

Block B: Tools and Equipment



TRU
Open Press



Plumbing Apprenticeship Program Level 1 Series

Block B: Tools and Equipment

BC Plumbing Apprenticeship, Level 1

SKILLEDTRADESBC

*AUDREY CURRAN; MARK OVERGAARD; BC PIPING ARTICULATION AND
CURRICULUM SUBCOMMITTEE; AND PAUL SIMPSON*

TRU OPEN PRESS, THOMPSON RIVERS UNIVERSITY
KAMLOOPS, B.C.



Block B: Tools and Equipment Copyright © 2026 by Skilled Trades BC, TRU Open Press is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License (<https://creativecommons.org/licenses/by-nc-sa/4.0/>), except where otherwise noted.

Original material © SkilledTradesBC, All Rights Reserved. The original material provided by SkilledTradesBC has been adapted and modified with permission. ©COPYRIGHT TRU, 2026. Licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/deed.en>)) licence.

This licence allows you to retain, reuse, copy, redistribute, and revise this resource — in whole or in part — for **non-commercial purposes**, provided that the adapted version is released under the same licence and the original creators are properly attributed as follows:

Block B: Tools and Equipment (<https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/>) by SkilledTradesBC, revised by the BC Articulation Curriculum Subcommittee, Audrey Curran, Mark Overgaard and TRU Open Press, is used under a CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/deed.en>) licence. **Download for free at:** <https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/>

Suggested citation (APA 7th edition):

SkilledTradesBC. (2026). Block B: Tools and Equipment (Rev. ed.; adapted by Audrey Curran, Mark Overgaard, the BC Articulation Curriculum Subcommittee, & TRU Open Press). TRU Open Press, Thompson Rivers University.
<https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/>

Cover art attribution:

This book was produced with Pressbooks (<https://pressbooks.com>) and rendered with Prince.

Contents

Block B: Tools and Equipment Introduction	1
Acknowledgements	5
Accessibility	xi
 Part IV. B-4 Use Rigging, Hoisting, Lifting and Positioning Equipment	
 B-4 Use Rigging, Hoisting, Lifting and Positioning Equipment	459
B-4.1 Describe the Principles of Lifting and Hoisting	462
B-4.2 Describe Hoisting, Lifting and Rigging Equipment	470
B-4.3 Describe Lifting and Hoisting Communication	506
B-4.4 Select Slings and Tie Knots, Bends, and Hitches	518
B-4.5 Use Hoisting, Lifting and Rigging Equipment	553
B-4.6 Rig Load for Cranes	572
Self-Test B-4.1: Describe the Principles of Lifting and Hoisting	586
Answer Key: Self-Test B-4.1	587
Self-Test B-4.2: Describe Hoisting, Lifting and Rigging Equipment	588
Answer Key: Self-Test B-4.2	590
Self-Test B-4.3: Describe Lifting and Hoisting Communication	591
Answer Key: Self-Test B-4.3	593
Self-Test B-4.4: Select Slings and Tie Knots, Bends and Hitches	594
Answer Key: Self-Test B-4.4	596
Self-Test B-4.5: Use Hoisting, Lifting and Rigging Equipment	597
Answer Key: Self-Test B-4.5	599
Self-Test B-4.6: Rig Load for Cranes	600
Answer Key: Self-Test B-4.6	602
 Version History	806
Plumbing Apprenticeship & Trade Resources in BC	807

Block B: Tools and Equipment of the Plumbing Apprenticeship Program Level 1 Series features Skilled Trades BC industry-authority content that builds on the safety foundations introduced in Block A by focusing on the correct selection, use, and care of essential plumbing tools and equipment. Safe work practices remain central, but the emphasis in this block is on developing hands-on technical competence in the tools apprentices use every day on the job.

In Block B, apprentices learn how to safely and effectively use hand tools and measuring tools; operate portable power tools; access work areas using ladders, scaffolds, and other access equipment; and perform rigging, hoisting, lifting, and positioning tasks. This block also introduces the safe use of soldering, brazing, oxy-fuel cutting, and welding equipment. Mastery of these skills supports workplace efficiency, reduces the risk of injury or equipment damage, and lays the groundwork for more advanced plumbing tasks in later levels of the apprenticeship.

Plumbing Apprenticeship Program Level 1 Series

The *Plumbing Apprenticeship Program Level 1 Series* offers comprehensive training materials designed to build on foundational skills and knowledge. The series is divided into four main blocks, each focusing on critical areas of plumbing systems and installations.

Block A: Safety Related Functions

(<https://a-safetyfunctions-bcplumbingapprii.pressbooks.tru.ca>)

A-1: Workplace Hazards

A-2: WorkSafeBC Regulations

A-3: Safe Handling of Hazardous Materials

A-4: Personal Safety Practices

A-5: Fire Safety

Block B: Tools and Equipment

(<https://b-handmeasuringtools-bcplumbingapprii.pressbooks.tru.ca>)

B-1: Use Hand Tools and Measuring Tools

B-2: Use Portable Power Tools and Use

B-3: Use Access Equipment

B-4: Use Rigging, Hoisting, Lifting and Positioning Equipment, and Rigging

B-5: Use Soldering and Brazing Equipment and Oxy-Fuel Cutting Equipment

B-6: Use Welding Equipment

Block C: Routine Trade Activities and Electrical Concepts (<https://c-tradeactivities-electrical-bcplumbingappri1.pressbooks.tru.ca>)

