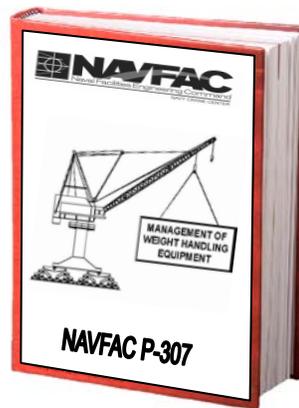




Navy Crane Center



NAVFAC P-307 Training

CATEGORY 2 AND CAB-OPERATED CATEGORY 3 CRANE SAFETY WEB BASED TRAINING STUDENT GUIDE NCC-C2CS-02

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INTRODUCTION

Welcome

Welcome to Category 2 and Cab-Operated Category 3 Crane Safety. Category 2 and Cab-Operated Category 3 Crane Safety is designed to acquaint crane operators with Navy requirements for the safe operation of Category 2 and Cab-Operated Category 3 cranes and provide a knowledge base on which to build upon with on-the-job experience.

Topics covered include NAVFAC P-307 familiarization, crane components, Operator's Daily Checklist (ODCL), crane and lift types, determining load weight, load weight distribution, sling angle stress, D to d ratio, rigging gear requirements, crane communications, crane team concepts, safe operations, and crane and rigging gear accidents.

Course Learning Objectives

Upon successful completion of this course you will be able to: understand the requirements of NAVFAC P-307, identify crane component types, complete an Operator's Daily Checklist (ODCL), determine load weights, load weight distribution, and sling angle stress, identify proper selection and use of rigging gear, explain the crane team concept, identify proper crane communication methods, and identify crane and rigging gear accidents.

NOTES

[NAVFAC P-307 MODULE](#)

Welcome

Welcome to the NAVFAC P-307 module.

Instructional Objectives

Upon successful completion of this module, you will be able to state the purpose of NAVFAC P-307, identify covered equipment, describe the training and qualification requirements of NAVFAC P-307, and determine which types of cranes require licenses for operation.

Purpose

The overall purpose of NAVFAC P-307 is to maintain the level of safety and reliability that was originally built into the equipment, ensure optimum service life, provide training and qualification standards for all personnel involved with maintenance, inspection, test, certification, engineering, rigging and operation of Weight Handling Equipment, or WHE, and ensure the safe lifting and controlling capability of WHE and promote safe operating practices.

Weight Handling Equipment includes both cranes and the rigging gear used for lifting operations.

Applicability

NAVFAC P-307 applies to Navy shore activities, including Navy activities on joint bases and bases of other military services and agencies; Naval Construction Forces, including the naval construction training centers, and naval special operating units; and fleet activities and detachments that operate shore based weight handling equipment. Also included are Navy fleet activities and detachments that operate shore based WHE. NAVFAC P-307 meets or exceeds all applicable OSHA requirements for maintenance, inspection, testing, certification, repair, alteration, and operation of equipment.

NAVFAC P-307 Contents

For an overview of the NAVFAC P-307, review this table of contents.

NAVFAC P-307 Table of Contents

Section	Contents
1	General Overview
2	Maintenance
3	Certification
4	Crane Alterations
5	Equipment History File
6	Operator Licensing Program
7	Operator Qualification and Testing
8	Licensing Procedures and Documentation
9	Operator Checks
10	Operation Safety
11	Additional Requirements
12	Investigation and Reporting of Crane and Rigging Gear Accidents
13	Training and Qualification
14	Rigging Gear and Miscellaneous Equipment

Category 2 and Cab-Operated Category 3 Crane Safety Student Guide

Maintenance and Inspection Requirements

NAVFAC P-307 provides requirements for documentation of maintenance and inspection, including: types and frequency of inspection; deficiencies to load bearing parts, load controlling parts, and operational safety devices; repairs and alterations made to cranes; and minimum requirements for record keeping retention.

Certification

The crane identification number, certified capacity and certification expiration date must be posted on or near the crane.

Posting a copy of the actual certification, crane test cards, stickers or signs, are all acceptable methods provided they include the required information.

CERTIFICATION OF LOAD TEST AND CONDITION INSPECTION				12B-094		
CRANE NO.	TYPE	LOCATION	BOOM LENGTH	OPER'S RATED CAPACITY	CERTIFIED CAPACITY	TEST DATE
GR-4792-05509	MOBILE	MOBILE	34' to 50'	1000 1000 2000 2000 3000 3000 4000 4000 5000 5000 6000 6000 7000 7000 8000 8000 9000 9000 10000 10000	1000 1000 2000 2000 3000 3000 4000 4000 5000 5000 6000 6000 7000 7000 8000 8000 9000 9000 10000 10000	10-9-12
REASON FOR TEST				IF CERTIFIED CAPACITY IS DIFFERENT FROM OPER'S RATED CAPACITY, EXPLAIN BY "REMARKS"		
ANNUAL CERTIFICATION (5 PART LINE)				NAVFAC P-307, APPENDIX "E" APPLICABLE CRANE TEST PROCEDURES PARAGRAPHS (INCLUDE APPLICABLE SUBPARAGRAPHS)		
CHECK CATEGORY GROUP	SPECIAL PURPOSE	ANNUAL CERTIFICATION	TEST HOOK SET	REMARKS		
1 <input checked="" type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/>	GENERAL PURPOSE <input checked="" type="checkbox"/>	5		1. 34 ft. of Boom, on outriggers, over the side. 2. 30 ft. of Boom, on outriggers, Lined Moment. 3. 34 ft. of Boom, on rubber. Stationary Defined Rev. 4. 34 ft. of Boom, on rubber. Trestle. 5. 105 ft. of Boom, on outriggers, over the side.		
HOST	TEST LOAD %	MINIMUM RADIUS	MAXIMUM RADIUS	Weight Distribution:		
		FOUNDS	FEET	1. Base/Head Block: 1000 lbs 2. Headline Roll: 240 lbs 3. Axle Hook Weir: 140 lbs 4. Wire Rope Load (2): 180 lbs (2) 90 lbs (4) 80 lbs		
W-11	105.363	57.024	12	57.024	12	
W-12	109.292	23.077	11	23.077	11	
W-13	109.179	13.501	10	13.501	10	
W-14	107.474	13.501	10	13.501	10	
W-15	106.242	10.195	09	10.195	09	
HOOK TRAM MEASUREMENTS				CODEING CONFORMANCE		
HOST	BASE	REQUIRED	BEFORE TEST	AFTER TEST		
W-11	9'6"	9'6"	2 3/8"	2 3/8"		
W-15	9'7"	9'7"	3 1/2"	3 1/2"		
CERTIFICATION				THIS IS TO CERTIFY THAT INSPECTIONS AND TESTS ARE CONDUCTED IN ACCORDANCE WITH THE CRANE TEST PROCEDURES SET FORTH IN THE CURRENT NAVAL FACILITIES ENGINEERING COMMAND P-307 AND AS DIRECTED IN LATER P-307 UPDATES. IT IS FURTHER CERTIFIED THAT THE CRANE IDENTIFIED ABOVE IS SATISFACTORY TO LIFT ITS RATED CAPACITY AT ITS BELTED RADIUS.		
INSPECTOR	DATE	TEST OFFICER	DATE	COOR T/O	DATE	CERTIFICATION DATE
Robert Nelson	10-31-12	Robert Nelson	10-31-12	E. Todd Bouchard	11/01/12	6/4/13
Donna B. Johnson	10/31/12	NA	NA	NA	NA	6/3/2014

Types of Equipment Covered

NAVFAC P-307 covers category 1, 2, 3, and 4 cranes, as well as rigging gear. Detailed descriptions of the cranes are included in Section 1. Illustrations of individual crane types can be found in Appendix B. Rigging gear is covered in Section 14.

Knowledge Check

1. **Select the best answer.** NAVFAC P-307 uses the term Weight Handling Equipment to refer to:
 - A. All cranes and rigging gear
 - B. Only rigging gear
 - C. Cranes, crane gear, rigging gear, and all equipment
 - D. Anything within the crane envelope

Category 2 and Cab-Operated Category 3 Crane Safety Student Guide

2. **True or False.** NAVFAC P-307 provides guidance to shore based naval activities for management of weight handling equipment.

- A. True
- B. False

Overview Section 1

Section 1 describes cranes and crane-related equipment used in weight handling operations, discusses qualifications of personnel involved in the maintenance, alteration, repair, inspection, testing and operation of Weight Handling Equipment (WHE), discusses Third Party Certification of cranes, and provides requirements for Non-Navy owned cranes and rigging equipment at Naval Activities.

Category 1 Cranes

This is a list of category 1 cranes.

Category 1 cranes include: Portal cranes, Hammerhead cranes, Locomotive cranes, Derricks, Floating cranes, Tower cranes, Container cranes, Mobile cranes, Aircraft crash cranes, Mobile boat hoists including self-propelled and towed types, and Rubber-tired gantry cranes.

They are considered Category 1 cranes regardless of capacity.

All category 1 cranes require a license to operate.

Category 1 Crane Examples

Category 1 Crane

Hammerhead

Consists of:

- rotating counterbalanced, cantilevered boom equipped with one or more trolleys that move in and out on the boom

Supported by:

- a pintle or turntable mounted atop a traveling or fixed tower



Hammerhead



Category 1 Crane

Floating Crane

Types:

- barge
- pontoon or
- hull-mounted
- rotating superstructure mounted on an integral base

Luffing booms:

- capable of continuous 360° rotation

Primary power

- supplied by a diesel-electric generator or diesel-driven hydraulic pumps

- While some are self propelled, most require tug boat assist to move about



Floating Crane



Category 1 Crane

Container Cranes

Consist of:

- hinged boom and main beam
- with a traveling trolley mounted on a rail mounted traveling gantry structure

At military port facilities

Used for:

- quickly transferring containers on and off ships



Container Cranes



Category 1 Crane

Derrick

Example:

- jib-equipped crane having a boom hinged near the base of a fixed mast

Typically:

- boom may rotate 90° or more between the mast supports or "stiff legs" or members capable of resisting both tensile and compressive forces

Load movement:

- toward the mast by raising the boom
- away from the mast by lowering the the boom



Derrick



Category 2 and Cab-Operated Category 3 Crane Safety Student Guide

Category 1 Crane Portal

- Consist of:**
- Rotating superstructure mounted on a gantry structure with:
 - operator's cab
 - machinery
 - luffing boom

- Primary power:**
- diesel-engine driven generators or hydraulic pumps

- Support:**
- supported by wide gauge rail allowing the portal crane to move about the facility



Portal



Category 1 Crane Mobile Crane

- Example:**
- Truck mounted hydraulic Cranes
 - most common mobile cranes

- Consists of:**
- rotating superstructure
 - upperworks mounted on a specialized truck chassis equipped with a power plant and cab for traveling over the road

- Primary power:**
- one engine for both the upper works and the carrier or
 - a separate engine for each

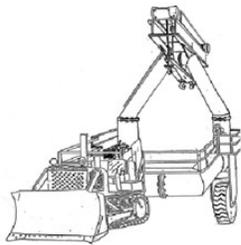
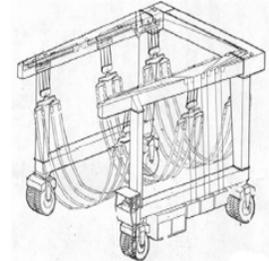


Mobile



Mobile Boat Hoist

The mobile boat hoist consists of a steel structure of rectangular box sections, supported by four sets of wheels capable of straddling and carrying boats.

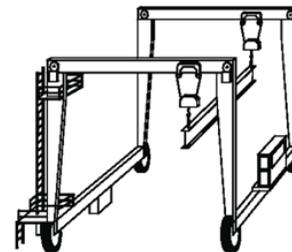


Landing Craft Retrieval Unit (LCRU)

The landing craft retrieval unit is a type of mobile boat hoist with self-propelled or towed carriers consisting of a wheeled steel structure capable of straddling and carrying boats.

Rubber Tire Gantry

The rubber tire gantry crane shown is a Category 1 crane as described in NAVFAC P-307.



- Portable elevated bridge crane or hoist(s) mounted on legs
- Legs mounted on rubber tires
- May be self-propelled or towed

Category 2 and 3 Cranes

Category 2 and Category 3 cranes include: Overhead traveling cranes; Gantry cranes; Wall cranes; Jib cranes; Davits; Pillar cranes; Pillar jib cranes; Monorails and associated hoists; Fixed overhead hoists, including fixed manual and powered hoists; Portable A-frames and portable gantries with permanently installed hoists; and Pedestal mounted commercial boom assemblies attached to stake trucks, trailers, flatbeds, or railcars, or stationary mounted to piers, etc., with certified capacities less than 2,000 pounds. Portable manual and powered hoists are covered in Section 14 of the NAVFAC P-307 (they are defined in Section 1). The activity may, however, treat them as Category 2 or 3 cranes.

Category 2 and Cab-Operated Category 3 Crane Safety Student Guide

Crane Capacity

The certified capacity of these cranes determines the category.

Category 2 cranes have a certified capacity of 20,000 lbs. and **greater**.

Category 3 cranes are those with a certified capacity of **less than** 20,000 lbs.

Category 2 and 3 Crane Examples

These are examples of Category 2 and Category 3 Cranes.

Bridge or OET Crane

Example:

- cab-operated
- can be
 - pendant or
 - radio controlled

Consists of:

- a single or multiple bridge girders spanning a building with top-running
- or under-hung trolleys

Mobility:

- limited to the area between the runways



Bridge or OET Crane



Pillar-Jib Crane

- A fixed crane consisting of a rotating vertical member with a horizontal arm supporting a trolley and hoist

- Normally rotates 360°



Pillar Jib



Jibs

Points:

- normally category 3 cranes
- category 2 if certified capacity of 20,000 pounds or greater

Consist of:

- a rotating horizontal boom (either cantilevered or supported by tie rods) carrying a trolley and hoist.
- usually mounted on a wall or building column



Jib



Trolley Mounted Overhead Hoist

Consist of:

- an under-hung, trolley-
- one or more drums and sheaves for wire rope
- or they may utilize chain

Powered by:

- manual
- electric
- hydraulic
- or pneumatic powered

Mobility:

- fixed
- or may travel on jib crane booms or monorail track



Trolley Mounted Overhead Hoist



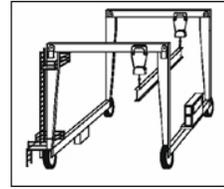
Knowledge Check

1. Select the best answer. Category 2 and Category 3 cranes are separated by:
 - A. Certification date
 - B. Boom capacity and length
 - C. Licensing requirements
 - D. Certified capacity
2. True or False. Boom length is the distance from the boom “heel” or “foot” pins to the center of the boom tip sheave.
 - A. True
 - B. False

Category 2 and Cab-Operated Category 3 Crane Safety Student Guide

3. Select the best answer. What is the category of this crane?

- A. Category 1
- B. Category 2
- C. Category 3
- D. Category 4



4. Select the best answer. What is the category of a jib crane with a capacity of less than 20,000 lbs?

- A. Category 1
- B. Category 2
- C. Category 3
- D. Category 4

5. Select the best answer. What is the category of this crane?

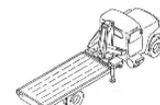
- A. Category 1
- B. Category 2
- C. Category 3
- D. Category 4



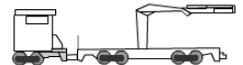
Category 4 Cranes

Mounts

Category 4 cranes may be attached to stake beds, trailers, flatbed trucks, rail cars, or may be stationary mounted on piers, barges, etc.



Category 4 Cranes



Mobile:

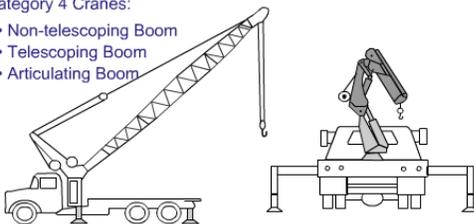
- Attached to:
 - Flatbed Trucks
 - Trailers
 - Stake Beds
 - Rail cars

Stationary:

- Mounted to:
 - Piers

Category 4 Cranes:

- Non-telescoping Boom
- Telescoping Boom
- Articulating Boom



Booms

Category 4 Cranes may have a non-telescoping, telescoping, or articulating boom.

Category 2 and Cab-Operated Category 3 Crane Safety Student Guide

Pedestal Mounted

Pedestal mounted commercial boom assembly cranes with less than 2,000 lbs. capacity are considered Category 3 cranes.

Capacities greater than 2,000 lbs. are Category 4 cranes and require a licensed operator.



Pedestal mounted commercial boom assembly:
Category 3 = Capacity less than 2,000 lbs.
Category 4 = Capacity 2,000 lbs. or greater

Considerations

Commercial truck mounted cranes [described in ASME B30.5] and articulating boom cranes [described in ASME B30.22] of all capacities are Category 4 cranes and require a licensed operator - even if the crane is down rated for administrative purposes.

Category 4 Crane Examples

These are examples of Category 4 cranes.

Category 4 Cranes

Boom Assemblies

- Non-Telescoping
- Articulating
- Telescoping

Mounted on:

- Mobile Units
 - flat bed trucks
 - trailers
 - stake beds
 - rail cars
- Stationary Units
 - Piers



Use the navigation button to move through these examples.
After viewing the examples return to the topics for this module

Truck Mounted Commercial Boom Assembly

Hydraulic Boom Crane

- Commercial
- Truck-Mounted
- Standard Ground Control

Structure:

- carrier, usually a flatbed truck
- independently operated crane

Power:

Power to operate may be from the truck's engine by way of a power take off unit



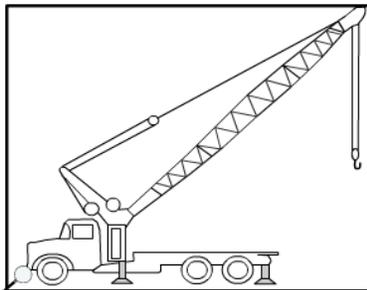
Truck Mounted Commercial Boom Assembly

Non Telescoping Boom

Consists of:

- a rotating superstructure (center post or turn-table)
- boom,
- operating machinery
- one or more operator's stations

Its function is to lift, lower, and swing loads at various radii.



Non-Telescoping Boom

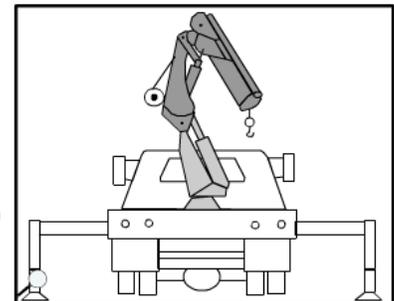
Articulating Boom

Consists of:

- the carrier, usually a flatbed truck
- independently operated articulating boom crane.

Power:

Power to operate may be from the truck's engine by way of a power take off unit



Articulating Boom Crane

Category 2 and Cab-Operated Category 3 Crane Safety Student Guide

Truck Mounted
Articulating Boom



Articulating Boom Crane
Truck Mounted

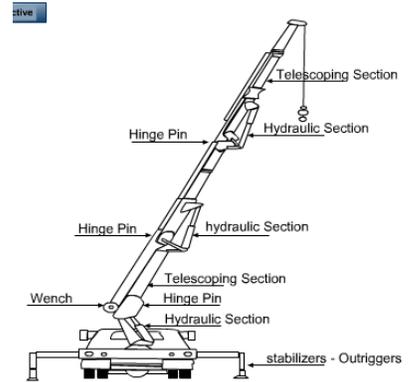
Hydraulic
Extendible Boom



Hydraulic Extendible Boom

Components

Using your mouse, explore these Category 4 crane components.



Category 4 Cranes

All Category 4 cranes require a licensed operator.



Maintenance, Certification, and Alterations (Sections 2, 3, and 4)

NAVFAC P-307 Section 2 (Maintenance) provides maintenance inspection frequencies and details. Personnel performing maintenance inspections shall be trained and qualified as inspectors per section 13. Section 3 (Certification) provides crane certification requirements. Section 4 (Alterations) provides crane alteration requirements.

Licensing (Sections 6, 7, and 8)

NAVFAC P-307 provides uniform standards for crane operator licensing. Cat 1, Cat 2, cab-operated Cat 3, and Cat 4 operators must be trained and licensed according to Sections 6, 7, and 8. Licenses are not required to operate non-cab operated Cat 3 cranes. However, training and a demonstration of ability to operate safely is required.

Operator Training

Prior to taking any performance test, the license candidate shall be thoroughly trained on the operation of the type of crane for which a license is to be issued.

The candidate shall operate that type of crane only under the direct observation of a licensed operator. The licensed operator shall retain full responsibility for the safe operation of the crane.

The supervisor shall approve lifting of loads based upon the candidate's demonstration of knowledge of the equipment and operation without loads.

The candidate shall not perform complex lifts.



Operator Checks (Section 9)

A complete check of the crane shall be performed by the operator prior to the first use of the crane each day (whether the crane is used in production, maintenance, testing, or being relocated).

NAVFAC P-307 Section 9 covers pre-use check and documentation requirements, procedure requirements, specific instructions, and deficiency reporting and requirements.

Operation Safety and Additional Requirements (Sections 10 and 11)

NAVFAC P-307 Section 10 includes crane operation safety procedures, crane team responsibilities and lifting and crane operation requirements.

Section 11 provides additional crane requirements.

Crane and Rigging Accidents (Section 12)

In the event of an accident, activities shall investigate and report the accident in accordance with NAVFAC P-307 Section 12, as well as OPNAV Instructions 5102.1 and 5100.23.

Crane and Rigging Gear Accident definitions can be found in Section 12.

Training (Section 13)

Section 13 of NAVFAC P-307 provides training and qualification requirements for personnel involved in the operation, maintenance, inspection, and testing of Navy Weight Handling Equipment.

Rigging Gear and Miscellaneous Equipment (Section 14)

Section 14 of NAVFAC P-307 provides maintenance, inspection, test requirements, and specific use criteria and precautions for rigging gear and miscellaneous equipment not covered in sections 2 through 11.

Category 2 and Cab-Operated Category 3 Crane Safety Student Guide

Knowledge Check

1. True or False. Non-Cab Operated Category 3 cranes require a license to operate.
 - A. True
 - B. False

2. Select all that apply. A license is required to operate:
 - A. Category 1 cranes
 - B. Category 2 cranes
 - C. Cab-operated Category 3 cranes
 - D. Category 4 cranes

NOTES

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CRANE COMPONENTS

Welcome

Welcome to Crane Components.

Learning Objectives

Upon successful completion of this module you will be able to define and identify critical crane components, load bearing parts, load controlling parts, and operational safety devices.

Category 1 and 4 Crane Power Types

Category 1 and 4 cranes generally use electric or hydraulic power that is supplied by a diesel engine.

A collector ring system conveys electrical current from the revolving portion of the crane to the lower crane structure.



Category 2 and 3 Crane Power Supply

Current to Category 2 and 3 cranes is carried from the building or shore power to the bridge and trolley by an insulated electrification conductor system, festoon system, or cable track system.

Category 1 and 4 Crane Components

The principal parts of most Category 1 and 4 cranes are: the boom, machinery house, roller path or rotate bearing, supporting structure, and travel system.



Critical Crane Components

Careful repair and maintenance are essential to safe crane operations.

To ensure repairs are not compromised by sub-standard parts, critical crane components are clearly identified.

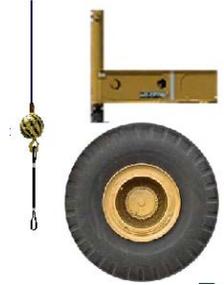
NAVFAC P-307, Appendix F provides examples of load bearing parts, load controlling parts, and operational safety devices.

Load-Bearing Parts

Load-bearing parts support the load.

Failure of a load-bearing part can cause dropping, uncontrolled shifting or uncontrolled movement of the load.

There are many different load bearing parts; this picture shows three examples.



Wire rope,
Hooks, & Blocks



Sheaves

Examples

Examples of load-bearing parts are wire rope, sheaves, hooks, hook blocks, and hoist drum pawls. The next example screen shows a boom dog, used to prevent unwanted rotation of a boom or hoist drum.



Carrier Frame Structures

The carrier frame provides a working base for the upper works of the crane. The tires, wheels, and axles support the carrier frame for transporting and for lifting loads on rubber.

Outriggers, stabilizers, and locking devices provide support for on-outrigger operations.

Failure of any one of these components or systems can cause the load to drop or cause uncontrolled movement of the load. These are critical components that must be carefully checked before operations or testing.



On Bridge Cranes

Two examples of load-bearing parts found on bridge cranes include the bridge girders that carry the weight of the trolley including hoisting machinery and the load; and the wire rope drum and hoisting machinery that lifts and supports the load.



Appendix F of NAVFAC P-307 provides additional examples of load-bearing parts.

Load Controlling Parts

Load-controlling parts are crane components that position, restrain, or control movement of the load.

Malfunction of these parts can cause dropping, uncontrolled shifting, or movement of the load.

Shown are two examples of load controlling parts.



Foot-controlled Brakes



Travel-Gear Assemblies



Rotate-Gear Assemblies

Examples 1

Examples of load-controlling components are foot-controlled brakes used as secondary brakes for hoist speed control, travel gear assemblies, rotate gear assemblies, and rotate locks.

Appendix F of NAVFAC P-307 provides additional examples of load-controlling parts.

Examples 2

Some additional examples are crane-mounted diesel engines and generators, electrical-power-distribution systems, and electrical crane-control circuits related to rotate and travel including brakes and clutches.

Knowledge Check

1. Select the best answer. What types of power does a Category 1 or 4 crane generally use and what is its source?
 - A. Pneumatic and electric power supplied by a backup generator
 - B. Electric or hydraulic power supplied by a diesel engine
 - C. Hydraulic and water power supplied by a compressor
 - D. Pneumatic and hydraulic power supplied by a compressor
2. Select the best answer. Load - _____ parts are those that restrain, position, or control the movement of the load.
 - A. Operation
 - B. Bearing
 - C. Controlling
 - D. Handling
 - E. Lifting
3. Select the best answer. A hook is what type of component?
 - A. Load-Controlling Part
 - B. General Safety Device
 - C. Operational Safety Device
 - D. Load-Bearing Part

4. Select the best answer. Hydraulic foot brakes are what type or group of components?
 - A. General Safety Device
 - B. Load-Controlling Parts
 - C. Operational Safety Device
 - D. Load-Bearing Parts

5. Select the best answer. Load - _____ parts are those that support the load.
 - A. Lifting
 - B. Operational
 - C. Bearing
 - D. Handling
 - E. Controlling

6. Select the best answer. How is electrical current conveyed from the revolving portion of the crane to the lower crane structure?
 - A. Through the main circuit board
 - B. Through the collector ring system
 - C. Through transistors
 - D. Through the electrical panels

Safety Devices

Safety devices are divided into two groups, general safety devices and operational safety devices.

Operational safety devices affect the safe lifting and handling ability of the equipment.

Operational safety devices are critical crane components.

General safety devices provide protection for personnel and equipment on or in the crane operating path.

Load Indicators

Load-moment indicators are operational aids providing the crane operator necessary information to stay within the capacity of the crane.

Load-moment indicators that provide shutdown capabilities are operational safety devices. They may provide the operator with load weight, boom angle, and boom length.

As the operator approaches critical limits, load moment devices may sound an audible alarm, illuminate warning lights, or lock out functions that could possibly allow the operator to overload the crane.

If a load moment device has lockout capability, it must be treated as an operational safety device.





Angle Indicators

Mechanical boom angle indicators are operational safety devices.

These devices provide the operator with the boom angle needed to calculate the radius of the crane.

Mechanical boom angle indicators are usually mounted on the boom where they can easily be read from the cab.

