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Crane Safety: Are You Prepared to Hold the Load of a Major Incident?

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Introduction

Crane-related injuries are often severe and pose a serious hazard for employees and operators – Crane-related fatal occupational injuries in the United States from 1997 to 2006 identified an average of 81.6 fatalities per year (BLS 2008). Despite the fact that there are a considerable number of regulations and standards as a reference to establish controls, Cummins, Inc. required an internal crane safety strategy with specific selection of standards based on internal needs.

The general situation, in this case study, reflected operations where incidents started to occur at a higher frequency than expected. Fortunately, incidents were associated mainly with near hits (no human injury) and a minority of incidents with minor injuries – e.g. collapse, overturning or failure of lifting equipment. The monitoring of this proactive indicator laid the path to prevent catastrophic incidents with cranes, including fatalities.

The company ventured to develop a customized internal strategy, aimed at preventing crane related incidents, sustained on the following elements: A. Pre-defined training levels; B. Custom-built inspection types; C. Crane design parameters and design of fundamental components; D. Safe operation elements, and E. Internal rigging plan. This arrangement of in-house-designed hazard-control elements based on past crane-related incidents in the corporation (including near hits) translated into a robust strategy applicable to more than 116 manufacturing sites. Key experienced individuals were selected to participate and contribute in the development of the strategy.

Pre-defined Training Levels

The prevention of crane incidents is influenced by adequate and effective training. An analysis of crane incidents from OSHA (*Occupational Health & Safety Administration*) public records concluded that in 70% of incidents, proper training could have prevented the consequence (Lang 2011). Internal incident analysis in the company concluded that concurrent root causes were associated with "safe operation" elements. As a result, four core levels of training were defined:

1. *Awareness level* training aimed at all employees who may be affected by the operation of cranes. Customized training content compiled with fundamental crane hazards awareness and basic hazard mitigation controls as key components.
2. *Management level* training focused on managers, supervisors and leaders at the site who influence decision-making processes on any crane aspect and/or the site safety program. Also, customized training with basic and technical content necessary to make informed decisions (i.e. crane types, uses and associated hazards).
3. *Operator level* training as designed in conventional programs (e.g. crane components, controls, operation, rigging and inspection) and mainly concentrated in overhead and/or floor cranes per the nature of the company manufacturing environment. Certification and license-issuing operator program was also defined and implemented internally.
4. *Specialty level* training focused on special pre-defined circumstances associated with singular hazards and content delivered by a qualified contractor. The identified circumstances for *equipment operations* include: a) mobile cranes; b) tower cranes; c) remote-operated cranes, and; d) cab-operated cranes. Circumstances for *load handling* include: a) multiple crane or hoist activities; b) load turning, up righting or laying loads 90-180 degrees; c) loads regarded as complex, high consequence or critical, e.g. hazardous materials, significant production areas, irreplaceable items, high potential risk to personnel, or significant commercial impact; d) lifting of personnel in a crane supported manbasket, and; e) load handling near power lines.

This training approach provided the framework to maintain employee engagement, leaders informed operators, qualified operators and cover special circumstances. Theoretical and practical training was a key component – a printed-license operator program proved to be key for a robust system.

Custom-Built Inspections

The majority of regulations in different countries are prescriptive in the hoist and crane inspection elements. However, unique internal issues may not be inspected at the right level of detail to ensure incident prevention; therefore such aspects were included in addition to regulatory requirements.

The company experienced crane incidents related to ropes, hooks and sling failure. Consequently, inspection criteria were strengthened at every level around these three components. In general, the company re-designed the common inspection types in the following:

- *Initial Inspection*. Detailed examination, by a qualified contractor, for new, altered and/or modified cranes before initial utilization. Predefined criteria were established with added elements and were also focused on internal incident trends.
- *Daily Inspection*. A visual and operational inspection by the operator of the hoist & crane at the beginning of the shift or when it is first operated each day.
- *Frequent Inspection*. Visual examination by an internal qualified party with frequency based on service classification (i.e. normal use - quarterly, heavy use – monthly and severe use - weekly).
- *Periodic Inspection*. Detailed examination by a qualified contractor in which period is defined by crane service classification:

- Annually - Normal service: service that involves operating at less than 85% of rated load and not more than 10 lift cycles/hr except for isolated instances.
- Bi-annually - Heavy service: service that involves operating at 85 to 100% of rated load or in excess of 10 lift cycles/hr as a regular specified procedure.
- Quarterly - Severe service: service that involves handling load approaching the rated capacity in excess of 20 lift cycles/hr and/or abnormal operating conditions.

The addition of such inspection elements (e.g. hooks, ropes and synthetic slings criteria at every level) to regulatory requirements resulted in a more comprehensive inspection process. A key input for the identification of these additional inspections elements was an effective crane incident management and analysis that unveiled trends on root causes – ASME B30.10 and ASME B30.26 were important references.

Crane Selection and Design Parameters

Selection of the appropriate crane for the lifting need is important for an effective operator-crane interaction and the prevention of incidents. Only some regulations and standards worldwide offer information on this regard (e.g. ISO 23813). Essential points to evaluate before crane selection were defined in Table 1. In addition, guidance was provided for the "design safety factor" (ratio between nominal or minimum breaking strength and rated load capacity of the component) by establishing minimum values – or compliance with local regulations if more stringent parameters apply.

