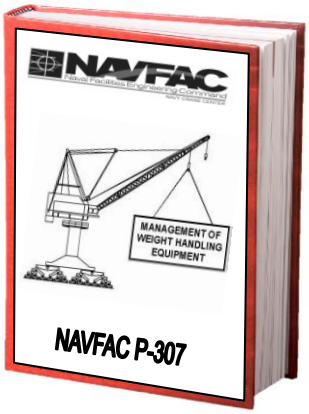
Navy Crane Center



NAVFAC P-307 Training

CRANE MECHANIC

WEB BASED TRAINING STUDENT GUIDE

NCC-CM-01

Naval Facilities Engineering Command
Navy Crane Center
Norfolk Naval Shipyard, Bldg. 491
Portsmouth, VA 23709-5000
Comm. Phone: 757.967.3803, DSN: 387
Fax: 757.967.3808
https://portal.navfac.navy.mil/ncc

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INTRODUCTION

COURSE DESCRIPTION

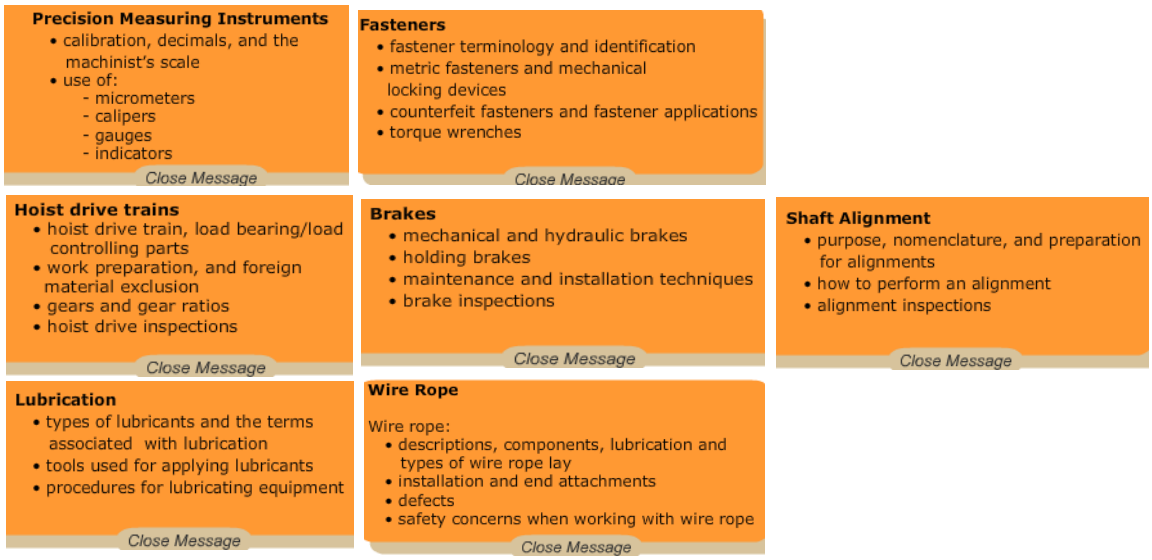
Crane Mechanic is designed to acquaint crane mechanics with Navy requirements for the safe mechanical maintenance of Navy cranes and provide a knowledge base on which to build upon with on-the-job experience.

TOPICS COVERED

The Crane Mechanic course covers NAVFAC P-307 familiarization, basic electrical safety, as well as adjustment, repair, replacement, and overhaul for crane components and systems.

CRANE MECHANIC MODULES

Here are the modules presented in the Crane Mechanic course. Some of the subjects have more than one module.



REFERENCES

Support materials for this course can be located and obtained from the course reference area.

NOTES

NAVFAC P-307

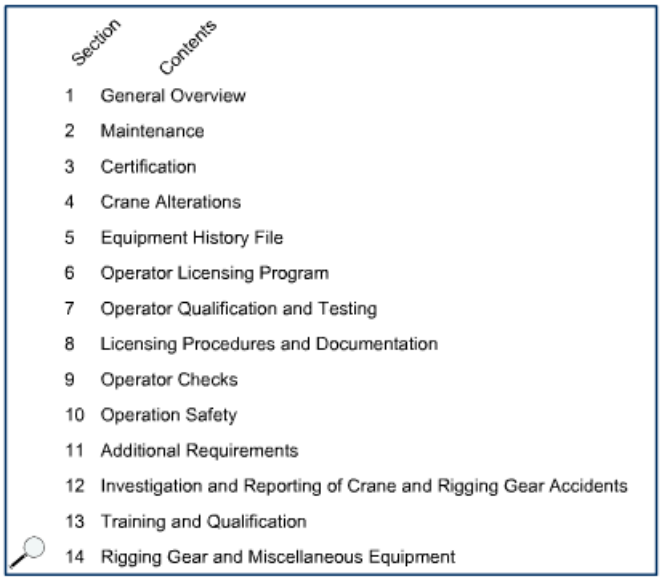
APPLICABILITY

NAVFAC P-307 applies to Navy shore activities, Naval Construction Forces including the Naval Construction Training Centers, and Naval Special Operating Units. NAVFAC P-307 meets or exceeds all OSHA regulations that apply to the operation of cranes.

NAVFAC P-307 CONTENTS

For and overview of 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

WEIGHT HANDLING REQUIREMENTS

NAVFAC P-307 provides requirements for Weight Handling Equipment including maintenance (repairs and alterations), inspection, test, certification, operations, training, licensing, and rigging gear use.

MAINTENANCE AND INSPECTION REQUIREMENTS

NAVFAC P-307 also provides requirements for documentation.

Certification

CRANE NO.	TYPE CRANE	TEST LOAD (lbs.)	TEST PROCEDURE
12345-7	OET	12,500	APPENDIX E
MAIN HOIST	MAIN HOIST	AUX HOIST	WHP HOIST
RATED CAPACITY	10,000 lbs.	5,000 lbs.	lbs.
TYPE SERVICE AUTHORIZED	SPECIAL PURPOSE SERVICE OR GENERAL PURPOSE SERVICE		
GPS			
CERTIFICATION DATE	CERTIFICATION EXPIRATION DATE		
1 July 20xx	30 JUNE 20xx 1 YEAR		
I certify inspection and test has accurately been performed according to specified requirements.			
SIGNATURE OF TEST DIRECTOR	DATE		
John Q.Tester	1 July 20xx		
OPERATOR AND LICENSE NUMBER			
Pat Operator	#123456		

Crane Testing Information Card can be used to display crane certification information.

All cranes require certification in accordance with NAVFAC P-307

Certification Includes:
- Crane Number
- Crane Capacity
- Certification Expiration Date

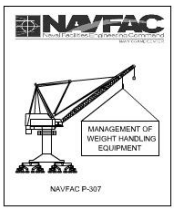
CERTIFICATIONS

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.

TYPES OF EQUIPMENT

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.

Types of Equipment



NAVFAC P-307 covers:
- Crane Categories 1,2,3,4
- Rigging Gear

Category 1 Cranes

Require a license to operate:

- Portal Cranes
- Hammerhead Cranes
- Locomotive Cranes
- Derricks
- Floating Cranes
- Tower Cranes
- Container Cranes
- Mobile Cranes
- Aircraft Crash Cranes
- Mobile Boat Hoists
- Rubber Tire Gantry Cranes

CAT 1 CRANES

This is a list of category 1 cranes. All category 1 cranes require a license to operate.

CAT 1 CRANE EXAMPLES

These are examples of Category 1 cranes.

Category 1 Crane
Floating Crane

Types:
- barge or pontoon 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
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
Container Cranes

Consists 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:
- crane with 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

Derrick

Category 1 Crane
Portal

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

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

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

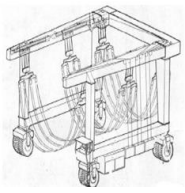
Consists of:
- rotating superstructure
- upperworks mounted on an specialized truck chassis equipped with a power plant and cab for traveling over the road

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

Mobile

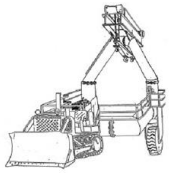
STRADDLE TYPE

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



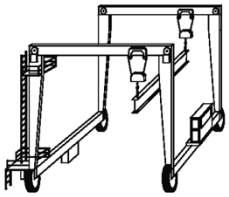
MOBILE BOAT HOIST

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 shone is a Cat 1 crane as described in NAVFAC P-307.



Category 2 and Category 3 cranes include:

- Bridge Cranes
- Rail Mounted Gantry Cranes
- Pillar Jib Cranes
- Wall Canes
- Jib Cranes
- Monorail
- Fixed overhead hoists
  - Manual
  - Powered

Portable hoists are defined in:
Section 14 of NAVFAC P-307

The activity may, however, treat them as Cat 2 or 3 cranes.

CAT 2 AND 3 CRANES

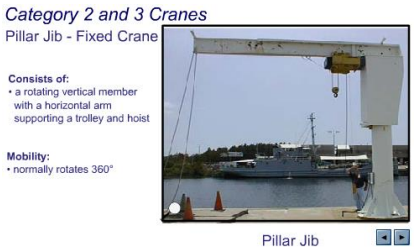
This is a list of Category 2 and Category 3 cranes. Portable manual and powered hoists are covered in Section 14 of the NAVFAC P-307. The activity may, however, treat them as Category 2 or 3 cranes.

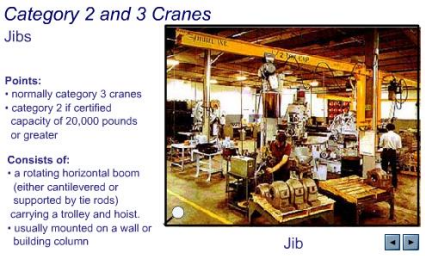
CAPACITY

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.

CAT 2 AND 3 CRANE EXAMPLES

These are examples of Category 2 and Category 3 Cranes.





CATEGORY 4 CRANES

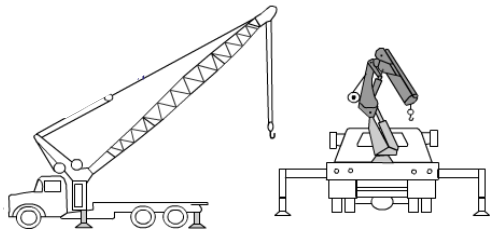
All Category 4 cranes require a licensed operator.

CATEGORY 4 CRANES – MOUNTING

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

CATEGORY 4 CRANES – BOOMS

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



PEDESTAL MOUNTED – CAPACITY

Pedestal mounted commercial boom assembly cranes of 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

CATEGORY 4 CRANES - SPECIAL 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.

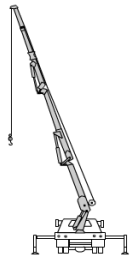
CATEGORY 4 CRANES – EXAMPLES

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



Category 4 Crane

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

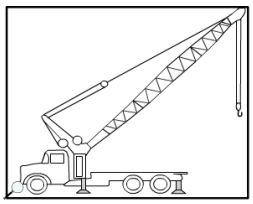
Truck Mounted
Commercial Boom Assembly

Category 4 Crane

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.



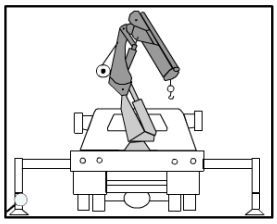
Non-Telescoping Boom

Category 4 Crane

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 4 Crane

Truck Mounted
Articulating Boom

Articulating Boom Crane
Truck Mounted

Category 4 Crane

Hydraulic
Extendible Boom

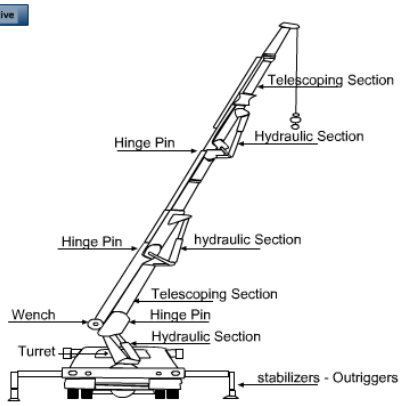
Hydraulic Extendible Boom

CATEGORY 4 CRANES – COMPONENTS

Using your mouse, explore these Category 4 crane components.

Category 4 Components

Return to Interactive



P-307 SECTION 7 OPERATOR QUALIFICATION AND TESTING

NAVFAC P-307 provides uniform standards for weight handling operator licensing.

Licensing (Sections 6, 7, and 8)

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.

CRANE ACCIDENTS

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

Crane Accidents Defined

A crane accident occurs when any of the elements of the operating envelope fail to perform correctly during operations, including operation during maintenance or testing resulting in the following:

- Personnel Injury or death
  Minor injuries that are inherent in any industrial operation, including strains and repetitive motion related injuries, shall be reported by the normal personnel injury reporting process of the activity in lieu of these requirements.
- Material or equipment damage
- Dropped load
- Derailment
- Two-blocking
- Overload
- Collision including unplanned contact between the load, crane, and/or other objects.

Rigging Gear Accident Defined

A rigging gear accident occurs when any of the elements of the operating envelope fails to perform correctly during weight handling operations resulting in the following:

- Personnel injury or death.
  Minor injuries that are inherent in any industrial operation, including strains and repetitive motion related injuries, shall be reported by the normal personnel injury reporting process of the activity in lieu of these requirements.
- Material or equipment damage that requires the damaged item to be repaired because it can no longer perform its intended function.
- Dropped load
- Two-blocking or cranes and powered hoists covered by section 14 (Rigging Gear and Miscellaneous Equipment)
- Overload

P-307 – TRAINING

Personnel training requirements are found in section 13 of NAVFAC P-307.

NAVFAC P-307 - Section 13
Training

Section 13 of NAVFAC P-307 provides training and qualification requirements for personnel involved in the management of Navy Weight Handling Equipment.

All personnel must be trained.

P-307 SECTION 14 - RIGGING GEAR

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

NOTES

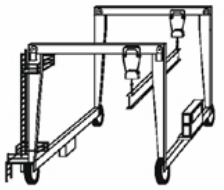
NAVFAC P-307 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. The purpose of NAVFAC P-307 is to:

A. maintain safety & reliability
B. ensure optimum service life
C. provide standards for crane operations and rigging
D. ensure safe crane and rigging operations
E. ensure all of the above

2. What is the category of this crane?



A. category 1
B. category 2
C. category 3
D. category 4

3. NAVFAC P-307 provides guidance to shore based Navy activities for management of weight handling equipment.

A. True
B. False

4. What is the category of this crane?

Capacity: Less than 20,000 lbs.

A. category 1
B. category 2
C. category 3
D. category 4

5. What is the category of this crane?

A: category 1
B. category 2
C. category 3
D. category 4

6. What is the category of this crane?

A: category 1
B. category 2
C. category 3
D. category 4

7. What is the category of this crane?

A: category 1
B. category 2
C. category 3
D. category 4

8. There is no difference in capacity between category 2 and category 3 cranes.

A. True
B: False

9. What is the category of this crane?

A: category 1
B. category 2
C. category 3
D. category 4

CRANE ELECTRICAL SAFETY 1

ELECTRICAL SAFETY POLICIES

Your local electrical safety policies should be more than your supervisor requiring that everyone “work safe” or shop personnel telling their supervisors that they always follow all the rules. They should be more than management hoping to make it through another quarter without an accident. Electrical safety policies should be written down in compliance with governing standards and available to all workers.

ELECTRICAL SAFETY POLICIES 2

Electrical safety policies are required to be in compliance with the following standards: Title 29 CFR, Section 1910, Subpart S: Electrical Safety; OPNAVINST 5100.23, Navy Safety and Occupational Health Program; and NAVFAC P-307, Management of Weight Handling Equipment."

ELECTRICAL SAFETY POLICIES 3

Each Navy activity shall adopt the requirements of OPNAVINST 5100.23 as a minimum. If additional requirements are identified by an activity, they shall be included in their local safety manual. Where available publications do not cover an activity’s specific needs, then the activity shall prepare requirements and include them in their respective safety manual.

CRANE HAZARDS

Some electrical hazards that you encounter are easy to spot. The exposed conductors in this picture are made up of a span wire system, including a pickup staff and pickup shoes. These are obvious hazards and you must not come into contact with them while they are energized. Adequate safety precautions for these and other obvious safety hazards must be taken.

HIDDEN HAZARDS

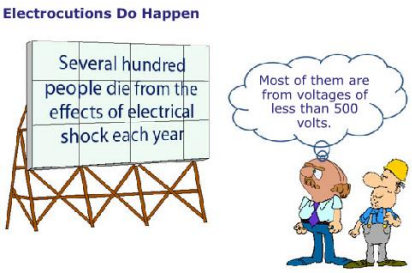
Electrical hazards on cranes may not be obvious. OSHA requires exposed electrical conductors on or near a work floor to be guarded to ensure workers do not come in contact with them. By elevating equipment greater than 8 feet and restricting access to 'authorized workers only', cranes are released from this standard. Cranes are not designed to protect onboard workers in areas other than the operator's cab. Maintenance personnel are often onboard the crane in many locations other than the cab. Therefore, workers providing maintenance or performing repairs on cranes may be exposed to many types of hazards including electricity. Workers should be trained in safety policies, procedures and hazard identification or mitigation principles."

ELECTRICITY IS DANGEROUS

Electricity is dangerous. The electrical power found on cranes is sufficient to cause injury or death. Electrical shocks can lead to falls. Due to the heights involved with crane maintenance and the remote areas where cranes may be located, a shock received by a worker may go unnoticed allowing an injury to turn into a fatality.

WHY ELECTRICAL SAFETY?

You claim that you have never been electrocuted so why should you be concerned? Let's take a look at some facts.

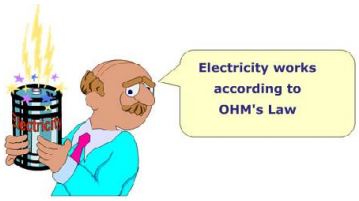


ELECTROCUTIONS DO HAPPEN

Several hundred people die of the effects of electrical shock each year. Most of them are electrocuted from systems that have less than 500 volts.

ELECTRICITY

Electricity works according to Ohm's law. In the early nineteenth century, Georg Ohm proved that a precise relationship exists between current, voltage, and resistance. This relationship is called Ohm's Law.



OHM'S LAW

Ohm's Law relates the properties of electricity and is expressed using the formula E = I times R, where E represents voltage, I represents amperage, and R represents resistance. Voltage is the force that causes electrons to flow. Voltage is represented by the letter E and is measured in volts. Current is the flow of electrons. Current is represented by the letter I and is measured in amps. Resistance is the opposition to current flow. Resistance is represented by the letter R and is measured in ohms. Ohm's Law simply states that one volt will cause one amp to flow through one ohm of resistance.

OHM'S LAW EQUATIONS

Using the equation for Ohm's Law, to determine volts, you would multiply amps times ohms, to determine amps you would divide volts by ohms and to determine ohms you would divide volts by amps.

$$E = IR \qquad I = \frac{E}{R} \qquad R = \frac{E}{I}$$

$$R = \frac{E}{I}$$

OHM'S LAW - CONSTANT RESISTANCE

Ohm's law, I = E / R, provides that with a constant resistance, R, an increase or decrease in voltage, E or current, I will result in a corresponding increase or decrease in the other factor in the equation. In other words E and I have a proportional relationship with constant R. Example: When I = 6 and E= 6 then R = 1, When I is increased to 12 and R is constant at 1, E will increase to 12 and vice versa when E is increased to 12, I will increase to 12.

$E = IR$

$I = \frac{E}{R}$

$R = \frac{E}{I}$

E=IR

OHM'S LAW - CONSTANT VOLTAGE

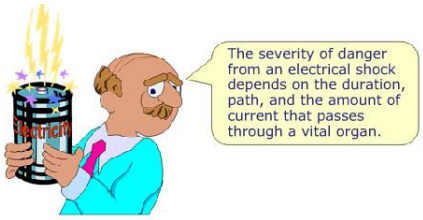
Ohm's law, I = E / R, provides that with a constant voltage, E, an increase or decrease in resistance, R, will result in a corresponding yet opposing decrease or increase in current, I. In other words, R and I have an inversely proportional relationship with a constant E. When I = 6 and R= 2 then E is12, inversely, when I = 2 and R = 6 then, E also = 12. When I is increased to 12 and R is decreased to 1, E remains at 12. Inversely, when I is decreased to 1 and R is increased to 12, E remains at 12.

RESISTANCE AND SAFETY

Resistance is the property of electricity on which electrical safety is based. The worker cannot control the current or the voltage. Current is dependent on voltage and resistance. Voltage is set by the manufacturer. Resistance therefore is the only property the worker can control. Resistance should be kept as high as possible to reduce the worker's exposure to electrical hazards.

DANGERS OF ELECTRICAL SHOCK

The danger electricity poses to people occurs when current passes through a vital organ. The damage caused to the vital organ depends on the severity of the shock. The severity of the shock depends on the duration of the shock, the path the current takes through the body, and the amount of current present during the shock.

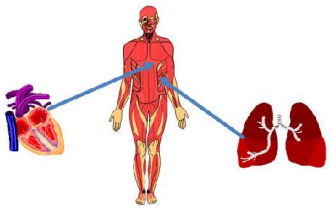


DURATION OF SHOCK

Duration is the length of time that current flows through the body. The longer a vital organ is exposed to a current, the more danger of damage or organ failure that may occur.

PATH OF SHOCK

Current that takes a path through the heart and the lungs poses the greatest risk. The heart and the diaphragm, which operates the lungs, receive electrical impulses from the brain that control their operation. Excessive current passing through the heart or diaphragm interferes with that operation. The brain and nervous system are the least affected by an electrical shock.

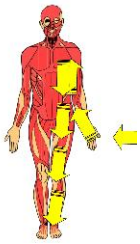


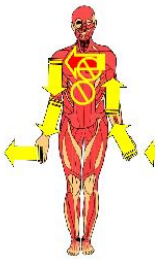
BODY CONTACT POINTS

The contact points on the body through which electrical current enters and exits, determines the path current takes through the body. Current needs at least two contact points on the body. The hands are the most common points, because they are involved in doing the work. The feet are the next most common points because they usually provide the ground path.

LESS HARMFUL PATH

The path current takes is less harmful if the two contact points are a hand and a foot. In the picture of the body depicted here, yellow arrows indicate the less harmful path through the body. It shows the path entering through the hand, continuing through the arm, leg and exiting the foot on the same side of the body. This current path does not pass through the diaphragm, heart or other vital organs.





MOST HARMFUL PATH

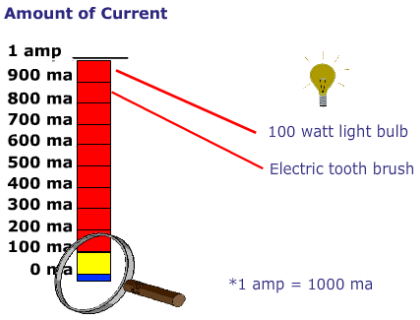
The path current takes is most harmful if the two contact points are the hands. In the picture of the body depicted here, yellow arrows indicate the most harmful path because it passes through vital organs. It shows the path entering through the hand and arm, through the chest, heart and lungs, and continuing through the other arm and exiting from the opposite hand.

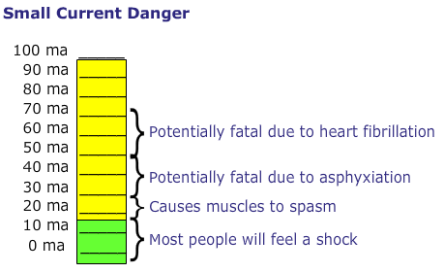
HIGH CURRENT DANGER

The severity of an electrical shock also depends on the amount of current. The more current that passes through a vital organ, the less likely the organ will survive.

AMOUNT OF CURRENT

To put things in perspective, let's look at some everyday objects and discuss the amount of current that they use and the potential dangers imposed by different amounts of current. Before we do that, you should know that amperages of less than 1 are measured in milliamps. One amp equals one-thousand milliamps. Milliamps are represented by the lowercase letters "m a". The scale on the screen is graduated in milliamps. Now, let's look at two examples of everyday objects you might use, a 100 watt light bulb and an electric toothbrush. A 100 watt light bulb requires about 1 amp of current while an electric toothbrush requires about 900 milliamps.





ELECTRICAL SAFETY - SMALL CURRENT DANGER

Now let's look at the dangers associate with exposure to currents less than 100 milliamps. At 0 to 20 millamps most people will feel a shock. At 20-30 ma muscles can begin to spasm. At 30-50 ma, the current is potentially fatal due to asphyxiation. At 50-75 ma the current is potentially fatal due to heart fibrillation. You cannot be too careful when working around electricity because even small amounts of current can be very dangerous, even fatal.

NOTES

CRANE ELECTRICAL SAFETY 1 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. The severity of an electrical shock is dependent upon which of the following conditions?

A. all listed items are correct
B. the duration of the shock
C. the amount of current
D. the path the current travels through the body

2. If current is determined by voltage, and the voltage is set by the manufacturer, what electrical property can you, the worker, control to mitigate exposure to electrical hazards?

A. voltage
B. amperage
C. current
D. resistance

3. The amount of electrical power found on cranes is sufficient to cause death from electrical shock.

A. True
B. False

4. The most harmful path current can take through the body is…

A. in the hand, down the side of the body, out the foot
B. in the shoulder, down the side of the body, out the knee
C. in the hand, through the chest, out the opposite hand
D. in the foot, through the leg, out the thigh

5. Workers should be trained in…

A: hazard identification
B. safety policies
C. tank cleaning
D. risk mitigation
E. customer service

6. The most common contact points where electrical shocks enter and/or exit the body are…

A: shoulders and arms
B. hands and feet
C. torso and legs
D. head and neck

7. As little as 30 milliamps can potentially cause death.

A: True
B. False

8. Electrical hazards on cranes may not be obvious.

A: True
B. False

9. Ohm's Law relates voltage, current, and resistance. Regarding Ohm's Law, which of the following is/are true?

A: R=AV
B. E=IR
C. I=E/R
D. R=E/I

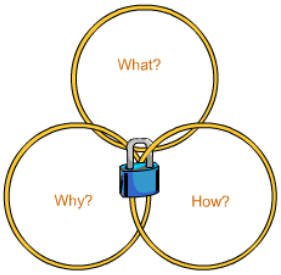
10. Electrical safety policies shall be written down, available to all workers, and _____.

A. labeled per ASME B30.19
B. comply with industry standards
C. posted in the crane cab
D. filed in the equipment history file

LOCKOUT/TAGOUT

PURPOSE OF LOCKOUT/TAG-OUT

The purpose of the lockout/tagout system is to control hazardous energy and prevent injury to personnel. Lockout procedures are a principle means of controlling energy hazards. A lockout procedure is a set of safe work practices and rules that makes it impossible for a worker to come into contact with an uncontrolled energy source.



WHO IS AFFECTED?

Affected employees are those who use the equipment or system that is about to be locked out or tagged out. This means that everyone in the area where the work is being performed must be notified

WHEN IS LOCKOUT/TAGOUT REQUIRED?

Lockout/tagout procedures are required when the safety of personnel may be affected by positive energy flow.

POTENTIAL HAZARDOUS ENERGY

Hazardous energy may include all of these sources around your workplace.

Kinetic Energy…
Blades, belts, and fly wheels.
Energy that keeps object moving after power supply is cutoff.

Potential Energy…
Raised loads
Counterweights
Springs
Capacitors
Accumulators

ENERGY ISOLATING DEVICES

Energy-isolating devices disconnect or shut down the energy source to the equipment that must be serviced.

LOCKOUT

The preferred method to prevent hazardous energy from injuring personnel is Lockout. Lockout means locking an energy isolating device in a safe position.

TAG-OUT

Tag-out is to place a tag on an energy isolating device.

DEVICES REQUIREMENTS

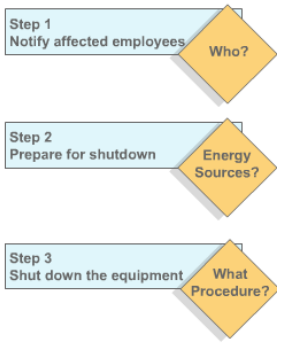
Lockout/tag-out devices must meet these requirements.

PROCEDURE OVERVIEW

The lockout/tagout system includes three fundamental procedures: Preparing for the lockout/tag-out, executing the lockout/tagout, and re-energizing the equipment or systems.

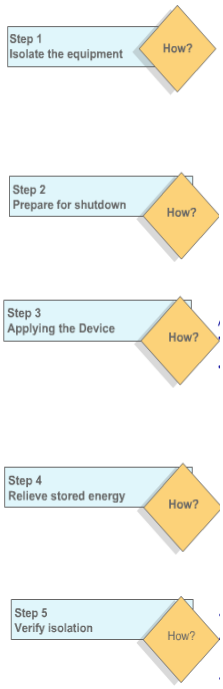
PREPARING FOR LOCKOUT/TAG-OUT

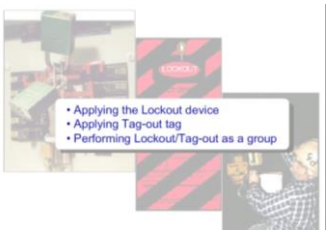
There are three steps in preparing for the lockout/tagout.



EXECUTING LOCKOUT PROCEDURES

There are five steps when executing Lockout procedures.



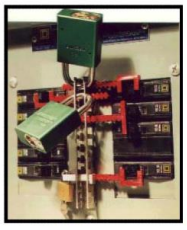


SPECIAL CONSIDERATIONS

Review and follow all special considerations when applying the lockout/tagout devices.

APPLYING DEVICES

The lockout/tagout device must ensure that it holds the isolating device in a safe or off position.



APPLYING TAGOUT DEVICES

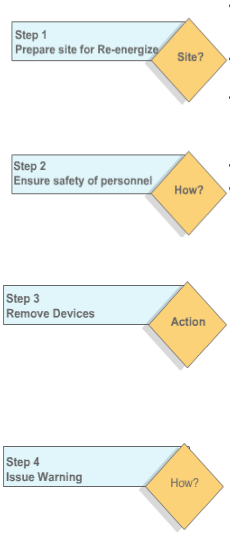
If only tag-out is used, for example no locking device, the tag must be attached so that it clearly indicates that operation or movement of the energy isolating device is prohibited. It must be attached at the same point where a lock would have been attached.

PERFORMANCE BY GROUP

When lockout/tagout procedures must be performed by more than one person, each worker is required to attach their own personal lockout/tagout out device. One person shall be responsible to oversee the procedure.

RE-ENERGIZING THE EQUIPMENT AND SYSTEMS

The final procedure in the Lockout / Tag-out System is to re-energize the equipment or systems. There are four steps to accomplish this.



NOTES

LOCKOUT/TAGOUT MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. When an isolation device has no place for a lock; a _____ is required.

A. lockout procedure
B. tagout procedure

2. Which of the following does not meet the requirements for a lockout device?

A. provides caution against energizing
B. substantial enough to prevent easy removal
C. equipment cannot be operated until device is removed
D. locks source in the “off” position

3. Provides positive control is a characteristic of…

A. a lockout tag
B. a lockout device
C. a lockout tag and a lockout device

4. Identify any of the following statements that are not a requirement for lockout/tagout devices.

A. must only be used for controlling energy
B. are provided by the employer
C. only removed by the person who places them
D. must not be used for any other purpose
E. must contain a phone number
F. must identify the person using them

5. When equipment must not be operated or energized; a _____ is required.

A: lockout procedure
B. tagout procedure

6. Who must be notified before a lockout/tagout procedure is started?

A: affected employees
B. everyone who uses
C. all people in the area where the work is to be done
D. all listed personnel

7. Who is authorized to remove lockout or tagout devices?

A: the authorized employee who installed the device
B. all operators of the equipment
C. anyone authorized to fix the equipment
D. affected employees
E. only the worker's supervisor

8. When performing the lockout/tagout procedure, before you relieve stored energy you must…

A. verify isolation
B: relieve stored energy
C. apply the lockout or tagout device

9. Which of the following person is responsible for applying locks or tags to machinery, equipment, or systems?

A: only the worker's supervisor
B. affected employee
C. authorized employee

10. Who must be notified before re-energizing equipment that has been locked our or tagged out?

A. all who use the equipment
B. everyone in the work area
C. affected employees
D. all listed personnel

11. The purpose of lockout/tagout is to prevent personal injury which can be caused by all of the following examples except…

A. routine minor adjustments
B. rotating unguarded machinery
C. stored hydraulic energy
D. electric shock
E. pressurized gases or liquids

12. ‘Identifies attaching person’ is a characteristic of a…

A. lockout tag
B. lockout device
C. lockout tag and lockout device

13. Which of the following is required when an employee removes or bypasses a guard or safety device to perform work?

A. no action
B. lockout
C. tagout

14. When performing the lockout/tagout procedure, the last step performed is to…

A. verify isolation
B. notify affected employees
C. shut down the equipment
D. apply the lockout or tagout device
E. relieve stored energy

15. When an isolation device has locking capability, a _____ is required.

A. lockout procedure
B. tagout procedure

16. In performing a lockout/tagout procedure, the first step is…

A. notify affected employees
B. apply the lockout or tagout device
C. shut down the equipment
D. relieve stored energy
E. verify isolation

17. Which of the following is required when an employee places any part of their body into an area where the unexpected re-energizing or release of stored energy from machinery could result in injury while performing of work?

A. no action
B. lockout
C. tagout

PRECISION MEASURING INSTRUMENTS 1

CALIBRATION

Knowing how to take accurate measurements on various crane components is essential for quality crane maintenance and repair work. Since precision measuring instruments can lose accuracy as a result of everyday wear and tear or mishandling, their accuracy should be verified by periodic calibration. In many cases, a precision instrument comes with a standard against which its accuracy may be checked. In addition, these instruments may be checked against each other. For example, an inside micrometer may be set at a given size and then measured with an outside micrometer to verify the reading.

UNDERSTANDING FRACTIONS

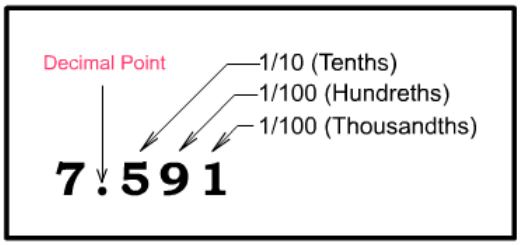
To learn how to use precision measuring instruments, it is important to have an understanding of decimals and fractions. Most of us are familiar with reading and using fractions of an inch that are common in everyday use such as 3/4 inch plywood or a 1/2 dozen eggs. Fractional linear measurements are a convenient way to divide up inches when absolute precision is not required. Carpenters, for example, very seldom measure anything closer than 1/16, however, for a machinist or a mechanic, 1/16 is often a very large increment. When working with fractions, remember that the top number in the fraction is called the numerator and the bottom number the denominator. For example, in this illustration showing the fraction 5/8, the 5 would be the numerator and 8 would be the denominator. We will use this information later, when learning to convert fractions to decimals.

USING DECIMALS

When working with precision measuring instruments, a clear understanding of decimal numbers is necessary. Due to the need for greater accuracy, precision measurements are normally expressed as a decimal. Using decimal numbers allows us to precisely divide measurements or dimensions into much smaller increments with greater precision.

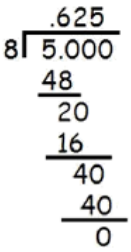
READING DECIMAL NUMBERS

Reading decimal numbers is a fairly straightforward process. In any number having a decimal place, numbers to the left of the decimal place are whole numbers. The number 7 in the illustration is a whole number. Numbers to the right of the decimal place are increments or parts of a whole number. The first position to the right is the tenths place. In this illustration, 5 represents five-tenths of an inch. The second position to the right is the hundredths place. In the example, the number 9 represents nine-hundredths of an inch. The third position to the right is the thousands place so the number 1 would represent one thousandths of an inch. This entire number could be read “seven inches, five-hundred-ninety-one thousandths". In some cases requiring extreme accuracy, measurements or dimensions to a ten-thousandth may be measured.



CONVERTING FRACTIONS TO DECIMALS

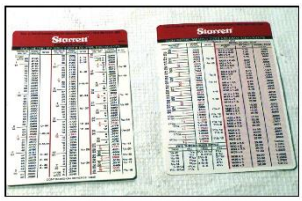
The conversion of fractions to decimals is a simple mathematical process. When converting fractions to decimals - divide the numerator by the denominator. In the example, the fraction 5/8 is converted to a decimal equivalent by dividing 5 by 8. The resulting decimal value is .625 or six hundred, twenty-five thousandths.



$$.375" = \frac{375"}{1000} = \frac{3"}{8}$$

CONVERTING DECIMALS TO FRACTIONS

To convert decimals to fractions you need to turn the decimal into the fraction. If the decimal number reads in thousandths, then the fractional form would be expressed as the decimal number over thousandths, as shown in the example. In this case .375 which is read as three hundred seventy five thousands is placed over 1000. Then reduce it to the lowest denominator. Find a number which both numerator and denominator can be divided by. In this case, 125 divides into both numbers. 125 divides into 375 three times and into 1000, eight times reducing this fraction to 3/8. This can be a very time consuming and subject to error when the numbers are not as easily divisible as the example used here, but there is another alternative.

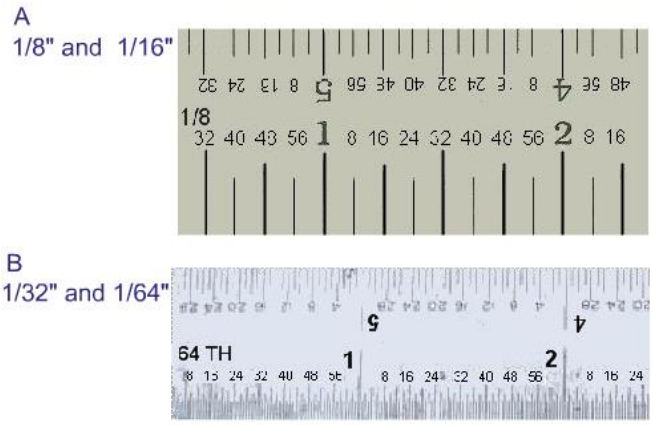


CONVERSION CHARTS

A conversion chart is a quick, accurate, and easy way to find a fraction's decimal equivalent.