Limit Switches

Limit switches are operational safety devices that prevent damage to the crane if a loss of control occurs. Most cranes are equipped with limit switches.

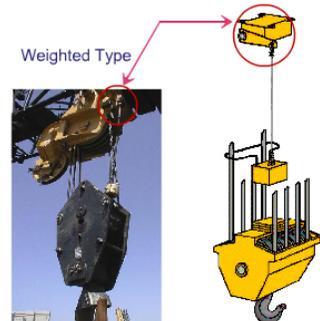
The purpose of a hoist limit switch is to prevent over-travel of the hook block and the possibility of two-blocking.

Two-blocking occurs when the hook block comes in contact with the upper sheave block during hoisting of the hook (or lowering the boom). Two-blocking is dangerous because it could result in damage to the crane, parting of the hoist lines, and dropping the load.

These images are examples of weighted-type hoist upper-limit switches.

A spring-loaded switch opens the circuit when the hook block raises the weight.

Interruption of power to the hoist function stops the upward movement of the hoist block to prevent two-blocking.



Over-speed Devices

Over-speed, pressure, and temperature devices on crane-mounted engines are **operational safety devices**

When the engine provides the power to move loads, the devices provide shutdown ability to protect the engine from damage.

Appendix F of the P-307 provides a comprehensive list of operational safety devices.



Horns, Bells, Whistles



Travel Alarms



Travel Warning Lights



Bumpers

General Safety Devices

General safety devices are those devices that protect or alert the operator or personnel working in the vicinity of the crane.

Some general safety devices used to warn personnel working on or around the crane are horns, bells, whistles, travel alarms, travel warning lights, and bumpers.

Knowledge Check

1. Select the best answer. Safety devices that provide protection for personnel and equipment are considered _____ safety devices.
 - A. General
 - B. Load-bearing
 - C. Universal
 - D. Operational

2. Select the best answer. Safety devices that affect the safe load lifting and handling capabilities of equipment are considered _____ safety device.
 - A. Operational
 - B. General
 - C. Universal
 - D. Load-bearing

3. Select the best answer. Which of the following does not affect the safe operation of the crane?
 - A. Operational Safety Devices
 - B. General Safety Devices
 - C. Load-Bearing Parts
 - D. Load-Controlling Parts

4. Select the best answer. A travel alarm is what type or group of components?
 - A. General Safety Device
 - B. Load-Bearing Part
 - C. Operational Safety Devices
 - D. Load-Controlling Part

NOTES

Intentionally Blank

Knowledge Check

1. Select the best answer. A complete check of the crane is performed by the operator prior to:
 - A. The first use of the crane each day
 - B. Complex lifts only
 - C. Moving the crane to a new location
 - D. Securing the crane each day
2. Select the best answer. The ODCL is used to identify:
 - A. Who is licensed to operate the crane
 - B. Conditions that may render the crane unsafe
 - C. Necessary and missing paperwork
 - D. Members of the current crane team
3. Select all that apply. What are the four sections of a properly performed pre-operational check?
 - A. Stability check
 - B. Walk around check
 - C. Operator's cab check
 - D. Machinery House check
 - E. Operational check
 - F. Electrical function check
4. Select the best answer. What method of inspection is used in the operator's daily check of the crane?
 - A. Review of OEM manual
 - B. Observing the crane in operation
 - C. Sight, sound and touch
 - D. CCI inspection

Warning Tags

Before energizing the crane, look for warning tags. You may find warning tags posted with the certification card or information, attached on the pendant controller or other types of crane controls, or on the power source of the crane.

The red danger tag prohibits operation of equipment when its operation could jeopardize the safety of personnel or endanger equipment. If you discover one, never energize the crane with a danger tag attached! Energizing equipment with a danger tag attached may result in personnel injury or equipment damage.

The yellow caution tag generally gives some type of warning, precaution, or special instructions to the operator of the crane. Most caution tags inform



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of hazardous conditions such as rail stops, swing interference, crane clearance problems, etc. Always read and follow the written instructions on the tag before operating the crane. If you do not understand the instructions, ask your supervisor for clarification.

A Lockout Tag is installed to inform you that the energy has been locked out, and is used to protect the person or persons who hung the tag while they are working on the affected system or component. It is intended for one shift use and is usually accompanied by a physical locking device to prevent operation.

Another tag you may find is an “Out of Service” tag. An Out of Service tag is normally installed to perform maintenance, testing, or inspection. When you find this tag, do not use or operate the crane.

Remember, only authorized personnel may install or remove warning tags.

Who Can Remove These Tags?

Only authorized personnel may install or remove warning tags. Who are the authorized personnel? The person who applied the tag and sometimes his or her supervisor.

Critical Components

The ODCL identifies components that are critical to the safe operation of the crane.

Critical components are load-bearing parts, load-controlling parts, and operational safety devices.

They are identified by an asterisk (*) next to the item.

Any deficiency to a critical component or safety hazard must be reported to your supervisor immediately, and the crane shall not be operated until resolved.

1	WALK AROUND CHECK				S	U	NA		
a	2	MACHINERY HOUSE CHECK				S	U	NA	
b					S	U	NA		
c	3	OPERATOR CAB CHECK				S	U	NA	
d					S	U	NA		
e	c	4	OPERATIONAL CHECK				S	U	NA
f	d					S	U	NA	
g	e	a	Area Safety *						
h	f	b	Outriggers and Stabilizers *						
i	g	c	Unusual Noises						
j	h	e	Wire Rope or Chain						
k	i	f	Brakes and Clutches *						
l	j	g	Boom Angle						
m	k	h	Limit Switch						
n	l	i	Emergency						
o	m	j	Other Opera						
p	n	k	General Saf						
q	o	l	Fleeting She						

*** Critical components:**

- Load bearing parts
- Load controlling parts
- Operational safety devices

Limit Switches

Limit switches are operational safety devices that prevent damage to the crane if a loss of control occurs. Most cranes are equipped with limit switches.

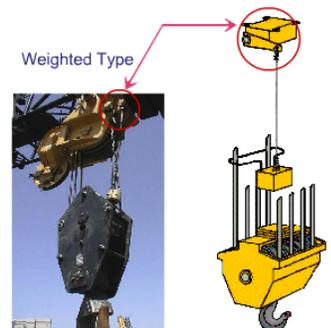
The purpose of a hoist limit switch is to prevent overtravel of the hook block and the possibility of two-blocking.

Two-blocking occurs when the hook block comes in contact with the upper sheave block during hoisting of the hook (or lowering the boom). Two-blocking is dangerous because it could result in damage to the crane, parting of the hoist lines, and dropping the load.

These images are examples of weighted-type hoist upper-limit switches.

A spring-loaded switch opens the circuit when the hook block raises the weight.

Interruption of power to the hoist function stops the upward movement of the hoist block to prevent two-blocking.



Unsatisfactory Conditions

You must give a detailed description of unsatisfactory conditions in the remarks block of the ODCL form.

If you discover a load bearing part, load controlling part or operational safety device that is unsatisfactory, you must

INSTRUCTIONS – Check all applicable items indicated, prior to the first use each day. Suspend operations immediately upon observing an unsatisfactory condition of any item indicated with an asterisk (*). Operations may continue if the condition has been reviewed and continued operation has been authorized by the activity engineering organization.

For any unsatisfactory item, identify the specific components and describe the deficiency in the “Remarks” block.

REMARKS
Bridge lights not working

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4. Select the best answer. Whether a critical component or not – any unsatisfactory conditions must be:
 - A. Described in the “Remarks” block of the ODCL worksheet
 - B. Delivered to maintenance and engineering for action

5. Select the best answer. Each item on the ODCL shall be marked:
 - A. Correct, incorrect, not applicable
 - B. Stable, unstable, or not applicable
 - C. Serviceable, unserviceable, or not applicable
 - D. Satisfactory, unsatisfactory, or not applicable

6. Select the best answer. What is the purpose of a hoist limit switch?
 - A. To cause the operator to slow down
 - B. To cut off power to the crane when contacted
 - C. To prevent over-travel of the hook block and the possibility of two-blocking
 - D. To prevent rotation of the hook

7. Select the best answer. Which of the following tags prohibits operation of equipment when its operation could jeopardize the safety of personnel or endanger equipment?
 - A. Danger Tag
 - B. Lockout Tag
 - C. Out of Service Tag
 - D. Caution Tag

8. Select the best answer. Who can remove a danger, caution, or lockout tag?
 - A. The building custodian
 - B. The crane operator
 - C. All crane maintenance personnel
 - D. The person who attached the tag or his or her supervisor when they are not available

Walk Around Check

This is a sample walk around check section from an ODCL. Begin this check by walking around the crane and the job site, observing anything that is out of order or out of place as well as any potential hazards or interference.

1 WALK AROUND CHECK			
	S	U	NA
a			
b			
c			
d			
e			
f			
g			
h			
i			
j			
k			
l			
m			
n			
o			
p			
q			



Safety Guards and Plates

Check for missing safety guards and plates.

General Hardware

As you walk around the crane look for missing and loose hardware such as nuts, bolts, brackets and fittings.



Wire Rope and Reeving

Visually check wire rope for unusual wear, fraying, birdcaging, corrosion, and kinking. Check end connections, where visible, for proper configuration, seating, and condition of wire rope.

Visually check the condition of wire rope or load chain reeving. Ensure wire rope or load chain is running true in the hook block and boom point sheaves, and laying correctly on the drum or sprockets

Block and Hook

Visually check the condition of the block and ensure all swivels rotate freely.

Check the condition of the hook for cracks, excessive throat opening, or twist. If rigging gear is on the hook and cannot be easily removed, check the hook to the maximum extent possible without removing rigging gear.



Sheaves or Sprockets

Check, where practical, the condition of sheaves or sprockets to determine that they are free to rotate and are not cracked or chipped.

Walkways, Ladders, Handrails

Check the condition of walkways, ladders, and handrails for loose mountings, cracks, excessive rust, loose rungs, or any other signs of unsafe conditions.

Ensure safety chains and gates are functional.

Ensure safety chains and gates are functional.





Stops and Bumpers

Check stops and bumpers on the crane for cracks or other damage.

Wheels and Tracks

Check wheels to ensure they are not loose or damaged. On track machines, look for excessive slack, broken or loose pads, or any other obvious defects.



Leaks

Check for evidence on the crane and on the ground beneath the crane, of any leakage of fuel, lubricating oil, hydraulic fluid, or engine coolant.

Load Chain

Check for damaged or deteriorated links.



Area Safety

Check the work area and ensure that the exact locations of obstacles or hazards are known.

Ensure ground conditions are sufficiently firm to support a loaded crane.

Verify temporary connections are removed or cleared for operation (e.g., temporary shore power or hotel power).



Machinery House Check

This graphic represents the machinery check section of a typical ODCL.

2 MACHINERY HOUSE CHECK				
		S	U	NA
a	Housekeeping	✓		
b	Diesel Engine and Generator *	✓		
c	Leaks			
d	Lubrication			
e	Battery			
f	Lights			
g	Glass			
h	Clutches and Brakes *			
i	Electric Motors *			
j	Auxiliary Engine and Compressor			
k	Danger/Caution Tags *			
l	Fire Extinguishers			
m	Hoist Drum Pawls and Ratchets *			



Housekeeping

Check to ensure that the machinery house and accesses are clean. The crane operator is responsible for the cleanliness and housekeeping of the crane. Ensure tools and authorized materials are properly stored and that waste and debris are removed.



Leaks

Inspect for excessive grease on machinery. Look for hydraulic brake fluid leaks around brake linings and cylinders. Check for lubricating oil leaks around gear cases. If they appear to be more than normal seepage, report the condition to your supervisor.

Lubrication

Check gear cases for lubricant level and evidence of over or under lubrication of crane components.



Clutches and Brakes

Check accessible portions of clutches and brakes for evidence of excessive heat, wear, or grease and oil on the linings. Check for evidence of loose fasteners and for missing or broken parts. If a brake is equipped with a manual release mechanism, check to ensure the mechanism is not in the released position.

Electric Motors

Check all motors for evidence of loose fasteners, oil or grease splashes, and any indications of overheating.

Danger/Caution Tags

If danger or caution tags are posted, read, understand, and follow the directions on the tags.

Check the appropriate ODCL column as follows: "S" - all tags are properly hung; "U" - tags improperly hung or otherwise deficient; "NA" - no tags.



Fire Extinguishers

Ensure fire extinguishers are in place, seals are unbroken, and inspection tags are up to date.

Knowledge Check

1. Select the best answer. Discoloration of the brake drum is usually caused by:
 - A. Overloading the crane
 - B. Overheating
 - C. Lubrication
 - D. Normal operations

2. Select the best answer. During inspection, cracked or flaking paint may indicate:
 - A. latex paint over alkyd primer
 - B. Structural damage or loose bolts
 - C. Poor quality paint
 - D. Aluminum paint on steel components

Operator's Cab Check

This is a typical Operator's Cab Check section from an ODCL.

The operator should enter the cab and ensure all controls are in the neutral or off position prior to starting the engine.

Start the engine and check the items in the Operator Cab Check section.

3 OPERATOR CAB CHECK			
	S	U	NA
a Gauges		✓	
b Indicator and Warning Lights	✓		
c Visibility *	✓		
d Load Rating Charts *	✓		
e List/Trim Indicator (Floating Cranes) *			
f Boom Angle/Radius Indicator *			
g Fire Extinguisher			
h Level Indicator (Mobile Cranes) *			
i Danger/Caution Tags *			



Gauges, Indicator and Warning Lights

Check gauges to ensure none are broken or missing and that they are operating normally.

Check indicator and warning lights to ensure none are broken or missing and that applicable indicator and warning lights are lit.

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Visibility

Check visibility to ensure that all windows and mirrors are clean, unbroken, and that any vandal guards have been removed from windows.



Load Rating Charts

Ensure that the load rating charts are posted in the operator's cab and that they are legible.

Verify that the crane number is correct, the certification expiration date is not expired, and the crane capacity is listed.

The two expiration dates that are of particular importance to all crane operators are the expiration date of the certification of the crane being operated, and the expiration date of the operator's license. The operator cannot operate a crane if his or her license is expired, and a crane may not be operated to perform production lifts if the crane certification is expired.



Fire Extinguishers

Ensure fire extinguishers are in place, seals are unbroken, and inspection tags are up to date.

Danger/Caution Tags

If danger or caution tags are posted, read, understand, and follow the directions on the tags.

Check the appropriate ODCL column as follows: "S" - all tags are properly hung; "U" - tags improperly hung or otherwise deficient; "NA" - no tags.



Operational Check

The final check before placing the crane in service is the "No Load" operational check.

When possible, the no load operational check shall be conducted away from personnel and any hazardous surroundings.

A qualified rigger, if present during the operational check, should control access, observe crane operation, and report any unusual noises or other indications of unsafe conditions to the crane operator.

When performing the operational check portion of the ODCL in cold weather or icy conditions, the operator should raise the blocks and boom before lowering them to avoid damage when sheaves may be frozen.

Operators should inform rigging personnel to stand clear of the area below the blocks and boom prior to operation.

The operator should hoist up slowly, in small increments, to break any ice and/or snow free, and monitor the sheaves to ensure proper movement and operation of the sheaves and wire rope.

4 OPERATIONAL CHECK			
	S	U	NA
a Area Safety *	✓		
b Outriggers and Stabilizers *	✓		
c Unusual Noises			
d Control Action *			
e Wire Rope or Chain *			
f Brakes and Clutches *			
g Boom Angle / Radius Indicator *			
h Limit Switches *			
i Emergency Stop *			
j Other Operational Safety Devices *			
k General Safety Devices			
l Fleeting Sheaves			



Area Safety

Check the work area and ensure that the exact locations of obstacles or hazards are known.

Unusual Noises

After starting the engine, be alert for unusual noises, fluid leaks, improper functioning, incorrect readings of gauges, and loss of power or bad response to control of the engine or motors.

Control Action

Check controls through a range sufficient to ensure that they operate freely and that the corresponding component actuates properly when controls are activated.

Check hoist controls through the full speed range.





Wire Rope or Chain

Check for proper paying-out of the wire rope or chain, that the wire rope or chain and hook blocks do not twist/spin, and that the wire rope or chain is running freely through the sheaves or sprockets and blocks.

If the boom and hoist drums or load sprocket are visible from the operator's station, check for proper spooling of the wire rope on/off the drum or chain on/off the load sprocket.

After lowering the hooks and the boom for limit switch tests and hook inspections, observe sections of wire rope or chain that may not be visible during the walk around check.

Brakes and Clutches

Check brake and clutch actions and ensure they are functioning normally and that there is no slippage, excessive play, or binding. Exercise brakes and clutches to ensure they are dry.



Limit Switches

Checking of limit switches shall be performed at slow speed and include each upper hook hoist primary limit switch and the upper and lower boom hoist primary limit switches. (Verifying the operation of the upper and lower boom hoist limit switches is required only during the initial check of the crane each day.)

Checking of hook hoist lower limit switches is not required if the hook can be lowered to its lowest possible position (e.g., bottom of drydock being worked at minimum radius) while still maintaining a minimum of two wraps of rope on the hoist drum (three wraps for ungrooved drums).

For cranes that do not have the requisite number of wraps, the hook hoist lower limit switch shall be checked where operationally possible, i.e., if the crane is at a location where the limit switch can be checked (where the lower limit switch is not checked during the pre-use check, it shall be checked if the crane is subsequently relocated to a position where it can be checked).

For cranes without hoist upper limit switches, do not check hoist overload clutches if so equipped. (See NAVFAC P-307, section 10 for specific precautions for these hoists.)

Checking of secondary limit switches is not required unless a specific operation is planned where the primary limit switch will be bypassed.

Emergency Stop

Check the emergency stop or power-off button. Know its location and ensure it is working properly. If the emergency stop is checked while a motion is in operation, check at the slowest possible speed.

Note: This is not applicable to diesel engine shutdowns on portal and floating cranes.





Other Operational Safety Devices

Check any other operational safety devices as directed by the activity engineering organization. An example would be deadman controls.

These pictures show two types of deadman controls. A foot switch and a push-button thumb switch on top of the controller.

General Safety Devices

Check general safety devices such as sirens, horns, and travel alarms for proper operation.



Knowledge Check

1. Select the best answer. The crane number, certification expiration date and certified capacity are found:
 - A. In the EOM
 - B. In the operator's manual
 - C. Posted on the crane
 - D. Posted in the crane maintenance area
 - E. In the load lift review
2. Select the best answer. Dead man controls refer to controllers that automatically ...
 - A. Change operational speeds to suit conditions
 - B. Push your hand away from the handle when the crane stops
 - C. Compensate for slow operator response
 - D. Stop operations when released
3. Select the best answer. If you observe a red tag on a piece of equipment, you should:
 - A. Remove the tag and continue operations
 - B. Fix the problem and operate the equipment
 - C. Verify the tag was from previous work
 - D. Under no circumstances operate this piece of equipment
 - E. Review the special instructions and operate accordingly

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4. Select the best answer. If you observe a yellow tag on a piece of equipment, you should:
- A. Review the special instructions and operate accordingly
 - B. Under no circumstances operate the piece of equipment
 - C. Remove the tag and continue operations
 - D. Fix the problem and operate the equipment
 - E. Verify the tag was from previous work

NOTES

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COMPLEX AND NON-COMPLEX LIFTS

Welcome

Welcome to the complex and non-complex lifts module.

Objectives

Upon successful completion of this module you will be able to define complex and non-complex lifts, identify complex lifts, and state complex lift requirements.

Non-Complex Lifts

Non-complex lifts are ordinary in nature, do not require direct supervisory oversight, and are made at the discretion of the rigger in charge.

Complex Lifts Overview

Complex lifts have a moderate to high level of risk.

Activities are required to identify complex lifts and prepare detailed written procedures for their execution.

Procedures may be in the form of standard instructions or detailed procedures specific to a lift.

Complex Lift Categories

Complex lifts include: hazardous materials, large and complex geometric shapes, lifts of personnel, lifts exceeding 80 percent of the capacity of the crane's hoist and lifts exceeding 50 percent of the hoist capacity for a mobile crane mounted on a barge (Excluded from this rule are lifts with jib cranes, pillar jib cranes, fixed overhead hoists, and monorails, and lifts of test weights during maintenance or testing when directed by a qualified load test director), lifts of submerged or partially submerged objects, multiple crane or multiple hook lifts on the same crane, lifts of unusually expensive or one-of-a-kind equipment or components, lifts of constrained or potentially constrained loads (a binding condition), and other lifts involving non-routine operations, difficult operations, sensitive equipment, or unusual safety risks.

Complex Lift Procedures

Activities shall identify complex lifts and prepare procedures (including rigging sketches where required) for conducting these lifts. Procedures may be standard written instructions or detailed procedures specific to a lift.

A supervisor or working leader must review on-site conditions and conduct a pre-job briefing for all complex lifts.

A supervisor or working leader must supervise lifts over 80% (except for category 3 cranes), multiple hook lifts when the weight exceeds 80% of any hoist, and lifts of ordnance involving the use of tilt fixtures.

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If the lifts are repetitive in nature, supervisors must be present during the first complex lift evolution with each team.

Subsequent identical lifts by the same crew may be done under the guidance of the rigger-in-charge.

Complex Lift Exceptions

Exceptions to the complex lift requirements include lifts over 80% of capacity made with jib cranes, pillar jib cranes, fixed overhead hoists, and monorail cranes. These cranes are usually smaller capacity cranes used primarily to service only one workstation, machine or area.

Lifts of test weights during maintenance or load test are excluded from the complex lift requirements.

Ordnance lifts covered by NAVSEA OP 5 in lieu of the NAVFAC P-307 are also excluded; except for lifts using tilt fixtures, lifts where binding may occur, lifts of submerged loads, multiple crane or multiple hook lifts.

Knowledge Check

1. Select the best answer. Detailed written procedures are required for:
 - A. All lifts
 - B. Complex lifts
 - C. Some lifts
 - D. Non-complex lifts
2. Select the best answer. For all complex lifts, a supervisor or working leader must review on-site conditions and ...
 - A. Inspect all rigging gear
 - B. Select rigging gear
 - C. Define the crane operating envelope
 - D. Conduct a pre-job briefing
3. Select the best answer. Lifts of test weights during maintenance or load test are ...
 - A. Evaluated according to the complex lift requirements
 - B. Included in the complex lift requirements
 - C. Excluded from the complex lift requirements
 - D. Routine lifts because they are not complex shapes
4. Select the best answer. A crane with a capacity of 100,000 pounds is performing a lift of 40,000 pounds. This is a(n):
 - A. overload lift
 - B. non-complex lift
 - C. complex lift
 - D. hazardous lift

Complex Lift Examples Hazardous Materials

Lifting hazardous materials with a crane is a complex lift.

Materials such as oxygen, acetylene, propane or gasoline in bottles, cans or tanks that are properly secured in racks designed for lifting by a crane are **excluded**.



Large and Complex Shapes

Complex lifts also include large and complex shapes.

For example, objects with large sail area that may be affected by winds, objects with attachment points at different levels requiring different length slings, and odd shaped objects where the center of gravity is difficult to determine.

Personnel Lifts

Use cranes for lifting personnel only when no safer method is available.

Cranes, rigging gear and personnel platforms shall conform to OSHA requirements: 29 CFR Part 1926.1431 and ASME B30.23.

The total weight of the loaded personnel platform and rigging shall not exceed 50% of the rated capacity of the hoist.

A trial lift with at least the anticipated weight of all personnel and equipment to be lifted shall be performed immediately before placing personnel in the platform.

A proof test of 125% of the rated capacity of the platform must be held for 5 minutes. This may be done in conjunction with the trial lift.

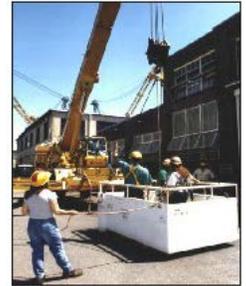
A body harness and shock absorbing lanyard shall be worn and attached to a structural member within the personnel platform capable of supporting the impact from a fall. The harness and anchorage system shall conform to OSHA requirements.

Tag lines shall be used unless their use creates an unsafe condition.

Hoisting of the personnel platform shall be performed in a slow, controlled, cautious manner with no sudden movements of the crane.

Personnel shall keep all parts of the body inside the platform during raising, lowering, and positioning.

Before personnel exit or enter a hoisted platform that is not landed, the platform shall be secured to the structure where the work is to be performed, unless securing to the structure creates an unsafe situation.



Lifts over 80% of capacity

Lifts exceeding 80% of the capacity of the hoist are considered complex lifts.

Use a larger capacity hoist if possible to avoid exceeding 80% of capacity.

Multiple Crane or Hook Lifts

Lifts with multiple cranes or multiple hook lifts on the same crane, except for bridge or gantry cranes with hooks coupled together and specifically designed for simultaneous lifting, are complex lifts.

These lifts require special planning, coordination and skill.

The weight of the load and the weight carried by each crane and hook must be determined prior to the lift to avoid overloading of the cranes and/or rigging gear.

One signal person must be assigned to direct and control the entire operation.



Knowledge Check

1. Select the best answer. Which of the following identify the two basic categories of crane lifts?
 - A. Usual and unusual
 - B. Complex and non-complex
 - C. Critical and non-critical
 - D. Common and non-common
 - E. None of these
2. Select the best answer. Personnel lifts are ...
 - A. Not considered complex if personal protective gear is worn
 - B. Considered complex only under special conditions
 - C. Always considered complex lifts
 - D. Not considered complex if personnel lifting devices are used
3. Select the best answer. Personnel in a man-lift platform or basket must ...
 - A. Wear aircraft reflective tape on their hard hat
 - B. Wear a full body harness with a shock-absorbing lanyard
 - C. Stand with knees bent to absorb motion shock
 - D. Wear a safety belt with a shock-absorbing lanyard
4. Select the best answer. For personnel lifts, the total load must not exceed ...
 - A. The load chart capacity
 - B. 80% of the hook capacity
 - C. 50% of the hook capacity
 - D. The gross capacity if designated as a complex lift

NOTES

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DETERMINING LOAD WEIGHT

Welcome

Welcome to Determining Load Weight.

Instructional Objectives

Upon successful completion of this module you will be able to identify the importance of knowing the weight of an item, choose acceptable ways to obtain weight information, calculate area and volume of basic objects, and determine the weight of basic shapes.

Determining Weight Load Weight

Load weight determines the capacity of the crane and the rigging gear required.

Load weight must be verified or calculated whenever it is estimated to exceed 50% of the crane's hook capacity or 80% of the rigging gear capacity

Acceptable Methods

Load-indicating devices, label plates, documentation, engineering evaluation and calculation are all acceptable methods of determining load weight.

When using a load-indicating device (LID) to determine load weight, the rigger-in-charge shall have a reasonable estimate of the weight to be lifted. An appropriate stop point shall be established and the load indicating device shall be carefully monitored to ensure the stop point is not exceeded.

Unacceptable Methods

Never take word of mouth to establish load weight! Word of mouth may be used as a starting point for sizing the crane and rigging gear so the component can be weighed with a load indicating device, but never shall it be used as the final determination of load weight.

To avoid overloading any equipment used in a crane lift, the rigger-in-charge shall know or have a reasonable estimate of the weight to be lifted. If the weight is estimated to exceed 50% of the capacity of the hoist or 80% of the capacity of the rigging gear, platform/skid, below-the-hook lifting device, etc., the weight shall be verified by performing an engineering evaluation or using a local procedure approved by the certifying official or activity engineering organization. Alternatively, a load indicating device shall be used.

Guidelines for Determining Weight

When determining the weight of an object you can always round up the dimensions and the weight, but never round down.

Never mix feet and inches and double-check your answers.

