program for general, crane rail, wire rope, and wire sling maintenance.

2.6 Human Factor

2.6.1 Emergency Response Team (ERT)

2.6.1.1 Form an emergency response team (ERT) to react to the forecast of a severe windstorm or fire alarm in accordance with the emergency response plan (ERP) and crane securement procedure manual (CSPM). Include crane operators, ground crew, and security personnel in the ERT. Conduct periodic training so each ERT member is familiar with his or her duties.

2.6.1.1.1 At a minimum, include the following actions in the ERP:

A. Discontinue operating the crane when the wind-indicating device on a crane gives an alarm. Park and prepare the crane for excessive wind conditions. Give crane operators the authority to shut down operations and stow a crane against windstorm in the event of a weather disturbance being seen on the horizon even if the wind-indicating device is not registering an increased wind velocity.

B. Set up a weather monitoring system. Define who is responsible for monitoring and issuing severe storm warnings to operating and service personnel.

C. As the wind speed reaches the maximum in-service velocity, or when unattended, move the crane to its securement location and engage or deploy the appropriate securement (e.g., rail clamps, wheel chocks, stowage pins and tie-downs, etc.).

D. Train the ERT to use portable fire extinguishers, fire hoses, crane fire protection systems, and electrical disconnect switches.

E. Keep written emergency procedures, including crane securement procedures, readily accessible in the operator's cab and on the crane structure at ground level.

2.6.2 Management of Change (MOC)

2.6.2.1 Establish MOC programs in accordance with Data Sheet 7-43, *Process Safety*.

2.6.2.2 Implement MOC programs in accordance with Data Sheet 7-43, *Process Safety*, to ensure no changes occur that could increase the severity or consequences of an existing hazard or introduce a hazard where none previously existed. Examples of such changes include structural modifications, changes resulting in increased fire exposure, and changes of parts that are not of like kind.

2.6.3 Structural Modifications

2.6.3.1 Review and analysis of additions or modifications to the crane or crane securement should be conducted by the manufacturer and/or a qualified structural engineer prior to performing such additions or modifications.

2.6.3.2 Follow the recommendation in Section 2.6.2 for all structural modifications.

2.6.3.3 Test modifications to cranes prior to use per Section 2.5.4.

2.6.4 Housekeeping

2.6.4.1 Keep operator cabs, machinery houses, control rooms, and similar areas free of combustible rubbish, oily waste, rags, or work clothes, or store them in suitable metal containers or lockers.

2.6.5 Ignitable Liquids

2.6.5.1 Before refueling, shut off gasoline-powered equipment and allow it to cool sufficiently. Use FM Approved small portable ignitable liquid containers.

2.7 Contingency Planning

2.7.1 When a crane breakdown would result in an unplanned outage to site processes and systems considered key to the continuity of operations, develop and maintain a documented, viable crane equipment contingency plan per Data Sheet 9-0, *Asset Integrity*. See Appendix C of that data sheet for guidance on the process of developing and maintaining a viable equipment contingency plan. Also refer to sparing, rental and redundant equipment mitigation strategy guidance in that data sheet.

In addition, include the following elements in the contingency planning process specific to cranes:

A. Include identifying resources for emergency repairs and sourcing supplies of equipment breakdown spare parts.

B. Define alternate procedures or resources (including rental options and any associated special handling/access requirements) to ensure continued operation.

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Commentary

Table 2 contains additional explanatory material related to Section 2.0. The specific section or recommendation number to which the commentary applies is identified within the table.

Table 2. Commentary for Section 2.0, Loss Prevention Recommendations

Section Number	*Commentary*
2.1	In the United States the recognized national standard is the American Society of Mechanical Engineers (ASME) B30. Many countries around the world have similar national standards.Many countries require crane operations to conform to the safety standards of the local regulatory authority. For example, in the United States all cranes are operated subject to Occupational Health and Safety Administration (OSHA) standards. The OSHA standards that pertain to cranes are included in Appendix D.
2.3.4.3	Load-moment indicators sense the load and boom angle.
2.3.4.5	A self-setting brake is usually referred to as a “holding brake.”
2.3.4.11	Shop-made or makeshift rigging attachments unlikely comply with national safety standards. Welded links are an example of fabricated rigging attachments.
2.3.4.14	Boom stops prevent the boom from toppling or being pulled backward over the top of the machine.
2.5.1.11	The maximum in-service wind speed for many cranes is in the range of 35 mph to 40 mph (sustained), which is equivalent to approximately 42 mph to 48 mph (3-second gust); and the wind speed threshold for storm securement is often at roughly 75 mph (sustained), which is equivalent to 90 mph (3-second gust).
2.5.1.12	Securement of booms and cabs against rotation is often done by leaving the clutches for the rotating structure engaged and setting a latched handbrake for the hoist.
2.5.3.3	**Frequent inspections** are visual examinations that include observations during operations by the crane operator or other designated person, at daily to monthly intervals depending upon crane service, with reports not generally required. **Periodic inspections** are thorough inspections of the crane by a designated person at 3-month to 12-month intervals depending on the crane service and its environment, with reports of apparent conditions to provide a basis for continuing evaluation

3.2 Types of Hazards

3.2.1 Wind

The wind hazard for outdoor cranes includes exposure to both operating wind speeds and full windstorm wind speeds, which can greatly exceed operating wind speeds.

Operating wind speed hazards can include unexpected winds that do not allow the operator or others enough time to properly brake or secure the crane, and impaired or inadequate crane securement.

Most of the time, cranes have sufficient protection against accidental (horizontal) movement by the friction load and the holding power of their wheel brakes when the brakes are in good working order. However, when wind speeds exceed operating wind speeds or the rails are wet or greasy, it is usually necessary to provide additional securement or anchorage to avoid accidental movement and costly damage.

Automatic or remotely-operated storm brakes can increase the holding force tremendously and resist movement caused by much higher wind velocities. However, these storm brakes cannot be used to resist uplift due to overturning moment effects. Therefore, additional special positive anchorage (e.g., cable guys, tie-downs) is necessary to provide adequate safe sliding and tipping resistance for the maximum wind exposure at a given location.

The first line of resistance against sliding due to wind is the operating brakes, supplemented by automatic or remotely-operated storm brakes where provided. Therefore, it is imperative that all brakes and storm brakes be in good working order. This must be confirmed by reviewing the latest inspection reports and maintenance records and if possible, by asking operators, observing operations, and noting there are no missing brake components.

Outdoor cranes may be blown from their rails or otherwise seriously damaged, unless precautions are taken. Such accidents have occurred to many inadequately anchored cranes, with significant damage occurring.

Operating brakes on outdoor cranes do not provide adequate resistance against high winds, and therefore additional securement is needed. The maximum possible resistance to crane motion with all the wheels locked is only about 10% to 15% of the weight on these wheels. Wind forces exerted by severe squalls, gales, or hurricanes can slide the outdoor cranes along the rails even if all wheels are locked by the brakes, and therefore storm brakes are needed.

Automatic storm brakes are typically a fail-safe apparatus that either grips the sides of rails or to pushes on the tops of rails, and are specially adapted to resist wind and other external forces on track-mounted cranes; however, supplemental wheel chocks or stowage pins are also effective and sometimes needed to provide adequate crane securement.

3.2.2 Inadequate Inspection, Testing, and Maintenance

Fatigue failure of structural members and mechanical and electrical failures of other crane equipment have resulted in major crane overturning and collapse losses. This is due to improper inspection procedures and poor maintenance.

The safety and reliability of the crane cannot be ensured unless it receives regular inspections, tests, and maintenance. Regular inspections are particularly important because they provide the only reliable means of detecting many hazards. Depending upon the nature of the critical crane components and their tendency toward wear, deterioration, or malfunction, items may be checked at either “frequent” or “periodic” intervals. Frequent inspections are daily, weekly, or monthly; periodic inspections are usually semi-annually or annually. Consideration should be given to environmental conditions in assessing the ITM program scope; for instance, where the corrosion aspect is elevated (e.g., portal cranes exposed to seawater and loading facilities processing corrosive materials such as potash), shorter inspection frequencies should be considered compared to installations where such factors do not exist.

In order to keep the crane operating reliably and efficiently, it is essential that maintenance be carried out before breakdown. This necessitates implementing an inspection, testing and maintenance program based on the equipment manufacturer’s recommendations. However, most of the crane’s maintenance will be dictated by what is found during the inspection.

Due to the wide variation in job applications, severity of service, machine activity, and environment, it may be impossible for the manufacturer to develop a single, complete maintenance program that will fit all applications. Maintenance personnel must modify the manufacturer’s recommendations to suit the specific needs of the equipment.

3.2.3 Operational Hazards

Operation is probably the most important area relative to loss prevention and safety. Conformance with good practice in this area is the responsibility of the owner and operating personnel.

It is the responsibility of management and supervisors to ensure that those who prepare, erect, operate, and work with or around cranes and equipment are well trained in both safety and operating procedures. Proper training in operating procedures will prevent the majority of common accidents after the crane is shut down.

Inadequate training and failure to follow established, proper crane operating procedures have allowed major collapse, toppling, wind, and fire losses to occur.

Cranes are exposed to many accidents, such as collapse and toppling, because they are subjected to a wide variety of job applications and environmental conditions. To lessen the possibility of such accidents, the crane system must be equipped with mechanical and electrical limiting devices to shut off power to driving motors when the crane hook, trolley, and bridge approach the end of travel, or when other parts of the crane system would be damaged if power were not shut off.

It is important to include safety devices in the control system for the crane, in addition to the limiting devices. These ensure the controls will return to or maintain a safe holding position in case of malfunction, inadvertent operation or failure, or overspeed and over-torque conditions.

Overpower and overspeed conditions are considered an operating hazard as they may increase the hazards of malfunction or inadvertent operation. It is essential that the controls be capable of stopping the hoisting movement within acceptable limits.

Tower cranes are prone to toppling due to overloading.