MACHINIST'S SCALE

Although it is the least precise of the precision measuring tools we will be covering, the machinist's scale is an indispensable tool for the crane mechanic.
Typically, a machinist's scale is marked in 1/8 and 1/16 increments on one side, as shown on example "A", and 1/32 and 1/64 increments on the other side, as shown in example "B". The inch increments are numbered. On the 1/8 side of the scale, the 1/4 and 3/4 marks are slightly longer and the 1/2 mark is even longer so that they are easily identified. The same holds true for the sixteenth side, except the 1/8 marks are slightly longer than the 1/16 marks so that they are easily identified. In example "B", the increments are numbered at the 1/8 increments on the 1/32 and 1/64 increments sides. The numbering helps keep track of the smaller increments and also orients the user on the scale.



NOTES

PRECISION MEASURING INSTRUMENTS 1 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. Why would you want to calibrate precision measuring instruments?

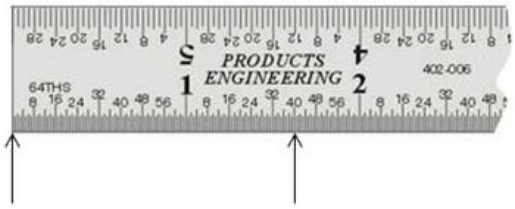
A. to fulfill a requirement
B. to provide job security to a metrologist
C. to make measuring easier
D. to insure their accuracy

2. When a fractional number needs to be converted to a corresponding decimal, a commonly used aid is a decimal equivalent chart.

A: True
B. False

3. Record the reading indicated on the 6” scale.

A. 1 1/2”
B. 1 5/8 “
C. 1 3/4”
D. 2 13/16“



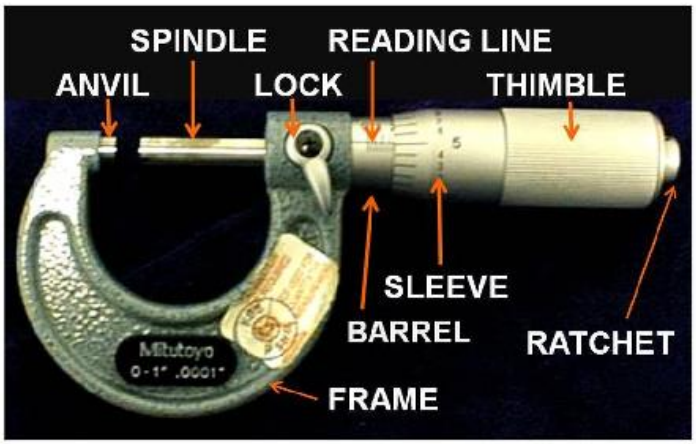
PRECISION MEASURING INSTRUMENTS 2

OUTSIDE MICROMETER

The outside micrometer is one of the most commonly used precision measuring tools. With a little practice it will allow the mechanic to obtain consistent and accurate readings for measuring outside dimensions. Micrometers cover ranges in one inch increments. Micrometers are sized zero to 1 inch, 1 to 2 inches, 3 to 4 inches and so forth. Normally, micrometers range up to 24 inches but there are micrometers that will measure up to 60 inches. Most micrometers are capable of measuring in increments as small as one ten-thousandth of an inch.

PARTS OF THE MICROMETER

A typical micrometer consists of the following basic parts: The frame is the backbone of the micrometer. The anvil is attached to the frame and is the stationary reading surface. The spindle is the moveable reading surface that, along with the anvil, makes contact with the part being measured. On the barrel we find the reading line which shows divisions for measurements. The sleeve holds the spindle and has a beveled surface with increments for measurements. Many micrometers are equipped with a ratchet that allows a more precise adjustment for operators needing a finer “feel” when taking a measurement. The thimble is permanently attached to the spindle as a single assembly. Rotating the thimble also rotates the spindle, moving the assembly in and out in relation to the frame and anvil. After taking a measurement, the thumb lock can be used to lock the sleeve and spindle in place to prevent accidental movement while interpreting the reading.

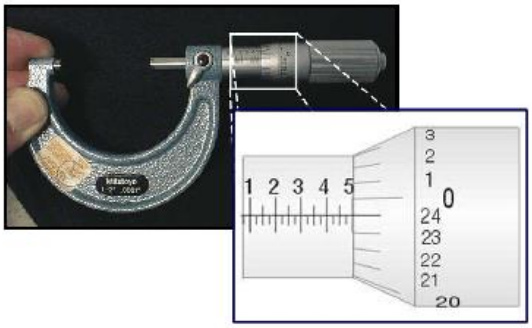


How to Read a Micrometer

Now that we know what the different parts are, and how they are used, all we need to know is how to read the measurements. This illustration shows a close-up of the barrel and thimble. To find the correct reading, we need to get 3 different measurements and add them together. After taking a reading on an object, look at the barrel and determine how many major divisions are showing. In this example there are 5 because the "5" mark is the greatest whole number exposed on the barrel. On this micrometer, each major division is equal to one tenth of an inch, or .100. Since 5 major divisions are showing, our first reading will be .500. Next, we need to check to see how many minor divisions are showing after the last whole number on the barrel. In this case there are 3 marks after the number "5". Each of these 3 marks represent .025 which will add up to .075. The third step is to read the thimble. Look for the mark that most closely lines up with the center line. The illustration shows two marks above the “10” making it "12". Each of these divisions in the thimble is equal to 1/1000 of an inch, or .001 Thus, our third reading is .012. To determine the actual dimension we have measured with the micrometer all that is left is to add the three readings together. In this case that would be: .500 + .075 + .012 = .587

Reading A 1 - 2” Micrometer

Micrometers are sized in 1 inch increments. The micrometer shown in this example has a range from 1 to 2 inches. This example means that it can measure dimensions ranging from 1 inch to 2 inches. When reading this micrometer, we know that the reading must be at least 1 inch or greater so we can assume our measurement will start at 1 inch. Looking at the illustration, notice that we’re not quite to the 5 so we read the 4 making the first digit to the right of the decimal a 4. There are 3 lines showing on the barrel, each with a value of .025. This adds up to .075. There is 24 showing on the thimble which, when added to the .075, adds up to 99 giving us a reading of 1.499



USING THE MICROMETER

The micrometer should be held as shown in the illustration. Hold the anvil against the work with one hand. Turn the spindle lightly with the other hand, rocking back and forth to ensure the that the highest point on the diameter is being measured. Do not force the reading. Tighter is not better. Always wipe the oil from your hands off the micrometer after use, as it will corrode the finish. Storing a micrometer with the spindle and anvil touching is not good practice, as it can result in electrolysis which, over time, may affect the accuracy of the instrument. Never run the micrometer back down by spinning the thimble, as this can cause damage to the precision threads.

INSIDE MICROMETER

Inside micrometers measure inside dimensions using the same principles as the outside micrometer. However, instead of using a different micrometer for every increment of one inch, the inside micrometer uses precision rods of different lengths to measure various internal diameters, typically from 2” to 12”. Measuring internal dimensions using an inside micrometer is more difficult than measuring outside dimensions. It is important to take a careful reading on the greatest internal dimension as a slight misalignment of the tool will cause an error in the reading. It is advisable to double or triple check your readings when measuring inside dimensions.

HOW TO USE AN INSIDE MICROMETER

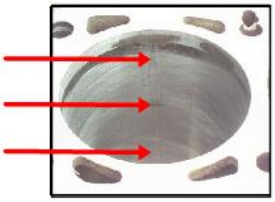
When using an inside micrometer it is a good idea to measure the inside dimension of the piece to be measured with a tape measure or machinist’s scale to get a rough idea of the size. After measuring with the tape or scale, the micrometer must be assembled for the correct size. For example, if the rough reading was 3 3/4” inches, the first step would be to choose the 3 - 4 inch rod from the micrometer case. Because the measurement is greater than 3 1/2”, the .500” spacer must be used. This spacer is used on all readings greater than 1/2” in the particular size range, because the thimble on the micrometer only has a 1/2” range or travel. Once the pieces have been selected, the micrometer must be assembled. The spacer should be slipped over the rod, and then the rod inserted into the micrometer head and the clamping screw tighten. On some instruments, there are match marks on the rod and the micrometer head for orienting their position.

TAKING A READING WITH AN INSIDE MICROMETER

After the micrometer has been assembled, it should be positioned in the object that is to be measured. One end of the micrometer should be held stationary against the side and then the other end must be gently rocked back and forth while the micrometer is gradually turned outwards. The micrometer should not be opened to the point that it binds in the object being measured. You should be able to rock back and forth to insure that the measurement is being taken at the largest point in the diameter, and that the micrometer is not misaligned.

MEASURING BORES

To ensure an accurate measurement when checking dimensions with an inside micrometer, it is essential that correct procedures are followed. When measuring a bore, measurements should be taken in three positions, 120 degrees out from each other in case the hole is out of round. In many cases more wear will occur on one side of a hole, especially in bushings for shafts, and taking only one reading will not indicate the true size of the bore. Additionally, readings should be taken close to each end and in the middle of the bore, so that any taper will be identified.



DEPTH MICROMETER

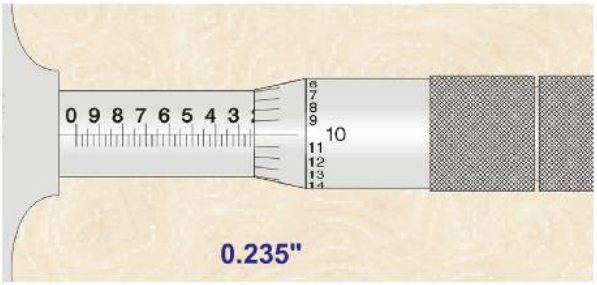
The depth micrometer is used for measuring the depth of holes, slots, keyways, and similar recessions. The depth micrometer consists of a ground tool steel base attached to a micrometer body. Interchangeable extension rods are used for taking measurements in excess of one inch increments as described in using the inside micrometer. The micrometer head has a one inch travel. The rods are inserted into the top of the head and protrude through a hole in the base. The micrometer head reads in the same fashion as the outside and inside micrometers, however, the depth micrometer reads in the opposite direction as the other micrometers we have discussed.

USING A DEPTH MICROMETER

In the photo you can see how a depth micrometer should be used. The base is held firmly on the piece to be measured. It is best to place two fingers on the top of the base. The thimble is then turned to advance the rod down towards the bottom of the slot. Turn the thimble with the tips of the fingers so that when the rod contacts the bottom you can feel it and stop. If you continue to turn the thimble the base will lift off the piece, so a very light touch is required.

READING A DEPTH MICROMETER

To read the depth micrometer, read the micrometer in the same manner as you would an outside micrometer, then add the micrometer reading to the rod length (including spacing collar, when installed) to obtain the total measurement. If the 0-1 inch rod is used, the reading will be less than 1 inch. If the 1 to 2 inch rod is used, the reading will be 1 inch to 2 inches. Using longer extension rods works in the same manner. On the micrometer head, the readings will be from right to left The other consideration is: one must read the lines which are covered rather than the lines which are uncovered. Remember, each line on the barrel represents .025 inches. In this example, the 2 is covered, telling us the reading will be greater than .200. The first marked increment after the 2 is covered telling us to add .025 to the reading, and the 10 line on the thimble is lined up on the reading line telling us to add .010, making the final reading 0.235 inches



NOTES

PRECISION MEASURING INSTRUMENTS 2 MODULE EXAM

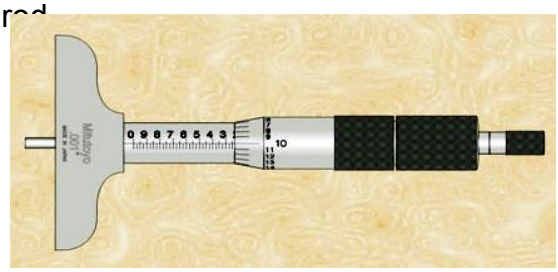
Online exam questions may appear in a different order than those shown below.

1. The inside micrometer below is equipped with a 2-3 inch rod and is being used by the mechanic to measure a bore. What is the reading?

A. 2.248
B. 2.325
C. 2.584
D. 2.230

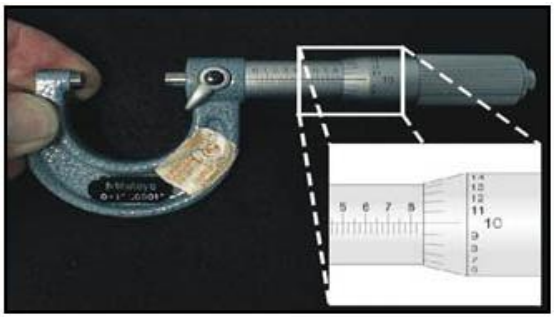
2. Read the depth micrometer depicted below and give the measurement. The rod in the mic is a 0-1" rod.

A. 3.135
B. 1.325
C. 0.325
D. 0.235



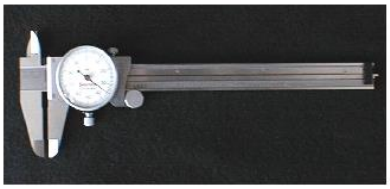
3. Read the outside micrometer depicted below and record the measurement.

A. 0.860
B. 8.010
C. 1.860
D. 8.100

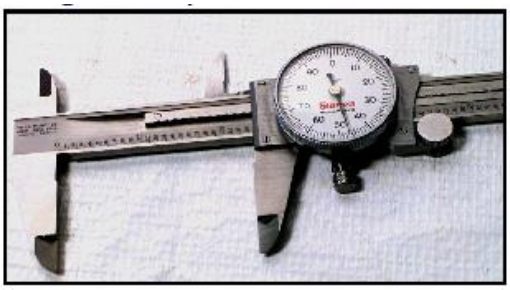


PRECISION MEASURING INSTRUMENTS 3

DIAL CALIPERS



A caliper is a device used to measure the distance between two symmetrically opposing sides. In this instrument, a small gear rack drives a pointer on a circular dial. Typically, the pointer rotates on the dial once every inch, allowing for a direct reading. Dial calipers are one of the most commonly used and frequently misused, of all the precision measuring instruments. When properly used, the dial caliper is capable of measuring outside diameters, inside diameters, and depths. As seen in the illustration, this type of dial caliper uses a dial which reads in thousandths of an inch or .001. The bar has major increments of 1 inch with minor increments of one-tenth of an inch or .100. The jaws of a dial caliper are opened and closed using a thumb wheel. The jaws of a dial caliper can usually be locked at a setting using a small lever or screw which allows simple “go - no go” checks of part sizes. When using dial calipers, the potential for errors in accuracy is greater than with the previous precision measuring tools we have discussed. If absolute accuracy is of high importance, then dial calipers may not be a suitable choice to take the measurement.

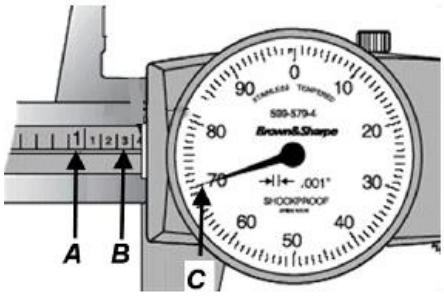


USING DIAL CALIPERS

A caliper must be properly applied against the part in order to take the desired measurement. For example, when measuring the thickness of a plate, a caliper must be held at right angles to the piece. Some practice may be needed to measure round or irregular objects correctly. Accuracy of measurement when using a caliper is highly dependent on the skill of the operator. When taking a measurement, close the jaws lightly, with pressure that is consistent from one reading to the next. As both part and caliper are always to some extent elastic the amount of force used affects the indication. A consistent firm touch is necessary. Too much force will result in an under indication as part and tool distorts; too little force gives insufficient contact resulting in an over indication. This is especially evident with digital calipers, calipers out of adjustment, or calipers with a poor quality beam.

READING DIAL CALIPERS

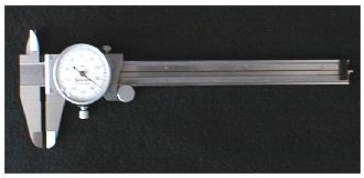
The use of the dial on this type of caliper makes for much easier reading. The measurement is obtained by adding the values shown on the bar and the dial. As seen in the illustration, add A plus B plus C, to obtain the correct measurement. In this case the measurement is 1.370 or one inch, three-hundred-seventy-thousandths.



	1.000	A
	.300	B
+	.070	C
=	1.370	

CARING FOR DIAL CALIPERS

It is important to properly care for the dial calipers. When not in use, calipers should always be stored in their case to protect the tool from damage and dirt. Don't let metal chips or dirt get in the gear rack. Debris in the gear rack may damage the caliper or affect its accuracy. It is a poor practice to store calipers with the jaws run together. Electrolysis may result, damaging the jaws. Wiping the caliper down after use is good practice to clean and prevent corrosion. Don't try to get a reading by using excessive force on the jaws. The consequence will be an inaccurate reading and possibly a damaged tool.



MECHANICAL CALIPERS

Mechanical calipers are normally used to measure the sizes and diameters of parts against a standard size or diameter or to compare a dimension on one part with the same dimension on another, similar part. The dimensions found using mechanical calipers are normally transferred to machinist's scales or micrometers, depending on the level of accuracy desired. There are three types of mechanical calipers. The illustration shows examples of inside calipers for measuring inside diameters, outside calipers for measuring outside diameters, and straight leg calipers for measuring the distance between two points.

USING MECHANICAL CALIPERS

To take a measurement with mechanical calipers first determine the type of caliper needed. In the illustration, a small bore is in need of measuring so “inside" calipers are selected. The caliper is pre-adjusted to a dimension slightly smaller than the bore size, inserted, and then opened with the thumbscrew until contact is felt against the sides of the bore. The “feel” is very important when using mechanical calipers. The calipers should be rocked back and forth to determine the largest diameter, and when placing them against the scale be sure that the legs are positioned evenly on the scale. Mechanical calipers have a spring built into them which works against the thumbscrew to position the legs. If opened too far against the walls of the bore, the legs will spring outwards when the calipers are removed, giving a false measurement. With some practice and a light touch, accurate measurements can be quickly and easily obtained with the mechanical caliper.

TELESCOPING GAUGES

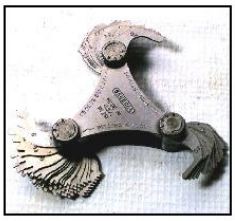
Telescoping gauges are used for finding internal dimensions in much the same way that inside mechanical calipers are used. The measurement taken with the telescoping gauge is read using a micrometer. Telescoping gauges are manufactured to measure in certain ranges such as 1/2” to 3/4”, 3/4” to 1 1/4”, 1 1/4” to 2 1/2” inches and so forth. The telescoping gauge consists of a handle which is attached to a fixed contact, inside of which a moveable plunger can be adjusted to fit a diameter within the range. There is a knurled knob on the end of the handle which locks the moveable plunger in position so that the reading may be accurately transferred to the micrometer.

USING THE TELESCOPING GAUGE

When using telescoping gauges, the correct size gauge should be selected. The gauge should be compressed to less than the inside diameter of the hole, and then locked. The gauge is inserted into the hole and holding the gage at a slight angle release the lock and allow the gauge’s telescoping rod to expand against the sides of the hole. Gently tighten the lock keeping the handle at a slight angle. Next, position the handle to the upright position (parallel to the sides of the hole) and carefully remove from the hole, ensuring the gauge’s lock is sufficiently tightened. Now, using an outside micrometer, the inside diameter of the hole can be determined.

THREAD GAUGE

The thread pitch gauge is used to measure the pitch or threads per inch of a screw thread. Typically, thread pitch ranges from 4 threads per inch to as many as 84 threads per inch. Metric thread pitch gauges are also available if working with metric threads or fasteners.



USING A THREADED PITCH GAUGE

To use a thread pitch gauge identify by eye the approximate size of the threads to be measured, and then select the gauge that will precisely engage the threads. The correct gauge will fit all the way across the threads. There will be no portion of the gauge which does not fit. If the gauge doesn't fit precisely, try the gauge directly adjacent to the one in use. If none of the gauges fit, the threads may be stretched, distorted, or possibly metric.

FEELER GAUGES

A feeler gauge is a precision tool in the form of a metal blade of precisely predetermined thickness and is used to measure the clearance between two parts. Typically feeler gauges are assembled in a set consisting of different blades graduated in thickness by increments of 0.001 inch and range from .0015 to .025. To measure clearances larger than .025 a combinations of blades may be used. The condition of the feeler gauge's blades and the accuracy of readings can be affected by corrosion, dirt, grease, and abuse therefore the blades should be kept clean, dry, and wiped down after use.

USING FEELER GAUGES

When preparing to check a clearance with a feeler gauge, first insure that the blade is free of oil, dirt, rust, or other forms of contamination. When using a feeler gauge, select a blade based on an estimation of the clearance to be measured and carefully try to engage the blade in the opening. If the blade fits easily, the next larger size should be tried. If the next larger size fits, without excessive force, the next larger size should be tried. Repeat this process until a blade fails to fit and then go back to the previous blade. Do not force blades. This may damage the blade, the piece being measured, or give an inaccurate reading. If a measurement requires the use of several specific feeler blades, and they are not assembled next to each other in the pack, they should be removed from the feeler gauge assembly so that they can be carefully stacked together without damaging the tool or causing an inaccurate reading.

USING FEELER GAUGES (CONT')

When multiple blades are used together, the thickness of the group will have to calculated or the selected blades may be measured with a micrometer. For example, if a measurement of .040 is needed use the .015 blade and the .025 blade for a total thickness of .040.

DIAL INDICATORS

A dial indicator is a precision instrument used to accurately measure a clearance or small distance. The reading is displayed on a dial. Dial indicators are typically used to check the variation in tolerance during the inspection process of a machined part as well as many other situations where a small measurement needs to be registered or indicated. Examples of dial indicator use may be detecting shaft run-out or end play, determining liner fit in engine blocks, checking motor and gear box installations, gear backlash, and many other similar uses associated with crane mechanical repair. Dial indicators are manufactured with the same precision as a fine watch. Increments are usually in thousandths, but can be as small as 50 millionths of an inch. Travel range can be from .003" to 12", but normal travel ranges are 1/4", 1/2" and 1". Dial indicators may be fitted with a variety of tips for special applications and are normally used with a stand allowing the operator to position them in correct orientation to take the reading.

USING A DIAL INDICATOR

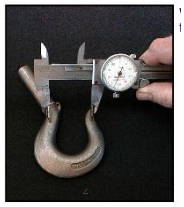
Since dial indicators are constructed much like watches, they should be handled with the same care as a fine watch. They should never be dropped or exposed to the elements. The sliding rod should be kept clean to prevent contamination from entering the inside of the dial. When positioning the dial indicator, be sure that the movement of the rod will be in line with the piece to be measured. Positioning the dial indicator at an angle to the piece will result in an inaccurate reading. Never snap the rod in and out, as this is very hard on the mechanism.

TRAMMEL POINTS

Trammel points utilized in crane applications are most commonly used for measuring the spread of hook throats when doing annual inspections on cranes. Although the trammels in the photo are constructed from calipers, many trammels have no measuring increments, and readings are normally transferred to a machinist's scale to obtain a measurement. The advantage of using a trammel instead of a straight leg mechanical caliper or dividers is that when a trammel is used, the points remain perpendicular to the work resulting in a more accurate measurement.

USING A TRAMMEL

When using the trammel, the same precautions should be employed as when using straight leg mechanical calipers or dividers. In the case of taking hook measurements, ensure that the points of the trammel are centered in the punch marks on the hook. Center the points in the same manner on the lines of the scale to find the measurement.



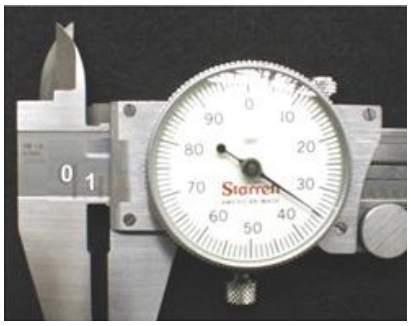
NOTES

PRECISION MEASURING INSTRUMENTS 3 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. Read the dial caliper in the picture below and give the measurement.

A. 1.045
B. 0.350
C. 1.035
D. 0.135

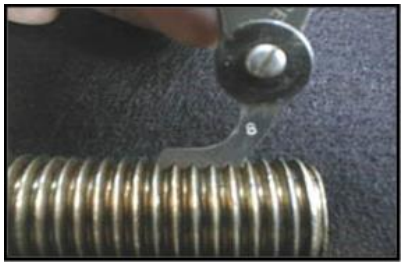


2. What must be considered when using a telescoping gauge to measure bores?

A. the correct size gauge for the bore must be selected
B. gauge should be placed in the bore at a slight angle
C. sufficiently lock gauge before removing from bore
D. all listed answers

3. What is the reading indicated by the picture below?

A. 4 threads per inch
B. none of the listed answers
C. 8 threads per inch
D. incorrect gauge for this bolt



FASTENERS 1

THE IMPORTANCE OF FASTENERS

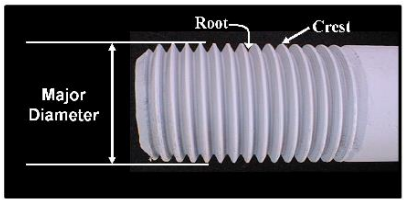
Fasteners play a very important role in crane construction and maintenance. The purpose of any mechanical joint is to connect two or more parts of a product or system. In most mechanical joints, the piece that fastens the parts together is the bolt. The function of the bolt is to hold the parts together by force. The behavior and life of that joint depends more on the correct clamping force than on any other design factors. Knowing how to select the proper grades, the correct size, and properly install fasteners can make the difference between a job that is sound and reliable, and one that is destined to failure.

FASTENER TERMINOLOGY

To better understand the function of fasteners, it is important to have a working knowledge of screw threads and pitch.

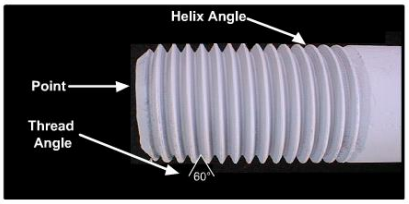
FASTENER TERMINOLOGY: THREADS (1)

A thread is a continuous helical ridge formed on the outside of a bolt or on the inside in the case of a nut. The top, or peak, of the helical ridge is called the crest. Between each crest is a space called the root. The major diameter is the distance from the top or crest of the thread across to the crest on the opposite side.



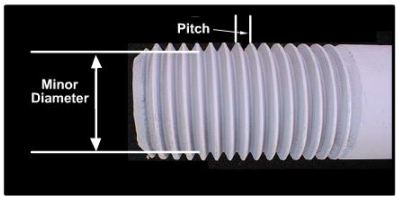
FASTENER TERMINOLOGY: THREADS (2)

Threads are set at an angle to the axis of the bolt or nut. This slope is called the helix angle or flank. The angle must be sloped, either upward to the right (for right-hand threaded screws) or upward to the left (for left-hand threaded screws). The thread forms a "V" shape between crests. The angle of this "V" is called the thread angle, and is determined by fastener engineers. The point is the chamfer on the threaded end of the bolt which permits easier starting of the thread.



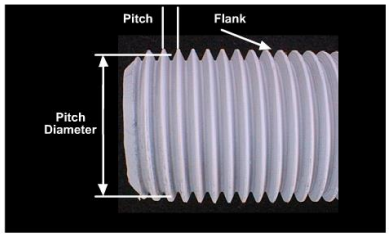
FASTENER TERMINOLOGY: THREADS (3)

The distance from the bottom or root of the thread to the root on the opposite side is called the minor diameter. Thread pitch is the distance from the crest of one thread to another crest measured along the length of the thread. Thread pitch is best measured using a thread pitch gauge.



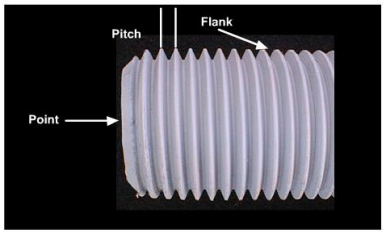
FASTENER TERMINOLOGY: PITCH (1)

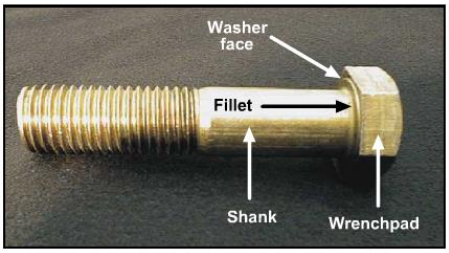
Another critical aspect of thread fit and interchangeability is call "pitch diameter". The pitch diameter is the diameter of the thread at a point where the width across the thread and the width across the groove between threads, are equal. The flank is the side of the thread.



FASTENER TERMINOLOGY: PITCH (2)

The pitch is the distance between the threads. The point is the chamfer on the threaded end of the bolt which permits easier starting of the thread.





FASTENER TERMINOLOGY: WASHER FACE

The flat face under the head of the bolt is called the washer face. The washer face is machined into the bolt to prevent the hex head from rubbing against the surface of the part being fastened. The shank is the unthreaded portion of the bolt. The fillet is the small radius where the shank of the bolt meets the washer face. The wrench pad is the flat surface on the bolt head that a wrench fits on.

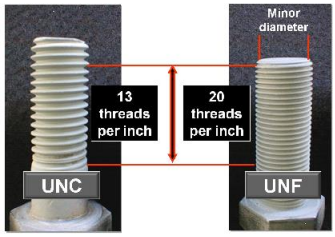
BOLTS

A threaded fastener may be referred to as a bolt or a screw depending on how it is used. Bolts utilize a nut to apply the clamping force. It can be any fastener shape or size as long as it's used with a nut.

SCREWS

A screw is a threaded fastener that does not utilize a nut for clamping force. Threaded fasteners that screw into a threaded component are labeled screws including self tapping fasteners.

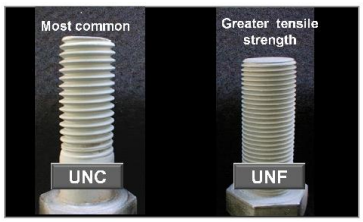
COARSE THREAD AND FINE THREAD



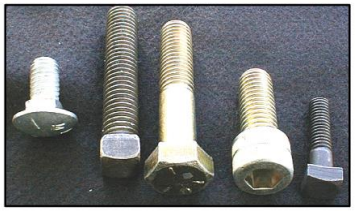
The Unified Thread Standard defines a standard thread form and series along with allowances, tolerances, and designations for screw threads commonly used in the United States and Canada. The Unified Thread Standard is currently controlled by ANSI or American National Standards Institute in the United States. The image labeled “UNC” is an example of a ½ inch course threaded bolt. The image to the right, labeled “UNF” is an example of a ½ inch fine threaded bolt. Fine threaded bolts will have more threads per inch and larger minor diameters. UNC stands for Unified National Course and UNF stands for Unified National Fine. Both UNC and UNF refer to the Unified Screw Thread Standard Series.

COARSE THREAD AND FINE THREAD (CONT.)

Coarse threaded fasteners are the most commonly used in industrial applications. They allow rapid assembly, tolerate minor damage, and have good corrosion resistance. Fine threaded fasteners have a greater tensile strength than coarse threads. They are used in applications when stripping of the thread is more of a concern than bolt breakage. For example, a course threaded steel fastener, tightened into a cast iron component may strip the internal threads before it breaks. A fastener with fine threads allows the necessary torque without stripping. Fine threads are also used when the surrounding wall thickness will not allow a course thread to be cut. Another benefit of fine threads is that they allow finer regulation when used as an adjusting mechanism.



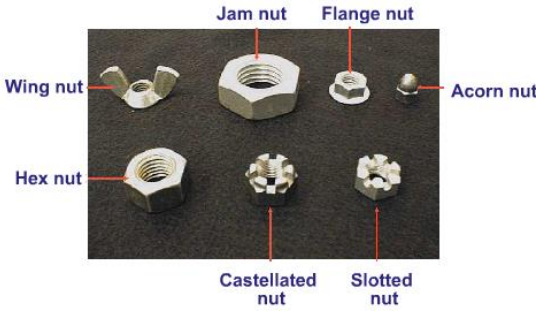
FASTENER IDENTIFICATION: BOLTS

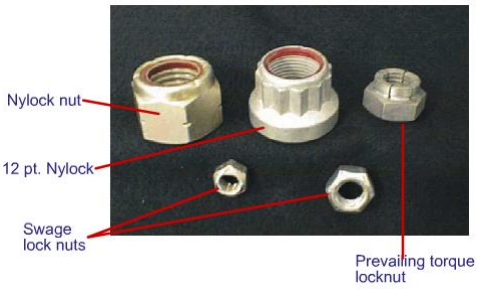


Bolts come with several different head configurations. Carriage bolts are designed with a square portion formed into the upper part of the shank which prevents unwanted rotation by either fitting into a square hole or biting into soft material. Jacking bolts have a square head about the size of the shank, and are typically used in machinery foundation assemblies to aid in alignment and adjustment of the machinery. Hex head bolts are the most common type of bolt. As the name implies, the head of this fastener has six sides to accommodate standard 6 and 12 point sockets and wrenches. Socket head or Allen head bolts have an internal hex designed to fit an Allen wrench or hex socket. Square head machine bolts were the industry standard prior to hex bolts gaining prominence.

FASTENER IDENTIFICATION: NUTS

Nuts are used in conjunction with bolts to make up a bolted joint. The standard hex nut is six-sided and comes in a variety of grades to match the bolt to which it will be fastened. Other types of nuts include: wing nuts, which have ears built into the sides of the nut which are used for installation and removal by hand. They should only be used in applications where quick removal and installation is the prime consideration. Jam nuts, which are used for locking a threaded part in position, such as a linkage or turnbuckle; flange nuts, which have a built-in washer face; acorn and cap nuts, which have a rounded head in which the bolt does not protrude through; slotted and castellated nuts which are designed to be locked in position by use of a cotter pin. Castellated nuts have the slot cut through a raised portion above the hex.





SELF-LOCKING NUTS

Self-locking nuts are designed not to loosen under vibration by using a locking feature within the nut. The most common types are prevailing-torque and nylon insert lock nuts. Prevailing-torque lock nuts have a section above the hex which is slit in several places and bent inwards. When the nut is installed the sectors between the splits are forced outward and grip the threads of the bolt. Swedge lock nuts are another type of prevailing torque lock nut which have a slightly raised portion that is distorted inward in

the manufacturing process. Nylon insert nuts, known as “Nylock” nuts, have a nylon insert above the threads. When the bolt is screwed into this nut, it is forced through the nylon insert, which prevents unwanted loosening from vibration. With repeated applications, the gripping force of the nylon insert will diminish and the nut should not be re-used. Twelve-point nuts are used in applications requiring high torque specifications. This type of nut must be tightened using a 12 point socket or box end wrench.

How to Size a Bolt

How to Size a Bolt: Step 1

It is important to know how to size a bolt. The first step in correctly sizing a bolt is to measure the bolt diameter. Generally, the measured major diameter of the threads will be slightly less than the nominal size of the bolt. For example, the measured size of a 3/4” diameter bolt might be .740.

How to Size a Bolt: Step 2

The next step in sizing a bolt is to determine the thread pitch. Use a thread pitch gauge to determine the thread pitch. If no thread pitch gauge is available, you may use a machinist's scale and count the number of threads in a one inch length.

How to Size a Bolt: Step 3

The final step is to measure the length of the bolt. For hex head and carriage bolts the measurement is made from under the bolt head to the end of the bolt.

How to Size a Bolt: Step 4

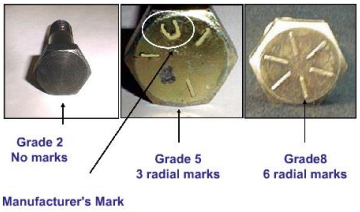
Sizing a nut is accomplished somewhat differently. Measure the inside diameter of the nut, this will correspond approximately with the minor diameter of the thread size, or with the tap drill size if using a chart.

How to Size a Bolt: Step 5

The final step is determining the threads per inch using a thread pitch gauge.

IDENTIFYING BOLT GRADES

In addition to the identification of bolts by size and pitch, bolts are also identified by grade or hardness. The SAE or Society of Automotive Engineers has developed a classification system for bolts and nuts based on their material, heat treatment and tensile strength. The bolts in these classification groups may be readily identified by the markings on the bolt heads. Typically, the markings will show the grade of the bolt and the manufacturer. As shown in the illustration, grade 1 or 2 bolts have no markings. Grade 5 bolts will have 3 radial marks and the grade 8 bolts will have 6 radial marks. Every legitimate manufacturer of bolts in the United States of America has an individual letter or mark which identifies their products. Notice that the 2 and 8 bolts, shown in the illustration, do not have a manufacturer's mark. These should be considered a suspect or counterfeit bolts.



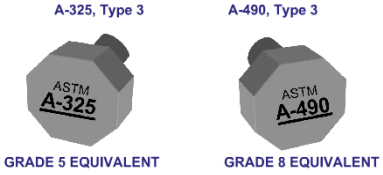
GRADE MARKINGS

Here is a chart showing standard SAE bolt head markings. These are the common grade markings for SAE standard grades. Most manufacturers use at least grade 5 bolts in their machinery. Some engine manufacturers, such as Caterpillar, use all grade 8 fasteners.