- C-1: Mathematics and Science
- C-2: Electrical Concepts and Principles of Electricity
- C-3: Drawings and Specifications
- C-4: Codes, Regulations and Standards
- C-5: Manufacturer and Supplier Documentation

Block D: Piping and Components (<https://d-pipingcomponents-bcplumbingappri1.pressbooks.tru.ca>)

- D-1: Install Pipe and Tubing
- D-2: Install Valves
- D-3: Install Fittings
- D-4: Penetrate Structures

Plumbing Apprenticeship Program Overview and Upcoming Resources

- **Plumbing Apprenticeship Program Level 1 Series** (<https://openpress.trubox.ca/2024/12/13/plumbing-apprentice-level-1/>) can be found in the TRU Open Press Collection.
- **Plumbing Apprenticeship Program Level 2 Series** (<https://openpress.trubox.ca/2024/04/26/bc-plumbing-apprenticeship-level-2/>) can be found in the TRU Open Press Collection.
- **Plumbing Apprenticeship Program Level 3 Series** (<https://collection.bccampus.ca/search/?q=%22pl3%22>) can be found in the BCCampus Open Collection (<https://collection.bccampus.ca/>).
- **Plumbing Apprenticeship Program Level 4 Series** (<https://bccampus.ca/projects/archives/zed-cred-z-degrees/ztc-open-educational-resources-for-trades/>) can be found in the BCCampus Open Collection. (<https://collection.bccampus.ca/>) (Block F: Commission and Service will be available soon.)

Disclaimer

The materials in these Learning Guides are intended for use by students and instructional staff. They have been compiled from sources believed to be reliable and to represent the best current opinions on these subjects. These manuals are designed to serve as a starting point for good practices and may not cover all minimum legal standards. No warranty, guarantee, or representation is made by the BC Piping Trades Articulation Committee, the Skilled Trades BC authority, or the King's Printer of British Columbia regarding the accuracy or sufficiency of the information contained in these publications. These manuals aim to provide basic guidelines for piping trades practices. Therefore, do not assume that all necessary warnings and safety precautions are included, and additional measures may be required.

Safety Advisory

The current Standards and Regulation in BC can be obtained at the WorkSafeBC website: <http://www.worksafebc.com> (<http://www.worksafebc.com>)

Please note that it is always the responsibility of any person using these materials to inform themselves about the Occupational Health and Safety Regulation pertaining to their areas of work.

[From previous 2021 book – confirm this message with Skilled Trades]

Symbol Legend



Important Information



Potentially Toxic/ Poisonous Situation



Required or Optional Resources



Potentially Flammable Situation



Complete a Self-Test



Possibly Explosive Situation



Use Protective Equipment



Potential Electric Shock

Acknowledgements

The development of the *Plumbing Apprenticeship Level 1* learning resources was a collaborative effort driven by a commitment to excellence in trades education. These resources were created to support apprentices and journeypersons in mastering the skills and knowledge essential to the piping trades. This achievement would not have been possible without the dedication and expertise of *Skilled Trades BC* and the *Piping Trades Articulation Committee*, whose contributions, leadership, and guidance have been instrumental in shaping high-quality, industry-aligned training resources. We extend our sincere gratitude for their contributions and ongoing stewardship in advancing the piping trades.

The content for *Block B: Tools and Equipment* (<https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/>) is adapted from the Piping Trades Apprenticeship Program from *SkilledTradesBC* (2019 Harmonized) and the Trades Access Common Core (TACC) (<https://collection.bccampus.ca/search/?q=%22Trades%20Access%20Common%20Core%22>) resources developed by Camosun College, originally created in 2015, revised in 2019, and made available through BCcampus:

- Line C: Tools and Equipment: Competency C-1: Describe Common Hand Tools and Their Uses (<https://collection.bccampus.ca/resource/BzEe9fcq>)
- Line C: Tools and Equipment: Competency C-2: Describe Common Power Tools and Their Uses (<https://collection.bccampus.ca/resource/zAYtfTec>)
- Line C: Tools and Equipment: Competency C-3: Describe Rigging and Hoisting Equipment (<https://collection.bccampus.ca/resource/hDUEqpfn>)
- Line C: Tools and Equipment: Competency C-4: Describe Ladders and Work Platforms (<https://collection.bccampus.ca/resource/7c8Ymhmk>)

The original materials were produced in collaboration with industry partners and aligned with the Industry Training Authority (ITA) / *SkilledTradesBC* harmonized program outlines for Plumbing, Steamfitting/Pipefitting, and Sprinkler Fitting. These works were released under a Creative Commons Attribution 4.0 International (CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/>)) licence, except where otherwise noted.

This TRU Open Press edition includes editorial revisions, updated content, and the addition of new images, alongside selected images carried forward from the original Camosun College/BCcampus edition. Images in this work are licensed separately under their respective Creative Commons licences or the public domain, as credited in individual figure captions or attribution statements, unless otherwise noted. All images originally copyright the BC Industry Training Authority are licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International licence (CC-BY-NC-SA (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)).

This adapted version has been reformatted and integrated into the current Thompson Rivers University / TRU Open Press open educational resource in collaboration with the BC Piping Articulation and Curriculum Subcommittee and *SkilledTradesBC*, in support of open, accessible, and up-to-date apprenticeship training.



The Open Press

The Open Press combines TRU's open platforms and expertise in learning design and open resource development to support the creation and reuse of open educational resources, while encouraging open scholarship and research.