Standard Weights of Materials

This is a standard chart showing the weights of various materials per square foot, per inch of thickness and weight per cubic foot of volume.

This chart is used as an aid when calculating load weights.

Material	Weight cubic foot	Material	Weight per sq foot per inch of thickness
Ash	42	Aluminum	14.5
Birch	41	Brass	44.5
Cedar	34	Bronze	42.2
Cherry	38	Copper	48.3
Fir	34	Iron	41.1
Hemlock	29	Lead	59.2
Maple	53	Mercury	48.3
Oak	50	Nickel	44.8
Pine (white)	25	Silver	54.7
Reinforced Concrete	150	Steel	40.8
Sand	100	Steel (stainless)	47.8
Steel	490	Tin	36.3
Aluminum	165	Zinc	38.7
Bass	543		

Finding Weight

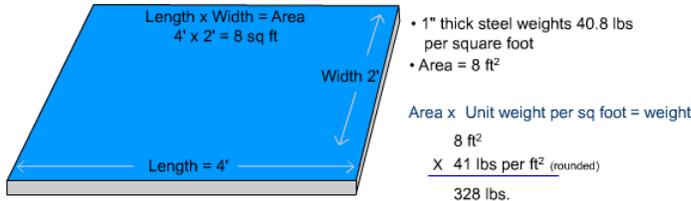
Weights may be calculated using either area or volume.

Find the weight of two-dimensional objects such as plates by multiplying the area in square feet by the material weight per square foot, for a given thickness.

To find the weight of three-dimensional objects multiply volume in cubic feet by the material weight per cubic foot.

Which calculating method you use, will depend on the item.

You may need to use both methods for complex objects.



Calculating Weight by Area

To calculate the weight of this plate, we must find the area and multiply it by the material weight per square foot.

Here, we have a steel plate, 4 feet by 2 feet by 1 inch thick. The

area is 8 square feet.

To calculate the weight, we need to find the unit weight, or weight per square foot for the material.

Using the standard material weight chart, we find steel weighs 40.8 pounds per square foot per inch of thickness.

The math can be simplified by rounding to 41 pounds. Multiplying 8 square feet by 41 pounds per square foot gives us 328 pounds.

Calculating Weights by Volume

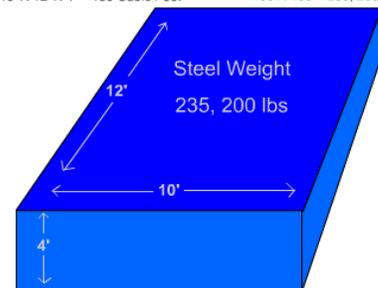
Volume is always expressed in cubic units, such as cubic inches, cubic feet, and cubic yards.

Let's calculate the volume of this box. The formula is length, times width, times height.

The length is 12 feet. The width is 10 feet. The height is 4 feet. When we multiply 12 times 10, times 4, the volume is 480 cubic feet.

Now we can use the standard materials weight chart and multiply the standard weight by the volume.

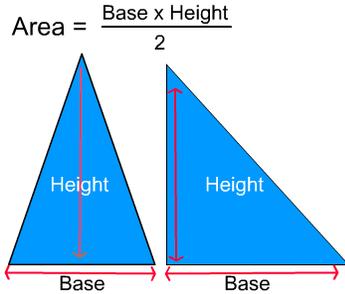
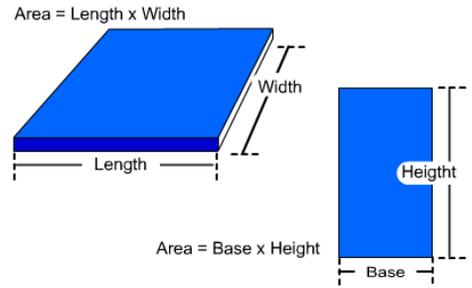
Volume = Length X Width X Height Steel Weights 490 lbs per cubic
10' X 12' X 4' = 480 Cubic Feet 490 X 480 = 235, 200 lbs



Load Weight By Area
Calculating Area

The area of a square or rectangular shaped object is determined by multiplying length times width or base times height.

The area is always expressed in units of square feet or square inches.



Triangle Area

To calculate the area of a triangle multiply the base of the triangle by the height of the triangle and then divide by 2. The height of a triangle is the perpendicular distance from the point opposite from the base to the base.

Circle Area

To calculate the area of a circle, multiply Pi, which is 3.14, by the radius squared.

Find the radius of the circle by dividing its diameter in half. To square the radius, multiply the radius by itself.

For example, if a circle has a diameter of 3 feet, the radius will be 1.5 feet.

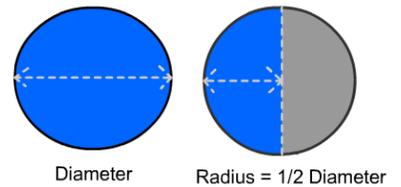
1.5 feet times 1.5 feet equals 2.25 square feet. Therefore, the radius squared is 2.25 square feet.

Pi times the radius squared would be 3.14 times 2.25 square feet, or 7.065 square feet.

$Area = \pi \times Radius^2$

$\pi (Pi) = 3.14$

$Radius^2 = Radius \times Radius$



Calculating the Area of a Complex Shape

Most complex shapes can be broken down into a series of simple shapes.

To calculate the area of this complex shape, calculate the area of the square using the formula length times width.

Next, calculate the area of the triangle using the formula base times the height divided by 2.

Then add the areas together to get the total area of the complex shape.



Begin Action



$L \times W = Area$



$\frac{B \times H}{2} = Area$



Use the tab to review individual steps...

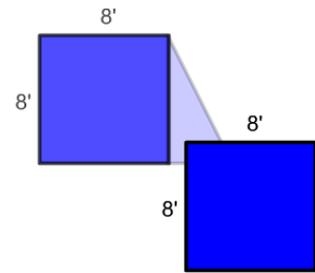
Calculating the Area of the First Part

The first step is to calculate the area of the rectangle, or square, as shown in this example.

The formula for the area of a rectangle is, length times width.

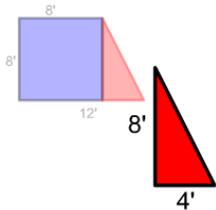
The length is 8 feet and the width is 8 feet.

8 feet, times 8 feet, equals 64 square feet.



$$\text{Area} = \text{Length} \times \text{Width}$$

$$8' \times 8' = 64 \text{ sq feet}$$



$$\text{Area of a Triangle} = \frac{\text{Base} \times \text{Height}}{2}$$

$$\frac{8' \times 4'}{2} = 16 \text{ sq ft}$$

Calculating the Area of the Second Part

Next, find the area of the triangle.

The formula for the area of a triangle is, base times height divided by 2

The base is 4 feet and the height is 8 feet

4 ft times 8 ft equals 32 ft²

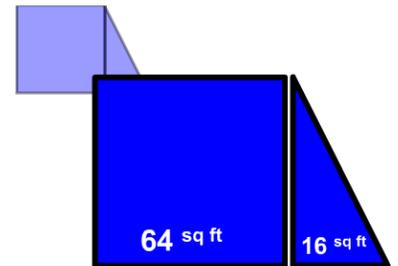
32 ft² divided by 2 equals 16 ft²

Adding Areas

Now that we have found the area of the two sections, all we have to do is add the area of the square to the area of the triangle to find the total area of the object.

64 square feet, plus 16 square feet, equals 80 square feet.

If we know what the material is and how thick it is, we can find its weight with one more calculation.



$$64 \text{ sq ft} + 16 \text{ sq ft} = 80 \text{ sq ft Total Area}$$



Calculating Weight Using Area Step One

To calculate the weight using area, we must find the material weight per square foot based on its thickness.

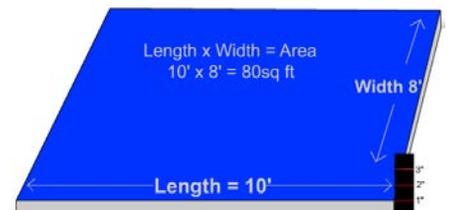
Then, we simply multiply the base weight by the area of material.

The area of this steel plate is 80 square feet.

Step 2

Now we need to know the plate's thickness.

According to the ruler, it is 1 inch thick.



Category 2 and Cab-Operated Category 3 Crane Safety Student Guide

Step 3

We can find the weight of common materials listed in several reference books available from various industry sources.

Here, in “Ace’s Book of Rigging”, we find these tables.

Material weight per cubic foot is in the left table.

In the right table, unit weights are listed by weight per square foot, per inch of material thickness.

We will use the table on the right since the material weights here are based on the thickness of material.

We find steel listed in the “Materials” column.

The unit weight is 40.8 pounds per square foot, per inch thickness of steel plate.

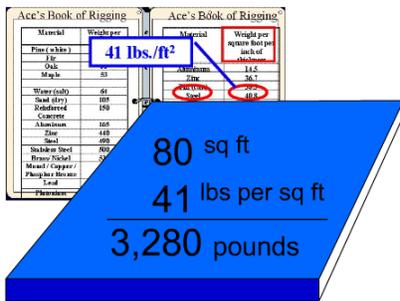
Now let’s apply the rule we learned earlier in the lesson to make the math easier and give us a safety margin in our calculations.

What was the rule on rounding that we should apply to this unit of weight?

Round up!

So, 40.8 pounds per square foot is rounded up to 41 pounds per square foot.

Material	Weight per cubic foot	Material	Weight per square foot per inch of thickness
Pine (white)	25	Aluminum	14.5
Fir	34	Zinc	36.7
Oak	50	Tin (cast)	38.3
Maple	53	Steel	40.8
Water (salt)	64	Stainless Steel	41.7
Sand (dry)	105	Brass / Nickel	44.8
Reinforced Concrete	150	Monel / Copper / Phosphor Bronze	46.4
Aluminum	165	Silver	54.7
Zinc	440	Lead	59.2
Steel	490		
Stainless Steel	500		
Brass / Nickel	537		
Monel / Copper / Phosphor Bronze	556		
Lead	710		
Plutonium	1211		



Step 4

To calculate the weight of the plate:

Multiply the area, 80 square feet by the unit weight of 41 pounds per square foot.

The weight of the plate is 3280 pounds

If 1-inch thick steel plate weighs 41 pounds per square foot, a 2-inch thick steel plate would weigh 82 pounds per square foot.

What would 1/2 inch thick steel plate weigh per

square foot? It would weigh 20.5 pounds.

Calculating the Weight of a Triangular Shape Step One

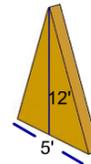
In this example, we have a triangular shape.

How do we find the area of this plate?

Multiply the base times the height and divide by 2.

12 times 5, divided by 2

The area of this plate is 30 square feet.



$$\text{Area of a Triangle} = \frac{\text{Base} \times \text{Height}}{2}$$

$$\frac{5' \times 12'}{2} = 30 \text{ sq ft}$$

Material	Weight per square foot per inch of thickness
Aluminum	14.5
Zinc	36.7
Tin (cast)	38.3
Steel	40.8
Stainless Steel	41.7
Brass / Nickel	44.8
Monel / Copper / Phosphor Bronze	46.4
Silver	54.7
Lead	59.2

Rounded up 45 lbs.

Step 2

To find the weight of this plate, we have to multiply the area (30 square feet) by the unit weight of the material per inch of thickness.

The material is brass, and the thickness is 3 inches.

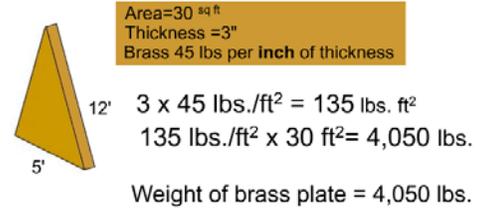
To find the total weight of the material we need to reference a table or chart to obtain the unit weight.

Step 3

We now know that brass weighs 45 pounds per square foot, per inch of thickness.

We multiply the thickness, 3 inches, by the unit weight of 45 pounds. The material weighs 135 pounds per square foot.

Next, we multiply the area, 30 square feet, times the weight per square foot, 135 pounds. We find that this item weighs 4,050 pounds.

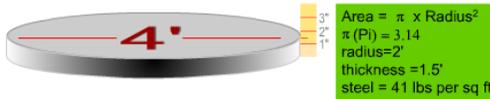


Area=30 sq ft
Thickness =3"
Brass 45 lbs per inch of thickness

12'
5'

$3 \times 45 \text{ lbs./ft}^2 = 135 \text{ lbs. ft}^2$
 $135 \text{ lbs./ft}^2 \times 30 \text{ ft}^2 = 4,050 \text{ lbs.}$

Weight of brass plate = 4,050 lbs.



Step 1
Area = 3.14×2^2
Area = 12.56 ft²

Step 2
Thickness x pounds per 1" thickness weight
 $1.5 \times 41 = 61.5 \text{ lbs / ft}^2$

Step 3
Area x lbs per sq. ft = Weight of plate
 $12.56 \text{ ft}^2 \times 61.5 \text{ lbs} = 772.44 \text{ lbs}$

Calculating the Weight of a Circular Shape

To calculate the area of a circle, multiply Pi, 3.14, by the radius squared.

This steel plate is 4 feet in diameter.

Therefore, the radius is 2 feet.

The plate is 1 ½ inches thick.

To find the area: multiply Pi, or 3.14 times the radius squared. 3.14 times 2, times 2 equals 12.56 square feet.

To find the weight per square foot: multiply the plate thickness, 1 ½ inches, times the weight of 1 square foot of 1-inch thick steel.

1.5 times 41 equals 61.5 pounds.

To find the weight: multiply the area, 12.56 times the unit weight of 1 ½ inch thick steel plate which is 61.5 pounds.

The weight of this circular steel plate is 772.44 pounds.

Rounding

Rounding numbers make calculations easier.

Always round up.

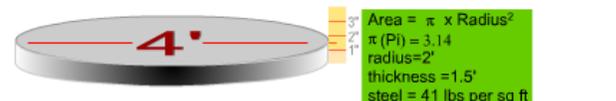
Rounding up gives a larger area and heavier weight, therefore an added safety margin.

Round up the plate area and the weight.

The area, 12.56 square feet, rounded is 13 square feet.

The weight, 61.5 pounds, rounded is 62 pounds.

13 times 62 equals 806 pounds.



4"
1.5"

Area = $\pi \times \text{Radius}^2$
 $\pi (\text{Pi}) = 3.14$
radius=2'
thickness =1.5"
steel = 41 lbs per sq ft

Step 1
Area = 3.14×2^2
Rounded Area = 13 ft²

Step 2
Thickness x pounds per 1" thickness weight
 $1.5 \times 41 = \text{Rounded } 62 \text{ lbs / ft}^2$

Step 3
Rounded Area X Rounded lbs/ft² = Weight of plate
 $13 \text{ ft}^2 \times 62 \text{ lbs/ft}^2 = 806 \text{ lbs}$

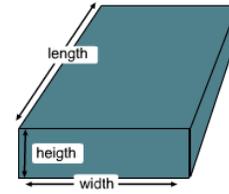
Knowledge Check

1. Select the best answer. To find the weight of a piece of aluminum plate, you would multiply ...
 - A. Square feet times material weight per square foot based on a specified thickness
 - B. Cubic feet times material weight per cubic foot
2. Select the best answer. A triangular shaped 1 inch thick metal plate has a base of 10 feet and a height of 15 feet. What is the area of the plate?
 - A. 1,500 feet
 - B. 150 feet
 - C. 75 square feet
 - D. 1,500 square feet
3. Select the best answer. A circular shaped $\frac{1}{2}$ inch thick metal plate has a base of 10 feet and a height of 15 feet. What is the area of the plate?
 - A. 22 square feet
 - B. 39 square feet
 - C. 22 feet
 - D. 7 square feet
4. Select the best answer. A complex shape of 1 inch thick aluminum plate has a rectangular area of 64 square feet and triangular area of 16 square feet. If aluminum weighs 14 pounds per square foot, how much does the plate weigh (rounded up to the nearest hundred pounds)?
 - A. 1,100 pounds
 - B. 1,300 pounds
 - C. 1,000 pounds
 - D. 1,200 pounds
5. Select the best answer. A complex shape of 1 inch aluminum plate measures 6 feet long on the top edge, 8 feet wide on the left edge, 12 feet long on the bottom edge, ending with a 10 foot long hypotenuse connecting back to the top edge. What is the correct equation to find the area of the triangular shape?
 - A. $8 \times 12 / 2$
 - B. $8 \times 6 / 2$
 - C. $6 \times 12 / 2$
 - D. $12 \times 10 / 2$

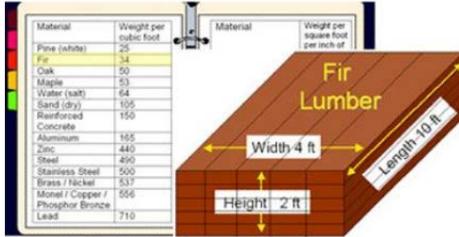
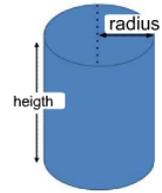
Calculating Volume

The volume of a square or rectangular object is figured as length times width multiplied by the height. The volume of a cylinder is Pi times the radius squared, times the height.

Volume = Length x Width x Height



Volume = $\pi \times R^2 \times \text{Height}$
 $\pi = 3.14$



80 cubic feet of fir lumber
 X 34 pounds per cubic foot
 2,720 pounds load weight

Calculating Load Weight Using Volume

To calculate weight, by volume, we need to find the unit weight, or weight per cubic foot for the material.

We go back to the tables to find the weight for a cubic foot of fir wood. This time we will use the table on the left since the material weights listed here are based on the weight per cubic foot of material.

Using the standard material weight chart, we find that fir weighs 34 pounds per cubic foot.

If the weight were listed in fractions or decimals, such as 33.8 pounds per cubic foot, we would simplify the math by rounding 33.8 up to 34 pounds. Multiplying 80 cubic feet by 34 pounds equals 2,720 pounds.

This stack of lumber weighs 2,720 pounds.

Load Weight for Cylinders Volume of a Cylinder

What is the formula for finding the volume of a cylinder? To calculate the volume we must first find the area of the circular end. The formula for area is Pi times radius squared.

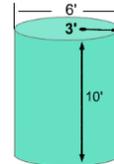
Once we know the area, we simply multiply it times the height or length.

So the formula we use to find the volume of a solid cylinder is, Pi times radius squared times the height.

If the cylinder were lying down you would use its length in place of the height.

Area (ft²) of the circular end (area of a circle) = Pi x radius²

Volume (ft³) of a solid cylinder = Pi x radius² x height



Volume of a Cylinder
 Volume of a Cylinder = Pi x Radius² x Height

Calculating the Volume of a Cylinder

Let's calculate the volume of this cylinder.

If the diameter of this object is 6 feet, what would the radius be?

The radius would be 3 feet.

The height is 10 feet.

We multiply Pi, which is 3.14, times 3 feet, times 3 feet.

The result is 28.26 square feet.

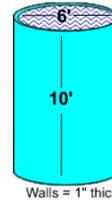
Now, multiply 28.26 square feet, times the height, 10 feet.

The result is the volume of this cylinder, 282.6 cubic feet.

If the cylinder is hollow, we will need to calculate the volume of the cylinder and the volume of the contents separately.

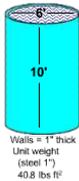
Calculate the volume as if the cylinder is solid. Then calculate the volume of the hollow.

Subtract the volume of the hollow section from the volume of the solid cylinder.



Dimensions:
Height=10'
Diameter = 6' Radius = 3'

Area of a Cylinder = $\pi \times \text{Radius}^2 \times \text{Height}$
 $3.14 \times (3' \times 3') = 28.26 \text{ sq feet}$
 $28.26 \text{ sq feet} \times 10' = 282.6 \text{ cubic feet}$



Bottom plate weight = $\pi \times \text{Radius}^2 \times 40.8 \text{ lbs ft}^2$

Step 1 $3' \times 3' = 9 \text{ ft}^2$
 Step 2 $3.14 \times 9 \text{ ft}^2 = 28.26 \text{ ft}^2$
 Step 3 $28.26 \text{ ft}^2 \times 40.8 = 1,154 \text{ lbs.}$

Cylinder wall weight = $\pi \times \text{diameter} \times \text{Height} \text{ ft} \times \text{weight of materials}$

Step 1 $3.14 \times 6' \times 10' = 1,884 \text{ ft}^2$
 Step 2 $1,884 \text{ ft}^2 \times 40.8 = 7,687 \text{ lbs.}$

Bottom Plate = 1,154 lbs
 Cylinder = 7,687 lbs

Calculating the Weight

One inch steel plate weighs 40.8 pounds per square foot.

The bottom plate is 6 feet in diameter, so the radius is 3 feet. 3 feet squared equals 9 square feet.

We multiply 9 square feet by 3.14. This gives us the area, 28.26 square feet.

We multiply this by the unit weight for steel plate of 40.8 pounds per square foot. The bottom plate weighs 1,154 pounds.

Calculate the cylinder wall weight as a flat plate. Multiply Pi, (3.14) times the diameter, 6 feet, times the height, 10 feet.

Multiply the area 1,884 square feet by the weight of steel plate, 40.8 pounds per square foot. The resulting weight is 7,687 pounds.

Cylinder Weight with Salt Water

Using the volume calculation, let's find the weight of the water contained in this thin-walled cylindrical tank.

Let's calculate the weight of this cylinder full of salt-water.

We need to know the weight per cubic foot of salt water.

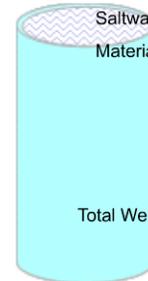
Looking at our material weight chart we see saltwater weighs 64 pounds per cubic foot.

We multiply the material weight times the cubic feet to find the weight of the water in the cylinder.

282.6 cubic feet times 64 pounds per cubic foot equals 18,086.4 pounds.

Now we will add up the weights.

1,154 pounds for the bottom plate, 7,687 pounds for the cylinder wall; and 18,087 pounds of water, for a total load of 26,928 pounds.



Saltwater = 64 lbs ft³
 Materials weight x cubic feet = weight of the water
 $64 \text{ lbs/ft}^3 \times 282.6 \text{ ft}^3 = 18,086.4 \text{ lbs}$
 Rounded up = 18,087 lbs

Bottom Plate = 1,154 lbs
 Cylinder = 7,687 lbs
 Water = 18,087 lbs

Total Weight of cylinder and water = 26,928 lbs

Knowledge Check

1. Select the best answer. A box has 27 cubic feet of sand in it. Sand weighs 105 pounds per cubic foot. The box weighs 1,200 pounds empty. The correct equation to find the total weight is:
 - A. $27 \times 105 = 2,835 + 1,200 = 4,035$ pounds
 - B. $27 \times 1,200 = 32,400 + 105 = 32,505$ pounds
 - C. $27 \times 105 = 2,835$ pounds
2. Select the best answer. A cylinder has a diameter of 12 feet, and a height of 17 feet. What is the volume of the cylinder rounded up?
 - A. 204 cubic feet
 - B. 7,687 cubic feet
 - C. 204 square feet
 - D. 1,922 cubic feet
3. Select the best answer. A cylinder is made of solid aluminum which has a unit weight of 165 pounds per cubic foot. What is the weight of this cylinder if the diameter is 4 feet and the height is 5 feet?
 - A. 10,000 pounds
 - B. 10,362 pounds
 - C. 12,532 pounds
 - D. 10,532 pounds
4. Select the best answer. A rectangular shaped tank has a length of 24 feet, a width of 10 feet, and a height of 12 feet. What is the volume of the tank?
 - A. 2,880 cubic feet
 - B. 2,900 feet
 - C. 2,880 square feet
 - D. 2,400 square feet

NOTES

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LOAD WEIGHT DISTRIBUTION

Welcome

Welcome to the Load Weight Distribution module.

Instructional Objectives

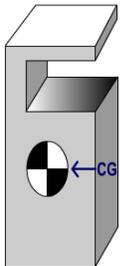
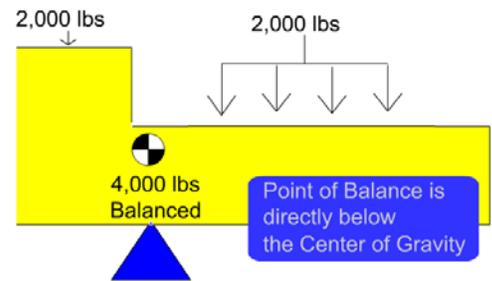
Upon successful completion of this module you will be able to: explain the difference between the center of balance or balance point, and the center of gravity, understand the importance of locating an object's center of gravity, calculate the center of gravity of various objects, discuss the determining factors of weight distribution to attachment points, apply the "Two legs carry the load" rule, explain the importance of weight distribution to attachment points, and calculate weight distribution to attachment points.

Center of Gravity

Center of Balance

An object will rest in a state of balance when supported at its balance point.

The balance point may not be located at the center of an object, but it is always directly below the center of gravity.



Center of Gravity (CG)

The center of gravity is the point where the entire weight of the object would balance in any direction, as if all the weight were concentrated in that one point.

It is a fixed point and does not change unless the shape of the object is altered.

Center of gravity is generally located in the center of symmetrical objects made of like material.

For non-symmetrical objects, it must be calculated and could be located outside the object.

The hook must be centered over the CG before lifting.

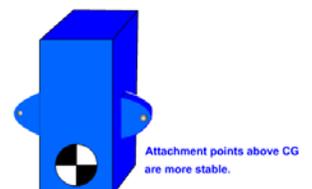
Why find the Center of Gravity

The location of the center of gravity will affect an object's reaction to movement.

If the attachment points are below the center of gravity, the object will tip over more easily when moved.



If the attachment points are above the center of gravity, the object is not likely to tip.

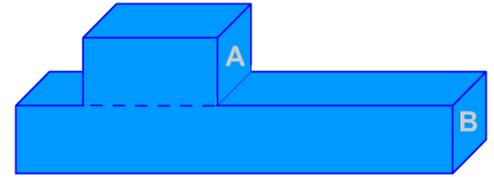


Finding the Center of Balance

Step 1

The balance point of a symmetrical object will be directly under its center.

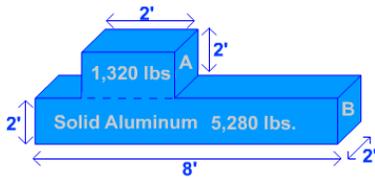
To find the balance point of a complex shape, we must first break the object into symmetrical sections or components.



Aluminum weighs 165 lbs per cu. ft.
 Part A = 2' X 2' X 2' = 8 cu. ft X 165 lbs = 1,320 lbs
 Part B = 2' X 8' X 2' = 32 cu. ft X 165 lbs = 5,280 lbs
 Add the sections: 1,320 + 5,280 = 6,600 lbs

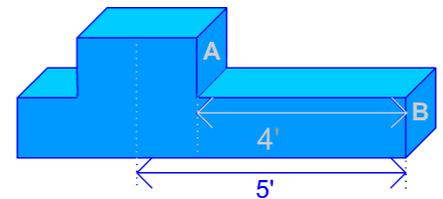
Step 2

The second step is to determine the weight of each section.



Step 3

The next step is to measure from the reference end to the center of each section of the object.



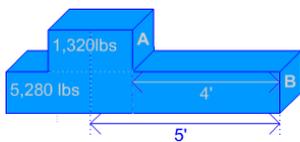
Multiply the weight of each section by the distance from the reference end to the center of each section.
 Moment of Section A = 1,320 lbs X 5' = 6,600 ft lbs
 Moment of Section B = 5,280 lbs X 4' = 21,120 ft lbs

Step 4

Then, multiply the weight of each section, by the distance from the reference end to the center of that section. The result is called moment.

