National Urban Search & Rescue Response System
Heavy Equipment & Rigging Specialist Training

Heavy Equipment & Rigging Specialist Training

Module 3 Unit 2:

Learning from Crane Accidents & Non Traditional Methods

8Oct08 1

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Unit Objective

- Demonstrate how human error and improper setup of mobile cranes have caused disastrous accidents
- Discuss Non-Traditional Methods to extend crane lifting capacity

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Enabling Objectives

- Discuss historical causes of accidents and fatalities
- Discuss causes of mobile crane collapses
  - Overload by winds
  - Improper outrigger support
  - Improper load control
  - Loss of load at high boom angle
  - Inadequate lubrication
  - Improper boom movement
- Discuss requirements for safe use of man baskets
- Discuss Methods to Extend Crane Lifting Capacity

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Information & Photos Provided by

- **Bernard Ross, Ph.D., P.E.
Exponent, Failure Analysis
Menlo Park, CA**

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The Problem

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Fatal Occupational Injuries
(by Industry, 1993)

Construction	920
Transportation and public utility	890
Agriculture and forestry	830
Retail trade	785
Manufacturing	780
Services	775
Government	640
Wholesale trade	260
Mining	180
Finance, insurance and real estate	110

Source: U.S. Bureau of Labor Statistics, U.S. Dept of Labor

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Construction Industry Injury Rates

(Total Cases per 100 Workers, 1993)

Hoists, cranes, and monorails	16.6
Mining machinery	16.1
Trucks and tractors	15.6
Construction machinery	14.0
Conveyors	13.3
Elevators and moving stairs	12.8
Oil and gas machinery	10.3

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Crane Accident Summary

(from I.U.O.E., Local #18)

Support failure	=	32%
Failure to use outrigger	=	23%
Operator error	=	33%
Structural failure	=	11%
High wind	=	2%

Over half relate to crane setup

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All Crane Fatalities

(Ref: Crane Safety, 1984-94)

Power lines	=	198	39%
Assembly/disassembly	=	58	12%
Boom buckling/collapse	=	41	8%
Overturn	=	37	7%
Rigging failure	=	36	7%
Overloading	=	22	4%
Struck by moving load	=	22	4%
Two-blocking	=	11	2%
TOTAL		425	

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Mobile Crane Fatalities
(Construction Industry, 1969-89)

Power lines	=	48	44%
Rigging	=	16	15%
Load handling	=	15	14%
Operator error	=	8	7%
Overload	=	8	7%
Dismantling boom	=	5	5%
Wire rope failure	=	5	5%
Miscellaneous	=	5	5%

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The Proof

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BIG BLUE - Collapse at Miller Park

Video was provided by Exponent / Failure Analysis

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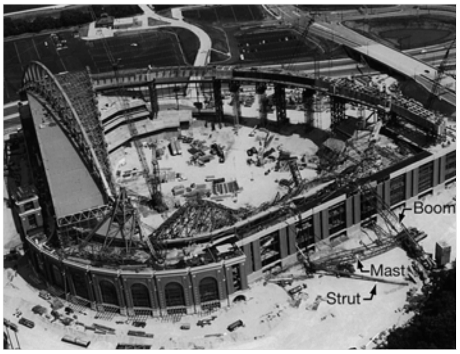
Post Accident Scene



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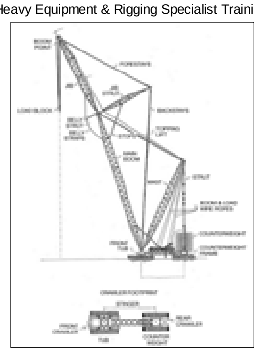

LTL-1500-IIIA **Post Accident**

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Roof Panel Section, 4R3

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Two Crane Lifts

Poor Planning leads to Poor Results

Pre-lift meetings are Required

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Take down this tower next to power line

But is there a Plan?

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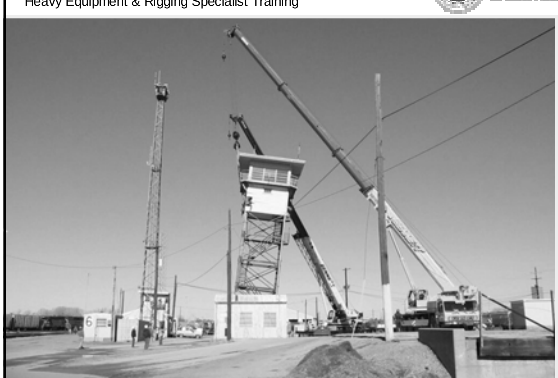

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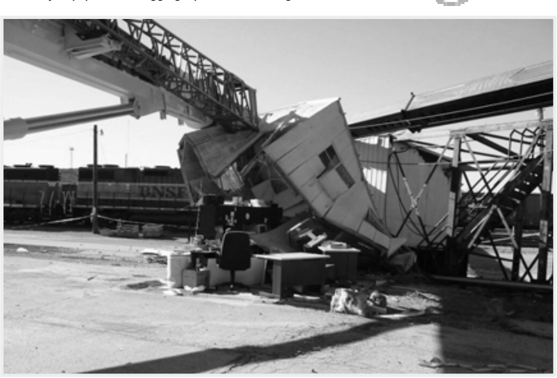

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Did the Plan Account for Railroad Traffic?