Resource Development Team 2024-2026

Content Review, Revision, and Development: BC Plumbing Articulation Curriculum Subcommittee and Audrey Curran

Final Content Review and Revisions: Audrey Curran and Mark Overgaard, BCIT

Project Lead (TRU Plumbing Trades): Paul Simpson, Curriculum Subcommittee Chair

Author: SkilledTradesBC

Publishing Manager/ Copy Editing: Dani Collins, MEd

Production: Jessica Obando Almache, BCS

- Co-op Students:
 - Greg Vilac
 - Riley Phillips
 - Vansh Sethi
 - Jesse Perkins, BCS Co-op Student
 - Daniel Abdulai
 - Kobe Shimoyama
 - Jose Contreras Antequera

Resources

Content adapted from:

- ©2019, Skilled Trades BC (Harmonized)
- Open School BC
- Camosun College
- Trades Training BC

For the latest BC Plumbing Trades Program Outline (2025), see the SkilledTradesBC website: www.skilledtrades.bc.ca (<https://skilledtradesbc.ca/>)

To order printed copies of Program Outlines or learning resources (where available) for BC Trades, contact:

Crown Publications, King's Printer

Web: www.crownpub.bc.ca

Email: crownpub@gov.bc.ca

Toll Free: 1 800 663-6105

The topics in this book are aligned with the competencies in the Industry Training Authority Program Outlines for the Piping Trades:

- Piping Trades Apprenticeship Program – Perform Safety Related Functions – Level 1 Harmonized (2019) (Binder) (ISBN: 978-0-7726-7362-6; product no. 7960000260) Crown Publications Online Catalogue – Piping Trades Apprenticeship Program – Perform Safety Related Functions – Level 1 Harmonized (2019) (Binder) (https://www.crownpub.bc.ca/Product/Details/7960000260_S)
- Piping Trades Apprenticeship Program – Use Tools and Equipment – Level 1 Harmonized (2019) (Binder) (ISBN: 978-0-7726-7362-6; Product no. 7960000261) Crown Publications Online Catalogue – Piping Trades Apprenticeship Program – Use Tools and Equipment – Level 1 Harmonized (2019) (Binder) (https://www.crownpub.bc.ca/Product/Details/7960000261_S)
- Piping Trades Apprenticeship Program – Perform Routine Trade Activities and Apply Electrical Concepts – Level 1 Harmonized (2019) (Binder) (ISBN: 978-0-7726-7362-6; product no. 7960000262) Crown Publications Online Catalogue – Piping Trades Apprenticeship Program – Perform Routine Trade Activities and Apply Electrical Concepts – Level 1 Harmonized (2019) (Binder) (https://www.crownpub.bc.ca/Product/Details/7960000262_S)
- Piping Trades Apprenticeship Program – Prepare Piping and Components – Level 1 Harmonized (2019) (Binder) (ISBN: 978-0-7726-7362-6; product no. 7960000263) Crown Publications Online Catalogue – Piping Trades Apprenticeship Program – Prepare Piping and Components – Level 1 Harmonized (2019) (Binder) (https://www.crownpub.bc.ca/Product/Details/7960000263_S)

The following suppliers have kindly provided copyright permission for selected images:

- RIDGID TOOLS/Emerson Professional Tools (EPT): All RIDGID tool images are used with permission from Emerson Professional Tools. Some of these images may have been adapted and carried forward from SkilledTradesBC learning resources; however, permission has been obtained directly from Emerson Professional Tools for their use here.

Any additional adapted versions of this content would require additional copyright permissions from the rights holders.

Creative Commons and site licensed images:

- Cover B-1: Red and Yellow Hand Tools on the Table (<https://www.pexels.com/photo/red-and-yellow-hand-tools-on-the-table-4312860/>) is by Anna Shvets on pexels, used as per the Pexels License. (<https://www.pexels.com/license/>)
- Cover B-2: A Person in Plaid Shirt Using a Power Tool (<https://www.pexels.com/photo/a-person-in-plaid-shirt-using-a-power-tool-8961527/>) by Mikael Blomkvist on Pexels, is used under the Pexels License. (<https://www.pexels.com/license/>)
- Cover B-3: Men on Brown Scaffolding, (<https://www.pexels.com/photo/men-on-brown-scaffolding-2209529/>) by Darya Sannikova, on Pexels, is used under the Pexels License. (<https://www.pexels.com/license/>)
- Cover B-4: Yellow crane hook against blue sky, (<https://www.pexels.com/photo/yellow-crane-hook-against-blue-sky-in-para-brazil-33346841/>) by Julia Nobre, on Pexels, is used under the Pexels License. (<https://www.pexels.com/license/>)
- Cover B-5: Propane torch soldering copper pipe, (https://commons.wikimedia.org/wiki/File:Propane_torch_soldering_copper_pipe.jpg) by Kevin L Neff via Wikimedia Commons, is used under a CC BY 2.0 (<https://creativecommons.org/licenses/by/2.0>) license.
- Cover B-6: Person in Welding Mask While Welding a Metal Bar, (<https://www.pexels.com/photo/person-in-welding-mask-while-welding-a-metal-bar-73833/>) by Pixabay, on Pexels, is used under the Pexels License. (<https://www.pexels.com/license/>)
- **All other CC-licensed, site-licensed, and public domain images are attributed in the sections where they appear.**