Head Marking	Grade and Material	Nominal Size Range (inches)	Mechanical Properties		
			Proof Load (psi)	Min. Yield Strength (psi)	Min. Tensile Strength (psi)
US Bolts					
 No Markings	**Grade 2** Low or medium carbon steel	1/4 thru 3/4	55,000	57,000	74,000
		Over 3/4 thru 1-1/2	33,000	36,000	60,000
 3 Radial Lines	**Grade 5** Medium Carbon Steel, Quenched and Tempered	1/4 thru 1	85,000	92,000	120,000
		Over 1 thru 1-1/2	74,000	81,000	105,000
 6 Radial Lines	**Grade 8** Medium Carbon Alloy Steel, Quenched and Tempered	1/4 thru 1-1/2	120,000	130,000	150,000

STRUCTURAL BOLTS

Bolts used for structural applications are graded in much the same way that machinery bolts are graded. The two predominant grades for structural fasteners are the ASTM A-325 bolt, which is the equivalent of the SAE grade 5 and the ASTM A-490, which is the equivalent of the SAE grade 8. Additionally, each of these grades is divided into type 1 and type 3. The type 3 bolts are best suited for applications where the fasteners will be exposed to the weather. The type threes in both grades are denoted by a line under the grade marking.

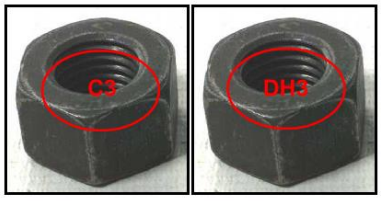


GRADE MARKINGS: NUTS

Nuts have grade markings. The grade of the nut must match the grade of the bolt because the tightening specifications will be higher for a higher grade and a lesser grade nut might strip. Grade 5 nuts may have 3 radial marks on the washer face or three dots. Some have one row of notches cut on the edges of the hex. Grade 8 nuts have 6 radial marks on the washer face, or 6 dots, or 2 rows of notches on the edges of the hex. When using nylon locking nuts, be careful not to assume that they are grade 8 because of the 6 crimp marks near the insert. Nylon locking nuts will have notches cut in the hex to denote grade 5 or 8.

STRUCTURAL NUTS

Structural nuts are made to specifications of the ASTM. Nuts for A325 Type 3 bolts will be marked with C3. Nuts for A490 Type 3 bolts will be a DH3. In most applications you may use A490 DH3 nuts with A325 bolts. Remember to always use a hardened washer behind the rotating surface when tightening.



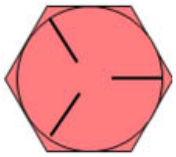
NOTES

FASTENERS 1 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

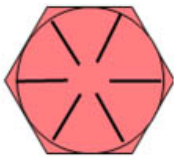
1. Identify the grade of this fastener by the marking;

A. grade 1 or 2
B. grade 3
C. grade 5
D. grade 6
E. grade 8



2. Identify the grade of this fastener by the marking:

A. grade 1 or 2
B. grade 3
C. grade 5
D. grade 6
E. grade 8



3. You measure a bolt. The outside diameter measures 0.870". The thread pitch measures 14. What is the size of the bolt?

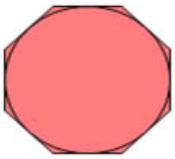
A. 1/2 - 14
B. 15/16 -14
C. 3/4 - 14
D. 7/8 - 14

4. You measure a nut. The outside diameter measures 0.656". The pitch gauge reads 10. What is the size of the nut?

A. 3/4 - 10
B. grade 8
C. 1/2 - 10
D. 10 MM

5. Identify the grade of this fastener by the marking;

A. grade 1 or 2
B. grade 3
C. grade 5
D. grade 6
E. grade 8



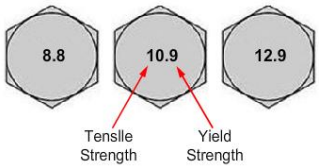
6. You measure a bolt. The outside diameter measures 0.495". The thread pitch measures 13. What is the size of the bolt?

A. 1/2 - 13
B. 5/8 -13
C. 1/4 - 20
D. 3/4 - 13

FASTENERS 2

METRIC FASTENERS

Many components used on cranes are manufactured internationally and often contain metric fasteners. It is important to be able to identify metric fasteners, because if they are mixed with SAE fasteners, thread damage to one or both fasteners will result. The quickest way to identify metric fasteners is by the head markings. They differ significantly from the markings on SAE standard bolts and nuts.



METRIC GRADE MARKINGS

Some common standard metric bolt grades are 8.8, 10.9, and 12.9. These are called strength designation numbers. The number preceding the decimal denotes the tensile strength. The number after the decimal signifies the yield strength.

METRIC VS. SAE THREADS

Metric threads use the same thread profile as SAE threads. The major difference is with metric threads, the thread pitch or distance between consecutive threads, is given instead of threads per inch. Where the strength of SAE bolts is identified as “grade”, the metric threads use the term “property class”.

SIZING METRIC THREADS

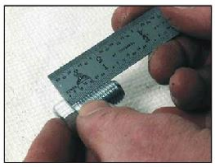
SIZING METRIC THREADS: STEP 2

The first step in sizing a metric bolt is to measure the diameter. This can be done with a metric micrometer or scale, but an English system micrometer or scale may be used along with a conversion chart.

SIZING METRIC THREADS: STEP 2

The next step in sizing metric threads is to use a metric thread pitch gauge to determine the pitch. The pitch will be a number like 1.0,1.5, 2.0, 2.5 and so forth. Unlike the inch system, which has a different pitch for each size, the metric system may share the same pitch for several sizes.

SIZING METRIC THREADS: STEP 3



The length is measured in the same fashion as an inch system thread, from the end of the bolt to the underside of the hex head. The measurement can be made with a metric scale, or an inch scale and then converted to a metric equivalent.

METRIC THREAD NOTATION

The digit following the 'M' is the nominal thread diameter in millimeters. The final expression for a metric bolt would be M12 - 1.75 x 25. The M12 is the diameter, 12 millimeters. The 1.75 is the pitch, it is 1.75 millimeters between the threads. The length is 25 millimeters.

M12 - 1.75 x 25

M12 = Diameter - 1.75 = Pitch - 25 = Length

LOCKWASHERS

A lockwasher is a solid or split washer that is placed underneath a nut or cap screw to help prevent it from loosening. The split lock washer is manufactured from spring steel. It has a split in the washer and the ends are bent up. When the washer is in place the ends or “tangs” bite into the part being clamped. The bolt or nut under which the washer is placed should only be tightened enough to flatten the washer. The high collar lock washer is used in places where a tight fit exists around the shank of the bolt. The outside diameter is smaller than the regular split lockwasher of the same nominal size. External star lockwashers utilize teeth that are located on the outside of the ring, giving them more surface area to provide a better connection with large fastener heads. Internal star lockwashers have the teeth on the internal diameter of the washer and ensure a good connection with small fastener heads. Lockwasher are not used on structural connections and connections where bolts are torqued. All lockwashers are sized by the nominal dimension of their internal diameter.

REASONS NOT TO USE LOCKWASHERS

There are situations where it is not advisable to use lockwashers. In some cases, the torque required to properly tighten a fastener will destroy the lockwasher in the process. It should be noted that the term “lock” as it appears in the word “lockwasher” is a generic term historically associated with their identification and is not intended to imply a permanent or absolute fixed attachment where they are used. Helical spring lock washers should be used only as anti-vibration retention when the spring tangs are not completely compressed.

FLAT WASHERS

The use of a flat washer under the head of a bolt or nut helps distribute the forces applied when tightening. Flat washers are sized by their inside diameter which will correspond nominally with the bolt size they are meant to fit. There will generally be about 1/32” clearance built into the washer. In addition to spreading the load of the bolt over a larger surface, flat washers protect the surface from damage when tightening a fastener. Washers are now graded according to size and according to outside diameter. The two common classifications for outside diameter are the SAE and USS sizes, with USS being the larger of the two. When using flat washers always ensure that the washers are graded for use with the fasteners. Do not use inferior grade washers with higher graded fasteners.

TAB WASHERS

Tab washers are used for locking purposes. A common application would be to lock a bearing retaining nut into a certain position in order to maintain a specific pre-load on a bearing. Many tab washers have multiple tabs so that they may be reused, however, if the washer has only one set of tabs, after it has been bent over once and straightened out, it should not be reused.

SCREWS

Screws for machinery applications may be divided up into three basic groups machine screws, tapping screws, and set screws. The machine screws use standard SAE thread sizes, but their heads come in different styles for a variety of different applications. Among these styles are round head, flat head, truss head, oval head, fillister head, clutch head, pan head, and hex slot head. The tapping screws have a thread that cuts into the material being threaded, usually sheet metal, and forms its own thread as it is being turned. These may also be referred to as thread-forming or sheet metal screws. Set screws are generally used to hold a collar, pulley, or gear in place. They may have a head, but most have a hexed recess for an Allen wrench. The ends of the screw may be flat, pointed, cupped, half or full dog, for fitting into a drilled recess.

SCREWS

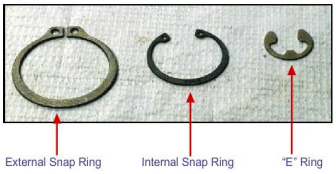
The socket head screw is tightened or loosened using an Allen wrench or hex key. The round head screw may have either a straight slot or a Phillips style slot. The countersunk head screw is designed to be flush with the material it is screwed into. The fillister head can be used with a counter-bored hole or with flat surfaces.

PINS

Let's look at some locking devices associated with the fasteners we've covered up to this point. Pins are locking devices typically used to secure other fasteners. There are several types of pins in common use for locking and positioning parts. Cotter pins are used to retain clevis pins, to keeps nuts from loosening, and other applications where ease of disassembly is a consideration. They are sized both by their diameter and their length. Taper pins are designed to fit in a hole which has been reamed with a special tapered reamer. They are removed by tapping them in the opposite direction from which they were installed. Split pins, spring pins, or roll pins - are made from rolled spring steel. When the pin is installed it is compressed due to the hole being smaller than the pin. This compression keeps the pin in the hole. Straight pins - are usually used in conjunction with a clevis. They are normally drilled on one end for a cotter pin.

SNAP RINGS

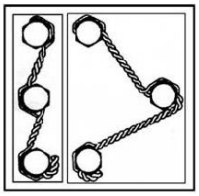
There are three basic types of retaining rings, commonly referred to as snap rings. Tapered external snap rings are applied with special pliers, which expand the ring over a shaft and then allow it to seat into a machined groove in the shaft. Tapered internal snap rings are applied with special pliers which compresses the ring for placement into a bore or housing, then allow it to expand and seat into a groove machined in the bore.



Reduced cross-section external E-rings, contain three prongs connected by a reduced section bridge to provide greater resilience during installation. They are installed radically, usually by means of an applicator, and provide a high shoulder for abutment by a retained part. Snap rings are normally identified according to a size chart.

LOCK WIRE

Lock wire, also known as safety wire, is a common method used to prevent unintentional loosening of fasteners due to vibration or other forces. This function is often referred to as positive locking. It also allows rapid and easy visual inspection of fasteners to ensure that they have been tightened. There are several different ways to apply lock wire. The publication, Mil-Std-763, Locking Devices, gives tips and techniques for running lock wire. The main concern when running lock wire is to insure that the lock wire tightens if the fastener loosens. Lock wire comes in a variety of sizes and materials depending on specific use requirements.



ANAEROBIC THREAD SEALANTS

Anaerobic thread sealants are an effective method for preventing threaded fasteners from backing off. Manufacturer's instructions for the sealers should be read and followed. Thread sealants must be applied with care to clean, primed threads. The solution should start about one thread back from the end of the bolt and should not be applied too heavily. Different compounds and strengths are manufactured for different applications. Be certain that the correct grade is used for the application. The compounds have a cure time that must be observed in order to achieve proper locking of the fastener.

NOTES

FASTENERS 2 MODULE EXAM

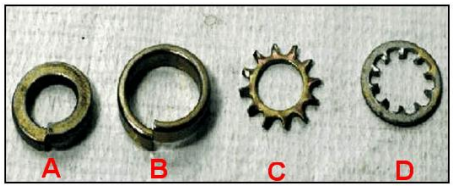
Online exam questions may appear in a different order than those shown below.

1. You measure a metric bolt. The outside diameter measures 0.390". The thread gauge reads 1.5. What is the thread size?

A. M10
B. 1.5
C. 0.398

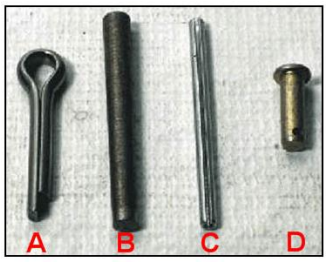
2. Which of the washers shown is a split lock washer?

A.
B.
C.
D.



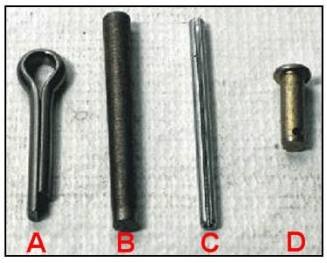
3. Which of the pin types shown is a split pin?

A.
B.
C.
D.



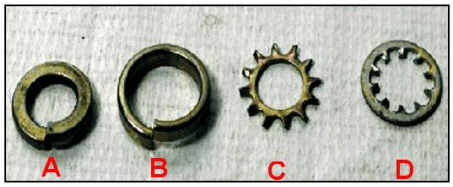
4. Which of the pin types shown is a taper pin?

A.
B.
C.
D.



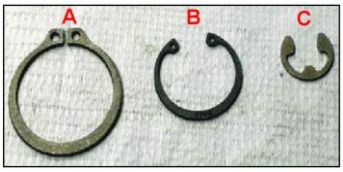
5. Which of the washers shown is an external star lock washer?

A.
B.
C.
D.



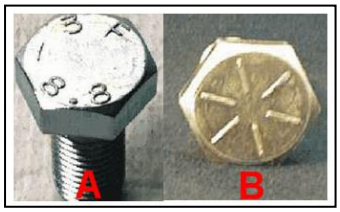
6. Which of the snap rings below would be used in a groove cut in a bore?

A.
B.
C.



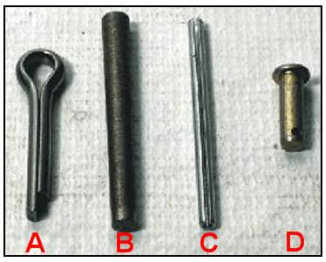
7. Which of the two bolts is a metric bolt?

A.
B.



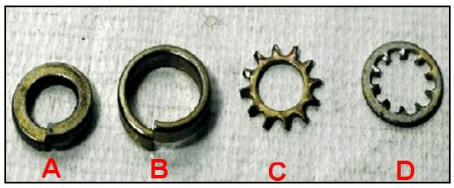
8. Which of the pin types shown is a cotter pin?

A.
B.
C.
D.



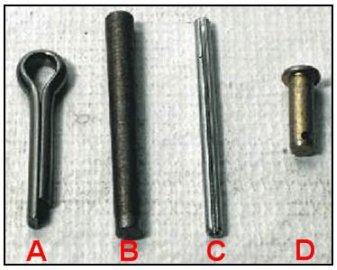
9. Which of the washers shown is an internal star lock washer?

A.
B.
C.
D.



10. Which of the pin types shown is a straight pin?

A.
B.
C.
D.

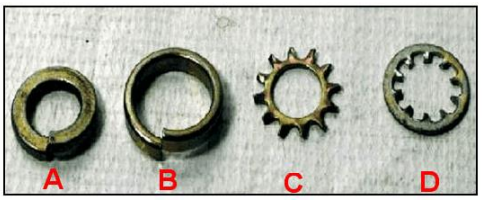


11. You measure a metric bolt. The outside diameter measures 0.468". The thread gauge reads 1.25. What is the thread size?

A. 1.25
B. 0.468
C. M12

12. Which of the washers shown is a high collar lock washer?

A.
B.
C.
D.



13. What distinguishes a bolt as metric?

A. bolt head markings
B. grade
C. diameter
D. thread pitch

FASTENERS 3

COUNTERFEIT FASTENERS

Counterfeit fasteners are fasteners marked to indicate that they meet certain specifications but are actually made of inferior materials. The Fastener Quality Act, or Public Law 101-592, has been passed by the United States Congress and is law. This far-reaching piece of legislation is intended to eliminate counterfeit fasteners from the marketplace. Counterfeit fasteners are fasteners made from something other than what is indicated by the head mark and will not perform to the strength level indicated. The law requires that certain fasteners, mainly threaded fasteners which are grade marked or quenched and tempered, be inspected and tested in an accredited laboratory, certified by their manufacturer to conform to stated standards, and delivered in packaging that is marked with the lot number. Any use of counterfeit fasteners that may be found or suspected, should be immediately brought to the attention of inspection personnel and reported to Navy Crane Center.

IDENTIFYING COUNTERFEIT FASTENERS - MARKINGS

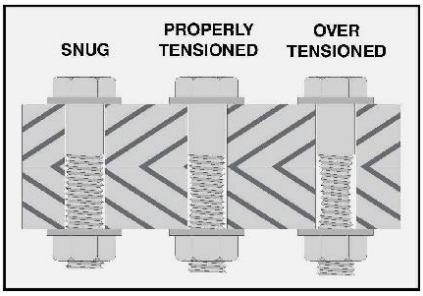
One way to identify a counterfeit fastener is by the markings on the top of the bolt head. Legitimate manufacturers all place a symbol or letter on the heads of the bolts they manufacture to identify their product. Bolts without these identifying marks should be immediately suspect. Lists are available showing the head markings of fasteners which have proved to be counterfeit. For information on the Fastener Quality Act, registered head markings or a list of counterfeit head markings, visit the web sites shown.

IDENTIFYING COUNTERFEIT FASTENERS: WHAT TO DO:

If you think you have identified a counterfeit fastener on a crane, here are some steps to follow. If your facility has a procedure in place for dealing with counterfeit fasteners follow that procedure first. Compare the suspected fastener to others on the crane. If all the others are from the same manufacture, this may be reason to investigate further. Report your finding to the facility's inspection personnel. This is a problem which should be documented in the crane’s history file. There may be more than one crane with the problem. Contact the Navy Crane Center. A problem such as this one may affect many cranes within the system. Additionally, the Navy Crane Center has the engineering staff to thoroughly research and analyze the problem and send out Crane Safety Advisories to other installations, if necessary.

FASTENER CRITERIA

When installing fasteners on cranes, there are several things to consider to assure the proper fastener has been selected. When working on cranes, you will be typically using two types of fasteners. Machinery applications such as engines and gear boxes use fasteners which conform to the standards of the Society of Automotive Engineers or "SAE". Fasteners which are used for structural applications such as bridge or jib construction will conform to American Society of Testing Materials or "ASTM" standards for structural fasteners. Any fasteners used on a crane should be a direct replacement as to material, size, and grade. Replacing a bolt with one of a higher grade is still considered a crane alteration. All fasteners should be inspected for damage before being replaced on a crane. Fasteners with threads that have dings, tears, missing or damaged areas should be replaced with an identical, new fastener.



HOW A FASTENER WORKS

Here's how a fastener works. When a fastener is properly tensioned, it stretches and applies a clamping force to the materials between its clamping faces. The bolt works on the same principle as a rubber band. When the rubber band is stretched over a roll of papers, the elastic force of the rubber band holds the papers tightly together. A bolt works in much the same fashion. When it is properly tensioned, the stretch of the bolt holds the material between it in place. If it isn't tight enough, the materials may slip, and if it is tightened too much the weakened bolt may break or yield. Proper tightening is critical step in the assembly process.

MACHINERY BOLT TIGHTENING

Most machinery bolts are tightened to specific torque requirements. Generally, the service manual for a piece of equipment will have torque specifications for particular component, and a general torque chart for different size fasteners of a certain grade. Some charts will specify whether the bolts are to be lubricated or not. Damage to the fasteners can result from using a chart meant for dry fasteners when tightening a fastener which has been lubricated.

TORQUING HINTS

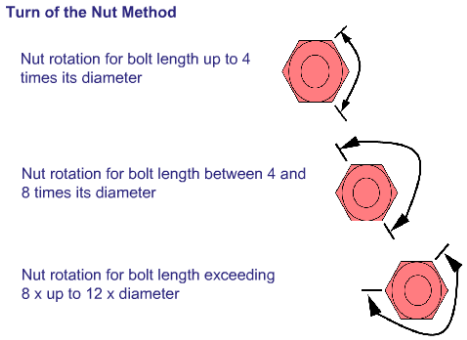
When using a torque wrench, the following techniques should be employed. Pull smoothly and evenly. If pulling on the wrench in an erratic or jerky manner, the reading will be inaccurate. Tighten all nuts until contact is made. Alternately tighten opposing nuts in at least three even increments. If there is a particular sequence specified in the manual, then that sequence should be followed. If there is no sequence specified, working from the inside to the outside and alternating back and forth from one side to another, will insure that the component is evenly tightened. To assure even tightening, fasteners should be torqued in steps, starting with a fraction of the required total torque, for example, 1/4, 1/2, 3/4, and then the final torque. Torquing in this fashion will tighten the piece evenly. Upon reaching the required torque, recheck the entire assembly again. A final torque check of all fasteners should always be made. Watch for yielding. If the torque reading stops increasing as the fastener continues to be tightened, the fastener has yielded and the assembly should be disassembled and checked for damage.

STRUCTURAL BOLT TIGHTENING

Fasteners used in structural applications should be structural type fasteners of the kind specified by the ASTM. These fasteners should be tightened by the turn of the nut method (although torquing may be used if a procedure is developed.) All bolts should be first brought to a snug-tight condition. Snug tight is when bolted members are in firm contact. Fasteners can be tightened using the following guidelines.

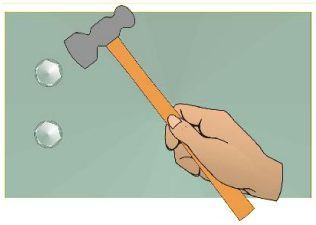
TURN OF THE NUT METHOD

When tightening structural fasteners, where torque specifications are not specified, the “turn of the nut” method is used. For fasteners where the length is up to four times the diameter of the bolt, the nut should be turned two flats from a snug tight condition. For fasteners where the length is between 4 and 8 times its diameter, the nut should be turned 3 flats from snug tight. For fasteners where the length is greater than 8 times the diameter, up to 12 times the diameter, the nut should be turned 4 flats from snug tight.



CHECKING STRUCTURAL BOLTS FOR TIGHTNESS

To check for indications of structural fastener tightness or looseness, sound the bolt. A tight bolt will emit a clear, sharp tone when hit with a small ball-peen hammer. A loose bolt, on the other hand, will emit a duller, less clear tone. The practiced ear can easily tell the difference. Report indications of structural fastener looseness to supervision, engineering, and/or QA personnel, as applicable, for evaluation. Replacement fasteners may be required. Always use authorized tensioning methods when tightening structural fasteners.



REUSE OF STRUCTURAL BOLTS OR HARDWARE

When reusing structural fasteners and hardware, you must research and follow industry or manufacturer's recommendations. In many cases the material is designed for one-time use as failure may result from re-use.

NOTES

FASTENERS 3 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. What should a mechanic do when a counterfeit fastener or suspect fastener is identified?

A. compare it to other bolts on the crane
B. contact Navy Crane Center
C. inform inspection personnel or supervisor
D. all listed answers

2. Which method should be used to tighten an A-325 bolt?

A. torque wrench
B. turn of the nut

3. Which type of fastener would be used on t hoist gear box?

A. structural
B. machinery

4. Which method should be used to tighten an A-490 bolt?

A. torque wrench
B. turn of the nut

5. If a fastener yields when it is being tightened, that may be a sign that it is counterfeit.

A. True
B. False

6. How can you tell that this may be a counterfeit fastener?

A. missing torque marking
B. grade designation missing
C. no manufacturer's mark on the head

7. Which type of fastener would be used on a bridge crane bridge?

A. structural
B. machinery

8. Which method should be used to tighten a grade 8 bolt?

A. torque wrench
B. turn of the nut

9. Which type of fastener would be used on a diesel engine?

A. structural
B. machinery

10. Which method should be used to tighten a grade 5 bolt?

A. torque wrench
B. turn of the nut

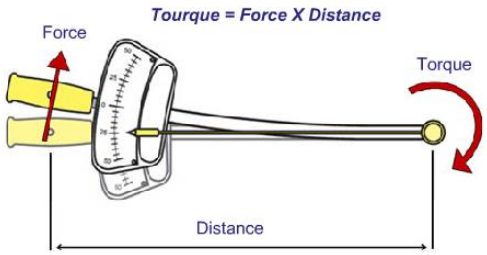
11. Which type of fastener would be used on a jib crane jib?

A. structural
B. machinery

FASTENERS 4

WHAT IS TORQUE?

The term “torque” as applied to crane mechanics may be defined as a measure of how much force, acting on a fastener, causes the fastener to rotate. Torque is generated any time you use a wrench to apply a force to a fastener. As the illustration demonstrates, torque is the product of force times distance. Units of torque are expressed in inch-pounds or foot pounds in the English system and Newton meters in the metric system. Engineers have found through experience and calculations, how much torque must be applied to a given fastener, to tension and stretch it the appropriate amount in order to achieve proper clamping force. It is important to assure that the fasteners being torqued are clean, and free of dirt or corrosion, which would contribute to unwanted friction and resulting errors in torque readings.



TORQUE WRENCHES: CLICK TYPE

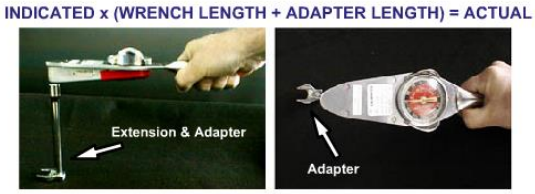
A torque wrench is used whenever the exact tightness of fasteners is considered critical. There are two basic types of torque wrenches in general use, the click type and the dial type. When using the click type, it must be pre-set for the torque required. As the fastener is tightened or torqued, an audible click is heard or felt in the tool handle when the pre-set torque has been reached. The click type is more convenient when working in a confined space where watching the dial of a torque wrench may be difficult. To preserve the internal spring, the click type torque wrench should be adjusted down to the lowest torque setting when not in use.

TORQUE WRENCHES: DIAL TYPE

The dial type torque wrench allows the user to see the torque which is being applied. This allows a great deal of precision in applying torque, as exactly the same torque can be applied each time. The dial type has the drawback of being hard to operate and read at the same time. This is true particularly of the larger wrenches.

ADAPTERS AND EXTENSIONS

Adapters and extensions may sometimes be used in conjunction with the torque wrench. Adapters extend lengthwise from the drive square. This, in effect, makes the torque wrench longer, changing the displayed torque value. Extensions, as shown in the illustration, extend longitudinally and attach to the drive square for the purpose of increasing the height of the torque wrench. Using extensions does not change the torque value. If adapters are used, the amount of torque exerted by the wrench will not be the same as the reading on the dial. To obtain a correct torque reading, use the following formula.



Indicated torque times total wrench and extension length to determine actual torque. If your facility has a fixture for checking torque wrenches, the fixture is an easier way of verifying the torque with a certain adapter set-up.

MULTIPLIERS

For jobs which require a larger amount of torque than the pull of the mechanic and available wrenches can provide, a torque multiplier can be used. The torque multiplier utilizes a planetary gear drive which multiplies the amount of torque exerted by the mechanic on the wrench. The most popular ratio for multipliers is 4 to 1, but the multiplication is never exact due to friction.

SELECTING THE PROPER TORQUE WRENCH

To select a torque wrench, you have to know the torque requirement of the fastener. The required torque is a function of the bolt's grade, diameter and requirements of the specific application. It is best to select a torque wrench where the torque value to be applied is in the upper two thirds of the range of the wrench. For low torque values, an inch-pound wrench may be preferable. For example, if a small torque value of less than 20 ft lb. is needed, an inch-lb. wrench may be the better choice.

TORQUE WRENCH TIPS

Here are some torque wrench tips which will help you do a better job. Do not jerk the wrench. Always apply smooth, steady pressure to a torque wrench. Remember to bring the torque down in 3 increments. Exercise the wrench through its full range of settings before final torque. Go back around after final torque.

NOTES

FASTENERS 4 MODULE EXAM

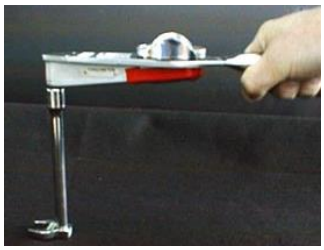
Online exam questions may appear in a different order than those shown below.

1. You need to torque a fastener to 15 foot pounds. You have two dial type torque wrenches to choose from. A 1-100 foot pound wrench and a 30-200 inch pound wrench. Which wrench is likely to provide the most accurate reading?

A. foot pound wrench
B. neither wrench would be suitable
C. inch pounds wrench

2. How does this adapter change the torque of the wrench at the fastener?

A. does not change the torque
B. increase the torque
C. decreases the torque



3. “You can see how close you are getting to the torque you want” applies to…

A. dial-type torque wrenches
B. click-type torque wrenches

4. “Hard to read the wrench and pull at the same time” applies to…

A. dial-type torque wrenches
B. click-type torque wrenches

5. “Easy to use in dark or cramped areas” applies to …

A. dial-type torque wrenches
B. click-type torque wrenches

HOIST DRIVE TRAINS 1

LOAD BEARING AND LOAD CONTROLLING COMPONENTS

Section 1 of NAVFAC P-307 defines load bearing parts as those parts that support the load and upon failure could cause dropping, uncontrolled shifting, or uncontrolled movement of the load. Load controlling parts are those parts that position, restrain, or control the movement of the load and upon failure could cause dropping, uncontrolled shifting or uncontrolled movement of the load. Hoist drive train components are considered load bearing parts because they support, or bear, the weight of the load, while the load is in the air. Load controlling parts, such as rotate and travel gears, help move the load to its destination. NAVFAC P-307, appendix F lists examples of load bearing, load controlling parts.

NAVFAC P-307 Appendix F
APPENDIX F - EXAMPLES OF LOAD BEARING PARTS, LOAD CONTROLLING PARTS, AND OPERATIONAL SAFETY DEVICES

EXAMPLES OF LOAD BEARING PARTS

HOIST DRUM BULL GEAR
HOIST DRUM PINION GEAR
GEAR TO SHAFT CONNECTION
GEAR TO DRUM CONNECTION
PINION SHAFT
PINION SHAFT BEARING HOUSINGS
PINION SHAFT BEARING HOUSING BOLTS & NUTS
AUTOMATIC HOIST BRAKES
PINION SHAFT TO HOIST GEARBOX COUPLING
OUTPUT SHAFT OF HOIST GEARBOX
HOIST GEARBOX GEARS
HOIST GEARBOX GEAR SHAFTS
HOIST GEARBOX INPUT SHAFT
GEARBOX INPUT SHAFT TO MOTOR COUPLING
HOIST AUTOMATIC BRAKE
BRAKEWHEELS
AS A COMPONENT, ENTIRE HOIST REDUCER
HOIST MOTOR SHAFT
ALL HOIST DRIVE TRAIN

F-1

EXAMPLES OF LOAD CONTROLLING PARTS

TRAVEL GEAR SHAFTS
TRAVEL GEAR SHAFT TO MOTOR COUPLING
TRAVEL GEARS
MOTOR SHAFT
BEARING HOUSINGS FOR TRAVEL AND ROTATE
TRAVEL AND ROTATE DRIVE KEYS
TRAVEL GEAR GEARBOX COMPONENTS
CRANE MOUNTED DIESEL ENGINES AND GENERATORS
CRANE MOUNTED ELECTRICAL POWER DISTRIBUTION
ELECTRICAL CONTROL CIRCUITS

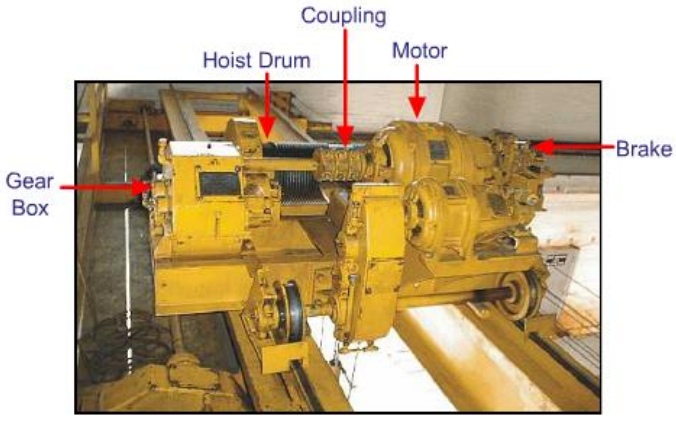
Note: Electrical circuit designs are too numerous to list.

The only electrical circuit components that are to be considered as load controlling are those associated with movement of the load.

F-2

TYPICAL HOIST UNIT

This illustration shows a typical hoist unit on a bridge crane. Each function such as hoist, swing, travel, and trolley on this and other types of cranes, will have its own set of components, although each one will operate in a similar fashion. Typical components in a crane hoist assembly include: the gear box, which increases the lifting power of the motor, the hoist drum, which spools the hoist wire rope in or out, the hoist motor, which powers the load up or down, the coupling, which connects the drive motor to the gearbox, and the hoist brake, which holds the load when hoisting is stopped.



HOIST DRIVE TRAIN LOAD BEARING COMPONENTS

Hoist drive train components are considered load bearing parts. These components include the hoist drum and drum supports, gear boxes and associated shafting, couplings, drive motor, drive motors & shafts, and brakes. Load bearing components must be treated with special care. Work performed on load bearing components may cause the crane certification to become void, necessitating load testing and re-certification.

BEFORE STARTING WORK

Before starting work on any crane remember, the crane mechanic must have authorizing paperwork and all work performed must be documented. Before disassembling any portion of a crane hoist unit, any load which may be supported by that hoist unit, must be lowered to a safe condition by a qualified person. The power to the function should be secured following approved lockout/tag-out procedures, to assure protection of personnel and equipment.

FOREIGN MATERIAL EXCLUSION

When working around gearboxes, care must be taken to keep foreign materials such as dirt, paint, fasteners, bird droppings, and so forth out of the open component. To prevent foreign material from entering open gearboxes, consideration should be paid to the external cleanliness of the component. Prior to opening, be sure to wipe all loose dirt and oil off the gearbox. The crane mechanic's pockets should be empty to prevent foreign material from accidently falling into the gearbox. If the lube oil has not been drained from the opened gearbox, you may not notice if something falls in. Keep track of tools. It is good practice not to lay tools down where they may fall in the gearbox. Don't keep a lot of tools laying around when a gearbox is open. Bag and tag parts. Bagging and tagging will help you to keep track of fasteners and other small parts and ensure that they are returned to their proper position on the gearbox.

BAGGING AND TAGGING COMPONENTS

Fasteners should be bagged and tagged when they are removed. Just because one individual disassembles a component, it does not guarantee that same person will be reassembling it. Bagging components will help to assure that all the correct parts are at hand and organized when reassembling. Any shims which are removed should be tagged so that they can be replaced where they came from. When bagging components, it is a good idea to put the crane number, the exact location that the part was removed from and the number and size of fasteners placed in the bag.

MATCH-MARKING

Match-marking is an important part of disassembly. This illustration shows a technique for match-marking components so that they are all accounted for and will be replaced in the same orientation as they were removed. Things such as bearing retainers may have oil passages, cut outs for retaining pins, and so forth which must be replaced in the same position for proper operation. On older gear cases, the cover holes may not be perfectly symmetrical, and if not replaced in the proper orientation they may not fit. Never use a chisel across the mating flanges as this can distort the mating surfaces and do not make the punch marks on mating surfaces.

MARKING GEARS AND SHAFTS

If gears and bearings are going to be pressed off the shaft, the original orientation should be recorded before pressing. Measure the distance from the end of the shaft in to the gear or between gears. Also, note the orientation of the teeth on the gear to assure correct reinstallation. Whenever possible, take photos before and during disassembly or draw a picture of the gear layout in the gearbox to help when reassembling. The person who disassembles the component may not be the one who reassemblies it. Photos or diagrams will help make reassembly easier.

PROTECTING CRITICAL SURFACES

When a gearbox is disassembled, the critical machine surfaces must always be protected from damage. This can be done with plywood, rubber 3M tape or other types of suitable protective material. If the gearbox is going to remain open, it should be covered with plastic or other suitable material and taped or tied in place.

NOTES

HOIST DRIVE TRAINS 1 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. Before starting work on a crane hoist drive system, what issues must be addressed?

A. Is the work authorized?
B. Is the load in a safe condition?
C. Is the power secured and the function locked out/tagged out?
D. Do you have the proper tools?

2. Is the coupling a load bearing part?

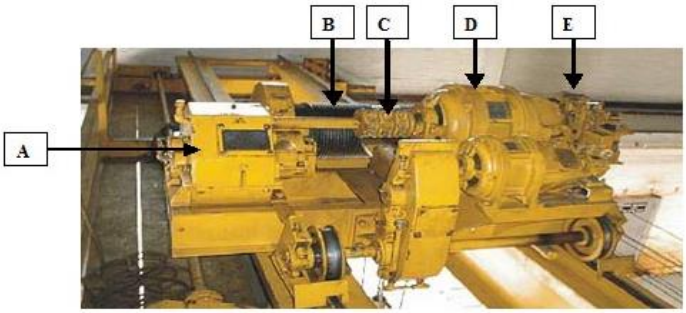
A. Yes
B. No

3. If the coupling failed, would the load fall or go out of control?

A. Yes
B. No

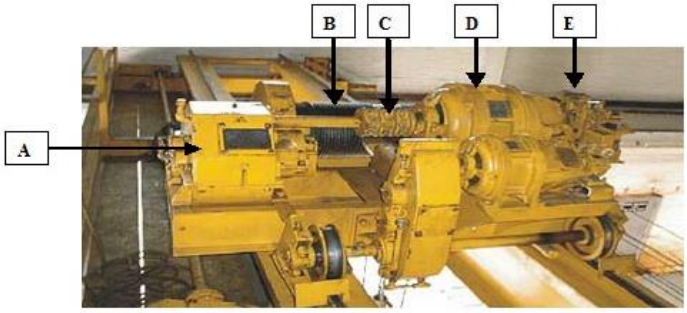
4. The label C identifies what part of the drive train?