Moment is an effect produced by a force at some distance from a fixed point, such as the center of gravity.

Moment, like torque, is often described in foot-pounds or pound-feet.

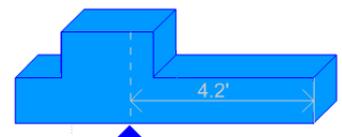


Step 5

Add the moments together and divide this number by the total weight of the object.

The balance point is where the moments, measured from each end, are equal.

Add the moments of each section (from step 4)
 Divide by the total weight (from step 2)
 Moment: 6,600 ft lbs + 21,120 ft lbs = 27,720 ft lbs
 Weight: 1,320 lbs + 5,280 lbs = 6,600 lbs
 27,720 ft lbs / 6,600 lbs = 4.2'



Pinpointing the Center of Gravity
CG Height

In this example the weight of section A is 2,640 pounds. The weight of section B is 5,280 pounds.

Measure the distance from the reference end to the center of each section.

Multiply the weight of each section by the distance from the reference end to the center of the section to obtain the moment.

The distance from the reference line to the center of section A is 3 feet and the distance from the reference line to the center of section B is one foot.

The moment for section A is 7,920 feet. The moment for section B is 5,280 pound feet.

Multiply:
 $3' \times 2,640 \text{ lbs} = 7,920 \text{ lb ft of moment}$
 $1' \times 5,280 \text{ lbs} = 5,280 \text{ lb ft of moment}$
Add: $13,200$
Divide: $13,200 / 7,920 = 1.666'$
 CG is located 1.666 feet above the Center of Balance

Add the moments together and divide by the total weight to find the height of the center of gravity.

7,920 plus 5,280 equals 13,200 pound-feet.

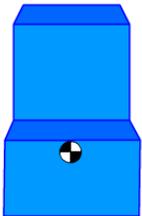
The weight is 2,640 plus 5,280 or 7,920 pounds.

Now divide 13,200 by 7,920. The center of gravity is 1.666feet up from the reference end.

If we convert decimal feet to inches, this equals 1 foot, 8 inches.

If the end view of the object is symmetrical

- the CG can be assumed to be centered between the sides.



CG Depth

To find the depth of the center of gravity, follow the five-step process using the front of the object as the reference end for step 3.

In this example, the end view shows the object is symmetrical.

Therefore, we can assume the center of gravity is in the center of the object – one foot from the front.

CG Pinpointed

The object's center of gravity is always directly above the balance point. It may be helpful to measure and temporarily mark the object's center of balance before rigging.

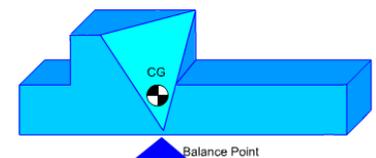
The Center of Gravity is found directly above the balance point.

When two sides are parallel

- the CG is centered between the sides.

When sides are not parallel

- the CG must be calculated for each plane.



CG Review

Remember to estimate the location of the Center of Gravity in relation to the attachment points before rigging or lifting loads.

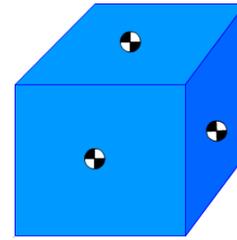
If the center of gravity is difficult to estimate, you may need engineering assistance.

Loads hoisted from the bottom without restraint are susceptible to tipping.

Loads should be lifted from their top, or restrained within the slings.

If a load is hoisted without keeping the hook over the center of gravity, the load will shift as it clears the ground.

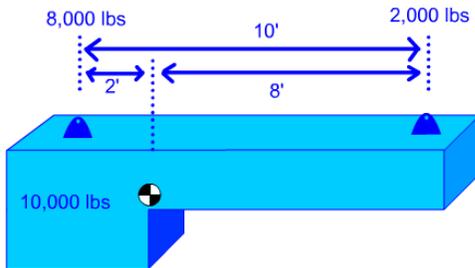
Sometimes the rigging must be re-adjusted before making the lift.



Estimate the location of the CG before choosing rigging.

If the CG is difficult to determine ask for engineering assistance

For safety make sure the hook is over the CG before lifting.



Weight Distribution

The center of gravity provides a quick reference for how the weight is distributed throughout a load.

However, before planning the lift it is necessary to refine how the load weight is distributed.

Weight distribution determines what each attachment point will have to carry.

This information ensures the selection of correctly rated rigging gear.

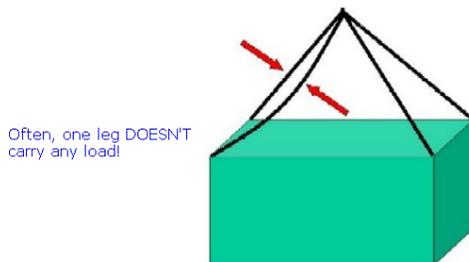
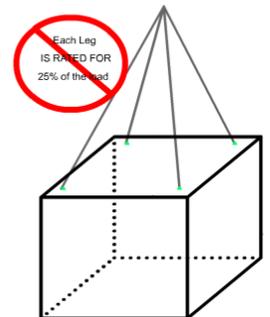
A Wrong Assumption

A common assumption is that 4 legs divide the load weight into 4 equal parts.

Each leg then carries 25% of the load.

Most often, this is not true.

Wrong Assumption!



Number of Legs that Really Carry the Load

We now understand that each leg will not always carry its share of the load.

In this example, one sling is longer than the others. Therefore that attachment point will not carry its share of the load.

No two slings are fabricated exactly the same length. When one sling is longer than the others,

when shackles or other hardware are different brands or sizes, or when one attachment point is higher than the others, one or more attachments may not carry any load at all.

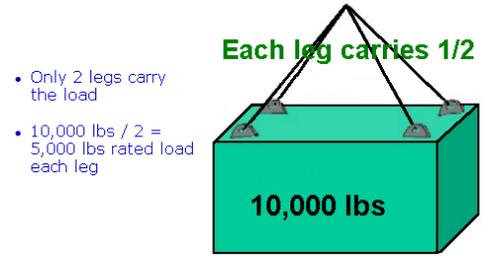
Don't assume that all legs will carry their share of the load.

A Safe Assumption

Here is a safe assumption:

At any given time, any two legs may carry the load, even if three or more legs are used.

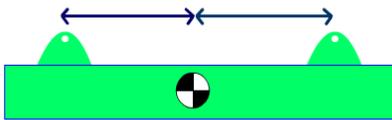
The "two-legs-carry-the-load" rule helps us to compensate for different sling lengths, attachment points at different elevations, and load flex.



Gear selections should be based on two legs being able to carry the load.

For example, if an object weighs 10,000 pounds then each leg would require a rated load of at least 5,000 pounds.

How much weight does each leg carry?



Determining Leg Weight

Gear selection is dependent upon how much weight is carried by each leg - the load's weight distribution.

The distances between the Center of Gravity and the attachment points will determine how much of the weight each attachment point will carry.

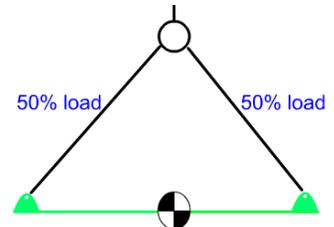
Equal Leg Weight

This drawing represents a load.

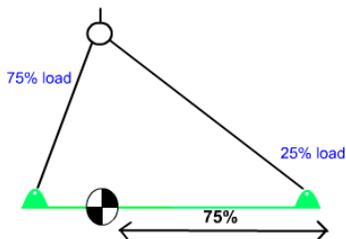
Notice the difference in weight distribution as the center of gravity changes distance from each attachment point.

In this first example, each attachment carries equal weight because the center of gravity is equal distance between the attachment points.

Watch the left attachment point as we move the center of gravity.



When distances between the CG and attachment points are equal, weight distribution is also equal.



When distances between the CG and attachment points are unequal, weight distribution is inversely proportionate.

Unequal Leg Weight

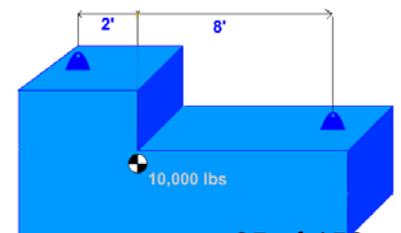
In the second example, the weight is greatest in the left attachment point because it's closest to the center of gravity.

When one attachment point is closer to the center of gravity than the other attachment point, it carries more weight.

It carries 75% of the weight and the opposite end carries 25%.

Calculating Weight Distribution

Now, let's move beyond estimating and show how to calculate the weight distribution.



Category 2 and Cab-Operated Category 3 Crane Safety Student Guide

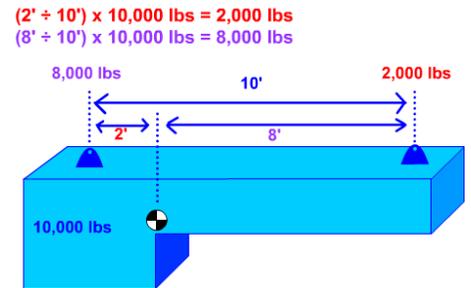
In order to calculate weight distribution, you must know the object weight, the location of the center of gravity and the distance of each attachment point from the center of gravity.

Weight Distribution Example

If we want to find out how much weight is distributed to the attachment closest to the center of gravity, we divide the 8-foot distance by the overall distance between attachment points, which is 10 feet.

Then we multiply this answer by the total weight of the object.

Eight divided by 10, times 10,000 equals 8,000 pounds.



Knowledge Check

1. Select the best answer. An attachment point is 2 feet from the center of gravity and the other attachment point is 6 feet from the center of gravity. What is the correct percentage of weight distribution to each attachment point with the attachment point 2 feet from the center of gravity being listed first?
 - A. 75%, 25%
 - B. 25%, 75%
 - C. 50%, 50%
 - D. 33%, 66%
2. Select the best answer. Center of Gravity is best described as:
 - A. Always in the center of an object
 - B. Where all the weight is concentrated
 - C. Where the item balances
3. True or False. The center of gravity is located below the center of balance.
 - A. True
 - B. False
4. True or False. The center of gravity (CG) is always located within the object.
 - A. True
 - B. False

Category 2 and Cab-Operated Category 3 Crane Safety Student Guide

5. Select the best answer. Attachment point #1 is 6 feet from the center of gravity (CG) and attachment point #2 is 3 feet from the center of gravity. There is a 10,000 pound load attached. What is the correct equation to find the weight distribution for attachment point #1?
- A. 3 divided by 9 multiplied by 10,000 ($3 / 9 \times 10,000$)
 - B. 6 divided by 3 multiplied by 10,000 ($6 / 3 \times 10,000$)
 - C. 3 divided by 6 multiplied by 10,000 ($3 / 6 \times 10,000$)
 - D. 9 divided by 3 multiplied by 10,000 ($9 / 3 \times 10,000$)
6. True or False. The center of gravity (CG) will always find its way directly under the crane hook when lifted off the ground.
- A. True
 - B. False

NOTES

SLING ANGLE STRESS

Welcome

Welcome to Sling Angle Stress.

Instructional Objectives

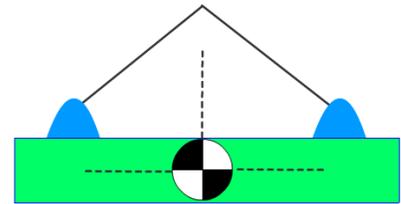
Upon successful completion of this module you should be able to: define sling angle stress and explain why it must be accounted for, calculate sling angle stress and determine the minimum sling length and rated capacity for lifts.

Introduction to Sling Angle Stress

Definition

What is sling angle stress?

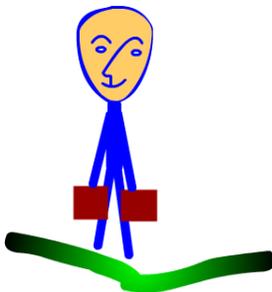
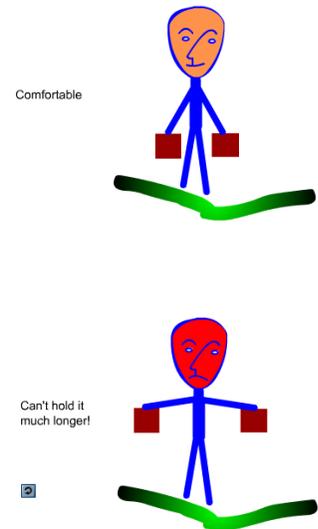
It is the added force created in the rigging when the slings are not perfectly plumb, vertical, and parallel.



Demonstration

It may be beneficial to use an illustration that we can relate to.

Though this is not exactly sling angle stress, it illustrates the concept very well.



90° Example

Here's Ace.

He is holding a fifty-pound weight in each hand.

His arms are vertical, similar to a 90° horizontal sling angle.

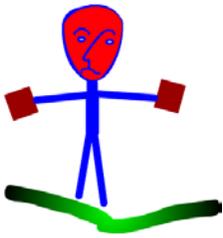
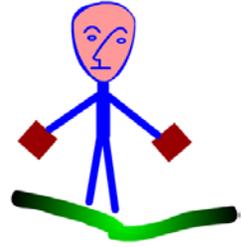
The amount of stress in Ace's arms is equal to the amount of weight he's holding, fifty pounds.

See what happened as Ace moved his arms increasingly further away from his body.

45° Example

When Ace has his arms at a 45° angle the stress in his arms increases even more.

The stress increase is 42% of the weight he's holding. It feels like he's holding 71 pounds in each arm.



30° Example

At a 30° angle, the amount of stress in Ace's arms increases further.

The stress increase at 30° is 100% of the weight he's holding. Now Ace feels like he's holding 100 pounds in each arm even though the weight is still actually 50 pounds.

This same effect, called sling angle stress, occurs in rigging gear because the legs of a lift are almost always at angles. This additional stress must be considered when selecting rigging gear.

Choosing Your Gear

The two-leg rule is followed when choosing gear capacities for a lift.

Rigging gear must have a capacity greater than the applied load.

The load applied to the rigging gear includes the weight carried by the attachment points multiplied by the sling angle factor.



- The lift triangle
 - » Attachment points
 - » Crane hooks
 - » The load
- Adds stress to load and rigging
- Can cause overload and/or gear failure

The Effects of Sling Angle

Nearly every lift creates a triangle.

All of the components that make up the sides of a lift triangle are affected by sling angle stress including the attachment points on the load, the crane hook, the rigging gear and the load itself.

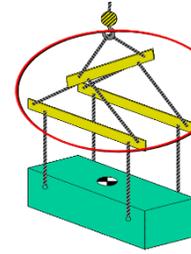
Sling angle stress can cause the load to flex and sag.

Excessive sling angle stress can cause a choker hitch or basket hitch to crush a fragile item.

Remember, sling angle stress does not change the weight of the load being lifted; only the load on the rigging.

Minimizing Sling Angle Stress

Sling angle stress can be minimized by using spreaders or other below the hook lifting devices. Lifting beams or strong-backs can help ensure each sling is carrying its share of the load and that the load remains level. Sling angles may still affect the rigging gear between the hook and spreaders, even if the slings between the spreader and the load are vertical!



Spreader bars allow legs to be rigged perpendicular to the center of gravity. Remember to account for sling angle between the hook and spreader.

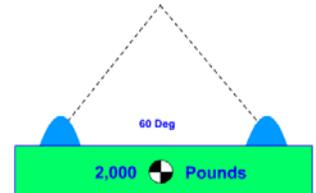
Sling Angle Stress Summarized

When referring to the effects of sling angle, we refer to horizontal sling angle. In other words, we are measuring the angle created between the sling and a horizontal line through the attachment points. Sling angle stress is proportional to the degree of the angle from horizontal. The more vertical the angle - the less added force. The more horizontal the angle - the greater the added force. Let's look at this principle on a load.

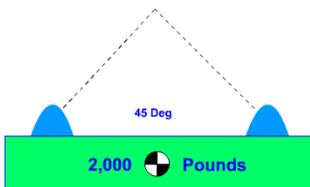
Examples

At a 60° angle the load on the rigging has increased to 1,155 pounds. Keep in mind each leg has 1,155 pounds of stress even though only one leg is shown. 60° is the preferred angle!

At a 60 Degree Angle
Sling stress = 1,155 lbs per sling



At a 45 Degree Angle
Sling stress = 1,414 lbs per sling

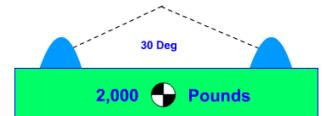


At a 45° angle the load has increased to 1,414 pounds in each sling. That's nearly a 42% increase!

At a 30° angle the stress has increased to 2,000 pounds. Each sling now has a load equal to the weight of the object! That is a 100% increase!

At a 30 Degree Angle
Sling stress = 2,000 lbs per sling

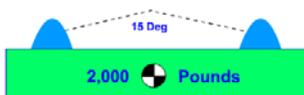
Never lift at less than a 30 degree sling angle without engineering approval!



Never lift with less than a 30° angle without engineering approval!

At a 15 Degree Angle
Sling stress = 3,860 lbs per sling

Never lift at less than a 30 degree sling angle without engineering approval!



At a 15° angle the load has increased to 3,860 pounds. That's a 286% increase in each sling!

Why Must We Account for Sling Angle Stress?

Not accounting for sling angle stress can lead to overloaded rigging gear and even catastrophic failure.

Minimum Rated Capacity

Remember, two legs must have the capacity to lift the weight of the object, plus the added force from sling angle stress.

After we calculate the sling angle stress, we can determine the minimum requirements for our rigging gear.

Angle Factor

Determining Sling Angle Stress

There are several ways to determine sling angle stress. We will use the angle factor chart, as it is readily available and easy to use.

Using an Angle Factor Chart

To use an angle factor chart, you first need to determine the sling angle.

Sling angle can be determined mathematically or measured.

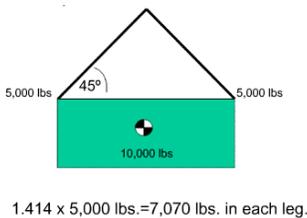
Once you have determined the sling angle, find the corresponding angle factor, and multiply that number by the weight carried in each leg.

When you look at the angle factor column, you will notice a dramatic increase for angles less than 30°.

That's why we do not use sling angles less than 30° unless authorized by an engineering document.

Horizontal Angle	Angle Factor
90	1.000
85	1.004
80	1.015
75	1.035
70	1.064
65	1.104
60	1.155
55	1.221
50	1.305
45	1.414
40	1.555
35	1.742
30	2.000
25	2.364
20	2.924
15	3.861
10	5.747
5	11.490

Horizontal Angle	Angle Factor
90	1.000
85	1.004
80	1.015
75	1.035
70	1.064
65	1.104
60	1.155
55	1.221
50	1.305
45	1.414
40	1.555
35	1.742
30	2.000
25	2.364
20	2.924
15	3.861
10	5.747
5	11.490



Angle Factor Chart Example

This shape represents the lift we are about to make.

Let's say that the angle created by the slings we use is 45°.

The angle factor for a 45° angle is 1.414.

We must multiply the angle factor, 1.414 by the weight carried in the leg.

How much weight will the leg carry?

That's right, 5,000 pounds.

1.414 times 5,000 equals 7,070 pounds. This is the total stress in each leg!

This number represents the minimum gear capacity that can be used for the lift.

What is Angle Factor?

Remember the lift triangle?

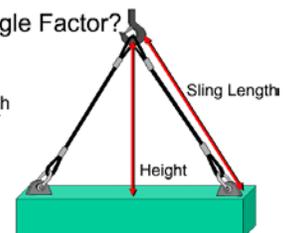
Now the whole triangle idea really comes into play.

The sling angle factor is a ratio of the side of the lift triangle, which in this case is the sling, and the height of the triangle.

To find it, divide the sling length by the height of the lift triangle.

What is Angle Factor?

$$\text{Angle Factor} = \frac{\text{sling length}}{\text{height}}$$



The height is the distance between the bearing area of the hook and an imaginary line running horizontally from the bearing area of the attachment point. If you cannot measure the height, it can be found mathematically.

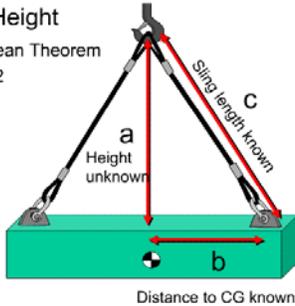
How to Find Height

Use the Pythagorean Theorem

$$a^2 + b^2 = c^2$$

To solve for a:

$$c^2 - b^2 = a^2$$



How to Find Height

The Pythagorean theorem states that the length of a side of a right triangle squared, equals the length of the base squared plus the height squared. A squared, plus B squared, equals C squared. Here the height of the lift triangle is A, the horizontal base is B and length of the sling is C. Only A, the height, is unknown.

To find the unknown height, A, use this variation: C squared minus B squared equals A squared.

Height (cont)

Use C squared minus B squared equals A squared to solve for height.

The sling, C, is twenty-feet long.

Multiplying the sling length times itself gives us C squared.

In this case, that is twenty times twenty or four hundred.

We measure the horizontal distance from the bearing area of the attachment to the top of the load directly above center of gravity.

This dimension, B, is ten feet. We multiply this number by itself.

Ten times 10 equals 100.

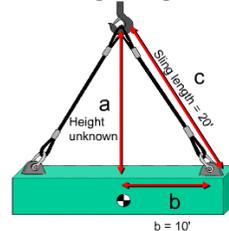
Subtract 100, Which is B squared, from 400, which is C squared.

Therefore A squared equals 300.

Now we use the square root function on our calculator to calculate the square root of 300.

The height equals the square root of 300, which is 17.32 feet.

Finding Height



$$c^2 - b^2 = a^2$$

$$(20 \times 20) - (10 \times 10) = a^2$$

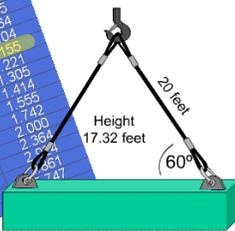
$$(400) - (100) = 300$$

$$\text{Square Root of } 300 = 17.32$$

Height = 17.32

Horizontal Angle	Angle Factor
100	1.000
90	1.000
85	1.015
80	1.035
75	1.064
70	1.104
65	1.155
60	1.221
55	1.305
50	1.414
45	1.555
40	1.742
35	2.000
30	2.309
25	2.667
20	3.061
15	3.501
10	4.000
5	4.557

Sling Length ÷ Height
 $20' / 17.32' = \text{Angle Factor } 1.155$



Finding the Angle Factor

Remember the angle factor equals sling length divided by height.

We just found the height of the lift triangle.

Now, here's how to find the angle factor:

The sling is 20 feet long and we found the height to be 17.32 feet.

20 divided by 17.32 equals 1.155. This is our angle factor.

Finally, we will multiply the angle factor by the

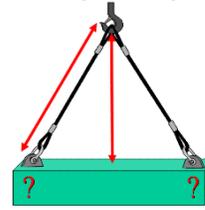
amount of weight at the attachment point.

Solving for Sling Angle Stress Mathematically

Now we can use everything we've covered thus far to solve for sling angle stress.

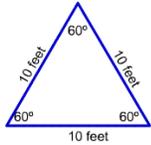
Here's the formula: Sling length divided by height, times the weight distributed to each leg.

Remember, weight distribution is determined by the distance from the center of gravity to the attachment points. This works for all lifts with level attachment points.



(Sling Length ÷ Height) × Weight Distribution = Sling Angle Stress

60° Sling Angle - Preferred Sling Angle



- Only 16% load increase
 - Easy to select slings
- But...
- Best sling lengths are not always available
 - Configuration may restrict
 - Overhead clearance

Sling Angle Methods 60 Degree Sling Angle

60° is the preferred sling angle.
At 60°, the load in the slings increases by 16%.

60° Sling Length

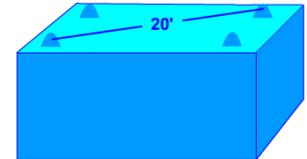
To ensure your slings will have at least a 60° sling angle simply measure the distance between attachment points.

Measure diagonally when there are more than two attachment points because it's the longest distance.

Then select a sling that is as long or longer than the distance measured.

If you use this method to select your slings, you will never have a sling angle less than 60°.

- Measure the distance between attachment points (20')
- Select a sling as long as the distance, or longer
- In this case 20 feet.



Selecting Minimum Rated Capacity for 60° Sling Angle



60° angle Factor of 1.155
1.155 x 2,500 lbs. = 2,888 lbs. Stress
Minimum capacity sling and rigging gear require 2,888 lbs.

60° Minimum Capacity

Now we can easily determine the stress in the rigging before we attach the gear. Let's say the weight of the object is 5,000 pounds. How much weight would each attachment point carry?

Each would carry 2,500 pounds.

What is the angle factor for a 60° sling angle?

The angle factor is 1.155 .

Multiply the angle factor, 1.155, times the weight distributed to the attachment point, 2,500 pounds.

2,888 pounds is the stress in the rigging gear and attachment points. It is also the minimum capacity for all rigging for this lift!

30° Minimum Capacity

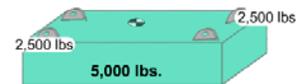
Using the same weight, let's look at the minimum rated capacities for a 30° sling angle.

The angle factor for 30° is 2. At a 30° sling angle, the rigging and attachment point stress will double.

Two times 2,500 pounds equals 5,000 pounds of stress.

The minimum capacity sling and rigging gear required is five thousand pounds.

Minimum Rated Capacity at 30°



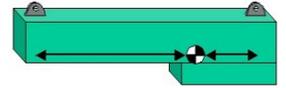
30° Angle Factor = 2.00
2.00 x 2,500 lbs. = 5,000 lbs. stress
Minimum capacity sling and rigging gear require 5,000 lbs.

Unequal Distances from the Center of Gravity

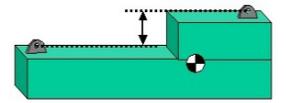
Where the center of balance is not equally distant between attachment points or when attachment points are on different levels, sling angle stress will not be equal between legs and extra calculations will be required.

Contact your supervisor and consult the activity engineers for guidance when there is a question about sling angle stress for these types of lifts.

- Never assume sling angle stress is equal between legs



- Calculations are required to find sling angle stress



Knowledge Check

1. True or False. A 60° sling angle will be formed when you match the sling length to the diagonal distance between attachment points.

- A. True
- B. False

2. Select the best answer. An object has a length of 4 feet, a width of 3 feet, and a distance of 5 feet 6 inches between top right and bottom left attachment points. What length slings would you select to ensure the horizontal sling angle was 60° or greater?

- A. 3 feet
- B. 5 feet
- C. 4 feet
- D. 6 feet

3. Select the best answer. To find sling angle stress ...

- A. Multiply the weight of the item times rated capacity of the gear
- B. Multiply the weight of the item times the distance between attachment points
- C. Multiply the weight in the attachment point times the height of the lift triangle
- D. Multiply the weight in the attachment point times the angle factor

NOTES

D/D RATIO

Welcome

Welcome to the D/d Ratio Module.

Objectives

Upon successful completion of this module you will be able to: explain the concept of "D" to "d" ratio (D/d), determine a sling's D/d ratio in a given application, determine sling efficiency, and determine the sling's rated load.

D/d Ratio

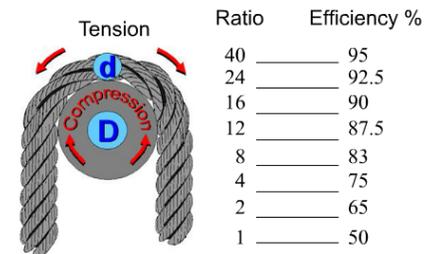
D/d ratio is the relationship between diameter of an object that a sling is bent around to the diameter of the sling. D/d ratio is generally applied to wire rope slings.