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Feb07 – Pleasanton, CA - One Killed

2 Crane Pick, Operator was Trapped & Survived

2 Crawlers fell on small RT Crane

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Mobile Cranes

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Crane Tip-Over
Due to Improper Load Control

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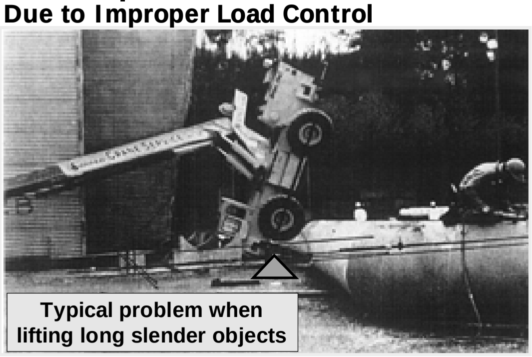
Crane Tip-Over
Due to Improper Load Control



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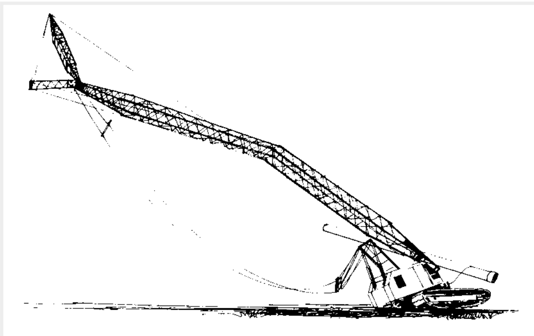
High Boom Angle Over Back



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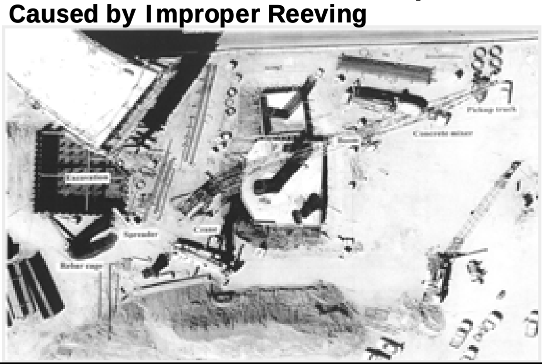
Accident at San Francisco Airport
Caused by Improper Reeving



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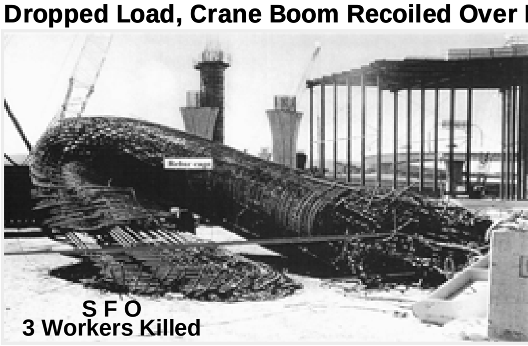
Lifting Cable Broke
Dropped Load, Crane Boom Recoiled Over Back



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S F O - Proper Reeving

This is what should have been done

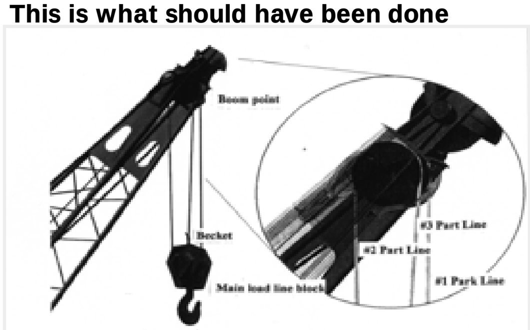

Figure 24a. Proper reeving of M4000 crane

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S F O - Improper Reeving

What was done – looked OK w/ boom down

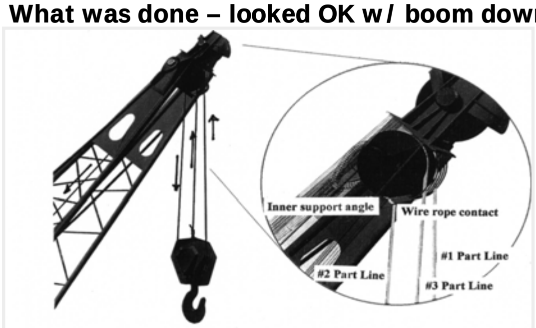

Figure 24b. Improper reeving M4000 crane at time of accident

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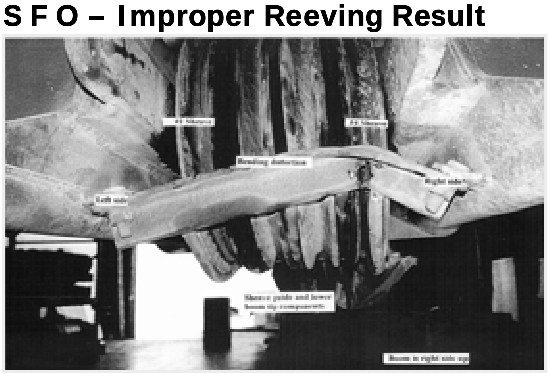
S F O – Improper Reeving Result



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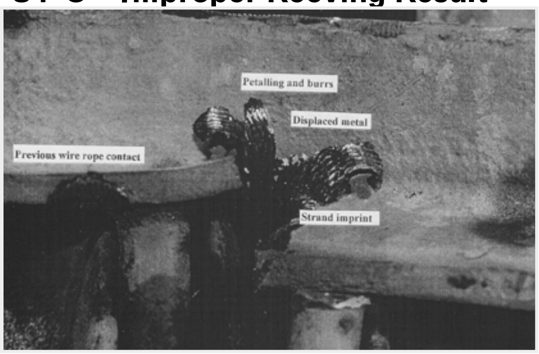
S F O - Improper Reeving Result