Climbing tower cranes are often used for high-rise building construction. There have been several catastrophic failures of climbing tower cranes in recent years. These failures often occur on high-rise projects in large cities and therefore involve not just damage to the crane, but damage to surrounding buildings as well, plus injuries to construction and other personnel in the area. Such failures are often due to inadequate rigging;

particularly temporary sling rigging used when installing the heavy steel collars that secure the crane tower to the building structure during a “jumping” where a new section of crane tower is added on top of the existing crane tower. Sling rigging that is worn, stretched, frayed, otherwise damaged, or improperly installed, could have significantly reduced load capacity and should not be used.

Travel with suspended loads involves many variables, such as swinging of the load, momentum in starting and stopping, track conditions, tower height, boom length, etc. If such an operation is attempted, the user must evaluate local conditions, determine safe practices, and exercise precautions such as those recommended in Section 2.5.2.

Substantial losses have been sustained due to improper positioning of rigging cables or failure to stabilize cranes, thus allowing them to topple.

3.2.4 Fire

Fire most frequently starts on main trolleys for container and similar cranes. Electrical wiring that is allowed to become covered with oil and grease becomes a hazard ready to be ignited by a spark from a grid, faulty wiring, or a defective motor. In large cranes, fire can start in the operator’s cab, in control and motor rooms, and in areas used for the storage of combustible materials.

For shiploaders, stackers, and other cranes that commonly have conveyors, many fires involve the conveyors.

Large cranes are sometimes equipped with high-voltage switchgear and a transformer room, trolley cable room, machinery room, elevator shaft, elevator machine room, grouped cable tray arrangement, etc. These areas usually have potential fire hazards due to the concentration of combustible materials. Hydraulic systems also present a fire hazard when they fail. Hydraulic or fuel lines may leak or break, with subsequent ignition of the fluid (e.g., by hot exhaust manifolds or electrical components).

There may be areas on large cranes used for limited storage of oil, grease, and ignitable solvent in drums. Other areas may be used for oxygen and acetylene cylinder storage. Cutting and welding can ignite combustible material in the surrounding areas.

4.0 REFERENCES

4.1 FM

Data Sheet 1-2, *Earthquakes*
Data Sheet 1-20, *Protection Against Fire Exposure*
Data Sheet 1-28, *Wind Design*
Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*
Data Sheet 4-0, *Special Protection Systems*
Data Sheet 4-5, *Portable Extinguishers*
Data Sheet 5-4, *Transformers*
Data Sheet 5-31, *Cables and Bus Bars*
Data Sheet 5-48, *Automatic Fire Detection*
Data Sheet 7-11, *Belt Conveyors*
Data Sheet 7-40, *Heavy-Duty Mobile Equipment*
Data Sheet 7-43, *Process Safety*
Data Sheet 7-88, *Ignitable Liquid Storage Tanks*

APPENDIX A GLOSSARY OF TERMS

Anemometer: See wind velocity indicator.

Axis of rotation: The vertical line about which a crane swings.

Basic wind speed: The 3-second gust wind speed at 33 ft (10 m) above grade, which represents the design windstorm condition as provided in DS 1-28.

Below-the-hook lifting devices: Links, slings, structural and mechanical lifting devices, etc. (see lifting devices).

Bogie: An assembly of two or more axles arranged to permit both vertical wheel displacement and an equalization of loading on the wheels.

Boom: A member hinged to the superstructure and used for supporting the hoisting tackle.

Boom angle: The angle above or below horizontal of the longitudinal axis of the base boom section.

Boom stop (crane): A device used to limit the angle of the boom at the highest position.

Brake: A device other than a motor used for retarding or stopping motion by friction or power means.

Brake, parking: A brake for bridge and trolley that may be automatically or manually applied to impede horizontal motion by restraining wheel rotation.

Brake, service: A brake for bridge or trolley used by the operator, during normal operation, to apply a retarding force.

Cab: A housing provided for the operator and containing the crane controls.

Clutch: A means of engaging and disengaging power.

Controls: A means of controlling the movement functions of a crane.

Crane: A machine for lifting and lowering a load and moving it horizontally, with the hoisting mechanism an integral part of the machine.

Crane grouping: The rail-mounted cranes sharing the same rail system.

Crane securement procedure manual (CSPM): A manual that documents and describes the processes and procedures used to secure cranes against various operational environmental hazards such as wind.

Derrick: An apparatus consisting of a mast or equivalent member held at the head by guys or braces, with or without a boom, for use with a hoisting mechanism and operating ropes.

Designated person: A person selected or assigned by the owner or owner's representative as being competent to perform specific duties.

Drum: The cylindrical member around which a rope is wound and through which power is transmitted to the ropes.

Dynamic loads: Loads introduced into a machine or its components by forces in motion.

Emergency response plan (ERP): The plan to secure and otherwise limit or prevent damage to cranes and associated equipment and site works; also to limit or prevent hazards to crane operators and other personnel. This includes crane securement per the CSPM.

Emergency response team (ERT): The personnel designated to carry out the ERP.

FM Approved: Products or services that have satisfied the criteria for Approval by FM Approvals. Refer to the *Approval Guide,* an online resource of FM Approvals, for a complete list of products and services that are FM Approved.

Gantry: A movable structural frame consisting of columns and bracing capable of supporting a crane with its working and dynamic loads.

Guy, derrick: A rope used to steady or secure the mast or other member in the desired position.

Guy, rope: A fixed length supporting rope intended to maintain a nominally fixed distance between the two points of attachment.

Hoist: Machinery unit that is used for lifting or lowering a freely suspended (unguided) load.

In-service: The condition of a crane ready for or engaged in work; an operator is at the controls.

In-service wind: The maximum prescribed wind velocity at the site before a (working) crane must be taken out of service.

Hurricane-prone regions: Refer to Data Sheet 1-28, *Wind Design,* for the definition. Includes tropical cyclone-prone and typhoon-prone regions.

Jib: An extension attached to the boom point to provide added boom length for lifting specified loads. The jib may be in line with the boom or offset to various angles.

Lifting devices: Devices that are not reeved onto the hoist ropes, such as hook-on buckets, magnets, grabs, and other supplemental devices used for ease of handling certain types of loads. The weight of these devices is to be considered part of the rated load.

Load: The total superimposed weight on the load block or hook.

Load block, lower: The assembly of hook or shackle, swivel, sheaves, pins, and frame suspended by the hoisting rope.

Load block, upper: The assembly of sheaves, pins, and frame contained on the trolley.

Luffing: Changing the boom angle by raising or lowering the boom at its head (outer end); also called booming in (out).

Mast (derrick): The upright member of the derrick used for support of the boom.

Out-of-service: The condition of a crane when unloaded, without power and with the controls unattended, and prepared to endure winds above the in-service level.

Out-of-service wind: The maximum prescribed wind velocity that an out-of-service crane is designed to endure, with or without special anchorages.

Overload: Any load greater than the rated load.

Parking base or track: For rail-mounted cranes, a section of track supported so that it is capable of sustaining storm induced bogie loads; it is provided with storm anchorages when required.

Proof load: The specific load applied when performing the proof tests.

Proof test: A nondestructive load test made to a specific multiple of the rated load of the component (e.g., sling).

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

Radius (reach): The horizontal distance from the theoretical intersection of the axis of rotation and the ground line or waterline to the center of the hoist line(s) at the ground line or waterline.

Rail brake: A type of storm brake friction device used to secure a traveling crane to its rails by engaging the railhead - typically the top surface of the railhead.

Rail clamp: A type of storm brake friction device used to secure a traveling crane to its rails by engaging the railhead - typically the sides of the rail head.

Rated load (capacity): The maximum allowable working load designated by the manufacturer; rated loads are expressed in pounds, kilograms, short tons, or metric tons.

Reeving: A system in which a rope travels around drums, or sheaves.

Rope (cable laid): A cable composed of six wire ropes laid as strands around a wire rope core.

Rope (strand laid): A wire rope made with strands (usually 6 or 8) formed around a fiber core, wire strand core, or independent wire rope core (IWRC).

Runway: An assembly of rails, beams, girders, brackets, and framework on which the crane travels.

Sheave: A grooved wheel or pulley used with a rope to change direction and point of application of a pulling force.

Secondary braking (blocking) devices: See storm brakes.

Securement: Any type of physical device that is intended to keep the crane stable and secure. This could include brakes, chocks, blocking, stowage pins, and manual tie-downs.

Sills: Horizontal structural members that connect the lower ends of two or more legs of a gantry crane on one runway.

Skewing: The movement of either end of a skew-type traveling-bridge crane, independently of the other end.

Slewing (swing): Rotation of the upper-structure for movement of loads in a horizontal direction about the axis of rotation.

Sling: An assembly used for lifting. The upper end is connected to a lifting mechanism and the lower end supports the load.

Stiffleg, derrick: A rigid member supporting the mast at the head.

Stop: A device to limit travel of a trolley or crane bridge. This device normally is attached to a fixed structure and normally does not have energy-absorbing ability.

Storm Brakes: Braking devices such as rail chocks, wedges, or clamps used to secure cranes when wind speeds exceed operating wind speeds.

Superstructure: The rotating upper frame structure of the crane and the operating machinery mounted on it.

Switch, limit: A device that is activated by the motion of a part of a power-driven machine or equipment to alter or disconnect the *electric, hydraulic, or pneumatic circuit associated with the machine or equipment.*

Tagline: A restraining line to control position of the load.

Ton: A ton (or tonne) in the crane industry typically refers to a metric ton (2200 lb; 1000 kg), rather than a long ton (2240 lb; 1020 kg) or a short ton (2000 lb; 907 kg) unless noted as such.

Tower (mast): A vertical structural frame consisting of columns and bracing capable of supporting an upper structure with its working and dynamic loads and transmitting them to the supporting surface or structure.

Trolley: The device that travels on the bridge rails or load jib and supports the load block.

Tropical cyclone-prone regions: See hurricane-prone regions.

Truck, travel: The assembly that includes a pivot, frame, axle(s), and wheel(s) on which a crane rides on rails; also, see bogie.

Typhoon-prone regions: See hurricane-prone regions.