A. gearbox
B. hoist drum
C. coupling
D. motor
E. brake



5. The label D identifies what part of the drive train?

A. gearbox
B. hoist drum
C. coupling
D. motor
E. brake

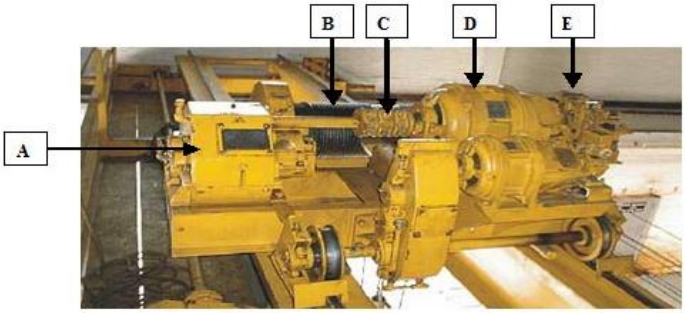


6. Looking at this picture, does the coupling support the load?

A. Yes
B. No

7. The label B identifies what part of the drive train?

A. gearbox
B. hoist drum
C. coupling
D. motor
E. brake

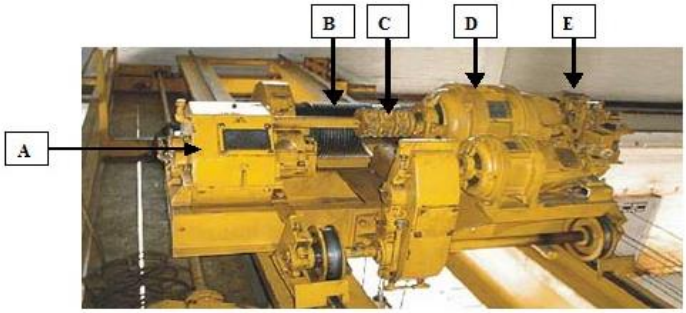


8. What action should be taken to ensure no foreign material enters a gear box when the cover is removed?

A. pockets are empty
B. keep track of all tools
C. all listed answers
D. external cleanliness

9. The label E identifies what part of the drive train?

A. gearbox
B. hoist drum
C. coupling
D. motor
E. brake

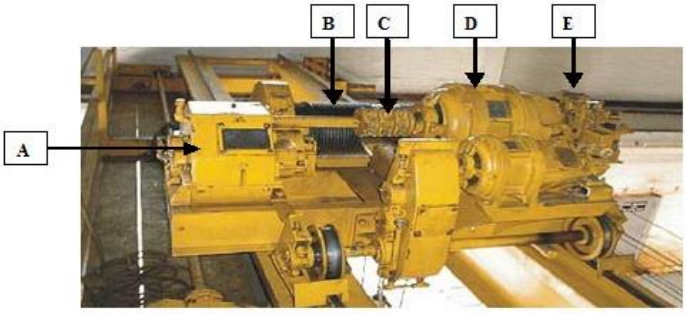


10. Gears can increase or decrease speed or torque.

A. True
B. False

11. The label A identifies what part of the drive train?

A. gearbox
B. hoist drum
C. coupling
D. motor
E. brake



12. Gears can change the direction of rotation.

A. True
B. False

13. Gears provide the energy to lift loads.

A. True
B. False

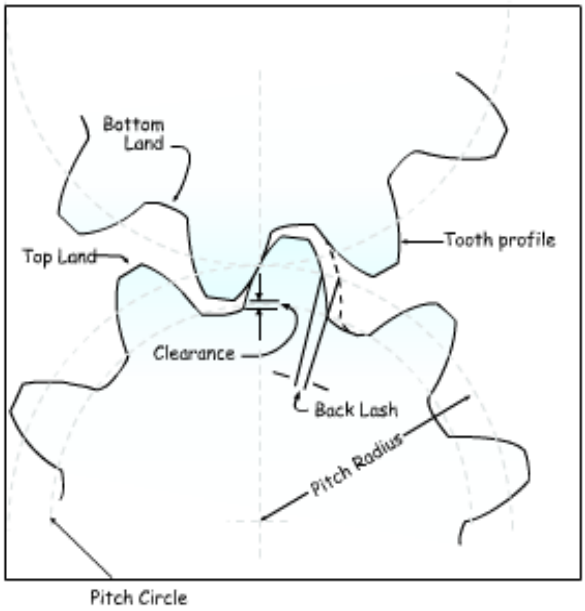
14. Gears transfer power from one shaft to another.

A. True
B. False

HOIST DRIVE TRAINS 2

PURPOSE OF GEARS

Gears are used for a variety of purposes on cranes. Common uses are transferring power from one shaft to another, increasing or decreasing speed, increasing or decreasing torque, and changing the direction of rotation.



GEAR TERMINOLOGY

The following is common terminology associated with gears. The pitch circle, which is determined from the point of contact of meshing gears, on the centerline between gears. Backlash is the amount by which the width of a tooth space exceeds the thickness of the engaging tooth on the pitch circle. Clearance is the amount by which the top land of a given gear clears the bottom land of its mating gear. Bottom land, or root, is the surface at the bottom of a tooth space adjoining its fillets. Top land (crest) is the surface on the top of the tooth. Tooth profile is the shape of the tooth. The profile can be different on different gears depending on the design.

SPUR GEAR

The spur gear is very common in crane applications. Its features are straight teeth cut on a cylindrical shape, parallel to the axis of rotation. Spur gears are designed to transmit power between parallel shafts. Since spur gear teeth engage along the full length of the tooth, they tend to generate more noise than other gear types.

HELICAL GEARS

Helical gears offer a refinement over spur gears and are found in many crane applications. The leading edges of the helical gear teeth are not parallel to the axis of rotation, but are set at an angle. The angled teeth engage more gradually than do spur gear teeth. This causes helical gears to run more smoothly and quietly than spur gears while providing greater strength and durability. A disadvantage of helical gears is a resultant thrust along the axis of the gear, which needs to be accommodated by appropriate thrust bearings.

HERRINGBONE GEARS

Herringbone gears, also known as double helical gears, are not as commonly used on cranes. Herringbone gears overcome the problem of axial thrust presented by 'single' helical gears by having teeth that are arranged in a 'V' shape. Each gear in a herringbone gear can be thought of as two standard, but mirror image, helical gears. This cancels out unwanted axial thrust since each half of the gear thrusts in the opposite direction. The two sets of teeth are often separated by an undercut down the center of the gear which expedites the machining process, aids in the alignment, and provides lubrication of the gear. Like helical gears, herringbone gears tend to run quiet. Herringbone gears are more expensive to manufacture than some other types of gears, and their alignment must be more precise.

WORM GEARS

A worm gear is a type of helical gear. Its helix angle is usually somewhat close to 90 degrees from its axis and resembles a screw. Its body is typically fairly long in the axial direction, which give it screw like qualities. The mating gear will have a concave top land on its teeth, which conforms to the shape of the worm. The prime feature of a worm gear set is that it provides high gear reduction with few parts, in a compact assembly. The worm gear ratio is calculated by taking the number of teeth on the gear and dividing it by the number of leads, or starts, on the worm. In a worm-and-gear set, the worm always drives the gear and is never the driven gear.

BEVEL GEARS

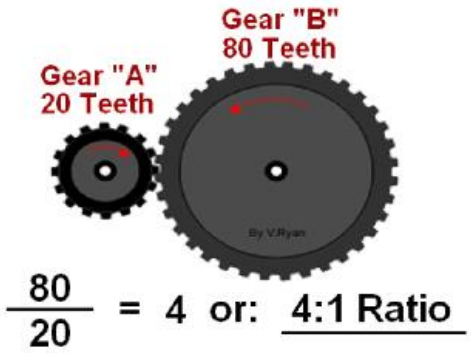
Bevel gears are essentially conically shaped with teeth cut on the sides, although the actual gear does not extend all the way to the vertex or tip of the cone. Bevel gears allow the power to be transmitted off at an angle, however the axes of the gear shafts will always intersect. Standard bevel gears mesh with the axes at right angles to each other, although the angle between the shafts can be anything except zero or 180 degrees. Bevel gears with equal numbers of teeth and shaft axes at 90 degrees are called miter gears. Bevel gears with the teeth cut on a spiral rather than straight are spiral bevel gears.

HYPOID GEARS

The last type of gear we will discuss is the hypoid gear. Hypoid gears are bevel gears with curved teeth. Their shafts are not in the same plane, which allows the input shaft to be higher than the axle. The most common application is in differentials and angle gearboxes. The action of the teeth is such that a lubricant with an extreme pressure additive is necessary.

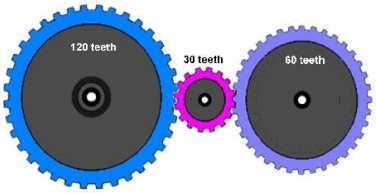
CALCULATING GEAR RATIOS

The gear ratio is the relationship between the number of teeth on two gears that are meshed. On most types of gear sets, the ratio of the gear is calculated by counting the number of teeth in the biggest gear and dividing that number by the number of teeth in the smaller gear or pinion. For example, in this illustration gear A, has 20 teeth and gear B has 80 teeth. 80 divided by 20 is 4 making this gear ratio 4 to 1. This means for every turn of the larger gear, the smaller gear, or pinion, would turn 4 times. If driven by the pinion, the larger gear would make 1 revolution for every 4 that the pinion makes.



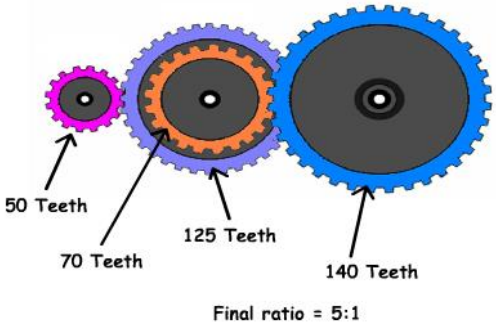
CALCULATING MULTIPLE GEAR SETS

The calculation of multiple gear sets is done slightly differently. Looking at the example we see that the gear set has 3 gears in mesh, each on its own shaft. The 120 tooth gear to the left will be the input and the 60 tooth gear at the right, the output. The middle gear is considered an idler gear and the number of teeth do not need to be factored in when doing the gear ratio calculations. Since the input gear has 120 teeth and the output gear has 60 teeth, the ratio would be 120 divided by 60, or a 2 to 1 ratio.



CALCULATING COMPOUND GEAR SETS

Notice in this illustration of a compound gear train, four gears are used and the center set of gears are fixed together on the same shaft. In this example, the gear on the left is meshing with the larger gear fixed on the center shaft. The smaller gear fixed on the center shaft is meshing with the gear on the right. In this case of “compound gearing”, the ratio is calculated for each set and then the results are multiplied by each other. These two gear sets are comprised of a 50 tooth gear meshing with a 125 tooth gear, and a 70 tooth gear meshing with a 140 tooth gear. The ratio for gear set one is calculated by dividing 125 by 50 which gives us a ratio of 2.5 to 1. The ratio for the second gear set is calculated by dividing 140 by 70 which gives us a ratio of 2 to 1. Multiplying the ratios of each gear set by each other provides us with a final ratio of 5 to 1.



MEASUREMENTS ON GEAR SETS

Many of the fits and relationships of gear sets are such that they cannot be fixed or adjusted by the mechanic in the field. After thoroughly cleaning the gear set, the crane mechanic takes measurements to determine if there are wear or alignment problems. The following screens identify the measurements to be taken and how to take them. Gear sets may experience more wear in certain sections of the gear than in others, so it is good practice to measure in four quadrants on the gear, the section with the most wear, the section with the least wear and two others. The three types of readings taken on gears are backlash, tooth clearance, and tooth contact.

MEASURING BACKLASH

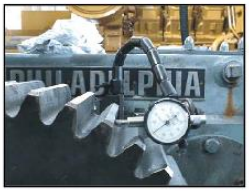
Backlash is the clearance between the thickness of a gear tooth and the width of the space between gear teeth in the mating gear. While excessive backlash can be destructive, some clearance is necessary to allow for a film of lubricant, binding from heat expansion and eccentricity, or minor manufacturing inaccuracies. Measuring backlash can be accomplished in several ways, however, the results may vary with the method used. Due to this variance, the method used should be noted along with the readings, so that future readings will be made using the same method. In this way, comparisons are more valid than if a different method of taking readings is used each time. The three methods of taking backlash readings are the use of feeler gauges, dial indicators, and the lead wire method.

FEELER GAUGES

A feeler gauge is the easiest and most direct method of measuring backlash. Feeler gauges may be used to measure backlash by inserting the blades between the mating teeth at the pitch line. Make sure you do this at the point where the teeth are fully engaged. Both ends of the gear tooth should be measured. If the measurements vary significantly from one side of the gear to the other, an alignment problem exists known as “lead error”.

DIAL INDICATOR

Dial indicators are commonly used to measure backlash tolerances especially in situations where feeler gauges might be difficult or impossible to use. A dial indicator may be used to measure backlash by holding one gear stationary and rocking the other gear back and forth. The indicator is positioned on the moving gear, with the point of the dial on the gear tooth pitch line, and the dial positioned perpendicular to the axis as shown in the illustration. One problem associated with using a dial indicator to measure backlash is that although the dial can measure the smallest amount of backlash, it will not indicate if there is any misalignment.



LEAD WIRE

Lead wire or solid core solder may also be used to measure backlash. The wire must be formed along the teeth, and three strands should be used: one on each side of the tooth and one in the middle. When the gears are rotated, the wire is compacted in between the meshed gears. The compacted lead wire is then measured with a micrometer. The drawbacks of this method are that the lead wire tends to center the tooth between its mating teeth, and it also has the tendency to push the gears away from each other to the extent that the gear shaft bearing clearances allow. For these reasons, it is very important to always indicate which method was used to measure the backlash, so that the same method may be used the next time.

READING LEAD WIRE

This photo shows the lead wire being measured. Notice that the measurement is made at the location of the pitch line.

TOOTH CLEARANCE

There are different ways to measure gear tooth clearance depending on the application. Tooth clearance is the distance between the crest or top land of a gear tooth, and the root or bottom land of its mating teeth. Feeler gauges or wires may be inserted between the crest of a tooth and the root of the mating teeth at the point where they are most fully engaged. The measurement can be read directly off the gauge. Lead wire may be positioned along the root of one gear and the gears rolled around until the wire is compacted between the mating teeth. The wire will then be read with a micrometer.

TOOTH CONTACT

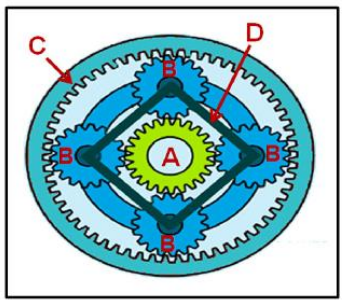
Tooth contact is generally determined by coating some of the teeth of one gear with a thin layer of machinist's bluing and then rolling the gears together and checking the transfer pattern which the bluing makes on the mating teeth. Coating the mating gear with dye penetrate developer may facilitate the transfer of the bluing. The transferred pattern should be of equal width across the flank of the tooth. An unequal pattern that is thicker on one side than the other indicates differences in the amount of backlash across the flank of the gear tooth.

READING GEAR TOOTH CONTACT

Once the gears have been rolled together the bluing transfer pattern can be read. This illustration shows a situation where only a very small area of contact is being made as these gears mesh.

PLANETARY GEARS

Many mobile cranes employ a system of planetary gears for their hoisting functions. Like the solar system, planetary gear assemblies have “planet gears” that rotate around a sun gear. The sun gear is in the center of the planetary cluster, and rotates on its own axis. The ring gear rotates around the planetary gear and is in constant mesh with the planet gear. Each planet gear axis is supported by the planetary carrier and the planetary gears are in constant mesh with both the sun gear and the ring gear.



ADVANTAGES OF PLANETARY GEARS

Planetary gears have many advantages over other gear train configurations. Planetary gear trains can serve as direct couplers, reduction gears, or reversing gears, depending

on which portions of the gear train are allowed to rotate. A planetary gear set allows gear ratios to be changed without engaging or disengaging the gears, so there is no interruption in the power flow. Planetary gear sets allow a much more compact power transmission unit. They allow the input and output shafts to rotate on the same axis and eliminate the need for a countershaft. The gear load is spread over several gear teeth, decreasing the load on individual teeth as well as spreading the load evenly over the circumference of the system, eliminating side stress on the shafts. Planetary gearing is commonly found in the hoist, travel, and rotate machinery of non-hydraulic mobile cranes.

GEAR CASE PERFORMANCE FACTORS

There are several conditions which may affect the way the gear case performs in service. Crane operators and maintenance personnel should be alert for any changes in the amount of noise or vibration coming from hoists; however, not all equipment will have the same noise levels. A gear case with spur gears, for example, will be inherently much noisier than a gear case with helical gears. It is important that gear cases are mounted and aligned properly. If the alignment of the shafts between the gearbox and its driving motor is not within the prescribed limits, the coupling shaft may suffer premature failure. In order for a gearbox to operate properly, it must be supplied with the correct amount and type of lubricant. The lubricant serves many functions. It reduces power loss due to friction and acts as a cooling medium for the unit. It can be a medium for carrying anti-wear and anti-scoring agents, and can help even out the temperature throughout the gear case by taking heat away from the high temperature areas and warming up low temperature areas.

NOTES

HOIST DRIVE TRAINS 2 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. Select the item from the following list that is best described as a cylindrical shape with diagonally cut teeth.

A. spur gear
B. helical gear
C. herringbone bear
D. bevel gear
E. worm gear
F. hypoid gear

2. Select the item from the following list that is best described as a radius measured from the center of the gear to the point of contact of meshing gears on the center line between gears.

A. backlash
B. top land
C. bottom land
D. pitch circle

3. Select the item from the following list that is best described as the surface space at the bottom of the tooth between teeth.

A. bottom land
B. top land
C. pitch circle
D. backlash

4. Select the item from the following list that is best described as a type of bevel gear often found in automotive differentials having teeth cut so that shaft centerlines do not intersect.

A. spur gear
B. helical gear
C. herringbone bear
D. bevel gear
E. worm gear
F. hypoid gear

5. What method of measurements may be used when checking gear clearances?

A. Prussian blue
B. feeler gauges
C. lead wire
D. dial indicator

6. Select the item from the following list that is best described as the surface on the top of the tooth.

A. top land
B. pitch circle
C. backlash
D. bottom land

7. Select the item from the following list that is best described as a gear that has straight cut or spiral cut teeth on a cone shape.

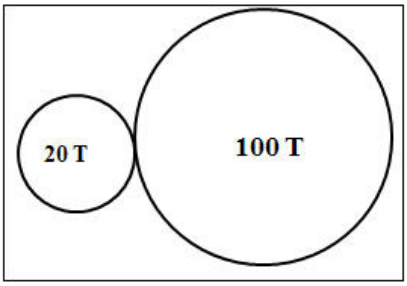
A. spur gear
B. helical gear
C. herringbone bear
D. bevel gear
E. worm gear
F. hypoid gear

8. What methods of measurements may be used when checking fear backlash?

A. Prussian blue
B. feeler gauges
C. lead wire
D. dial indicator

9. Calculate the ratio of the gear set shown below.

A. 7:1
B. 10:1
C. 2:1
D. 5:1



10. What method of measurements may be used when checking fear tooth contact?

A. Prussian blue
B. feeler gauges
C. dial indicator
D. lead wire

11. Select the item from the following list that is best described as a cylindrical shape with straight cut teeth.

A. spur gear
B. helical gear
C. herringbone bear
D. bevel gear
E. worm gear
F. hypoid gear

12. Select the item from the following list that is best described as a gear that has angled teeth in the shape of a letter “V” (double helical).

A. spur gear
B. helical gear
C. herringbone bear
D. bevel gear
E. worm gear
F. hypoid gear

13. Select the item from the following list that is best described as a gear that consists of a shaft with a screw thread, which would mesh with a corresponding gear.

A. spur gear
B. helical gear
C. herringbone bear
D. bevel gear
E. worm gear
F. hypoid gear

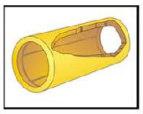
14. Select the item from the following list that is best described as the space between mating gear teeth.

A. bottom land
B. backlash
C. pitch circle
D. top land

HOIST DRIVE TRAINS 3

BEARINGS

Bearings are used throughout the crane in various configurations. In this module, we are going to look at some of the various types of bearings you will find on the crane, and how they are maintained.



TYPES OF BEARINGS

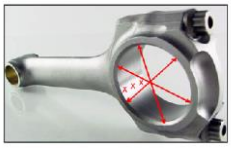
There are two basic types of bearings, solid (or plain) bearings and anti-friction bearings. Both types will be encountered on cranes.

PLAIN BEARINGS

Plain bearings are designed to reduce friction by supporting radial loads. They are often used when the load is light and motion is relatively continuous, such as in crankshafts. Plain bearings may also be known as sleeve bearings or journal bearings. When a shaft turns on the bearing surface, a thin layer of lubricant separates the bearing surface and the shaft. There are two types of plain bearings split-half bearings and sleeve bearings or bushings. The most common application for split-half bearings is in the internal combustion engine, where they are used as bearings for crankshafts and connecting rods. These split-half bearings are made up of layers of steel, aluminum and a lead-tin alloy. Other split type bearings are used as bearings in older gear cases and pedestal bearing applications on cranes. These bearings are usually a bronze alloy with grooves cut into them for grease distribution. Sleeve bearings are very similar to the split-half bearings as they use the same sliding action, but they are made in one piece. They can be made out of the same lead-tin alloy on an aluminum surface with a steel backing, or they can be made out of materials such as bronze. Sleeve bearings will normally have holes or grooves for distribution of lubrication.

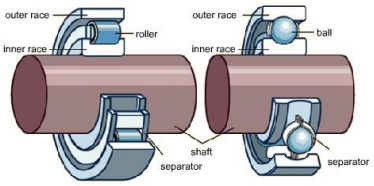
MEASURING PLAIN BEARINGS

When measuring plain bearings, readings should be taken in three places 60³ apart, and at three locations near each edge and in the middle of the bearing. By employing this method, the crane mechanic will be able to determine whether the bearing has elliptical or taper alignment issues to correct. Before installing the bearing in a bore, the bore should be checked in a similar manner, as any irregularity in the bore will be transferred to the bearing.



PARTS OF AN ANTI-FRICTION BEARING

Anti-friction bearings are a type of bearing using steel balls or rollers as the supporting device between hardened races. The components of the bearing move in relation to one another. The movement of the components permits free rotation. The basic parts of an anti-friction bearing are the outer race, which is pressed into a bore, the rolling elements, which can be either balls or rollers, the cage or separator, and the inner race.



BALL AND ROLLER BEARINGS

This type of bearing reduces friction by providing smooth metal balls or rollers, and a smooth inner and outer metal surface for the balls to roll against. These balls or rollers support the load while allowing the device to spin smoothly. This type of bearing is not designed for thrust loads.

ANGULAR CONTACT BEARINGS

Angular contact ball bearings are non-separable bearings that can accommodate radial loads and also thrust load in one direction. This type of bearing is assembled with a preload, which is applied between the inner race, the bearing ball, and the outer race to minimize gaps between the bearing balls and the inner and outer races. Angular contact bearings may operate with heavy thrust loads and moderate radial loads and are classified as single row, radial ball bearings. Angular contact bearings have a thicker side on one side of the outer race which is designed to take a thrust load. One common application of this type of bearing is in crane hook swivel assemblies. In this and other applications, it is essential that angular contact bearings are properly oriented in an assembly so that the outer races bear the applied load or thrust.

ROLLER BEARINGS

Another common anti-friction bearing is the roller bearing. Roller bearings use cylindrical rolling elements of slightly greater length than diameter. This type of bearing typically has higher radial load capacity than ball bearings, but a low axial capacity and greater friction under axial loads. While ball bearings are somewhat tolerant of slight misalignment, the capacity and lifespan of a roller bearing may be significantly reduced if not accurately aligned in an assembly. Although, in most cases, roller bearings have a shoulder on the outer race, they are not designed to take a thrust load.

TAPER ROLLER BEARINGS

Tapered roller bearings use conical rollers that run on conical races. Most roller bearings only take radial loads, but tapered roller bearings support both radial and axial loads, and generally can carry higher loads than ball bearings due to greater contact area. Their thrust capacity is approximately 60% of their radial capacity. Tapered roller bearings are commonly found as the wheel bearings for vehicles such as automobiles, busses, trucks, and industrial equipment. This type of bearing is normally found as a two piece construction with the outer race (or cup) being separate from the inner race and rollers (or cone). When assembled in place, tapered roller bearings must have their clearance (or pre-load) set properly to avoid overheating or noisy running resulting in premature failure.

BEARING MAINTENANCE

Proper maintenance of bearings is essential for reliable bearing life. Many times the mechanic will take pains to ensure the replacement bearings are kept clean, but will forget the importance of thoroughly cleaning the housings. Any dirt or debris left in the bearing housing may contaminate the new lubricant causing wear and shortened bearing life. Shafts and housings should be checked for burrs or other flaws. In some cases burrs may be accidentally raised on the shaft shoulders or housing seats during removal of bearings. Any burrs or particles not removed prior to assembly of the replacement bearing will prevent the bearing parts from seating properly resulting in misalignment and premature failure. Additionally, if a bearing is pressed onto a surface with high spots or burrs, this will create a high spot in the bearing race causing damage. Time spent in checking for and eliminating burrs or other flaws, is time well spent.

BEARING MAINTENANCE (2)

Always use the correct bearing driving tools when installing bearings. Bearing installation tools should be shaped so that only the portion of the bearing which is being installed is being pressed against by the tool. If properly selected and used, the bearing installation tool will press the inner race against the shaft or the outer race in the bore without damage. The installation tool size should be checked before use to assure proper clearances so it won't get stuck on the shaft or in the bore. If no tool is available, a pipe having the appropriate dimensions may be used although the ends should be machined to assure the bearing is pressed on squarely. Fully seat bearing races on shafts and in housings. Bearing adjustments that loosen up in service are often the result of not being fully seated when installed. When heating bearing cones, use thermostatically controlled oil baths or ovens and heat only to the temperature recommended by the bearing manufacturer. The heat will expand them as an aid to shrink fitting, but they must be held against the shaft shoulder while cooling to prevent the hot cone from pulling away from the cooler shoulder. Proper seating of cones and cups must always be checked by the use of feeler gauges.

BEARING MAINTENANCE (3)

To help eliminate inaccurate bearing adjustments, rotate or oscillate bearings while making or checking the adjustment. To oscillate the bearing turn it back and forth a quarter to a half turn forward and then backward. If the bearings are not rotated while adjusting, the rollers may not fully seat resulting in an inaccurate adjustment. This effect is most noticeable on equipment where greater than usual accuracy is required in the bearing adjustment. When making adjustments, a dial indicator may be mounted to read the shaft end movement or end play. While oscillating, the shaft is pushed in one direction and then pulled in the opposite direction to measure end play. It is also important to pay attention to the seals used in an assembly. Worn or damaged seals can undermine an otherwise effective overhaul program. The re-use of worn seals or damaged seal wiping surfaces can result in loss of lubricant through leaks, contamination of the lubricant by moisture, or introduction of foreign matter. Always check bearing or shaft seals and replace any which are worn or damaged.

COUPLINGS

Shaft couplings are used to join components of the hoist drive system. Couplings connecting machinery components allow the individual components to be easily removed. Specially designed flexible couplings compensate for minor shaft misalignment without damage and can serve as a buffer to vibration and shock, resulting in protection to bearings and shafts.

COUPLING TYPES

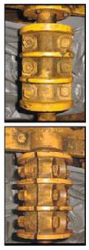
Couplings are standard commercial assemblies commonly used for joining rotating shaft assemblies and are designed to be rigid, semi-flexible, or full-flexible. The hubs have concentrically machined bore and outside diameters that permit the installation of specialized equipment for precise shaft alignment.

RIGID COUPLING

Rigid couplings are comprised of two flanged hubs bolted together. This type of coupling allows two components to be connected and disconnected from each other easily, but it is not tolerant of any misalignment. The most common utilization of a rigid coupling on a crane would be in conjunction with a semi-flexible coupling on a long shaft. Rigid couplings are permitted only on long shafts (with distant bearing supports) where shaft deflection may compensate for any misalignment.

SPLIT COUPLING

The split or compression type coupling is less common but found most frequently on older bridge crane travel drives. These are matched pairs of steel or ductile castings in the form of heavy-walled tubes. The single piece design is cut lengthwise on one side and slotted on the opposite side so that it can be clamped with a row of bolts along the cut side. The two piece coupling has a row of clamping bolts on both sides of the coupling. Machined key slots are usually provided on both ends of these coupling shells. Before installation, the shaft ends should be checked to assure a 1/8 inch to 1/4 inch gap. The coupling should be tightened down evenly and the split should be the same on both sides. To maintain the proper balance of the coupling, the bolts on opposite sides should be installed in the opposite direction. The coupling halves should be matched. Never interchange coupling halves and care should be taken to be sure the match marks are aligned.



SEMI-FLEXIBLE COUPLING

Semi-flex couplings feature a flexible coupling half on one side and a rigid coupling half on the other. They are commonly found where there is a long shaft that requires some rigidity. If a floating shaft has semi-flex on both ends, use either both the flex halves or both the rigid halves on the floating shaft. Semi-flexible couplings are mandatory for floating shafts and shaft arrangements where the bearing support of one shaft is adjacent to, and the other is distant from the coupling.

FULL-FLEX COUPLING

The most prevalent type of coupling is the full-flexible type. Full-flexible couplings have two hubs, which are pressed and keyed on the shaft or axle ends, and a two piece flange connected sleeve fitted over the hubs. The hubs have external gear teeth cut on their circumference and the sleeve has internal gear teeth that mate with those on the hubs. Typically, each sleeve flange has a lubrication plug in its outside edge and an O-ring seal on the hub seat. Torque is transmitted through the two sets of gear teeth. This coupling design is most tolerant of angular misalignment and parallel offset between the two ends.

GRID COUPLING

Grid couplings are a popular choice because they are very tolerant of misalignment. The basic grid coupling consists of two hubs that contain slots, which may be straight, tapered, or contoured. The two hubs are connected by one or more spring steel serpentine grids and enclosed by two cover halves, which are used to retain lubricant around the grid and hubs. Although every effort should be taken by the crane mechanic to align shafts properly, the grid couplings are designed to accommodate some parallel or angular misalignment and some axial movement. Care should be taken when using grid couplings to assure the grids are installed carefully, using a soft hammer. Inspect the slots of the hubs before grid installation to insure that there are no dents or burrs which will affect the free movement of the grids in the slots of the coupling.

GEAR TOOTH COUPLING

Each half of the gear tooth coupling consists of a hub which has gear teeth cut on the hub, and a flange and sleeve assembly with teeth cut on the internal diameter. Torque is transferred from one shaft, through the hub to the sleeve and flange, to the other flange and sleeve and through the opposite hub to its shaft. Gear tooth couplings are less tolerant of misalignment than the grid couplings, but they are more resistant to the effects of drive reversal. Couplings should be maintained as a matched set, whenever possible.

COUPLING INSTALLATION TIPS

When installing, replacing, or performing maintenance on couplings, make sure that you have a copy of the installation instructions for the specific coupling. Most coupling manufacturers provide information and recommendations for installation, maintenance, and lubrication of their couplings. Additionally, the engineering code for the activity should include complete installation procedures along with the authorizing paperwork for the job. Coupling components should be clean and free of any burrs and nicks on the mating surfaces. If they exist, remove them with a stone, file, or emery cloth. Take measurements to insure that the coupling will mate properly to the equipment. Many couplings have specific end gap requirements that will have to be adhered to. Assure in advance that the internal diameter of the coupling will fit the outside diameter of the shaft. Tapered bores should be blue checked to the mating shaft to assure adequate contact, which is at least 75%. Checks should also be made for keyway alignment and length of engagement.

KEYS AND KEYWAYS

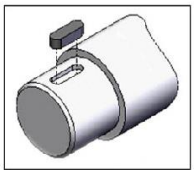
Keys and keyways are a common method used for assembling hubs to shafts. It is important to assure the keys are properly fitted in their seats or keyways.

KEY FITS

When installing a key in a keyway, the fit of the key needs to be verified to assure that it conforms to the drawings and specifications for the assembly. Normally, key material for cranes shall be equal to or stronger than the shaft material. Consult your local engineering code or the Navy Crane Center if necessary for design specifications. Keys should be a class 2 fit. Refer to manufacturer's drawings or ANSI B17.1 for key fit criteria.

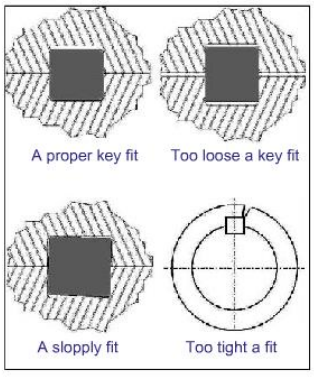
KEY FITS (RULES OF THUMB)

As a common rule, four key fits must be checked. The key should fit snugly in the shaft key-seat. The key should have a sliding fit (but not too loose) in the hub key-way. The key should have a clearance fit with the hub key-way at the top of the key and the key should be chamfered so that it fits the key-way and key-seat without riding on their radii.



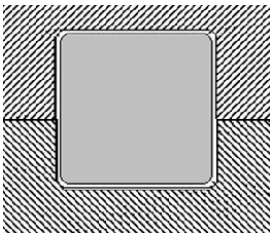
KEY PROBLEMS

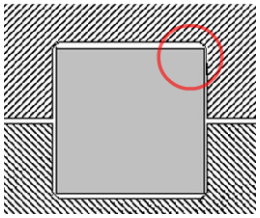
Here are some common key problems. The top left hand drawing shows a properly fitted key. It has rounded edges and clearance on the top. The key on the top right has square edges which keep it from fitting down into the seat. A sloppily fitted key, such as seen in the bottom left picture, can be the cause of the key rolling or shearing when loaded. The forces generated by torque tend to roll the key and cause high loading at the key edges. On the other hand, too tight a fit will make assembly very difficult, and will increase the residual stresses, which could cause premature failure of the hub or shaft, as can be seem on the bottom right.

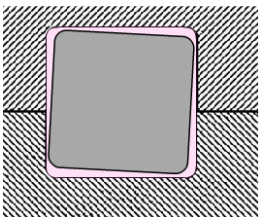


KEY PROBLEMS REVIEW

These are examples of common key problems.







NOTES

HOIST DRIVE TRAINS 3 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. The _____ of the shafts should be checked when installing couplings.

A. lubrication
B. end gap
C. match-mark
D. measurement

2. The picture below displays what type of bearing?

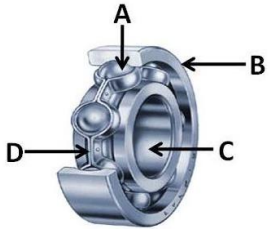
A. ball bearing
B. plain bearing
C. angular contact bearing
D. roller bearing

3. Couplings should be _____ before disassembly to be sure they are reassembled the same way.

A. measured
B. inspected
C. lubricated
D. match-marked

4. In this picture of a bearing, B is the _____.

A. ball
B. separator
C. inner race
D. outer race

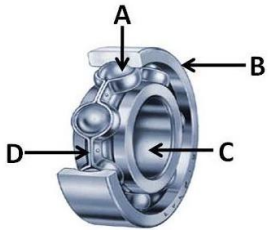


5. When heating a coupling for shrink fit, be sure to _____ the bore of the hub after it is heated to be sure it will slide over the shaft.

A. lubricate
B. inspect
C. measure
D. break

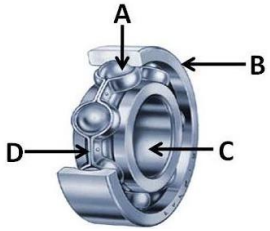
6. In this picture of a bearing, D is the _____.

A. ball
B. separator
C. inner race
D. outer race



7. In this picture of a bearing, C is the _____.

A. ball
B. separator
C. inner race
D. outer race



8. The corners of the key should be _____.

A. sharp
B. rounded

9. An angular contact bearing is used for _____.

A. a slow moving shaft with a heavy load
B. a whip swivel on a crane
C. a shaft with a medium load, no thrust
D. a shaft with a thrust load

10. The key should be a _____ fit in the key seat.

A. snug
B. sloppy

11. The key should _____ in the keyway.

A. slide
B. stick

12. A ball bearing is used for _____.

A. a slow moving shaft with a heavy load
B. a whip swivel on a crane
C. a shaft with a medium load, no thrust
D. a shaft with a thrust load

13. A plain bearing is used for _____.

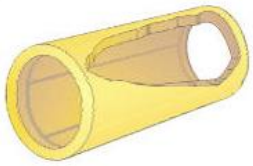
A. a slow moving shaft with a heavy load
B. a whip swivel on a crane
C. a shaft with a medium load, no thrust
D. a shaft with a thrust load

14. The Navy Crane Center requirements stat that a key should be _____ the material the shaft is made from.

A. at least as hard as
B. never as hard as

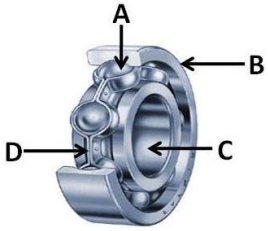
15. The picture below displays what type of bearing?

A. plain bearing
B. angular contact bearing
C. roller bearing
D. ball bearing



16. In this picture of a bearing, A is the _____.

A. ball
B. separator
C. inner race
D. outer race



17. The picture below displays what type of bearing?

A. roller bearing
B. ball bearing
C. plain bearing
D. angular contact bearing

18. After installation and before use, the coupling must be _____.

A. lubricated
B. measured
C. match-marked
D. inspected

19. A tapered roller bearing is used for _____.

A. a slow moving shaft with a heavy load
B. a whip swivel on a crane
C. a shaft with a medium load, no thrust
D. a shaft with a thrust load

20. Used couplings should be thoroughly _____ before being re-used.

A. match-marked
B. measured
C. inspected
D. lubricated

21. There should _____ be clearance on top of the key.

A. always
B. never

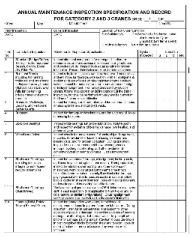
22. Mark the procedures that are not good shop practices when installing bearings.

