

CHAPTER 12

RIGGING HARDWARE

This chapter provides requirements for rigging accessories used in hoisting and rigging – shackles, eyebolts, eye nuts, links, rings, swivels, wire-rope clips, turnbuckles, rigging hooks, and load-indicating devices and implements the requirements of ANSI/ASME B30.26, “Rigging Hardware” (for latest ASME standards, see <http://catalog.asme.org/home.cfm?Category=CS>).

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12.1 GENERAL

- a. The information presented in this chapter provides guidance for safely handling lifted loads. Diagrams are used to illustrate hoisting and rigging principles and good and bad rigging practices. This is not a rigging textbook; the information should be applied only by qualified riggers.
- b. All manufacturer-provided lift points designed for and installed on engineered or manufactured equipment are considered part of the equipment and are acceptable for their intended use. Manufacturer-supplied lift points shall:
1. Meet manufacturer's pre-operational inspection, testing, and maintenance criteria.
 2. Be inspected by a designated person prior to use.
 3. Be used in accordance with manufacturer's instructions. In the absence of such information, further qualified technical support may be needed.
- c. Rigging accessories that have been damaged or removed from service shall be made unusable for hoisting and rigging operations before being discarded.
- d. Determine the weight of the load:
1. From markings on the load.
 2. By weighing, if the load is still on the truck or railroad car.
 3. From drawings or other documentation.
 4. By calculation, using the load dimensions and the weights of common materials in Table 12-1.
- e. Determine the center of gravity of the load as accurately as possible:
1. From drawings or other documentation.
 2. From markings on the load.
 3. By calculation.
- f. Determine the best method to attach the load and select the lifting devices (e.g., eyebolts or shackles).
- g. Evaluate load stability (i.e., evaluate load center of gravity with respect to lift points)
- h. Rigging equipment loading for applications other than vertical shall be evaluated as shown in Fig. 12-4.
- i. Manufacturer specifications and requirements for use and application of rigging accessories shall be followed.
- j. Multiple slings or rigging hardware gathered in a link or ring shall not exceed a 120° included angle (See Fig. 12-4).
- k. The horizontal angle of loading should not be less than 30° unless approved by a qualified person (See Fig. 12-4).
- l. All rigging attachment points (e.g., eyebolts, imbedded anchor bolts) shall be evaluated to ensure their capability to safely carry imposed rigging loads.
- m. The working load limit (WLL) of rigging hardware shall not be exceeded in its as configured application.
- n. Rigging hardware service is defined as follows for all types of rigging hardware other than rigging hooks (for hooks see Section 12.2.5.3.b):
1. Normal – Service that involves use of loads at or below the rated load.
 2. Severe – Service that involves normal service coupled with abnormal rigging or operating conditions.
 3. Special – Service that involves operation, other than normal or severe, which is approved by a qualified person.

12.1.1 GOOD AND BAD RIGGING PRACTICES

Figure 12-1 illustrates some good and bad rigging practices.

Table 12-1. Weights of Common Materials

Name of Metal	Weight (lb/ft ³)	Name of Material	Weight (lb/ft ³)
Aluminum	166	Bluestone	160
Antimony	418	Brick, pressed	50
Bismuth	613	Brick, common	125
Brass, cast	504	Cement, Portland (packed)	100-120
Brass, rolled	523	Cement, Portland (loose)	70-90
Copper, cast	550	Cement, slag (packed)	80-100
Copper, rolled	555	Cement, slag (loose)	55-75
Gold, 24-carat	1,204	Chalk	156
Iron, cast	450	Charcoal	15-34
Iron, wrought	480	Cinder concrete	110
Lead, commercial	712	Clay, ordinary	120-150
Mercury, 60 degrees F	846	Coal, hard, solid	93.5
Silver	655	Coal, hard, broken	54
Steel	490	Coal, soft, solid	84
Tin, cast	458	Coal, soft, broken	54
Uranium	1,163	Coke, loose	23-32
Zinc	437	Concrete or stone	140-155
		Earth, rammed	90-100
<u>Name of wood</u>		Granite	165-170
		Gravel	117-125
Ash	35	Lime, quick (ground loose)	53
Beech	37	Limestone	170
Birch	40	Marble	164
Cedar	22	Plaster of paris (cast)	80
Cherry	30	Sand	90-106
Chestnut	26	Sandstone	151
Cork	15	Shale	162
Cypress	27	Slate	160-180
Ebony	71	Terra-cotta	110
Elm	30	Traprock	170
Fir, Balsam	22	Water	65
Hemlock	31		
Maple, Oak	62		
Pine, Poplar	30		

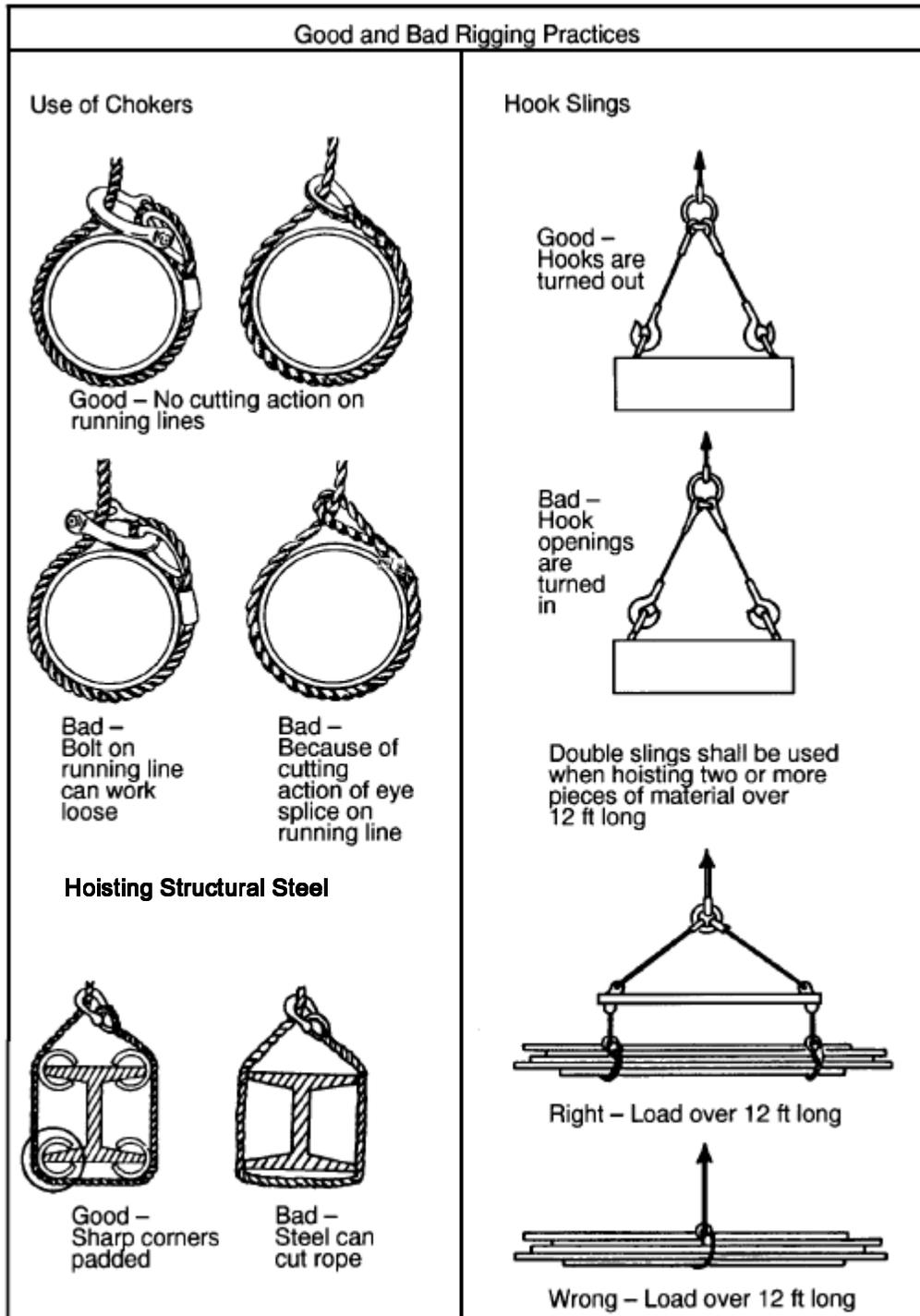


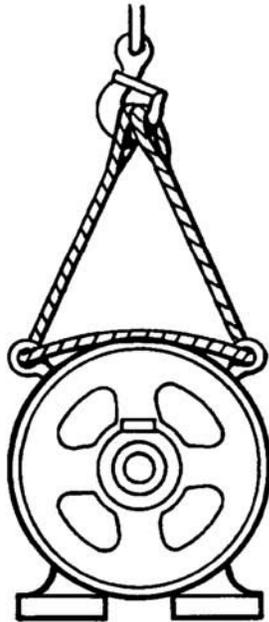
Figure 12-1. Good and bad rigging practices

GOOD AND BAD RIGGING PRACTICES

Eyebolts



Good practice—vertical lift on eyebolt

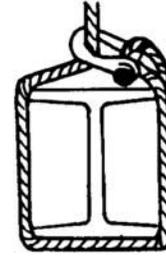


Bad practice – lifting on eyebolts from an angle reduces safe loads as much as 90%

Hoisting Structural Steel



Good – Use space blocks and pad corners



Bad – Can bend flanges and cut rope

Eye Splices



Good practice – Note use of thimble in eye splice



Good practice – Use of thimble in eye splice



Bad practice – Wire rope knot with clip. Efficiency 50% or less



Bad practice – Thimble should be used to increase strength of eye and reduce wear on rope

Figure 12-1. (continued).

12.2 RIGGING HOOKS

12.2.1 DESIGN

Hook design shall meet generally accepted hook design standards and shall comply with the requirements of ASME B30.10. (See Chapter 13, “Load Hooks,” for equipment load hook requirements).

12.2.2 MARKING

The manufacturer’s identification shall be forged, cast, or die-stamped on a low-stress and nonwearing area of the hook.