Unattended: A condition in which the operator of a crane is not at the operating controls.

Vertical wind shear: The natural phenomenon where wind speeds increase with height above the ground or water surface.

Weathervaning: Wind induced rotation (yaw) of a crane upper structure, when out-of-service, to expose minimal surface area to the wind.

Wind velocity indicator: A device, such as an anemometer, that has a readout giving wind speeds.

Windstorm brakes: See storm brakes.

APPENDIX B DOCUMENT REVISION HISTORY

The purpose of this appendix is to capture the changes that were made to this document each time it was published. Please note that section numbers refer specifically to those in the version published on the date shown (i.e., the section numbers are not always the same from version to version).

July 2023. Interim revision. Editorial changes were made for asset integrity and equipment contingency planning guidance to provide additional clarity.

January 2019. This document has been completely revised. Major changes include the following:

A. Reorganized the document to be consistent with other data sheets.

B. Added a statement to Section 1.0, Scope, and Section 2.5.1 stating that this data sheet applies to remote-operated, automatic tracked, and GPS-located cranes.

C. Updated the recommendations in Section 2.2.3, Fire.

D. Moved the recommendations for structural modifications to Section 2.6, Human Factor, and added a section on asset integrity and management of change.

E. In Section 2.0, added a new section on contingency planning.

F. In Section 3.0, added a new commentary section.

G. Added Appendix G, Maintenance,

January 2015. This document has been extensively revised. The following major changes were made:

A. Added guidance on tower cranes, portside (quayside) container cranes, and climbing tower cranes (Section 2.3).

B. Revised the level of crane securement (brakes and tie-downs) and safety factors recommended for associated wind speed thresholds (Section 2.3.1).

C. Added guidance on lube and hydraulic oils, grouped cable, and belt conveyers (Section 2.2.3).

D. Revised guidance on crane rigging and added guidance on synthetic slings for climbing tower cranes (Section 2.5.1).

E. Added guidance on worn or deficient rail brakes (Section 2.5.5).

F. Added a data collection checklist for the assessment of wind securement to Appendix E, Job Aids.

G. Added recommendations to address wind loading in certain FEM and ISO crane standards (Appendix F).

April 2012. Terminology related to ignitable liquids has been revised to provide increased clarity and consistency with regard to FM Global's loss prevention recommendations for ignitable liquid hazards.

September 2009. Replaced all references to Data Sheet 2-8N, *Installation of Sprinkler Systems (NFPA)*, with references to Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*.

September 2005. Changes regarding wind securement for cranes were made for this revision.

September 2004. References to FM Global earthquake zones have been modified for consistency with Data Sheet 1-2, *Earthquakes*.

May 2003. Minor editorial changes were made for this revision.

January 2001. This revision of the document was reorganized to provide a consistent format. In addition, the following changes were made:

- Recommendations are no longer presented as primary and supplemental.
- The sections on Loss History and Illustrative Losses have been updated.

May 1998. The data sheet was reformatted for publishing on the CD.

January 1993. The data sheet was revised to include the superseded Data Sheet 1-62S/17-16S, *Windstorm Protection For Portal Cranes*. The recommendations were also expanded to emphasize human element factors in the losses; manufacturer prescribed in-service and out-of-service wind velocities; and windstorm protection for stacker/reclaimers. The recommendations also were sub-divided into primary and secondary sections, and formatted to complement or supplement American Society of Mechanical Engineers (ASME) B30.

May 1979. First version of the data sheet which superseded Chapter 78 of the FM Global Handbook of Industrial Loss Prevention 2nd edition. The recommendations were expanded to include wind, improper operation, and improper maintenance.

1967. Handbook of Industrial Loss Prevention, Chapter 78 addressed Wind Anchorage for Cranes.

June 1942. FM Global Bulletin of Loss Prevention No: 7.80 titled ‘‘Anchorage of Crane Structures to Resist Wind Damage.’’

1927. Book titled ‘‘Windstorms’’ published by Inspection Department of Associated Factory Mutual Fire Insurance Companies. Part III titled ‘‘Anchorage of Cranes and Movable Structures’’. This is the earliest document on this subject.

APPENDIX C TYPES OF CRANES AND METHODS OF ANCHORAGE

C.1 Types of Cranes

An overhead traveling crane, also called a bridge crane, is a traveling machine with a single or multiple girder movable bridge carrying a fixed or trolley-mounted hoist and traveling on an overhead fixed runway structure inside a building or outdoors (see Figure 2).

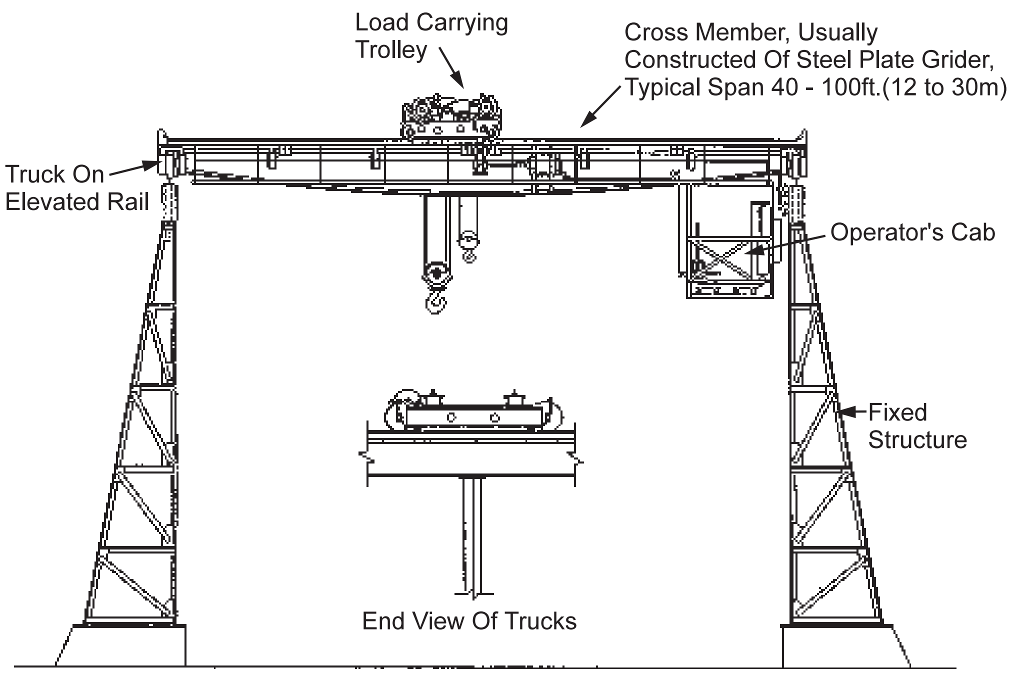

Fig. 2. Overhead traveling crane

A rail-mounted gantry (RMG) crane is similar to an overhead crane except the bridge for carrying the trolley(s) is rigidly supported on two or more legs running on fixed rails or other runway (see Figure 3).

An outdoor storage gantry crane, also known as a traveling-bridge crane, is a long span, gantry-type crane usually used for storage of bulk materials. The bridge girders or trusses are rigidly supported or socket supported on two or more legs to allow skew movement (see Figure 4).

A portal crane, also known as a whirly, consists of a rotating superstructure with operating machinery and luffing boom, usually with a portal opening between the gantry columns or legs for traffic to pass beneath the crane. The crane may be fixed or on a traveling base. (See Figure 5.)

A tower crane, also known as a portal tower crane and a whirly, is similar to a portal crane but with a tower intervening between the superstructure and the gantry or other base structure, usually without a portal opening between the gantry columns for traffic to pass beneath the crane. It may be on a traveling or fixed base. (See Figures 6 and 7.)

A tower crane (construction) is a class of tower crane built for use at construction sites and similar applications. It is characterized by provisions to facilitate frequent erection and dismantling, including arrangements that permit the crane to climb with the structure being built and brace to it as needed. The crane consists of a luffing boom connected to a revolving tower or to a fixed tower with an upper rotating superstructure mounted on a fixed or traveling base. (See Figure 8.)