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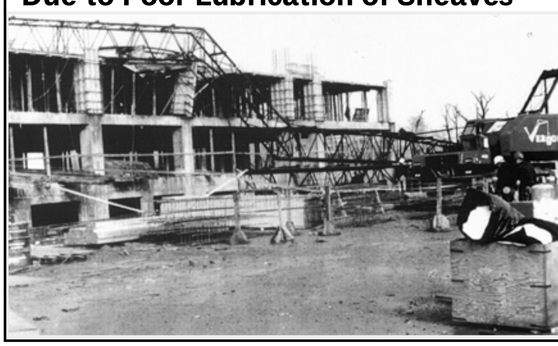
Boom Collapse Due to Poor Lubrication of Sheaves



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Boom Collapse Due to Poor Lubrication of Sheaves

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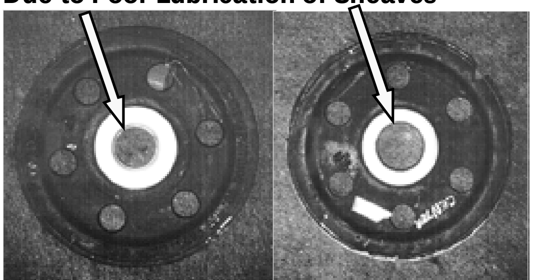
Boom Collapse
Due to Poor Lubrication of Sheaves



New sheave w/bearing | With bearing worn away

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Pin was worn through

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Santa Monica 1999 Accident
Boom Failure Due to Rapid Swing

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Santa Monica 1999 Accident
Boom Failure Due to Rapid Swing

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Santa Monica 1999 Accident
Pile Driver Fell on Hwy 101 Off-Ramp

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Santa Monica 1999 Accident
Pile Driver Fell on Hwy 101 Off-Ramp

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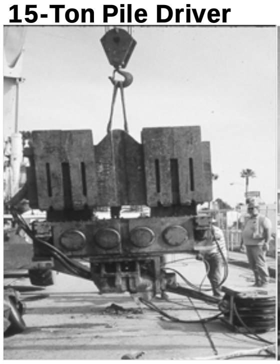
Santa Monica 1999 Accident
15-Ton Pile Driver



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Santa Monica 1999 Accident
"One Completely Used Mercedes"

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2nd Crane Accident, Santa Monica 2001
Boom struck building during shut-down

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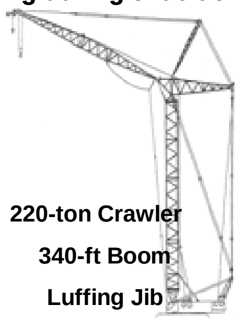
2nd Crane Accident, Santa Monica 2001
Boom struck building during shut-down



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2nd Crane Accident, Santa Monica 2001
Buckled Boom

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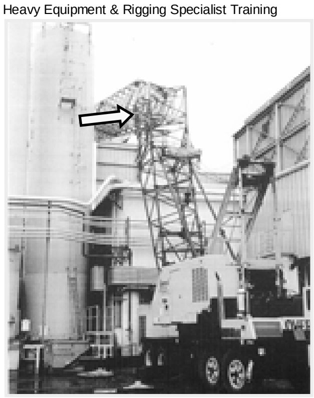

**Boom Struck Tank During Lift,
Buckled Boom**

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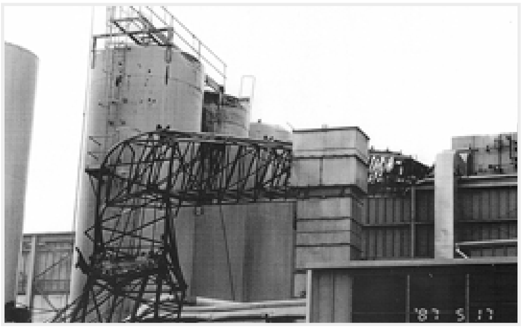
Boom Struck Tank During Lift
Buckled Boom



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Recent Crane Collapses 2005 - 2008 Caused by Wind and Human Error

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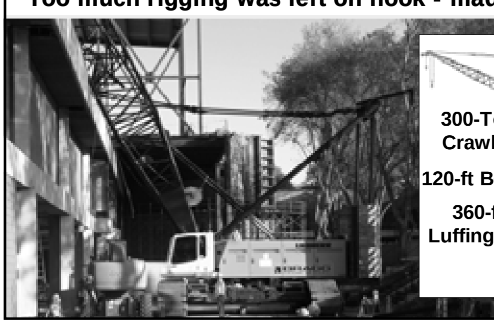
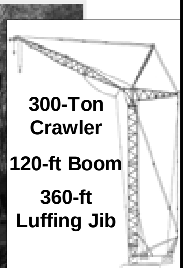
Valco Shopping Mall, CA
Collapsed in wind storm
Too much rigging was left on hook - made sail