The tighter the bend, the greater the loss of strength. The sling can be weakened and severely damaged if it's bent around a diameter smaller than its own diameter.

To determine how the bending will affect the sling: divide "D", the object diameter by "d", the sling diameter. The result is the D/d ratio.

Use table fourteen-three in the P-307 to determine sling efficiencies at various D/d ratios.

$$\text{D/d Ratio} = \frac{\text{OBJECT DIAMETER}}{\text{WIRE ROPE DIAMETER}} = \frac{D}{d}$$



Step 1
Determine D/d Ratio
 $1" / 1/2" = 2$

1" Diameter Hook
1/2" Wire Rope
WLL 4,000 lbs.

Step 2
Use the chart to find efficiency

Ratio	Efficiency %
40	95
24	92.5
16	90
12	87.5
8	83
4	75
2	65
1	50

1 leg is 65% efficient
2 legs in this configuration

Understanding Efficiency

Here we have a 1/2-inch wire rope sling with a rated load of 4,000 pounds, bent around a 1-inch hook.

The first thing we must do is determine the D/d ratio.

The hook diameter is 1 inch and the sling diameter is 1/2 inch. 1 divided by 1/2 equals 2.

The D/d ratio is 2.

Looking at the chart, we see that a D/d ratio of 2 provides 65% efficiency. One leg is 65% efficient. There are two legs in this configuration.

Using Efficiency to Find Rated Load

Now that we know the efficiency, let's figure out the maximum weight that could be lifted in this configuration.

First, we must determine the rated load of each leg.

We multiply the rated load by the efficiency; 4,000 times .65 or 65%, equals 2,600. 2,600 pounds is the rated load for one leg.

When we double a sling over an object, we effectively create two legs. Since two legs are carrying the load, we multiply the rated load by 2.



Determine WLL
 $4,000 \times 65\% = 2,600$

1" Diameter Hook
1/2" Wire Rope
WLL 4,000 lbs.

2 legs carry the load
 $2 \times 2,600 = 5,200 \text{ lbs.}$

2,600 times 2 equals 5,200.

This is the rated load of the doubled sling.

Whenever we bend a wire rope around an object, or double our wire rope slings, this D/d ratio must be calculated.

For D/d ratios that fall between the values shown, use the lower efficiency.

D/d Calculations

The D/d principle also applies to slings bent around corners.

In this case, the diameter of the curvature of the sling as it bends around the corner of the object to be lifted must be determined.

For many applications, special fittings such as pipe sections are placed on the corners of the object to ensure a large enough diameter of curvature for the sling so as not to reduce the sling efficiency too greatly.

NOTES

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RIGGING GEAR MARKING AND RECORD REQUIREMENTS

Welcome

Welcome to the Rigging Gear Marking and Record Requirements module.

Instructional Objectives

Upon successful completion of this module you will be able to: explain the primary goal of the test and inspection program, identify the section of NAVFAC P-307 that addresses rigging gear requirements, list the required equipment markings, identify what records must be kept and identify the equipment covered in section 14.

NAVFAC P-307 Section 14

Let's look at the section of NAVFAC P-307 that deals with rigging; Section 14. Section 14 provides administrative and technical requirements for inspection, testing, certification, alteration, repair, operation, and use of rigging gear. These requirements help ensure the rigging gear you use is safe. When followed, these requirements help ensure optimum service life of the gear. These requirements apply to Navy owned gear and to contractor owned gear used with Navy owned cranes. These requirements also apply to covered equipment used with multi-purpose machines, material handling equipment (e.g., forklifts), and equipment covered by NAVFAC P-300. Except for BOS contracts, these requirements do not apply to contractor owned equipment used with contractor owned cranes, forklifts, backhoes, excavators, and front-end loaders.

The Test and Inspection Program

P-307 requires each activity to establish a program that includes: initial visual inspection and load test of all equipment and markings, pre-use inspections before equipment is used, documented periodic inspections of all equipment, and documented periodic load tests of certain equipment.

Why Test and Inspection?

Why do we need a test and inspection program?

The primary goal is to prevent personnel injury!
The test and inspection program is designed to identify: sub-standard, defective, damaged, or worn equipment and remove unsafe equipment from service.

Covered Equipment

Test and inspection requirements apply to the following equipment used in weight handling operations.

Rigging hardware such as shackles, links and rings, swivels, eye bolts, swivel hoist rings, turnbuckles, and hooks. These requirements also apply to slings including chain slings, wire rope slings, metal mesh slings, synthetic web slings, synthetic rope slings and synthetic round slings.



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These requirements also apply to portable load indicators, portable manual and powered hoists, and crane structures without permanently mounted hoists.



Additional Covered Equipment

Equipment covered includes manually operated hoists as identified in ASME B30.16 and B30.21 which include chain hoists and lever operated hoists.

Equipment covered also includes miscellaneous equipment, including below the hook lifting devices as identified in ASME B30.20, such as spreader beams, plate clamps, magnet lifters, pallet lifters, tongs, container spreaders, personnel platforms, portable gantry/A-frames, and portable floor cranes used for general lifting, and cranes and hoists procured with, integral to, and used solely in support of larger machine systems.

Equipment Not Covered

Equipment not covered includes ordnance equipment, which falls under NAVSEA OP-5, original equipment manufacturer or OEM installed welded lift lugs, threaded holes and bolt-on pads, and OEM provided rigging gear used for limited lifts such as off-loading, re-loading, initial storage, and shipment.

Where OEM provided specialized rigging equipment is used, the activity shall ensure that the equipment is in good condition and that personnel using the equipment know how it is to be used.



Knowledge Check

1. Select all that apply. The reason test and inspection is required is to:
 - A. Prevent personnel injury
 - B. Identify sub-standard equipment
 - C. Remove unsafe equipment
2. Select the best answer. Rigging gear identification markings applied by the activity usually indicate that the equipment is:
 - A. New to the activity
 - B. Not damaged
 - C. Authorized for use
 - D. In an inspection program
3. Select the best answer. Equipment test and inspection requirements in section 14 of NAVFAC P-307 do not apply to:
 - A. Container spreaders
 - B. OEM installed integral attachments
 - C. Cranes and hoists integral to larger machines
 - D. Personnel platforms

Equipment Markings

Markings on each piece of equipment are the most apparent way for you, the user, to know the requirements of NAVFAC P-307 have been met.

Each piece of equipment must be clearly marked, tagged or engraved with the rated load of the equipment, an indication of the re-inspection due date, and a unique serial number that will allow it to be traced to its test and inspection documentation.

Below the hook lifting devices weighing more than 100 pounds shall be marked with the weight of the device.

Markings must be done in a manner that will not affect the strength of the component. Vibra-etch methods and low stress dot faced stamps are acceptable methods for marking equipment.

Contact the OEM for guidance on where and how to mark equipment.



Special Roundsling Markings

NAVFAC P-307 has additional requirements for alternate yarn roundslings. Alternate yarn roundslings are roundslings made from yarns other than nylon or polyester.

The certificate of proof test must include the diameter of the pin used for the proof test. This will be the minimum diameter over which the sling may be used.

The sling must be marked with the minimum allowable pin diameter.

Wire Rope Endless Slings

In non-specific use applications endless slings shall have a marked rated load based on a D/d efficiency of 50 percent and may be used over various size pins at loads not exceeding the marked rated load.

In specific applications where endless wire rope slings are designed for a particular use, they shall be marked to indicate the pin diameter used to determine the rated load.



Markings on Chain Slings

In accordance with 29 CFR 1915.112 and 29 CFR 1917.42, chain slings used in ship repair, shipbreaking, or cargo transfer require quarterly periodic inspections and must be marked to show the month and year they were inspected.

Chain slings not used in ship repair, shipbreaking, or cargo transfer require a 2-year periodic inspection frequency.

Markings on Lashing

Lashing must be marked to identify it to the spool or reel from which it came.

The rated load must be marked on each piece as well as the re-inspection due date.



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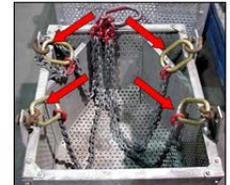


Multiple Part Equipment

Some rigging gear has multiple parts that can be disassembled. To help avoid miss matching parts, all individual components of equipment such as shackles and pins must be identified to each other. Matching ID marks are needed on the primary and subordinate parts.

Markings on Multi-leg Sling Assemblies

Multi-leg slings assemblies shall be marked with the rated load of each leg, the rated load of the entire assembly, and the sling angle upon which the rated load is based.



Markings for Multi-Part Slings

NAVFAC P-307 **requires** that multi-part slings (sometimes referred to as braided slings) shall have the OEM's marking re-marked at 70% of the OEM's rated load unless destructive tests are conducted on sample slings. The documentation is reviewed by the Navy Crane Center.

So, there are many additional markings that may be required for different equipment. Not only do these markings have to be present, they must be legible.



Hard to Read or Missing Markings

Sometimes markings become hard to read due to wear or they may even be removed during a repair process. Replace markings that are hard to read or have been removed.

Remember, all rigging equipment must be marked.

Required Records

Equipment markings should link the piece of equipment to its test and inspection records.

NAVFAC P-307 requires documentation of tests and inspections.

Records are the auditable proof that equipment has been tested and inspected and provide a basis for ongoing evaluation of the equipment.

The latest test and inspection record will be retained on file at the activity.

Computer generated files are acceptable if they identify the individual components and inspection results.

MASTER HISTORY RECORD CARD		EQUIPMENT TYPE / DWG NO		EQUIPMENT ID			
SPEC CAPACITY		MINIMUM RECOMMENDED PERIODIC TEST VALUE	MAX MATERIAL REMOVAL AUTHORIZED		PROOF TEST VALUE		
THIS CARD IS TO BE USED FOR RECORD BASE (ORIGINAL) DIMENSIONS AND INFORMATION FOR SPECIAL PURPOSE EQUIPMENT. REFER TO NAP 2A12-3 FOR DETAILED INSTRUCTIONS.							
FILL IN APPLICABLE ITEMS ONLY. USE REVERSE SIDE TO RECORD HISTORY AS REQUIRED BY NAP 2A12-3.							
ITEM	DESCRIPTION	ORIGINAL VALUE	SIGNATURE / DATE	FIRST REPLACEMENT VALUE	SIGNATURE / DATE	SECOND REPLACEMENT VALUE	SIGNATURE / DATE
HOOKS	CAPACITY						
	TRAIL DIMENSION						
FORGED FITTINGS	TYPE						
	SIZE (INCLUDE THREAD LENGTH)						
CHAIN	SIZE (INCLUDE AVERAGE LENGTH)						
	COVERS LINKS						
SLINGS	TYPE						
	DIA (WIDTH)						
	ATTACH (CERTIFICATION)						
LOAD INDICATOR	TYPE / BREAKING STRENGTH						
REMARKS REQUIRED							

Documented Test and Inspections provide:

- Auditable proof of tests and inspections
- The basis for ongoing evaluation
- Latest record to be kept on file

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Records Must Include

NAVFAC P-307 requires that the records include identification of individual components, latest test and inspection results, and dates of inspections and tests.

There are many ways to identify the equipment to the records.

MASTER HISTORY RECORD CARD		EQUIPMENT TYPE / DWG NO		EQUIPMENT ID CF 127D	
SPS CAPACITY	MANUF. RECOMMENDED PERIODIC TEST VALUE	MAX. MATERIAL REMOVAL AUTHORIZED	PROOF TEST VALUE		
RECORD OF INSPECTION / TESTING CYCLE	PURPOSE / DESCRIPTION	S	U	** C/740 VSR:DATE	MAINTENANCE REPAIR AND MODIFICATION RECORD CYCLE DESCRIPTION **C/740VSR:DATE
Annual	Load Test Chainhoist	X		J.W. Inspector 1/27/20XX	



Unique identification number
Letter designator followed by a number

Example:
S-27
"S" represents *shackles*
27 individually identified shackle

Identifying Gear to Its Record

A unique identification number may be used to identify the equipment to its record.

The ID number can be as simple or complex as you need it to be.

A simple method might be to use a letter

designator that represents a particular type of gear followed by a serialized number.

For example, "S" could represent shackles. If you have 50 shackles they could each be individually identified S1, S2, S3, etc.

Mark the equipment ID number on the gear. Write the ID number on the record.

Now the gear has identifiable records!

Gear Marking Example

This is an example of how the gear is marked at one Naval Shipyard. This is just one example of how an activity could choose to identify individual components to their records.

This example reflects a fairly complex system that may be useful for activities who own multiple groups of equipment that need to be segregated.

In this example, the unique identification number is used to identify three different things.

The first number "98" identifies which shop, group, or code owns the equipment.

Secondly, "P28" identifies the specific piece of gear with a serialized number.

This particular number indicates that it was the 28th sling manufactured or certified on a specific day.

The number 94-350 identifies the day it was manufactured or certified:

- 94 being the year 1994
- 350 being the day of the year.



- Year
- Julian date

Use your mouse to explore information

No matter what method you use, there is important information that should be included in the gears records.

Knowledge Check

1. Select all that apply. Markings on lashing must identify:
 - A. The spool or reel
 - B. Size
 - C. Rated load
 - D. Serial number
 - E. The re-inspection due date

2. Select the best answer. Rigging gear test and inspection records must include:
 - A. Identification of individual components
 - B. Dates of tests and inspections
 - C. Latest test inspection results
 - D. All of the data listed above

3. Select the best answer. Matching ID marks on rigging gear are required for:
 - A. All rigging equipment
 - B. Rope or chain sling bidle assemblies
 - C. End fittings on slings
 - D. Components that can be separated
 - E. Chin slings with permanent attachments

4. Select the best answer. Rigging gear test and inspection records are required to be kept on file:
 - A. For 6 months
 - B. For 1 year
 - C. Until replaced by a more current record
 - D. For 3 years

NOTES

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RIGGING GEAR INSPECTION

Welcome

Welcome to the Rigging Gear Inspection module.

Instructional Objectives

Upon successful completion of this module you will be able to list the required inspections, determine inspection frequency, describe inspection and rejection criteria, and identify repair requirements.

Inspections

Inspection Types

There are two types of required inspections, pre-use and periodic.

The pre-use inspection is performed prior to use.
No documentation is required for pre-use inspections.

The periodic inspection is a comprehensive, documented inspection, performed on a schedule.

Pre-Use Inspection

All equipment must be inspected prior to each use.

The pre-use inspection ensures the equipment is not damaged or worn beyond allowable limits.

The inspector must verify the rated load of the equipment and ensure the markings are legible.

If the inspection due date has passed, the equipment must not be used.

Remove any gear from service that fails inspection.

Periodic Inspection

Periodic inspections must be done by a qualified person.

If inspection reveals that the equipment has accumulated damage or is worn beyond the allowable limits it must be removed from service.

Records must be kept on file for all periodic inspections. Inspection records provide a basis for evaluation, and provide the audit trail proving the equipment is in a test and inspection program.

The inspection frequency varies depending on the type of equipment. See table 14-1 of NAVFAC P-307.

Annual Inspections

Periodic inspections are required every year for slings, lashing, hoists, equalizers, load indicating devices, container spreaders, personnel platforms, cranes integral to larger machine systems, and below the hook lifting devices.



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Equipment covered in the biennial inspection program includes:

Beam clamps
Blocks
Tackle
Snatch
Wire rope

Crane structures without permanent hoists

Eye bolts
Eye nuts
Hooks
Links and rings
Portable A-frames
Portable Gantries
Portable floor cranes
Shackles
Swivels
Swivel hoist rings
Turnbuckles



Biennial Inspection

Periodic inspections are required every 2 years for rigging hardware such as beam clamps, tackle blocks, snatch blocks and wire rope blocks.

Crane structures without permanent hoists are also included, as are: eye bolts, eye nuts, hook, links and rings, portable A-frames, portable gantries, portable floor cranes, shackles, swivels, swivel hoist rings and turnbuckles.

Inspection Every Three Months

In addition to the annual inspection noted previously, OSHA requires a periodic inspection every three months for chain slings used in ship repair and cargo transfer.



Damaged Rigging Gear

When damage to rigging gear is discovered during an inspection or when damaged rigging gear is returned to the gear room, and an accident is suspected, the gear shall be immediately removed from service and a comprehensive investigation initiated.

The activity shall follow the investigation and reporting requirements of NAVFAC P-307, Section 12, promptly perform a comprehensive investigation, and prepare a Crane and Rigging Gear Accident Report and forward a copy to the Navy Crane Center (Code 06) within 30 days of the accident. Local Weight Handling Equipment accident reporting procedures shall also be followed.

Knowledge Check

1. True or False. Documented records must be kept for periodic inspections.
 - A. True
 - B. False
2. Select the best answer. What are the two types of rigging gear inspections?
 - A. Periodic and Random
 - B. Annual and Biannual
 - C. Frequent and Annual
 - D. Periodic and Pre-Use

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3. Select the best answer. Who is required to perform an inspection prior to using rigging gear, and what is this inspection called?
- A. Gear Room Personnel, Pre-Operational Inspection
 - B. The User, Pre-Use Inspection
 - C. The User, Periodic Inspection
 - D. Rigging gear room personnel, Prior to Use Inspection
 - E. Gear Room Qualified Personnel, Pre-Use Inspection

Slings

Sling Rejection Criteria

A knot in any part of a sling is cause for rejection.

Chain Slings Inspection

Chain slings used for overhead lifting must be fabricated from chain that is grade 80 or 100.

Links are randomly marked by the manufacturer with 8, 80, or 800 for grade 80 chain, and 10, 100, or 1000 for grade 100 chain.

Chain Slings Inspection (Continued)

Chain slings are generally very tough and durable and consequently they tend to get a lot of hard use.

Carefully inspect each link and end attachment; including master links and coupling links.

Nicks and cracks may be removed by grinding. Measure the link or component after grinding. Rejection is required if the defect can not be removed or if any part of the link diameter is below the required minimum.

Look for deformation such as twisted, bent, stretched links, or broken welds.

Chain Slings Link Wear

Remove the sling from service if the thickness is below the value shown in NAVFAC P-307.



Link Wear

Inspect inner link surfaces

- Measure worn areas
- Remove from service if wear exceeds allowances



- Measure the length of each sling leg
- Look for increased chain length

Remove sling from service if inspection reveals detectable deformation.

Chain Slings Link Stretch

Chain links stretch when they are overloaded. Worn chain links will also cause the sling length to increase.

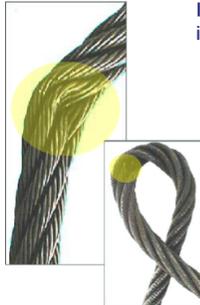
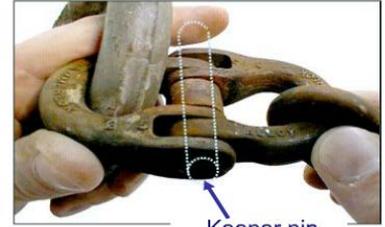
Measure the length of each sling leg and look for increased chain length that may indicate overloading or link wear.

Chain Slings

Inspect Hammer Link

Inspect hammer links carefully.

Make sure the keeper pin is not loose or protruding.



Inspect entire length including:

- splices
- end attachments
- fittings

Look for:

- kinks
- crushed areas
- birdcaged areas

Wire Rope Slings

Rejection Criteria

Inspect wire rope slings along the entire length of the sling including splices, end attachments, and fittings. Look for permanent distortion such as kinked, crushed, or birdcaged areas.

Wire Rope Slings

Rejection Criteria II

Look for core protrusion in-between the strands of the wire rope. Core protrusion is indicative of structural failure within the wire rope. The core should not be visible in straight runs. However, when a wire rope is bent, you will be able to see the core; this is not core protrusion. Fiber core wire rope slings may sometimes protrude between the strands in the end of an eye, opposite the bearing point; this too is not core protrusion.



Heat Damage

- Discoloration
- Damaged wires



Wire Rope Slings

Rejection Criteria III

Look for signs of heat damage such as discoloration and other more obvious signs as shown here.

Wire Rope Slings

Rejection Criteria IV

Look for severe corrosion or pitting of the wires or any condition that would cause loss of wire rope strength. Pay close attention to the outside area on each eye of the sling. This area wears more due to dragging the sling on concrete/paved surfaces.



Rejection Criteria

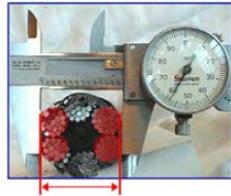
- Corrosion - Loss of flexibility
 - Pitting of the wire
- Loss of 1/3 diameter of individual wires
- Knots in any part of the sling

Note: Pay close attention to the outside area on each eye of the sling. This area wears more due to dragging the sling on concrete/paved surfaces.

Measure Crown to Crown



Not Flat to Flat



Wire Rope Slings II
Measuring Wire Rope

When measuring wire rope sling diameter with calipers, make sure you place the caliper on the crowns of the wire strands.

Do not place the caliper across the flats or valleys of the strands.

Wire Rope Slings II
Rejection Criteria VI

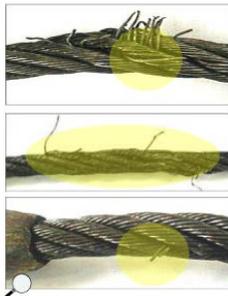
Do not run your bare hand along the wire rope to detect broken wires!

Bend the sling while watching for broken inside wires.

Bending will open the area between the two ends and expose a broken wire making it easy to detect.

Broken wire rejection criteria is based on a section of the wire determined by its “lay length”.

Lay length is the linear distance along the wire rope in which a strand makes one complete turn around the rope's center.



Remove from service if:

- 10 randomly distributed broken wires in one rope lay length
- 5 broken wires in one strand in one lay length
- 2 broken wires within one lay length of the end connection

Wire Rope Slings II
Rejection Criteria VII

Single part and strand laid wire rope slings must be removed from service if inspection reveals any of the following criteria, ten randomly distributed broken wires in one lay length, five broken wires in one strand in one lay length or two broken wires within one lay length of the end connection.

Wire Rope Slings II
Rejection Criteria VIII

For braided wire rope slings with less than eight parts, reject slings with 20 randomly distributed broken wires in one rope lay length, or one completely broken strand.

For braided wire rope slings with eight parts or more, reject slings with 40 randomly distributed broken wires in one rope lay length or one completely broken strand.



Less than eight parts

- 20 randomly per lay
- 1 broken strand

Eight parts or more

- 40 randomly per lay
- 1 broken strand

Knot(s) in any part of the sling

Wire Rope Slings II
Rejection Criteria IX

Cable laid wire rope slings must be removed from service if inspection reveals, 20 randomly distributed broken wires in one rope lay length, or one completely broken strand.

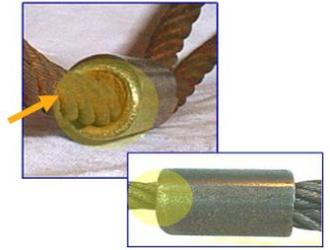
Wire Rope Slings II Rejection Criteria X

When inspecting slings with end fittings, ensure the fitting is not cracked, deformed or loose.

Make sure the wire rope in the fitting is not corroded.

Inspect the end attachment for wear that exceeds 10% of the OEM's nominal socket dimension or 5% of the socket pin diameter.

When inspecting slings with splattered sockets, the wire should not have any axial or lateral movement.



Metal Mesh Slings Rejection Criteria

Remove from service if:

- Broken wire in mesh
- Broken weld or brazed joint
- Reduction in diameter
25% due to abrasion
15% due to corrosion
- Lack of flexibility



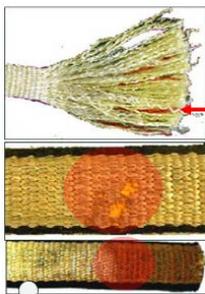
Metal Mesh Slings Rejection Criteria

Inspect the entire length of metal mesh slings including welds, end attachments, and fittings. Remove the sling from service if inspection reveals a broken wire in any part of the mesh, a broken weld or broken brazed joint along the sling edge,

reduction in wire diameter of 25% due to abrasion or 15% due to corrosion, lack of flexibility due to distortion of the mesh or any cracks in the end fitting.

Metal Mesh Slings Rejection Criteria (Continued)

Remove the sling from service if the eye openings in the end fitting are increased by more than 10%, or if there is a reduction of 15% of the original cross sectional area at any point around the hook opening of the end fitting.



Core warning yarns

Heat damage

Chemical damage

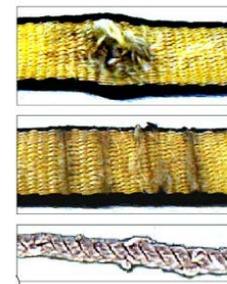
Synthetic Slings Rejection Criteria

Never use synthetic slings with exposed core warning yarns.

Do not rely on core warning yarns to indicate damage, as not all manufacturers use them and damage can reach rejection limits without exposing core yarns.

Synthetic Slings Rejection Criteria II

Other damage that would require a synthetic sling to be removed from service includes heat or chemical damage, punctures, cuts, and variations in size, thickness or roundness of the sling.



Snags or punctures

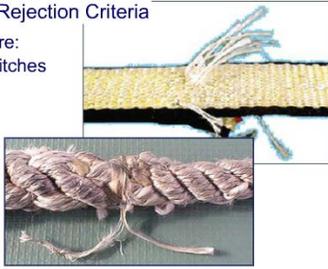
Cuts

Variations in size

Synthetic Sling Rejection Criteria

Reject if there are:

- Broken stitches
- Splicing
- Seizing



Synthetic Slings
Rejection Criteria III

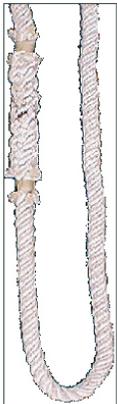
Look for broken or damaged stitches or splices. The stitching holds the sling together. Check it carefully.

Synthetic Slings
Rejection Criteria IV

Look for damage caused by prolonged exposure to sunlight, which can result in discoloration, fading or roughness.

Look for cracked, distorted, broken, or excessively worn, pitted, or corroded end fittings.

Also look for knots or indications the sling has been knotted. If you find evidence that a sling has been knotted, remove it from service.



- Adjacent strand filament breakage
- Broken filaments between the strands
- Variations in roundness
- Seriously worn surface fibers or yarns

Synthetic Rope Sling Rejection

Remove from service if considerable fiber or filament breakage is found along the line where adjacent strands meet. Light fuzzing is acceptable.

Look for powder or particles of broken filaments or fibers inside the rope between the strands.

Twist or pry the rope open for inspection. Inspect filaments or fibers for weakness, brittleness, or variations in the size or roundness of the strands.

Synthetic Round Sling Rejection

Remove the sling from service if inspection reveals any of the following: melting, burn marks, charring, or other evidence of heat damage; snags, punctures, tears, or cuts that expose any part of the core yarns; broken or worn stitches in load bearing splices; excessive wear, abrasion, or embedded abrasive particles; internal knots, bumps, bulges, or irregularities that can be felt by massaging the sling manually along its length. Note: A knot in the yarn where the cover is joined may be a termination made by the OEM, which is acceptable.) Cracked, distorted, broken, or excessively worn, pitted, or corroded end fittings; and any other condition that causes doubt as to the strength of the sling are also signs for removing a sling from service.

Synthetic roundslings have two covers. If the outer cover is torn, cut, or damaged, the sling should be removed from service and sent to the OEM for inspection and repair. If the inside cover is also torn or damaged and exposing the core yarns, the sling must be removed from service.