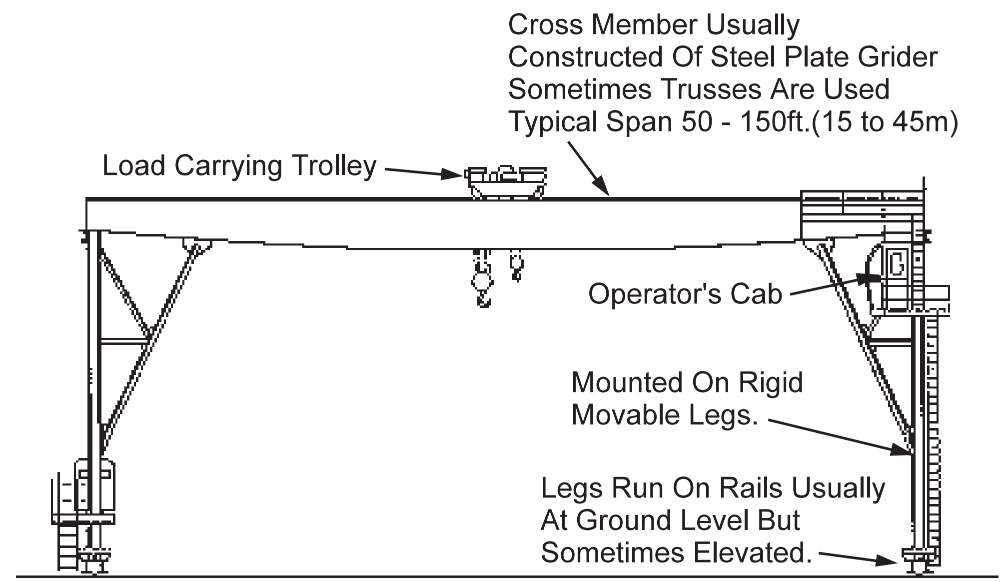

Fig. 3. Rail-mounted gantry (RMG) crane

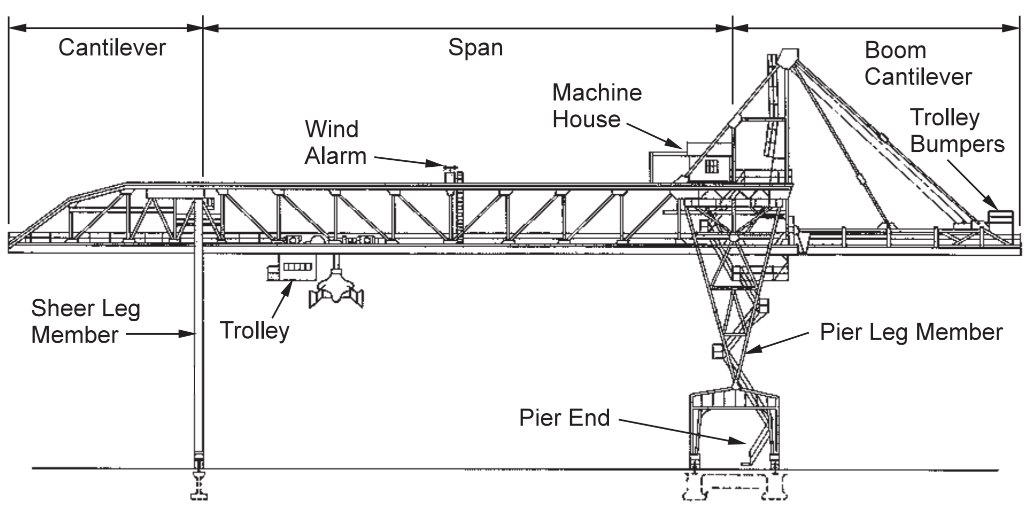

Fig. 4. Traveling-bridge crane

A hammerhead tower crane also is a class of tower crane built primarily for use at construction sites and similar applications. It is characterized by similar provisions to the tower crane (construction) discussed above. The crane may be rail-mounted or on a fixed base (free standing, guyed or braced). It consists of a tower with a superstructure that rotates, and includes a load jib (boom) with trolley extending horizontally and a counterweighted jib extending in the opposite direction; neither is arranged for luffing. (See Figures 9 and 10.) (See Figures 9 and 10.)

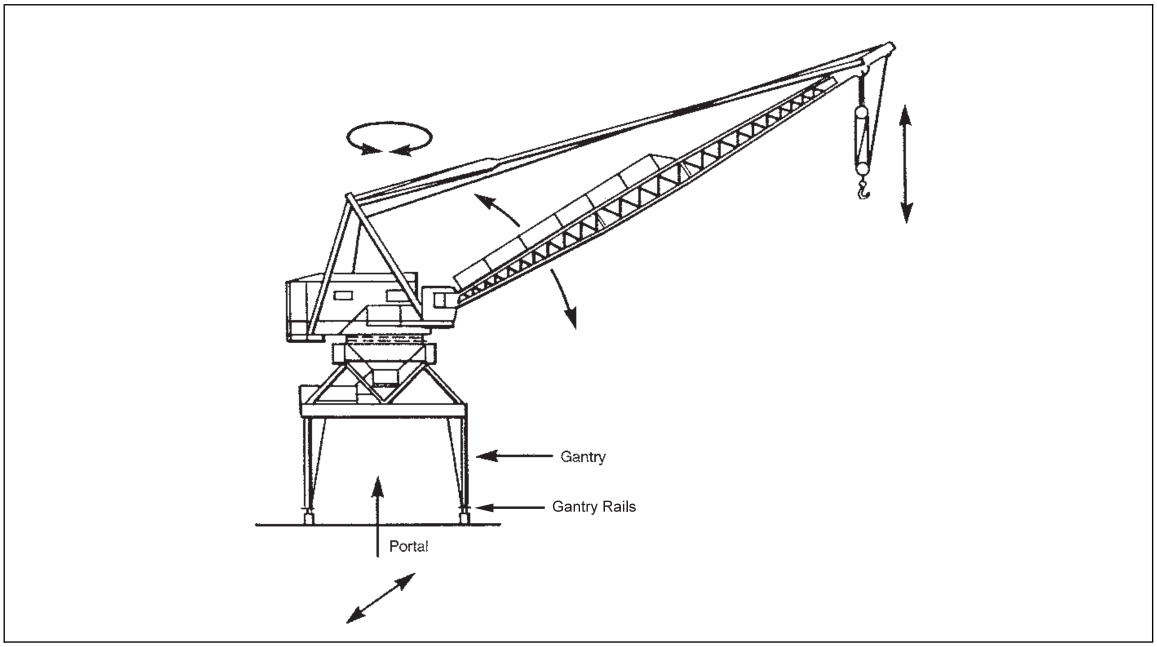

Fig. 5. Portal crane

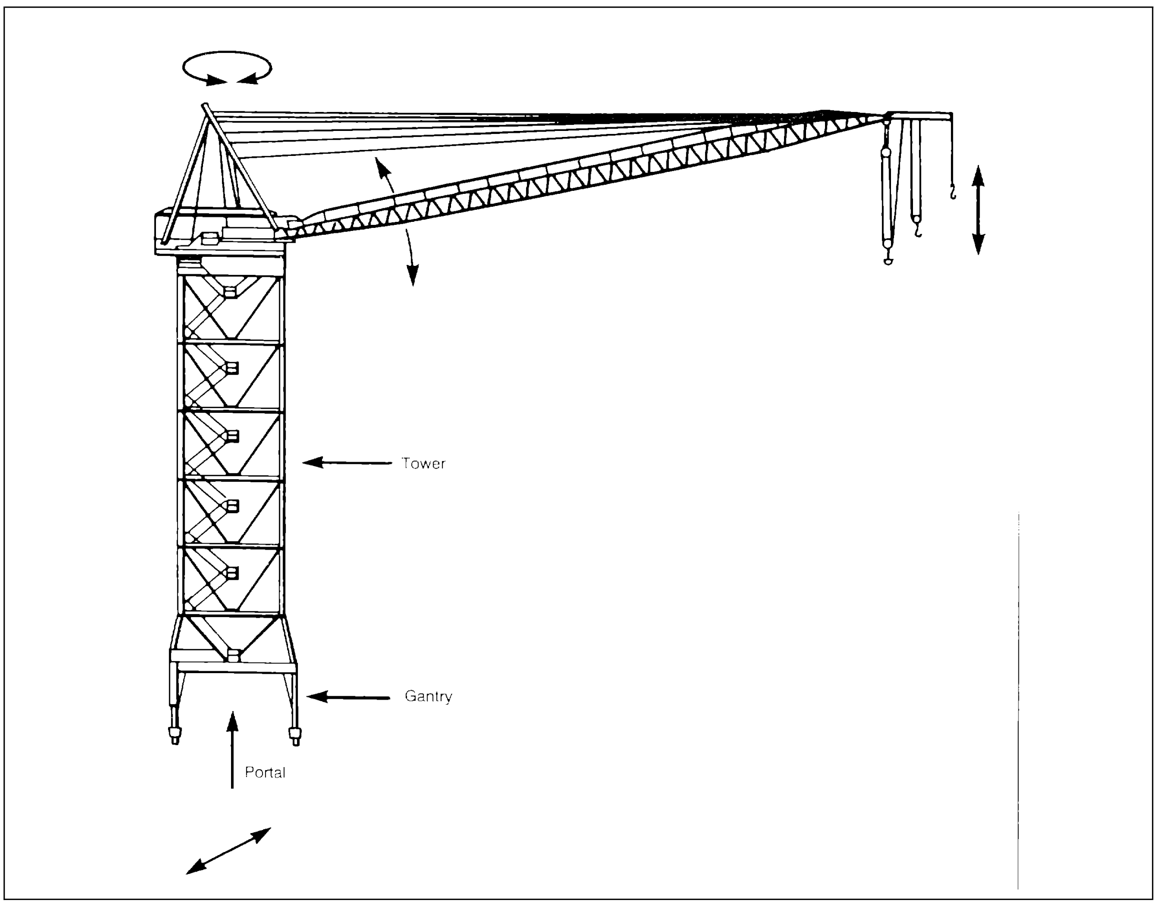

Fig. 6. Tower crane (traveling base)