300-Ton Crawler
120-ft Boom
360-ft Luffing Jib



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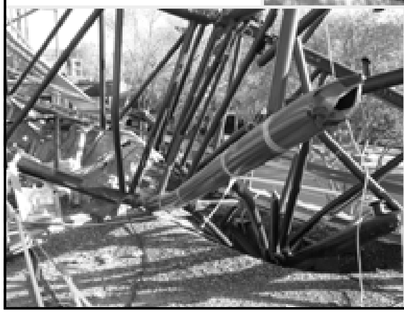
New Steel Framing was being placed over existing Stores



Valco Shopping Mall

Valco Shopping Mall
Crane Damage
Structure Damage
Loss of Business

San Jose, CA
82T Link Belt
120-ft Boom + 90-ft Pile Driving Leads w/Diesel Hammer

Hammer cap got stuck and operator tried to loosen by swinging boom, but collapsed boom

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Hanover Co.,VA Oct06 Lifting PC Panels
Carelessly Reconfigure Pick Points off Man Lift
Very vulnerable situation – Racing to Complete

Man Lift Bumped Panel

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Hanover Co.,VA Oct06 Lifting PC Panels

Fortunately no death, but Serious Injury to Operator

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Bellevue, WA – Nov06 – One Killed
Collapsed in Wind as Operator was Closing Down

210 Ft Tower Crane

Anchored w/Bolts

Damaged 3 Adjacent Buildings

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Bellevue, WA – Nov06 – One Killed

Operator fell 200ft & walked away

Damaged 3 Adjacent Bldgs

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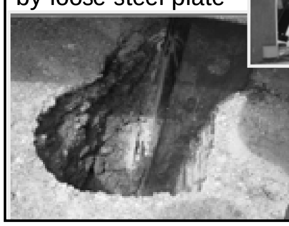
Tat Hong Plant
Hong Kong
100T Crane

Operator was Killed
by loose steel plate



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Tat Hong Plant Hong Kong 100T Crane

Operator was Killed
by loose steel plate

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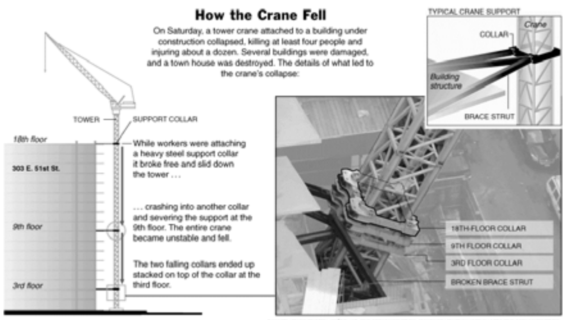
NYC Tower Crane Collapse- Mar08



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NYC Tower Crane Collapse- Mar08

Crane fell into bldgs across street

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NYC Tower Crane Collapse- Mar08

Searching for victims ⇑

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Castle Hill, Sydney – New 250T Crane

First use of $4mil Liebherr Crane Shoring failure in story below crane

Initial failure with crane teetering for 1 hour

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Castle Hill, Sydney – New 250T Crane

After 1 hour Crane collapsed into the story below

Each O. rigger was shored Shoring stability failure?

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Castle Hill, Sydney – New 250T Crane

Initial Failure

Final Collapse (after 1 hour)

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Near Perth, Australia – 160T Crane

Crane set too close to wall, so swing caused counterweight to hit wall brace

Tilt-up wall braces are vulnerable to buckling

(50k, 25ft high wall)

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Suspended Personnel Platforms (Man Baskets)

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Seattle Dome Man Basket Collapse

Too Much Noise to Communicate

OSHA Approved?

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Man / Woman Basket in Mexico City

OSHA Approved?
Crane Capacity?

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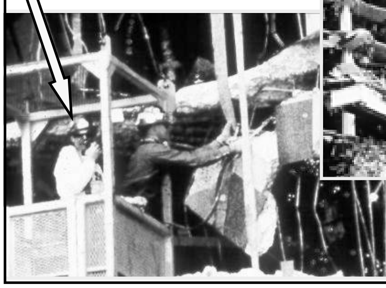
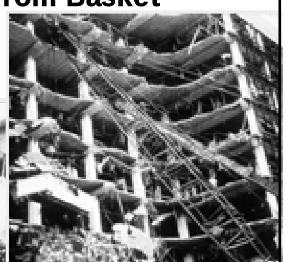
HERS needs to Work from Basket

Using Radio Comm.





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OSHA Requirements for Lifting Personnel

- **Rated capacity at lift radius divided by 4**
- **Full-cycle operational test before lifting**
  - **Verify stability of footing**
  - **Verify swing, obstructions, etc.**
- **Pre-lift plans—boom angle and max load**
- **Use outriggers, firm footing and level (1%)**
- **No more than 4 persons at one time**
  - **Estimate at 250 lb each**
- **Do not use free-fall option**
  - **Power up, power down operation only**
- **Do not use in poor weather conditions**

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California / OSHA Requirements for Lifting Personnel

- All persons to be secured by safety belt
- Use rated and approved man basket
- Operator and signal persons in continuous sight of persons in man basket
- Secure variable radius boom to prevent accidental movement
- Operator to remain at controls for entire lift

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Additional Requirements for Lifting Personnel

- No practical alternative
- Statement attesting need
- Inspect crane before lifting
- Pre-lift meeting with operator, signal person, and lifted personnel
- Test with empty man lift platform
- Maintain communications
- Two-block audible warning system
- No crane travel with personnel on platform