Knowledge Check

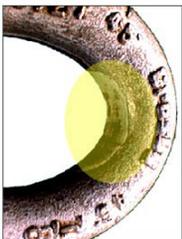
1. Select the best answer. What is the minimum grade of chain required for chain slings?
 - A. Grade 70
 - B. Grade 60
 - C. Grade 100
 - D. Grade 80
2. True or False. Two broken wires within one lay length of the end connection would remove a wire rope sling from service.
 - A. True
 - B. False
3. True or False. A knot in a synthetic sling is allowed as long as it does not cause permanent damage to the sling.
 - A. True
 - B. False
4. True or False. Chain slings used in cargo transfer should be inspected annually.
 - A. True
 - B. False
5. True or False. A metal mesh sling can remain in service if only one wire is broken in the mesh.
 - A. True
 - B. False

Hardware Damage

Types of Gear Damage

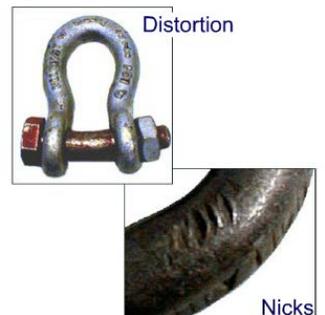
When inspecting rigging hardware look for corrosion or severe pitting that would leave an orange peel effect when cleaned. Slight surface rust is okay.

Inspect for wear, cracks, nicks, gouges, deformation, or distortion. Distortion may include elongation, peening, or heat damage.



Hardware Damage Areas to Inspect

Inspect the whole body of the hardware, but be particularly vigilant when inspecting the bearing surfaces for wear and distortion. Pay particular attention to the bearing surfaces since this is where the load is applied and will often show tell-tale signs of overload or abuse; just as the flattened area indicates on this picture.



Hardware Damage

10% Wear

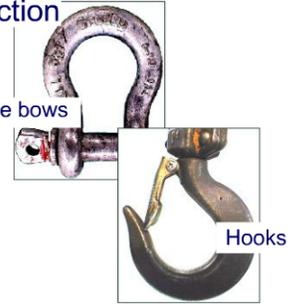
Remove shackle bows and welded links, from service when wear exceeds 10% of the nominal diameter shown in federal specification RR-C-271.

For shackle sizes not shown in federal specification RR-C-271, the OEM's listed nominal dimensions will be used.

Remove hooks from service when wear exceeds 10% of OEM's nominal dimensions.

10% Wear Reduction

Remove from service when wear exceeds 10% of nominal dimensions



Hardware Damage

5% Wear

Remove weldless links, shackle pins, and swivels, from service when wear exceeds 5% of the nominal diameter shown in federal specification RR-C-271.

For sizes not shown in federal specification RR-C-271, the OEM's listed nominal dimensions shall be used.

Remove eyebolts when wear exceeds 5% of the OEM's nominal eye section diameter.

Remove turnbuckles when end-fitting wear exceeds 5% of the OEM's nominal dimensions.

Remove swivel hoist rings when wear exceeds 5% of the OEM's minimum dimensions.



Hardware Damage

Areas to Inspect II

Threaded shanks must be inspected carefully before use or load testing.

When using gear with threaded shanks such as eyebolts, hoist rings, etc., inspect the shank carefully for bends, twists, or damaged threads.

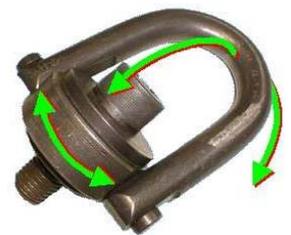
Hardware Damage

Moving Parts

Some hardware has moving parts such as hoist rings and turnbuckles.

Ensure that all moving parts move freely.

Hoist ring bases should swivel 360° and the bail should pivot at least 180°.



Hardware Inspections

Tackle Blocks

Tackle blocks shall be removed from service if inspection reveals distortion, cracks in the housing or sheaves, damaged sheaves, binding, abnormal sheave play, or any damage that may cause doubt as to the strength of the unit.

Hardware Inspections

Below the Hook Lifting Devices

Below the hook lifting devices and container spreaders shall be inspected in accordance with ASME B30.20 and OEM recommendations.

Always read and follow the information provided by the OEM.



Hoists, Cranes, A-Frames, Gantries

Chain hoists and portable hoists shall be inspected in accordance with: ASME B30.16 and OEM recommendations.

Lever operated hoists shall be inspected in accordance with ASME B30.21 and OEM recommendations.

Other equipment shall be inspected in accordance with applicable ASME B30 criteria and/or OEM recommendations.

Load Indicating Devices

Check for visible damage and any other attributes listed by the OEM.

Portable load indicating devices shall only be used in the range that ensures the proper design factor.

Ensure they are marked or tagged to indicate the reduced maximum rated load, if required.

- Ensure load bearing members have proper Design Factors

Steel = 5:1
Aluminum = 7:1

- Lesser design factors

Mark or tag with reduced rated load so it's only used in proper design factor range



Repair

Overview of Repairs

When minor damage, such as nicks or cracks are found, it may be possible, and more economical, to remove the defect rather than replace the gear.

Repairs must be performed in accordance with OEM or engineering instructions.

Alterations must be approved by the activity engineering organization.

Re-inspection and load test of the repaired or altered equipment shall be performed prior to returning to service.

Repair documentation for load bearing, load controlling, or operational safety devices must be retained for 7 years, all other repairs 1 year.

Alteration documentation must be retained for the life of equipment.

Authorized Repair

Grinding to remove defects is the only method authorized to repair rigging gear.

Heat or welding is not permitted to correct defects. And no attempt shall be made to straighten bent or twisted rigging gear.

Grinding shall follow the contour of the piece.

Blending with a maximum 1 to 3 taper.

The component dimensions after grinding must be within the wear limits for the piece being repaired.

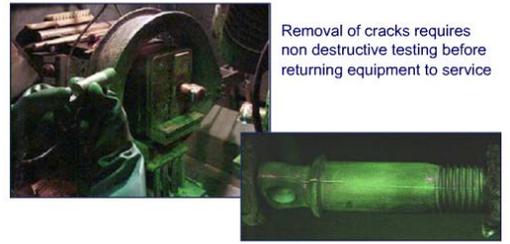
If the after-grinding dimensions exceed the wear limits specified by the OEM or NAVFAC P-307, the component must be removed from service.

Removal of defects as specified will not require a load test.

Non-Destructive Test

Removal of cracks must be verified by non-destructive testing before the hardware can be returned to service.

Non Destructive Tests



Removal of cracks requires non destructive testing before returning equipment to service

Knowledge Check

1. True or False. Rigging hardware that is bent can be repaired by straightening it back to original shape.
 - A. True
 - B. False
2. True or False. Rigging hardware such as eyebolts, hooks, and shackles are required to have a periodic inspection every 2 years.
 - A. True
 - B. False
3. Select the best answer. Distorted rigging hardware must be:
 - A. Heat treated and returned to service
 - B. Evaluated for repairs
 - C. Remarkered for a reduced capacity
 - D. Removed from service and destroyed
4. Select the best answer. Documentation for alteration or repair of rigging equipment is required to be retained for:
 - A. 2 years
 - B. 1 year
 - C. Until replaced by another record
 - D. The life of the equipment

NOTES

RIGGING GEAR GENERAL USE

Welcome

Welcome to the Rigging Gear General Use module.

Instructional Objectives

Upon successful completion of this module you will be able to describe safe work practices when using rigging gear, list selection criteria, identify possible hazards to rigging gear, and explain how to protect your rigging gear from damage during use.

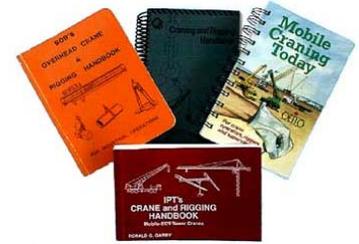
NAVFAC P-307 Section 14

NAVFAC P-307 provides specific rules for using rigging equipment described in section 14.

It does not, however, provide specific direction on rigging practices or techniques.

Rigging Manuals

Information on rigging techniques can be found in rigging handbooks, rigging manuals, OEM publications, textbooks, and consensus standards.



Let's cover some of the safety precautions that apply to all types of rigging equipment or operations.

General Safety Rules

Remain alert when performing crane rigging operations.

Hazards are always present.

Two common danger areas are between the rigging gear and the load; and between the load and other objects.

These areas are sometimes referred to as "the bight".

Be sure to your keep hands, feet, and head, out of the bight!



Never Use Homemade Gear

Never use shop made or homemade equipment unless it has been approved by engineering and certified for use in weight handling operations!

Selecting Rigging Gear

Use rigging gear only for the purpose it is designed for.

Rigging gear is a tool like a hammer or wrench. We've all heard the phrase...

"use the right tool for the job."

It's the same for rigging gear. If you don't have the right rigging gear to safely do the job, stop and get it!

Never use damaged gear.

Never use gear past its inspection due date!

Your safety and the safety of the rest of the crane team depend on the gear you use, and how you use it.

Take the time to do it right!

Selecting Rigging Gear (Continued)

Keep the following in mind when selecting rigging equipment.

Rigging equipment must be selected based on the total force that will be applied to the gear, not just the weight of the load. Remember, in some cases, the force in one leg of a multiple sling leg could exceed the weight of the load.

Keep the overhead height restrictions or clearances in mind when selecting sling length.

Sling lengths that are too long may cause the hook to reach the limit switch before the load reaches the desired height.

You must also think about the hazards the gear may be subjected to so you can choose the appropriate equipment.

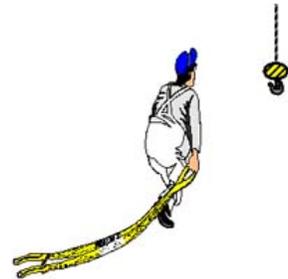
Rigging Gear Hazards

The first major hazard we must talk about is abuse.

Here the biggest hazard is you, the user!

Don't drag your slings on the ground. Cement or paved surfaces will quickly abrade slings and gear. Contact with the ground can embed grit and abrasives into the sling, which will cause damage.

Don't pull slings from under a load while the load is resting on them. Set the load down on blocking to keep from crushing the sling.



Hazards to Rigging Gear



Corrosives
• acids
• chemicals
• solvents



Heat

- welding
- burning
- heat treatment
- grinding

Hazards (Continued)

Keep gear away from corrosives, acids, paint thinners, and any other harmful chemicals.

Chemicals that may have a corrosive effect on one type of gear may not affect another.

For example, acids would quickly destroy a nylon sling but might not harm another synthetic material.

Protect your gear from all heat sources such as welding, burning, grinding, or heat-treating.

Hazards – Sharp Edges

Another common hazard is sharp edges.

No matter what type of gear you use, sharp edges will leave their mark if the gear is not protected.

Never use slings against sharp edges without adequate protection.



Hazards - Electrical

You must be aware of the danger electricity presents when working around energized components or electrical lines.

Watch out for welding leads, light strings, shore power and other common hazards when looking for lay down areas.

Wire rope, chain, and metal mesh slings should never be used if they could increase the possibility of electrical shock.

Protect yourself and the gear by ensuring all power is secured prior to installing your gear on or around electrical components.

Chafing Gear

Protective Materials

So how do we protect our gear from being damaged by sharp edges?

It's necessary to use protective materials, known as "chafing gear," to prolong the life of our rigging gear and items being lifted.

Chafing gear can be any material used for protecting rigging gear or loads. Chafing gear increases friction thereby reducing the tendency for rigging to slip.

Wood blocks, canvas, cardboard, rubber, leather and old fire hose are great for protecting critical or machined surfaces and increasing friction.

These are just a few examples of chafing gear.

Manufactured chafing gear is also available for purchase.



Using Chaffing Gear



Fire hose can be used as a protective sleeve



Shore up with wood blocks

on the sling!

Using Chafing Gear

Chafing gear can be many types of materials and it may be used many different ways. Wood blocks may be used to keep slings away from sharp edges.

Old fire hose can be placed between your gear and sharp edges or a sling can be passed through the hose and used as a protective sleeve.

Remove the hose to inspect for damage before and after each use. Hose can hide sling damage if left

Hoist and Crane References

Portable floor cranes, portable a-frames, portable gantries, and cranes integral to larger machine systems must be operated in accordance with applicable ASME B30 criteria and OEM recommendations.

Chain Hoists and portable hoists must be operated in accordance with ASME B30.16 and OEM recommendations.

Lever operated hoists must be operated in accordance with ASME B30.21 and OEM recommendations.

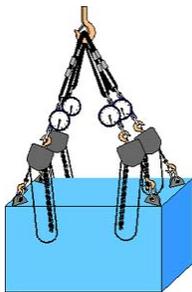
Other applicable equipment must be operated in accordance with ASME B30 and OEM recommendations.



Using Hoists and Cranes

When using chain hoists and portable floor cranes, ensure hoist capacities meet or exceed the expected load.

Load indicating devices may be used to help prevent overload of the hoist and related gear when leveling, rotating, or tilting objects.



- Load indicators help keep tension on each leg equal
- 2 and 3 point lifts tend to be self-leveling

Using Hoists to Distribute Sling Loading

When chain hoists are used to equalize a load at four or more points, they must be used in conjunction with load indicating devices.

Using Hoists and Cranes

Secure hand chain and excess load chain to prevent tangling and inadvertent operation.

A bag can be attached to the hoist body to hold excess chain.

Never use more than one person to pull the hand chain of a manual chain hoist. Do not use excessive force to operate a hoist. Never use extension bars on lever-operated hoists.



Usage Don'ts

Never use the load chain to choke around an object and never "tip load" the hook!

Below the Hook Lifting Devices

Below the hook lifting devices and container spreaders must be operated in accordance with ASME B30.20 and OEM recommendations. Never use below the hook lifting devices if you do not thoroughly understand the operating characteristics and limitations. Ensure the lifting device has sufficient capacity for the expected load.



Knowledge Check

1. Select the best answer. Which section of the NAVFAC P-307 is the rigging gear section?
 - A. Section 8
 - B. Section 12
 - C. Section 14
 - D. Section 10
2. True or False. It is okay to use home-made rigging gear as long as you are lifting light loads.
 - A. True
 - B. False
3. Select the best answer. When selecting rigging gear for a job, which of the statements below should be followed?
 - A. Never use damaged gear
 - B. Consider height restrictions when selecting sling lengths
 - C. Never use gear past its inspection due date
 - D. Base rigging gear on the total stress, not just the weight of the load
 - E. Follow all of the above
4. Select the best answer. What should be used between the rigging gear and the load to prevent damage to the load and rigging?
 - A. Your hand
 - B. Chafing gear
 - C. Metal spacers
5. True or False. Two people can operate a chain fall if the pull chain is too hard for one person to pull while hoisting a load.
 - A. True
 - B. False

NOTES

RIGGING HARDWARE

Welcome

Welcome to the Rigging Hardware module.

Instructional Objectives

Upon successful completion of this module you will be able to identify use limitations for shackles, eyebolts, swivel hoist rings, and other types of rigging hardware.

You will also be able to identify correct installation procedures and identify rated loads of rigging hardware in various configurations.

Using Rigging Hardware

Use the same size and type of shackle on each leg in multiple leg applications.

Different types, sizes, or brands of shackles may vary significantly in physical size. This in turn will affect the overall length of the leg and the tension created in each leg. When installing the pin into the bail, be sure the pin is fully seated into the bail.



When side loading screw pin or bolt type shackles:

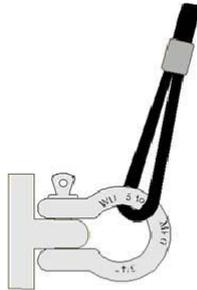
- Reduce the rated load by 50 percent unless specified otherwise by the OEM

Round pin shackles shall not be side loaded.



Note the cotter pin holding the shackle pin in place

Round Pin Shackle



Side Loading Shackles

It may be sometimes necessary to apply a side load to a shackle.

When side loading a screw pin or bolt type shackle reduce the rated load by 50% or as specified by the OEM .

Round pin shackles shall not be side loaded. Shackles should be loaded bail-to-bail, whenever possible. For pin-to-pin or pin-to-bail loading, and for all other attachments to a

shackle pin, the shackle is considered to be side loaded with the restrictions noted above unless the attachment is centered in the pin. Spacers may be used to ensure shackle pins are loaded in the center.

Eyebolt Types

There are two types of eyebolts you may find at your work site, shouldered eyebolts and non-shouldered eyebolts.

Non-shouldered eyebolts are sometimes referred to as plain pattern or regular nut eyebolts.

All eyebolts must be used in accordance with OEM instructions.



Non-shouldered Eyebolts

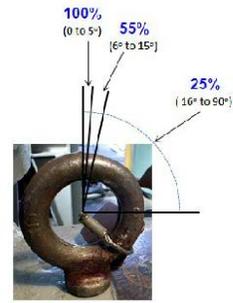
Non-shouldered eyebolts may be used in vertical applications only. Angled pulls greater than five degrees, even in the plane of the eye are not permitted.

Shouldered Eyebolts

Shouldered eyebolts may be loaded at an angle as long as it is loaded in the plane of the eye.

When loading a shouldered eyebolt at an angle the capacity of the eyebolt is reduced.

The rated load of the eyebolt shall be reduced in accordance with table 14-5 of NAVFAC P-307 or OEM recommendations.



Installing Shouldered Eyebolts

When loading shouldered eyebolts at an angle in the plane of the eye, the eyebolts must be installed with the shoulder seated flush against the mounting surface.

Using Eyebolts, Swivel Hoist & Lifting Rings

When checking the engaging hole in the item you are going to lift: Make sure the threads are not damaged. And the hole is free of debris.



Threaded length must be greater than the diameter!
Steel: 1-1/2 times the thread diameter
Aluminum: 2 times the thread diameter
All other materials: activity's engineering organization or OEM

Minimum Thread Engagement

The minimum thread engagement depends on the material into which you are installing the piece of rigging equipment.

When installing eyebolts into steel the minimum required thread engagement is one and one half times the diameter.

When installing eyebolts into aluminum, the

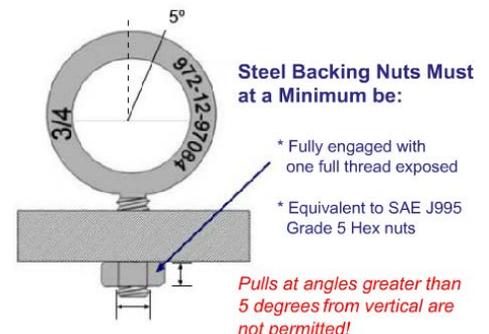
minimum thread engagement is two times the diameter.

For other materials contact your activity's engineering organization or the OEM.

Backing Nuts

When eyebolts are used with backing nuts, the backing nut must be at least SAE J995 grade five and fully engaged with at least one full thread exposed.

Note: With engineering approval, nut type eyebolts can be used without the shoulder being flush.



Shim Usage

Eye Alignment

To use eyebolts with an angular load, the loading must be in line with the plane of the eye.

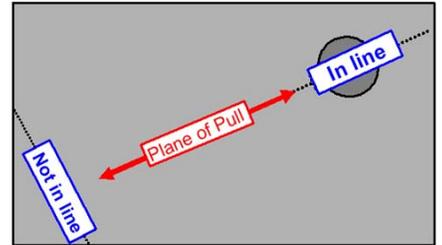
This may not always happen when installing eyebolts.

Look at this shape and imagine two slings connected to each eyebolt shown from the top.

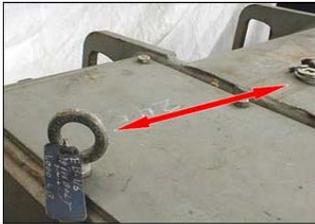
You can see that the top eyebolt would be in line with the plane if two slings were attached.

The bottom eyebolt ended up out of plane when tightened against the seating surface.

Align Eye With Plane of Pull



Shims May Be Used To Align Eyebolts



Shim Use Overview

If the shoulder seats flush and the eyebolt is not in the plane of pull shims may be used to align the eye with the plane of pull.

When using shims, use the minimum thickness that will orient the eye in the plane of the pull. The total thickness of shims must never exceed one thread pitch.

The thread pitch represents one full revolution or rotation of the shank. If there are 16 threads per inch, then the thread pitch is 1/16th inch.

Determine Thickness

In order to determine shim thickness we must determine how much rotation is required.

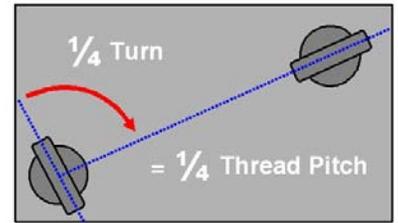
How far would this eyebolt have to rotate in order to line up in the plane of pull?

It must rotate 1/4 of a turn.

How much shim would that require?

One quarter of the thread pitch would orient the eyebolt in line to the plane of pull.

For the eyebolt noted previously with a thread pitch of 1/16th inch, total shim thickness would be 1/64th inch.



Incorrect Usage

This is an example of shims being used incorrectly.

Do you see the problem with this eyebolt installation?

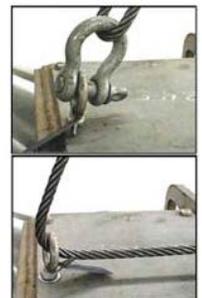
The total shim thickness is more than the thread pitch.

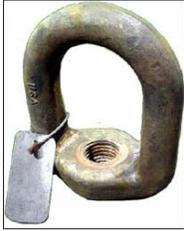
Side Pulls

Side pulls on eyebolts are very dangerous and may cause the eyebolt to fail.

Side pulls result from loading out of the plane of the eye.

Never install a sling through two separate eyebolts. The result will be side pulls on both eyebolts and damage to the sling.



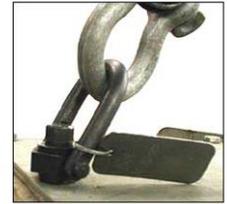


Eye-nuts

Eye-nuts must be used in accordance with OEM instructions. They must have full thread engagement. This means the shank or stud they are attached to must be long enough to allow complete engagement of the eye-nut. Eye-nuts must be used for vertical applications only.

Swivel Hoist Rings

Angular pulls do not reduce rated load of a swivel hoist ring. When using swivel hoist rings, they must be installed with the shoulder flush with the mounting surface. The minimum thread engagement shall be 1 and 1/2 times the diameter of the bolt for steel (or threads fully engaged for swivel hoist rings with thread projections less than 1 and 1/2 times the diameter of the bolt). They must be tightened with a calibrated torque wrench in accordance with OEM requirements.



Check the OEM instructions prior to installing any shims. Most manufacturers do not allow the use of shims with swivel hoist rings.



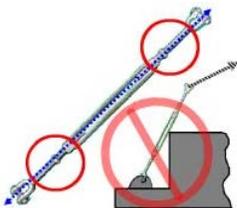
Swivel Hoist Rings (Continued)

Swivel hoist rings must be used in accordance with OEM specifications. They must be tightened to the OEM specified torque. And The torque value is usually marked on the hoist ring itself.

Before using backing nuts on hoist rings, check the OEM specification to see if it is allowed.

Selection and Use of Turnbuckles

Turnbuckles are commonly used for tensioning lines and securing loads but may be used for crane rigging if they meet the test, inspection and certification requirements of NAVFAC P-307.



Turnbuckles (Continued)

Turnbuckles are used only for in-line pulls. Jam nuts, when used, must be tightened in accordance with OEM instructions to prevent rotation. If the possibility of rotation still exists, the turnbuckle must be secured by safety wire or other suitable means in addition to jam nuts.

Threaded Attachment Point

Remember to use extreme caution when using a threaded item such as an eyebolt or a hoist ring as a single attachment point ! Never rotate or spin an object being lifted with a single threaded attachment point.

Category 2 and Cab-Operated Category 3 Crane Safety Student Guide

The lifting attachment may unthread and the object may fall.

Knowledge Check

1. True or False. Pulls outside the plane of the eye are allowed on eyebolts as long as the rated load has been decreased.
 - A. True
 - B. False
2. Select the best answer. The minimum depth of thread engagement for a $\frac{3}{4}$ inch eyebolt into a steel object is:
 - A. 1 $\frac{1}{8}$ inch
 - B. 1 $\frac{1}{2}$ inch
 - C. $\frac{1}{2}$ inch
 - D. 1 inch
3. True or False. An angular pull of 45° is allowed on non-shoulder type eyebolts.
 - A. True
 - B. False
4. True or False. The rated load of swivel hoist rings must be reduced when they are used for angular pulls.
 - A. True
 - B. False

NOTES

SLING USE

Welcome

Welcome to the Sling Use module.

Instructional Objectives

Upon successful completion of this module you will be able to list sling limitations, explain proper sling attachment and identify the three different hitches and the rated capacities for each.

Wire Rope Sling Use

A common metal sling is the wire rope sling. Wire rope slings have some limitations even though they are generally strong and durable.

D-to-d is the term for the ratio between the diameter of the object around which the sling is bent and the diameter of the sling body.

The capital D represents the diameter of the object and the small d represents the diameter of the sling.

When using wire rope slings always maintain a minimum D-to-d ratio of one to one in the body of the sling.

In other words, never bend a wire rope around a diameter smaller than itself!

Bending a wire rope around a diameter smaller than its minimum D-to-d ratio will damage the wires and weaken the sling.

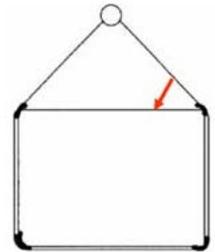
Wire Rope (Continued)

For loads with a non-circular cross section the bend diameter is derived from the minimum bend diameter of the wire rope around the corner of the load.

For slings bent around corners, the corners must be rounded to provide the minimum D/d efficiency.

Chafing protection is used to protect the load and sling from damage.

Except for braided slings, wire rope slings shall not be used in single leg vertical hitches, unless a method is used to prevent unlaying of the rope.



Do not use wire rope at temperatures:

- below - 40°F
- above 400°F (*wire core*)
- above 180°F (*fiber core*)

Wire Rope Temperature Restrictions

Wire rope must also be protected from extreme temperatures, which can seriously affect the wire's strength.

Do not use wire rope slings below minus 40 degrees or above 400° Fahrenheit.

Fiber core rope wire should not be used above 180° Fahrenheit.

Wire Rope Restrictions

Wire rope clips should not be used to fabricate slings. And wire rope slings should never be knotted.



Chain Sling Use

Chain slings are a good choice when the job demands abrasion and damage resistant slings. However, if used improperly, they too can be damaged.

Chain slings should not be used on loads that are damaged easily. Never use knots or bolts to shorten or extend the sling.

Use chafing on sharp corners and edges to prevent damage to slings and load.

Always check OEM instructions for the chain sling you are using.

When a chain sling is used in a choker hitch, the capacity shall be reduced to reflect the efficiency percentages shown in table 14-4 of NAVFAC P-307.

Chain Sling Temperature Restrictions

For use in temperatures below minus 40 (-40) or above 400 degrees Fahrenheit (F), follow OEM recommendations for rated load reduction.



Metal Mesh Sling Temperature Restrictions

Metal mesh slings are often used in abrasive or high temperature environments that would damage slings.

Do not use bare metal mesh slings when temperatures are below -20° or above 550° Fahrenheit.

Do not use elastomer coated slings when temperatures are below 0° or above 200° Fahrenheit.

Always follow OEM recommendations.

Types of Synthetic Slings

There are three types of synthetic slings, synthetic rope slings, synthetic webbing slings, and synthetic roundslings. Synthetic slings should be used **only** when they can be protected from damage!

Natural fiber rope slings are **not to be used** for overhead lifting.



• Natural fiber rope slings are not to be used for overhead lifting.

Using Synthetic Slings

Synthetic slings cannot be substituted for other slings specified on rigging sketches. Avoid chemical exposure to synthetic slings and always use chafing gear! Minimize exposure to sunlight and other sources of ultraviolet light. Store all synthetic slings indoors in a cool dry place.