12.2.3 CONSTRUCTION

- a. The hook material shall have sufficient ductility to permanently deform before failure at the temperature at which the hook will be used.
- b. Rated capacities for hooks shall equal or exceed the rated capacity of the chain, wire rope, or other suspension members to which they are attached.

12.2.4 LOAD LIMITS

A hook shall not be loaded beyond its rated capacity, except as is necessary to conform to the requirements for load testing of the sling or hardware to which it is attached.

12.2.5 INSPECTIONS

12.2.5.1 Initial Inspection

- a. A designated inspector shall inspect all new and repaired hooks prior to initial use. Dimensional data on the hooks shall be recorded to facilitate subsequent inspections for wear and throat openings. Dated and signed inspection records shall be kept on file and shall be readily available.
- b. Inspection procedure and record keeping requirements for hooks in regular service shall be determined by the kind of equipment in which they are used. When such requirements for hooks are stated in standards for the specific equipment, they shall take precedence over the requirements of this section.

12.2.5.2 Daily Inspection

- a. The operator or other designated person shall visually inspect hooks daily or prior to first use, if the hook is not in regular service, for the following (records are not required):
 1. Cracks, nicks, gouges.
 2. Deformation.
 3. Damage from chemicals.
 4. Damage, engagement, or malfunction of latch (if provided).
 5. Evidence of heat damage.
- b. A designated person shall examine deficiencies and determine whether they constitute a safety hazard and whether a more detailed inspection is required.

12.2.5.3 Frequent Inspection

- a. The operator or other designated personnel shall visually inspect the hook at the following intervals (records are not required):
 1. Normal service – monthly.
 2. Heavy service – weekly to monthly.
 3. Severe service – daily to weekly.
- b. Hook service is defined as follows:
 1. Normal service – operation at less than 85 percent of rated capacity except for isolated instances.
 2. Heavy service – operation at 85 to 100 percent of rated capacity as a regular specified procedure.
 3. Severe service – operation at heavy service coupled with abnormal operating conditions.
- c. These inspections shall, in addition to the requirements of Section 12.2.5.2, “Daily Inspection,” include the following:
 1. Wear.
 2. Hook attachment and securing means.
- d. A designated person shall examine deficiencies and determine whether a more detailed inspection is required.

12.2.5.4 Periodic Inspection

- a. A designated inspector shall perform a complete inspection at the following intervals:
 - 1. Normal service – yearly.
 - 2. Heavy service – semiannually.
 - 3. Severe service – quarterly.
- b. A designated inspector shall examine deficiencies and determine whether they constitute a safety hazard.
- c. The inspection shall include the requirements of Section 12.2.5.3, “Frequent Inspection.”
- d. Hooks having any of the following conditions shall be removed from service until repaired or replaced:
 - 1. Any visibly apparent bend or twist from the plane of the unbent hook.
 - 2. Any distortion causing an increase in throat opening exceeding 5 percent not to exceed ¼ inch, (or as recommended by the manufacturer).
 - 3. Any wear exceeding 10 percent (or as recommended by the manufacturer) of the original section dimension of the hook.
 - 4. Cracks.
- e. If a latch is provided and it becomes inoperative or fails to fully bridge the throat opening, the hook shall be removed from service until the device has been repaired or replaced

12.2.6 TESTING

- a. Performance testing of hooks shall not be required except where necessary to conform to the requirements for the equipment of which they are part. When tests are specified, documentation shall be uniquely identified to the hook by serial number or other identifier.
- b. If detailed inspections are performed (refer to Sections 12.2.5.2.b, 12.2.5.3.d, and 12.2.5.4.c), the results shall be evaluated by a designated

person to determine the need for subsequent nondestructive testing (NDT). If NDT is deemed necessary, it shall be performed in accordance with Section 13.4.3.

12.2.7 MAINTENANCE

- a. A designated person shall repair cracks, nicks, and gouges by grinding longitudinally, following the contour of the hook, provided that no dimension is reduced more than 10 percent of its original value (or as recommended by the manufacturer).
- b. All other repairs shall be performed by the manufacturer.

12.2.8 OPERATION

The following shall apply to rigging hook users:

- a. Determine that the load does not exceed the lesser of the rated capacity of the hook or the load rating of the equipment of which it is a part.,
- b. Avoid shock loading.
- c. Keep hands, fingers, and body from getting between the hook and the load.
- d. Load shall be centered in the base of the hook to prevent point loading of the hook.
- e. Hooks shall not be used in such a manner as to place a side load or back load on the hook.
- f. When using a device to close the throat opening of the hook, care shall be taken that the load is not carried by the closing device
- g. The use of a hook with a latch does not preclude the inadvertent detachment of a slack sling or a load from the hook. Visual verification of proper hook engagement is required in all cases.
- h. Self-locking hooks shall be locked during use.
- i. When a lock is equipped with a latch, the latch shall not be constrained from closing during use.

12.3 SHACKLES

12.3.1 GENERAL

- a. Shackles are made of drop-forged steel bent into shape. The shackle shall have sufficient ductility to permanently deform before losing the ability to support the load at the temperatures at which the manufacturer has specified for use. They are strong, closed attachments that will not come unhooked. The size is specified by the diameter of the body. Side pulls on the shackle body are only permitted if the manufacturer has rated the shackle for that type of lift.

NOTE: Round pin shackles (restrained by cotter pin only) shall not be used for lifting.

- b. Types:
1. Body types covered are anchor, chain, and synthetic sling (see Fig. 12.2).
 2. Pin types covered are screw pin and bolt-type (see Fig. 12.2).
 3. Shackles other than those detailed in this chapter shall be used only in accordance with recommendations of the shackle manufacturer or a qualified person.
- c. Shackle pins shall fit free without binding. A bolt shall not be used as a substitute for a shackle pin. Figure 12-3 shows the components and typical inspection points of shackles.
- d. Each shackle body shall be permanently and legible marked by the manufacturer. Raised or stamped letters on the side of the bow shall be used to show:
1. Manufacturer's name and trademark.
 2. Size.
 3. Rated capacity.
- e. Pins for shackles manufactured after May 20, 2006 shall be marked by the manufacturer with raised or stamped letters showing:
1. Name or trademark of manufacturer
 2. Grade, material type or load rating
- f. When shackles are side loaded, the safe loading shall be reduced as specified by the manufacturer (See Figure 12-5).
- g. Design Factor:

1. The design factor for shackles up to and including a 150 ton rated load shall be a minimum of 5:1.
 2. The design factor for shackles over 150 ton rated load shall be a minimum of 4:1.
- i. Rated load shall be in accordance with the recommendation of the shackle manufacturer. The terms "rated capacity" and "working load limit" are commonly used to describe rated load.

12.3.2 EFFECTS OF ENVIRONMENT

- a. When shackles are to be used at temperatures above 400°F (204°C) or below -40°F (-40°C), the shackle manufacturer or a qualified person should be consulted.
- b. The strength of shackles can be affected by chemically active environments such as caustic or acid substances or fumes. The shackle manufacturer or a qualified person should be consulted before shackles are used in chemically active environments.

12.3.3 TRAINING

Shackle users shall be trained in the selection, inspection, cautions to personnel, effects of environment, and rigging practices as covered by this standard.

12.3.4 INSPECTIONS

- a. Initial Inspection
1. Prior to use, all new, altered, modified, or repaired shackles shall be inspected by a designated person to verify compliance with the applicable provisions of this chapter. Written records are not required.
- b. Frequent Inspection
1. A visual inspection shall be performed by the user or other designated person each day before the shackle is used. Semi-permanent and inaccessible locations where frequent inspections are not feasible shall have periodic inspections performed.
 2. Conditions such as those listed in Section 12.3.5 or any other condition that may result in a hazard shall cause the shackle to be removed from service. Shackles shall not be returned to service until approved by a qualified person.

3. Written records are not required.
- c. Periodic Inspection:
 1. A complete inspection of the shackle shall be performed by a designated person. The shackle shall be examined for conditions such as those listed in Section 12.3.5 and a determination made as to whether they constitute a hazard.
 2. Periodic inspection intervals shall not exceed one year. The frequency of periodic inspections should be based on:
 - i. Frequency of use.
 - ii. Severity of service conditions.
 - iii. Nature of lifts being made.
 - iv. Experience gained on the service life of shackles used in similar circumstances.
 3. Guidelines for the time intervals are:
 - i. Normal service – yearly.
 - ii. Severe service – monthly to quarterly.
 - iii. Special service – as recommended by a qualified person.
 4. Written records are not required.

12.3.5 REMOVAL CRITERIA

- a. Shackles shall be removed from service if damage such as the following is visible, and shall only be returned to service when approved by a qualified person:
 1. Missing or illegible manufacturer's name or trademark and/or rated load identification.
 2. Indications of heat damage including welding spatter or arc strikes.