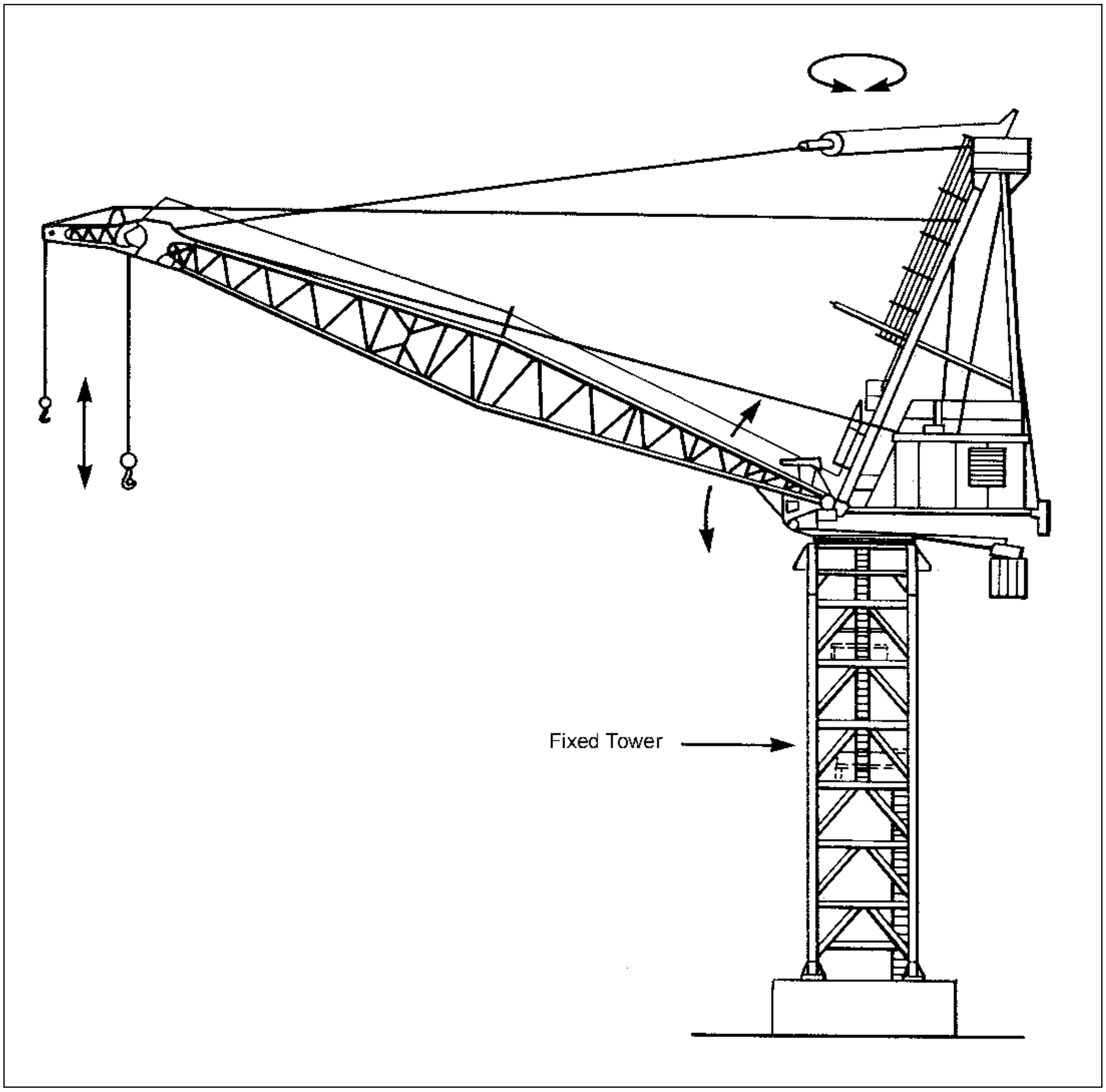

Fig. 7. Tower crane

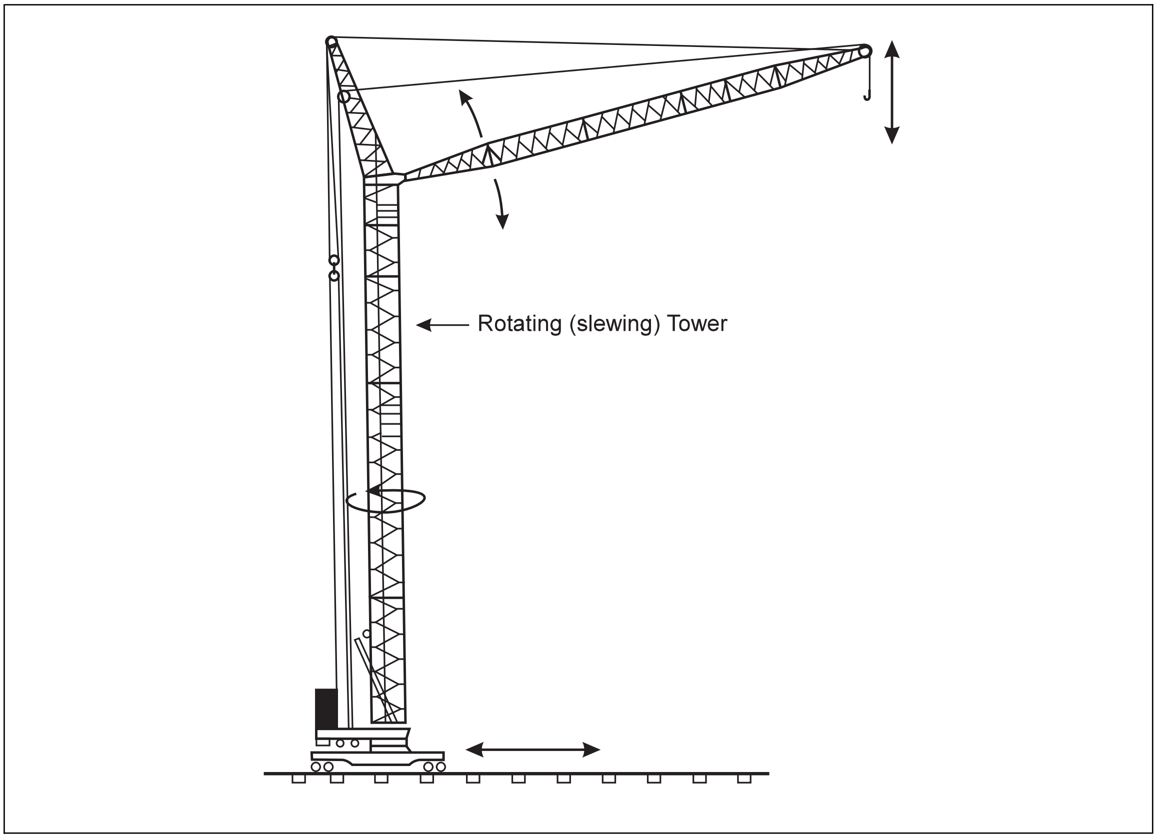

Fig. 8. Tower crane (construction)

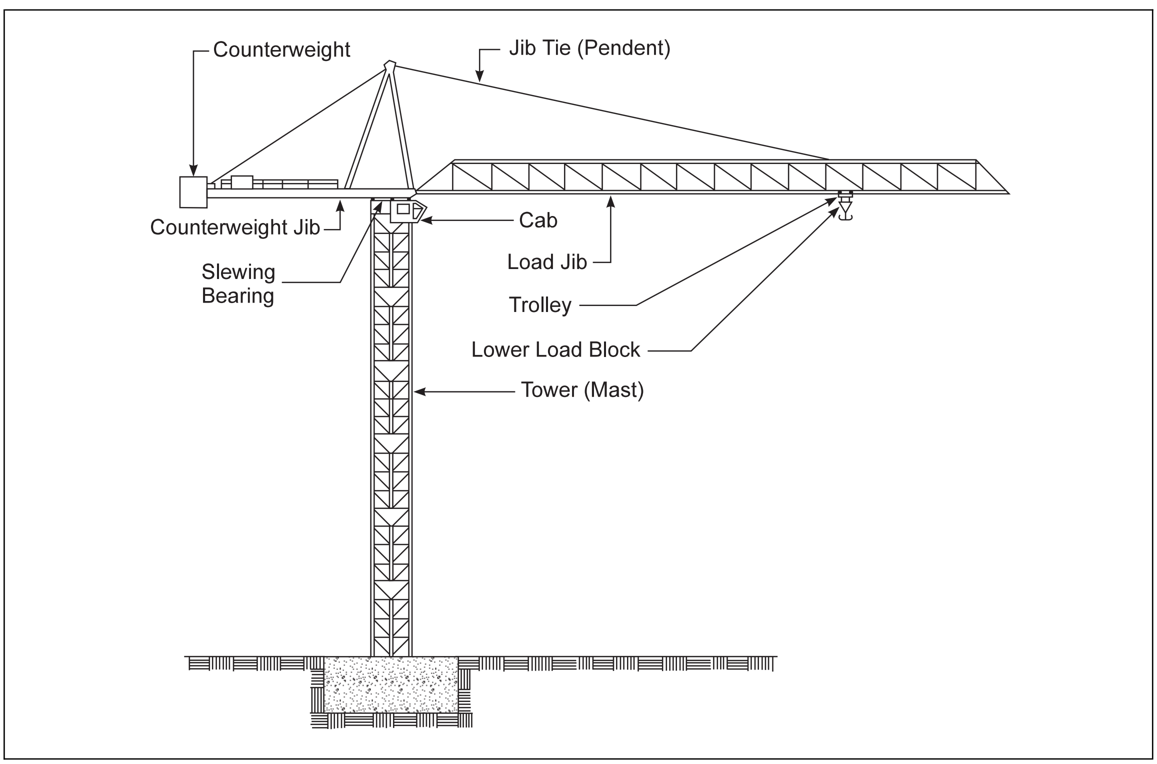

Fig. 9. Hammerhead tower crane

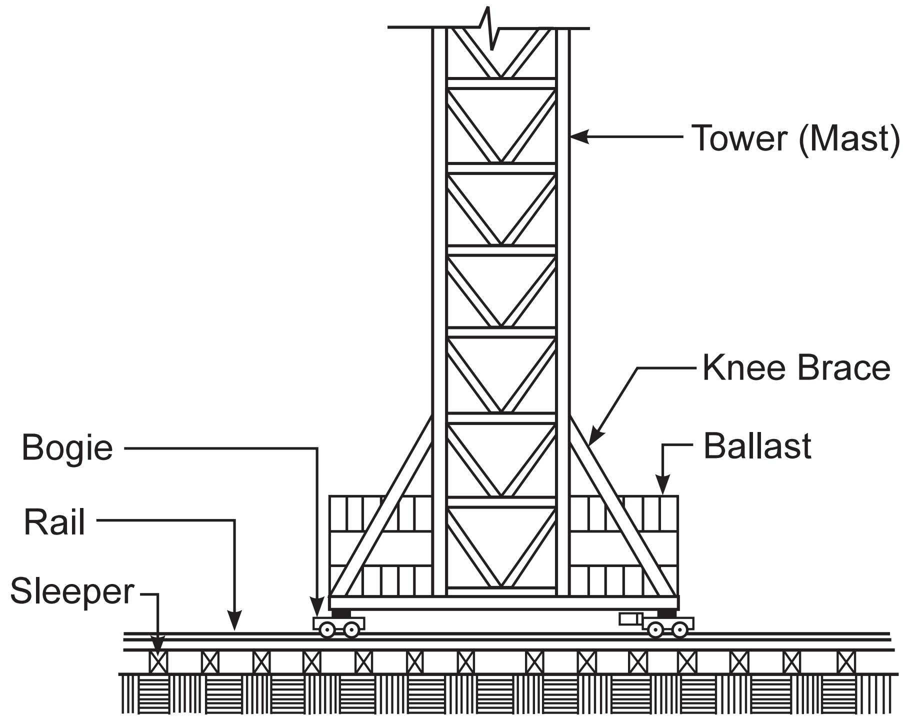

Fig. 10. Travel base for free standing crane

Climbing or self-climbing cranes are tower cranes that use steel collars and tie beams to laterally support the crane tower to the adjacent building structure. As construction of the building progresses vertically, additional sections of crane tower are added (i.e., jumping) to provide sufficient crane height (see Figure 11).