And, always follow OEM recommendations when using synthetic slings.

Synthetic Web Sling Use

Synthetic webbing slings shall be used in accordance with OEM recommendations.

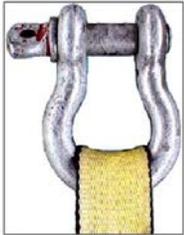
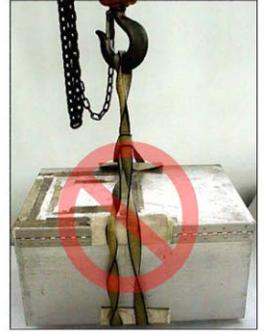
Where a synthetic webbing sling is used in a choker hitch, the total capacity shall be reduced to reflect the efficiency percentages shown in table 14-4 of NAVFAC P-307.

Web slings must be installed flat around the load without kinks or twists. Kinks and twists reduce friction on the load and can cause the sling to roll or slide out of position.

These slings are not affected by D-to-d ratio.

Eye length in relation to the diameter of the hook is critical.

The eyes of webbing slings are stitched and the stitching can be damaged if the eye is spread excessively.



Using Shackles with Web Slings

Shackles used with synthetic web slings must allow the sling to lay relatively flat without excessive curling of the edges.

Curling causes uneven loading of the sling.

Slight curling, however, is acceptable.

Web Sling Temperature Restrictions

Do not use synthetic web slings at temperatures above 194° Fahrenheit or OEM recommendations, whichever is more restrictive.



Synthetic Rope Use

Stranded synthetic rope slings shall not be used in a single part vertical hitch, unless a method is used to prevent unlaying of the rope.

When making single point lifts with eye and eye synthetic rope slings, use two slings or double up a single sling.

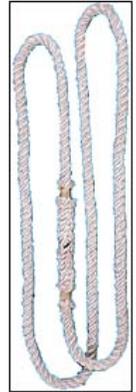
If they are allowed to spin, the splice could come undone and drop the load!

The minimum D-to-d ratio is 1 to 1.

This means a one half-inch diameter synthetic rope sling cannot bend around any object that is smaller than one half-inch.

Synthetic Rope Temperature Restrictions

Nylon and polyester slings shall not be exposed to temperatures exceeding 194 degrees Fahrenheit (140 degrees Fahrenheit for polypropylene slings) or OEM recommendations, whichever is more restrictive.



Roundsling Use

Roundslings shall be used only in the lifting application for which they were designed by the OEM, and in strict compliance with the OEM's instructions.

For new roundslings, a certificate of proof test shall be retained in the history file for the life of the sling.

Roundslings constructed of yarns other than nylon or polyester shall be used only with the following additional restrictions: (1) The certificate of proof test shall include the diameter of pin used during actual proof test. (2) Alternate yarn roundslings shall not be used over a hook, pin, or shackle that is smaller than the diameter of the pin used during the sling proof test.

Roundsling Temperature Restrictions

Follow OEM recommendations when using roundslings in extreme temperatures.

Sling Use Considerations

Slings must not be used at angles less than 30° from horizontal unless specifically authorized by an engineering work document.

Never use a sling that has been knotted.

Chafing gear should be used where needed.

Rigging gear including slings, shackles, turnbuckles, and eyebolts, must be sized such that two legs can carry the load to allow for variations in sling length and load flex.

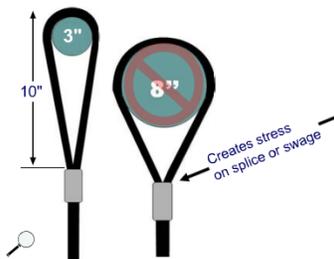


- Don't use at angles less than 30°
- Never tie a knot in a sling!
- Use chafing gear as needed

• Rigging gear must be sized as if **two legs carry the load**

For Wire Rope Slings:

Never: place an eye around a diameter greater than 1/2 the eye length



For synthetic web and rope slings:

The object cannot be greater than one-third the length of the eye.

Eye and Hook Considerations

The size of the hook or shackle relative to the size of the sling eye can be critical.

If we place a ten-inch long sling eye on a load which is 3 inches in diameter, the eye opens slightly and causes very little added stress to the eye or the splice.

However, if we place that sling on a hook with a diameter of 8 inches, this can stress the eye and can cause the swage or stitches to fail.

Never place the eye of a wire rope sling around an

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object which has a diameter greater than 1/2 the length of the eye.

Never place the eye of a synthetic web or rope sling around an object which has a diameter greater than 1/3 the length of the eye.

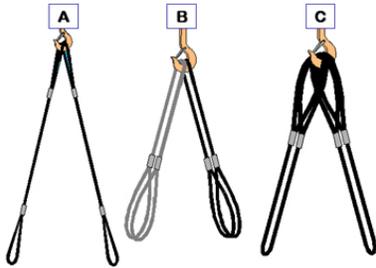
If the hook diameter is too large, a shackle can be used to connect the slings to the hook, thereby reducing the diameter over which the sling eyes are placed.

Attaching Gear to Hooks

When attaching rigging gear to hooks be sure the safety latch is working properly and closes the throat opening without obstruction. Failure to do so can allow the gear to come off the hook.



All gear attached to the hook must seat properly in the bowl. Do not stack slings or allow slings to cross each other in the hook. That can lead to crushing of the slings!



Correct Attachment of Slings to Hooks

These graphics illustrate correct ways to attach slings to a hook.

Graphic “A” shows a vertical application with two sling eyes seated in the bowl of the hook.

Graphic “B” shows two slings doubled over the hook and sling eyes pointing down to attachment points.

Graphic “C” shows two slings doubled with sling eyes

on the hook and the bight pointing down to attachment points.

When wire rope slings are used as in graphics “B” and “C”, and a heavy load is applied, individual wires may become permanently deformed or bent.

If a sling is doubled to the point where it is permanently set, it should not be used in a vertical or straightened out configuration because straightening the sling could cause the wires to break in the strands.

Incorrect Use of Slings on Hooks

These graphics illustrate some incorrect ways of attaching slings to a hook.

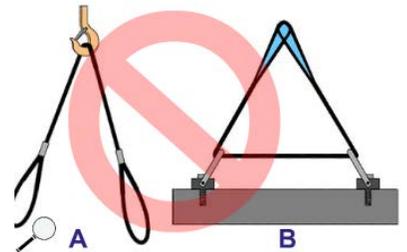
Incorrect sling applications can be extremely dangerous and can result in loss of load control and personnel injury!

Graphic “A” shows a single sling with the “bight” riding the hook and the eyes attached to two separate attachment points.

Slings applied in this manner could slip on the hook causing the load to shift.

Graphic “B” shows a sling through two attachment points.

Installing a sling through more than one attachment point will create excess stress on the sling, the attachment points, and the gear.



Included Angle

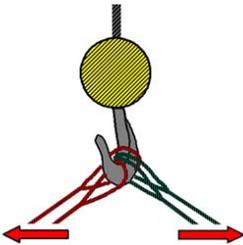
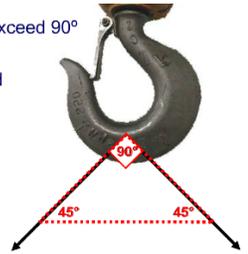
Included angle is the angle measured between two slings sharing a common attachment point.

To prevent tip loading when lifting with two slings, the included angle created by slings attached to the hook must not exceed 90°.

If the horizontal angle of the slings is less than 45°, the included angle will exceed 90°.

In this case, you must use a shackle or other collection device to connect the slings to the hook.

- Included angle must not exceed 90°
- Sling angles less than 45° must use alternate method to connect to hook



Inside and Outside Sling Attachment

When rigging four slings to a hook, separate the slings into two pairs, inside and outside so they do not pull in the plane of the hook.

Attach the inside slings to one end of the object and the outside slings to the other end, being careful that they are not crossed.

3 Types of Hitch Configurations

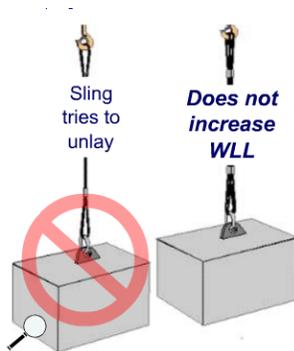
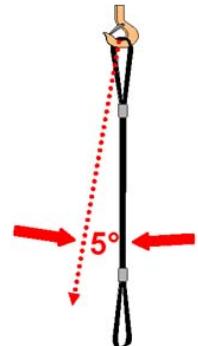
Slings are used in three types of hitches: the vertical hitch, the choker hitch and the basket hitch.

The rated load for the same sling with each hitch will be different.

WLL of Vertical Hitches

The rated load for a vertical hitch is 100% of the sling's capacity.

Sling angle stress is encountered any time the vertical angle exceeds 5° and must be taken into account.



Use of 2 Legs for Vertical Hitches

To prevent unlaying of the wire rope, do not use a single sling leg wire rope sling in a vertical hitch.

Use two legs for single point lifts. The second leg prevents the sling from spinning.

It is important to note that the configuration shown here does not increase the rated load because slings are rarely the exact same length.

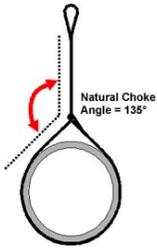
The shorter of the two will carry the load.

Choker Hitches

Using a shackle to set a choker hitch will prolong the life of the sling. Whenever a shackle is used to set a choker hitch set the eye of the sling on the pin of the shackle.

This will prevent the “running” part of sling from rotating the pin of the shackle as it passes over it.

Never set the choker so the running part of the sling passes against the shackle pin.



WLL of Choker Hitches

Whenever a choker hitch is used the sling’s rated load is reduced.

The natural choke angle is 135° if a choker hitch is allowed to tighten itself as the load is lifted.

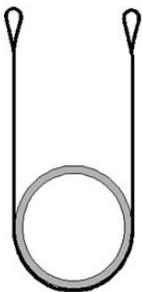
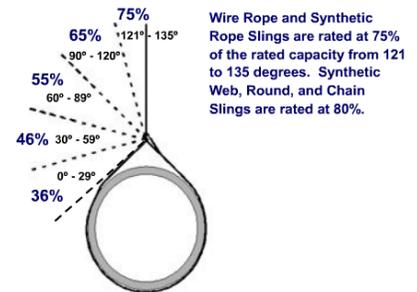
When Choke angles are less than 120° the rated load must be reduced further.

Choker Hitch Efficiency

This chart shows the efficiency of the sling’s capacity when choking with a wire rope or synthetic rope sling. Refer to NAVFAC P-307 Table 14-4 for choker efficiencies of other slings.

For angles 121° to 135°, the rated load is reduced to 75% of the vertical capacity (80% for synthetic web and round slings).

This does not apply to braided multi-part wire rope slings.



WLL of Basket Hitches

Basket hitches are the strongest of the three hitches.

Slings in a basket hitch can carry 200% of the sling’s single rated load when the sling angle is less than 5° from vertical, and the required D-to-d ratio is maintained.

Wire rope requires a D-to-d ratio of greater than 40 to 1.

Synthetic rope requires a D-to-d ratio of at least 8 to 1.

Knowledge Check

1. Select the best answer. The minimum D/d ratio in the body of a synthetic rope sling is:
 - A. 1:1
 - B. 2:1
 - C. 3:1
 - D. 4:1

2. True or False. D/d ratio does not affect synthetic web slings.
 - A. True
 - B. False

3. True or False. It is acceptable to bend a 1 inch wire rope sling around a $\frac{3}{4}$ inch shackle.
 - A. True
 - B. False

4. Select the best answer. The minimum D/d ratio allowed for wire rope slings is:
 - A. 1:1
 - B. 2:1
 - C. 3:1
 - D. 4:1

5. Select the best answer. With the proper D/d ratio a sling in a basket hitch can lift _____ of the rated load of the sling.
 - A. 75%
 - B. 100%
 - C. 150%
 - D. 200%

NOTES

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CRANE COMMUNICATIONS

Welcome

Welcome to Crane Communications.

Learning Objectives

Upon successful completion of this module you will be able to describe the communication methods used during crane operations at Navy facilities including: hand signals, radio communications and direct voice.

Crane Communication Methods

Standard hand signals provide a universal language, understood by everyone involved with weight handling; consequently, they are the most common method used in crane operations.

When presented properly, standard hand signals help prevent miscommunication and play a very important part in safe crane operations.

When making lifts where hand signals are not feasible (such as when the operator can not see the signal person), the rigger giving the signals shall remain in constant voice communication with the operator. The operator shall stop the crane at any time and in any situation judged to be unsafe or when communication is lost or unclear. If communication is lost, the operator shall stop operation until communication is reestablished.

In addition, the operator shall immediately respond to a direction from any person to stop the crane.

Radio communications are well suited for blind and complex lifts.

As a general rule, direct voice should only be used when the operator and rigger are working in close proximity and ambient noise is not a factor.

Hand Signals

Hand signals are the most widely used method of communication between signalers and crane operators. Hand signals like those found in the American Society of Mechanical Engineers, A.S.M.E. B30 standards must be posted in the crane in clear view of the operator. Your activity may approve local signals in addition to these standard signals.

Additional hand signals, must be

- Approved by crane and rigger supervisors
- Included in rigger and operator training
- Posted in crane cab in clear view



Relay Signalers:

- From signaler to signaler to the operator
- Results in lag time
- Not more than two signalers
- Not recommended for close tolerance lifts
- Requires positive transfer of load control

Hand Signal Rules

Signalers must remain in clear view of the crane operator.

If the crane operator can't see you, another method of communication must be used.

Only one signaler communicates with the crane operator at a time.

Radio Communications

Radios can be used to direct crane lifts while keeping crane team members informed of the lift status.

Radio guidelines

The device, or devices, used shall be tested on-site prior to crane operations. Use an isolated channel and clear the line of other traffic. Limit background noise. The operator's reception of signals shall be by a hands-free system

Radio work practices

Voice directions given to the operator shall be given from the operator's directional perspective. Identify the crane and yourself. Each voice signal shall contain the following elements, given in the following order: function (such as hoist, boom), direction; distance and/or speed; function, stop command. Allow time between commands. Verify the command

Note: The operator shall stop the crane at any time and in any situation judged to be unsafe or when communication is lost or unclear. In addition, the operator shall immediately respond to a direction from any person to stop the crane.



Knowledge Check

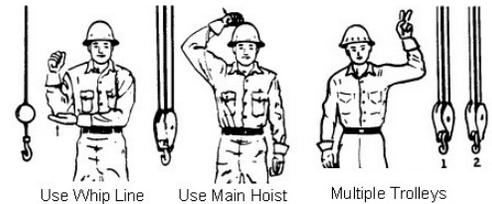
1. Select the best answer. Direct voice should only be used when:
 - A. No other form of communication is available and ambient noise is high
 - B. The operator and rigger are working in close proximity and ambient noise is low
 - C. The rigger has not learned hand signals
 - D. The operator and the rigger are working in close proximity and ambient noise is high
2. Select the best answer. In the crane cab, the crane operator must have a clear view of the ...
 - A. Crane lift history
 - B. EOM
 - C. ASME Hand Signal Chart
 - D. Crane maintenance records
3. Select the best answer. For multiple crane lifts, _____ will communicate with the crane operators.
 - A. One signaler at a time
 - B. No signalers unless directed by the rigger in charge
 - C. One signaler for each crane involved
 - D. Up to three signalers

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4. Select the best answer. A universal language understood by everyone involved with weight handling is:
- A. Signal flags
 - B. Hand signals
 - C. Direct voice commands
 - D. Spoken word
5. Select the best answer. Any additional hand signals must be ...
- A. Approved by the activity
 - B. Approved by the ASME
 - C. Approved by OSHA
 - D. Approved by NOSH
6. Select the best answer. Another form of communication, other than hand signals, must be used if ...
- A. The signaler is not in clear view of the crane operator
 - B. Ambient noise is greater than the lack of visibility
 - C. Activities designate alternative methods
 - D. The signaler is in clear view of the rigger in charge

Hook and Trolley Signals

These signals indicate which hook or trolley to use and are used in conjunction with operating signals.



Whip Line or Auxiliary Hook

When calling for the whip line or auxiliary hoist: the elbow is tapped with the opposite hand and followed with the appropriate hook movement signal.

Main Hoist

When calling for the main hoist, the signaler: taps a fist on his or her hard hat and follows with the appropriate hook movement signal.



Multiple Hooks/Trolleys

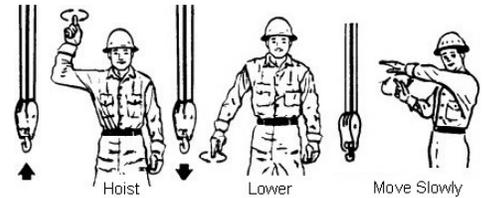
When working with a multiple trolley crane, these signals indicate which trolley to use.

They are always followed by movement signals.

Hoist Signals

Hoist and lower signals are the same for all cranes.

The distinct circular motion helps the operator see the signal clearly from greater distances and helps distinguish them from other signals.



Hoist

The hoist signal is given with the forearm vertical, the index finger pointing up, and the hand moving in small horizontal circles.

Lower

The lower signal is given with the arm extended downward, the index finger pointed down and the hand moving in small horizontal circles.



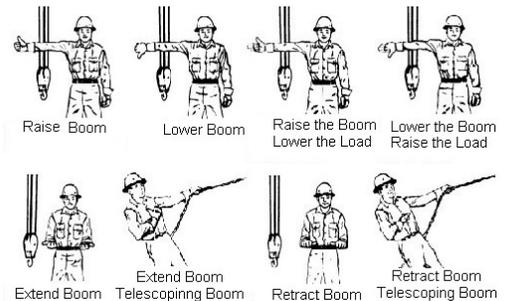
Hoist/Move Slowly

A hand held motionless in front of any signal indicates to move slowly. In this clip the rigger is signaling to hoist slowly.

Boom Signals

Boom signals direct the operator to raise and lower or to extend and retract the boom.

Combination boom and hoist signals allow the load to remain at the same height while booming up or down.



Raise the Boom

The signal to raise the boom, or boom up, is given with an extended arm, fingers closed and thumb pointing upward.

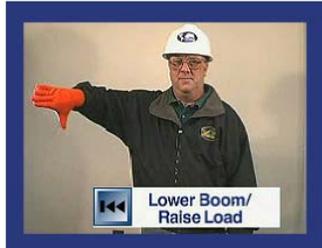
Lower Boom

The signal to lower the boom, or boom down, is given with an extended arm, fingers closed and thumb pointing downward.



Raise Boom/Lower Load

The signal to raise the boom and lower the load is given with an extended arm, thumb pointing upward and fingers flexing in and out.



Lower Boom/Raise Load

The signal to lower the boom and raise the load is given with an extended arm, thumb pointing downward and fingers flexing in and out.

Extend

The signal to extend the boom is made with both fists in front of the body and thumbs pointing outward away from each other.



Extend One Handed

The one handed extend signal is made with one fist in front of the chest and the thumb pointing inward with a tapping motion.

Retract

The signal to retract the boom is made with both fists in front of the body and thumbs pointing toward each other.

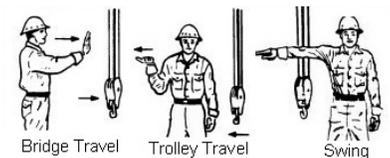


Retract One Handed

The one handed retract signal is made with one fist in front of the chest, and the thumb pointing outward, with a tapping motion.

Directional Signals

Directional signals are used to guide horizontal crane movements such as bridge, trolley and swing.



Travel

The signal for crane or bridge travel is made with an extended arm, hand open with palm facing outward, and the hand moving horizontally in the desired direction of travel.



Trolley

The signal for trolley travel is made with a palm up and fingers closed and the thumb moving in the desired direction of travel.

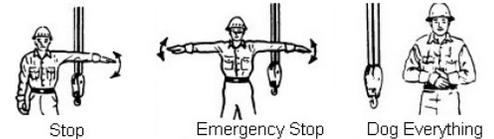
Swing

The signal for swing or rotate is an extended arm with the index pointed in the desired direction of rotation.



Signals for Stopping Crane Movements

Stop and emergency stop signals can be given by anyone. When these signals are given, the operator must stop operations as quickly and as safely as possible. The dog everything signal is used when all operations must be secured.



Stop

The stop signal is an extended arm, palm down, moving back and forth horizontally.

Emergency Stop

The signal for an emergency stop is both arms extended with palms down, moving them back and forth horizontally.

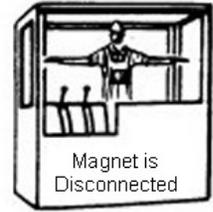


Dog Everything

The signal to dog everything is clasped hands in front of the body.

Magnet Signals Overview

Magnet signals are used to communicate the current status of the magnet - whether it is on or off.



Magnet Disconnected

The magnet disconnect signal is used to let the person on the ground know that the electricity has been secured and it is safe to disconnect the magnet from the crane.

The magnet disconnected signal is given with both extend arms, palms up and fingers open.

Knowledge Check

1. Select the best answer. This signal indicates:

- A. Main hoist
- B. Auxiliary hoist
- C. Travel
- D. Raise hoist



2. Select the best answer. When the signalers fingers are flexing in and out, this signal indicates:

- A. Lower the hoist
- B. Stop activities
- C. Lower the boom
- D. Raise the load – lower the boom



3. Select the best answer. This signal indicates to:

- A. Raise the load
- B. Extend the boom
- C. Stop
- D. Forward



4. Select the best answer. This signal indicates to:

- A. Retract the boom
- B. Move closer
- C. Separate the load
- D. Lower the load



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5. Select the best answer. This signal indicates:

- A. Travel back
- B. Swing
- C. Stop
- D. Emergency stop



6. Select the best answer. This signal indicates:

- A. Stop
- B. Swing
- C. Magnet disconnect
- D. Emergency stop



7. Select the best answer. This signal, given by the operator, indicates:

- A. Magnet disconnected
- B. Emergency stop



8. Select the best answer. This signal indicates:

- A. Retract boom
- B. Emergency stop
- C. Lower load
- D. Dog everything



NOTES

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CRANE TEAM CONCEPT

Welcome

Welcome to Crane Team Concept.

Learning Objectives

Upon successful completion of this module you will be able to explain the crane team concept, define how a crane team is organized, and understand the roles and responsibilities of each team member.

Crane Team Concept

The crane team concept was developed to help ensure that crane operations are executed without injury to personnel, and without damage to property or equipment. To accomplish this goal, the crane team works together to identify and eliminate obstacles to safety.

Crane Team Members

The basic crane team consists of the crane operator and the rigger-in-charge. The supervisor may assign other personnel as required. Additional members may include crane riggers, and a crane walker. The rigging supervisor assigns the crane team members depending on the complexity and scope of work. Either the rigging supervisor or rigger-in-charge may conduct team briefings.

Knowledge Check

1. Select the best answer. The Crane Team Concept was developed to ensure that all operations involving the crane are executed without:
 - A. Injury to personnel
 - B. Damage to property
 - C. Damage to equipment
 - D. All of the above
2. Select the best answer. The minimum crane team consists of:
 - A. The Crane Operator, Crane Supervisor, and Crane Rigger
 - B. The Crane Operator, Crane Walker, and Crane Rigger
 - C. The Crane Operator and Rigger-in-Charge
 - D. The Crane Operator, Rigger Supervisor, and Crane Rigger

3. Select the best answer. Additional crane team members may be assigned by ...
- A. The EOM designation
 - B. The crane rigger as required
 - C. The crane operator as required
 - D. The supervisor as required

Shared Responsibilities

While each member of the crane team has individual responsibilities, all team members share some common responsibility, including participation in pre-job briefings, watching for potential problems and making other team members aware of them.

All team members are responsible for keeping non-essential personnel away from the crane's operating envelope during lifting evolutions.

Pre-Job Briefing

A pre-job briefing for complex lifts is **conducted by** the rigging supervisor, operator supervisor or the working leader and shall be **conducted to ensure** that all crane team personnel understand the requirements of the lift.



Communications

Communications during the lift are just as important as the pre-lift brief.

All team members must be made aware of any problems that are discovered.

When making lifts where hand signals are not feasible, the rigger giving the signals shall remain in constant voice communication with the operator. It shall be understood that if the communication ceases, the operator shall stop operation until communication is re-established.

Safety

Stop crane operations before personnel board the crane.

Cranes should be positioned to allow safe boarding.

Stop work if you're unsure about the assigned task or, if you feel safety is in jeopardy. Have problems resolved before resuming operations.

Crane Operator Responsibilities

The crane operator must ensure that his or her license is not expired, and that the certification of the crane is not expired prior to operation. These are the two expiration dates that are of particular importance to crane operators.

The crane operator is responsible for performing the pre-use check of the crane and the operator's main concern during crane operation is operating safely.

The crane operator must have a full understanding of each lift prior to execution and moves only when directed by the signal person.

Pre-Use Check

When performing the pre-use check of the crane, the operator follows and completes the Operator's Daily Checklist, the ODCL.



Full Understanding of the Lift

Before making a lift, the crane operator must have a full understanding of the lift and how it is to be executed.

The operator must know the exact or estimated load weight, the destination and the capacity of the crane as it is configured.

Stopping Operations

The crane operator must immediately stop operations when the operating envelope is penetrated, if communications are lost during a blind or complex lift, and anytime a stop signal is given by anyone.

Knowledge Check

1. Select the best answer. While the members of the crane team have individual responsibilities, each have joint responsibilities as well. Each member must:
 - A. Support the goal of safe crane operation
 - B. Attend the pre-lift briefing. Any new members who replace another team member must be briefed as well
 - C. Keep the Rigger-in-charge well informed of conditions affecting personnel or the equipment during lifts
 - D. Keep non-essential personnel out of the operating area
 - E. Stop operations whenever safety is in question
 - F. Perform all of the listed actions above
2. Select the best answer. Securing the crane envelope is the ...
 - A. combined responsibility of the crane operator and the crane supervisor
 - B. combined responsibility of all team members
 - C. sole responsibility of the rigging supervisor
 - D. sole responsibility of the crane operator
3. Select the best answer. Crane operators are responsible for all of the following except:
 - A. Lifting and landing all loads safely
 - B. Slowing down when signals are unclear
 - C. Doing a thorough ODCL inspection
 - D. Maintaining communication with the signaler

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4. Select the best answer. If you feel safety is in jeopardy during the performance of your task, you should:
 - A. Call your supervisor for clarification
 - B. Stop work and have the problem resolved
 - C. Use the OEM manual to solve the problem
 - D. Evaluate the lift plan

5. Select all that apply. The crane operator must immediately stop operations when ...
 - A. Communications are lost during a blind or complex lift
 - B. The weather forecast is not good
 - C. Operations have exceeded allowed time
 - D. The operating envelope is penetrated
 - E. Any time a stop signal is given

Rigger-In-Charge Responsibilities

The rigger-in-charge has overall responsibility for the safety, planning, and control of the lift.

The Rigger-In-Charge ensures that each load is rigged properly and the crane envelope is kept clear.

He or she also signals the crane operator or designates other personnel to provide signals and coordinates the activities of the crane team members.

Lift Planning

The rigger-in-charge plans all aspects of each lift. He or she determines the load weight and center of gravity of each load and then selects the proper rigging.

Next, the load path is determined and the method of communication is planned.

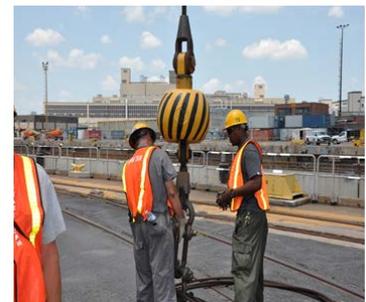
Crane Rigger Responsibilities

A crane rigger is responsible for carrying out assignments from the rigger-in-charge or the rigging supervisor.

