Part 21
Rigging

Highlights

• Section 292 recognizes fatigue rating according to a specified European standard, as well as safety factors for specific wire rope rigging components.

• Section 297 requires employers to ensure that slings meet the requirements of the American Society of Mechanical Engineers (ASME) Standard B30.9-2006, Safety Standard for Cableways, Cranes, Derricks, Hoists, Jacks and Slings. Section 297 also requires that below-the-hook lifting devices meet the requirements of ANSI Standard B30.20, Below the Hook Lifting Devices.

• Section 298 requires the employers to ensure that synthetic slings are marked with the maximum load rating for the types of hitches permitted.

• Section 303 prohibits the use of makeshift fittings or attachments that are load bearing.

• Sections 305 through 309 present rejection criteria for synthetic fibre slings, wire rope, metal mesh slings and hooks.

Requirements

Section 292  Breaking strength

Subsection 292(1)

To guard against failure of a rigging component due to shock load, overload, wear, etc., the load being lifted should not exceed the Safe Working Load (SWL). The SWL is calculated as a fraction of the weakest component’s actual breaking strength. Breaking strength is the measured load required to “break” the component. SWL is calculated by dividing that breaking strength, as identified by the manufacturer or a professional engineer, by a “factor of safety”.
Subsections 292(1)(b) and (c)

“Fatigue” is the tendency of material to break under repeated stress. “Fatigue rating” means that the rigging will provide improved fatigue resistance when rated in accordance with CEN Standard EN 1677-1: 2000, *Components for slings - Part 1: Forged steel components grade 8*. This standard specifies mechanical properties and test procedures for forged steel components to be “fatigue rated”.

Fatigue rated rigging components can be subjected to increased loads when compared to rigging components that have not been fatigue rated. This provision permits the use of lifting chain and other hardware at a design factor of 25 percent (4:1), provided fatigue testing has been done by the manufacturer according to CEN Standard EN1677-1: 2000 Part 1.

Section 292.1 lists minimum safety factors that apply to specific wire rope rigging components. For all other components, the safety factor is

(a) 20 percent of the component’s ultimate breaking strength if the component is not fatigue rated according to EN standard 1677-1: 2000 – a safety factor of 5:1, or

(b) 25 percent of the component’s ultimate breaking strength if the component is fatigue rated according to EN standard 1677-1: 2000 and not used to raise or lower a worker – a safety factor of 4:1.

Subsection 292(2)

The factors of safety specified in subsection (1) can be modified for a dedicated rigging assembly, the use of which is restricted to a specific lift and is designed and certified by a professional engineer as safe for that lift. Once the specific lift is completed, the dedicated rigging assembly must be re-rated according to subsection (1) if it is to be used again.

Section 292.1 Safety factors

Subsection 291.1(1)

The total stress in a wire rope, in service, is composed of several separate elements. These are reduced to a single tensile load value (working load). When this value exceeds the breaking strength of the wire rope, a failure occurs.

The factor to provide a margin of safety between the applied tensile forces and the breaking strength of the rope is defined as the safety factor.
Except as provided in section 292, the safety factor for wire rope used in various applications is as follows:

<table>
<thead>
<tr>
<th>Application</th>
<th>Safety Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running line (also known as hoisting line) (Running line on overhead cranes is typically 5:1)</td>
<td>3.5 to 1</td>
</tr>
<tr>
<td>Non-rotating line (often used as a single part hoisting line)</td>
<td>5 to 1</td>
</tr>
<tr>
<td>Tugger lines (lines on a small drum winch), for pulling only (Tugger lines used for hoisting must be 5:1)</td>
<td>3 to 1</td>
</tr>
<tr>
<td>Pendant lines (attached to and support the boom head)</td>
<td>3 to 1</td>
</tr>
<tr>
<td>Guy lines (stabilizing structures, etc.)</td>
<td>3 to 1</td>
</tr>
<tr>
<td>Winch lines (typically mounted on a truck or crawler tractor)</td>
<td>2 to 1</td>
</tr>
</tbody>
</table>

Subsection 292.1(2)

Impacts or sudden “jolting” when towing can pull rigging components and lines into yield (stretching). Yield reduces ultimate breaking strength which may reduce the factor of safety necessary for lifting service.

Section 293  Load ratings

Subsection 293(1)

The “maximum load rating” is the maximum weight that a piece of rigging is authorized by the manufacturer or a professional engineer to support. It is also known by a variety of other terms such as Working Load Limit (WLL), Safe Working Load (SWL), rated load value, resultant safe working load, rated capacity, and maximum working load.