All symbol icons are from the Noun Project and are used under a CC BY license:

- Important by Larea from Noun Project (<https://thenounproject.com/browse/icons/term/important/>) (CC BY 3.0 (<https://creativecommons.org/licenses/by/3.0/deed.en>))
- Skull and Crossbones by Luis Prado from Noun Project (<https://thenounproject.com/browse/icons/term/skull-and-crossbones/>) (CC BY 3.0 (<https://creativecommons.org/licenses/by/3.0/deed.en>))
- Resources by popcornarts from Noun Project (<https://thenounproject.com/browse/icons/term/resources/>) (CC BY 3.0 (<https://creativecommons.org/licenses/by/3.0/deed.en>))
- Flammable by yogi rista from Noun Project (<https://thenounproject.com/browse/icons/term/flammable/>) (CC BY 3.0 (<https://creativecommons.org/licenses/by/3.0/deed.en>))
- Checkbox by ims.icon from Noun Project (<https://thenounproject.com/browse/icons/term/checkbox/>) (CC BY 3.0 (<https://creativecommons.org/licenses/by/3.0/deed.en>))
- Explosive Materials by Ervin Bolat from Noun Project (<https://thenounproject.com/browse/icons/term/explosive-materials/>) (CC BY 3.0 (<https://creativecommons.org/licenses/by/3.0/deed.en>))
- Work gloves by perilous graphic from Noun Project (<https://thenounproject.com/browse/icons/term/work-gloves/>) (CC BY 3.0 (<https://creativecommons.org/licenses/by/3.0/deed.en>))
- Danger by Alice Design from Noun Project (<https://thenounproject.com/browse/icons/term/danger/>) (CC BY 3.0 (<https://creativecommons.org/licenses/by/3.0/deed.en>))
- Electricity by Alice Design from Noun Project (<https://thenounproject.com/browse/icons/term/electricity/>) (CC BY 3.0 (<https://creativecommons.org/licenses/by/3.0/deed.en>))
- Eye protector by Vectoricons from Noun Project (<https://thenounproject.com/browse/icons/term/eye-protector/>) (CC BY 3.0 (<https://creativecommons.org/licenses/by/3.0/deed.en>))

Land Acknowledgement

Thompson Rivers University (TRU) campuses are situated on the ancestral lands of the Tk'emlúps te Secwépemc and the T'exelc within Secwepemcúl'ecw, the ancestral and unceded territory of the Secwépemc. The rich tapestry of this land also encompasses the territories of the St'át'imc, Nlaka'pamux, Tšilhqot'in, Nuxalk, and Dakelh. Recognizing the deep histories and ongoing presence of these Indigenous peoples, we express gratitude for the wisdom held by this land. TRU is dedicated to fostering an inclusive and respectful environment, valuing education as a shared journey. TRU Open Press, inspired by collaborative learning on this land, upholds open principles and accessible education, nurturing respectful, reciprocal relationships through the shared exchange of knowledge across generations and communities.



TRU Wolves (<https://www.flickr.com/photos/thompsonrivers/52667199689/>) (Thompson Rivers University/Flickr) CC BY-NC-SA 2.0 (<https://creativecommons.org/licenses/by-nc-sa/2.0/>)

If you are using a printed copy, you can scan the QR code with your digital device to go directly to the video: Introducing SkilledTradesBC (<https://www.youtube.com/watch?v=OQgwdP0rNog>)



Starting December 1, 2022, Industry Training Authority was officially renamed to SkilledTradesBC. Hear more in this video from SkilledTradesBC CEO, Shelley Gray, on what this means for the trades industry and British Columbians. Closed captioning and transcripts are available with this video, Introducing Skilled Trades BC (<https://www.youtube.com/watch?v=OQgwdP0rNog>) (2022) on YouTube.



One or more interactive elements has been excluded from this version of the text. You can view them online here: <https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2446> (<https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2446>)

AI Use Statement

ChatGPT (<https://chatgpt.com/>) and other (AI) tools may have been used to assist with the development of glossary definitions, support copy editing for grammar, clarity, and readability, and revise some image content. All content was reviewed, revised, and verified by the authors to ensure accuracy and alignment with course and industry standards.

References

- Camosun College. (n.d.). *Line C: Tools and Equipment*. BCcampus. <https://collection.bccampus.ca/resource/BzEe9fcq/>
- SkilledTradesBC. (2025). Plumber program outline (Implementation date: August 18, 2025; Last revised: December 16, 2025) [PDF]. Province of British Columbia. <https://skilledtradesbc.ca/media/2776/download>
- SkilledTradesBC. (2022, December 1). Introducing Skilled Trades BC. YouTube. <https://www.youtube.com/watch?v=OQgwdP0rNog>

Accessibility

The web version of Block B: Tools and Equipment (<https://b-handmeasuringtools-bcplumbingappr1.pressbooks.tru.ca/>) has been designed to meet Web Content Accessibility Guidelines 2.0 (<https://www.w3.org/TR/WCAG20/>), level AA. In addition, it follows all guidelines in Appendix A: Checklist for Accessibility (<https://opentextbc.ca/accessibilitytoolkit/back-matter/appendix-checklist-for-accessibility-toolkit/>) of the Accessibility Toolkit – 2nd Edition (<https://opentextbc.ca/accessibilitytoolkit/>).