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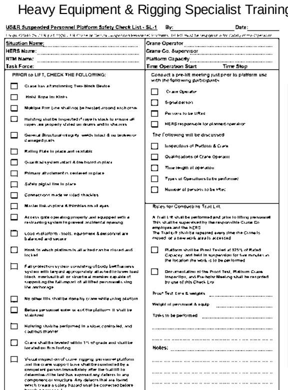

Suspended Personnel Platform Check List

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Non-Traditional Methods

- Describe non-traditional uses of cranes in difficult and unusual conditions
- Explain out-of-chart lifts
  - The risks
  - Non-traditional techniques
  - Mitigating the risks
- Identify the limits of unique lifts

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Sometimes Your Ass is Too Small

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The Risks

- Crane overturn
  - Safety Factor 1.18 to 1.25
  - Governs at boom angles less than about 45 degrees—depending on configuration
- Boom failure
  - Unknown Safety Factor
  - Governed by buckling for lattice boom
  - Governed by main hydraulic cylinder for hydro cranes
  - Jibs may be governed by buckling

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The Risks (continued)

- Wire rope failure
  - Safety Factor is 3.5 to 1 for running ropes
  - Safety Factor is 3.0 to 1 for standing ropes
- Outrigger failure
  - Hydraulic cylinder failure
  - Structural failure
- Other structural or system failure
  - Pivot bearing
  - Hoist drums

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Non-Traditional Methods

- Partial pick
  - Up enough to rescue or crib
  - Up on outriggers
- Pick and hop
- Pick and scoot
- Two Crane Picks

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Non-Traditional Methods
Minimum Requirements

- No other alternative practical within given timeline
  - Always need rigging plan and meeting
  - One signal person to control lift
- Crane will be operating in load chart range governed by overturning
  - Best considered when load less than 25% of crane's maximum capacity

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Non-Traditional Methods
Minimum Requirements (continued)

- Rigging of adequate capacity
- Ground bearing capacity under tracks or outriggers adequate

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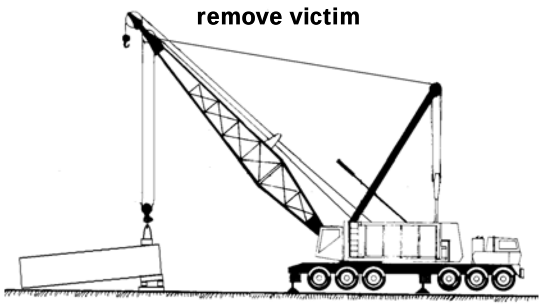
Partial Pick
Lift only part of the load, then crib to remove victim



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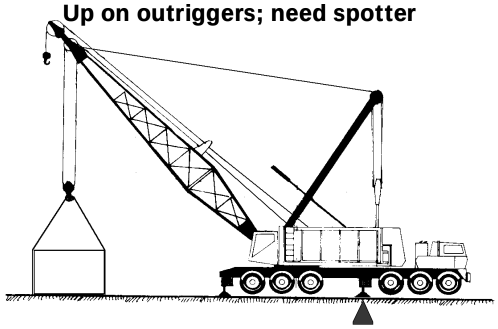
Partial Pick (continued)
Up on outriggers; need spotter



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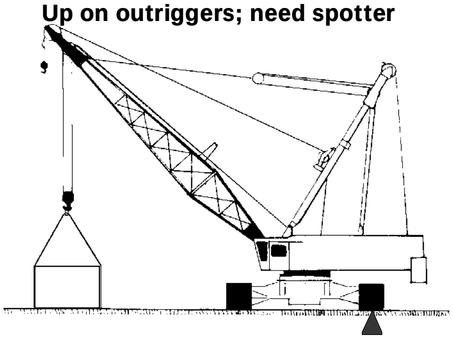
Partial Pick (continued)

Up on outriggers; need spotter



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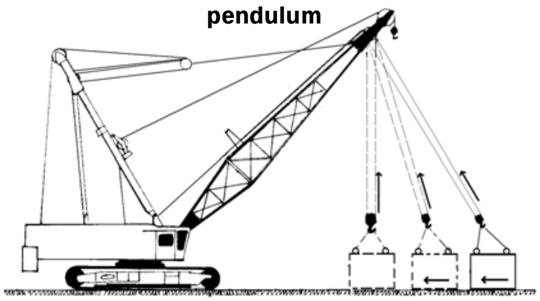
Pick and Hop

Use series of short lifts and the action of a pendulum



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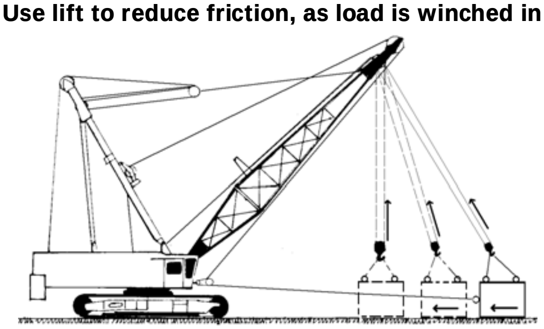
Pick and Scoot

Use lift to reduce friction, as load is winched in



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Mitigating the Risk

- Controlled drop
  - After picking up, need to get rid of load
  - Allow load to drop freely
  - Catch load just as it contacts ground
  - Crane is saved from overturning, forward and/or backward
- Selling load
  - When picking up load that is over limit, pre-plan location to drop load
  - Location needs to be near pickup point

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Mitigating the Risk (continued)