These duties include assisting the crane operator with the pre-use check, selection and inspection of rigging gear, safely rigging the loads and keeping the rigger-in-charge informed.

Assisting with the ODCL

The crane rigger assists the operator in performing the pre-use check of the crane and work area.



Selecting and Inspecting Rigging

The crane rigger selects and inspects crane rigging gear, and establishes proper attachment points as directed by the rigger-in-charge.

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Communicating

A crane rigger keeps the rigger-in-charge informed of questionable or unsafe conditions and changes that may affect the operation.

Crane Walker Responsibilities

Often a crane supervisor will assign a crane walker to the crane team.

Like the crane rigger, the crane walker is responsible for carrying out the assignments of the rigger-in-charge and the rigging supervisor.

Assisting with the ODCL

A crane walker assists the crane rigger and crane operator in performing the pre-use check of the crane.

Safe Travel of the Crane

The crane walker ensures the crane's travel path is clear by watching for potential obstructions, monitoring portions of the crane such as the gantry, boom, and counterbalance to ensure adequate clearance is maintained, and checking the proper alignment of the crane track switches.



Communicating Stop

Crane walkers stay near the emergency stop button to be in a position to immediately notify the operator to stop operations should a potential problem arise.

Supervisor Responsibilities

The supervisor is familiar with NAVFAC P-307 and supports the crane team concept. The supervisor designates crane team personnel, reviews and inspects site conditions for potential safety problems and complex lifts, reviews procedures for operations near electrical lines, investigates and reports crane accidents, and supports the team anytime they feel they need to stop a lift due to safety concerns.

Site Conditions

The supervisor reviews onsite conditions for all complex lifts.

Operation near Power Lines

The supervisor assesses potential hazards and establishes procedures for safe operations around overhead electrical power lines.



Complex Lifts

A supervisor shall review on-site conditions for complex lifts and perform a pre-job briefing with all crane team personnel.

A supervisor shall personally oversee all lifts exceeding 80% of the certified capacity of the crane's hoist (except for lifts using pillar, pillar jib, fixed overhead hoists, or monorail cranes) or 50% for mobile cranes mounted on barges.

A supervisor shall also supervise multiple hook lifts when the weight exceeds 80% capacity of any hoist, and lifts of ordnance involving the use of tilt fixtures.



Accidents

The supervisor shall inspect suspected accident scenes, notify appropriate personnel, and ensure that the accident report is filed.

Knowledge Check

1. Select the best answer. If an accident is reported, the preliminary investigation will be performed by the:
 - A. Rigger-in-charge
 - B. Crane operator
 - C. Supervisor
 - D. Crane rigger
2. Select the best answer. Planning the lift route is the responsibility of the:
 - A. Crane rigger
 - B. Crane operator
 - C. Crane supervisor
 - D. Rigger-in-charge
3. Select the best answer. Coordinating the activities of the crane team is the responsibility of the:
 - A. Rigger-in-charge
 - B. Crane rigger
 - C. Crane operator
 - D. Crane supervisor
 - E. Activities

NOTES

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SAFE OPERATIONS

Welcome

Welcome to Safe Operations.

Learning Objectives

Upon successful completion of this module you will be able to explain operator responsibilities, describe proper methods to lift and land loads, identify safe operating procedures and state securing procedures for cranes

Understanding the Crane

Most crane accidents can be avoided by consistently practicing basic safety procedures.

Team members are often to blame for crane accidents, due to inattention, poor judgment, overconfidence, or haste.

Crane operators at naval activities may be required to operate various types, makes, and models of cranes. Operators must be trained, licensed, and thoroughly familiar with the operating characteristics, including posted operational restrictions or limitations, of each type, make, and model of crane that may be operated.



Operator Training

Prior to being licensed, operator trainees must be thoroughly trained on the operation of the type of crane for which a license is to be issued.

The operator trainee shall operate the crane only under the direct observation of a licensed operator. The licensed operator shall retain full responsibility for the safe operation of the crane.

The supervisor shall approve lifting of loads based upon the candidate's demonstration of knowledge of the equipment and operation without loads.

The trainee shall not perform complex lifts.

Operations Manual

Operators must read and follow the manufacturer's requirements, written procedures, safety instructions and precautions.

Posted Information

The operator must heed posted warnings and instructions on the crane such as hand signal placards, controller function labels, and warning labels.

Certification information should be posted in plain sight.

Pre-operational Check

To make sure the crane and work area are safe, the operator performs a mandatory daily crane inspection using the **Operator's Daily Checklist**.

When performing the operational check portion of the ODCL in cold weather or icy conditions, the operator



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should raise the blocks and boom before lowering them to avoid damage when sheaves may be frozen.

Operators should inform rigging personnel to stand clear of the area below the blocks and boom prior to operation.

The operator should hoist up slowly, in small increments, to break any ice and/or snow free, and monitor the sheaves to ensure proper movement and operation of the sheaves and wire rope.

This should also be performed periodically throughout the day to ensure proper operation during cold weather or icy conditions.

Knowledge Check

1. Select the best answer. When operating cranes, the operator's primary responsibility is to:
 - A. Keep the crane clean
 - B. Do pre-use checks
 - C. Use the shortest boom length possible
 - D. Operate safely
2. Select the best answer. Crane operators at naval activities may operate various types, makes, and models of cranes for which they are licensed. How must safety and operator proficiency be assured under these circumstances?
 - A. Operators must operate at reduced speeds until confident and capable
 - B. Operators must receive written and performance tests by a crane license examiner as outlined in the NAVFAC P-307 manual
 - C. Operators must be familiarized (as directed by a supervisor) before operating
3. Select the best answer. What information should be posted, clearly understandable, and readily available to the operator?
 - A. Certification information
 - B. Travel speed through congested areas
 - C. Crane Operator's license number
4. Select the best answer. Which of the following operator responsibilities is considered the basis for ensuring a safe and reliable crane?
 - A. Periodic lubrication and servicing
 - B. Operator Daily Checklist (ODCL)
 - C. Proper set-up on outriggers
 - D. Firm and level supporting surface

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5. Select the best answer. What information should be posted, clearly understandable, and readily available to the operator?
- A. Labels for each control function
 - B. Operator's License number
 - C. ODCL Checks
6. Select the best answer. When can an unlicensed crane operator trainee operate a crane?
- A. Only under the direct observation of a licensed operator
 - B. When he or she needs to operate a crane to get the job done
 - C. When their supervisor tells them to operate a crane
 - D. In an emergency

Operator Awareness

When operating a crane, the operator must be aware of everything in the operating envelope including hazards, obstructions, and personnel.

At the same time the operator must be aware of the sound, feel and behavior of the crane.

Unsafe Conditions

Whenever an unsafe condition exists, operators must immediately stop operation and the condition must be resolved before continuing.

If you cannot resolve a safety issue with the team members, contact the supervisor for assistance.

Remember, operators have the **authority and responsibility** to stop and refuse to operate the crane until safety is assured.

Lifts Near Personnel

Loads must never be moved or suspended over personnel.

Choose an alternate load path or evacuate personnel from the area.



- Adjust rigging from other access if possible
- Look for an alternate route
- Never use the load as a means of transportation!

Riding Loads

Personnel must never ride loads.

Use only approved personnel-lifting devices if personnel must be lifted.

Overhead Lines

Whenever working near overhead power transmission lines, have the power de-energized and visibly grounded. When the power cannot be de-energized, the minimum required clearances described in figure 10-3 of NAVAC P-307 must be maintained.

If any part of the crane or load could approach the distances noted in figure 10-3 of NAVAC P-307, a designated signaller shall be assigned.

In addition, a supervisor shall visit the site, assess potential hazards, and establish procedures to safely complete the operation.

Follow the requirements of NAVFAC P-307 paragraphs 10.11.1 through 10.11.1.6 for crane operations near or below overhead electrical transmission lines, operation near communication towers, and travelling below power lines.

Required clearance for normal voltage in operation near high voltage power lines and operation in transit with no load and boom or mast lowered.	
NORMAL VOLTAGE, KV (PHASE TO PHASE)	MINIMUM REQUIRED CLEARANCE, FT (M)
Operation Near High Voltage Power Lines	
0 to 50	20 (6.10)
Over 50 to 200	20 (6.10)
Over 200 to 350	20 (6.10)
Over 350 to 500	50 (15.24)
Over 500 to 750	50 (15.24)
Over 750 to 1000	50 (15.24)
Operation in Transit with No Load and Boom or Mast Lowered	
0 to 0.75	4 (1.22)
Over 0.75 to 50	6 (1.83)
Over 50 to 345	10 (3.05)
Over 345 to 750	16 (4.87)
Over 750 to 1000	20 (6.10)

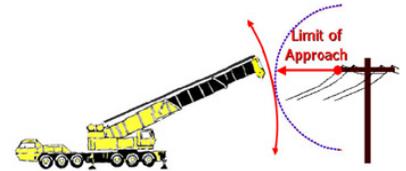
Limit of Approach

When operating a crane in the vicinity of overhead electrical transmission lines, for voltages less than 350 kV, the minimum required clearance is 20 feet. Where the voltage is known to be 350 kV or more, the minimum required clearance is 50 feet.

A designated spotter shall be assigned by the supervisor and be positioned to effectively gauge and monitor the clearance distance and communicate directly with the operator.

When operating in the vicinity of overhead transmission lines, the best crane set up is one in which no part of the crane or load can enter the clearance limit.

Even boom failure should not allow the crane, load line, or load to enter the limit.



Operating Practices

The crane operator must operate the crane in a safe manner, moving loads slowly and smoothly.

Avoid rapid starts and sudden stops to help reduce load swing. Anticipate stopping points, and slow down before bringing loads to a stop. Crane swing should be relatively slow to prevent outward swing of the load due to centrifugal force.

The operator shall remain at the controls at all times while a load is suspended from the crane. This does not include

slings and other gear used to rig the load and does not include a load attached to the crane with slack in the rigging gear. This also does not apply to under- running bridge cranes, jib cranes, pillar cranes, pillar jib cranes, monorails, and fixed overhead hoists used in industrial processes that require a suspended load such as cleaning, degreasing, painting, testing, and similar processes. For such cases, the suspended load shall be less than 80 percent of the crane's rated capacity, the area shall be secured to prevent unauthorized personnel from entering, the crane shall be tagged to indicate this condition, and the load shall not be suspended longer than required.

Lifting Loads

Prior to lifting, position the freely suspended hook directly over the loads center of gravity when attaching the load. This prevents side loading the boom or crane and prevents dragging or shifting of the load as it is picked up.

Sufficient tag lines shall be used to minimize load swing and rotation unless their use creates a hazard.

Take the slack out of rigging gradually and watch for hook movement that indicates the need to reposition the crane before lifting.

When lifting a load, stop hoisting when the load lifts a few inches off the ground and check to ensure there is no slippage of the hoist brake. This must be performed for every load.

Accelerate smoothly to reduce dynamic loading.

Extreme caution shall be used when making lifts out of water. When the load comes out of the water, buoyancy is lost and the load on the crane may increase. Also, just as the load leaves the water, the surface tension (suction) can increase the load on the crane momentarily. Water held inside the object may also increase the load weight.



Landing Loads

Prior to lowering loads, be sure the surface that you plan to land the load on will support the load.

When landing loads: slowly lower the load as you approach the landing surface, stop the load a few inches off the ground or landing surface, then slowly lower the rest of the way.

Ensure the load is stable and secure before slacking and removing the rigging gear.



Securing the Crane

When securing cranes remove gear from the hook, stow hooks near, but not in, the upper limit switches, place all controls in the neutral or off position, engage all brakes, rotate locking devices and drum pawls, and secure power.

Operators shall ensure local safety requirements are followed.

For mobile cranes, set the carrier brake and chock wheels if the crane is on an incline.

Traveling

When traveling cranes with loads, stow unused hooks, follow OEM requirements and keep loads close to the ground while avoiding obstructions.

Maintain communication with and operate under the direction of a signaler.

Use slow speeds for better load control.

Be aware of travel restrictions, and other cranes working in the area.

Remember to check clearances and watch for obstructions.

OET and Gantry Crane Operations

The bridge travel function is used to travel the crane in the selected direction along the length of the runway rails.

This allows the operator to move the entire crane along its supporting rail structure, in the selected direction.

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The trolley function is used to move the hoisting machinery in the selected direction along the trolley rails.

The hoist function is used to raise and lower the hooks.

Operating Characteristics

There are a variety of operating characteristics and issues that the users of Category 2 and 3 cranes must consider. Listed below are just a few.

Operating of Category 2 and 3 cranes may be from the cab or from the ground using a pendant controller or remote controls. A disadvantage of operating a very high mounted overhead traveling crane from the cab is that the operator may have difficulty in judging position and in seeing signals.

Some cranes are equipped with dynamic lowering controls. A dynamic lowering control is an automatic device that speeds the lowering of an empty hook or light load, and slows a heavy load.

On some cranes a heavy load may lower when the hoist control is initially moved from the neutral position to the hoist position. The load may not lift until the hoist speed is high enough to support and raise the load. This characteristic is called hoist roll back.

When positioning heavy loads, the final vertical adjustment should be made by lowering the load because of hoist roll back.

OET and Gantry Cranes Operating

Overhead electric traveling cranes are generally operated indoors so congestion is often an issue. Watch for changes in the work area that may cause interference. Storage racks with material stacked too high are a common problem.

Operators should always check for trolley and bridge drift before operating the crane. Lift loads vertically. Side pulls can cause uneven or overlapped spooling of the hoist wire and may cause the wire rope to be cut or severely damaged. In addition, ensure the hook and block are not swinging prior to hoisting. Improper or overlapped spooling of the wire rope on the drum can occur with or without a load on the hook when hoisting. Avoid sudden starts and stops with the bridge. This can result in skidding and uneven wear on the wheels.

A sudden start with a heavy load on one end of the bridge or a slippery track may cause a crane to skew. Skewing is a condition where one end of the bridge gets ahead of the other end, frequently causing binding on the rails. Excessive skew may be straightened by slowly bumping the bridge into the end stops.

OET and Gantry Cranes – Operating II

Always board cab-operated cranes at designated places.

Access the crane cab or bridge walkway using fixed ladders, stairs, or platforms.

Remain aware of other cranes working on the same rail system.

For gantry cranes, watch travel truck clearances.

For cab-operated gantry cranes, this may require additional personnel to ensure a clear travel path.

Use radio controls according to the manufacturer's instruction.

Turn off power to the radio controller and properly store when finished operating.





Operating Techniques

When slowly taking the slack out of rigging gear, and when starting to move a light load or empty hook smoothly, the first hoisting point or slowest possible speed should be used.

A technique called "Inching", or performing a motion very slowly, a little at a time, can be used when a crane operation or function requires small movement.

Another technique, "Plugging", is the use of reverse power instead of a brake to slow or stop the bridge or trolley travel. This method of braking or stopping movement is not used for hoisting or lowering motions. As a precaution, the operator should be ready to use the foot brake to stop movement if the power or operation should fail.

Securing

Move cab-operated cranes to a boarding platform or ladder (Never attempt to walk the rails to enter or exit an OET crane); move the trolley out of the way of traffic or interferences if necessary; raise the hoist block near, but not into the upper limit switch; place the controls in the neutral or off position; and secure the power.

Operators shall ensure local safety requirements are followed.

When necessary for OET or gantry cranes located outside, secure the crane against movement by the wind. The bridge brake shall be locked, or the bridge shall be locked by setting the spud lock or by blocking the travel trucks or wheels as necessary.

Activities are required to develop instructions for securing WHE in adverse weather conditions. Operators shall be aware of these requirements.

Knowledge Check

1. Select the best answer. When lifting loads with a crane, which of the following is the first thing an operator should do?
 - A. Center the hook over the center of gravity of the load
 - B. List the load slightly to check the brake
 - C. Change speeds smoothly
 - D. Take the slack out of the rigging
2. Select the best answer. The second step in the procedure for lifting loads is to:
 - A. Hoist slowly and remove slack from the rigging gear
 - B. Hoist slowly until the load lifts
 - C. Hoist at one speed until the load lifts
3. Select the best answer. The third step for lifting loads is to:
 - A. Lift until the load clears all obstacles and stop
 - B. Lift the load until a desired height and stop
 - C. Lift the load until completely suspended and stop

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4. Select the best answer. While operating, the crane operator becomes concerned over the safety of the lift. The Rigger-in-charge sees no problem and tells the operator to continue. The operator should:
 - A. Tell his/her supervisor at the end of the shift
 - B. Refuse to continue until safety is assured
 - C. Proceed slowly with caution
 - D. Note the incident on the back of the ODCL card

5. Select the best answer. Side loading a crane boom by dragging loads or lifting a load with a non-vertical hoist may result in:
 - A. Destructive stresses placed on the boom and sheaves
 - B. Possible overload due to swinging of the load after lifting
 - C. Uncontrolled movement of the load due to shifting
 - D. Any of the listed factors above

6. Select the best answer. In general, which of the following things should an operator do when traveling cranes with loads?
 - A. Keep loads just high enough to clear obstacles
 - B. Start slowly and increase speeds gradually
 - C. Avoid sudden stops
 - D. Stow or secure unused hooks
 - E. Perform all of the listed actions above

7. Select the best answer. What is meant by “skewing”?
 - A. Where one end of the bridge gets ahead of the other end, frequently causing binding on the rails
 - B. Skewing is when the crane is used to push another crane
 - C. Where the operator comes to a stop quickly, causing the crane to slide

8. Select the best answer. What is “inching”?
 - A. Lifting a load one inch, then checking the hoist brake
 - B. Performing a motion very slowly, a little at a time
 - C. Selecting one inch shackles and slings for a lift

9. Select the best answer. What is “plugging”?
 - A. Operating a crane function very slowly, a little at a time
 - B. Depressing a crane function repeatedly on a pendant controller as fast as possible
 - C. The use of reverse power instead of a brake to slow or stop the bridge or trolley travel
 - D. Operating the hoist in the reverse direction to stop movement

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CRANE AND RIGGING GEAR ACCIDENTS

Welcome

Welcome to Crane and Rigging Gear Accidents.

Instructional Objectives

Upon successful completion of this module you will be able to identify the elements in the crane and rigging gear operating envelopes, define a crane accident, define a rigging gear accident, identify the primary causes of accidents and explain the procedures to follow when an accident happens.

Accident Categories

There are two general categories of weight handling accidents: Crane Accidents and Rigging Gear Accidents.

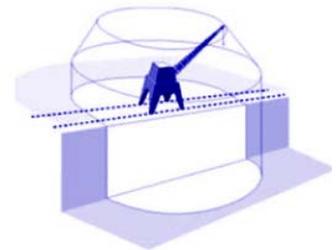
Crane Accidents are those that occur during operation of category 1, 2, 3, or 4 cranes.

Rigging Gear Accidents are those that occur when gear covered by NAVFAC P-307 section 14 is used by itself in a weight handling operation, i.e., without a crane. Or, when covered gear is used with multi-purpose machines, material handling equipment (forklifts), and with equipment covered by NAVFAC P-300 in a weight handling operation.

Crane Operating Envelope

In order to define a crane accident, you must first understand the crane operating envelope.

The operating envelope includes the crane, the operator, the riggers, the crane walkers, other personnel, the rigging gear between the hook and the load, the load itself, the supporting structures, such as the rails or the ground, and the lift procedure.



Rigging Gear Operating Envelope

The rigging gear operating envelope contains: the rigging gear and miscellaneous equipment covered by NAVFAC P-307 section 14, the user of the gear, the load itself, other personnel involved in the operation, the structure supporting the gear, the load rigging path, and the rigging procedure.

Knowledge Check

1. Select all that apply. The crane operating envelope includes the crane, the operator, the riggers, the crane walkers, and ...
 - A. The load
 - B. The area where the load will be landed
 - C. Any supporting structures
 - D. Rigging gear between the hook and the load
2. Select all that apply. The rigging gear operating envelope contains the rigging gear and miscellaneous equipment covered by P-307 section 14, the load itself and ...
 - A. The gear or equipment's supporting structure
 - B. The rigging procedure
 - C. The load rigging path
 - D. Other personnel involved in the operation
 - E. The crane removal procedure
 - F. The user of the gear or equipment

Near Misses

A near miss is a situation where an accident was avoided by mere chance or where intervention prevented an ongoing sequence of events that would have resulted in an accident.

Near misses and other unplanned occurrences with lessons to be learned that do not fall under the crane and rigging gear accident definitions, shall be reported using NAVFAC P-307, Section 12, Figure 12-2 (Near Miss Report). This report must be e-mailed (nfsh_ncc_accident@navy.mil) to the Navy Crane Center (Code 06) within 30 days of the occurrence.

Crane Accident Definition

A crane accident occurs when any of the elements in the operating envelope fails to perform correctly, during operations, including operations during maintenance or testing, resulting in personnel injury or death, material or equipment damage, dropped load, derailment, two-blocking, overload, or collision.



Rigging Gear Accident Definition

Rigging gear accidents occur when any of the elements in the operating envelope fails to perform correctly during weight handling operations resulting in the following: personnel injury or death, material or equipment damage, dropped load, two blocking, or overload.

Accident Examples

Some common examples of accidents are: dropped loads, injuries from a shifting load, failure of rigging gear resulting in a dropped load, overloads, and improperly secured loads falling from pallets.

Damaged Rigging Gear

When damage to rigging gear is discovered during an inspection or when damaged rigging gear is returned to the gear room, and an accident is suspected, the gear shall be immediately removed from service and a comprehensive investigation initiated.

The activity shall follow the investigation and reporting requirements of NAVFAC P-307, Section 12, promptly perform a comprehensive investigation, and prepare a Crane and Rigging Gear Accident Report and forward a copy to the Navy Crane Center (Code 06) within 30 days of the accident.

Local Weight Handling Equipment accident reporting procedures shall also be followed.



Accident Exception

Component failure such as motor burnout, gear tooth breakage, bearing failure, etc., is not considered an accident just because damage to equipment occurred, unless the component failure causes other damage such as a dropped boom or dropped load.

Accident Causes

In most cases, crane accidents result from personnel error and can be avoided. Most crane accidents are caused by: inattention to the task, poor judgment, bad communication, team members having too much confidence in their abilities, or operating the crane too fast.

Operator Responsibilities

The operator can play a significant role in eliminating human error and accidents.

Drugs and alcohol can affect a person's capability to think, reason, or react in normal situations and can certainly lead to serious accidents.

Operators must always consult their physicians regarding effects of prescription drugs before operating equipment, and recognize that medications often affect people differently.

An operator is responsible for evaluating his or her physical and emotional fitness.

WHE Accident Response

Upon having an accident or having seen evidence of damage, the crane team, riggers, equipment users, etc., shall stop all operations and notify immediate supervisor(s).

If there is impending danger to the equipment or personnel, place the crane and/or load in a safe position prior to notifying supervision.

Ensure the accident scene is secured and undisturbed so as to facilitate the investigation.

The supervisor shall review the situation and take any further emergency action.

The supervisor shall notify management personnel as well as the activity safety office.

Crane Accident Actions

If a crane accident occurs, personnel must take the following actions:

Stop operations as soon as possible, however don't stop at the expense of safety.

In some circumstances, for example, if a crane is involved in a collision as a load is being lowered, the operator should first land the load, then, follow the accident response procedure.

Don't try to correct the problem unless life or limb is in danger.

Call, or have someone call 911 if an injury occurs.

Secure the crane.

Secure power as required.

If danger exists to the crane or personnel, place the crane and load in a safe position.

Notify supervision as soon as safely possible.

Ensure that the accident scene is preserved to aid the investigation.

General Reporting Procedures

Activities shall notify the Navy Crane Center (Code 07) by fax, phone, or e-mail as soon as practical but not later than 24 hours after an accident involving a fatality, in-patient hospitalization, overturned crane, collapsed boom, or any other major damage to the crane, load or adjacent property.

For all other accidents the Navy Crane Center must be notified no later than three working days after the accident.

For each suspected accident, activities shall promptly perform a comprehensive investigation, prepare a Crane and Rigging Gear Accident Report and forward a copy to the Navy Crane Center within 30 days of the accident.

Contractor Accident Reporting Procedures

The contractor shall notify the contracting officer as soon as practical but no later than four hours after any WHE accident. Secure the accident site and protect evidence until released by the contracting officer. Conduct an accident investigation to establish the root cause(s) of any WHE accident.

Crane operations shall not proceed until cause is determined and corrective actions have been implemented to the satisfaction of the contracting officer.

Contractors shall provide to the contracting officer, within thirty days of any accident, a Crane and Rigging Gear Accident Report using the form provided in NAVFAC P-307 Section 12 consisting of a summary of circumstances, an explanation of cause or causes, photographs (if available), and corrective actions taken.

Contracting Officer Reporting Procedures

The contracting officer shall notify the host activity of any WHE accident upon notification by the contractor and provide the Navy Crane Center and the host activity a copy of every accident report, regardless of severity, upon receipt from the contractor.

The contracting officer shall notify the Navy Crane Center of any accident involving a fatality, in-patient hospitalization, overturned crane, collapsed boom, or any other major damage to the crane, load, or adjacent property as soon as possible, preferably within twenty four hours of notification by the contractor. For all other accidents, notify the Navy Crane Center as soon as practical but no later than three working days after the accident.

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When the contracting officer is not in the local area, the contracting officer shall designate a local representative to ensure compliance with the above noted requirements. The above requirements are in addition to those promulgated by OPNAVINST 5100.23 and related local instructions.

Knowledge Check

1. Select the best answer. During maintenance the rigging gear between the crane hook and the load fails and results in equipment damage. This is reported as a:
 - A. Rigger error
 - B. Operator error
 - C. Crane accident
 - D. Rigging gear deficiency
2. Select the best answer. During crane operations the load shifts. The operator reacts quickly and saves the load but causes the crane to derail. This is reported as a:
 - A. Crane walker's error
 - B. Load configuration error
 - C. Crane accident
 - D. Operator error
3. Select the best answer. When rigging gear covered by P-307 Section 14 fails while suspended from a structure and drops the load it is a:
 - A. Load configuration error
 - B. Rigging gear accident
 - C. Rigging error
 - D. Crane accident
4. Select the best answer. If component failure occurs, such as motor burnout, and does not result in damage, the component failure is considered:
 - A. A rigging gear accident
 - B. A non-accident
 - C. A crane accident
 - D. Crane maintenance's responsibility
5. Select the best answer. To whom or to what are the majority of crane accidents attributed?
 - A. Weather conditions
 - B. Personnel error
 - C. Crane operators
 - D. Riggers or signalmen
 - E. Equipment failure

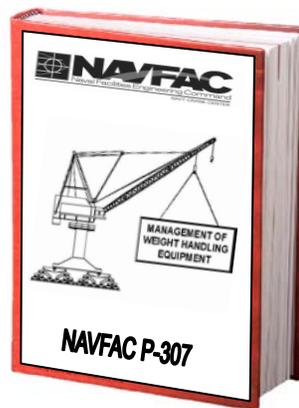
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6. Select all that apply. Over-confidence and poor judgment among team members can contribute to crane and rigging gear accidents. Select additional factors that can contribute to accidents:
 - A. Engineering lift specifications
 - B. Inattention to the task
 - C. Operating the crane too fast
 - D. The crane operating envelope

7. Select the best answer. If you have an accident with a crane or you find damage and suspect an accident has happened, your first step is to:
 - A. Stop operations as soon as safely possible
 - B. Call emergency services if anyone is injured
 - C. Notify your supervisor immediately
 - D. Secure the crane and power as required

NOTES

Navy Crane Center



NAVFAC P-307 Training

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