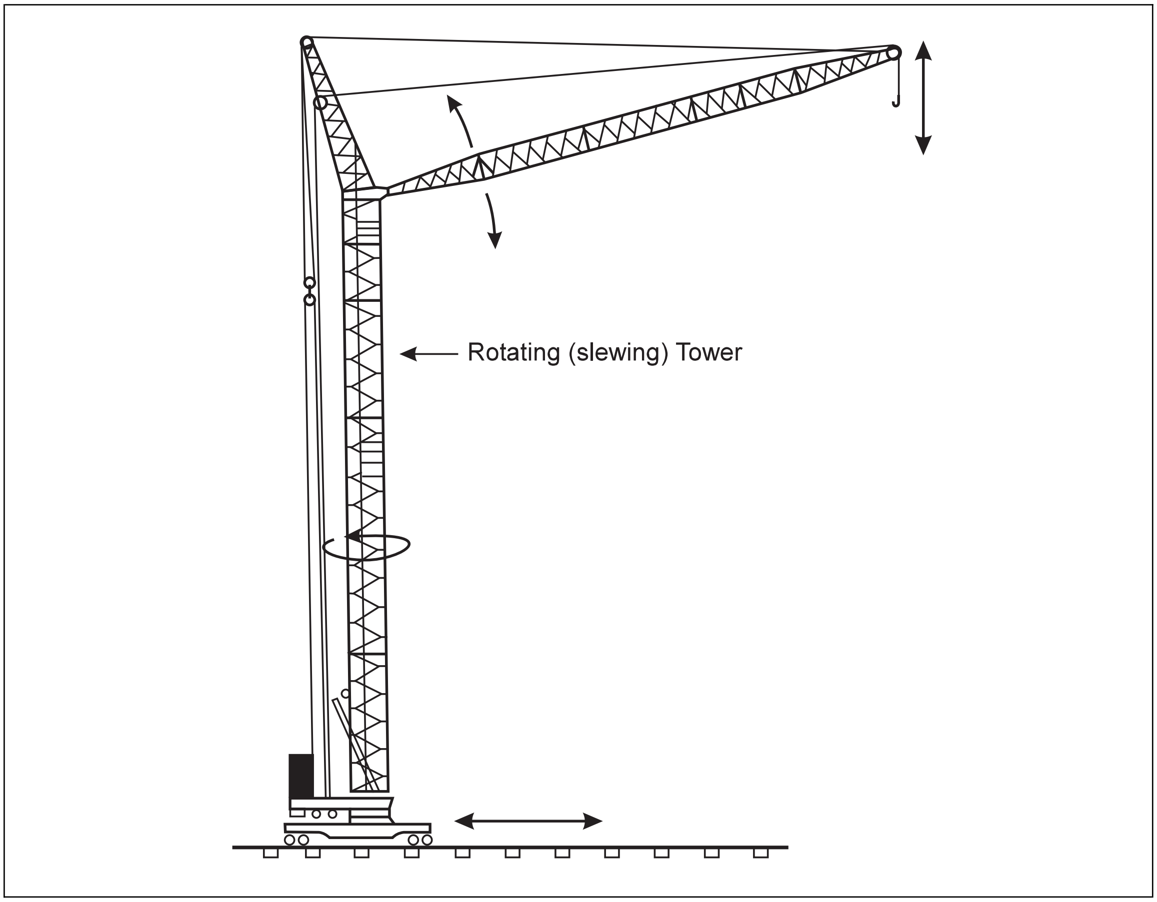

Fig. 11. Climbing tower crane

A stacker/reclaimer consists of a rotating superstructure with operating machinery and luffing boom. The superstructure is mounted on a gantry structure that straddles a yard conveyor and travels on rails for the full length of a storage yard for bulk materials (e.g., coal and iron ore pellets). The luffing boom and its conveyor accommodate a stacker and/or a bucket wheel reclaimer. The stacker receives bulk material from the yard conveyor and deposits it on stockpiles, whereas the bucket wheel reclaimer receives material from the stockpile and deposits it on the yard conveyor (see Figure 12).

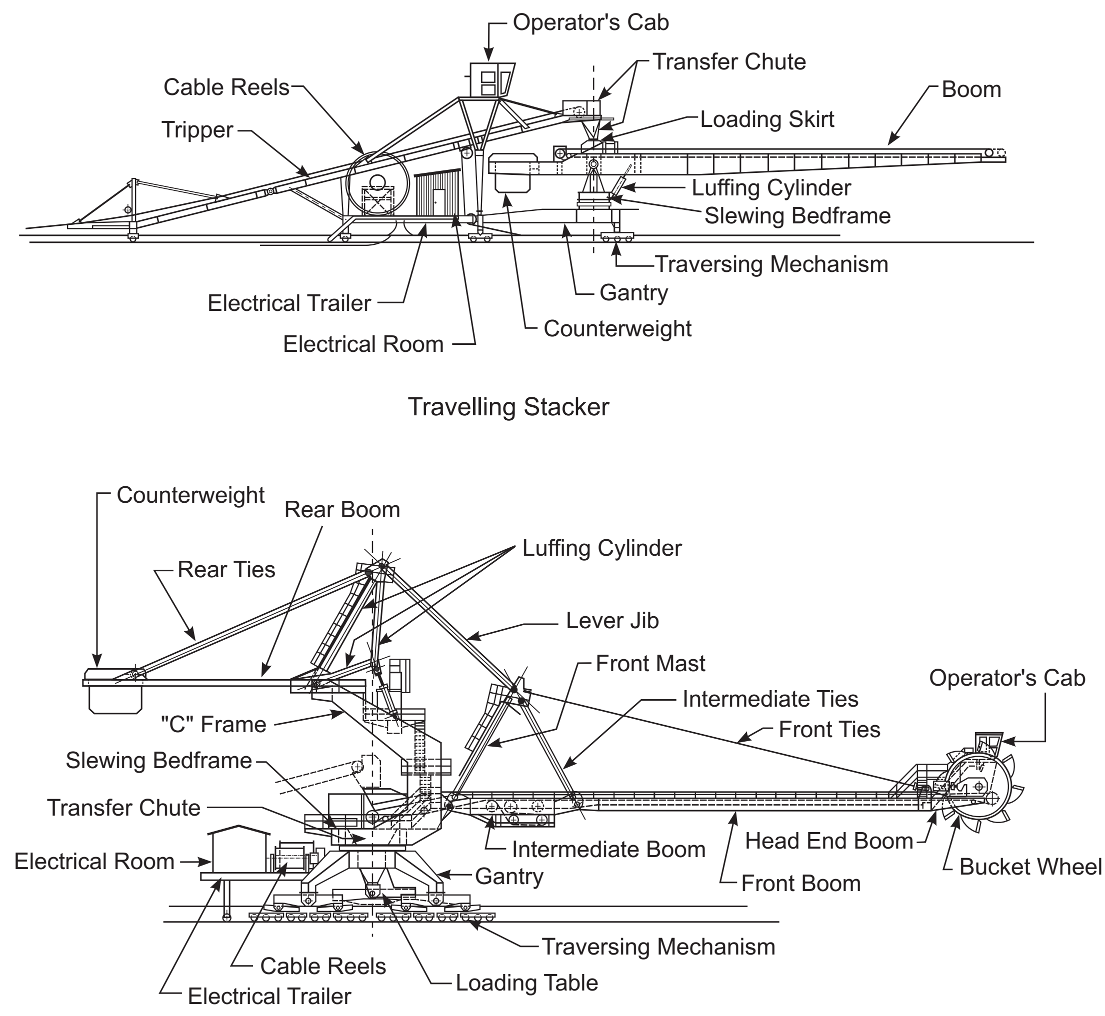

Fig. 12. Traveling stacker and stacker/reclaimer

A shiploader is typically mounted on a gantry and travels on rails (see Figure 13). It operates similar to a stacker and is used to load dry bulk materials (e.g., coal, gypsum, grain, iron ore) from a conveyor onto a ship. A ship unloader is similar to a shiploader but operates like a reclaimer.

A container crane is also known as a ship-to-shore crane, or dockside or quayside container crane. These cranes are used to transfer shipping containers from land to container ships and vice versa, and can have a single or double trolley, and a fixed, articulating, or sliding boom (see Figure 14).

C.2 Methods of Crane Anchorage

C.2.1 Overhead Traveling Cranes

Latches are mounted on the runway stop or bumper. They automatically engage a substantial holding piece when the crane is at the end of the runway. Ordinarily, a solenoid, rod, or cable is provided to enable the operator to disengage the latch from the cab. Electric interlocking will prevent application of power from moving the crane before the latches are raised.

Heavy, lever-operated bars called locking bars can be attached to the crane girder. These are arranged to slide sideways through guides into a notched plate fastened to the runway. With locking bars at both ends of the crane, each slot must be about 12 in. (300 mm) long to allow for misalignment of the crane.