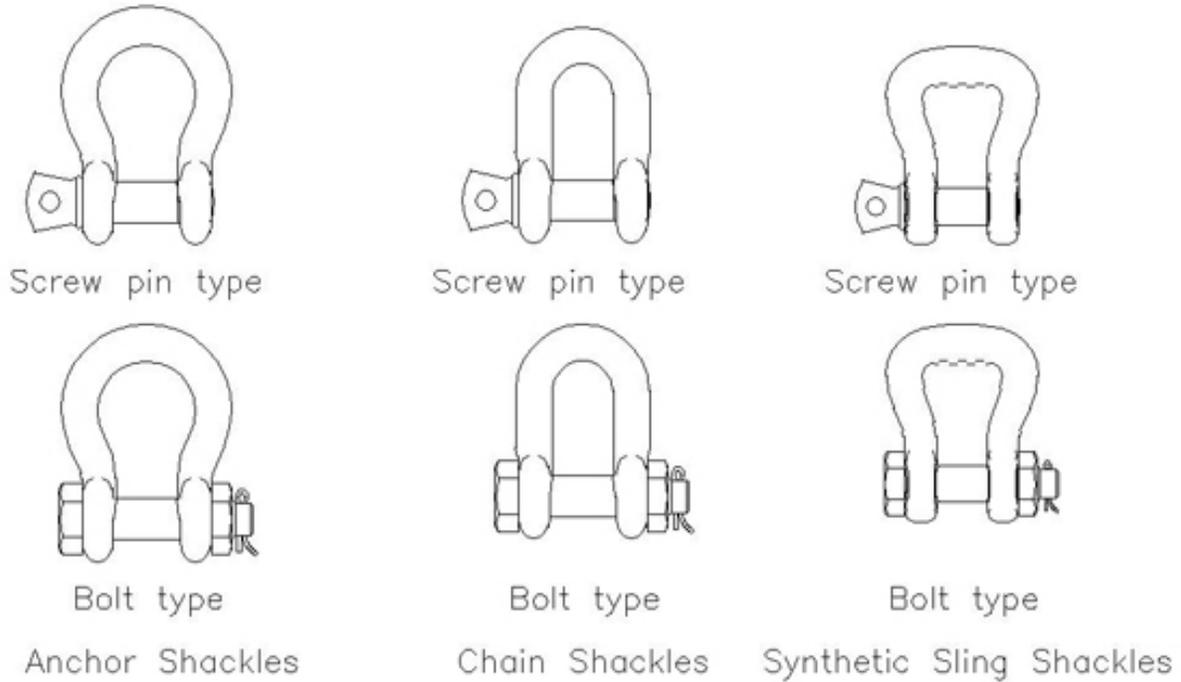
3. Excessive pitting or corrosion
4. Bent, twisted, distorted, stretched, elongated, cracked, or broken load-bearing components
5. Excessive nicks or gouges
6. A 10% reduction of the original or catalog dimension at any point around the body or pin.
7. Incomplete pin engagement
8. Excessive thread damage.
9. Evidence of unauthorized welding.
10. Other conditions, including visible damage, that cause doubt as to the continued use of the shackle..

12.3.6 REPAIRS

- a. Repairs, alterations, or modifications shall be as specified by the shackle manufacturer or a qualified person.
- b. Replacement parts shall meet or exceed the original equipment manufacturer's specifications.

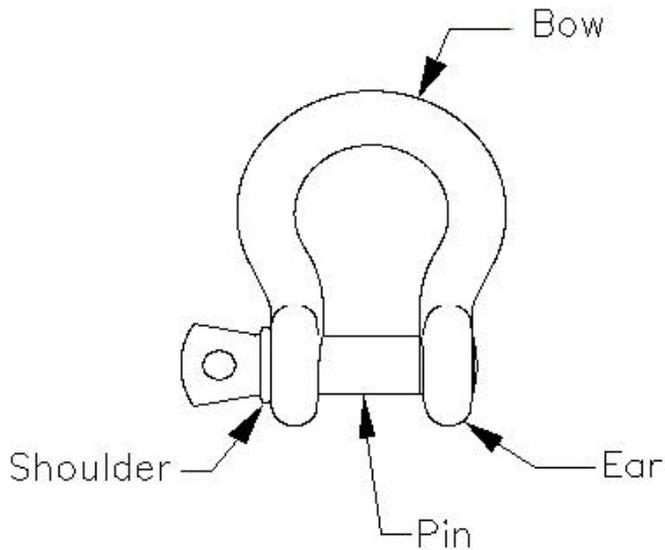
12.3.7 CRITICAL LIFTS

- a. See Chapter 2, "Critical Lifts," for critical lift requirements.
- b. Shackles used for critical-lift service shall have an initial proof load test of 200 percent of the rated capacity. Test loads shall be accurate to within -5 percent, +0 percent of stipulated values. If proof testing cannot be verified, the shackle(s) shall be proof tested before being used to make a critical lift.



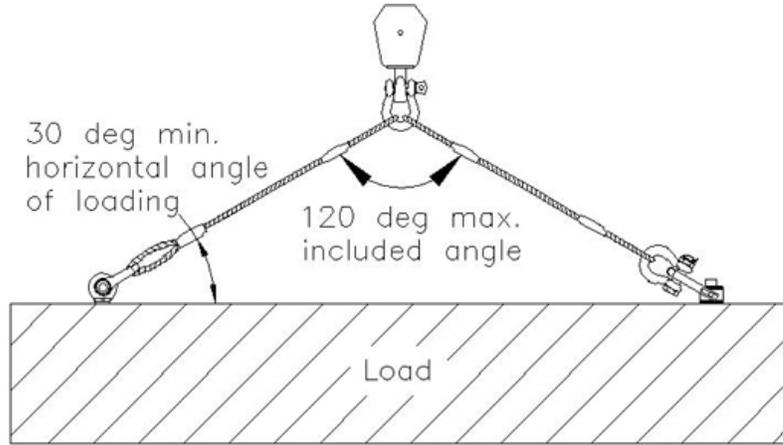
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Figure 12-2. Shackle Types



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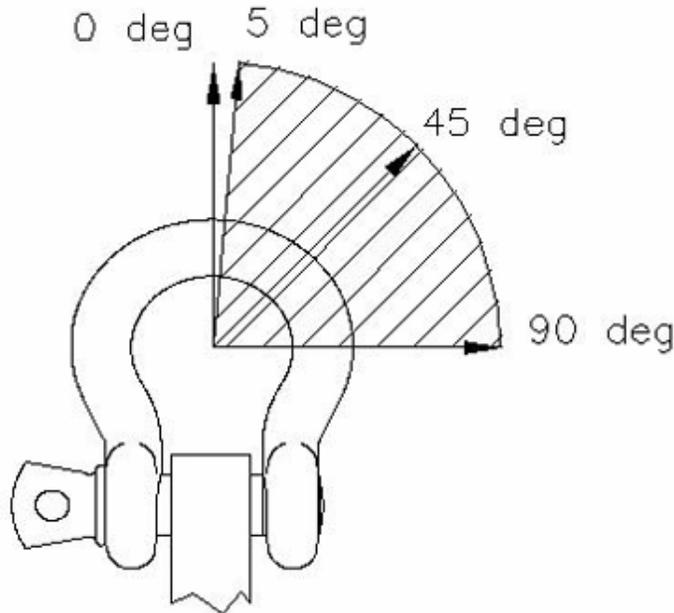
Figure 12-3. Typical Shackle Inspection Points



Horizontal Angle, deg.	Load Multiplier
90	1.000
60	1.155
45	1.414
30	2.000

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Figure 12-4. Effect of Loading Angle



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Figure 12-5. Side Loading

12.4 EYEBOLTS

12.4.1 GENERAL

- a. This section specifies requirements for eyebolts that are used as rigging hardware during normal hoisting and rigging activities.
- b. Eyebolts used for hoisting shall be fabricated from forged carbon or alloy steel and shall have sufficient ductility to permanently deform before losing the ability to support the load at temperatures at which the manufacturer has specified for use.
- c. Each eyebolt shall be marked to show:
 1. Name or trademark of manufacturer.
 2. Size or rated load.
 3. Grade for alloy eyebolts.
- d. Eyebolts shall have a minimum design factor of 5:1.
- e. Only shouldered eyebolts shall be used for rigging hardware, except when prohibited by the configuration of the item to be lifted. Where non-shouldered eyebolts are required, they shall only be used in vertical pulls or in rigging systems that are designed and approved by a qualified person.
- f. Nuts, washers, and drilled plates shall not be used or assembled to make shouldered eyebolts.
- g. Wire-type or welded eyebolts shall not be used.
- h. Shoulders shall seat uniformly, snugly and flush against the surface on which they bear (See Fig. 12-6).
- i. When eyebolts cannot be properly seated and aligned, a steel washer or spacer with the smallest inside diameter that will fit the eyebolt shank may be used to put the plane of the eye in the direction of the load when the shoulder is seated. The washer or spacer shall not exceed one thread pitch in thickness or as recommended by the manufacturer.
- j. Eyebolts shall be tightened or otherwise secured against rotation during the lift.
- k. When used in a tapped blind hole, the effective thread length shall be at least one and one half times the diameter of the bolt for engagement in steel (see Fig. 12-6). For other thread engagements or engagement in other materials, contact the eyebolt manufacturer or qualified person.

- l. When used in a tapped through-hole of less than one and one half diameter thickness, a nut shall be used under the load and shall be fully engaged and tightened securely against the load (see Fig. 12-6).
- m. Only shouldered eyebolts shall be used for angular loading. The shoulder shall be securely tightened against the load and the eye shall be aligned with the direction of the loading. The working load limit shall be reduced as recommended by the manufacturer.
- n. Shock loading shall be avoided.

12.4.2 EFFECTS OF ENVIRONMENT

- a. When alloy steel eyebolts are to be used at temperatures above 400°F (204°C) or below 40°F (-40°C), the eyebolt manufacturer or a qualified person should be consulted.
- b. Carbon steel eyebolts shall not be used at temperatures above 275°F (135°C) or below 30°F (-1°C) unless approved by manufacturer or a qualified person.
- c. The strength of eyebolts can be affected by chemically active environments such as caustic or acid substances or fumes. The eyebolt manufacturer or a qualified person should be consulted before eyebolts are used in chemically active environments.

12.4.3 TRAINING

Eyebolt users shall be trained in the selection, inspection, cautions to personnel, effects of environment, and rigging practices as covered by this standard.

12.4.4 INSPECTIONS

- a. Initial Inspection
 1. Prior to use, all new, altered, modified, or repaired eyebolts shall be inspected by a designated person to verify compliance with the applicable provisions of this chapter. Written records are not required.
- b. Frequent Inspection
 1. A visual inspection shall be performed by the user or other designated person each shift before the eyebolt is used. Semi-permanent and inaccessible locations where frequent inspections are not feasible shall have periodic inspections performed.

2. Conditions such as those listed in Section 12.4.5 or any other condition that may result in a hazard shall cause the eyebolt to be removed from service. Eyebolts shall not be returned to service until approved by a qualified person.
 3. Written records are not required.
- c. Periodic Inspection:
1. A complete inspection of the eyebolt shall be performed by a designated person. The eyebolt shall be examined for conditions such as those listed in Section 12.4.5 and a determination made as to whether they constitute a hazard.
 2. Periodic inspection intervals shall not exceed one year. The frequency of periodic inspections should be based on:
 - v. Frequency of use.
 - vi. Severity of service conditions.
 - vii. Nature of lifts being made.
 - viii. Experience gained on the service life of eyebolts used in similar circumstances.
 3. Guidelines for the time intervals are:
 - i. Normal service – yearly.
 - ii. Severe service – monthly to quarterly.
 - iii. Special service – as recommended by a qualified person.
 4. Written records are not required.