The maximum load rating is not the breaking strength of the piece of rigging. An employer must ensure that the load rating of the piece of rigging is based on the appropriate factor of safety.

Components can be marked in a variety of ways, i.e. stamping, etching, embossing, printing, tagging. When choosing a particular marking system, consideration should be given to legibility and durability.

Subsection 293(2)

If the maximum load rating cannot be marked on a rigging component, information about the component’s maximum load must be made available to the lifting supervisor and to the operator before commencing the lifting operation. This information must also be readily available to other workers involved in the lifting operation.
Section 294  Inspection

The rigging assembly must be thoroughly inspected before each period of continuous use during the shift. Refer to ASME Standard B30.9-2006 for detailed information regarding initial, frequent and periodic inspections. This inspection should be done by a competent worker and should include, but not be limited to:

(a) inspection of wire rope for wear, elongation, damage, i.e. bird caging, kinks, core protrusion, cuts, etc., signs of overloading, corrosion and pitting;
(b) inspection of slings for abrasion, cuts/tears, melting or burn marks, bleaching/corrosion, increased stiffness of material;
(c) inspection of sheaves and hooks for deformation, cracks, wear;
(d) inspection of shackles for crown (bow) wear, cracks, chips, gouges, deformation, and pin wear, deformation, thread damage;
(e) inspection of eye bolts and lift rings for gouges, cracks, wear, deformation; and
(f) inspection of spreader bars, lift beams, equalizer beams, beam clamps, beam trolleys, plate clamps for wear, excessive movement, cracks, broken/worn teeth, loose components, deformation, integrity of connection points.

The criteria for rejection are more fully described in sections 305 through 309. If no criteria are mentioned, reference should be made to manufacturer’s specifications or the specifications of a professional engineer. Rejection criteria for slings are also described in ASME Standard B30.9-2006, Safety Standard for Cableways, Cranes, Derricks, Hoists, Jacks and Slings.

Section 295  Prohibition

A worker must not use rigging that does not comply with the requirements of this Part of the OHS Code.

Section 296  Rigging protection

To minimize damage to a sling, sharp corners of the load that are in contact with the sling must be guarded to prevent damage to the slings or straps of the rigging e.g. padded with protective material of sufficient strength and thickness, or with prefabricated protective devices as shown in Figure 21.1. The padding or protective device can be placed on the load itself or affixed to the sling.
Section 297  Sling standard

Subsection 297(1)

ASME Standard B30.9-2006, Safety Standard for Cableways, Cranes, Derricks, Hoists, Jacks and Slings, applies to slings intended for lifting, made from alloy steel chain, sewn synthetic webbing, wire rope, metal mesh and synthetic fibre rope. The Standard describes technical requirements for construction, load rating, proof testing, identification, maintenance, environmental effects, end attachments, inspection, repair and use. Figures 21.2 to 21.7 show a variety of different types of slings. The Standard specifies that inspections be conducted as described in Table 21.1.
Figure 21.2 Example of metal mesh fabric

Figure 21.3 Example of metal mesh sling
Figure 21.4 Chain sling major components

Quadruple leg slings

Single leg slings
Figure 21. 5 Synthetic webbing slings

Type I — Sling made with a triangle fitting at one end and a slotted triangle choker fitting at the other end. It can be used in a basket hitch or choker hitch.

Type II — Sling made with a triangle fitting at both ends. It can be used in a vertical or basket hitch only.

Type III — Sling made with a flat loop eye at each end with loop eye opening on same plane as sling body. This type is sometimes called a flat eye and eye, eye and eye, or double eye sling.

Type IV — Sling made with both loop eyes formed as in Type III, except that the loop eyes are turned to form a loop eye at a right angle to the plane of the sling body. This type is commonly referred to as a twisted eye sling.

Type V — Endless sling, sometimes referred to as a grommet. It is a continuous loop formed by joining the ends of the fabric with a splice.

Type VI — Return eye (reversed eye) sling is formed by using multiple widths of webbing held edge to edge with an assembly. A wear pad is attached to one or both sides of the sling body and on one or both sides of the loop eyes to form a loop eye at each end which is at a right angle to the plane of the sling body.
Figure 21.6 Wire rope slings

(a) Eye-and-eye — both ends hand tucked and covered with serving.

(b) Eye-and-eye — both ends mechanically spliced.

(c) Swaged sockets — open socket right end, closed socket left end.

(d) Poured sockets — open socket left end, closed socket right end.