Includes:

- **Easy navigation.** This resource has a linked table of contents and uses headings in each chapter to make navigation easy.
- **Accessible videos.** All videos in this resource have captions.
- **Accessible images.** All images in this resource that convey information have alternative text. Images that are decorative have empty alternative text.
- **Accessible links.** All links use descriptive link text.

Accessibility Checklist

Element	Requirements	Pass
Headings	Content is organized under headings and subheadings that are used sequentially.	Yes
Images	Images that convey information include alternative text descriptions. These descriptions are provided in the alt text field, in the surrounding text, or linked to as a long description.	Yes
Images	Images and text do not rely on colour to convey information.	Yes
Images	Images that are purely decorative or are already described in the surrounding text contain empty alternative text descriptions. (Descriptive text is unnecessary if the image doesn't convey contextual content information.)	Yes
Tables	Tables include row and/or column headers with the correct scope assigned.	Yes
Tables	Tables include a title or caption.	Yes
Tables	Tables do not have merged or split cells.	Yes
Tables	Tables have adequate cell padding.	Yes
Links	The link text describes the destination of the link.	Yes
Links	Links do not open new windows or tabs. If they do, a textual reference is included in the link text.	Yes
Links	Links to files include the file type in the link text.	Yes
Video	All videos include high-quality (i.e., not machine generated) captions of all speech content and relevant non-speech content.	Yes
Video	All videos with contextual visuals (graphs, charts, etc.) are described audibly in the video.	Yes
H5P	All H5P activities have been tested for accessibility by the H5P team and have passed their testing.	Yes
H5P	All H5P activities that include images, videos, and/or audio content meet the accessibility requirements for those media types.	Yes
Font	Font size is 12 point or higher for body text.	Yes
Font	Font size is 9 point for footnotes or endnotes.	Yes
Font	Font size can be zoomed to 200% in the webbook or eBook formats.	Yes

Known Accessibility Issues and Areas for Improvement

- Images in H5P self-tests lack alt text, attributions, and licenses to avoid revealing answers.
- Some tables may use merged cells, but they have been structured to work properly with screen readers and there may be long descriptions included in each section if readers prefer to see the table data in a bulleted list.
- Youtube videos do not have edited captions.

Adapted from the Accessibility Toolkit – 2nd Edition (<https://opentextbc.ca/accessibilitytoolkit/>) by BCcampus, licensed under CC-BY (<https://creativecommons.org/licenses/by/4.0/>).

Other Formats Available

- In addition to the web version, this book is available in a number of file formats, including PDF. The Print PDF has passed our Accessibility Check.

PART IV

B-4 USE RIGGING, HOISTING, LIFTING AND POSITIONING EQUIPMENT

Plumber Apprenticeship Program – Level 1



Yellow crane hook against blue sky (<https://www.pexels.com/photo/yellow-crane-hook-against-blue-sky-in-para-brazil-33346841/>) (Julia Nobre/pexels)
Pexels License (<https://www.pexels.com/license/>)

B-4 Use Rigging, Hoisting, Lifting and Positioning Equipment

Rigging, hoisting, lifting, and positioning are important skills in the plumbing and pipe trades, where workers often need to move heavy materials, tools, and equipment safely on construction sites. Understanding how loads behave, selecting the correct lifting equipment, and communicating clearly during lifting operations are critical for preventing injuries and damage. In this section, you will learn the basic principles of lifting and hoisting, become familiar with common hoisting, lifting, and rigging equipment, and understand the communication practices used during lifting operations. You will also learn how to select appropriate slings, tie common knots, bends, and hitches, and safely use rigging equipment when lifting and positioning loads, including when working with cranes.

Learning Objectives

After completing this section, you should be able to:

- Describe the principles of lifting and hoisting.
- Describe hoisting, lifting and rigging equipment.
- Describe lifting and hoisting communication.
- Select slings and tie knots, bends, and hitches.
- Using hoisting, lifting and rigging equipment.
- Using rigging loads for cranes.

You will be required to reference publications and videos available online at WorkSafeBC. (<https://www.worksafebc.com/en>)

Supplementary Video Series: Trades Access Common Core — Tools and Equipment



To support your learning in this section, you may find the following video series helpful. These short instructional videos were developed by Camosun College and shared through BCcampus as part of the Trades Access Common Core learning resources.

1. Knots and Hitches – BCcampus (https://media.bccampus.ca/media/Knots%20and%20Hitches/0_1zyju8c0)
2. Truckers Hitch – BCcampus (https://media.bccampus.ca/media/Truckers%20Hitch/0_x4iyzc34)
3. How to Whip the End of a Rope – BCcampus (https://media.bccampus.ca/media/How%20to%20Whip%20the%20End%20of%20a%20Rope/0_rhafq2j5)

The following terms will be used throughout this section. A complete list of terms for this section can be found in the **Glossary**.