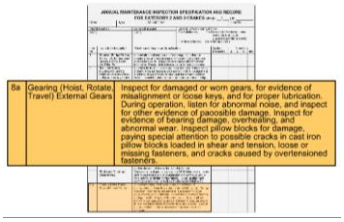
A. check the shaft and housing for burrs and dings
B. use a driving tool that will press on the correct portion of the bearings
C. oscillate bearings when making adjustments
D. clean the bearing housing before installing bearings
E. keep pressure on the bearing when it is cooling to make sure it stays against the shoulder or seat
F. knurl the surface of the shaft to insure a tight fit
G. press bearing on with socket or pipe nipple
H. heat bearing until they are a nice blue color

HOIST DRIVE TRAINS 4

MAINTENANCE SPECIFICATION AND RECORD (MISR)

When performing a maintenance inspection, the maintenance inspection specification and record form, or MISR, is used. In each section of the MISR, a component or system is named, and then the required types of inspections and verifications are listed. Remember that these instructions are minimum requirements, so none of them should be omitted or ignored. The following screens will show you examples of the types of things to be looking for when you perform your crane hoist inspections.

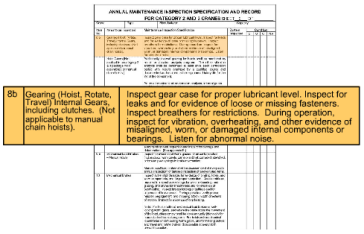




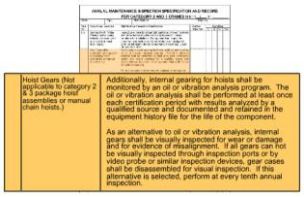
INSPECTING EXTERNAL GEARS

The inspection of external gears is the first attribute on the MISR form. For each function, external gears assemblies should be inspected for: damaged or worn gears, misalignment, loose keys, and proper lubrication. While the machinery is operating, check for abnormal noise, evidence of bearing damage, overheating, and abnormal wear.

INSPECTING INTERNAL GEARS



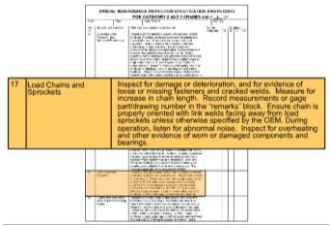
The next set of attributes listed on the MISR addresses internal gears in gear boxes. Gear case lubricant levels should be checked using the dipstick, sight glass, level plugs, or stand pipe. Check the appearance of the lubricant for any evidence of metal filings, condensation or other contamination. Visually check for loose or missing fasteners or any restriction in the breathers. Grease reliefs, which may have been painted over, should be noted on the MISR. With the hoist drive train engaged, i.e., the gears in the gear case rotating, check for unusual noise or vibration, overheating (usually concentrated around the bearing areas), and other evidence of misaligned, worn, damaged internal components, or bearings.



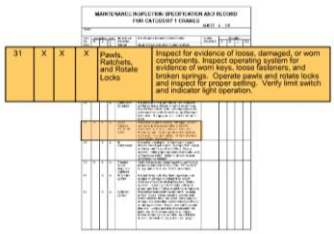
OIL OR VIBRATION ANALYSIS

There is an additional requirement that gear boxes be monitored using an oil or vibration analysis program. The oil or vibration analysis shall be performed at least once each certification period with results analyzed by a qualified source. The results of the analysis must be retained in the WHE history file for the life of the component. As an alternative to oil or vibration analysis, internal gears shall be visually inspected for wear or damage and for evidence of misalignment. If this alternative is selected, perform inspections at every third "C" inspection for category 1 cranes, and at every tenth annual inspection for category 2 and 3 cranes, and document the results in the equipment history file.

CHAINS AND SPROCKETS



Load chains and sprockets in the drive system must be inspected for damage or deterioration, loose shafts or keys, evidence of loose or missing fasteners, cracked welds, overheating, or other evidence of worn or damaged components. Chains shall be measured for any increase in length and the measurement recorded in the remarks block. Check for proper tension and lubrication by laying a straight edge from sprocket to sprocket, then measure the chain deflection midway between the sprockets. Ensure chain is properly oriented with link welds facing away from load sprockets unless otherwise specified by the OEM. During operation, listen for abnormal noise.

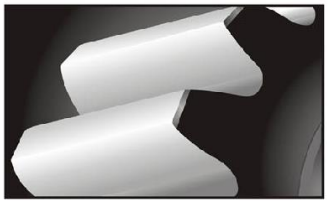


INSPECTING PAWLS, RATCHETS AND ROTATE LOCKS

When inspecting the pawls, ratchets, or rotate locks, the following attributes should be checked for loose, damaged, or worn components. Inspect the system for worn keys, loose fasteners, or broken springs. Operate pawls and rotate locks and verify proper engagement. This means that the pawl should fully engage the ratchet teeth when it is set. When the rotate lock is operated it should fully engage as well. Verify that limit switches and indicator lights operate properly.

GEAR WEAR

The following screens will show examples of different types of gear wear. The first example shows normal wear and the following examples show wear which would be considered abnormal or wear which is caused by conditions such as inadequate lubrication, poor design, or misalignment. If signs of abnormal wear are found during an inspection, consult with your activity's engineering department.

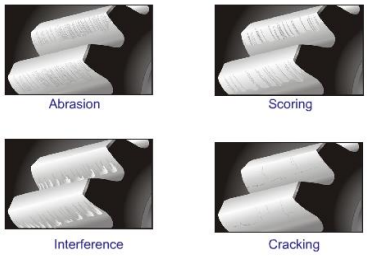


NORMAL WEAR

Before we look at the abnormal wear patterns, we need to see what normal wear looks like. After many hours of service even a properly aligned, well manufactured, and properly lubricated gear, operating within its capacity, will show signs of wear. A normal wear pattern will be spread along the surface of the tooth, from the pitch diameter to the tip. The surface should have a polished appearance.

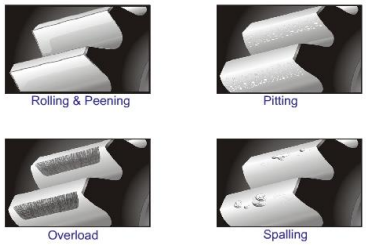
WEAR PATTERNS 1

Here are some typical wear patterns. Abrasive wear is caused by contaminants in the gear lube or by fine particles embedded in the tooth surfaces. Scoring is caused by a thinning or rupture of the lubricant film on the gear teeth. Interference can be caused by misalignment or mismatched gears mated together. Cracking is normally caused by improper heat treating or poor machining during manufacture.



WEAR PATTERNS 2

More gear wear patterns include rolling and peening, which is the result of overload and sliding leaving a burr on the tooth edge. Peening is the result of backlash and the resulting hammering of the teeth against one another with a very heavy impact. Another gear wear pattern is pitting which is generally seen in poorly made gears. Some new gear sets may show slight pitting when new, but during normal operation these pits will disappear. A poorly made gear set or one which is under considerable stress will continue to pit and this pitting will eventually lead to gear failure by tooth breakage or corrosive wear. Overload wear is caused by overloading gears where the metal has been removed by sliding pressure, causing a depression in the length of the teeth. Spalling is a condition most often found on case-hardened gears. Spalling starts with fine surface cracks and will eventually result in large flakes or chips leaving the tooth face.



GEAR CASE INSPECTION

Many things can be learned about a gearbox's condition by observing it when it is running. Listen for unusual noises. In some cases, noises may seem excessive, but may only be the result of the gearbox having spur gears instead of the quieter helical gears. The crane operator can be an excellent source of information about noises which have started or changed recently. New or different noises are often a symptom of a problem in the gearbox. Feel the gear case. Localized vibrations can be a symptom of bearings going bad or other problems with gears or shafts. Take the time to run the function through several cycles and check for bearing housings which are hot to the touch, possibly indicating a bearing that is too tight. Look for evidence of overheating, leaking from seals around shafts, and gear case seams. Check for movement of the gear case when a load is applied or direction is reversed. When you open the inspection cover, smell the oil in the box. Normally, gear oil will not have a pleasant smell, but should not smell burnt.

NOTES

HOIST DRIVE TRAINS 4 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. This picture shows that type of wear?

A. interference
B. spalling
C. rolling and peening
D. cracking
E. overload
F. abrasion

2. This picture shows that type of wear?

A. interference
B. spalling
C. rolling and peening
D. cracking
E. overload
F. abrasion

3. This picture shows that type of wear?

A. interference
B. spalling
C. rolling and peening
D. cracking
E. overload
F. abrasion

4. Mark the components of the hoist drive train that must be inspected.

A. rotate locks
B. external gears
C. chains and sprockets
D. pawls and ratchets
E. internal gears

5. This picture shows that type of wear?

A. interference
B. spalling
C. rolling and peening
D. cracking
E. overload
F. abrasion

6. This picture shows that type of wear?

A. interference
B. spalling
C. rolling and peening
D. cracking
E. overload
F. abrasion

7. Mark the items which must be inspected when inspecting internal gears.

A. loose or missing fasteners
B. restriction in the breathers
C. unusual vibration or noise when running
D. proper size and ration of gear sets
E. evidence of misalignment or unusual wear

8. Select the attributes that are not a part of the inspection of chains and sprockets.

A. look for worn or damaged teeth on the sprockets
B. check for proper lubrication
C. make sure that every part of the chain swivels
D. check for loose or missing fasteners
E. check for proper tension

9. This picture shows that type of wear?

A. interference
B. spalling
C. rolling and peening
D. cracking
E. overload
F. abrasion

BRAKES 1

WHY BRAKES ARE IMPORTANT

Brakes play a vital role among the multitude of components that enable a crane to function. Whenever a load is hoisted by a crane, at some point it must be securely held at the required height by a reliable braking system. A crane's braking system is often used to regulate the hoisting speed allowing for safer and more precise positioning of a load. In many modern cranes, secondary braking, or failsafe systems, can stop a load from falling even if other components before they fail.

BEFORE STARTING WORK

Any work performed on cranes must be documented. Before commencing repairs on a crane's brakes, the crane mechanic must have all authorizing documentation. An example would be a shop repair order or SRO that authorizes and describes the work to be performed. Have the proper tools on hand. Pre-plan the job to help determine which tools will be required. Ensure the crane's load and hook block have been placed in a safe condition. Remember many brakes are supporting a load when not energized. If a mechanic changes the spring setting on the brake any suspended load, including an empty hook block, could drop. Ensure compliance with lockout / tag-out and asbestos handling requirements, as necessary.

WHAT IS A BRAKE?

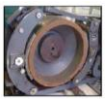
A brake is a mechanical device used for slowing or stopping the motion of a machine and preventing it from moving again.
The kinetic energy lost by the moving component is usually translated to heat as a result of friction. How well the brake lining can tolerate heat will determine how it will operate under repeated cycle operation.

COEFFICIENT OF FRICTION

In a braking system, coefficient of friction is the amount of frictional force developed between two moving components in contact, and can be changed either permanently or temporarily by heat, moisture, or contamination of the surfaces. When a brake is applied, the resulting friction is the force which causes the motion between the braking surfaces to be reduced or stopped. The coefficient of friction is not always constant and can change or fade as a result of brake linings heating up from heavy use. Moisture or other contamination on braking surfaces will cause a reduction in friction resulting in fading or in some cases, failure of the brake's ability to hold a suspended load. When working on a braking system, it is important to remember that even when lining-to-wheel contact and all other adjustments have been carefully set to specifications, new brake linings may not have the same coefficient of friction as the linings they replaced.

BRAKE TYPES

Brake types are classified in two ways: configuration and application. These methods of classification will help the crane mechanic organize how he or she approaches the repair and troubleshooting process.



BRAKE CONFIGURATIONS

Typically, there are three basic configurations for crane brakes, wheel brakes, multiple disc brakes, and caliper disc brakes.

WHEEL BRAKES

Wheel Brakes are the most common type of brakes found on cranes. A typical wheel brake consists of a shaft mounted wheel which rotates within a set of brake shoes or inside a brake band. When the brake is applied, the shoes or band clamp around the wheel and apply force to it. The force of the brake linings against the wheel results in friction which slows or stops the wheel, depending on the amount of force applied.

MULTIPLE DISK BRAKES

Multiple disc brakes are typically found on category 2 and category 3 cranes. The discs are attached by splines or other means to an internal rotating shaft, and alternately, to an external stationary housing. The rotating shaft is usually the hoist, bridge, or trolley motor shaft. When the brake is in the applied mode, the discs are forced together by spring pressure and the friction created between the stationary discs fixed to the housing and the rotating discs on the motor shaft stops the rotation of the assembly. This type of brake is spring applied and, when energized, electro-magnetically released. On this type of brake, a loss of power would cause the spring to apply pressure to the discs, setting the brake.

DISC CALIPER BRAKES

The disc-caliper type brake is becoming more common for crane applications. This type of brake utilizes a disc or rotor which is attached to a rotating member, such as a shaft or drum. A stationary caliper assembly containing pistons and brake friction pads is positioned on the rotor. When the caliper is applied, hydraulic pressure forces the brake pads to press firmly against both sides of the rotor, creating friction to slow or stop the rotor. The current style hoist-drum mounted disc brakes are of the configuration shown in the illustration.

BRAKES TYPES BY APPLICATION

The other method of categorizing brakes is by how they are applied. There are four basic means of brake application. Brakes are applied mechanically, hydraulically, spring applied, or pneumatically.

MECHANICAL BRAKES

Although mechanically applied brakes are less and less common, there are still brakes on cranes which are applied mechanically. Mechanical brakes are set by the mechanical force exerted by the crane operator. This type of brake is operated through a direct connection between the operator's cab and the brake. This connection can be in the form of a rod or a cable and usually provides mechanical advantage through leverage. Most of the mechanical brakes are band type brakes, although there are mechanical shoe type brakes as well.

MECHANICAL BRAKE ADJUSTMENTS

There are three adjustment criteria when adjusting mechanical brakes.
The first is band clearance around the wheel. Usually the band is held away from the

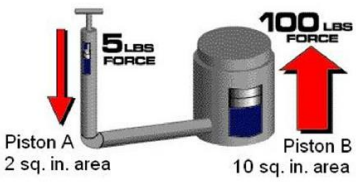
wheel by a combination of hangers and stops. These must be adjusted to give as even a clearance as obtainable around the wheel without any drag or contact. The next consideration is the crane operator's pedal height adjustment. The pedal height must be set so that the operator can obtain a full application of the brake without the pedal hitting the floor, but the pedal must not be so high as to cause difficulty when applying the brake. The final criteria to consider is assuring that the brake has been adjusted correctly and will securely hold the required load.

HYDRAULIC BRAKES

A hydraulic brake system can be either a wheel or disc-caliper type. This type of brake uses a hydraulic master cylinder to transmit the mechanical force applied by the crane operator into hydraulic flow and pressure which is transmitted through hydraulic lines to a slave cylinder. The slave cylinder converts the hydraulic pressure to the mechanical force needed to apply the brakes. This type of brake is normally used as a control brake and is normally open except when applied to control the load. The principle components of a hydraulic brake are the master or control cylinder, the slave or actuating cylinder, and the frame components, which provide support for the brake shoes and adjusters around the wheel. Hydraulic brakes usually have a reservoir that provides a balance of system static pressure to the actuating cylinder as well as bleeding capabilities.

HYDRAULIC MULTIPLICATION OF FORCE

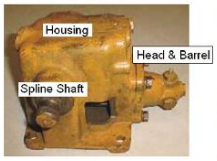
The basic idea behind any hydraulic system is very simple. Force that is applied at one point is transmitted to another point using an incompressible fluid. Hydraulic multiplication of force is the mechanical advantage gained by the difference in size of one piston and cylinder relative to the other, as shown in this illustration. By applying a force of 5 pounds to piston A which has an area of 2 square inches, we are able to exert a force of 100 pounds on piston B which has an area of 10 square inches. If piston B is



made larger, the resulting force will increase, or if piston A is made smaller, the pressure in the liquid will be greater, and the force acting on piston B be will be increased. Most hydraulic systems are designed to multiply force or increase mechanical advantage. For this reason, the size of a control or actuating cylinder should not be changed, as it will change the application force of the brake. A change of this nature, in a crane's hydraulic brake system, would constitute an alteration of the crane and shall not be performed without approval of the Navy Crane Center.

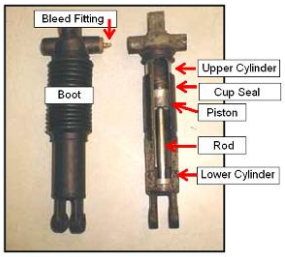
CONTROL (MASTER) CYLINDER

This is an example of a “Wagner” control cylinder often used on cranes. The interior of this control cylinder unit contains a cylinder with an internal piston. This is called the head and barrel assembly. Inside the head and barrel assembly, a cup seal is pushed by a piston. There is a return spring between the cup seal and the bottom of the cylinder. There may also be a check valve at the bottom of the cylinder, which works with the return spring to keep a slight pressure in the lines. This pressure keeps the fluid in the lines when the actuating (or slave) cylinder is located higher than the control cylinder. The interior of the control cylinder may serve as a reservoir, or a remote reservoir may be attached. When a remote reservoir is used, a non-vented cap must be used on the control cylinder.



ACTUATING (SLAVE) CYLINDER

This is an example of a “Wagner” actuating (or slave) cylinder. The component parts are the upper and lower cylinders, the piston-cup and rod assembly, and a rubber boot. The base of the piston assembly rests in the outer cylinder, while the piston-cup is contained in the upper cylinder. When fluid enters the actuating cylinder, it fills the area inside the upper cylinder above the piston-cup. As the volume of fluid increases, the upper piston is forced upward, which in turn applies force to the brake arm. There is a weep hole drilled in the bottom of the lower cylinder in case there is minor leakage past the cup seal. The weep hole allows the brake fluid to escape.

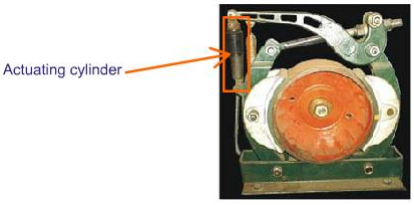


HYDRAULIC BRAKE UNIT

The hydraulic brake unit is manufactured in different sizes for different applications. Typical wheel sizes range from 6 to 18 inches. The unit is self-centering, but not self-equalizing. This means that when the brake is applied the force will be applied equally to both shoes, but they will not necessarily retract an equal distance from the wheel.

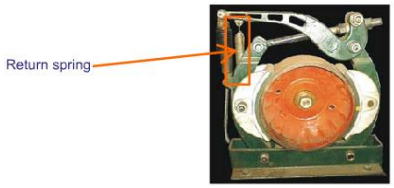
Hydraulic Brake Unit

The hydraulic wheel brake consists of the following basic parts. This illustration shows the location of the actuating cylinder. The actuating cylinder turns the hydraulic pressure and flow into mechanical force to operate the brake.



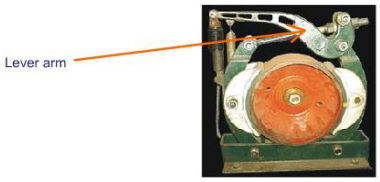
Hydraulic Brake Unit

The return spring pulls the lever arm back down to its “at rest” position when the pressure is released from the actuating cylinder.



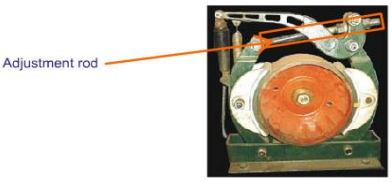
Hydraulic Brake Unit

The lever arm multiplies the force exerted by the actuating cylinder and equalizes the force between the two shoes.



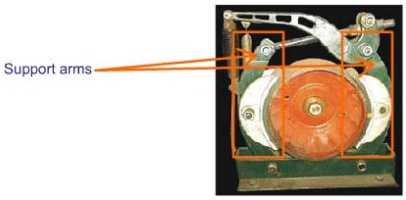
Hydraulic Brake Unit

The adjustment rod is used to adjust the clearance between the brake shoe and the wheel.



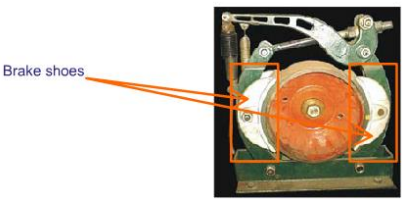
Hydraulic Brake Unit

The support arms support the brake shoes and are hinged at the bottom by pins which run through the brake assembly foundation.



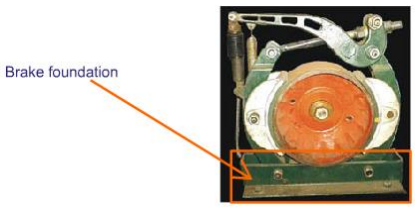
Hydraulic Brake Unit

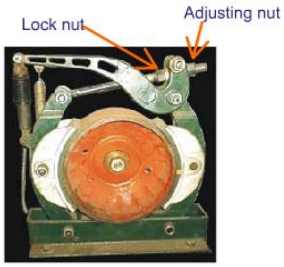
The brake shoes are hinged on the support arms and have the brake lining either riveted or bonded to them.



Hydraulic Brake Unit

The brake foundation supports the remainder of the stationary components of the brake. The brake foundation is bolted to the crane’s hoist foundation, and must be aligned in such a manner as to center the shoes in relation to the wheel.





HYDRAULIC BRAKE ADJUSTMENTS

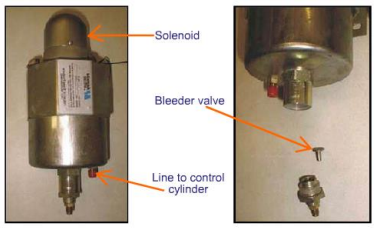
This type of hydraulic brake is adjusted using the following procedure: Loosen the lock-nut and turn the adjusting nut clockwise until the shoes contact the wheel. Loosen the adjusting nut approximately 3 full turns, or until the shoe clearance is at specifications. Then tighten the lock-nut and recheck the clearance.

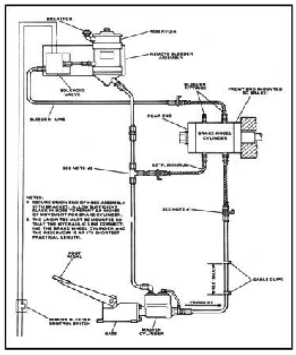
FLUID RESERVOIR/BLEEDER

The fluid reservoir provides storage for the fluid in the system and, when equipped with a remote bleed control, gives the crane operator the capability to bleed the brake system as necessary. Care must be taken to install the reservoir at least 14” above the next highest component in the brake system. After a hydraulic brake system has been repaired, the system is refilled using the fluid reservoir. When bleeding the system using a remote bleed control, always activate the bleed control button before applying pressure to the brake pedal. In this way the system does not build up pressure that the solenoid would have to overcome.

FLUID RESERVOIR/BLEEDER

To use the bleeder function, the operator must press the bleed button first. This energizes the solenoid on top of the reservoir and opens the bleed valve on the bottom. While keeping the bleed button depressed, the operator may then pump the brake pedal which forces unwanted air in the system back to the reservoir, where it can vent out. The label on the side of the reservoir gives the voltage rating of the solenoid. When servicing, assure the voltage on the label plate and the crane voltage match. When filling the reservoir, do not fill it all the way to the top, as changes in temperature may cause the fluid to expand and leak out of the vent cap.



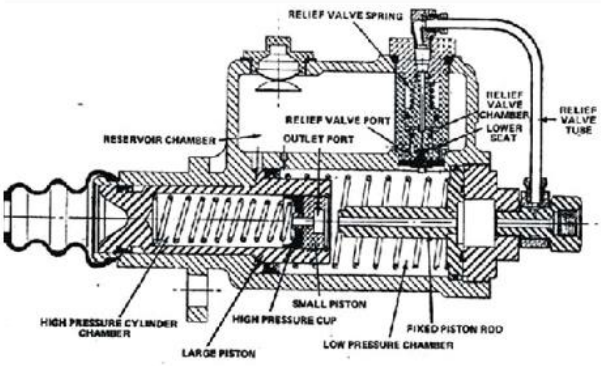


P & H Type Hydraulic Brake System

The P & H hydraulic brake is plumbed in a similar fashion to the Wagner System. The bleed valve in this system is outside of the reservoir. This plumbing arrangement provides brake fluid to the back of the cylinder which keeps the system lubricated, reduces contamination, and keeps air out of the system.

P & H Type Hydraulic Brake System

The P&H type hydraulic brakes use a different style of control cylinder from the Wagner unit. In this type there are two pistons inside each control cylinder. One piston moves enough fluid at low pressure to set the brake shoes against the wheel, and another, smaller, high pressure piston which provides the actual brake application force. This arrangement produces a slightly mushy pedal feel in the first portion of the stroke which should not be misinterpreted as air in the brake line. On the receiving end of this system, the actuating (or slave) cylinder consists of a double rod piston in a cylinder housing. The piston utilizes a “T” seal and O-ring seal on the rods and caps. The back section is filled with hydraulic fluid from the reservoir, keeping the cylinder lubricated and air out of the system.



Hydraulic Brake System Precautions

When filling a hydraulic brake system, use only clean, fresh fluid. Brake fluid attracts moisture, so it is good practice to only open a container of fluid of a size where you will be using the entire amount. It is not a good idea to use fluid that has been stored for long periods of time. When repairing hydraulic brake systems never use petroleum-based solvents for cleaning components as these may cause permanent damage to vital parts. Use only clean brake fluid for cleaning components. Isopropyl alcohol may be used if the components are completely disassembled and can be dried. When assembling brake cylinders, all parts should be coated with clean brake fluid.

NOTES

BRAKES 1 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. What is the first action to take before starting work on a crane brake?

A. make sure load is in a safe condition
B. start the job
C. be sure you have authorizing paperwork
D. make sure the function is locked out and tagged out
E. get proper tools

2. What is the second action to take before starting work on a crane brake?

A. be sure you have authorizing paperwork
B. get proper tools
C. make sure the function is locked out and tagged out
D. make sure load is in a safe condition
E. start the job

3. What is the third action to take before starting work on a crane brake?

A. start the job
B. be sure you have authorizing paperwork
C. make sure the function is locked out and tagged out
D. make sure load is in a safe condition
E. get proper tools

4. What is the fourth action to take before starting work on a crane brake?

A. make sure the function is locked out and tagged out
B. be sure you have authorizing paperwork
C. get proper tools
D. start the job
E. make sure load is in a safe condition

5. The operator's pedal _____ should be checked to make sure it is not too high or too low.

A. leverage
B. clearance
C. height
D. drag

6. The brake band should not _____ on the brake wheel.

A. adjust
B. drag
C. fit
D. leverage

7. Only petroleum-based solvents should be used to clean brake cylinder components.

A. True
B. False

8. Brake bands should be stored on their edge to prevent warping.

A. True
B. False

9. After adjustment, the brake pedal may go to the floor as long as the crane operator is comfortable.

A. True
B. False

10. What does the control (master) cylinder do in a hydraulic brake system?

A. applies the brake
B. converts mechanical force into hydraulic flow and pressure
C. controls the amount of force applied to the brake
D. if performs all listed functions

11. An important consideration in adjusting mechanical band brakes is whether or not the brake _____ the load.

A. drags
B. adjusts
C. fits
D. holds

12. Rivet depth is an important consideration.

A. True
B. False

13. A band brake will safely hold a load with almost no lining to wheel contact.

A. True
B. False

14. An important consideration in adjusting a mechanical band brake is the band _____ around the wheel.

A. height
B. clearance
C. drag
D. interference

BRAKES 2

HOLDING BRAKES

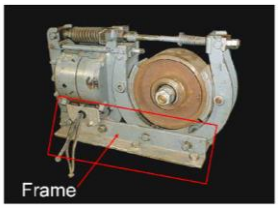
Control brakes are the brakes that control the speed of the load. This module will cover holding brakes, which play a different role on the crane. When the crane is not hoisting or lowering, holding brakes hold the load in position. This is a very important consideration, as any adjustments made on the brake without making sure that the load is supported may cause a suspended load or crane boom to drop. Holding brakes are spring applied and remain set unless the function they are associated with is engaged, and then are electro-magnetically released. Holding brakes are either open or closed, and not used for load control purposes.

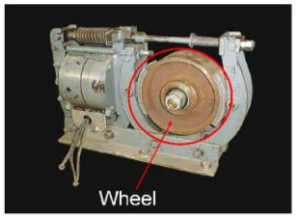
ELECTROMAGNETIC SHOE BRAKES

One type of holding brake commonly found on cranes is the electro-magnetic shoe type brake. There are many designs of electro-magnetic wheel brakes, but most are of a similar design and adjust in a similar fashion. Although this illustration shows a Magnetek brake, the components will be very similar on other electric brakes.

Electromagnet Shoe Brakes

The following screens illustrate the principle components of a spring applied, electro-magnetically released wheel brake. This illustration shows the frame which supports the brake assembly components and secures them in the correct relationship to the wheel. The brake frame assembly is bolted to the crane's hoist foundation.



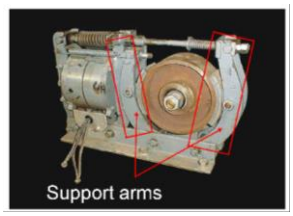


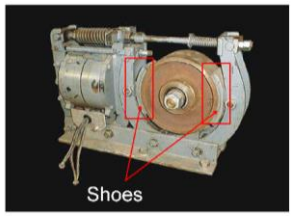
Electromagnet Shoe Brakes

The brake assembly's wheel is mounted to the motor or gearbox shaft and provides the surface on which the brake shoes contact. The wheel is designed to dissipate normally occurring heat which is generated from friction.

Electromagnet Shoe Brakes

The support arms position the brake shoes in the correct relationship to the wheel. In addition, they serve as levers to increase the clamping force when the brake is applied.



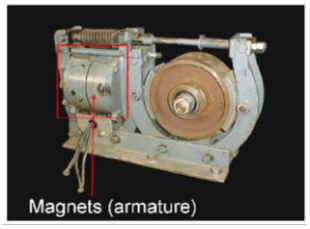


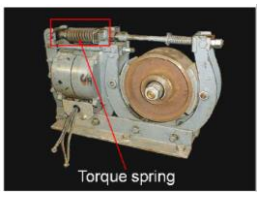
Electromagnet Shoe Brakes

The brake shoes are an vital part of the braking system. When the brake is applied, the brake shoe is the part that contacts the wheel and prevents it from rotating. The backing of the brake shoe is a metal part, but the area that actually comes in contact with the brake is lined to provide the necessary friction to stop and hold the movement of the wheel. The brake lining may be riveted, bonded or attached by mechanical means to the shoes.

Electromagnet Shoe Brakes

This illustration shows the location of the electro-magnets or armature on an electro-magnetic holding brake. When the magnets are energized, they overcome the force of the torque spring and cause the shoes to disengage from the wheel. The magnets are rated for their electrical voltage. This rating should be verified if installing new magnets.



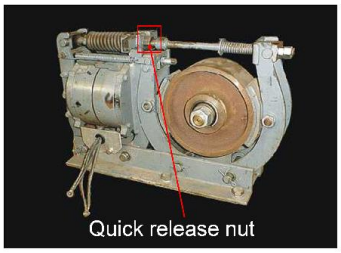


Electromagnet Shoe Brakes

This illustration shows the location of the torque spring. When the magnet is de-energized, the torque spring provides the clamping force for the brake, preventing rotation of the wheel.

Electromagnet Shoe Brakes

The brake data plate is located on the back of the armature and contains information on the brake such as the serial number and the frame size. The data plate also contains information valuable to the crane mechanic such as: the voltage rating of the brake, the torque required to set the brake, and the length at which the torque spring must be set to achieve specified torque.



Electromagnet Shoe Brakes

This illustration shows the location of the quick release nut. The quick release nut is used to release the brake manually. The nut should be tightened against its stop when not in use so that it does not back off and prevent the brake from applying. Other designs of this type of brake may use levers or other mechanisms for manual release.

ELECTRIC SHOE BRAKE ADJUSTMENTS

Due to the many different styles of electric shoe brakes, there is potential for confusion as to which adjustment points are associated with the corresponding brake part. The important thing to remember is that on brakes of this type, there are three basic adjustments: the torque spring, the armature gap, and the shoe equalization. The shoe equalization adjustment ensures the shoes will clear the wheel by an equal distance.

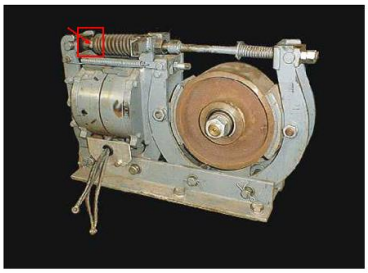
Adjusting the amount of pre-load on the torque spring affects how tightly the brake shoes clamp to the wheel. Adjusting the armature directly affects how much space there is between the magnets which, when energized, compresses the torque spring. This adjustment controls how far the shoes will move away from the wheel when the magnets come together and will change as the brake linings wear. If a need for adjustment is discovered while the adjustment is still within the limits, it may be brought down to minimum specs without necessitating a load test. When re-adjusting hoist brakes to within their established range or tolerance, when they are outside the established range or tolerance, load testing is not required providing all of the conditions found in NAVFAC P-307 3.4.2.2.2 have been met.

ADJUSTING MAGNETEK TYPE TM

The Magnetek (formally Westinghouse) TM brake is a common brake type found on cranes. In the following screens we will go through the basic adjustment procedures for the Magnetek brake and compare them to another common type of crane brake.

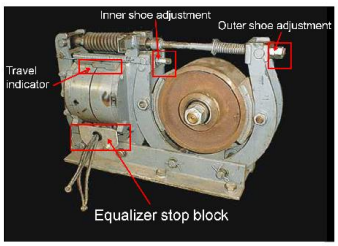
TORQUE SPRING ADJUSTING NUT

Adjusting the torque spring is an important step in brake adjustment. The torque spring will normally only need an occasional adjustment, but its length must be verified every time the armature gap is reset. The proper torque spring length setting may be determined by reading the manufacturer's documentation for the crane, or if not available, the data plate on the back of the armature may be consulted. The torque spring is adjusted by turning the adjusting nut until the length of spring reaches the specified value. The spring length is normally measured with a machinists scale. Be aware that over time these springs may gradually weaken and, although adjusted within specifications, may not provide the specified torque value. If the brake fails to hold after adjusting to specifications, the condition of the torque spring should be closely examined.



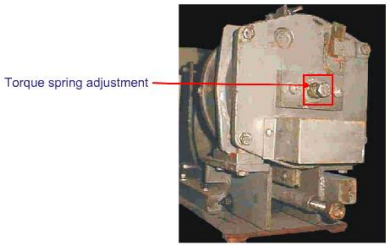
ARMATURE GAP

The adjustment of the armature gap, or shoe clearance must be periodically performed to compensate for brake shoe wear. The inner and outer shoe adjustments should be set so that the gap between the tops of the magnets corresponds to the brake data sheet. The two shoes should be adjusted so that the gap between the magnets is centered above the equalizer stop block. The travel indicator shows the mechanic or crane operator when the linings are worn to the point where re-adjustment is needed. When the ends of the indicator plates line up, the maximum gap has been reached, indicating re-adjustment is due. The brake equalization process is complete when both shoes have been equally adjusted to specifications.



ADJUSTING THE GE 9528

The GE 9528 brake unit is commonly found in bridge (or overhead) crane applications. When adjusting this brake, the same three points we discussed previously are being checked, but the adjustments are carried out in a different manner from the Magnetek brake.

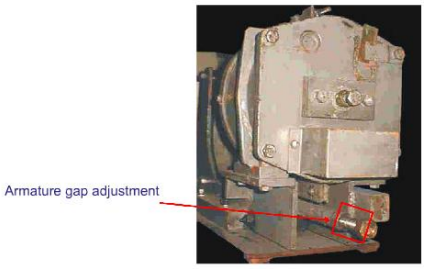


Adjusting the GE 9528

The torque spring for the GE 9528 brake is enclosed in the armature and the adjustment bolt is threaded into a plate on the back of the armature housing. The adjustment is made by loosening the lock-nut and turning the adjustment bolt until the bottom of the bolt head is the prescribed distance from the plate.

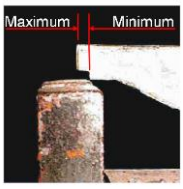
Adjusting the GE 9528

The armature gap is adjusted using the adjustment hex indicated in the illustration. Loosen the lock-nut and then turn the adjustment hex until the armature gap indicator is lined up with the minimum mark. It is important to remember that prior to adjusting the armature gap, the equalization adjustment must be loose before this adjustment is made.



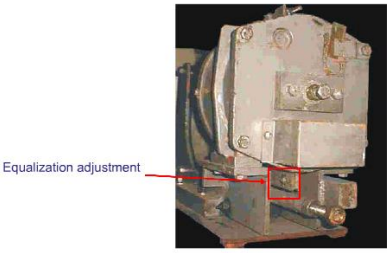
Adjusting the GE 9528

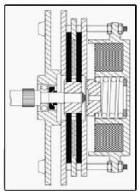
The armature gap indicator on the GE 9528 brake is located on the top of the armature coil and indicates the range of acceptable armature adjustments. As shown in the illustration, the minimum indicator is in line with the lug in the slide and the maximum indicator is the end of the indicator plate. Load testing is not required when re-adjusting the setting within its established range or tolerance, provided all conditions outlined in NAVFAC P-307, paragraph 3.4.2.2.2 are met.