(e) Eye-and-eye sling — cable laid rope

(f) Multipart sling
Figure 21.7 Synthetic roundsling configurations

Endless roundsling

Endless roundsling with center cover (eye and eye)

Endless roundsling with fittings
### Table 21.1: Sling inspections based on sling type

<table>
<thead>
<tr>
<th>Type of sling</th>
<th>Inspection Type</th>
<th>What to look for</th>
<th>How often</th>
</tr>
</thead>
</table>
| Chain         | Frequent        | ▪ Chain and attachments for wear, nicks, cracks, breaks, gouges, stretch, bends, weld splatter, discoloration from excessive temperature, and throat opening of hooks  
▪ Missing/illegible markings  
▪ Seating, free hinging, distortion of hooks/latches | ▪ *Normal service – monthly  
▪ *Severe service – daily to weekly  
▪ *Special service – as recommended by qualified person |
|               | Periodic        | ▪ Same as “Frequent” inspection, link by link  
▪ Inner surfaces of each link  
▪ Wear not to exceed manufacturer’s specifications | ▪ *Normal service – annually  
▪ *Severe service – monthly to quarterly  
▪ *Special service – as recommended by qualified person |
| Wire rope     | Frequent        | ▪ Distortion such as kinking, crushing, unstranding, birdcaging, main strand displacement, core protrusion, loss of rope diameter, unevenness of outer strands  
▪ General corrosion  
▪ Broken or cut strands  
▪ Number/distribution/type of visible broken wires  
▪ Missing/illegible markings | ▪ Daily |
|               | Periodic        | ▪ Deterioration warranting removal  
▪ 10 randomly distributed broken wires in one rope lay, or 5 broken wires in one strand in one rope lay  
▪ severe localized abrasion or scraping  
▪ kinking, crushing, birdcaging, or other distortion  
▪ evidence of heat damage  
▪ cracked, deformed, worn attachments  
▪ severe corrosion | Based on how often the sling is used and severity of service conditions, but at least annually |
<table>
<thead>
<tr>
<th>Type of sling</th>
<th>Inspection Type</th>
<th>What to look for</th>
<th>How often</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial</strong></td>
<td></td>
<td>• Verify correct sling is being used</td>
<td>Prior to first use as new or repaired</td>
</tr>
<tr>
<td>Metal mesh</td>
<td><strong>Frequent</strong></td>
<td>• Broken weld or brazed joint along edge</td>
<td>Daily</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Broken wire in mesh</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reduction in wire diameter of 25 percent due to abrasion or 15 percent due to corrosion</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Distortion in the mesh</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Distortion of the slot in choker fitting by more than 10 percent</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Distortion of end fittings</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 15 percent reduction of original cross-sectional area at any point around hook opening or end fitting</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cracked or visibly distorted end fittings</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Missing/Illegible markings</td>
<td></td>
</tr>
<tr>
<td><strong>Periodic</strong></td>
<td></td>
<td>• Same as for “Frequent” inspection</td>
<td>Based on how often the sling is used and severity of service conditions, but at least annually</td>
</tr>
<tr>
<td>Type of sling</td>
<td>Inspection</td>
<td>What to look for</td>
<td>How often</td>
</tr>
<tr>
<td>--------------</td>
<td>------------</td>
<td>-----------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Synthetic rope</td>
<td>Initial</td>
<td>Verify correct sling is being used</td>
<td>Prior to first use as new or repaired</td>
</tr>
<tr>
<td>Frequent</td>
<td></td>
<td>Cuts, gouges, extensive fibre breakage along the length, abraded areas</td>
<td>Daily</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reduction of rope diameter by more than 10 percent</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Uniform fibre breakage along major part of the length of the rope such that the entire rope appears covered with “fuzz” or “whiskers”</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fibre breakage or melted fibre involving 10 percent of the fibre in the strand at any point</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Discolouration, brittle fibres, chemical or ultraviolet damage</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Foreign matter permeated in the rope attracting and holding grit</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Kinks/distortion</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Melted or charred areas that affect more than 10 percent of rope diameter or affect several adjacent strands to more than 105 of individual diameters</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Corrosion, cracks, distortion, localized wear of thimbles or other fittings</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other visible damage</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Missing/ illegible markings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Periodic</td>
<td>Same as for “Frequent” inspection</td>
<td>Based on how often the sling is used and severity of service conditions, but at least annually</td>
</tr>
<tr>
<td>Type of sling</td>
<td>Inspection Type</td>
<td>What to look for</td>
<td>How often</td>
</tr>
<tr>
<td>---------------</td>
<td>----------------</td>
<td>-----------------------------------------------------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>Synthetic webbing</td>
<td>Initial</td>
<td>Verify correct sling is being used</td>
<td>Prior to first use as new or repaired</td>
</tr>
<tr>
<td></td>
<td>Frequent</td>
<td>Acid or caustic burns</td>
<td>Daily</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Melting or charring</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Holes, tears, cuts, snags</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Broken/worn stitching in load-bearing splices</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excessive abrasive wear</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knots</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excessive pitting or corrosion, or cracked, distorted or broken fittings</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other visible damage</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Missing/illegible markings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Periodic</td>
<td>Same as for “Frequent” inspection</td>
<td>Based on how often the sling is used and severity of service conditions, but at least annually</td>
</tr>
<tr>
<td>Synthetic roundsling</td>
<td>Initial</td>
<td>Verify correct sling is being used</td>
<td>Prior to first use as new, altered, modified or repaired</td>
</tr>
<tr>
<td></td>
<td>Frequent (records not required)</td>
<td>Melting or charring</td>
<td>*Normal service – daily</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Holes, tears, cuts, abrasive wear, snags, exposed core yarns</td>
<td>*Severe service – each use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Damaged, stretched, cracked, worn, pitted, distorted fittings</td>
<td>*Special service – as recommended by qualified person</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knotting</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other visible damage</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Missing/illegible markings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Periodic (recorded as basis for continued use)</td>
<td>Same as for “Frequent” inspection</td>
<td>*Normal service – daily</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>*Severe service – each use</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>*Special service – as recommended by qualified person</td>
</tr>
</tbody>
</table>