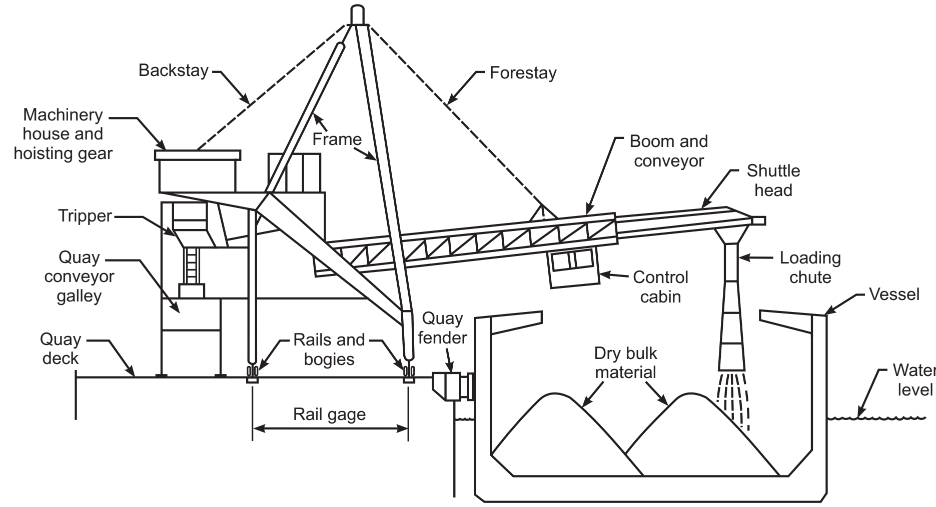

Fig. 13. Shiploader

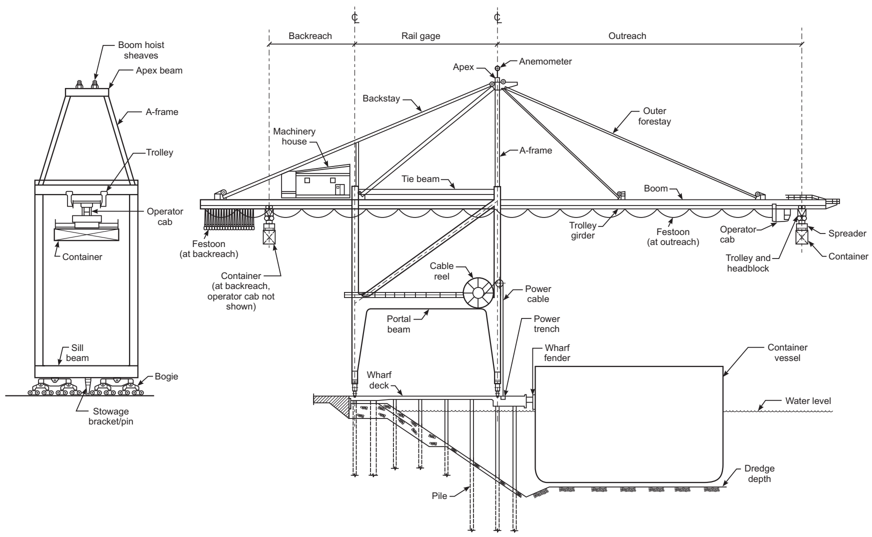

Fig. 14. Container crane (views perpendicular and parallel to the crane rails)

Heavy drop plates attached to the outside top and bottom of the truck girder result in making crane traps. When the crane is moved to the end of the runway, the drop plate rides up a slope and drops by gravity behind a stop lug. This lug is so bolted or welded to the runway girder that the crane is trapped between the lug and the end bumper. To release the crane, the drop plate is raised by a solenoid wired to a push button in the cab.

A large block of buried concrete with a firmly embedded eyebolt or hook is sometimes used for anchorage. This is called a deadman. Although one of the previously described methods would be preferable, a deadman can be acceptable. The hoisting hook is engaged in the eyelet and drawn up tight to hold the crane against the runway stops or bumpers. The deadman must be located well beyond the end of the runway so the force in the hoisting cable will have a large horizontal component.

C.2.2 Gantry, Tower, and Other Cranes

Automatic brakes are usually built into the truck sills of gantry, tower, or bridge cranes. They operate either by friction or jamming. If by friction, resistance depends on friction of the clamp shoe against the rail head by spring, weight, or hydraulic pressure against levers. If by jamming, the clamp shoe is forced against the rail head by a system of springs and levers. Pressure exerted by a cam forces the clamp shoe tighter against the rail head if there is any movement of the crane after the clamp is set.

Several automatic brakes may be actuated by a heavy spring arrangement that causes the clamp shoe to grip the top or sides of the rail head. With this arrangement, the springs are compressed by an electric-motor or hydraulically actuate plunger to release the clamping action. The levers also may be actuated by a heavy weight (raised by a cable-and-motor, large solenoid, air pressure or hydraulic system) which, in falling, causes the rail clamp shoes to grip the rail head.

Another type of jamming rail clamp is simple in design and easily operated. The main elements are a heat treated cam having a serrated face that engages one side of the rail head, and a mild-steel shoe that is secured to the clamp assembly and pushes against the other side of the rail. The top of the cam has a flange that rests on top of the rail when the clamp is in the lowered or ready position, as when the crane is at rest. Any movement of the crane structure, either backward or forward while the clamp is in this position, causes the flange to rotate the cam on its axis. The serrated face thus comes into contact with the rail, forcing the serrations into it, and locks or jams the rail between the cam and the shoe. The clamp is released by moving the crane a few inches along the rails in a direction opposite to that which caused the clamping force to be applied. When the crane is moved for normal operation, the cam is lifted from the rail by a solenoid and held in the raised position.

Consistent, dependable holding power, controlled speed in engaging and proper speed in releasing are the most important features in any automatic brake.

Manual rail clamps are similar in general construction to automatic rail clamps, but must be applied by clamp personnel or riggers stationed near the base of the crane. Lever-operated, quick-acting clamps are preferable to the slower-acting, wheel-operated types. The effectiveness of tightening friction clamps with hand wheels or hand-operated wing nuts is questionable because they may not be pulled with sufficient force to develop the full resistance of the clamp or may slack off.

Tong clamps, which grip under the rail heads, exert no effective clamping force against the sides of the rail head; they are of little value in resisting horizontal wind forces.

Wheel wedges are frequently used at idler wheels to increase windstorm resistance. They are preferably made of wood, with a long tapering toe and with side frames to hold them on the rail. They may be used in an emergency or during repairs to rail clamps. Their resistance is uncertain, but a well-designed, undamaged and properly placed wedge on a clean rail may furnish a resistance equal to 20% of the weight on the wheel. Wedges must be wired or chained to the crane sills.

Some revolving-tower cranes have wheel wedges that can be set automatically to act on idler wheels. When the propelling power is shut off, the wedges set automatically. They are released by closing a circuit through the first contact on a controller of the crane-travel motor. A time-delay device allows wedges to be released before driving power is applied to the wheels.

Rail chocks are heavy steel castings attached to the rail head by bolts or drive wedges. There are numerous designs of these portable chocks that are sometimes erroneously called “manual rail clamps.” They all have the disadvantages of manual devices. There may be delay in application, uncertainty of rail resistance and impossibility of application if the crane is in motion. They are useful during repair of the automatic rail clamps or when the crane is idle for an extended period.

Manual anchoring with wire ropes (cables) is sometimes used. One end of the ropes is attached to the end of the crane sills or to the superstructure (tower), and the other ends are fastened to eyebolts in large concrete anchors. Ropes may be satisfactory for anchoring cranes at night or during idle periods, but they require too much fastening time during a windstorm emergency. All details of fastenings must be carefully designed to resist the calculated out-of-service wind forces on the crane.

Supplementary friction-band brakes are used on some rack-and-pinion drive cranes to provide resistance to wind forces.

Safety struts are used on many bridge cranes to supplement automatic rail clamps. The struts are pivoted at one end of the truck or bridge structure. They are arranged so that the other end can be engaged in a slot in the concrete foundation under the rails, or attached to the rail heads with clamps.

APPENDIX D BIBLIOGRAPHY

D.1 United States Standards

D.1.1 American Society of Mechanical Engineers (ASME)

ASME B30, *Safety Standard for Cableways, Cranes Derricks, Hoists, Hooks, Jacks, and Slings*, applies, in general, to the construction and installation; inspection, testing and maintenance; and operation of the various types of equipment included within its scope. With the requirements prescribed, the standard provides direction to manufacturers, owners, employers, and supervisors responsible for its application, and it guides governments and other regulatory bodies with the establishment of safety directives.

The following is a list of the separate chapters of ASME B30:

- B30.1, Jacks, Industrial Rollers, Air Casters, and Hydraulic Gantries
- B30.2, Overhead and Gantry Cranes
- B30.3, Tower Cranes
- B30.4, Portal and Pedestal Cranes
- B30.5, Mobile and Locomotive Cranes
- B30.6, Derricks
- B30.7, Winches
- B30.8, Floating Cranes and Floating Derricks
- B30.9, Slings
- B30.10, Hooks
- B30.11, Monorails and Underhung Cranes
- B30.12, Handling Loads Suspended From Rotorcraft
- B30.13 Storage/Retrieval Machines and Associated Equipment
- B30.14, Side Boom Tractors
- B30.15, Mobile Hydraulic Cranes
- B30.16, Overhead Hoists (Underhung)
- B30.17, Overhead and Gantry Cranes
- B30.18, Stacker Cranes
- B30.19, Cableways
- B30.20, Below-the-Hook Lifting Devices
- B30.21, Lever Hoists
- B30.22, Articulating Boom Cranes
- B30.23, Personnel Lifting Systems
- B30.24, Container Cranes
- B30.25, Scrap and Material Handlers
- B30.26, Rigging Hardware
- B30.27, Material Placement Systems
- B30.28, Balance Lifting Units
- B30.29, Self-Erecting Tower Cranes

D.1.2 Occupational Safety and Health Administration (OSHA)

OSHA regulations pertaining to cranes are covered in several parts of Chapter XVII of Title 29, Code of Federal Regulations (29 CFR), according to the occupational industry. The regulations applicable to general industry are in Part 1910; maritime industry pertinent to cranes, Parts 1917, 1918 and 1919; and the construction industry, Part 1926.

Note the OSHA mandatory regulations are more stringent as the list progresses from “general” to “construction” to “maritime” industries.