Adjusting the GE 9528

The equalization adjustment is normally performed by loosening the bolt which holds the two equalization plates together and then adjusting the armature gap. Once the armature gap is adjusted, then, the bolt on the equalization plates is tightened. The brake should then be operated electrically to insure that there is an equal gap between the shoe and the wheel on both sides. If the gap is not equal, then the equalization plates must be moved to equalize the distance. This adjustment will not necessitate a load test.

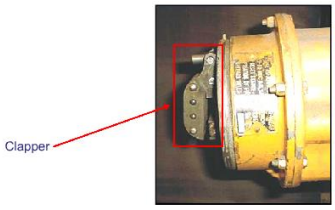




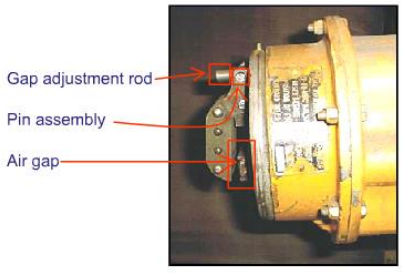
Multiple Disc Brakes

Multiple disc brakes are generally found on category 2 and 3 cranes and are found in two configurations, lever-fulcrum and direct operating.

Lever Fulcrum Brake



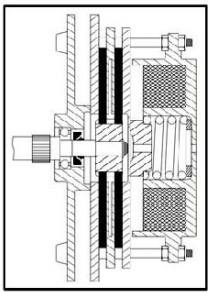
The lever fulcrum type multiple disc brake utilizes a series of levers which override a spring to release the brake. In the de-energized or set position, spring pressure against a lever bears on the brake plate, keeping the brake set. When the brake is energized, the clapper is pulled against the coil by magnetic force which pushes a plunger, compressing the spring, which releases the brake.



Lever/Fulcrum Brake Adjustments

Adjusting the lever fulcrum multiple disc brake is a fairly simple process. The primary adjustment on the brake is the air gap. The adjustment is made by removing the pin, shown in the illustration, then turning the adjusting screw until the proper air gap is established between the clapper and the coil. The adjusting screw can only be locked in place at 180° increments so the adjustment will be made as close to the minimum gap as possible, but never less than the minimum gap dimension. The air gap adjustment specification can be found on the brake data plate or in the equipment history file.

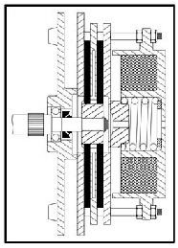
Lever/Fulcrum Brake Adjustments



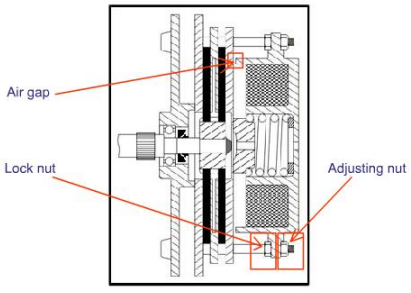
This diagram shows a direct operation, multiple disc brake. In this type brake, the magnet pulls against a spring loaded pressure plate which bears directly against the other brake plates and keeps them from turning.

Direct-Operation Brake Adjustments

The procedure for adjusting the direct operation brake is much different from the lever-fulcrum brake. The primary adjustment on a direct operation brake is the air gap. The air gap is adjusted by moving the magnet (which is supported by 3 studs) in relation to the pressure plate. The adjustment points are next to each support stud for the coil housing and the measurement is made between the magnet and the pressure plate at each of the three adjustment points. The gap should be measured with feeler gauges and all measurements should be equal. Let's take a closer look at how to do these steps.



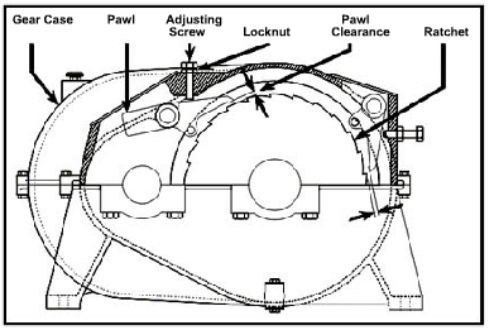
Adjustment Points for the Direct Acting Multiple Disc Brake



This diagram shows the adjustment points for the direct acting multiple disc brake. To make the adjustment the lock nut must be backed off before the adjusting nut is turned. To provide the correct air gap between the coil housing and the top plate, the measurement should be made next to each stud and should be equal at all three points.

MECHANICAL LOAD BRAKE

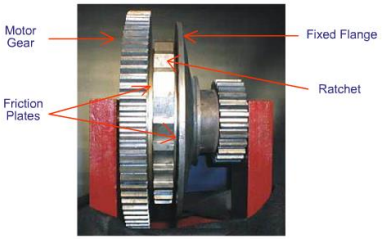
The mechanical load brake is contained within the hoist gear box of many AC powered bridge cranes. After the load has been hoisted, the load brake is designed to support the weight of the load. It is also designed to control the speed of load lowering. While

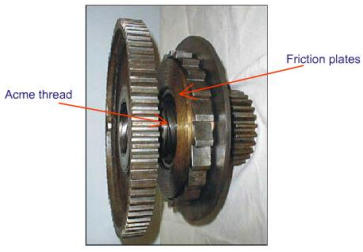


designs may vary, the brakes work on a similar principle. Two or more friction surfaces are held tightly together when a load is lifted by the action of a screw (helix) or an inclined plane. This type of brake commonly uses a ratchet and pawl mechanism or a sprag clutch for holding the centermost friction plate stationary when the load is lowered.

MAIN SECTION OF MECHANICAL LOAD BRAKE

This illustration shows the main section of a mechanical load brake. The main components consist of a threaded shaft with a fixed flange, a motor gear with a threaded bore, a ratchet with friction linings on each side, and spring loaded pawls that are mounted in the gear case.





MAIN SECTION OF MECHANICAL LOAD BRAKE: MOTOR GEAR

This illustration shows a close up view of the motor gear, the ratchet plate and the flange, with the friction discs in between. For clarity, the brake unit has been backed off to show the large acme thread that connects the two outer pieces.

LOAD BRAKE OPERATION

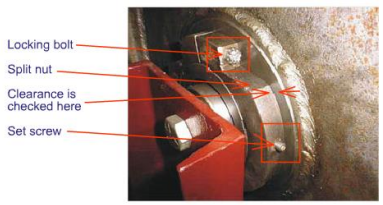
The operation of the load brake is as follows. When the hoist is energized in the “raise direction”, the motor shaft turns and, through the action of the helix, screws the friction plates together. This causes the entire assembly to turn past the ratchet pawls as the crane’s load is raised. When the upward motion is stopped, the weight of the load turns the assembly in the opposite direction allowing the ratchet pawls to engage the ratchet teeth, preventing the load from lowering. The weight of the suspended load keeps pressure on the friction plates. When the hoist is energized in the “lower” direction, the motor pinion turns the motor gear on the helix, unscrewing the frictions, allowing the load to lower. The ratchet plate will still be held by the pawls when the load is lowering. If the speed of the load tends to exceed the speed of the motor, the action of the frictions will slow the load. During lowering, the weight of the load will attempt to screw the frictions together and the motor will be trying to screw them apart, effectively assisting the controlled lowering of the load. For this reason it is normal for heat to be generated while lowering the hoist, and a higher current draw in the motor may be detected in the “lower” direction.

ADJUSTMENTS TO LOAD BRAKES

There are two basic adjustments to the mechanical load brake. The first is the clearance between the friction plates. This is usually a very minimal clearance and just sufficient to let the plates slip through but not so much that the plates come together too tightly when the load is lifted. The second adjustment only applies to those larger mechanical load brakes with the ratchet and pawl assemblies. The pawls must be adjusted so that they just clear the ratchet without hitting it. If the pawls can be heard when the load is being lifted, the adjustment is too tight or the bushings in the pawl may be worn. This applies to the helix type only. No adjustment is required for inclined type load brakes.

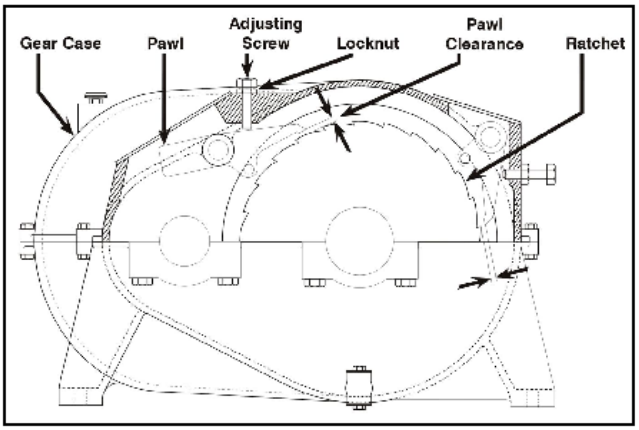
ADJUSTING DISC CLEARANCE

To adjust the disc clearance, the locking bolt, shown in the illustration, must be loosened, then the clearance between the friction discs and the plates may be adjusted by turning the split nut. There is a set screw that tightens into a notch on the shaft that must be backed off before the split nut may be turned. Adjustment is accomplished by backing off the split nut and checking the clearance between the nut and the motor gear. There must be sufficient clearance so that the plates can unscrew when the motor is turning in the “lower” direction, but not so much that when they screw back together the force will lock them together.



PAWL ADJUSTMENT

Pawl adjustment is accomplished by first loosening the adjusting screw lock-nut. Carefully operate the hoist in the raising direction and slowly turn the adjusting screw counterclockwise until the clicking sound stops. Stop the hoist and turn the adjusting screw an additional one-half turn then tighten the adjusting screw lock-nut. Repeat these steps on the other pawl. Check the lowering motion to be sure the pawls engage the ratchet firmly at the start of the lowering motion. If the pawls noisily hammer into the ratchet teeth, the clearance is excessive and should be re-adjusted.



NOTES

BRAKES 2 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. Holding brakes cannot be used to _____ the speed of the load.

A. control
B. release
C. open
D. stop

2. Mechanical load brakes _____ the load after it is hoisted.

A. speed
B. stop
C. control
D. hold

3. The primary adjustment on a multiple disc brake is the _____.

A. spring length
B. equalization
C. air gap
D. armature gap

4. The adjustment made to electric brakes, which determines if shoes apply evenly, is _____.

A. armature gap
B. air gap
C. spring length
D. equalization

5. Load brakes may use a helix or a(n) _____ to separate the friction plates.

A. inclined plane
B. armature gap
C. watchet
D. Belleville washers

6. The adjustment made to electric wheel brakes, which controls shoe clearance and is affected by lining wear is _____.

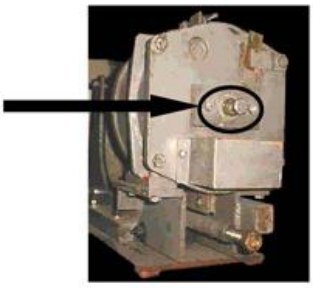
A. equalization
B. spring length
C. speed
D. armature gap

7. A _____ or sprag clutch may be used to allow the main section of the mechanical load brake to rotate in raised direction, and hold when stopped.

A. inclined plane
B. torque spring
C. ratchet
D. control

8. Turning the bolt identified on the brake in the photo adjusts the _____.

A. spring length
B. torque spring
C. air gap
D. armature gap



9. The adjustment made to electric brakes, which controls the clamping force of the brake, is _____.

A. torque spring
B. armature gap
C. air gap
D. Belleville washers

10. Mechanical load brakes control the _____ of the load when it is being lowered.

A. equalization
B. speed
C. spring length
D. air gap

11. When the hoist is not running, the electric brakes on that function are normally _____.

A. closed
B. open
C. equalized
D. released

BRAKES 3

BRAKE LINING PREPARATION

In order for the crane's brake linings to function at their optimum, the radius or "arc" of the lining must match the radius of its counterpart, the brake wheel. This matching process is called "arcing the brake lining". For smaller units, arcing may be done by a special machine at a brake service facility, but on large brake assemblies, the final fit up is commonly performed manually on the brake being serviced. When installing new brake shoes or having the old shoes relined, do not assume that the arc of the lining will accurately fit the arc of the wheel. The fit can be checked by installing the shoes, applying the brake several times, and then removing the shoes or opening the brake so that the lining may be examined. For proper brake operation, the lining contact should be in the range of 75% to 80% on shoe type brakes, and 85 to 90% on band type brakes. Increased contact results in increased frictional surface and better heat dissipation.

LINING CONTACT

When examining brake linings check to verify the contact area is spread across the full length of the shoe. There should not be any large areas having no contact. Effectively dissipating the heat that is normally developed by the action of the brake is dependent on full and equal contact between the brake wheel and the linings. If the arc of the brake lining does not match the arc of the wheel, it will result in a smaller area of contact in a section of the lining, overheating of the lining and, if not remedied, a reduction in brake performance. Many of the new synthetic lining materials are susceptible to burning, so it is important that the arcing be performed correctly. The final determination as to whether a brake lining has adequate contact area is the brake's ability to support a test load. Keep in mind that there are other factors such as the force exerted by the torque spring which can also affect the brake's performance.

ARCHING METHODS

There are several ways to match the arc of the linings to the wheel. One method is to have the shoe arced on a specialized machine. Although this option gives a very good result, few machine shops are equipped to handle crane brake shoes, making this solution somewhat limited. Another effective method is to glue non-skid abrasive pads (of the type used for stair steps) to the brake wheel then operate the function at a slow speed while carefully pushing on the brake arm. This method will effectively abrade down any high spots, resulting in the arc of the brake lining closely matching that of the wheel. This method also requires frequent checking to avoid removing too much material. Be aware that with the non-skid on the wheel, it's diameter will be slightly larger so the arcing will not be exact. Hand filing or sanding may be used on shoes when only small amounts need to be removed. After assembly, if the arc of the linings is very close to that of the wheel, the brake may be simply "run in" or operated with no load taking care not to overheat the linings, which may cause glazing or burning.

BRAKE LUBRICATION

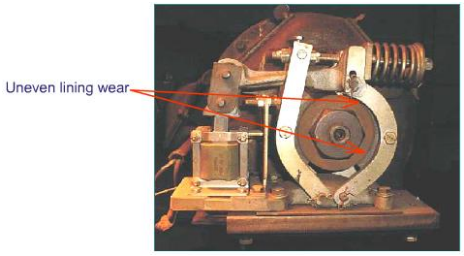
Due to the number of pins and bushings found on most crane brakes, lubrication is an essential part of brake maintenance. If the moving parts are not lubricated, they will rapidly wear and may seize up. In one circumstance, a floating crane in San Diego experienced a boom hoist failure as a result of lack of lubrication of the pins on the bottom of the brake band. The pins seized up and the brake would not actuate. On brake applications, too much lubrication can be detrimental. Excessive lubrication may result in contamination of the wheel and brake linings resulting in a brake failure. When greasing fittings on brakes, always wipe up any excess that may come out around the pins. It is good practice to check for (and clean up) any excess grease after the crane has been operating.

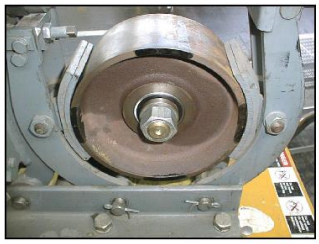
BRAKE INSTALLATION

When installing a brake shoe assembly, it must be centered both vertically and horizontally around the brake wheel. To accomplish this, the crane mechanic should scribe a horizontal and vertical centerline on the wheel which will be used to facilitate accurate alignment. Many brake units will have a center mark on the brake foundation. In some cases, OEM instructions may be available specifying a procedure for establishing centers. If no instructions exist, the center of the shoe pivots may be used for the vertical center line. The horizontal center line may be established by measuring half the distance between the support arm pivots. The shoes must be centered so that there is no overhang of the brake linings on either side of the wheel. When working with brake units on direct current motors, be aware that, when energized, the position of the motor shaft will shift slightly making it important to ensure the brake shoes are centered on the wheel.

IMPROPER MOUNTING

This is an example of a brake lining that has become unevenly worn as a result of improper alignment at the time of assembly. Just replacing the lining will not remedy this problem. In this situation, replacing the brake linings and then accurately centering the brake shoe assembly around the shaft would be the only acceptable repair.





CENTERING THE BRAKE ASSEMBLY

When the wheel is installed on the shaft, the center can be determined by using a straight edge across the center of the shoe pivot bolts to establish the vertical center line. The horizontal center may be determined using a plumb line at a point exactly half way between the two shoe pivot pins.

NOTES

BRAKES 3 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. Band-type brakes generally require _____.

A. less lining surface contact than shoe-type brakes
B. absolutely no lining surface contact
C. about the same lining surface contact than shoe-type brakes
D. more lining surface contact that shoe-type brakes

2. Brake pins should be lubricated, but all excess must be wiped up.

A. True
B. False

3. If linings are worn unevenly, replacing them will fix the problem.

A. True
B. False

4. The contact area on the lining should be _____.

A. spread evenly along the whole surface of the lining
B. mostly around the edges of the lining
C. concentrated in the middle of the lining

5. It doesn't matter if the shoe overhangs the wheel somewhat.

A. True
B. False

6. A brake should be centered horizontally as well as vertically to the wheel.

A. True
B. False

7. What should the final criteria be when testing lining contact?

A. Is the test director satisfied?
B. Is the inspector satisfied?
C. Are you satisfied?
D. Does the brake hold the load?

8. The minimum shoe contact for a shoe-type brake should be _____.

A. 75%
B. 100%
C. 50%
D. 60%

9. Even if brakes are never lubricated, they will still work fine.

A. True
B. False

BRAKES 4

NAVFAC P-307 Requirements for Maintenance Inspection

When performing brake maintenance, the minimum inspection requirements can be found in NAVFAC P-307, appendices C and D. Some makes and models of cranes in the Navy inventory with unique or special components, may require additional instructions. For items not identified in these specifications, the individual activities shall develop appropriate inspection criteria. Components need not be disassembled for inspection, except where specifically noted to disassemble, activity experience warrants disassembly of specific components, or where problems indicated by these inspections require disassembly for further inspection. Reducing or deleting the frequency of inspections requires Navy Crane Center approval and justification for the request. Additional or more frequent inspections based upon activity experience or OEM recommendations may be performed at the discretion of the activity. Where necessary, to ensure the safety of inspection and maintenance personnel, the crane shall be de-energized in accordance with approved lockout/tag-out procedures.

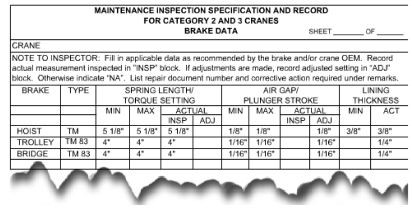
NAVFAC P-307 Inspection Requirements

For inspections involving fluids, such as brake fluids hydraulic fluid, or grease, inspect the visual appearance, smell, and feel of the fluid for indications of damaged or malfunctioning components. Where an unsatisfactory condition is found, the item shall be identified, with a statement of the condition observed, on the maintenance inspection specification and record "unsatisfactory items" sheet. Corrective action in terms of adjustments, repairs, or replacements of items shall be detailed on a shop repair order or other appropriate document.

NAVFAC P-307 Inspection Requirements

Brake data measurements shall be recorded on the brake data sheet, which will become part of the equipment history file. If measurements are inaccessible without disassembly, those measurements need only be taken when the brake is disassembled. Where other measurements are specified or required for acceptance, these measurements shall be recorded on the brake data sheet. When an inspection item applies to multiple components, each component shall be identified in the ”system inspected" column.

NAVFAC P-307 Inspection Requirements



MAINTENANCE INSPECTION SPECIFICATION AND RECORD
FOR CATEGORY 2 AND 3 CRANES
BRAKE DATA

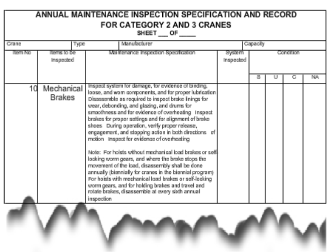
SHEET ______ OF ______

CRANE

NOTE TO INSPECTOR: Fill in applicable data as recommended by the brake and/or crane OEM. Record actual measurement inspected in "INSP" block. If adjustments are made, record adjusted setting in "ADJ" block. Otherwise indicate "NA". List repair document number and corrective action required under remarks.

BRAKE	TYPE	SPRING LENGTH/ TORQUE SETTING				AIR GAP/ PLUNGER STROKE				LINING THICKNESS	
		MIN	MAX	ACTUAL		MIN	MAX	ACTUAL		MIN	ACT
				INSP	ADJ			INSP	ADJ		
HOIST	TM	5 1/8"	5 1/8"	5 1/8"		1/8"	1/8"		1/8"	3/8"	3/8"
TROLLEY	TM 83	4"	4"	4"		1/16"	1/16"		1/16"		1/4"
BRIDGE	TM 83	4"	4"	4"		1/16"	1/16"		1/16"		1/4"

The data sheet should list minimum and maximum adjustments, and the actual adjustment of the brake. Measurement attributes and criteria shall be based on the brake and/or crane manufacturer's recommendations as well as any activity engineering organization recommendations. Where measurements are specified by the activity engineering organization, these measurements shall be recorded. In addition to minimum and maximum settings, a preferred setting shall be specified where appropriate. Where measurements are inaccessible without disassembly, those measurements need only be taken when the brake is disassembled. A "remarks page" is provided to with the brake data sheet to record any additional information.



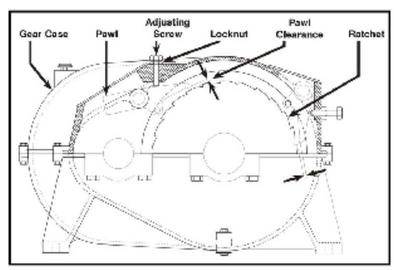
ANNUAL MAINTENANCE INSPECTION SPECIFICATION AND RECORD
FOR CATEGORY 2 AND 3 CRANES
SHEET ___ OF _____

Crane	Type	Manufacturer	Capacity

Item No	Items to be Inspected	Maintenance Inspection Specification	System Inspected	Condition			
				S	U	C	NA
10	Mechanical Brakes	Inspect system for damage, for evidence of binding, loose, and worn components, and for proper lubrication Disassemble as required to inspect brake linings for wear, debonding, and glazing, and drums for smoothness and for evidence of overheating Inspect brakes for proper settings and for alignment of brake shoes During operation, verify proper release, engagement, and stopping action in both directions of motion Inspect for evidence of overheating Note: For hoists without mechanical load brakes or self-locking worm gears, and where the brake stops the movement of the load, disassembly shall be done annually (biennially for cranes in the biennial program) For hoists with mechanical load brakes or self-locking worm gears, and for holding brakes and travel and rotate brakes, disassemble at every sixth annual inspection					

Annual Maintenance Inspection Specification and Record

This is an example of the Annual Maintenance Inspection Specification and Record form that you will use when performing category 2 and 3 crane inspections. In each section, a component or system is named, along with the types of inspections and verifications that must be made. Remember that these instructions are minimum requirements, so none of them should be omitted or disregarded. In the following screens, we will review the types of brakes along with the inspection requirements for each one as well as examples of specific check points.



Mechanical Load Brakes

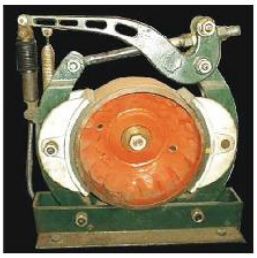
The first brake covered in the maintenance inspection specification and record forms is the mechanical load brake. The following attributes shall be inspected. Ensure proper type of lubricant is used and note any indication of leakage around gearbox seams or shaft seals. Check the appearance of the lubrication oil for signs of contamination and that it is up to the proper level. While the hoist is in operation, inspect for abnormal noise, chattering, vibration, overheating, or other evidence of misaligned, worn, or damaged internal components. When checking the gearbox for overheating, be aware that as the brake functions, it is normal that a certain amount of heat will be present. Abnormal heat found in the bearing housing area would call for closer inspection. For mechanical load brakes that cannot be tested independently, disassemble at every tenth annual inspection and inspect for damage and deterioration.

MECHANICAL WHEEL BRAKES

The next brake type on our list is the mechanical wheel brake. Mechanical wheel brakes should be inspected for damage, loose or worn components, and for proper lubrication. Since this type of brake is manually applied, the crane mechanic should ensure the brake functions in a smooth and normal manner without any binding or need for excessive force by the operator. In some cases, brake assemblies must be disassembled to inspect linings for wear, de-bonding, or glazing. Brake drum surfaces should be inspected for smoothness and for evidence of overheating. The proper alignment of brake shoes and adjustment settings should be verified. Inspect brake linings for significant wear, which may cause rivets to contact the wheel, and uneven wear, which can be a symptom of improper mounting, worn parts, or improper adjustments.

OPERATIONAL TEST

Brakes need to be inspected when they are operating as well as inactive. During operation verify proper release, full engagement, and stopping action in both directions Allow the brake to get to full operating temperature by making a series of applications. After the brake is exercised and up to full operating temperature, recheck the clearances and verify that the brake does not overheat. Be aware that brake wheels expands as the brake assembly warms up. As a result of this expansion, the clearances will be reduced necessitating a check to verify there is no unwanted lining contact with the wheel.



HYDRAULIC BRAKE SYSTEM

Hydraulic brake systems are inspected for many of the same attributes as the mechanical brakes. The hydraulic brake system must be inspected for damage, evidence of binding, loose or worn components, correct alignment and proper lubrication. The brake settings must be checked to verify they are within the manufacturer's or locally developed specifications. The alignment of the brake shoes to the wheel should be verified and there should be no shoe overhang. The hydraulic master cylinder or reservoir should be checked for proper fluid level. All hydraulic lines should be checked for damage, leakage or loose connections. If the brake uses rubber lines, these should be checked for cracking or signs of deterioration. Disassemble as required to inspect brake linings for wear, debonding, and glazing.

Drums must be checked for smoothness and for evidence of overheating. During operation, verify proper release, engagement, and stopping action in both directions of motion as well as evidence of overheating.

AIR BRAKE SYSTEMS

Air brake systems should have all of the same checks as the previous types of brakes. In addition, they should be checked for damage to air lines and evidence of leaks or loose fittings. During operation, check for proper release and engagement, proper stopping in both directions, and proper operation of air application valves and lines. Be alert for any evidence of loose fittings or leaks. If the air brakes are powered by a compressor, it is a good idea to verify that the compressor has been bled, by checking the bleed valve on the bottom of the tank.

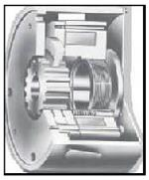
CHASSIS TRAVEL BRAKES

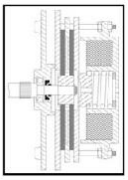
Mobile crane chassis travel brakes of all types must be inspected annually. At every second type “C” maintenance interval, brake assemblies shall be disassembled as required to inspect brake linings for wear, debonding, and glazing. It is important to closely check the slack adjuster travel measurement at this service interval. These brakes are hydraulically operated and most of the components are checked for the same attributes as previously discussed. OEM manuals should be consulted for the proper specifications. Normally, a removable inspection cover is provided to allow inspection of the brake lining thickness.

ELECTRIC MAGNETIC BRAKES (SHOE TYPE)

Shoe type electric magnetic brakes are found on larger bridge cranes and some types of category 1 cranes. Inspect this brake type for damage, evidence of binding, wear, loose or worn components, overheating, and proper lubrication. Closely inspect all wiring for signs of damage, deterioration, or evidence of loose connections. During operation, inspect for proper release, engagement, and stopping action in both directions of motion and timing of release and engagement. For category 1 cranes, these checks shall be performed at all maintenance interval as specified in NAVFAC P-

307, Appendix C. For category 2 and category 3 cranes, an annual inspection shall be performed as specified in NAVFAC P-307, Appendix D. Disassemble as required to inspect brake linings for wear, de-bonding, or glazing or for damaged brake discs, splines, or other internal components. For hoist brakes that stop the movement of the load under normal operation conditions this shall be done annually. For other hoist brakes (i.e., holding brakes) and for rotate and travel brakes, disassemble as required at every second “C” inspection.





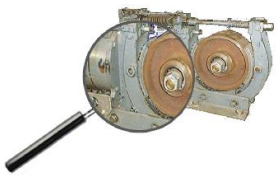
ELECTRIC MAGNETIC BRAKES (DISC TYPE)

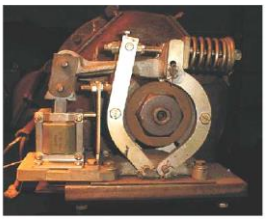
Electric magnetic disc brakes have slightly different inspection requirements. The housings should be closely inspected for damage or evidence of loose hardware. Check to ensure proper settings. Operate the hoist and inspect the brake for proper release, engagement, and stopping action in both directions of motion. While operating the hoist, check for vibration, overheating, and any abnormal noise.

At the type B and C maintenance intervals, disassemble hoist and rotate brakes, as required, to inspect for glazed or damaged brake discs, damaged internal components, and for proper brake lining thickness. At the type C maintenance interval, disassemble and inspect 50% of the travel brakes and at the next type C service, the other 50% should be disassembled and inspected.

INSPECTION ATTRIBUTES

When inspecting a crane brake, having a clear idea of the various check points will help assure nothing is overlooked. The following screens will illustrate the inspection attributes that have been discussed, what they look like, and their location on the brake assembly.



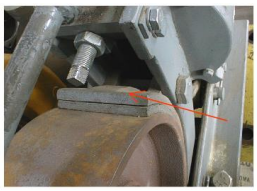


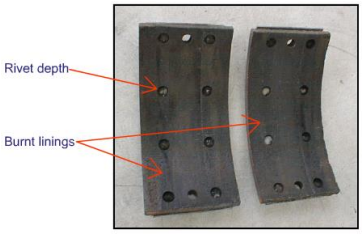
INSPECTION ATTRIBUTES - UNEVEN SHOE WEAR

Here is an example of uneven shoe wear. Notice in this illustration the brake shoe on the right side has much more lining on the lower part of the shoe than on the upper part. This condition is usually caused by improper mounting of the brake when it was installed. In this particular case, the uneven wear may also have been caused by an inadequate foundation allowing the brake to flex. In either case, when the shoes are replaced, the root cause should be determined and the situation remedied before the brake is put back into service.

INSPECTION ATTRIBUTES - LINING SEPARATION

The brake lining should be a tight fit against the shoe to aid in the transfer of heat from the lining to the shoes. This illustration shows an example of unacceptable lining separation.



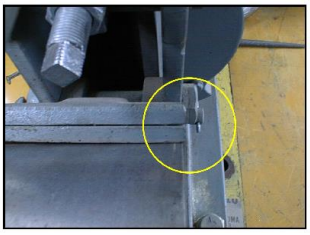


INSPECTION ATTRIBUTES - RIVET DEPTH AND LINING CONDITION

The rivet depth in the lining is another important check point on the brake assembly. If the lining wears too much, the rivets will contact the wheel resulting in damage. The condition of the lining should also be checked. This illustration shows a brake lining that has been overheated and should be replaced.

INSPECTION ATTRIBUTE SHOE OVERHANG

When brakes are mounted, it is important that the shoes do not overhang the wheels. If a brake shoe overhangs the wheels, the wheel will wear a step in the shoe lining and the application of braking force will not be even. If the step is prominent, the lining may require replacement. The brake will probably require re-mounting on the foundation to properly align the shoes. If the overhang is slight, it may be possible to submit an alteration request to slightly chamfer the edge of the lining so that it does not overhang the wheel.

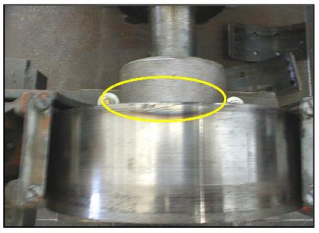



INSPECTION ATTRIBUTES – GLAZING

When brakes are opened for inspection, one of the attributes to inspect for is glazing. Glazing is caused by an overheating of the lining material. The surface of the brake, once glazed, loses its co-efficient of friction and the brake efficiency may be significantly reduced.

INSPECTION ATTRIBUTES - WHEEL SURFACE

When inspecting a brake wheel look for the following conditions. Scoring, which is usually caused by the rivets in the lining coming in contact with the wheel, or contamination in the lining, bluing or hot spots, that are often caused by the brake shoes dragging on the wheel when the brake is released, cracks, which can be a result of a bad casting, or in some cases overheating or overloading. With the brake in operation, check the wheel for run-out which can be a result of poor installation or manufacture, or may be a indication that the wheel is becoming loose on the shaft.



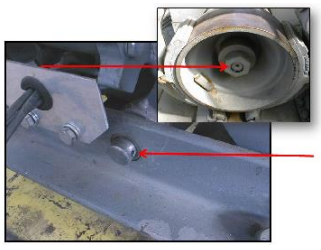
INSPECTION ATTRIBUTES - WIRING

The wiring on the brake assembly should be checked for three things. General

condition: the insulation and the connections should be checked for wear, damage, or deterioration, looseness: loose connections may result in high resistance and heat, and, routing: the wires should be routed so that they are not stepped on or damaged by normal crane operation.

INSPECTION ATTRIBUTES LOOSE OR MISSING FASTENERS

Brakes should be checked for loose or missing fasteners. Empty holes are often an indication of a missing cotter pin or other keeper. Bolts should be checked for tightness as well. Finding a loose washers is usually quick indicator of loose bolts. While inspecting the brake assembly, remember to check the brake wheel nut and the foundation bolts for tightness.



INSPECTION ATTRIBUTES - CRACKED AND DAMAGED HOSES

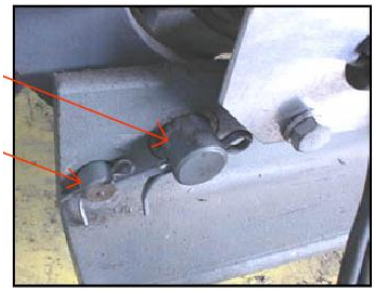
On hydraulic and pneumatic brakes, the condition of hoses and lines should be closely checked. If the hose has a spring around it, move the spring so that the actual condition of the hose may be observed. Over time the rubber will deteriorate and crack or the outer casing may separate from the reinforcing mesh underneath. The lines may crack if unsupported, so check for properly installed hangers. Ensure all fittings are tight and not leaking.

INSPECTION ATTRIBUTES - ACTUATING CYLINDERS

Hydraulic actuating cylinders are often a problematic area on crane brakes. When inspecting the cylinder check for leakage at the weep hole on the bottom. If fluid is coming out here, it is an indication that the seal is leaking. Verify the cylinder makes a full return. Newer cylinders may not return all the way, but the brake shoes must clear the wheel when released. Inspect for cracks on the cylinder. Very old cylinders may crystallize and form cracks which may result in brake failure during hard braking. Assure free movement of cylinder on the clevis pins. If the holes in the clevises were not machined accurately, binding may occur which will affect brake action.

INSPECTION ATTRIBUTES - LOOSE PIN-TO-BUSHING FITS

The proper operation of the brake may be affected by worn pins or bushings in the brake assembly. This illustration shows pins that are properly fitted. The easiest way to check for excessive movement of a pin is to observe the brake assembly while in operation. If the pin fit appears to be excessive it can be checked by measurement, although this would normally involve disassembly and is often deferred until the next scheduled service interval.




VERIFYING ADJUSTMENTS

One of the most important checks performed on a crane brake is the verification of accurate adjustments. In an earlier lesson, the process of brake adjustments was discussed and now we will cover the steps for verifying adjustments. When making adjustments be sure to use the appropriate tools for the measurement which is being made. If the measurement that you are verifying is in fractions of an inch, you don't need to use something which reads in thousandths.

WHAT IF A DEFICIENCY IS FOUND?

The question you might ask yourself is, "What should I do if I find a deficiency?" As we learned earlier, NAVFAC P-307 defines a deficiency to a load bearing or load controlling part or operational safety device as a major deficiency. If found during a maintenance inspection, a notation is also made on the Maintenance Inspection Specification and Record form, and an SRO or other appropriate documentation generated to accomplish repair. The repair should be re-inspected, re-tested, and the repair documentation signed by a mechanical inspector and the deficiency report filed in the equipment history file. Notify the Navy Crane Center within five days if deficiency may affect other Navy cranes. Submit a summary of the deficiency to the Navy Crane Center within 21 days on deficiencies which affect other installations.

NOTES

BRAKES 4 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. Where are brake [adjustment] measurements recorded?

A. on a small piece of paper which goes in the mechanics wallet
B. in the mechanic's notebook
C. in the crane operator's logbook
D. on the brake data sheet

2. Mark all the action that must be taken when a deficiency is discovered.

A. notify NCC within 5 days if deficiency may affect other activities and send a summary within 21 days
B. re-inspect and retest the repair, sigh the repair document to record the action
C. file deficiency report form in equipment history file
D. annotate in Maintenance inspection and Report form if found during an inspection
E. get the deficiency corrected
F. fill out a deficiency report form

3. Which of the listed conditions is not an important check while performing a brake inspection?

A. quick cooling on shutdown
B. full engagement
C. overheating
D. stopping action in both directions
E. proper release

4. The clearance of the brake should be verified when the brake is at its proper operating temperature.

A. True
B. False

SHAFT ALIGNMENT 1

THE IMPORTANCE OF SHAFT ALIGNMENT

Shaft alignment is the positioning of two or more joined shafts so that they are collinear, or, in other words, share exact common linear properties. In past incidents, Navy cranes have experienced mechanical failures which have been found to be the result of misaligned shafts. Often, catastrophic failures are easier to deal with due to the greater attention and resources dedicated to determining and resolving the cause. With less obvious problems, like a bearing which seems to fail every 6 months or so, the actual cause of the failure may be more difficult to detect. The reason for the bearing failure might be shaft misalignment, but because the bearing can be easily replaced, it is tempting to fix the immediate problem without exploring the root cause of the problem.