- Create no-fly zones
  - For near capacity lifts, clear zone that will allow for collapse of boom, as well as dropping load
- Attempt out-of-chart lifts only when other alternatives not practical within given timeline
- Mitigate extra risks involved
  - Special rigging meetings and planning

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Two-Crane Picks

- Considered as last resort
  - Always need rigging plan and meeting
  - One signal person to control lift
  - Site needs to be cleared of rescue personnel
- Position cranes so as to minimize swinging and booming when hoisting
  - Hydro boom length should be set before lifting—no telescoping when lifting
  - Minimize traveling with load
- Check all machinery and rigging before lift
- Control load with tag lines

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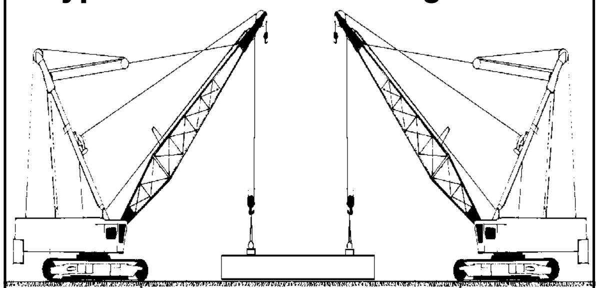
FEMA

Typical Two-Crane Configuration



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Two-Crane Lift at OKC Bombing Site

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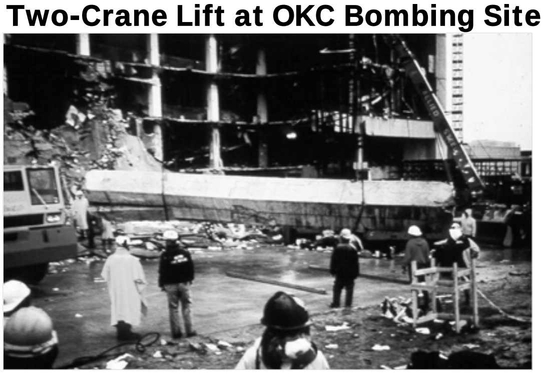
FEMA

Two-Crane Lift at OKC Bombing Site



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Saureman w/ or w/o High Line

- Unique system allows work at great distance (such as in very soft ground)
- Need bomb-proof dead man
- Need experienced operator
- Need to drag Saureman bucket to fill it
- May be configured with operable jaws as is done in timber harvesting

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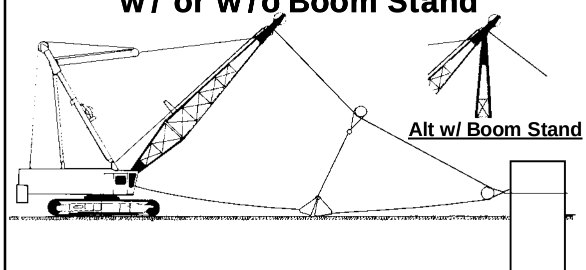
Saureman on Trolley w/ or w/o Boom Stand



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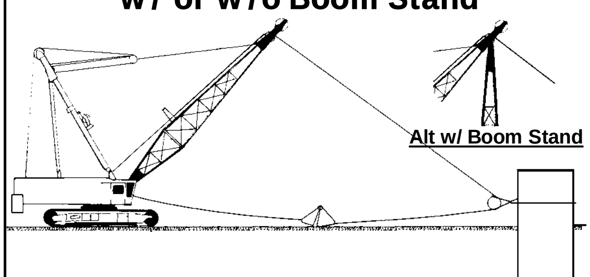
Saureman w/o Trolley w/ or w/o Boom Stand



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Non Traditional Methods Summary

- Attempt out-of-chart lifts only when other alternatives not practical within given timeline
- Mitigate extra risks involved
  - Special rigging meetings and planning

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Overall Summary

- Cranes are very complicated machines that are subject to human error
- Factors of safety are small and failures can be sudden and catastrophic
- Successful operations are best assured through careful planning
- Attempt out-of-chart lifts only when other alternatives not practical within given timeline
  - Mitigate extra risks involved
  - Special rigging meetings and planning

We Do Not Want to Create Another Disaster

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Evaluation

Please complete the evaluation form for Module 3 Unit 2: Learning from Crane Accidents & Non Traditional Methods

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STUDENT MANUAL

HEAVY EQUIPMENT & RIGGING SPECIALIST TRAINING

MODULE 3

UNIT 2: LEARNING FROM CRANE ACCIDENTS & NON-TRADITIONAL USE OF CRANES

Unit Objective

Upon completion of this unit, you will be able to identify the Principal Causes of Crane Accidents and the non-traditional uses of mobile cranes that might be employed in Urban Search and Rescue (US&R) operations.

Enabling Objectives

You will:

- Review the Data on Causes of Accidents
- Review numerous Case Studies from previous Crane Accidents
- Describe non-traditional uses of cranes in difficult and unusual conditions;
- Explain out-of-chart lifts:
    - ♦ The risks,
    - ♦ Non-traditional techniques, and
    - ♦ Mitigating the risks; and
- Identify the limits of unique lifts:
    - ♦ Two-crane lifts and
    - ♦ Saureman on high line.

Overview

In this section, we will review the principal causes of Crane Accidents, in order to better prepare the Disaster Site to mitigate the risks when using these helpful, but potentially dangerous machines. In addition the classroom presentation will include the Case Studies of about a dozen Crane Accidents, all of which have occurred since 1995.