Type of sling service:
- Normal — involves use of loads within maximum load rating
- Severe — involves normal service coupled with abnormal operating conditions
- Special — involves operation, other than normal or severe, that is recommended by a “qualified person” (a person who, by possession of a recognized degree in a relevant field or certificate of professional standing, or who, by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject).
Subsection 297(2)

A below-the-hook lifting device is a device used for attaching loads to a hoist. ASME Standard B30.20-2006, Below the Hook Lifting Devices, presents requirements that apply to the marking, construction, installation, inspection, testing, maintenance, and operation of such devices. These include

- structural and mechanical devices e.g. plate clamps, bar tongs, spreader bars,
- vacuum devices e.g. single pad, multiple pad,
- close-proximity operated machines e.g. electrically-controlled, manually-controlled,
- remotely operated magnets e.g. circular, rectangular, and
- scrap and material-handling grapples e.g. orange peel grapple, magnetic grapple.

The Standard requires that each device be marked with its related load limit, manufacturer name and address, serial number, lifter weight and other information as noted, directly on the device or on a tag attached to it.

The Standard specifies the following inspection intervals:

- Visual examination before and during each lift
  - Surface of the load for debris
  - Condition/operation of controls
  - Condition/operation of indicators or meters
- Frequent visual examinations reflecting the degree of use
  - Normal service – monthly
  - Heavy service – weekly to monthly
  - Severe service – daily to weekly

Inspectors are to look for the following:

(a) deformation, cracks, or excessive wear in structural members;
(b) loose or missing guards, fasteners, covers, nameplates;
(c) proper function/alignment of operating mechanisms;
(d) proper operation of vacuum generators;
(e) vacuum pad seals for cracks, tears, excessive wear, leakage, cuts, kinks of vacuum lines and connections;
(f) appropriate levels in the entire vacuum system;
(g) condition of magnetic device face, lifting bails, control handles, indicators, electrical conductors, battery (where applicable); and
(h) condition of hydraulic lines and cylinders.
The Standard requires complete inspection based on the degree of use

- Normal service – yearly
- Heavy service – semiannually (quarterly on magnetic devices and grapples)
- Severe service – quarterly (monthly on magnetic devices and grapples)
- Other as noted in the Standard or in the manufacturer’s specifications or instructions

Inspectors are to look for the following:

(a) all items under “Frequent” inspections;
(b) loose bolts, fasteners;
(c) cracked/worn gears, pulleys, sheaves, sprockets, bearings, chains, belts;
(d) excessive wear at hoist hooking points and support shackles or pins;
(e) damage to motors, controls, auxiliary components;
(f) condition of electrical motors and components;
(g) condition of hydraulic motor; and
(h) other components as noted in the Standard or in the manufacturer’s specifications or instructions.

Subsection 297(3)

Many spreader bars are extendable and their load capacity varies with their length. Table 21.2 provides an example of a capacity data sheet for a spreader bar. If such a data sheet is not available from a device manufacturer, it is important to have one prepared by a professional engineer.