12.4.5 REMOVAL CRITERIA

Eyebolts shall be removed from service if damage such as the following is visible, and shall only be returned to service when approved by a qualified person:

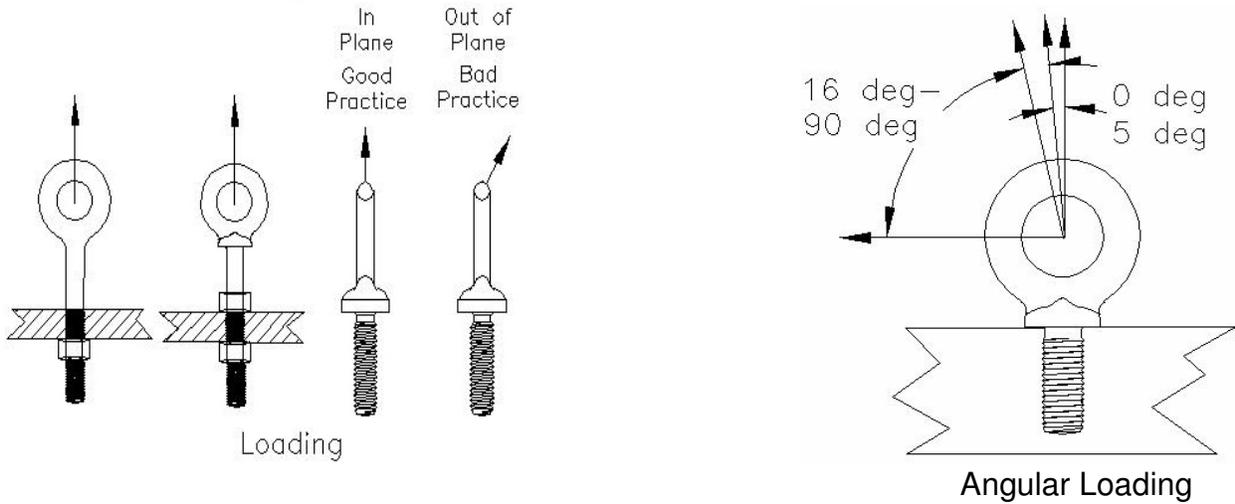
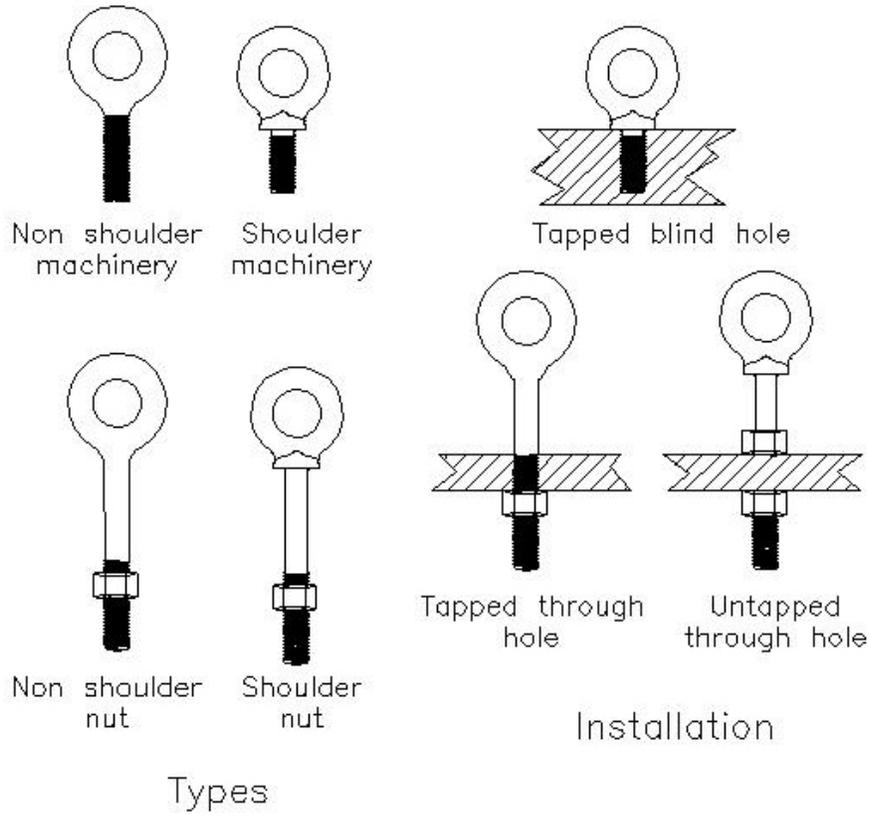
- a. Missing or illegible manufacturer's name or trademark and/or rated load identification.
- b. Indications of heat damage including welding spatter or arc strikes.
- c. Excessive pitting or corrosion.
- d. Bent, twisted, distorted, stretched, elongated, cracked, or broken load-bearing components.
- e. Excessive nicks or gouges.
- f. A 10% reduction of the original or catalog dimension at any point around the body or pin.
- g. Excessive thread damage or wear.
- h. Evidence of unauthorized welding or modification
- i. Other conditions, including visible damage, that cause doubt as to continue use.

12.4.6 REPAIRS

- a. Repairs, alterations, or modifications shall be as specified by the eyebolt manufacturer or a qualified person.
- b. Replacement parts shall meet or exceed the original equipment manufacturer's specifications.

12.4.7 CRITICAL LIFTS

- a. See Chapter 2, "Critical Lifts," for critical lift requirements.
- b. Eyebolts used for critical-lift service shall have an initial proof test of 200 percent of the rated capacity. Test loads shall be accurate to within - 5 percent, +0 percent of stipulated values. If proof testing cannot be verified, the eyebolts shall be proof tested before being used to make a critical lift



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Figure 12-6. Eyebolts

12.5 EYE NUTS

12.5.1 GENERAL

- a. This section specifies requirements for eye nuts that are used as rigging hardware during normal hoisting and rigging activities.
- b. Eye nuts used for hoisting shall have sufficient ductility to permanently deform before losing the ability to support the load at temperatures at which the manufacturer has specified for use.
- c. Each eye nut shall be marked to show:
 1. Name or trademark of manufacturer.
 2. Size or rated load.
- d. Eye nuts shall have a minimum design factor of 5:1.
- e. Eye nuts shall be secured against rotation during the lift.
- f. The threads of the eye nut shall be fully engaged (See Fig. 12-7).
- g. Eye nuts shall only be used for in-line loads.
- h. The plane of the eye may be positioned with a flat washer(s) or lock nut.
- i. Shock loading should be avoided.

12.5.2 EFFECTS OF ENVIRONMENT

- a. When eye nuts are to be used at temperatures above 400°F (204°C) or below -40°F (-40°C), the eye nut manufacturer or a qualified person should be consulted.
- b. The strength of eye nuts can be affected by chemically active environments such as caustic or acid substances or fumes. The eye nut manufacturer or a qualified person should be consulted before eye nuts are used in chemically active environments.

12.5.3 TRAINING

Eye nut users shall be trained in the selection, inspection, cautions to personnel, effects of environment, and rigging practices as covered by this standard.

12.5.4 INSPECTIONS

- a. Initial Inspection
 1. Prior to use, all new, altered, modified, or repaired eye nuts shall be inspected by a designated person to verify compliance with the applicable provisions of this chapter. Written records are not required.
- b. Frequent Inspection
 1. A visual inspection shall be performed the user or other designated person each shift before the eye nut is used. Semi-permanent and inaccessible locations where frequent inspections are not feasible shall have periodic inspections performed.
 2. Conditions such as those listed in Section 12.5.5, or any other condition that may result in a hazard shall cause the eye nut to be removed from service. Eye nuts shall not be returned to service until approved by a qualified person.
 3. Written records are not required.
- c. Periodic Inspection:
 1. A complete inspection of the eye nut shall be performed by a designated person. The eye nut shall be examined for conditions such as those listed in Section 12.5.5 and a determination made as to whether they constitute a hazard.
 2. Periodic inspection intervals shall not exceed one year. The frequency of periodic inspections should be based on:
 - i. Frequency of use.
 - ii. Severity of service conditions.
 - iii. Nature of lifts being made.
 - iv. Experience gained on the service life of eye nuts used in similar circumstances.
 3. Guidelines for the time intervals are:
 - i. Normal service – yearly.
 - ii. Severe service – monthly to quarterly.
 - iii. Special service – as recommended by a qualified person.

- d. Written records are not required.