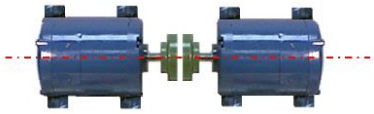
THREE MAJOR CAUSES OF MECHANICAL FAILURE

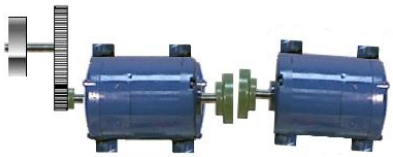
Machinery is designed and manufactured to specifications that permit operation for long periods of time before the machine wears out. The three major causes for machine failure are improper alignment, frame or foundation strain, and improper lubrication.

Misalignment causes vibration and machine strain which can destroy critical parts of the machine such as bearings, seals, gears, and couplings. Failures of this type are usually evident, although often mistakenly identified as "normal wear and tear“. To lessen the chance of failures, it is important for the crane mechanic to properly set up and align equipment.

ALIGNMENT

Alignment is the process of adjusting the positioning of a machine so that its shaft will line up perfectly with the shaft of the machine to which it is being coupled. The equipment to be aligned must checked to ensure it is properly adjusted both vertically and horizontally.



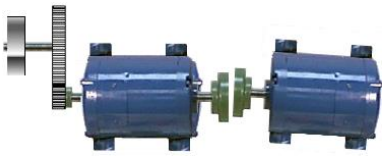


STATIONARY MACHINE

Of the two units to be coupled, normally one is kept stationary and the other is adjusted to align perfectly with its counterpart. If one component of the assembly is already connected and aligned with another machine, as shown in the left example, then this half of the assembly should be left as the stationary component to avoid affecting existing alignment.

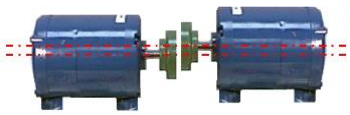
MACHINE TO BE MOVED

The machine to be moved is the component which will be moved horizontally and/or vertically to achieve proper shaft alignment. In this illustration the component on the right would be selected for alignment. The other half of the assembly is left stationary since it would be difficult to adjust because of its size, physical attachment to other objects, or how it is attached to the foundation. In most industrial applications, the driver (motor) will be the machine that must be adjusted to achieve proper alignment. In some applications, however, the driven component will be adjusted.



OFFSET MISALIGNMENT

Offset misalignment is also referred to as parallel misalignment. As you can see from this side view, the centerline of the two shafts are parallel to each other although not in alignment. The offset is the distance between two shaft centerlines which is usually measured in thousandths of an inch. For purposes of standardization, this distance will always be calculated (or measured) at the centerline of the coupling and must be determined in both the vertical and horizontal planes.

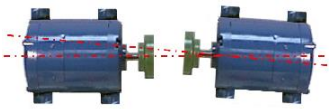


SKEWED MISALIGNMENT

Skewed misalignment is the most common type of misalignment problem encountered. It is a combination of both angular misalignment and offset misalignment.

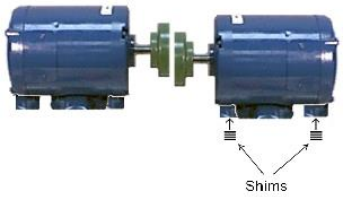
ANGULAR MISALIGNMENT

Angular misalignment is sometimes called "face misalignment". This is the term for the condition created when the centerline of the two shafts meet at an angle. As you can see in the illustration, the centerlines intersect, but are not parallel with each another. Note that this view is looking down from the top so we are looking at horizontal angularity. Angularity is the angle that one shaft centerline makes in relation to the other shaft centerline. For clarity, this is expressed as a "slope" of so many thousandths of an inch per inch, rather than as an angle of so many degrees. This must be determined in both the vertical and horizontal planes or vertical angularity and horizontal angularity.



VERTICAL MISALIGNMENT

This side view is an example of vertical misalignment. Vertical misalignment is the condition where the machine to be moved must be adjusted vertically with shims to bring it into its correct position.

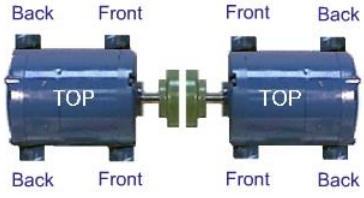


HORIZONTAL MISALIGNMENT

This view, looking from the top, is an example of horizontal misalignment. Horizontal misalignment occurs when the machine to be moved must be adjusted horizontally to bring it into its correct position. Shims are not used to correct horizontal misalignment.

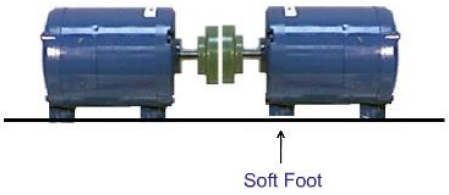
FRONT FEET, BACK FEET

To help clarify the shimming and alignment process we will label the machines' feet either front or back. When looking at the machine to be moved, the machine's front feet are those closest to the coupling and the back feet are those farthest from the coupling.



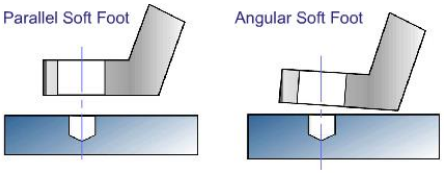
SOFT FOOT

The term “soft foot” is used to describe a gap between a machine foot and its foundation. For example, consider a chair with one short leg. The chair will never be stable unless the other three legs are shortened or the short leg is shimmed up. When a machine is in this condition, the dial indicator readings can be different each time the hold-down nuts are tightened, loosened, and re-tightened. This can be frustrating since attempted corrections may not produce the results desired. In some cases, it is possible that the machine will be resting on only two diagonal feet. In this case, the machine will have two soft-feet. If not corrected prior to tightening down the mounting bolts, this condition will cause machine frame strain, resulting in another form of misalignment called internal misalignment. This condition will most likely result in accelerated bearing wear and possible shaft failure.



TYPES OF SOFT FOOT

Soft foot is a condition in which one of the machinery feet does not sit flat on the base. When you tighten the mounting bolt on the foot, the machinery will distort and become misaligned. Parallel soft foot is where there is a parallel gap between the machine foot and its support surface. Angular soft foot is an angled gap between the machine foot and its support surface. Induced soft foot - is a result of forces exerted on the machinery by piping, wiring and so forth. These forces must be relieved before aligning the machine. A soft foot condition must not be present after all work is completed.

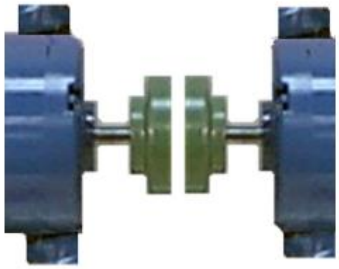


SHAFT ALIGNMENT VS. COUPLING ALIGNMENT

Often, the job of machinery alignment is referred to as coupling alignment although our true intent is to make sure that the shafts are aligned; not the couplings. When we consider machinery alignment, we are concerned with the practice of positioning the machine to be moved so that its rotating elements and those of the stationary machine rotate as one concentric unit. Precise alignment will eliminates undue mechanical stresses on the shafts, couplings, and bearings. If all couplings were bored straight and true through their exact center and machined perfectly about their rim and face, it might be possible to simply align the two coupling halves and achieve correct alignment. Unfortunately, irregularities in the machining process and even the forces imposed on the coupling halves during installation can cause a significant alignment error. To avoid this error, dial indicators may be positioned on the couplings, and the two shafts rotated simultaneously to obtain the desired readings. In this manner, the couplings actually become an extension of the shaft centerlines and irregularities do not affect the readings.

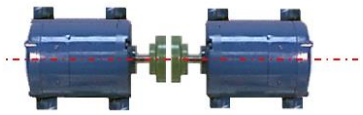
THE PRE-ALIGNMENT PROCEDURE

Before starting the alignment procedure there are some things to consider. First, ensure the machine feet, base, and shims to be used are clean. The machine base and feet must be free of any rust or burrs before setting the machine on the base. Wire brush or stone these areas if necessary. Use only clean shims that are free of any burrs or distortion. Correct any soft foot condition before attempting an alignment. Perform a rough horizontal alignment and coupling gap before starting. Set the machine in place but do not tighten the hold-down bolts. Attempt to pass a thin feeler gauge (or piece of shim stock) underneath each of the four feet. Any foot which is not solidly resting on the base is considered a soft-foot. If the feeler passes beneath a foot, determine the exact amount of gap beneath the foot with feeler gauges and place this amount of shims beneath that foot. This will be considered the "initial" soft-foot correction.



The Pre-Alignment Procedure

Using the correct procedure, tighten the hold-down bolts on the machine to be moved. The tightened hold-down bolts will help ensure that any unequal stresses that may cause a shifting of the movable machine during the tightening procedure will remain the same throughout the entire alignment process. The proper procedure for this step is to number each foot of the movable machine in the sequence in which you will be tightening the hold-down nuts during the alignment procedure. Always tighten the nuts in the sequence in which the positions are numbered (1, 2, 3, and 4). Loosen nuts in the opposite sequence (4, 3, 2, and 1). Tighten all nuts with the same amount of force, preferably using a torque wrench. Always tighten the nuts in the same manner as you would for the final adjustments, even if you have not taken your first set of readings.



ROUGH ALIGNMENT

The next step is a rough alignment. Using feeler gauges and straight edges begin by rough aligning in the horizontal plane although if alignment error is large and obvious, rough align with shims it the vertical plane. Use a scale to set parallel alignment and a feeler gauge to set angular alignment. Use jacking bolts, when they are provided, to adjust for horizontal offset and angular misalignment and to hold the machine in place while shimming. Jacking bolt assemblies should be welded onto the base of large machinery. If they are not provided, it would be a good idea to get approval to add them before starting your alignment procedure.

FINAL SOFT FOOT CORRECTIONS

The final soft-foot correction should be done as follows. Torque all hold-down nuts on the machine to be moved. Secure a dial indicator holder to the base of the machine to be moved in such a manner that the stem of the dial indicator is placed vertically above the foot which is to be checked for soft-foot. Be sure the magnetic base is attached to something that will not move when you change the torque on the bolts, then set dial indicator to zero. Completely loosen the hold-down nut on that foot only, record the dial indicator reading, then re-torque the foot. Move the dial indicator and holder to the next foot to be checked and repeat the process. Work around the machine, loosening, recording, and retightening. Examine your readings. The foot with the largest amount of movement is the soft foot. If no movement greater than 2 thousandths exists, there is no soft foot and the alignment may proceed.

NOTES

SHAFT ALIGNMENT 1 MODULE EXAM

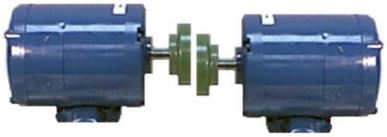
Online exam questions may appear in a different order than those shown below.

1. Sometimes called “face misalignment”, where the centerlines of the two machines meet at an angle is called _____.

A. soft foot
B. angular misalignment
C. horizontal misalignment

2. The view of the machines below is a side view. Would this misalignment be horizontal or vertical misalignment?

A. vertical
B. horizontal



3. The machine that will not be adjusted or moved is referred to as _____.

A. previous aligned machine
B. stationary machine
C. offset equipment
D. fixed component

4. The machine that will be moved side to side or shimmed up and down is referred to as _____.

A. horizontal alignment
B. machine to be moved
C. stationary machine
D. adjustable component

5. The gap between a machined foot and its support surface is referred to as _____.

A. angular misalignment
B. offset misalignment
C. soft foot
D. horizontal misalignment

6. Mark any procedure that is not a part of the pre-alignment procedure.

A. clean and de-burr shims
B. perform a final vibration analysis
C. rough alignment
D. check for and correct soft foot
E. tighten hold down bolts
F. final soft foot corrections
G. clean the feet of the machine and the foundation

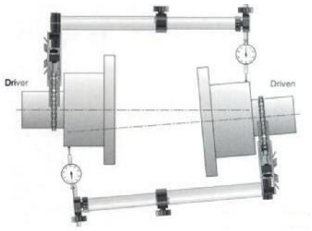
SHAFT ALIGNMENT 2

WHICH METHOD?

When preparing to align machinery, keep in mind there is more than one method to accomplishing this task. One effective method is the dual dial reverse indicator method which does not rely on obtaining readings from the couplings themselves. Another common technique is the laser alignment method. This technique involves expensive equipment, which, if not used frequently, may not justify the cost. Whichever method is chosen, when properly executed, the results can be very accurate. The main differences will be in the time expended, the difficulty in interpreting the results, and the cost of the equipment needed.

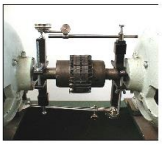
DUAL DIAL REVERSE INDICATOR METHOD

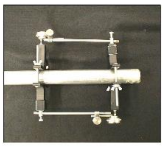
The dual dial reverse indicator method of shaft alignment uses two dial indicators which are attached by brackets to the shafts which are to be aligned. This method can be used on most rotating machinery and is the preferred method for measuring rotating machinery shafts. Notice there is a long rod which supports each dial indicator. Even though properly attached to the machine shaft, the rod will deflect due to the weight of the dial indicator. This deflection must be compensated for when taking the reading. “Indicator sag” is the term used to describe this deflection of the mounting hardware as the dial indicator is rotated from the top position to the bottom position during the alignment procedure.



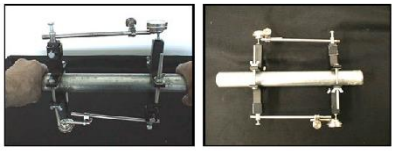
SETTING UP FOR DUAL DIAL REVERSE INDICATOR METHOD

Setting up for the dual dial reverse indicator method involves several steps. The first step is to attach the brackets to the machine shafts to be aligned. This step is performed to determine the distance between the brackets and how long the rods will have to be for the indicators to make contact with their opposing bracket. Next, detach the set-up from the machine shafts. Using the dimensions established from the previous step, re-attach to a piece of thin-walled tube or light pipe so that the indicator sag may be measured and recorded.





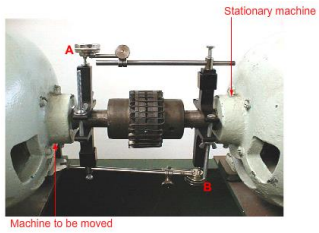
DETERMINING INDICATOR SAG



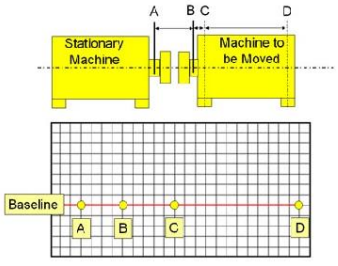
Once the brackets have been attached to the pipe and the indicators are positioned against the brackets as they would be in the actual set-up, the first step in determining indicator sag is to zero each dial indicator. One indicator should be at the 12 o'clock position and the other should be at the 6 o'clock as shown in the photo. Rotate the pipe 180 degrees so the indicators are in the opposite position. Next, read the dial on each indicator. The reading will be the "sag" of each indicator. This sag will have to be compensated for on the indicators when taking the actual alignment readings. For example, if the dial indicator reads "plus three-thousandths" when it is reversed, it should be set at "minus three-thousandths when it is in the original position.

SETTING UP THE INDICATORS

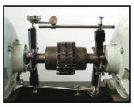
After the indicator sag has been determined, the indicator brackets should be positioned back on the machinery to be aligned as shown in the photo. Two sets of readings will need to be taken to perform an alignment, a vertical set and a horizontal set. For vertical readings, zero the dial indicator closest to the stationary machine, at the top position. We will call this the "A" dial. Next, zero the dial closest to the machine to be moved at the bottom position. We will refer to this as the "B" dial. Remember to factor in the pre-determined indicator sag by adding the amount of sag to the dial when zeroing at the top and subtract the amount of sag from the dial when zeroing at the bottom. For horizontal readings, looking toward the stationary machine, zero the "A" dial at the 3 o'clock position, and zero the "B" dial at the 9 o'clock position. No compensation for indicator sag is needed at the 3 o'clock and 9 o'clock positions since the movement of the indicators in this position will not affect the readings.



MEASURING SET-UP



Before the readings can be taken and graphed, the actual set-up on the shaft needs to be measured. Measure the distance from the center of dial "A" to center of dial "B". Then measure the distance from the center of dial "B" to the center of the bolt holes on the front feet (position "C"). Finally, measure the distance from "C" to the center of the bolt holes on the back feet (position "D"). Using 1 inch to represent each square on the horizontal plane, plot these positions on a "base line" drawn on graph paper, as shown in the illustration.


Set up dials for vertical reading


Rotate 180°


Set up for horizontal

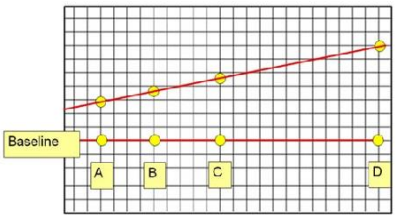

Rotate 180°

TAKING READINGS

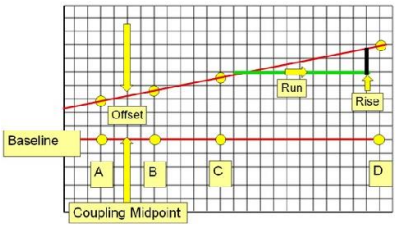
Readings are taken by rotating the shafts 180 degrees from their original position. Divide this reading by 2 and record on the graph. Remember there will be 2 sets of readings. The vertical plane will start with dial A at the 12 o'clock position and then rotating to the 6 o'clock position. The horizontal plane will start with dial A in the 3 o'clock position and rotated to the 9 o'clock position.

PLOTTING THE GRAPH

Plot dial indicator readings vertically from point A for the "A" dial and from point B for the "B" dial, each square on the vertical plane representing a nominal amount (normally, one thousandth of an inch). Positive readings are plotted above the base line and negative readings are plotted below the base line. Draw a line through the plotted points of A and B and extend the line past the last point. In this example that would be point D. Count the squares vertically from points C and D on the base line up to the extended line to determine the amount of shims required for the front and back feet. If the value is above the baseline you must remove shims. If the value is below the base line you must add shims.



Plotting the Graph

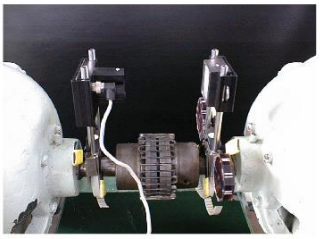


The next step in plotting the graph is determining angularity, which is equal to rise over run. Angularity is positive if the coupling halves are closer together at the bottom, and negative if closer together at the top. The rise is the vertical distance between the plotted line and the base line and is represented by the bold black line in the illustration. The measurement for determining rise is taken at a specific horizontal distance called the "run" which is represented by the green line in the illustration. The illustration shows a run of 10 inches and a rise of 15 thousandths of an inch. Dividing the 15 thousandths rise by the 10 inch run shows an angular misalignment of 15 ten-thousandths of an inch. The vertical distance at the coupling midpoint, between the base line and the plotted line, indicates the offset misalignment. The offset is positive if above the base line, and negative if below. Remember, you will have two graphs to plot, one for the vertical plane and one for the horizontal plane.

JUST WHEN IS ALIGNMENT GOOD ENOUGH?

This is a difficult question to answer because of the vast differences in machinery strength, rotational speed, or type of coupling. Some mechanics have the misconception that flexible couplings will cure any misalignment problems. It is true that they may, to some extent, dampen the effects of misalignment, but it should be remembered that the coupling manufacturer has no idea of the specific limitations on the machinery which the coupling will be used. Each coupling is made to fit a variety of machines. If you check the alignment tolerances for a specific coupling, you will find that the coupling manufacturer guarantees satisfactory performance of the coupling within those tolerances, but not necessarily on the machinery on which it is used. The equipment manufacturer's specifications or your facility engineer are the best sources for a decision as to whether the alignment is satisfactory. After the alignment is complete and the machinery has been in operation, make sure to check the coupling gap for the specified clearance.

LASER ALIGNMENT



There are many laser alignment tools available on the market for aligning shafts. One of the more common laser alignment tools used at some of the larger Navy activities is the Optalign Laser Alignment System. We will refer to this system for the purposes of discussing laser alignment techniques and procedures on subsequent screens. The operator does not have to calculate alignments or determine machine movements, as the computer performs the entire operation. The need to compensate for sag is eliminated. The laser system is faster and more accurate, reducing fatigue and mechanical error and does not rely on the mechanical action of dial indicators.

COMPONENTS OF THE OPTALIGN

Let's take a look at the components which make up the kit, and discuss their functions.

TRANSDUCER

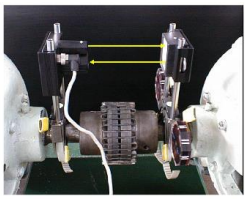
The transducer is a combination of a laser and a detector. The laser is a semiconductor laser which emits light in the visible range. It is small and rugged in construction and its low power and pulsed operation ensure that no danger can exist under normal use. The detector is a biaxial, analog photoelectric semiconductor position detector with a resolution of one micron. Each detector has unique linearization characteristics which are stored in the computer. The detector and computer are specifically matched to each other and must be used as a set so when using this system, verify that the serial numbers of the computer and transducer match.

PRISM/MIRROR

The laser alignment system utilizes a prism which receives and reflects the laser beam in parallel planes. As the prism shifts along the radial axis during rotation, the spacing between the beams is altered, and from this difference the offset of the shafts are determined. In the perpendicular plane, the prism acts as an ordinary mirror. As the prism is rotated about its vertical axis, the angle between the entering and reflected beams changes, allowing angular misalignment to be computed.

Prism/Mirror

In use, laser beam pulses, alternating from the transducer to the prism and back, as seen in this illustration. The angle at which the beam bounces back is processed by the computer to determine any misalignment of the components.



COMPUTER

The computer receives its input data from the detector through a connecting cable and calculates the status of the coupling alignment. The computer also displays the amount of correction for the feet of the movable machine and may be programmed to display in either English or metric mode.

BRACKETS, INCLINOMETER, AND TAPE MEASURE

The kit also contains brackets, an inclinometer, and a tape measure. The standard bracket system consists of two universal brackets, two gear belts, and posts of different lengths. The belt bracket system can be used on shafts up to eight inches in diameter. The inclinometer is filled with a special oil that matches the thermal coefficient of expansion of the sealed case. The tape measure that comes with the kit reads in English or metric units and has a level and special point for drawing circles.

HOW IT WORKS

The computer guides the operator through the entire alignment process. A sheet is provided that the operator can use to record measurements and the alignment findings, although alignments can be taken just by using the machine itself. The machine prompts the user to make and enter a series of dimension measurements such as: the distance between the transducer and prism, the distance between the transducer and the front foot of the machine to be moved, the distance between the feet, the distance between the coupling and prism, and the diameter of the coupling. The user will then record four position readings: 12, 3, 6, and 9 o'clock. The set-up is stopped in each position and the operator enters the position so that the machine can record the reading at this point. If it is not possible to take 4 readings, the machine can still make its calculations based on 3 readings. After the readings are taken, the machine will give the operator four readings including vertical and horizontal offset, and vertical and horizontal angularity. In addition, the laser alignment system will also tell the operator how many and what size shims to add or remove from the feet, and how much to adjust the machine from side to side as well as a function for assisting the operator in making the horizontal moves.

NOTES

SHAFT ALIGNMENT 2 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. Listed are the steps involved in doing a machine alignment. What is the fourth step?

A. move the machine
B. take a set of readings
C. set-up the equipment on the machine
D. evaluate the readings
E. measures the distances between the alignment components and the machines

2. Listed are the steps involved in doing a machine alignment. What is the fifth step?

A. set-up the equipment on the machine
B. move the machine
C. measures the distances between the alignment components and the machines
D. evaluate the readings
E. take a set of readings

3. What factor does not help determine if an alignment is satisfactory?

A. the amount of torque the coupling sees
B. ambient temperature of the machinery
C. the speed at which the machinery turns
D. the type of coupling on the shafts being aligned

4. Listed are the steps involved in doing a machine alignment. What is the third step?

A. move the machine
B. take a set of readings
C. evaluate the readings
D. measures the distances between the alignment components and the machines
E. set-up the equipment on the machine

5. Four different readings are recorded when doing an alignment. Identify the reading that is not recorded during an alignment check.

A. vertical angularity
B. horizontal offset
C. horizontal angularity
D. soft foot
E. vertical offset

6. Who can make the best determination as to whether an alignment is “good enough”?

A. the facility engineer or the Crane Center
B. the coupling manufacturer
C. the Psychic Hotline
D. the mechanic who takes the readings

7. Listed are the steps involved in doing a machine alignment. What is the first step?

A. set-up the equipment on the machine
B. move the machine
C. measures the distances between the alignment components and the machines
D. take a set of readings
E. evaluate the readings

8. Listed are the steps involved in doing a machine alignment. What is the second step?

A. set-up the equipment on the machine
B. move the machine
C. evaluate the readings
D. measures the distances between the alignment components and the machines
E. take a set of readings

SHAFT ALIGNMENT 3

REMEMBER! COUPLINGS SUPPORT THE LOAD!

When performing a shaft alignment inspection that requires disassembly of the coupling, remember that the coupling may be supporting any suspended load including the crane's boom or empty hook. Any suspended load must be put in a safe condition by a qualified operator before disassembling any coupling.

NAVFAC P-307 INSPECTION REQUIREMENTS SHAFTS AND COUPLINGS

While the crane is stationary, the inspector checks for damage, leaking seals on the couplings, loose keys in coupling hubs, loose bolts in the couplings, and loose or missing coupling covers. With the function running, the inspector should check for vibration or other evidence of misalignment or damaged components. Severe misalignment would normally be visible even to the untrained eye. If couplings are misaligned the internal components may bind against each other. Listen for any abnormal noise that may indicate this condition. Finding frequent bearing damage, overheating, and/or abnormal wear on an assembly is often the result of misalignment.

SHAFTS AND COUPLING INSPECTIONS

Inspect shafts and couplings, including couplings integral to motor/speed reducer assemblies, for the items discussed on the previous screen, per NAVFAC P-307 requirements. Category 1 cranes shall have their shafts and couplings inspected at every "B" inspection. Category 2 and 3 cranes shall have their shafts and couplings inspected at every annual inspection.

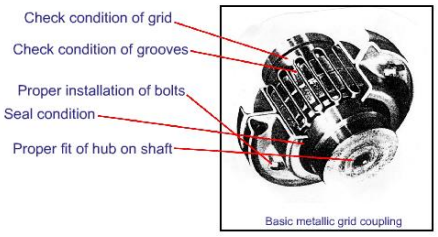
BOOM, HOIST AND SINGLE ROTATE DRIVES

Coupling covers must be removed and the coupling internals inspected for damage and unusual wear. An indication of problems is finding coupling grease with metal particles in it, or grease which has obviously been overheated. When the grease is cleaned off, look for broken pieces, burred or distorted parts, and other evidence of damage and wear. The coupling alignment must be measured and must follow OEM specifications. If no OEM specifications can be located, the Navy Crane Center can provide guidance as to acceptable criteria, based on the type of components, rpm of shafts and so on. As a minimum, category 1 boom, hoist and single rotate drive couplings should be inspected

at every "C" inspection. Category 2 and 3 hoist drive couplings should be inspected at every sixth annual inspection. All hoist and rotate drive couplings must be inspected to current NAVFAC P-307 requirements and coupling alignment verification shall be filed in the crane history file.

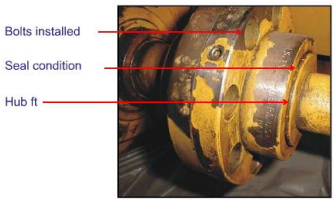
INSPECTING GRID COUPLINGS

When inspecting steel grid type couplings, verify the following points. Check the condition of the steel grid. Ensure it is not broken, excessively worn, and fits properly in the grooves. Verify the grooves are in good condition and not showing excessive wear from reversing under heavy loads. Before the coupling is disassembled, check the seal for leakage, and after disassembly, check the condition of the seal. Check the fit of the hub on the shaft and check the area around the keyway for any signs of cracking or distress.



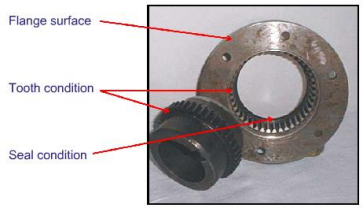
INSPECTING GEAR TOOTH COUPLINGS

When inspecting gear tooth type couplings prior to disassembly, check to ensure the bolts are installed correctly. Looseness may be an indication of misalignment. Check the seal for leakage and inspect the hub fit on the shaft. Check the fit of the key and for any signs of cracking or distress.



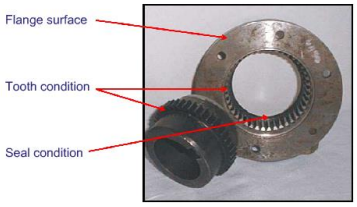
INSPECTING GEAR TOOTH COUPLINGS

When the coupling is disassembled there are other things to check for. Ensure the flange surface is smooth with no dents or damage which would prevent it from mating with its counterpart. The teeth should not be distorted or excessively worn. Be sure the hub was placed on the shaft correctly so that the teeth mesh properly with the sleeve and inspect the seal for any signs of deterioration.



INSPECTING SPLIT COUPLINGS

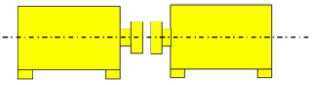
Due to the fact that there are no moving parts in the split coupling, the inspection is fairly straightforward. The inspector must verify the width of the split is the same on both sides of the coupling and that it is even down the length of the coupling. Check to verify the bolts on one side of the coupling are oriented in the opposite direction as the bolts on the other side.



SHAFT ALIGNMENT VERIFICATIONS

When verifying shaft alignment, the chosen method should ensure accurate results. As we discussed in an earlier lesson, laser alignment systems are becoming very prevalent throughout naval activities. Laser systems offer quick, reliable data and if not available at an activity, there are many private alignment companies which will verify alignments on your equipment. The reverse dial indicator method is accurate and effective but more complicated to use and to determine results. Whichever method is used, the data must be recorded and placed in the equipment history jacket.

INSPECTING SHAFT ALIGNMENTS



When inspecting shaft alignments and existing hoist installations, ensure the shims under the feet of the moveable machine are made of steel or stainless steel, not brass or aluminum. Limit the number of shims to three or four. Thicker shims should be used if more than four are needed. Use the same number under each foot pair, unless shims have been added to correct soft foot. The foundation bolts should be checked for tightness. It is good shop practice to use taper pins through the feet or welded blocks around the feet to hold the machine is position once good alignment has been obtained. Be aware when checking alignments that the readings may change as conditions change. A heavy person walking out on a bridge crane can cause alignment readings to change significantly. Other things which can cause changing readings are movement of the crane or components and changes in temperature.

NOTES

SHAFT ALIGNMENT 3 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. Shaft alignment inspection for loose bolts in couplings _____.

A. should be performed with the function running
B. should be performed with the function stopped
C. should not be performed during a shaft alignment inspection

2. Shaft alignment inspection for vibration or other indication of misalignment _____.

A. should be performed with the function running
B. should be performed with the function stopped
C. should not be performed during a shaft alignment inspection

3. Shaft alignment inspection for loose coupling covers _____.

A. should be performed with the function running
B. should be performed with the function stopped
C. should not be performed during a shaft alignment inspection

4. Shaft alignment inspection to verify the proper type of coupling has been used _____.

A. should be performed with the function running
B. should be performed with the function stopped
C. should not be performed during a shaft alignment inspection

5. How often do *[boom, hoist, and single rotate drive]* coupling alignment verifications need to be accomplished after the initial verification?

A. every second “C” PM for cat 1 cranes and every sixth certification for cat 2 and cat 3 cranes
B. right before each audit
C. every year
D. when the time seems right

6. Shaft alignment inspection for loose keys in coupling hubs _____.

A. should be performed with the function running
B. should be performed with the function stopped
C. should not be performed during a shaft alignment inspection

7. Shaft alignment inspection for bearing damage (overheating or abnormal wear) _____.

A. should be performed with the function running
B. should be performed with the function stopped
C. should not be performed during a shaft alignment inspection

8. Shaft alignment inspection for abnormal noise _____.

A. should be performed with the function running
B. should be performed with the function stopped
C. should not be performed during a shaft alignment inspection

9. Shaft alignment inspection for leaking seals or couplings _____.

A. should be performed with the function running
B. should be performed with the function stopped
C. should not be performed during a shaft alignment inspection

LUBRICATION 1

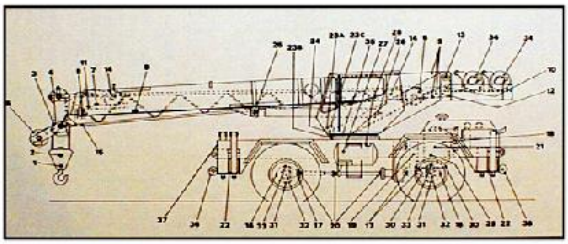
WHY IS LUBRICATION IMPORTANT?

The main objective of lubrication is to separate moving metallic parts by inserting a layer of fluid between them in the form of a thin, friction reducing film. Friction cannot be eliminated completely but can be reduced by applying appropriate lubrication techniques which we will learn in this module. There are many frictional surfaces on cranes such as shafts running in plain or roller bearings, wire ropes running in sheaves, and gears meshing with each other. Without adequate lubrication, these critical components would rapidly wear out causing expensive and time consuming break downs. As metal wears or breaks off, the metallic particles act as an abrasive, contributing to the destructive situation. Proper lubrication procedures, performed by a knowledgeable servicer, are an essential element for safe, reliable, and efficient crane operations.

BEFORE STARTING WORK...

All work performed on cranes must be authorized and documented. Prior to beginning a lubrication job, ensure all authorizing paperwork such as shop repair orders have been obtained. Before beginning the service, obtain and follow available lubrication sheets and charts for the crane. The lubrication chart locates where the lubrication points are on the crane, and the lubrication sheet provides a place for the person performing the service to record the details of the lubrication job. Ensure local lock out/tag-out procedures are followed and the crane cannot be operated while it is being lubricated. When working at heights, ensure all fall protection requirements are followed. Be aware of any slipping hazards from grease and oil and follow all precautions for using various lubricants. Any excess oil and grease must be wiped up and oily rags shall be removed and properly disposed of. Any equipment used to transfer or apply lubricants should be thoroughly cleaned at the completion of the job.

LUBE CHARTS



The best way to carry out a complete lubrication on a crane is by following a lube chart. Lube charts locate the positions on the crane where the lubrication is applied. Due to the number of grease fittings on a typical crane, it would be easy to miss some without referencing a chart. Lube sheets identify the type of lubrication to be applied, as well as the fitting type. The frequency of the lubrication will normally be specified on the lube sheet. Lubrication requirements may specify daily, weekly, monthly, quarterly, or in some cases, yearly service.

WHAT IS A LUBRICANT?

So, just what is a lubricant? Lubricant is defined as an oily or slippery substance such as a grease which reduces friction, heat, and wear when introduced as a film between solid surfaces. Friction is the resistance encountered when one object or surface is moved in contact with another. When examined under a microscope, even a very smooth appearing surfaces will actually present a coarse or rough surface that, when moving in contact with each other, will result in friction. When a lubricant is introduced between the two surfaces so that no contact is made between them, the condition is termed "hydrodynamic lubrication“. When two surfaces maintain some contact, but the amount is limited by very thin layers of lubrication, the condition is termed "boundary lubrication".

LUBRICATING OIL

Petroleum based oils are the most common of all lubricating oils. These oils are available in a wide range of viscosities, allowing for a greater range of load, speed, and temperature conditions. Properly selected lubrication oil will consistently provide a low co-efficient of friction. Petroleum based oils have low compressibility and are effective in carrying away heat from bearing surfaces.

HOW OILS ARE CATEGORIZED

Oils are categorized according to viscosity or resistance to flow, adhesion or the ability to cling to metal surfaces, and cohesion or the ability to resist breaking down.

VISCOSITY

The Society of Automotive Engineers or SAE, classifies engine lubricating oils by ten viscosity grades. The SAE viscosity classification system classifies oil according to viscosity at 100 degrees centigrade and at various low temperatures depending on the viscosity grade. High temperature viscosity is related to an oil's consumption and wear characteristics, while low temperature viscosity is related to cold starting performance and low temperature lubrication. Viscosity grades with a “W" suffix are based on a maximum low temperature viscosity, maximum borderline pumping temperature, and minimum viscosity at 100 degrees centigrade. A multi-graded oil is one whose viscosity and borderline pumping temperature satisfies the requirements for one of the “W" grades, and whose 100 degree viscosity is within the prescribed range for a higher non-W grade. The use of multi-graded oil allows the oil to be used in a much wider range of temperatures than that allowed by a single weight oil. A “W" graded oil is labeled with only the lowest “W” grade satisfied. If an oil meets the requirements for SAE grades 10W, 15W, 20W, 25W, and 30, it would be referred to as SAE 10W-30.

ADDITIVES

Hydrocarbon oils can have their performance enhanced by various chemical additives, which are added during the refining process. Among the common additives are metallic detergents. These are metallic ash-containing compounds having a detergent/dispersant action in controlling deposits and keeping engine parts clean. Metallic detergents help clean up existing deposits as well as disperse particulate contaminants in the oil and have good anti-wear, anti-scuff, and anti-rust qualities. Another additive called ashless dispersants are ashless organic compounds having a detergent/dispersant action in controlling deposits and keeping engine parts clean. Oxidation inhibitors are added to help prevent oxygen from attacking the lubricant base oil. Without oxidation inhibitors, the oil would react with oxygen, eventually solidifying or turn acidic, causing bearing corrosion. Bearing corrosion inhibitors are additives intended to inhibit acid from attacking the oxides in the bearing metals by forming protective barrier films on the bearing surfaces.