Subsection 297(4)

Where a capacity data sheet is used in accordance with subsection (3), an employer must ensure that the correct and corresponding sheet is used with each spreader bar. This is accomplished by ensuring that the data sheet and corresponding spreader bar are identified by a unique numbering system. Procedures for use of the bar should include an initial check to ensure that the correct data sheet is being followed.
Table 21.2 Spread bar capacity data sheet

<table>
<thead>
<tr>
<th>Sling Length</th>
<th>Bar Capacity at Listed Length in Tons (1 Ton = 2000 lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11'-0&quot;</td>
</tr>
<tr>
<td>8'</td>
<td>32</td>
</tr>
<tr>
<td>10'</td>
<td>46</td>
</tr>
<tr>
<td>12'</td>
<td>58</td>
</tr>
<tr>
<td>15'</td>
<td>64</td>
</tr>
<tr>
<td>20'</td>
<td>66</td>
</tr>
<tr>
<td>25'</td>
<td>67</td>
</tr>
<tr>
<td>30'</td>
<td>67</td>
</tr>
</tbody>
</table>

Notes:
(a) Capacities shown below the bold line indicate bar length/sling length combinations with
sling angles of 60 degree or greater. Sling angle measured from horizontal spreader
bar and the diagonal sling.
(b) Use only shackles as listed above.
(c) This load chart applies to only the models and serial numbers listed above.
(d) If no rating is available for 6" increments, use rating for the next longer length.
(e) All rigging and crane use must be in accordance with applicable CSA standards and
provincial OHS legislation.
(f) Any incident, deviation from normal operation or unauthorized structural repairs will void
the certification of the bar.
(g) Do not exceed rated capacity.
(h) In addition to the annual certification by a professional engineer, this rigging shall be
visually inspected prior to each use by qualified rigging personnel or crane operators.
(i) Use capacity for next shorter sling length if actual sling length is not listed in table.
Section 298 Slings

Subsection 298(1)

Synthetic fibre web slings are constructed of flat webbing. This webbing is typically layered into plies with more plies meaning a stronger sling. To ensure that the sling and the way it is used is appropriate for the load, working load limits and the information listed in this section must be permanently and legibly marked on the sling (See Figures 21.8 and 21.9).

Figure 21.8 Example of manufacturer's load limits for synthetic web slings

Subsection 298(2)

Typically, sling manufacturers verify sling load ratings by pull-testing in excess of 100 percent of the rated capacity. This is often done in accordance with a technical standard such as ASME Standard B.30.9-2006. Pull-testing for recertification purposes must be done this way as well.

If improperly pull-tested or pulled repeatedly beyond rated capacity, a sling’s safety factor can be reduced to an unsafe level, leading to premature failure due to undetected fatigue damage. The pull testing described in this subsection refers to pull testing conducted at a work site, perhaps as part of an inspection or quality assurance program. This pull testing does not apply to manufacturers. Subsection 297(1) applies to manufacturers.
Section 299  Ropes wound on drum

Figure 21.10 shows examples of acceptable methods of securely fastening rope to a winding drum. The purpose of having not less than 5 full wraps on a drum is to reduce the force on the dead end attachment.

Section 300  Cable clips

Subsection 300(1)

Cable clips, also known as “cable clamps”, can be used safely for lifts up to 80 percent of line strength. Commonly used types include the U-bolt clamp (see Figure 21.11), the double-saddle clamp (see Figure 21.12) and the double-base clamp (see Figure 21.13). New bolts should always be used. Cable clips should be used in accordance with ASME Standard B30.26-2004, Rigging Hardware Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks and Slings.
“Never saddle a dead horse.” This means that the “saddle” part of the clip must not bear on the short or “dead” side of the rope (see Figure 21.14). Applying the clip incorrectly can reduce the effectiveness of the connection.

Subsection 300(2)
If the clips are tightened beyond specified torque values, the hoisting cable will be crushed and its strength reduced.

Subsection 300(3)
Double-saddle clamps can produce greater efficiency in the connection by applying a greater clamping force on the rope without damaging it.

Subsection 300(4)
Spacing of clamps should not exceed six to seven times the diameter of the rope.

Section 301 Ferrules

Subsection 301(1)
In a wire rope, a splice is made by joining interweaving strands or by overlapping and binding. Three types of common splices for creating an eye loop are the Flemish eye splice (see Figure 21.15), the tuck splice (see Figure 21.16), and the fold-back splice (see Figure 21.17).