- **boom truck:** Frequently used on construction sites to lift and position pipe, equipment, and materials at height. Plumbers often work directly with boom truck operators during installations. (Section B-4.2)
- **boom radius:** Also referred to as the operating radius, this is the horizontal distance from the centre of rotation to the hook and is a function of boom angle and length. This concept is crucial to understanding safe crane capacity. (Section B-4.6)
- **centre of gravity:** The point in an object where its weight is balanced. (Section B-4.1)
- **chain hoist (chain fall):** Commonly used in mechanical rooms, shops, and construction sites to lift and position heavy pipe, pumps, or mechanical equipment. (Section B-4.2)
- **come-along (puller):** A very common hand tool used by plumbers to pull pipe into alignment, tension materials, or position equipment before fastening or welding. (Section B-4.2)
- **dog everything:** A safety instruction used in lifting and hoisting operations that means to secure or lock all controls and equipment so that no movement can occur. It ensures the load and machinery remain safely in place before workers approach or handle the load. (Section B-4.3)
- **drop stops:** Safety devices installed on lifting equipment, such as trolleys or hoists, that prevent the load or trolley from accidentally falling or running off the end of a beam or track. (Section B-4.2)
- **effort (input force):** The force a person applies to move or lift an object. (Section B-4.1)
- **lift plan:** A written or discussed plan that explains how a load will be safely lifted and moved. It includes details such as the weight of the load, the equipment being used, the lifting path, possible hazards, and how workers will communicate during the lift. (Section B-4.1)
- **lifting point:** The place on a load where the lifting equipment is attached. (Section B-4.1)
- **load integrity:** The condition in which a lifted load remains secure, stable, and properly contained so that individual items do not shift, separate, or fall during lifting, moving, or positioning operations. (Section B-4.1)
- **mechanical advantage (MA):** How much a machine increases the force you put into it to make work easier. (Section B-4.1)
- **outrigger:** A support member that projects beyond the natural outline of a crane to provide additional support and to prevent toppling. (Section B-4.6)
- **pallet jack (manual forklift):** Widely used in warehouses, shops, and job sites to move skids of pipe, fittings, and equipment. (Section B-4.2)
- **peening:** Damage that occurs when wire rope repeatedly strikes or rubs against a hard surface, causing the wires or strands to flatten, distort, and become brittle over time. (Section B-4.5)
- **pick and carry:** A lifting operation in which a crane or lifting machine raises a load and then moves it horizontally to another location while the load remains suspended, usually carried low to the ground for safety. (Section B-4.1)
- **pulley:** A wheel with a rope or cable that helps lift or move heavy loads. (Section B-4.1)
- **resistance (load force):** The force that must be overcome to move or lift a load. (Section B-4.1)
- **rigging:** The equipment and methods used to attach and lift loads safely with cranes or hoists. (Section B-4.1)

- **safety factor:** A margin of safety used to ensure equipment can handle more than the expected load. (Section B-4.1)
- **signal person:** A trained worker who gives hand signals or radio instructions to a crane operator during lifting operations. (Section B-4.1)
- **sling:** A strong strap, rope, or chain used to lift heavy objects. (Section B-4.1)
- **snatch block:** Important for rigging setups because it allows workers to change the direction of a pull or increase pulling power when moving heavy materials. (Section B-4.2)
- **snub line:** A rope or line attached to a load to help control its movement and prevent it from swinging while it is being lifted or moved by a crane. (Section B-4.1)
- **tag line:** A rope attached to a suspended load that workers hold to guide and steady the load, helping control its direction and rotation during lifting or positioning. (Section B-4.1)
- **thimble:** A metal fitting placed inside the eye (loop) of a wire rope or fibre rope to protect it from wear and crushing. The thimble helps the rope keep its shape and prevents damage when the rope is attached to hooks, shackles, or other rigging hardware. (Section B-4.4)
- **unstable load:** A load that shifts, tilts, or moves unexpectedly when lifted. (Section B-4.1)
- **whipping:** A method of tightly wrapping twine or wire around the end of a rope to prevent it from fraying or unraveling. (Section B-4.4)
- **working load limit (WLL):** The maximum weight a piece of lifting equipment can safely carry. (Section B-4.1)

B-4.1 Describe the Principles of Lifting and Hoisting

Mechanical Advantage

The **mechanical advantage (MA)** of a mechanism is the factor by which input effort is multiplied to produce greater output force. Mechanical advantage describes how much a machine increases applied force. The mechanical advantage of a device can be used to determine how well it performs and whether it can perform a given job.

Most **simple machines** operate using the principle of MA, and it can be calculated using the following formulas.

- **Levers:** $MA = \text{length of effort arm} \div \text{length of resistance arm}$.
- **Pulleys:** All pulleys have a fixed MA, depending on the type. A single fixed pulley has an MA of 1:1. A single movable pulley has a MA of 2:1. A pulley with six ropes (block-and-tackle system) has an MA of 4:1.
- **Wheel and Axle:** $MA = \text{radius of wheel} \div \text{radius of axle}$
- **Inclined Plane:** $MA = \text{length of slope} \div \text{height of slope}$

Understanding mechanical advantage helps workers safely lift and move loads using rigging and hoisting equipment.

Pulleys

Single fixed **pulleys** can change the direction in which a force is applied and can transmit rotational motion into linear motion. However, they do not provide mechanical advantage, because the amount of force required is equal to the force of the load.

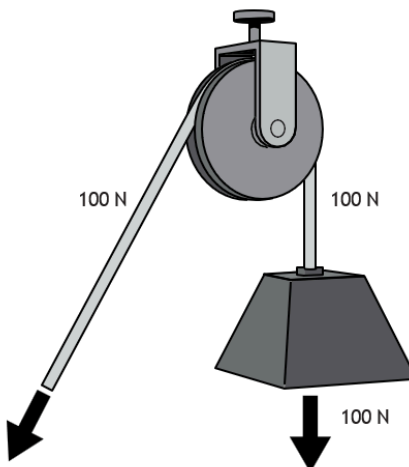


Figure 1 Fixed pulley (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Movable and multiple pulleys can be used to provide significant mechanical advantage. In this case, there is a trade-

off between force and distance: less force is required, but the distance required to do the work increases. (**Note, the product of force $\times$ distance remains the same.**) In Figure 2, although the effort is cut in half, the length of rope required will be twice the distance that the load travels.