12.5.5 REMOVAL CRITERIA

Eye nuts shall be removed from service if damage such as the following is visible, and shall only be returned to service when approved by a qualified person:

- a. Missing or illegible manufacturer’s name or trademark and/or rated load identification.
- b. Indications of heat damage including welding spatter or arc strikes.
- c. Excessive pitting or corrosion.
- d. Bent, twisted, distorted, stretched, elongated, cracked, or broken load-bearing components.
- e. Excessive nicks or gouges.
- f. A 10% reduction of the original or catalog dimension at any point around the body or pin.
- g. Excessive thread damage or wear.
- h. Evidence of unauthorized welding or modification

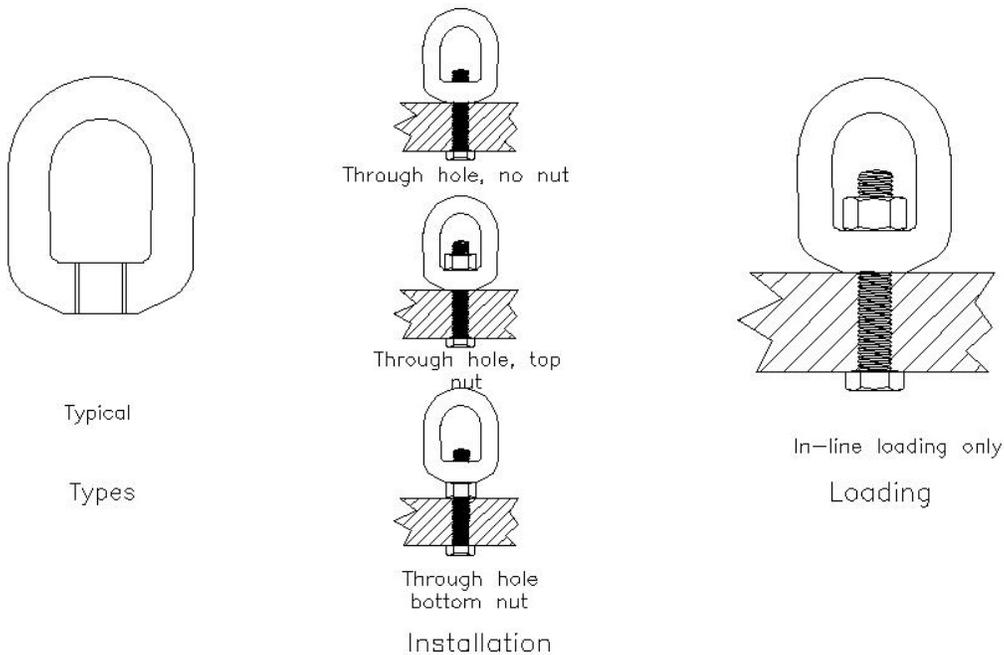
- i. Other conditions, including visible damage, that cause doubt as to continue use.

12.5.6 REPAIRS

- a. Repairs, alterations, or modifications shall be as specified by the eye nut manufacturer or a qualified person.
- b. Replacement parts shall meet or exceed the original equipment manufacturer’s specifications.

12.5.7 CRITICAL LIFTS

- a. See Chapter 2, “Critical Lifts,” for critical lift requirements.
- b. Eye nuts used for critical-lift service shall have an initial proof test of 200 percent of the rated capacity. Test loads shall be accurate to within - 5 percent, +0 percent of stipulated values. If proof testing cannot be verified, the eye nut shall be proof tested before being used to make a critical lift.



Eye Nuts

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Figure 12-7. Eye Nuts

12.6 TURNBUCKLES

12.6.1 GENERAL

- a. Turnbuckles include open and pipe bodies and have hook, eye, jaw, or stub end fittings (See Figure 12-8). Before each use, turnbuckles shall be inspected for damage. Damaged threads, jamb nuts, or bent frame members make the unit unsuitable for use.
- b. Turnbuckles shall be fabricated from material of sufficient ductility to permanently deform before losing the ability to support the load within the temperature range that the manufacture specified and shall have a minimum design factor of 5:1.
- c. Each turnbuckle body shall be permanently and legibly marked by the manufacturer to show:
 1. Manufacturer's name or trademark.
 2. Size or rated load.

12.6.2 OPERATING PRACTICES:

- a. Turnbuckle end fitting threads shall be fully engaged in the body threads.
- b. Components, including pins, bolts, nuts, or cotter pins used with jaw ends, shall be in good working condition prior to use.
- c. Contact with obstructions that could damage or bend the turnbuckle should be avoided.
- d. Shock loading should be avoided.
- e. The load applied to the turnbuckle should be in line and in tension.
- f. When turnbuckles are used at load angles other than 90 degrees, the safe-load rating shall be reduced per the manufacturer's recommendations.
- g. Turnbuckles should not be side loaded.
- h. Turnbuckles used in applications where there is vibration shall be secured to the frame with locks, pins, or wires to prevent turning or loosening.
- i. Turnbuckles should be rigged or secured to prevent unscrewing during the lift.
- j. For long-term installations, turnbuckles shall be secured to prevent unscrewing.
- k. Turnbuckles should not be dragged on and an abrasive surface.

1. Turnbuckles should be adjusted with a properly sized wrench, used on the flats of the turnbuckle body.

12.6.3 EFFECTS OF ENVIRONMENT

- a. When a turnbuckle is to be used at temperatures above 400°F (204°C) or below -40°F (-40°C), the turnbuckle manufacturer or a qualified person should be consulted.
- b. The strength of turnbuckles can be affected by chemically active environments such as caustic or acid substances or fumes. The turnbuckle manufacturer or a qualified person should be consulted before turnbuckles are used in chemically active environments.

12.6.4 TRAINING

Turnbuckle users shall be trained in the selection, inspection, cautions to personnel, effects of environment, and rigging practices as covered by this standard.

12.6.5 INSPECTIONS

- a. Initial Inspection
 1. Prior to use, all new, altered, modified, or repaired turnbuckles shall be inspected by a designated person to verify compliance with the applicable provisions of this chapter. Written records are not required.
- b. Frequent Inspection
 1. A visual inspection shall be performed the user or other designated person each shift before the turnbuckle is used. Semi-permanent and inaccessible locations where frequent inspections are not feasible shall have periodic inspections performed.
 2. Conditions such as those listed in Section 12.6.6 or any other condition that may result in a hazard shall cause the turnbuckle to be removed from service. Turnbuckles shall not be returned to service until approved by a qualified person.
 3. Written records are not required.
- c. Periodic Inspection:
 1. A complete inspection of the turnbuckle shall be performed by a designated person. The turnbuckle shall be examined for conditions such as those listed in Section

- 12.6.6.and a determination made as to whether they constitute a hazard.
2. Periodic inspection intervals shall not exceed one year. The frequency of periodic inspections should be based on:
 - i. Frequency of use.
 - ii. Severity of service conditions.
 - iii. Nature of lifts being made.
 - iv. Experience gained on the service life of turnbuckles used in similar circumstances.
 3. Guidelines for the time intervals are:
 - i. Normal service – yearly.
 - ii. Severe service – monthly to quarterly.
 - iii. Special service – as recommended by a qualified person.
 4. Written records are not required.

12.6.6 REMOVAL CRITERIA

Turnbuckles shall be removed from service if damage such as the following is visible, and shall only be returned to service when approved by a qualified person:

- a. Missing or illegible manufacturer's name or trademark and/or rated load identification.
- b. Indications of heat damage including welding spatter or arc strikes.
- c. Excessive pitting or corrosion.

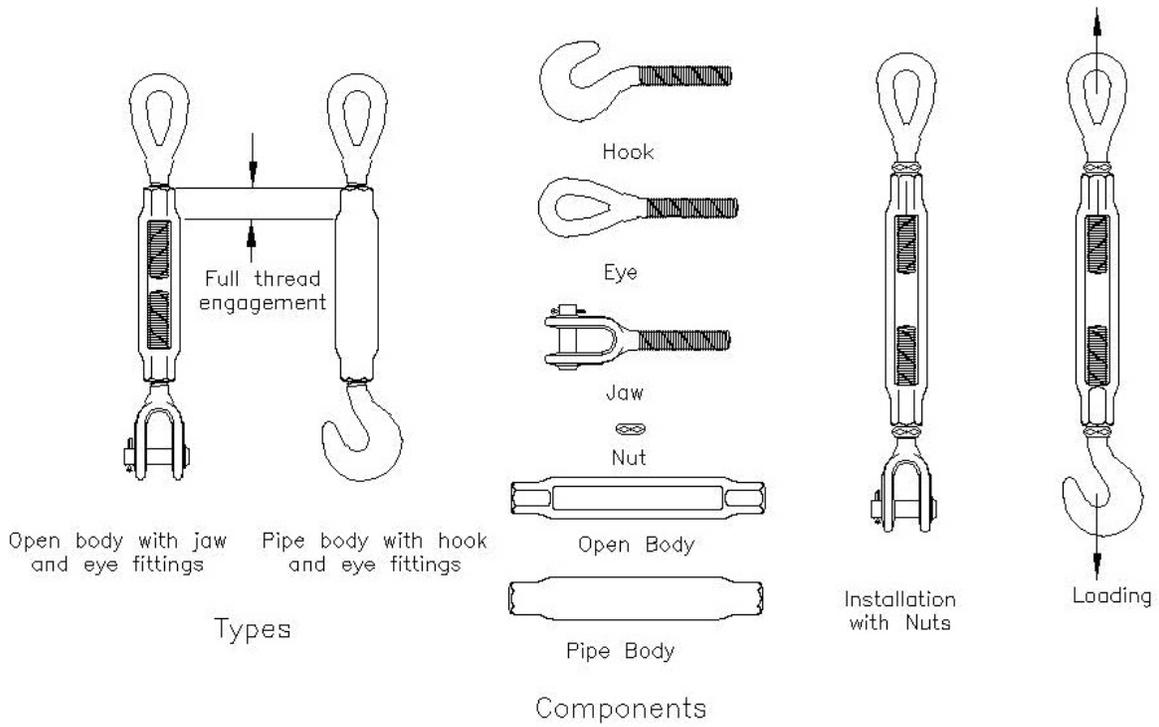
- d. Bent, twisted, distorted, stretched, elongated, cracked, or broken load-bearing components.
- e. Excessive nicks or gouges.
- f. A 10% reduction of the original or catalog dimension at any point.
- g. Excessive thread damage or wear.
- h. Evidence of unauthorized welding or modification
- i. Other conditions, including visible damage, that cause doubt as to continue use.

12.6.7 REPAIRS

- a. Repairs, alterations, or modifications shall be as specified by the turnbuckle manufacturer or a qualified person.
- b. Replacement parts shall meet or exceed the original equipment manufacturer's specifications.

12.6.8 CRITICAL LIFTS

- a. See Chapter 2, "Critical Lifts," for critical lift requirements.
- b. Turnbuckles used for critical-lift service shall have an initial proof test of 200 percent of the rated capacity. Test loads shall be accurate to within -5 percent, +0 percent of stipulated values. If proof testing cannot be verified, the turnbuckles shall be proof tested before being used to make a critical lift. If proof tested, turnbuckles shall be inspected after the test for the removal conditions stated above.