We will, also, discuss some of the alternatives when one is faced with the situation at the disaster site in which the available crane does not quite have the rated capacity to perform a particular lift.

These "non- traditional" methods are intended to be used only when other, less risky alternatives are not available within the necessary timeframe. We do not advocate the routine use of cranes, or any other rescue tools, beyond their rated capacity, but situations may be encountered in which cranes can be used in non-traditional ways to successfully accomplish difficult tasks.

Crane Accident Summary

As with most accidents, human error causes most crane accidents.

According to the International Union of Operating Engineers (IUOE), over half of crane accidents relate to crane setup.

The causes that relate to setup include:

- Ground subsidence beneath outriggers/outriggers blocking,
- Soft footing for crawlers,
- Failure of outrigger blocks,
- Crane slipping off blocks,
- Operator neglect during setup,
- Lifting boom without outriggers, and
- Changing boom and/or counterweights without outriggers.

Other causes include:

- Violent control movements,
- Boomed out beyond safe working radius,
- Overload,
- Out of level,
- Boom collapse—backwards and structural failure,
- Boom hoist failure,
- Outrigger structural failure, and
- High winds.

Crane Accident Statistics

The Construction Industry, unfortunately is one of the most dangerous work places. Within this industry, the use of heavy equipment is at the top of the list for highest percentage of accidents, as is noted in the statistics listed below:

Fatal Occupational Injuries, by Industry 1993

- Construction 920
- Transportation and public utility 890
- Agriculture and forestry 830
- Retail trade 785
- Manufacturing 780
- Services 775
- Government 640
- Wholesale trade 260
- Mining 180
- Finance, insurance and real estate 110

Source: U.S. Bureau of Labor Statistics, U.S. Dept of Labor

Construction Industry Injury Rates (Total Cases per 100 Workers, 1993)

- Hoists, cranes, and monorails 16.6
- Mining machinery 16.1
- Trucks and tractors 15.6
- Construction machinery 14.0
- Conveyors 13.3
- Elevators and moving stairs 12.8
- Oil and gas machinery 10.3

Crane Accident Summary (from I.U.O.E., Local #18)

- Support failure 32%
- Failure to use outrigger 23%
- Operator error 33%
- Structural failure 11%
- High wind 2**%**

Over half relate to improper Crane Setup

All Crane Fatalities (Ref: Crane Safety, 1984-94)

Power lines	198	39%
Assembly/disassembly	58	12%
Boom buckling/collapse	41	8%
Overturn	37	7%
Rigging failure	36	7%
Overloading	22	4%
Struck by moving load	22	4%
Two-blocking	11	2%
TOTAL	425	

Mobile Crane Fatalities

The leading by far cause of fatalities that have occurred during the operation of mobile cranes is contact with power lines.

Special safety rules apply when cranes are required to operate near them.

- Depending on power line voltage, the required clearance from live wires varies from 10 to 25 feet.
- A spotter/signaler must be stationed near the clearance distance from the power line whenever a crane is within boom's length of the limit of approach.
- This person should have no other job than to signal the crane operator regarding the boom's position relative to the power line.

Mobile Crane Fatalities (Construction Industry, 1969-89)

Power lines	48	44%
Rigging	16	15%
Load handling	15	14%
Operator error	8	7%
Overload	8	7%
Dismantling boom	5	5%
Wire rope failure	5	5%
Miscellaneous	5	5%

The Risks

Crane Overturn

The rated capacity of a crane is governed by overturning when the lifting radius is greater than 50 feet or so in most cases.

Most cranes are rated for their maximum lift at a radius of only 10 feet.

- In this case, the capacity is usually governed by the structural strength of the boom (the critical parts), and the Safety Factor (SF) may be 2 or more.

However, when the boom angle is less than about 45 degrees, most cranes are governed by overturning.

- In this case, the SF is 1.18 for cranes on outriggers and 1.33 for crawler cranes.

The boom angles (and radius) for which a crane's capacity is governed by overturning is highly dependent on type and configuration and is indicated in the crane's load charts.

Boom Failure

Crane manufacturers do not indicate the SF for booms and other crane parts that govern a crane's capacity. One would expect that they are greater than 2.

A lattice boom will usually fail by buckling, an undesirable, sudden failure mode.

Hydraulic booms are normally governed by the strength of the main hydraulic cylinders.

The capacity of jibs is usually determined by the buckling strength of the jib's lattice boom.

Wire Rope Failure

The running wire ropes on cranes have an SF of 3.5 to 1.

Stationary wire ropes have an SF of 3 to 1.

Wire rope fails in a sudden, brittle mode that justifies the large SF.

All wire rope should be inspected when it arrives at the disaster site.

Outrigger Failure

It is most common for some part of the hydraulic cylinder system to fail when outriggers are overloaded. Structural failure of the outrigger arm or foot is also possible and should be expected to fail in a sudden mode.

Other Structural or Systems Failures

There are many other parts on these complex machines that could fail, when overloaded such as:

- Pivot bearings and
- Hoist drum brakes.

Non-Traditional Techniques

We will now discuss seven methods to make lifts when the conditions are such that the load is in a position beyond what is listed in the crane load charts. These are so called "out-of-chart" lifts:

- Partial pick,
- Pick and hop,
- Pick and scoot,
- Extra counterweight, and
- Boom stand.

Minimum Requirements

The following conditions are ones in which these non-traditional techniques might be considered.