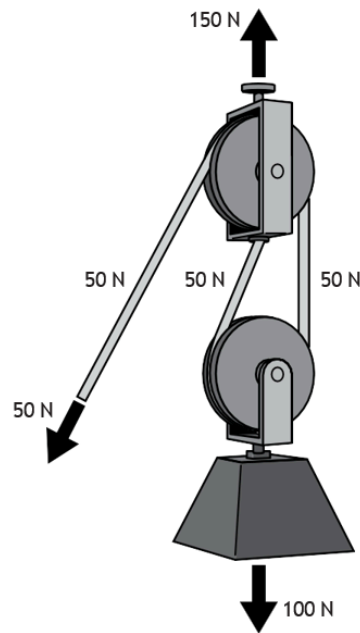


Figure 2 Compound (movable) pulley (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Balance Points and Load Stability

Properly **rigging** a load of material (supporting or fastening it for lifting or transport) helps keep the load level and stable as it is lifted into the air by a **crane** or hoisting device. A poorly rigged load may shift and could cause the load to fall. To maintain stability, workers must consider the centre of gravity, **sling** locations, and sling types.

Centre of Gravity

The **centre of gravity** of an object is the point at which the object will balance, regardless of whether the object is upright, on its side, top, bottom, or end.

A suspended object will always move so that its centre of gravity is located directly below its point of support.

You must consider the location of the centre of gravity whenever you rig a load to be lifted by a crane. Estimate the location of the centre of gravity for the object to be lifted. Although the centre of gravity can be calculated using complex formulas, workers in the piping trades often determine it using careful judgment and short trial lifts. Complex or critical lifts should always be rigged by a competent, certified rigger. Use a sling arrangement that positions the lifting hook directly above the centre of gravity.

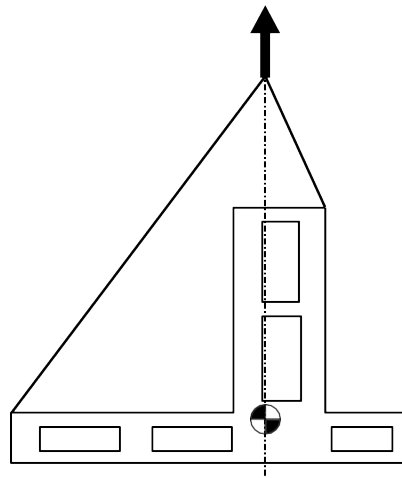


Figure 3 Stable load (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

A load with the hook to the side of the centre of gravity will shift or tilt when lifted. This shift will continue until the centre of gravity rests directly below the hook.

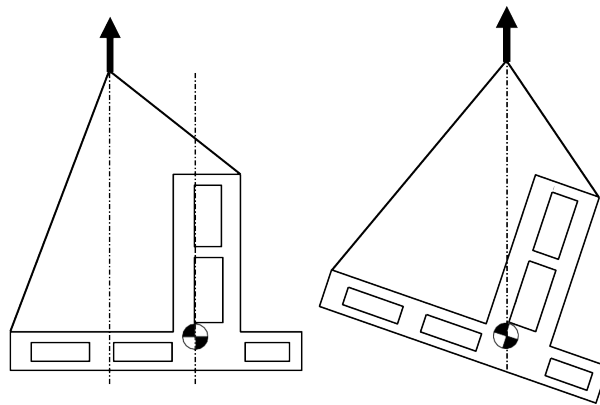


Figure 4 Movement of unstable load (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



NEVER rig a load with the centre of gravity above the lifting point (or points). Doing so may cause the load to turn over. The natural position for the centre of gravity is below the point of attachment.

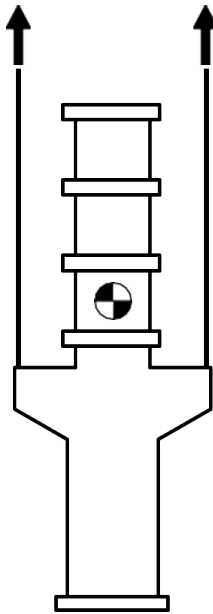


Figure 5 Incorrect position of the load (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Sling Locations

The position of the **sling** attachment to the load is very important.

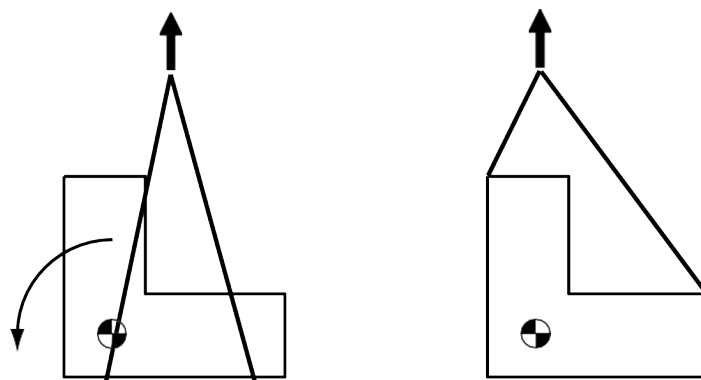


Figure 6 Sling application (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

When using a sling, as shown here, ensure that the centre of gravity is located between the two slings. If the centre of gravity is beyond the slings, the load may topple over at the start of the lift. Rigging loads with their centre of gravity

close to one sling is considered poor practice because of the increased risk of tipping. Always use a sling arrangement that places the centre of gravity below the sling's point of attachment to the load.