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Figure 12-8. Turnbuckles

12.7 LINKS, RINGS AND SWIVELS

12.7.1 GENERAL

- a. Links, rings and swivels are usually designed and manufactured as a part of the lifting hardware for a specific purpose, such as the peak link on multiple-leg slings positioning. However, the rings and links may also be found on the load-attachment end of slings. Figure 12-9 shows typical rings, links and swivels.
- b. Links, rings and swivels shall be fabricated from material of sufficient ductility to permanently deform before losing the ability to support the load within the temperature range specified by the manufacturer, and shall have a minimum design factor of 5:1.
- c. Each link, ring or swivel body shall be permanently and legibly marked by the manufacturer to show:
 1. Manufacturer's name or trademark.
 2. Size or rated load.
 3. Grade, if required to identify rated load.

12.7.2 OPERATING PRACTICES:

- a. Contact with obstructions that could damage the link, ring, or swivel should be avoided.
- b. Shock loading should be avoided.
- c. The load applied to the link, ring or swivel should be in line and in tension.
- d. Links, rings and swivels should not be side loaded.
- e. Links, rings and swivels should not be dragged on any abrasive surface.
- f. The link, ring or swivel shall be of proper shape and size to ensure that it seats properly in the hook or lifting device.

12.7.3 EFFECTS OF ENVIRONMENT

- a. When link, rings or swivels are to be used at temperatures above 400°F (204°C) or below 40°F (-40°C), the link, ring or swivel manufacturer or a qualified person should be consulted.
- b. The strength of link, rings or swivels can be affected by chemically active environments such as caustic or acid substances or fumes. The link, ring or swivel manufacturer or a qualified person

should be consulted before links, rings or swivels are used in chemically active environments.

12.7.4 TRAINING

Link, ring or swivel users shall be trained in the selection, inspection, cautions to personnel, effects of environment, and rigging practices as covered by this standard.

12.7.5 INSPECTIONS

- a. Initial Inspection
 1. Prior to use, all new, altered, modified, or repaired link, ring or swivel shall be inspected by a designated person to verify compliance with the applicable provisions of this chapter. Written records are not required.
- b. Frequent Inspection
 1. A visual inspection shall be performed the user or other designated person each shift before the link, ring or swivel is used. Semi-permanent and inaccessible locations where frequent inspections are not feasible shall have periodic inspections performed.
 2. Conditions such as those listed in Section 12.7.6 or any other condition that may result in a hazard shall cause the link, ring or swivel to be removed from service. Links, rings or swivels shall not be returned to service until approved by a qualified person.
 3. Written records are not required.
- c. Periodic Inspection:
 1. A complete inspection of the link, ring, or swivel shall be performed by a designated person. The links, rings or swivels shall be examined for conditions such as those listed in Section 12.7.6 and a determination made as to whether they constitute a hazard.
 2. Periodic inspection intervals shall not exceed one year. The frequency of periodic inspections should be based on:
 - i. Frequency of use.
 - ii. Severity of service conditions.
 - iii. Nature of lifts being made.
 - iv. Experience gained on the service life of links, rings or swivels used in similar circumstances.

3. Guidelines for the time intervals are:
 - i. Normal service – yearly.
 - ii. Severe service – monthly to quarterly.
 - iii. Special service – as recommended by a qualified person.
4. Written records are not required.

12.7.6 REMOVAL CRITERIA

Links, rings or swivels shall be removed from service if damage such as the following is visible, and shall only be returned to service when approved by a qualified person:

- a. Missing or illegible manufacturer’s name or trademark and/or rated load identification.
- b. Indications of heat damage including welding spatter or arc strikes.
- c. Excessive pitting or corrosion.
- d. Bent, twisted, distorted, stretched, elongated, cracked, or broken load-bearing components.
- e. Excessive nicks or gouges.
- f. A 10% reduction of the original or catalog dimension at any point.
- g. Excessive thread damage or wear.
- h. Evidence of unauthorized welding or modification

- i. For swivels, lack of ability to freely rotate when not loaded
- j. For swivels, loose or missing nuts, bolts, cotter pins, snap rings, or other fasteners or retaining devices
- k. Other conditions, including visible damage, that cause doubt as to continue use.

12.7.7 REPAIRS

- a. Repairs, alterations, or modifications shall be as specified by the link, ring or swivel manufacturer or a qualified person.
- b. Replacement parts shall meet or exceed the original equipment manufacturer’s specifications.

12.7.8 CRITICAL LIFTS

- a. See Chapter 2, “Critical Lifts,” for critical lift requirements.
- b. Links, rings and swivels used for critical-lift service shall have an initial proof load test of 200 percent of the rated capacity. Test loads shall be accurate to within -5 percent, +0 percent of stipulated values. If proof testing cannot be verified, the links and/or rings shall be proof tested before being used to make a critical lift. If proof-tested, the link, ring or swivel shall be inspected after the test for the removal conditions stated above.

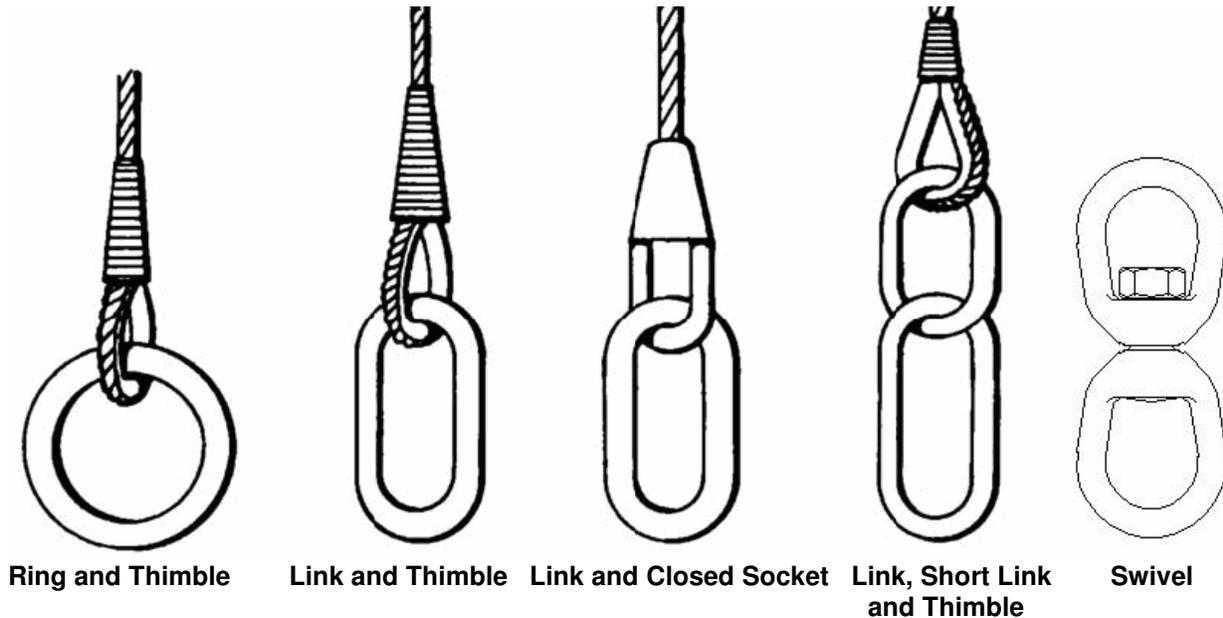


Figure 12-9. Ring, Links and Swivels

12.8 SWIVEL HOIST RINGS

12.8.1 GENERAL

- a. This section specifies requirements for swivel hoist rings that are used as rigging hardware during hoisting and rigging activities.
- b. Swivel hoist rings, excluding bushings and bearings, shall have sufficient ductility to permanently deform before losing the ability to support the load at temperatures at which the manufacturer has specified for use.
- c. Each swivel hoist ring shall be marked to show:
 1. Name or trademark of manufacturer.
 2. Size or rated load.
 3. Torque value.
- d. Swivel hoist rings shall have a minimum design factor of 5:1.
- e. When used in a threaded hole, the effective thread length shall be at least one and one half times the diameter of the bolt for engagement in steel (see Fig. 12-10). For other thread engagements or engagement in other materials, contact the swivel hoist ring manufacturer or qualified person.
- f. When used in a through-hole application, a nut and washer shall be used. The washer and nut shall be in accordance with the swivel hoist ring manufacturer's recommendations. The nut shall be fully engaged (see Fig. 12-10).
- g. The bushing flange (Fig. 12-10) shall fully contact the load surface.
- h. Spacers or washers shall not be used between the bushing and the mounting surface of the load being lifted.
- i. The swivel hoist ring shall be tightened to the manufacturer's torque specifications.
- j. The swivel hoist ring shall be free to rotate and pivot without interference during lifting (see Fig. 12-11).
- k. The load applied to the swivel hoist ring shall be centered in the bail to prevent side loading.
- l. Any attached lifting component shall be narrower than the inside width of the bail to avoid spreading (see Fig. 12-11).
- m. Ensure that the swivel hoist ring working load

limit meets or exceeds the anticipated angular rigging tension (see Fig. 12-11).

- n. Shock loading should be avoided.

12.8.2 EFFECTS OF ENVIRONMENT

- a. When swivel hoist rings are to be used at temperatures above 400°F (204°C) or below 20°F (-40°C), the swivel hoist ring manufacturer or a qualified person should be consulted.
- b. The strength of swivel hoist rings can be affected by chemically active environments such as caustic or acid substances or fumes. The swivel hoist ring manufacturer or a qualified person should be consulted before swivel hoist rings are used in chemically active environments.

12.8.3 TRAINING

Swivel hoist ring users shall be trained in the selection, inspection, cautions to personnel, effects of environment, and rigging practices as covered by this standard.