Figure 21.15 Example of Flemish eye splice

Figure 21.16 Example of a tuck splice
A splice can be covered by a clamp (see Figure 21.18), a pressed sleeve or ferrule (see Figure 21.19), or wrapped with wire serving (see Figure 21.20).
The most common splice is the Flemish eye splice with a pressed (swaged) ferrule. Swaging is the process of applying great pressure such that the metal of the ferrule flows into the crevices between wires and their strands. This makes a permanent bond and develops almost 100 percent of the breaking strength of the rope.

The ferrule is not covering the entire splice if splice ends are visible. To ensure adequate strength, the ferrule must be of steel and properly swaged onto the splice. When a Flemish splice is used to form an eye loop in a wire rope, the steel ferrule must identify the splice as being a Flemish eye splice.

**Subsection 301(2)**

Aluminum alloy ferrules are not suitable if exposed to temperatures greater than 204°Celsius or where caustic conditions are present. To avoid the possibility of aluminum alloy ferrules being used under such conditions, they must be identified as made of aluminum alloy and must be commercially manufactured and properly swaged onto the splice.

**Commentary about “commercially manufactured”**

In general, a commercially manufactured product has the following qualities

(a) it is designed and built to some standard or generally accepted engineering principles that make it safe for use;

(b) it is designed and built by person(s) with the skill or competence to be able to make the product safe;

(c) it is produced with the intention of being generally available to anyone who wants to buy it — normally there is an exchange of money;

(d) it is normally supported by the manufacturer with a warranty, guarantee, and product support; and

(e) liability and safety issues related to its use have been addressed by the manufacturer.

It is implied by the OHS Code, that a product that is “commercially manufactured” is “safe” because it has been produced by a “manufacturer” that has the skills and competencies to do so.

Criterion (a) refers to the product being designed and built to some “generally accepted engineering principles”. It is expected that a “manufacturer” is able to provide drawings or sketches of the product that include an assessment of the product’s strength, load-bearing capacity, etc. Further, criterion (d) mentions “product support”. This may include, among other elements, the availability of written manufacturer specifications.
**Section 302  Matching components**

Subsections 302(1) and 302(2)

Unless otherwise specified by the manufacturer, the diameter of winding drums should not be less than 20 times the diameter of the rope. This will reduce the likelihood of weakened rope caused by excessive bending stresses.

Subsection 302(3)

Wire rope can be damaged if the angle and width of the sheave groove is incorrect for that wire rope. Too narrow a groove will pinch and bind the rope, causing excessive abrasion and fatigue leading to shortened rope life (see Table 21.2). A groove that is too wide will not properly support and guide the rope, causing the rope to flatten (see Figure 21.21).

Figure 21.21  Example of a sheave providing a proper arc of support to a rope

![Diagram of sheave providing proper arc of support to rope]

The condition and contour of sheave grooves have a major influence on rope life. The grooves must be smooth and slightly larger than the rope to prevent the rope from being pinched or jammed in a groove. The bottom of the groove should have an arc of support of at least 120 to 150 degrees and the sides of the groove should be tangent to the arc.
The depth of a sheave groove should be at least 1.5 times the rope's diameter and the tapered side walls of the groove should not make an angle of more than 18 degrees from the centre line.

Table 21.2 Example of manufacturer's specifications matching wire rope diameter with sheave characteristics

<table>
<thead>
<tr>
<th>Nominal Outside Diameter</th>
<th>Stock Number</th>
<th>Pattern Number</th>
<th>Wire Line Size</th>
<th>Bore Size</th>
<th>Hub Width</th>
<th>Raw Width</th>
<th>Nominal Hub Outside Diameter</th>
<th>Nominal Tread Diameter</th>
<th>Material</th>
<th>Approximate Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>905051</td>
<td>1161</td>
<td>3/16</td>
<td>3/8</td>
<td>25/32</td>
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<td>1</td>
<td>2-3/8</td>
<td>P.M.</td>
<td>1.00</td>
</tr>
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<td>1161</td>
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<td>1/2</td>
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<td>1</td>
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<td>P.M.</td>
<td>1.00</td>
</tr>
<tr>
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<td>5/8</td>
<td>25/32</td>
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<td>2-3/8</td>
<td>P.M.</td>
<td>1.00</td>
</tr>
<tr>
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<td>3/8</td>
<td>1/2</td>
<td>1/2</td>
<td>1</td>
<td>2-5/8</td>
<td>P.M.</td>
<td>.75</td>
</tr>
<tr>
<td>3</td>
<td>905042</td>
<td>1161</td>
<td>1/4</td>
<td>1/2</td>
<td>1/2</td>
<td>1/2</td>
<td>1</td>
<td>2-5/8</td>
<td>P.M.</td>
<td>.75</td>
</tr>
<tr>
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<td>15410</td>
<td>1161</td>
<td>3/8</td>
<td>3/8</td>
<td>25/32</td>
<td>3/4</td>
<td>1</td>
<td>2-3/8</td>
<td>P.M.</td>
<td>1.00</td>
</tr>
<tr>
<td>3</td>
<td>905088</td>
<td>1161</td>
<td>3/8</td>
<td>1/2</td>
<td>25/32</td>
<td>3/4</td>
<td>1</td>
<td>2-3/8</td>
<td>P.M.</td>
<td>1.00</td>
</tr>
<tr>
<td>3</td>
<td>905104</td>
<td>1161</td>
<td>3/8</td>
<td>5/8</td>
<td>5/8</td>
<td>3/4</td>
<td>1</td>
<td>2-5/8</td>
<td>P.M.</td>
<td>.60</td>
</tr>
</tbody>
</table>