Crane Selection Elements	Design Safety Factor
1. Masses, dimensions and characteristics of loads 2. Operational speeds, radius, heights of lifts and areas of movement 3. Number, frequency and types of lifting operations 4. Length of time for which the crane will be required or anticipated life expectancy for a permanently installed crane; 5. Site, ground and environmental conditions or restrictions arising from the use of existing buildings 6. Clearances to overhead electrical power lines 7. Space available for crane access, erection, travelling, operation and dismantling 8. Any special operational requirements or limitations imposed. 9. Physical condition of the crane.	Wire rope – 5 Steel chain – 4 Synthetic slings – 5 Load block – 4 Rigging hardware – 5

Table 1. Crane selection elements and Design Safety Factors (ISO 2007)

Safe Operation

As previously stated, effective training plays a key role in the prevention of incidents by providing knowledge and guidelines to allow for a safe operation of the crane and identifying potentially hazardous conditions – errors while operating is the main root cause of company crane incidents. The principle "cranes should be operated with the expectation that the load (or components) could fall at anytime" was communicated as an operating guideline. This fact not only increased awareness but also facilitated the identification of general safe operating rules, which have been related with incidents in the general industry. Some rules defined were referenced to specific incidents that occurred in the company, e.g. capacity calculations errors when lifting with two or more cranes.

Multi-hoisting (lifting loads with two or more cranes) safety criteria were also improved with the following elements:

a. Qualified person shall be in charge of the operation
b. Placement of the hook in relation to the identified center of gravity is critical
c. Each crane load proportion shall be calculated
d. Multiple lifting should comply with ISO 12480-1 standard

Different regulations and standards offer safe operation guidelines (i.e. ASME, OSHA, CMAA, ISO, etc.). Communication, enforcement and adequate understanding by operators are essential for the prevention of potentially catastrophic incidents.

Internal Rigging Plans

Improper arrangement of rigging hardware could cause the load to drop and potentially result in injury and environmental or property damages. The most common root cause of load drops is poor rigging practices (59%) as stated by Lang (2011) in a recent study. Internal incident analysis also reflected that specific rigging hardware required special attention: hooks, wire ropes and synthetic slings.

As a result, a rigging plan form was designed with general rigging elements but also with customized points that would ensure specific needs were addressed. Adequate rigging processes require the rigger to assess: a) the weight of the load and rigging hardware, b) the capacity of the crane, and c) the working load limit of the rigging hardware. This rigging plan focused on weight-capacity interaction among these three elements.

This form or rigging plan was designed to be completed by a qualified person – with the aid of operators and supervisors – on a periodic basis or sooner if the rigging arrangement required modification. See Table 2.

Rigging Lift Plan

PART A – General Information

Document Number:		Prepared by:		Date:	

Load(s) description *(insert lines as needed)*

#	Load description	Weight	Material	Symmetrical (Y/N)	Center of gravity identified? (Y/N)	Load share (when center of gravity is side-tilted)	Rigid or flexible (R/F)	Tag line used (Y/N)	Edge Softener /Pads (Y/N)	Observations

Precautions and limitations:-	Ensure that rigging hardware, cranes, hoists, and other lifting equipment are never loaded beyond their rated capacity. It shall not be assumed that a multi-sling hoist will safely lift a load equal to the rated capacity of one sling multiplied by the number of slings. With lifts of more than two slings and a rigid load, two of the slings alone could be bearing the full load while the other slings merely balance it.

Lifting Equipment Information

Lifting Equipment (Crane) ID/ Description:		Rated Capacity (specify units):		Location:	

Manufacturers' Instructions, scheduled inspections documentation, and Rigging Capacity Card available at the point of use (please circle)	Yes	No

Lifting Equipment analysis *(insert lines as needed)*

Lifting items	Description /Type	Size	Quantity	Length (Slings)	Horizontal Angle	Sling mode (Vertical, Choker or Basket)	Rated capacity	Calculated sling load/share	Design safety factor	Observations
Slings - Wire rope, chain, synthetic OR other										
Hooks										
Shackles										
Turnbuckles, eye bolts, eye nuts, swivel hoist										
Links, rings and swivels										
Rigging Block										
Wire rope clips, wedge sockets.										
Below the hook devices										

Lift Plan Approvals

Lead Crane operator		Signature		Date	
Foreman/ Supervisor		Signature		Date	
Qualified Rigging Approver		Signature		Date	

Lift Plan Review Dates

Released date		1st Year Review		2nd Year Review	
3rd Year Review		4th Year Review		5th Year Review	

Table 2. Rigging Lift Plan (Cummins 2011).

Conclusions

Statistics show that crane accidents are more likely to cause injuries and/or deaths than most other types of equipment (Howell 2007). Hence, the importance of focusing on crane incidents before injury occurs (near hits) should trigger the strategy to prevent potentially disastrous events.

Each implemented element of this strategy posed advantages at different levels. The augmented training content at the defined levels (awareness, manager, user and specialty) provided the framework for informed employees at all levels in the organization. The re-designed inspection types (i.e. daily, frequent and initial/periodic) strengthened the verification processes. Moreover, the addition of crane selection criteria and design parameters increased knowledge for a more informed decision-making process. Finally, an innovative approach in ensuring all rigging hardware met capacity requirements was sustained in an auditable-documented plan that helped fill verification gaps for below-the-hook devices.

All the elements in this strategy are complemented (and exceed in some cases) by local regulations in various countries. In addition, the elements create an environment to prevent crane hazards that could potentially result in serious incidents. This model is the result of a selected team of subject-matter experts within the company and a comprehensive review of national and international standards.

Main strategy outcomes:

1. Reduced monthly average of crane-related incidents (near hits)
2. Strengthened the operator and manager training and a generally raised crane safety awareness among employees
3. Improved and customized inspection processes based on company's needs
4. Innovated below-the-hook or rigging evaluation plans aimed at reducing hardware capacity failures and revised/audited on an annual basis.
5. Collectively design a thoughtful strategy, leveraged on cross-functional teams, based on internal needs and company-based approaches.

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