Title 29 of the Code is revised at least once each calendar year and issued annually, as of July 1, whether or not it has been amended. The above Regulations, by industry, are printed in three books. They are for sale at U.S. Government Printing Offices.

The following is a list of the Parts and Subparts, pertinent to cranes, of Chapter XVII-OSHA, Department of Labor:

- Part 1910, Occupational Safety and Health Standards, Subpart N, Materials, Handling and Storage
- Part 1917, Marine Terminals, Subpart C-Cargo Handling Gear and Equipment
- Part 1918, Safety and Health Regulations for Longshoring, Subpart G-Cargo Handling Gear and Equipment Other than Ship’s Gear
- Part 1919, Gear Certification, Subpart H-Certification of Shore-Based Materials Handling Devices
- Part 1926, Safety and Health Regulations for Construction, Subpart N-Helicopters, Hoists, Elevators and Conveyors and Subpart CC-Cranes and Derricks in Construction

D.2 Australian Standards

AS 1418, *Cranes (Including Hoists and Winches)*

- Part 1: General requirements-2004
- Part 3: Bridge, gantry, and portal cranes (including container cranes)-2002
- Part 4: Tower cranes-2004
- Part 5: Mobile cranes-2013
- Part 6: Guided storing and retrieving appliances-2004
- Part 7: Builders’ hoists and equipment-1999
- Part 8: Special purpose appliances-2008
- Part 14: Requirements for cranes subject to arduous working conditions-1996
- Part 15: Concrete placing equipment-1995
- Part 17: Design and construction of workboxes-1996

AS 1666, *Wire-Rope Slings*

- Part 1: Product Specification-2009
- Part 2: Care and use-2009

AS 2549-1996, *Cranes (Including Hoists and Winches) - Glossary of Terms*

AS 2550, *Cranes - Safe Use*

- Part 1: General requirements-2011
- Part 2: Serial hoists and winches-1997
- Part 4: Tower cranes-1994
- Part 5: Mobile cranes-2002
- Part 6: Guided storing and retrieving appliances-1995
- Part 15: Concrete placing equipment-1994

AS 2759-2004, *Steel Wire Rope - Application Guide*

AS 4324, *Mobile Equipment for Continuous Handling of Bulk Materials*

- Part 1: General requirements for the design of steel structures-1995

D.3 British Standards

BS 7121, Part 1: *Code of Practice for Safe Use of Cranes*

- Part 1: General
- Part 2: Inspection, Testing and examination
- Part 3: Mobile Cranes
- Part 4: Lorry Loaders
- Part 5: Tower cranes
- Part 6: Derrick cranes
- Part 7: Electric overhead travelling cranes
- Part 8: High Pedestal and portal jib dockside cranes
- Part 9: Container handling cranes
- Part 10: Rail mounted cranes

D.4 International Standards

ISO 4302, *Cranes - Wind Load Assessment*

ISO 8686-1, *Cranes - Design Principals for Loads and Load Combinations*

ISO 11994, *1997 Cranes - Availability - Vocabulary*

ISO 12478, *1997 Cranes - Maintenance Manual*

- Part 1: General
- Part 3: Tower cranes
- Part 4: Jib cranes
- Part 5: Overhead travelling and portal bridge cranes

D.5 Federation Europeenne De La Manutention (FEM)

FEM 1.001, *Rules for the Design of Hoisting Appliances*

FEM 1.004, *Recommendations for the Calculation of Wind Loads on Crane Structures*

FEM 1.005, *Recommendation for the Calculation of Tower Crane Structures in Out of Service Conditions*

FEM 1.007, *Recommendation to Maintain Tower Cranes in Safe Condition*

D.6 Other

Useful storm brake sources:

- Johnson Industries, www.brakes.ca/trippers.html
- Hillmar Industries Ltd., www.hillmar.com
- Rima Group., eqseco.ma/product-rima.html

Checklist of Data Needed to Assess Crane Stability and Securement Documentation for Wind Loading

A. Wind Speed

1. Verify that the recommended 3-second gust wind speed is used for out-of-service conditions (e.g., storm secured), and that the proper threshold wind speeds are used for in-service and shutdown conditions (e.g., pre-alarm, alarm, and shutdown initiation).

2. Verify that the recommended basis for the wind speed duration (e.g., 3-second gust, 1-minute mean), height (e.g., 33 ft [10 m] above grade), and surface roughness (e.g., Exposure C or D) are used.

3. Verify that the wind speeds recorded from wind speed indicators (anemometers) used to trigger various crane securement procedures are based on the proper wind speed duration.

B. Wind Direction

Verify that critical wind directions have been evaluated. For example, for a crane on rails, verify that wind directions both parallel and perpendicular to the rails have been included, as well as wind in diagonal directions.

C. Wind Loading and Effective Wind Area

Verify that the wind effects on various crane component shapes are accounted for. Verify that wind loading on the crane boom is properly addressed, including when the wind direction is parallel to the crane boom.

D. Industry Codes and Standards

1. Determine which code or standard has been used to establish wind loading.

2. Ensure that mixing and/or substituting wind load factors and coefficients from different codes and standards is avoided. For example, the use of FEM and ISO standards is acceptable as described in Appendix F; however, using FEM or ISO standards along with gust factors (G) and directionality factors (Kd) from ASCE 7 or DS 1-28 (which is not the intent of FEM, ASCE 7, or DS 1-28) is unacceptable and can result in substantially reduced wind load determinations and inadequate crane securement.

It is not intended that FM plan review obtain copies of the industry codes and standards, but rather to verify which codes or standards were used.

E. Verify that adequate safety factors for crane securement against rolling, sliding, and overturning are used under reasonably adverse conditions, including wind direction, crane configuration (e.g., boom raised or lowered, and crane load and position), and wet or greasy rails. Wind securement can include wheel motor brakes, wheel brakes, storm brakes, stowage pins, and tie-downs.

F. Verify that the means of moving the crane (e.g., gantry wheel motors) are adequate under reasonably adverse conditions, including moving the crane into its secured location against a direct headwind.

G. Request a summary sheet from the crane manufacturer or a licensed engineer who has evaluated the crane to address the points listed in this checklist.

APPENDIX F ADJUSTMENTS TO WIND SPEED OR WIND PRESSURE WHEN USING CERTAIN FEM

When ISO 4302 or the Federation Europeenne De La Manutention (FEM) standard FEM 1.001 with FEM 1.004 or FEM 1.005 are used to determine design wind pressures on cranes, use the following wind speed or wind pressure adjustments for the given Surface Roughness (Exposure) conditions:

1. Surface Roughness (Exposure) B: No wind speed or wind pressure adjustments are needed.

2. Surface Roughness (Exposure) C: Increase the basic wind speed by 5%, or increase the design wind loads by 10%.

3. Surface Roughness (Exposure) D: Increase the basic wind speed by 10%, or increase the design wind loads by 20%.

For in-service conditions where wind speed thresholds are based on adequate and reliable anemometer wind speed readings located at or near the top of a crane, these adjustments are not necessary.

Refer to DS 1-28, *Wind Design*, for basic wind speeds and definitions of ground surface roughness (exposure).

APPENDIX G MAINTENANCE

The following are actions to include (as applicable) in the general, crane rail, wire rope and wire sling inspection, testing and maintenance program.

G.1 General Maintenance

A. Before adjustments and repairs are started on a crane, make certain it is completely shut down. If it shares a runway with other cranes, use rail stops to isolate the crane.

B. Ensure only designated persons make repairs and adjustments.

C. Choose replacement parts that are in accordance with the original equipment manufacturer's specification. Make repairs with the same factor of safety and reliability as the original design.

D. Adjust and maintain storm brakes so they operate properly and with the maximum holding power.

E. Adjust all normal stops, over-travel, and skew-limit switches for each major function to ensure proper operation.

F. Keep all drives equipped with brake solenoids and mechanical shoe brakes in good working order. Make adjustments for wear and alignment or replace brake shoes to ensure proper braking.

G. Ensure the boom hoist drum has sufficient rope capacity to operate the boom at all positions from horizontal to the highest angle recommended, and uses the manufacturer's recommended reeving and rope size.

H. Ensure the swing (slewing) mechanism can start and stop smoothly with the varying degrees of acceleration and deceleration required in normal crane operation.

G.2 Crane Rail Maintenance

Keep crane rails in good operating condition.

A. Keep rails level, straight, and properly spaced for crane tracks.

B. Keep rails securely attached to the supporting surface, and electrically grounded.

C. Keep rails adequately spliced, and with tight smooth joints.

D. Keep rails maintained to permit automatic rail brakes to function effectively.

E. Keep rails clear of stones and scrap, and free of greases, hydraulic fluid, beadings, and bends.

G.3 Wire Rope/Sling Maintenance

A. Store rope and rope slings in such a manner as to minimize damage or deterioration.

B. Unreel or uncoil rope as recommended by the rope manufacturer and with care to avoid kinking or twisting.

C. During installation, take care to avoid dragging the rope in dirt or around objects that will scrape, nick, crush, or induce sharp bends.

D. Maintain rope on cranes in a well-lubricated condition. Ensure lubricant applied as part of a maintenance program is compatible with the original lubricant and of a type that does not hinder visual inspection.

E. Discontinue service of wire rope or wire rope slings when any of the following conditions are disclosed by inspection:

1. In running ropes, six randomly distributed broken wires in one lay, or three broken wires in one strand in one lay

2. In standing ropes, more than two broken wires in one lay in sections beyond end connections, or more than one broken wire at an end connection

3. In rope slings, ten randomly distributed broken wires in one rope lay, or five broken wires in one strand in one rope lay

4. Wear of one-third the original diameter of outside individual wires

5. Kinking, crushing, bird caging, or any other damage resulting in distortion of the rope structure

6. Evidence of any heat damage from any cause

7. Reduction from nominal rope diameter per industry standards

8. Excessive wear or corrosion, deformation, or other defect in the wire or attachments, including cracks in attachments

9. Hooks that have been overloaded and deformed (for example, normal throat opening exceeded or twisted from the plane of the unbent hook)