Subsection 302(4)


Figure 21.22 Example of socketing operation
Subsection 302(5)
Figure 21.25 shows a sheave with cable keepers, dividers and shell (guard) in place. Combined, the keepers, dividers and shell prevent wire rope from leaving the sheave groove and must not be removed except for maintenance, inspection or adjustment, and then immediately replaced.

Figure 21.25 Example of a sheave with dividers and shell in place
Section 303  Safety latches

Subsection 303(1)
If a hook is used in any circumstances during which dislodgement could injure workers, the hook must be replaced with
(a) a hook with a safety latch (see Figure 21.26),
(b) an anchor-type shackle with a bolt, nut, and retaining pin (see Figure 21.27), or
(c) the hook must be “moused” i.e. a method of covering the throat opening of a hook by wrapping it with soft wire, rope, heavy tape or similar materials.

Figure 21.26   Examples of hooks with safety latches

Figure 21.27   Example of an anchor-type shackle with a bolt, nut and retaining pin

Subsection 303(2)
A safety latch is not required where a hook is used in an application where manipulation of the latch may pose a hazard to a worker. This might be the case, for example, where the load is awkwardly shaped and the only way a worker could release the safety latch is to climb onto the load.

Subsection 303(3)
A safety latch, mousing or shackle is not required if a sorting hook is used to lift components of a skeleton steel structure or during a similar operation (see Figure 21.28).
Figure 21.28  Example of sorting hooks and how it might be used

Subsection 303(4)

Figure 21.29 shows an example of a spring-loaded safety latch. Hoisting operations in a caisson must be foolproof — a load cannot be allowed to drop because of a safety latch that binds. A shackle assembly as described in this subsection must be used.

Figure 21.29  Example of spring-loaded safety latch

Examples of acceptable and unacceptable shackles are shown in Figures 21.30 and 21.31.

Figure 21.30  Example of an acceptable shackle
Section 304 Makeshift rigging and welding

Section 304(a)
All rigging components that carry any portion of a load must be commercially manufactured. These components are engineered and typically certified to comply with various standards. Makeshift rigging components (see Figure 21.32) are not permitted.

Sections 304(b) and 304(c)
Any rigging components that have been repaired by welding must be certified by a professional engineer as safe for use before the components are put back into service.

Annealing is the process by which metal is heated and then cooled, softening it and thus making it less brittle. Subjecting metal to non-uniform temperature change as in welding or annealing produces thermal stress in the metal. This stress can weaken the metal and lead to its premature failure.
Rejection Criteria

Section 305  Synthetic fibre slings

Synthetic fibre web slings are easily cut and have poor abrasion resistance when compared with chain and wire rope slings. It is important to use slings made of the right material for the job. Nylon slings are damaged by acids, but resist caustics. Polyester slings are damaged by caustics, but resist acids. Sunlight, moisture and temperatures above 90°Celsius damage both nylon and polyester slings.

Subsection 305(1)

Figure 21.33 visually shows the rejection criteria stated in this subsection. Damaged slings must be permanently removed from service to prevent further use.

Figure 21.33  Examples of synthetic web sling rejection criteria
Subsection 305(2)

Acid and caustic heat burns, broken stitching in load-bearing splices, and damaged eyes and end fittings all affect the load-carrying capability of slings. Damaged slings must be permanently removed from service and physically altered to prevent further use.