12.8.4 INSPECTIONS

- a. Initial Inspection
 1. Prior to use, all new, altered, modified, or repaired swivel hoist rings shall be inspected by a designated person to verify compliance with the applicable provisions of this chapter. Written records are not required.
- b. Frequent Inspection
 1. A visual inspection shall be performed the user or other designated person each shift before the swivel hoist ring is used. Semi-permanent and inaccessible locations where frequent inspections are not feasible shall have periodic inspections performed.
 2. Conditions such as those listed in Section 12.8.5 or any other condition that may result in a hazard shall cause the swivel hoist ring to be removed from service. Swivel hoist rings shall not be returned to service until approved by a qualified person.
 3. Written records are not required.
- c. Periodic Inspection:
 1. A complete inspection of the swivel hoist ring shall be performed by a designated person. The swivel hoist ring shall be examined for conditions such as those listed

- in Section 12.8.5 and a determination made as to whether they constitute a hazard.
2. Periodic inspection intervals shall not exceed one year. The frequency of periodic inspections should be based on:
 - i. Frequency of use.
 - ii. Severity of service conditions.
 - iii. Nature of lifts being made.
 - iv. Experience gained on the service life of swivel hoist rings used in similar circumstances.
 4. Guidelines for the time intervals are:
 - i. Normal service – yearly.
 - ii. Severe service – monthly to quarterly.
 - iii. Special service – as recommended by a qualified person.
 5. Written records are not required.

12.8.5 REMOVAL CRITERIA

Swivel hoist rings shall be removed from service if damage such as the following is visible, and shall only be returned to service when approved by a qualified person:

- a. Missing or illegible manufacturer's name or trademark and/or rated load identification.
- b. Indications of heat damage including welding spatter or arc strikes.
- c. Excessive pitting or corrosion.

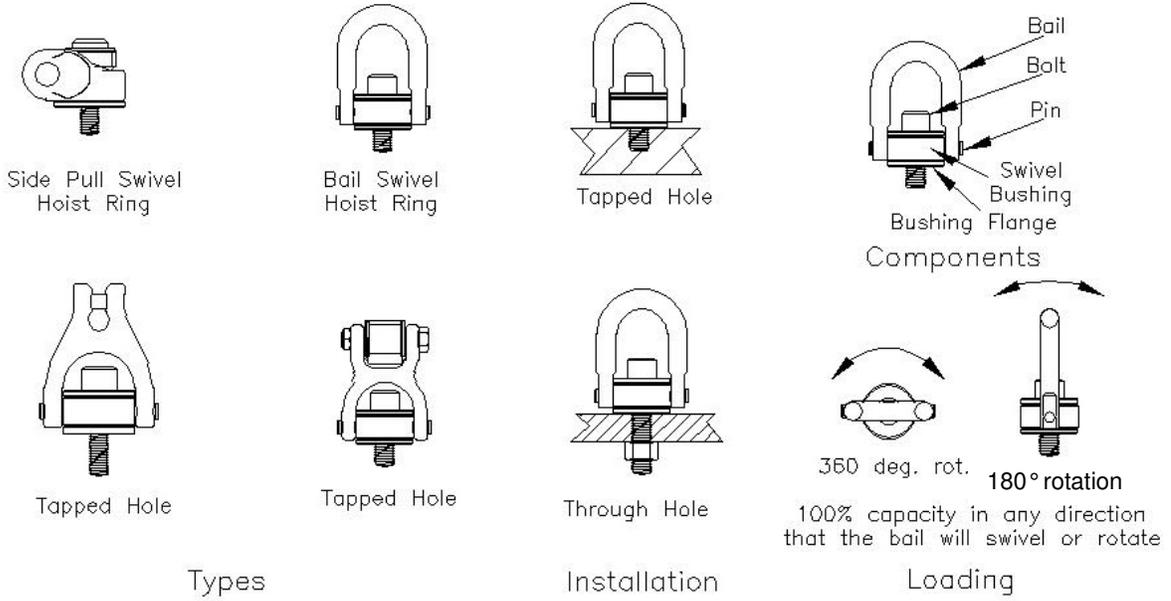
- d. Bent, twisted, distorted, stretched, elongated, cracked, or broken load-bearing components.
- e. Excessive nicks or gouges.
- f. A 10% reduction of the original or catalog dimension at any point.
- g. Excessive thread damage or wear.
- h. Evidence of unauthorized welding or modification
- i. Lack of the ability to freely rotate or pivot
- j. Other conditions, including visible damage, that cause doubt as to continue use.

12.8.6 REPAIRS

- a. Repairs, alterations, or modifications shall be as specified by the swivel hoist ring manufacturer or a qualified person.
- b. Replacement parts shall meet or exceed the original equipment manufacturer's specifications.

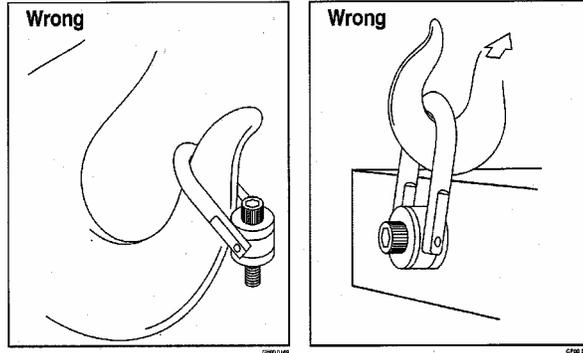
12.8.7 CRITICAL LIFTS

- a. See Chapter 2, "Critical Lifts," for critical lift requirements.
- b. Swivel hoist rings used for critical-lift service shall have an initial proof test of 200 percent of the rated capacity or as recommended by the manufacturer. Test loads shall be accurate to within -5 percent, +0 percent of stipulated values. If proof testing cannot be verified, the swivel hoist rings shall be proof tested before being used to make a critical lift.

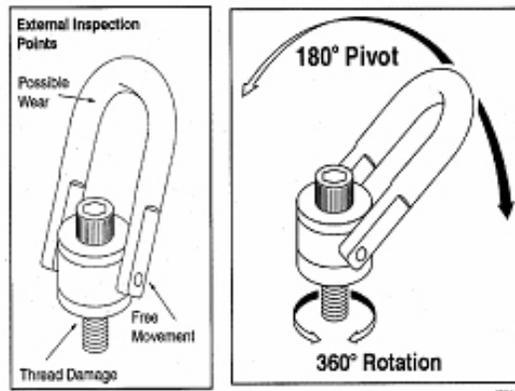


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Figure 12-10. Swivel Hoist Rings



Attach lifting device ensuring free fit to swivel hoist ring bail and ensuring no interference between load (work piece) and bail.



Always ensure free movement of the bail. Never use hoist rings if bail is bent or elongated.

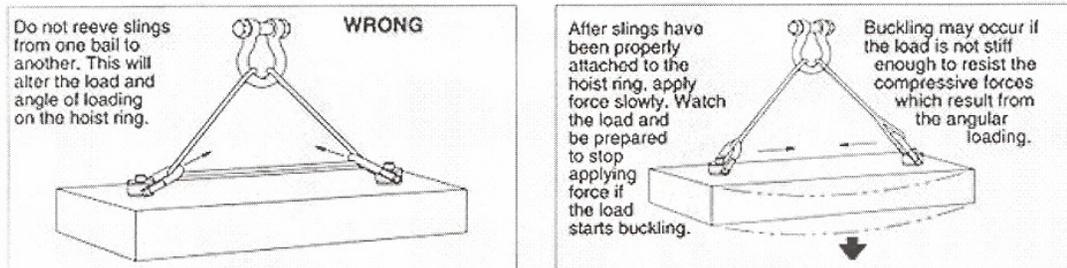


Figure 12-11. Guidelines for Attaching and Using Swivel Hoist Rings

12.9 LOAD INDICATING DEVICES

12.9.1 GENERAL

- a. Load-indicating devices are not required in routine operations where loads of known and essentially consistent weight are to be handled. Rather, load-indicating devices are required for use with loads of uncertain weight that could be within 90 - 100 percent of the rated capacity of the equipment or maximum working load of any part of the tackle. Use load-indicating devices where the equipment/tackle configuration could result in binding or friction of the load that could cause a greater stress in the hoist or tackle than would result from the apparent hook load.
- b. The accuracy of load-indicating devices shall depend on the requirements of the load system planned, and shall not restrict the system requirements; an accuracy of 2 percent of full-scale reading within 10 - 70 percent of instrument range is recommended. The device should be selected so that the estimated hook

load lies between 10 and 70 percent of the instrument range.

- c. Load-indicating devices shall have a design factor of not less than 3:1.
- d. Dynamometers and load cells shall be calibrated at least once a year and when specified in the critical lift procedure. This also applies if they have not been used in the previous 6 months. All calibrated devices shall have a tag affixed indicating date of calibration, by whom they were calibrated, and the date that the next calibration is due.

12.9.2 CRITICAL LIFTS

- a. See Chapter 2, "Critical Lifts," for critical lift requirements.
- b. Load indicating devices used for critical-lift service shall have an initial proof load test per the manufacturer's specifications confirming the load rating. If proof testing cannot be verified, the load indicating device shall be proof tested before being used to make a critical lift.

12.10 PRECISION LOAD POSITIONERS

12.10.1 GENERAL

- a. A precision load positioning device in the load path shall have a design factor of no less than 5:1, based on ultimate strength of the device's load bearing components.
- b. A precision load positioner shall be operated, maintained, calibrated and tested in accordance with the manufacturer's instructions.
- c. Prior to initial use, all new, repaired, and altered precision load positioning devices shall be load tested, and a written report shall be furnished, confirming the load rating. If the load test is not performed by the manufacturer, it shall be done under the direction of a designated or authorized person in strict compliance with the

manufacturer's instructions. Special attention should be paid to the manufacturer's instructions concerning testing of devices equipped with load gages as they may be damaged during the load test.

12.10.2 CRITICAL LIFTS

- a. See Chapter 2, "Critical Lifts," for critical lift requirements.
- b. Precision load positioners used for critical-lift service shall have an initial proof load test per the manufacturer's specifications confirming the load rating. If proof testing cannot be verified, the precision load positioners shall be proof tested before being used to make a critical lift.