Rust inhibitors are added to lubrication oil to diminish the effects of oxygen attacking metal surfaces found in thin film areas such as hydraulic lifters and push rods. Another common additive, anti-wear compound, is a film-forming compound intended to overcome metal to metal contact. Since detergent/dispersant-type oils tend to entrain foam causing air, foam depressants are added to control release of entrained air. Pour point depressants are additives intended to reduce the effects of hydro-carbons solidifying into waxy materials

at lower temperatures. The use of pour point depressants in the oil modifies the wax crystal structure, resulting in low pour point and, in some instances, improved low temperature fluidity. Petroleum oils thin out with increasing temperature. The oil's viscosity index is a measure of this rate of viscosity change. The addition of a viscosity index improver will slow down the rate of "thinning"; thus the oil will remain thicker at a given operating temperature. Viscosity index improvers are used extensively to formulate multi-grade oils.

SERVICE CLASSIFICATIONS "S" & "C" CATEGORIES

The American Petroleum Institute (or API) service classes have two general lubrication oil classifications: "S" for spark ignition applications including typical passenger cars and light trucks using gasoline engines, and "C" for compression ignition diesel equipment. API SJ and newer oils are specific to automobile and light truck use. The latest API service standard designation is SM for gasoline automobile and light-truck engines where control of high-temperature deposits is required. Current API service categories for gasoline engines include: SH, SM, SL and SJ. All previous service designations are obsolete. There are seven current API service categories for diesel engine service including: CJ-4, CI-4, CI-4 Plus, CH-4, CG-4, CF, CF-2, and CF-4.

MILITARY SPECIFICATIONS

The military has developed a series of specification tests for oils of various grades. Although the tests mirror the specifications set up by the SAE and other organizations, these specification tests insure that oil of a constant quality is purchased under government contracts. These tests include oil detergency, oil oxidation, and bearing corrosion. The current military standard for internal combustion engines of both spark and compression ignition is MIL-L-2104E.

OIL FILTERS

Most internal combustion engines utilize a filtering system for lubricating oil. Oil filters are generally of two types. The spin-on, which is a self-contained unit that threads onto a machined base plate, and the cartridge type, which is an element that is installed inside of a filter housing. When installing filters, the following precautions must be taken. Prior to removal, clean area around the filter to prevent any dirt or contamination from entering the engine. Before installation of a new filter, be sure that all seals are coated with a film of oil. If the filter is an upright, spin-on type, before installation fill the new filter with fresh clean oil of the type to be put into the engine. Do not tighten a spin-on filter more than 3/4 of a turn after the seal contacts the sealing surface and never tighten with a wrench.

Spin on


Cartridge


Cartridge

GEAR OILS

Gear oils, like engine oils, contain various additives depending on the service classification of the oil. Some of the more important gear oil additives are anti-oxidants, rust and foam preventatives, and extreme pressure or EP additives. When an extreme pressure additive is added to straight mineral oil, it enables it to withstand much greater pressure between the gear teeth. Gear oils have API and SAE classifications similar to those for engine oils. SAE viscosity numbers range from 75W for the lightest oil to 250 for the heaviest. API service classifications GL-1 through GL-5 are the standard gear oil classifications. GL-5 lubricants will normally satisfy the requirements of MIL-L-2105D.

GEARBOX LUBRICATION

Most crane gearboxes are lubricated by a "splash" system. The lower half of the gearbox is partially filled with gear oil and the action of the gears turning through it splashes or carries the oil up and over the entire gear system. The oil runs over the surfaces of the gears and back down into the sump. In most cases the bearings for these boxes are independently lubricated by means of grease fittings, but may be internally lubricated by the gear oil. Frequent oil level checks and properly maintained oil levels are essential for maintaining the reliability and operating life of a gearbox. The oil level in a gear box is generally verified by a sight glass, level plug, or stand pipe. Normally, there are no filters in this type of system so extreme caution must be exercised to avoid contaminating the oil during servicing.

GREASES

Grease is a solid or semi-liquid lubricant consisting of a thickening agent in a liquid lubricant. The typical thickening agent is a soap made by the reaction of fatty acids and alkalis. The main alkalis used are lime (calcium hydroxide), sodium hydroxide and lithium hydroxide, which in turn produce calcium, sodium and lithium soaps. Some high temperature greases use non-soap thickeners where soap thickened greases might break down. Generally, the thickness of the grease is determined by the amount of thickener present. In the case of soap greases, this can vary from about 5 to 35%. The essential properties a grease must possess are the ability to form a film between surfaces, so that surface-to-surface contact is minimized, the ability to seal against dirt and other contaminants, and the ability to remain stable under conditions of heat, moisture, and vibration. Additives and modifiers commonly used in lubricating greases have much the same function as similar compounds added to lubricating oils.

GREASE VISCOSITY

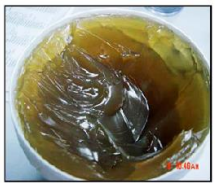
The National Lubricating Grease Institute of America categorizes various greases by their penetrability. Soft products such as fluid greases are classified in 0 (zero) grades, medium greases such as automotive chassis grease in number 2 range, medium industrial grease such as high speed bearing grease in number 3 range, and hard block greases in number 6 range. A drop point test is done to determine the temperature at which the grease will flow. This is not the temperature at which the grease can be used. The drop point may be 100 degrees centigrade but the maximum temperature for continuous use should not exceed 60 degrees C.

Grease Viscosity

NLGI NUMBER	ASTM WORKED PENETRATION
000	445-475
00	400-430
0	355-385
1	310-340
2	265-295
3	220-250
4	175-205
5	130-160
6	85-115

ADDITIVES IN GREASE

Additives are used in grease just like in engine oil. Additives and modifiers commonly used in lubricating greases are oxidation or rust inhibitors, pour point depressants, extreme pressure anti-wear agents, lubricity or friction reducing agents, and dye or pigments. Most of these materials have much the same function as similar materials added to lubricating oils. Molybdenum disulfide is used in many greases for applications where loads are heavy, surface speeds are low, and restricted or oscillating movement is involved. In these cases, the use of molybdenum disulfide reduces friction and wear.



GREASE COMPATIBILITY

Because of the different compounds used in formulating greases, many greases are not compatible with each other. Greases may be incompatible because of their thickener types, base fluids, or additives. If incompatible grease is used, the old grease may cause the new grease to soften or harden. If you are in doubt as to compatibility, have your engineering code contact the grease manufacturer. It is always best to assume that greases are not compatible and to make sure old grease is purged or cleaned out when a different type is used.

NOTES

LUBRICATION 1 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. The additive that protects the lubricant base oil from reacting with oxygen and solidifying of turning acidic and causing corrosion is called a/an _____.

A. detergent
B. viscosity index improver
C. octane booster
D. oxidation inhibitor

2. What physical force resists the relative motion two bodies in contact and is the fundamental reason we lubricate machinery?

A. inertia
B. friction
C. gravity
D. magnetism

3. Anti-wear compounds form a film intended to overcome _____.

A. cleanliness
B. rust
C. metal to metal contact
D. tensile deformation

4. An oil delivery system where the lower half of the gearbox is partially filled with gear oil and the action of the turning gears carries the oil up and over the entire gear system is called a/an _____.

A. recirculation system
B. drip system
C. splash system
D. sump system

5. Without adequate lubrication, critical components would _____.

A. heat up
B. wear out
C. break down
D. all listed items are correct

6. The addition of a/an _____ _____ _____ will slow down the rate of “thinning” thus the oil will remain thicker at a given operating temperature.

A. oxygenation rate inhibitor
B. viscosity index improver
C. pour point depressant
D. cohesion index improver

7. Always assume lubricants are _____.

A. incompatible with each other
B. safe to use
C. compatible with each other
D. approved for use

8. Metallic detergent additives help _____.

A. clean existing deposits
B. possess anti-wear, anti-scuff, and anti-rust qualities
C. disperse particulate contaminants
D. maintain oil thickness

9. Additives intended to inhibit acid from attacking the oxides in the bearing metals by forming protective barrier films on their surfaces are called _____.

A. detergent depressants
B. bearing corrosion inhibitors
C. cohesion index improvers
D. antacids

10. Any equipment used to transfer lubricants should be _____ _____ at the completion of the job.

A. thoroughly cleaned
B. disposed of
C. shipped out
D. pressure tested

11. A lubricant is defined as _____.

A. a fluid that resists the force tending to cause the fluid to flow
B. the lowest temperature at which a substance will flow under given conditions
C. something that is added to alter quality or counteract undesirable properties
D. a substance which reduces friction between two surfaces

12. A drop point test determines the temperature at which a/an _____.

A. lubricant will flow
B. grease will vaporize
C. ail will thicken
D. engine will seize

13. What is the typical thickening agent used in grease?

A. soap
B. chlorine
C. alcohol
D. silica

14. Safe, reliable and efficient crane machinery requires _____.

A. proper lubrication procedures
B. knowledgeable lubricator
C. some type of lubrication

15. Additives intended to reduce the effects of hydrocarbons solidifying into waxy materials at lower temperatures are called _____.

A. detergents
B. adhesion index improvers
C. pour point depressants
D. oxidation inhibitors

16. When a lubricant is introduced between the two surfaces so that no contact is made between them, the condition is termed _____.

A. maximum lubrication
B. hydrodynamic lubrication
C. partial lubrication
D. boundary lubrication

17. Machinery locations where lubricant is to be applied are found in_____.

A. lube charts
B. ASLE appendix L
C. lube sheets
D. NAVFAC P-307

18. Before beginning a lubrication job, you will need to _____.

A. review electrical safety policy
B. obtain authorizing paperwork
C. review lube charts and sheets
D. mix the additives with the grease
E. implement lockout/tag out procedures

19. Cross contamination of lubricants can be avoided by _____.

A. purging equipment between uses
B. cleaning equipment between uses
C. following established procedures
D. using the specified lubricant

20. Oils are categorized by various characteristics or properties such as_____.

A. adhesion
B. viscosity
C. cohesion
D. clarity
E. size
F. color

21. When two surfaces maintain some contact, but the amount is limited by very thin layers of lubrication, the condition is termed _____.

A. boundary lubrication
B. hydrodynamic lubrication
C. partial lubrication
D. maximum lubrication

22. The best way to carry out a complete lubrication on a crane is to _____.

A. follow lube charts and sheets
B. contract out the work
C. add lubricants to all visible zerk fittings
D. rely on experience

23. Any excess lubricant spilled on machinery or left on fittings must be_____.

A. wiped up
B. saved for future use
C. bagged and tagged
D. reported to local authorities

24. _____ inhibitors are added to lubrication oil to diminish the effects of oxygen attacking metal surfaces found in thin film areas such as hydraulic lifters and push rods.

A. Rust
B. Pleistocene
C. Viscosity
D. Detergent

25. To prevent contamination from entering the engine when removing an oil filter, you should_____.

A. clean the area around the filter
B. remove the filter very slowly
C. place a drip pan under the filter
D. remove the old oil from the reservoir

26. A lubricant’s ability to cling to metal surfaces is called_____.

A. adhesion
B. clarity
C. viscosity
D. size
E. color
F. cohesion

27. Select the organizations that have established industry standards and service classifications for testing and use of lubricants.

A. SAE
B. API
C. DOD
D. CSA
E. NCC

28. When a (an) ___ ___ additive is added to straight mineral oil, it enables it to withstand much greater pressure between the gear teeth.

A. extreme pressure
B. anti oxidant
C. foam depressant
D. rust inhibitor

29. Types of lubricant to be applied, as well as fitting type, can be found in_____.

A. lube sheets
B. ASME B30 standards
C. lube charts
D. lubrication handbook

30. A lubricant’s ability to resist breaking down is called _____.

A. cohesion
B. adhesion
C. clarity
D. viscosity
E. size
F. color

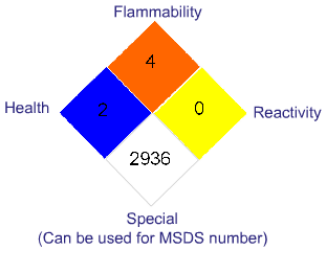
LUBRICATION 2

OIL APPLICATION TOOLS

There are many different types of dispensers for oil. Small oil cans are used for dispensing oil a few drops at a time into small fittings on machinery while quart and gallon size containers with spouts would be utilized for transferring oil from larger containers into crankcases or gear boxes. Barrel pumps, both pneumatic and manual are used for transferring oil from large bulk containers to machinery or smaller dispensers. Funnels and other spout type devices are used to facilitate the transfer of oil into small openings in engines or gear boxes.

PRECAUTIONS WHEN TRANSFERRING OIL

When transferring oil from larger bulk containers to dispensers taken to the job site, care must be taken to eliminate any possibility of contamination. Whenever a portable dispenser is utilized, it must be thoroughly cleaned before filling to ensure that dust, dirt, or a different lubricant type does not contaminate the lubricant to be used. The same precautions should be applied to funnels and other devices. When transferring barrel pumps from one container to another, both barrel tops should be cleaned. If the new container does not contain the same type of lubricant, the pump should be purged of all old lubricant to avoid cross-contamination.



NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) STICKER

When transferring any lubricant to an unlabeled container, the servicer should identify the contents on the container and apply a “National Fire Protection Association”. The NFPA sticker, with the correct ratings, should be applied to the outside of the container. On the NFPA sticker, the blue block indicates the level of health hazard, the red block indicates how flammable the material is, and the yellow block shows reactivity. The white block can be used for any special information or the MSDS number which can be found in the material safety data sheet for the lubricant in question. Filling in the MSDS number in the white block will provide a ready reference number for the next person using the material to consult.

WHY YOU NEED TO CLEAN FUNNELS

When using a funnel to install lubrication oil ensure that the funnel is clean. This illustration of a dirty funnel is an example of why you need to clean out the funnels before you transfer oil with them. If grit and other contaminants are not removed from this funnel before use, it will contaminate the clean oil and may result in damage to equipment.

GREASE DISPENSING EQUIPMENT

The two principle ways for dispensing grease are the hand operated grease gun and the bucket pump. Bucket pumps include all large capacity hand-operated and pneumatic grease pumps. Pressure varies from a few psi for transfer pumps to 15,000 psi in heavy duty models. Such pumps generally consist of a pail, a pail cover, a hand pump fastened in the cover, a flexible hose, and a coupling or nozzle.

GREASE FITTINGS

Zerk fitting

Button head fitting

The two most common types of grease fittings used on cranes are the hydraulic fitting (often called a zerk fitting) and the button head fitting. Both types of grease gun nozzles should be carried by the servicer so that both varieties of fittings may be lubricated. Both types incorporate a check valve inside the fitting to prevent grease from running back out of the fitting. If grease comes out of the fitting after the gun is removed it may allow contamination to enter the machinery, and should be replaced.

CORRECT METHODS OF APPLYING GREASE

Before greasing a fitting, the servicer should locate the fitting on the lube chart and determine what type of grease is to be used and in what quantities. Usually, a fitting will require just one or two pumps of the grease gun to adequately lubricate it. If excess grease is used it just ends up coming out of the other side of the bushing. Before putting the gun on the fitting, the servicer should wipe the fitting to remove any dirt or other contamination which might get carried into the machinery along with the grease. This precaution will also prevent the grease in the grease gun nozzle from becoming contaminated. In addition to wiping the fitting, any grease which has pushed out of the machinery should be wiped off of areas where it serves no purpose. A small cleaning job during lubrication will prevent a larger cleaning job during the next preventative maintenance cycle. A grease relief, if so equipped, should be checked for free action. A grease relief which has been painted over or damaged could cause a seal to blow out due to excess pressure.

GREASING PRECAUTIONS

Due to its consistency, grease attracts and retains contaminants. Care must be taken when filling grease guns to avoid getting dirt, paint, and other contaminants into the grease. Be sure to clean the outside of the grease gun before filling it, and also the container the grease is in. Any container which sits around the shop with a film of grease on the outside of it will attract dirt, grit, and other contaminants. When changing types of grease in a grease gun, all of the old grease should be removed first. Do not forget to purge the hose by pumping some grease through it before using the gun on equipment. When filling a grease gun with grease, be sure to label the gun with the proper NFPA information to identify the grease contained in it.

OVER LUBRICATION

The servicer must always be careful not to over lubricate machinery. An application

such as this pin and clevis, if over lubricated will be messy to clean up, but that is usually the extent of the problem. A bearing in a sealed housing, however, should not be more than half full of grease. If a bearing in a housing has too much grease, the grease can create enough friction and heat to actually burn up the bearing. When lubricating bearing housings on motors and other sealed housing applications, there should be an open relief plug opposite the Zerk fitting which will allow excess grease to escape. After the grease has come out the open relief, it is even good to run the machinery for awhile to let the excess escape.

GOOD HOUSEKEEPING

Here are some tips for good housekeeping. When lubricating equipment on which the grease can ooze out around shafts, the servicer should ensure that he has wiped up all excess grease. Upon completion of lubrication, any oil or grease-soaked rags should be removed from the crane and placed in a hazardous waste container designated for this purpose. When lubricating brake assemblies take extra care to wipe off excess grease and oil so the drums and shoes do not become contaminated. Any grease or oil which has fallen on the deck or other walk-ways on the crane must be cleaned up so that it does not become a slip hazard.

NOTES

LUBRICATION 2 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. When transferring lubricant from one container to another container or component, you should _____.

A. adhere to GMC requirements
B. make sure containers and equipment openings are clean
C. post a watch stander
D. transfer any labeling
E. purge or wipe funnels or other transfer equipment or non-similar lubricants

2. Select items from the list below that describe the correct method for applying grease.

A. wipe the fitting after greasing
B. apply the grease in a predetermined pattern
C. determine the correct type of grease
D. make sure that grease reliefs are unplugged
E. locate the fitting on the lube chart
F. apply to a thickness of 7/16”
G. pump until grease oozes out around edges
H. wipe the fitting before greasing

3. What should be done with any oil or grease soaked rags upon completion of the lubrication?

A. stored in the gang box
B. saved for future use
C. placed in a hazardous waste container
D. removed from the crane
E. piled in the corner

4. What is/are the principal means for dispensing grease?

A. bucket pump
B. drip loader
C. injector
D. grease gun

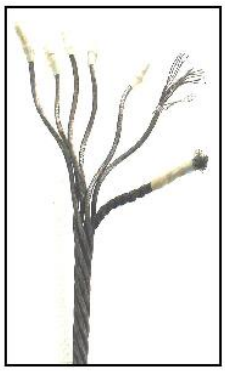
5. What is/are the most common type(s) of grease fittings?

A. clam
B. zerk
C. button head
D. screw type

WIRE ROPE 1

WIRE ROPE DEFINITION

Wire rope is defined as a rope made from steel wires which are formed into multi-wire strands that are then twisted about each other in a spiral configuration usually around a natural, synthetic, or metallic core.



THE PRECISION MACHINE

Keep these questions in mind as you watch the video “The Precision Machine”.

What three basic components are used to construct a wire rope?

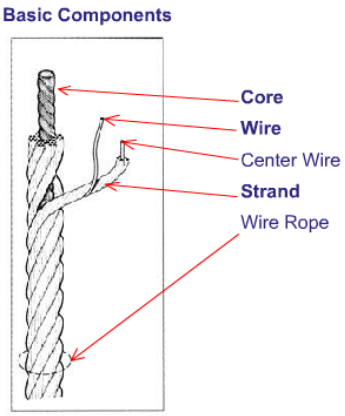
What is a lay length?

What is considered the foundation of a wire rope?

What are the two most common types of wire rope lay?

BASIC COMPONENTS

Wire rope components vary in both complexity and configuration to produce ropes for specific purposes or working characteristics. The three basic components of a standard wire rope design are the individual wires, the strands, and the core.



PLOW STEEL WIRE GRADES

Of the various grades of wire rope, the following three grades are the most commonly used on weight handling equipment. They are improved plow steel or IPS, extra improved plow steel or XIPS, and extra-extra improved plow steel or XXIP.

PLOW STEEL WIRE GRADES IPS

Improved Plow Steel (IPS) has 15% higher tensile strength than plow steel, is fatigue and abrasion resistant, and has good bending qualities.

PLOW STEEL WIRE GRADES XIPS

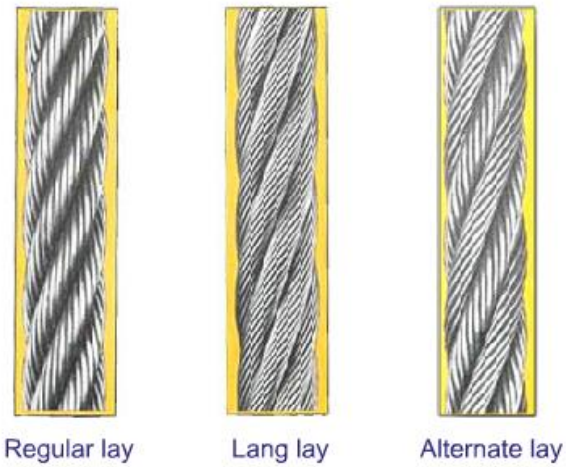
Extra Improved Plow Steel (XIPS) has 15% greater tensile strength than IPS and is used in operations requiring a high breaking strength or safety factor.

PLOW STEEL WIRE GRADES XXIPS

Extra-Extra Improved Plow Steel (XXIPS) is 10% greater in tensile strength than XIPS and is not as commonly used as IPS and XIPS.

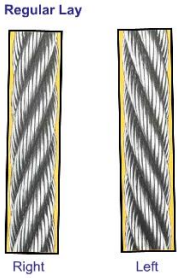
WIRE ROPE LAY

Another identifying factor is the lay of the rope. There are 3 common types of rope lay: regular lay, lang lay, and alternate lay.



REGULAR LAY

Regular lay ropes are made so that the direction of the wire in the strand is parallel with the axis of the rope. The direction of lay can be right or left as in right regular lay or left regular lay.

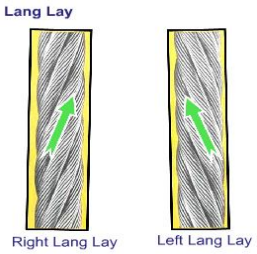


REGULAR LAY CHARACTERISTICS

The characteristics of regular lay rope are greater stability than other lay type, a higher resistance to crushing, and less surface area of the wires is exposed to external abrasion.

LANG LAY

In lang lay ropes, the wires are at an angle to the axis of the rope. Lang lay ropes are made with the strands and wire running in the same direction. The direction of lay can be right or left.

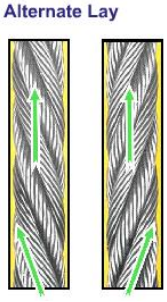


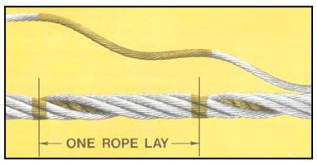
LANG LAY CHARACTERISTICS

Some of the characteristics of lang lay rope include its flexibility, which is better than other wire ropes, and it has greater fatigue and overall abrasion resistance. This lay type allows the wear to be spread over a greater length of exposed wire. On the down side, lang lay wire rope is more susceptible to kinking and un-laying (or unravelling). Lang lay rope is not recommended for use as a single part hoist line and ends must be securely fastened to prevent rotation under load.

ALTERNATE LAY

The third type of rope lay that we will discuss is the alternate lay. Alternate lay rope is a combination of regular and lang lays. As you can see from the illustration, regular lay strands are combined with lang lay strands in the same rope. This is a special application use rope which combines the advantages of both regular and lang lay rope in the same rope.



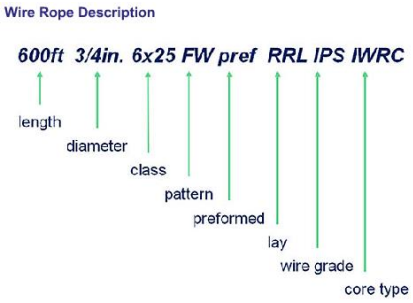


LAY LENGTH

The term “lay length” is a measurement of wire rope and is described as the length along the rope in which one strand uses to make one complete spiral around the rope core.

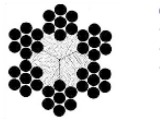
WIRE ROPE DESCRIPTION

A wire rope’s complete description is needed for the selection, identification and replacement of wire rope. A complete wire rope description should include the length, the diameter, the class, such as 6 by19 or 6x37, the strand patterns, such as filler wire or seal, whether the wire is preformed or non-preformed, the lay type such as right regular lay or left lang lay, the wire grade, and the core type. If wire finish is omitted from the description, it is presumed to mean uncoated bright finish.

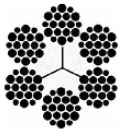


WIRE ROPE CLASSIFICATIONS

6 X 7 Classification



6 X 19 Classification



Wire rope is available in a wide range of construction types, diameters, lays, and cores. Classification descriptions, while standard, describe the approximate number of wires in a rope. Shown here are cross sections of two wire rope construction types although a much greater range of wire rope types is available to meet various application requirements. The 6 X 7 wire rope contains from 3 to 14 wires per strands and is used where resistance to abrasion is needed. This wire rope type would not be suitable in applications where greater flexibility is important. The other example shown is 6 X 19 wire rope which has 6 strands each having 15 to 26 wires per strand. This classifications of wire rope is commonly used in lifting and handling applications due to its balance of flexibility and wear resistance.

LUBRICATION

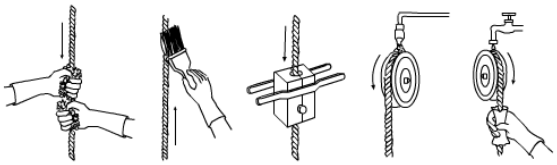
Wire rope should be kept lubricated at all times. The manufacturer’s initial application of lubrication is not sufficient for the life of the rope. When lubricating wire rope ensure the lubricant used is designated as wire rope lubricant or recommended by the wire rope manufacturer. Periodic inspections will indicate how often lubrication is required.

LUBRICATION CHARACTERISTICS

Wire rope lubricants should be corrosion resistant, water repellent have a penetrating ability, be chemically neutral, and be adhesive.

PREPARATION AND CLEANING

Wire rope should be properly cleaned prior to applying any new lubricant. Old lubricant should be removed by wire brushes and a light penetrating cleaner for built-up spots as necessary. Never use gasoline or kerosene as a cleaner. Aside from being a fire hazard these solvents will remove internal lubricants.



APPLYING LUBRICATION

Rope must be clean and dry prior to application of lubricants. Lubricants are normally applied by hand, brushing, drip method, spraying, or mechanically forced. When lubricating wire rope by hand, be very careful not to allow yourself to be injured by loose or protruding wires.

NOTES

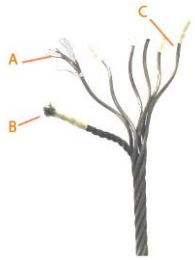
WIRE ROPE 1 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. Choose the two most common grades of carbon steel used in the lifting and handling industry today.

A. stainless steel
B. spring wire
C. extra improved plow steel
D. cold rolled steel
E. improved plow steel

2. In this diagram, A points to…

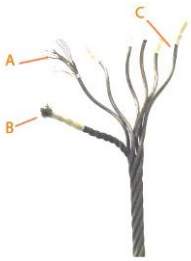


A. wire
B. core
C. strand

3. Select the identifying factor(s) found in a complete wire rope description.

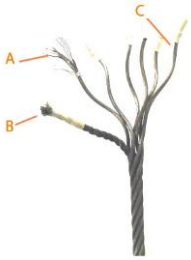
A. core type
B. manufacture
C. requirements
D. diameter
E. wire grade
F. lay type
G. lubrication

4. In this diagram, C points to…



A. wire
B. core
C. strand

5. In this diagram, C points to…



A. core
B. wire
C. strand

6. Used crank case oil is an acceptable wire rope lubricant.

A. True
B. False

7. Looking at the wire rope examples shown below, example C is:

A. left regular lay
B. right lang lay
C. left lang lay
D. right regular lay
E. right alternate lay

8. The term lay length is best describe as _____.

A. a linear measurement in inches
B. a linear measurement in feet
C. the area it takes to lay out a complete length of wire rope
D. the length in which on strand makes on complete spiral around the rope core

9. Looking at the wire rope examples shown below, example B is:

A. left lang lay
B. right alternate lay
C. right lang lay
D. right regular lay
E. left regular lay

10. Looking at the wire rope examples shown below, example D is:

A. left regular lay
B. left lang lay
C. right lang lay
D. right alternate lay
E. right regular lay

11. Looking at the wire rope examples shown below, example E is:

A. right regular lay
B. left lang lay
C. right lang lay
D. right alternate lay
E. left regular lay

12. Select the desirable characteristics for wire rope lubricants.

A. thin consistency
B. adhesive
C. chemically neutral
D. corrosion resistant
E. thick consistency
F. water repellant

13. Looking at the wire rope examples shown below, example A is:

A. left regular lay
B. right alternate lay
C. right lang lay
D. right regular lay
E. left lang lay

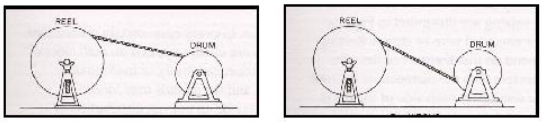
14. Gasoline or kerosene should be used to remove old lubricant.

A. True
B. False

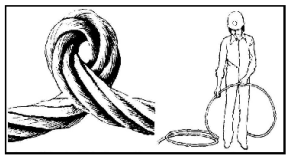
WIRE ROPE 2

WIRE ROPE INSTALLATION

To avoid placing a reverse bend into wire rope, correct installation procedures must be followed. The rope should be installed from the top of reel to the top of the crane's wire rope drum or if spooling the rope to the bottom of the crane's wire rope drum, it must be unwound from the bottom of the reel. It is especially important to keep a tight first (or foundation) layer on the wire rope drum leaving no gaps. As the layers build, any gaps or sloppy spooling will allow the successive wire rope layers to spool incorrectly resulting in crushing, abrasion, distortion, or kinking of the wire rope. Keep the rope taut by using a reel brake will help maintain tight and neatly spooled layers.



Correct Wrong



HANDLING WIRE ROPE

When handling wire rope, care should be exercised to avoid damaging the rope. Be especially careful to prevent loops from forming as this may result in kinking of the wire rope. Dragging wire rope over the ground or on abrasive surfaces can cause metal loss and a reduction in rope diameter. While installing wire rope take care not to allow wire to chafe over sharp corners.

WIRE ROPE STORAGE

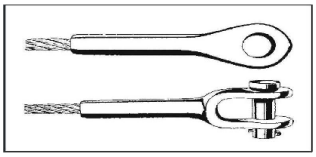
Proper storage of wire rope is essential to preserve the rope in a usable condition. Wire rope should be stored in coils or on reels in a clean, dry place. Outdoor storage can be utilized if the surfaces are covered to prevent foreign matter or moisture from collecting on the rope. Wire rope must be stored away from heat or steam. Coiled wire rope must not be stored for lengthy periods of time on concrete floors as the lime in the concrete can be corrosive to the rope.

POURED SOCKET END CONNECTIONS

Poured sockets are 100% efficient when properly installed and recommended for use on all standing ropes. If resin sockets are used they should be fabricated in accordance with the manufacturer's instructions. Contact Navy Crane Center for a list of approved resin. Spelter sockets are attached to the wire rope with molten zinc and shall be installed per NAVFAC P-307, section 11 requirements.

SWAGED SOCKET END CONNECTION

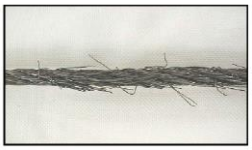
Swaged sockets are 100% efficient when properly installed. This type of wire rope end connection is made by compressing a steel sleeve over the wire rope with a hydraulic press. Swaged sockets must only be installed using equipment designed for this purpose and recommended by the manufacture of the swage fittings.



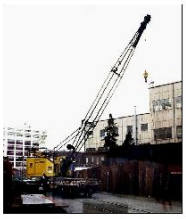
WEDGE SOCKET END CONNECTIONS

Wedge sockets are rated at 70% to 80% efficiency due to the crushing action of the wedge. This type of end connection is intended for use on cranes having frequent configuration changes requiring quick wire rope attachment. Wedge sockets should only be used when necessary since they are not a preferred end attachment. If used, wedge socket end connections shall be installed in accordance with NAVFAC P-307, section 11. Wedge socket end connections shall not be used on non-mobile cranes such as portal, gantry, bridge, hammerhead, and floating cranes.

BROKEN WIRES



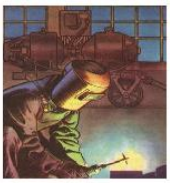
Common causes of broken wires are fatigue, tension, and abrasion. Wire rope fatigue is caused by repeated bending beyond the elastic limits of the wire. Tension related wire rope failures are caused by forces exceeding the nominal strength of the wire. When wire rope has been subjected to abrading, broken wires, loss of strength, and ultimately, failure of the rope may result.



LOCATING BROKEN WIRES

Inspecting for external breaks requires careful inspection of running wire rope, end fittings, and wire at equalizers sheaves.

HEAT DAMAGE



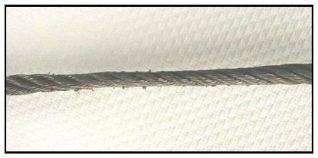
Wire rope should be protected from fire, torches, or arc welding at all times and careful inspection should be performed on areas of the wire rope where possible heat damage is suspect. Fiber cores are particularly susceptible to heat damage. Evidence of heat damage from any cause is reason for rejection as outlined in NAVFAC P-307 Appendix C and D.

END FITTING INSPECTION

Inspection of end fittings is critical to insure the fitting is properly secured to the rope.

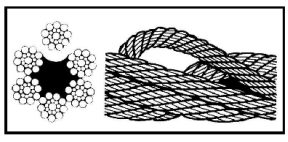
Check closely for broken wires, undue looseness, or inadequate end attachments such as improperly made swage connections or socket fittings.

FLATTENED SECTIONS



Flattened sections of wire rope are cause for rejection if the diameter is less than 5/6 of nominal diameter. This does not apply to rope installed around eyes, thimbles, or shackles.

HIGH STRANDING



High stranding can be caused by a sudden release of wire rope tension or the rope operating through an undersized sheave groove. The rope shall be rejected if the height of the high strand exceeds 10% of the nominal diameter.

KINKS, BIRDCAGES, DOGLEGS, AND CRUSHING

Kinked, bird caged, doglegged, or crushed rope in straight runs where the core is missing or protrudes through or between strands, or where the rope does not fit properly in sheave or drum grooves is criteria for wire rope rejection.

CRANE HOIST DRUM CONDITION

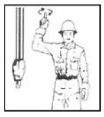
During operation verify in all operating conditions, including extremes of hook or boom positions, that no less than two complete wraps of wire rope remain on grooved drums and at least three complete wraps remain on smooth drums.

SAFETY CONSIDERATIONS

Good safety practices should always be followed when working around wire rope. Avoid working around moving wire rope when possible. If working with moving wire rope is necessary, ensure wire is moving in the direction which will allow the greatest margin of safety, for example: away from sheave or drum. Never place hands on moving wire rope. If necessary to use hands to detect variations in the wire, have the moving rope brought to a stop. For increased safety, inspect wire rope in teams of at least two individuals. The preferred margin of safety is to use a remote "emergency stop" switch held by a second person next to the inspector.

COMMUNICATION





Continuous communication should be maintained at all times when working around moving wire rope. Hand signals relayed by a second individual are necessary if the mechanic is out of the crane operator’s view. Although radio communications may not be suitable in a noisy crane machinery house, if radios are used they must be of an approved type and users must ensure no breaks in contact with the crane operator.

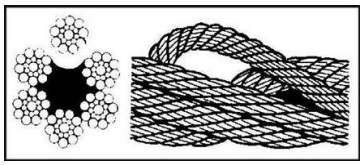
NOTES

WIRE ROPE 2 MODULE EXAM

Online exam questions may appear in a different order than those shown below.

1. Another common defect shown below is known as _____.

A. high strand
B. bird cage
C. flattened rope
D. crushed rope



2. Improper drum spooling of wire rope can result in which of the following?

A. crushing the wire
B. all listed conditions
C. distortion
D. abrasion
E. flattening the wire

3. Which end connection is installed o wore rope using a hydraulic press?

A. wedge socket
B. speltered socket
C. swaged socket
D. resin socket

4. Due to the durability of wire rope, it is unaffected by abrasion or chafing.

A. True
B. False

5. Kinks are normally the result of improper handling by allowing _____ to form in the wire rope.

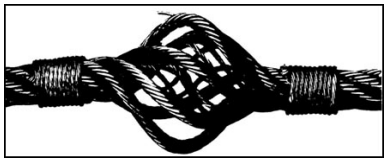
A. slack
B. loops
C. stress
D. knots

6. The proper method of transferring wire rope from a reel to a drum is to _____.

A. transfer from the top of the reel to the top of the drum
B. transfer from the bottom of the reel to the top of the drum
C. transfer from the top of the reel to the bottom of the drum
D. transfer wire from the bottom of the reel to bottom of drum

7. The defect in the picture below is commonly known as a _____.

A. kinked rope
B. popped core
C. dog leg
D. bird cage



NAVFAC
Naval Facilities Engineering Command
NAVY CRANE CENTER

CRANE MECHANIC COURSE EVALUATION

Student Name: _____

Command/Activity/Organization: _____

Instructor: _____ Date: _____

Directions: To assist in evaluating the effectiveness of this course, we would like your reaction to this class. Do not rate questions you consider not applicable.

Please rate the following items:	Excellent	Very Good	Good	Fair	Poor
Content of the course met your needs and expectations.					
Content was well organized.					
Materials/handouts were useful.					
Exercises/skill practices were helpful.					
Training aids (slides, videos, etc) were used effectively.					
Instructor presented the material in a manner, which was easy to understand.					
Instructor was knowledgeable and comfortable with the material.					
Instructor handled questions effectively.					
Instructor covered all topics completely.					
Probability that you will use ideas from the course in your work.					
Your opinion of the course.					
Your overall opinion of the training facilities.					

What were the key strengths of the training? How could the training be improved? Other comments?

_____

_____

_____

_____

List other training topics in which you are interested: _____

_____

_____

Note: If you would like a staff member to follow up and discuss this training, please provide your phone number_____