Subsection 305(3)

If no single type of damage exceeds the specified limits, the employer must consider the sum of the individual effect of the various types of damage. If this is approximately equivalent to the effect from a single type of damage, the sling must be permanently removed from service and physically altered to prevent further use.

Subsection 305(4)

A synthetic fibre web sling that is permanently removed from service must be physically altered to prevent its further use. The simplest way to do this is to cut the sling into many small, unusable pieces. The pieces should be disposed of immediately.

Section 306  Wire rope

In applying the requirements of this section, it is helpful to understand how a wire rope is constructed. As shown in Figure 21.34, wire rope is made of three parts: wires, strands and core.

Figure 21.34  Example of wire rope

Rope lay describes the direction the strands rotate around the core:

- regular lay rope — the strands rotate in the direction opposite to which the wires rotate. This is to counteract the torque in the rope and prevent unwinding under load;
• lang lay (non-rotating) — the strands rotate in the same direction as the wires. These ropes are used in special applications where torque would cause the line to twist in one direction, e.g. single line lifts, but are approximately 20 percent weaker than regular lay ropes.

A “lay” is the distance it takes one strand to make a complete revolution around the rope.

Figures 21.35 through 21.39 show examples of various types of wire rope damage.

Figure 21.35  Examples of rope damage due to kinking

An open kink such as this is often caused by improper handing and uncoiling as shown

These ropes show the severe damage that results when kinked ropes are used. Local wear, distortion, misplaced wires and early failure are inevitable.
Figure 21.36 Examples of birdcaging

Multi-strand rope “bird cages” due to torsional unbalance. Typical of build up seen at anchorage end of multi-fall crane application.

A “bird cage” which has been forced through a tight sheave.

A “bird cage” caused by sudden release of tension and resultant rebound of rope from overloaded condition. These strands and wires will not return to their original positions.
### Figure 21.37 Examples of wire rope damage

<table>
<thead>
<tr>
<th>Image</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>Narrow path of wear resulting in fatigue fractures, caused by working in a sheave groove that was too wide or over small support rollers.</td>
</tr>
<tr>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>Break up of strands resulting from high stress application. Note nicking of wires in outer strands.</td>
</tr>
<tr>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>Two parallel paths of broken wires indicative of bending through a sheave groove that was too narrow.</td>
</tr>
<tr>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>Wire fractures at the strand or core interface, distinct from crown fractures, caused by failure of core support.</td>
</tr>
<tr>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>An example of fatigue fracture of a wire rope that has been subjected to heavy loads over small sheaves. The usual crown breaks are accompanied by breaks in the valleys of the strands, these breaks being caused by strand nicking resulting from the heavy loads.</td>
</tr>
<tr>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>Wire rope that shows wear and fatigue from operating over small sheaves with heavy load and severe abrasion.</td>
</tr>
<tr>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>A rope failing from fatigue after bending over small sheaves.</td>
</tr>
<tr>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>A wire rope that has jumped a sheave. The rope itself is deformed into a &quot;curl&quot; as if bent around a round shaft. Close examination of the wires shows two types of breaks: normal tensile &quot;cup and core&quot; breaks and shear breaks which give the appearance of having been cut on an angle with a cold chisel.</td>
</tr>
<tr>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>Mechanical damage due to rope movement over sharp edge projection while under load.</td>
</tr>
<tr>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>A rope break due to excessive strain.</td>
</tr>
<tr>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>Snagged wires resulting from drum crushing.</td>
</tr>
<tr>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>A rope that has been jammed after jumping off a sheave.</td>
</tr>
<tr>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>Rope subjected to drum crushing. Individual wires are distorted and have been displaced from their normal position. This is usually caused by the rope scrubbing on itself.</td>
</tr>
</tbody>
</table>
Section 307  Metal mesh slings

See Table 21.1 for inspection information. Only a metal mesh sling manufacturer is able to undertake repairs to a damaged sling. Repaired slings must be proof-tested to a minimum of 2 times their vertical hitch rated load.
Section 308  Electric arc damage

Electric arc contact can result in burn damage or removal and weakening of material. A rigging component that has been contacted by an electric arc must therefore be removed from service unless a professional engineer certifies that it is safe to use.

Section 309  Damaged hooks

Unless otherwise specified by the manufacturer, a worn or damaged hook must be permanently removed from service if

(a) the throat opening, measured at the narrowest point, has increased by more than 15 percent of the original opening,

(b) the hook has twisted more than 10 degrees from the original plane of the hook,

(c) the hook has lost 10 percent or more of its cross-sectional area, or

(d) the hook is cracked or otherwise defective.