12.11 COMPRESSION HARDWARE

12.11.1 GENERAL

- a. This section specifies requirements for U-bolt and double saddle wire rope clips (see Fig. 12-12) and wedge sockets (see Fig. 12-13). Other compression hardware shall be used only in accordance with recommendations of the manufacturer or a qualified person.
- b. Wire rope clip materials shall be of sufficient strength such that failure of the wire rope will occur before failure of the wire rope clip at the temperatures that the manufacturer has specified for use. Saddles shall be forged steel.
- c. Wedge socket materials shall be of sufficient strength such that failure of the wire rope will occur before failure of the wedge socket at the temperatures, specified for use by the manufacturer.
- d. The rated load for wire rope assemblies using compression hardware is based on the wire rope minimum breaking force, 80% minimum connection efficiency and the design factor of the wire rope application. The rated load shall not be exceeded
- e. Compression hardware is not required to be proof tested unless specified by the purchaser. If a proof test is specified, the load shall be applied to the wedge socket or the connection made by the wire rope clips after the assembly is complete. The proof load shall be at least 40%, but not exceed 50% of the minimum breaking force unless approved by the compression hardware manufacturer or a qualified person. After proof testing, wire rope clips on a finished assembly shall be re-tightened to the torque recommended by the wire rope clip manufacturer or a qualified person. The compression hardware shall then be inspected in accordance with Section 12.11.6.
- f. Wire rope clips shall have the manufacturer's name or trademark and the saddle size either forged or die-stamped into the saddle.
- g. Wedge sockets shall have the manufacturer's name or trademark, the size and model (if required to match the wedge to the body) either forged, cast or die stamped into the wedge and socket body.
- h. Compression hardware should not be in contact with the load or any obstruction during the lift.

- i. Rigging using compression hardware should not be dragged on an abrasive surface or in contact with sharp edges.
- j. Wedge sockets should not be side loaded.
- k. Impacts can dislodge the wedge from the body and should be avoided.

12.11.2 ASSEMBLY – WIRE ROPE CLIPS

- a. Before installing a wire rope clip on plastic coated or plastic impregnated wire rope, consult the wire rope clip manufacturer, wire rope manufacturer, or a qualified person.
- b. For U-bolt clips used to create end terminations, the saddle shall be placed on the live end of the wire rope, with the U-bolt on the dead end side (see Fig. 12-12).
- c. The minimum number of clips, spacing, turn-back and torque values shall be as recommended by the manufacturer or a qualified person.
- d. After assembly, the connection shall be loaded to at least the expected working load. After unloading, wire rope clips shall then be re-tightened to the torque recommended by the manufacturer or a qualified person.

12.11.3 ASSEMBLY – WEDGE SOCKETS

- a. The wedge socket shall be assembled as recommended by the manufacturer or a qualified person.
- b. Before installing a wedge socket on plastic coated or plastic impregnated wire rope, consult the wedge socket manufacturer, wire rope manufacturer, or a qualified person.
- c. The live end of the wire rope in the wedge socket cavity shall be in alignment with the socket's pin (see Fig. 12-13).
- d. The assembler shall match the proper wedge with the socket for the wire rope to be installed.

NOTE: Wedges shall not be interchanged between different manufacturers' sockets or models.

- e. The length of the dead end tail of the wire rope shall be as required by the manufacturer or a qualified person.
- f. The dead end tail of the wire rope extending beyond the wedge socket shall be secured in a manner recommended by the wedge socket

manufacturer or a qualified person (see Fig. 12-13).

- g. The dead end of the wire rope shall not be secured to the live end of the wire rope such that it restricts the movement of the live end (see Fig. 12-13).
- h. After assembly, the connection shall be loaded to fully seat the wedge before use.

12.11.4 EFFECTS OF ENVIRONMENT

- a. Compression hardware are to be used at temperatures above 400°F (204°C) or below 40°F (-40°C), the compression hardware manufacturer or a qualified person should be consulted.
- b. The strength of compression hardware can be affected by chemically active environments such as caustic or acid substances or fumes. The compression hardware manufacturer or a qualified person should be consulted before compression hardware are used in chemically active environments.

12.11.5 TRAINING

Compression hardware users shall be trained in the selection, inspection, cautions to personnel, effects of environment, and rigging practices as covered by this standard.

12.11.6 INSPECTIONS

- a. Initial Inspection
 - 1. Prior to use, all new, altered, modified, or repaired compression hardware shall be inspected by a designated person to verify compliance with the applicable provisions of this chapter. Written records are not required.
- b. Frequent Inspection
 - 1. A visual inspection shall be performed by the user or other designated person each shift before the compression hardware is used. Semi-permanent and inaccessible locations where frequent inspections are not feasible shall have periodic inspections performed.
 - 2. Conditions such as those listed in Section 12.11.7 or any other condition that may result in a hazard shall cause the compression hardware to be removed from service. Compression hardware shall not be returned to service until approved by a qualified person.
 - 3. Written records are not required.

c. Periodic Inspection:

- 1. A complete inspection of the compression hardware shall be performed by a designated person. The compression hardware shall be examined for conditions such as those listed in Section 12.11.7 and a determination made as to whether they constitute a hazard.
- 2. Periodic inspection intervals shall not exceed one year. The frequency of periodic inspections should be based on:
 - i. Frequency of use.
 - ii. Severity of service conditions.
 - iii. Nature of lifts being made.
 - iv. Experience gained on the service life of compression hardware used in similar circumstances.
- 3. Guidelines for the time intervals are:
 - i. Normal service – yearly.
 - ii. Severe service – monthly to quarterly.
 - iii. Special service – as recommended by a qualified person.
- 4. Written records are not required.

12.11.7 REMOVAL CRITERIA

Compression hardware shall be removed from service if damage such as the following is visible, and shall only be returned to service when approved by a qualified person:

- a. Missing or illegible manufacturer's name or trademark and/or rated load identification.
- b. Indications of heat damage including welding spatter or arc strikes.
- c. Excessive pitting or corrosion.
- d. Bent, twisted, distorted, stretched, elongated, cracked, or broken components.
- e. Excessive nicks or gouges.
- f. A 10% reduction of the original or catalog dimension at any point.
- g. Evidence of unauthorized welding or modification
- h. Unauthorized replacement components
- i. Insufficient number of wire rope clips
- j. Improperly tightened wire rope clips
- k. Indications of wire rope slippage

1. Improper assembly or other conditions, including visible damage, that cause doubt as to continue use.

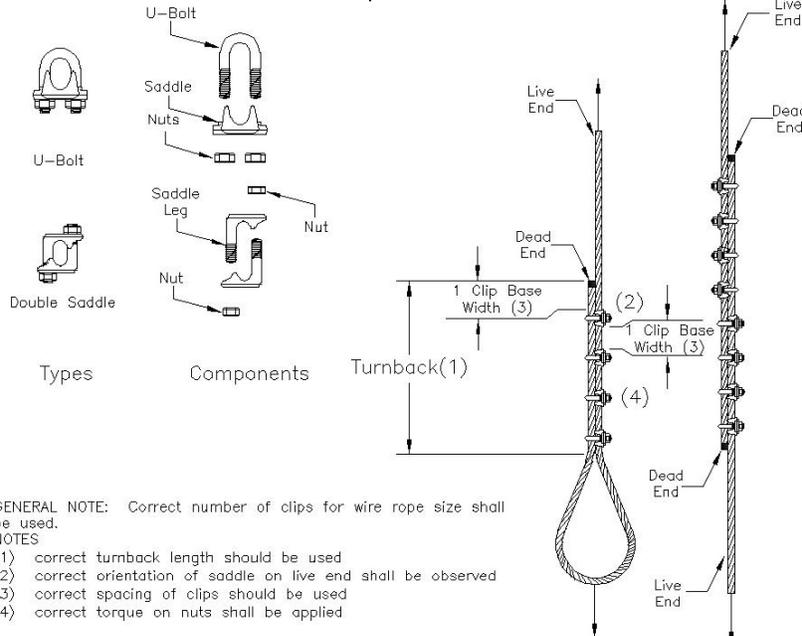
12.11.8 REPAIRS

- a. Repairs, alterations, or modifications shall be as specified by the compression hardware manufacturer or a qualified person.
- b. Replacement parts shall meet or exceed the

original equipment manufacturer's specifications.

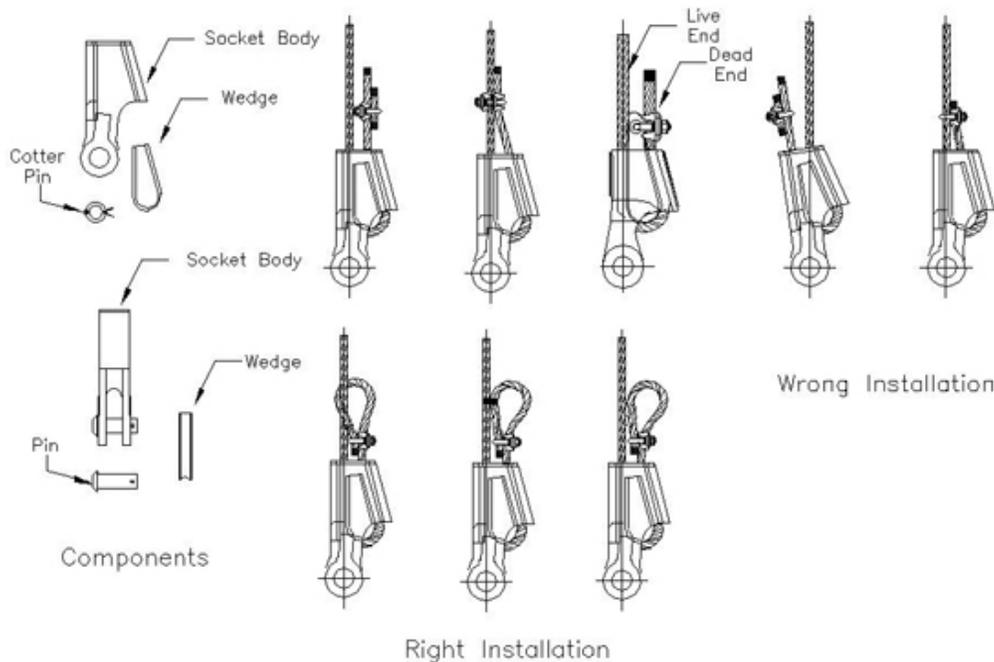
12.11.9 CRITICAL LIFTS

- a. See Chapter 2, "Critical Lifts," for critical lift requirements.
- b. Compression hardware used for critical-lift service shall be proof tested as part of the completed assembly.



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Figure 12-12. Wire Rope Clips



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Figure 12-13. Wedge Sockets