- No other reasonable alternative can accomplish the job within the required timeline.
- A victim can be rescued, and the risk versus reward ratio has been carefully considered.

A planning meeting will be held that includes all affected leadership persons.

- A rigging plan will be prepared.
- The lift will be controlled by one person.

The crane has been configured such that the lift in question is governed by overturning, as indicated by the crane load charts.

- This will most often be the case when the indicated chart load is less than 25 percent of the crane's maximum capacity.

Minimum Requirements (continued)

Structural capacity of the boom & other components will not be governing factors in this case.

All wire rope components should be configured so that they will have adequate safety factors for the lift.

It is assumed that in some cases, the 5 to 1 SF of wire rope slings might be reduced in rescue work based on careful inspection and short-term use.

The bearing capacity of the ground under the outriggers or crawler tracks has been carefully assessed.

Partial Pick

This method assumes that the weight of the load is just above the crane's listed capacity. In the first case, the rigging is attached to the near end of the load and is lifted and cribbed just enough to remove a victim.

In the next case, a truck crane with outriggers fully extended is used just beyond its listed capacity.

- A spotter is stationed to signal when the crane lifts up on the rear outrigger.
- Most operators can feel when the crane is becoming "light" on the rear outriggers.

In the final example, we show the same condition, except the crane is a crawler, and the spotter will watch the rear track.

Pick and Hop

This method also assumes that the weight of the load is just above the crane's listed capacity.

The load is beyond a position directly below the end of the boom, and as it is just barely lifted off the ground, the load will tend to move to a position under the tip in a series of short hoops.

Pick and Scoot

The pick and scoot technique is similar to the pick and hop technique, but in this case, the crane lifts the load just enough to reduce the friction between the load and the ground.

- A winch is then used to bring the load under the boom tip.

This method can be very tricky and should only be used when the load is less than 25 percent of the crane's maximum rated capacity.

- This will tend to ensure that outriggers/tracks will not be overloaded.

The extra counterweight should be gradually reduced as the load is moved in towards the crane.

Mitigating the Risk

The following are methods that can be used to reduce the risk when employing the non-traditional techniques:

- Controlled drop,
- Selling the load, and
- No-fly zones.

Controlled Drop

If a crane operator picks up a load that has been miscalculated or otherwise is greater than the crane can lift, he or she may need to quickly unload the crane boom.

One method of doing this is to use a controlled drop.

The load is allowed to fall freely until it just contacts the ground, and then the load is caught (winch brake applied) so that the crane is saved from overturning either backward or forward.

Selling the Load

Selling the load is a potential mitigating measure used when lifting any load that is near (within 85 percent of) capacity or just over capacity. The rigging plan needs to designate one or more locations where the load may be dropped. At least one of these drop zones should be located near the original location of the load—a first drop zone.

No-Fly Zones

When using any of the non-traditional techniques, and also when lifting near capacity loads, the area where the boom and load will fall into should be evacuated.

- For high boom angles, one needs to consider the possibility of the boom overturning backwards from the recoil of unexpectedly dropping the load.

This should apply for the full travel of the load from pickup to final position.

Unique Lifts

Two-Crane Picks

Two-crane lifts may be used quite often in construction work, especially when erecting large, tilt-up wall panels. However, in US&R operations, this type of crane configuration is rare.

If one needs to use two cranes to lift a large or awkward load, the following should be considered:

- This type of lift should only considered as a last resort.
- A meeting must be called, the lift procedures discussed, & detailed rigging plan prepared.
- One person needs to control the lift and do all the signaling (except anyone can signal a danger).
- Cranes need to be positioned so as to minimize the swinging and booming when hoisting.
- The hydro boom length should be set prior to lifting, as there should be no telescoping when lifting.
- All crane components & rigging need to be re-inspected & carefully checked prior to lift.
- The load needs to be controlled during the lift, using tag lines or another method.
- The cranes should not travel with the load, except in special circumstances (some special traveling outriggers are used when lifting large wall panels).
- The site needs to be cleared of all rescue personnel and others.
- At least two configurations using a pair of cranes to lift a load are used.
  - ♦ One configuration involves each crane lifting from opposite ends of the load.
  - ♦ The other configuration is used in the unusual case of one crane providing a boom support for the other crane, similar to the boom stand technique.

Saureman on High Line

This is a relatively complicated system that allows a crane to work at great distances from the load. The load must be relatively small, but this system has been used by the logging industry and in areas adjacent to soft ground, such as marshland.

The high-line, crane main line anchored to a large "dead man" object is used to raise and lower the bucket.

Instead of being run over the boom tip, the whip line is extended horizontally, anchored to the "dead man," and used to move the bucket back and forth.

- The Saureman bucket cannot be closed remotely, so it is filled by dragging it across loose, soft ground or mud.
- An operable grapple is used to pick up, move, and drop logs during timbering operations.
- Operable clamshell buckets could be used to pick up and move concrete rubble.

The "dead man" must be carefully chosen so that it will be able to reliably resist the forces exerted by the system's cables.

The operator needs to be familiar with this system for it to be considered.

Obviously, this is a system that would be considered only when no simpler method was practical and available.

Unit Summary

Non-traditional crane operations, especially those involving "out-of-chart lifts," should be attempted only after all other possibilities have been considered.

Since extra risk is involved, they should only be considered when the reward of saving a live victim outweighs the risk, such as in the rescue of a time-critical victim.

All measures to mitigate the risk should be discussed and understood by all in a special pre-lift planning meeting.