When you are lifting loads with a crane, start the initial lift very slowly, and watch the load for signs of tilting or shifting. If the load tilts more than 5°, lower the load and rearrange the rigging.

Steps to a Safe Lift

Certification Requirements

The OHS Regulation Part 15: Rigging (<https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-15-rigging>) states that “Rigging and slinging work must be done by, or under the direct supervision of, qualified workers familiar with the rigging to be used and with the code of signals authorized by the Board for controlling hoisting operations.”

Training standards are often site-specific, where employers define what constitutes a qualified worker, with the OHS Regulation as the minimum requirement.

Labour organizations, private third-party training companies, and equipment manufacturers also offer training. The Canadian Standards Association Group (CSA Group) provides a rigging certification course developed with United Association Canada (UA) and the National Association of Union Schools and Colleges (NAUSC).

Lift Plan

A **lift plan** is a process that includes calculating load weight, identifying the lift-route, recognizing potential hazards (such as weather or overhead powerlines), selecting equipment and safety protocols, and establishing communication procedures. Lift plans can range from a quick, informal chat between a worker acting as a signal-person and a boom-truck operator to a formal process for a critical lift, requiring signed documentation from riggers, supervisors, engineers, and crane operators. This distinction between non-critical and critical lifts is often set by employers or crane companies.

Factors that may classify a lift as critical include:

- The proximity of the lift to power lines
- The need for two or more lifting devices
- Load weight exceeding 75% of the crane's capacity
- Uneven ground or side loading on the crane

Calculations of Weight

Knowing the approximate weight of the load and rigging hardware is crucial for proper equipment selection. Load weights may be obtained from reliable sources such as shipping documents and forms, manufacturers' specifications,

or design plans (drawings). Weights of common material can be sourced from publications such as the IPT Pipe Trades Training Manual (<https://iptbooks.com/product/pipe-trades-manual/?v=5435c69ed3bc>). Other scenarios may require calculations using standard weight of common material and applying the formulas for area and volume.

Equipment Selection

Approved hoisting equipment has a rated load called its *rated capacity* or **working load limit (WLL)**. This indicates the maximum safe load the equipment can handle. This is based on the ratio of the ultimate breaking strength to the safety factor. Rigging load calculations are based on a design safety factor of 5:1 for material and 10:1 for critical or personnel lifts. This means that if a 1-inch wire rope has an ultimate breaking strength of 41,000 kg, with a safety factor of 5, the WLL would be 8,200 kg.

Communication

During a lift, the crane operator and **signal person** work together to execute the lift safely. Only an experienced, trained operator should control lifting equipment and ensure that movements are planned, slow, and thoughtful. Signal persons must know the proper hand signals or radio communication procedures and should have a pre-lift consultation with the operator to clarify the lift plan and communication. **Clear communication is essential for safe lifting operations!**

Load Security

Load integrity is considered if multiple objects are hoisted at once, as in the case of pipe bundles, or if a **pick-and-carry** operation is required. If the load consists of many like objects, use the proper sling arrangement for security or carry the load in a basket. During a pick-and-carry lift, the load is carried low to the ground and a **snub line** is used in addition to **tag lines** to control swing.



Self-Test B-4.1: Describe the Principles of Lifting and Hoisting

Complete Self-Test 4.1 and check your answers.

If you are using a printed copy, please find Self-Test A-4.1 and Answer Key in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.



An interactive H5P element has been excluded from this version of the text. You can view it online here:
<https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2877#h5p-10> (<https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2877#h5p-10>)

References

- BC Industry Training Authority. (2019). *Piping trades apprenticeship program: Use Tools and Equipment—Level 1 harmonized* [Binder]. Crown Publications, Queen's Printer for British Columbia. https://www.crownpub.bc.ca/Product/Details/7960000261_S
- Camosun College. (2019). Line C: Tools and Equipment—Competency C-3: Describe Rigging and Hoisting Equipment (Rev. ed.) [Learning guide]. BCcampus. <https://collection.bccampus.ca/textbook/7c8Ymhnk/>
- Camosun College. (2015). Trades Access Common Core Competency C-3: Describe Rigging and Hoisting Equipment. Victoria, B.C.: Crown Publications. Download for free from the B.C. Open Textbook Collection (<https://open.bccampus.ca/browse-ourcollection/find-open-textbooks/>).
- Lee, R. A. (2006). *IPT's pipe trades handbook and training manual* (Rev. ed.). IPT Publishing & Training Ltd.
- WorkSafeBC. (n.d.). *Occupational health and safety regulation: Part 15—Rigging*. <https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-15-rigging>

Media Attributions

All figures are sourced from Industry Training Authority (2019) and/or Camosun College (2019) and are used under the Creative Commons Attribution 4.0 (CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/>)) licence unless otherwise noted. Images copyrighted by the BC Industry Training Authority are licensed under a Creative Commons

Attribution-NonCommercial-ShareAlike 4.0 (CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)) licence.

B-4.2 Describe Hoisting, Lifting and Rigging Equipment

The following rigging accessories and lifting devices are commonly used in the pipe trades and must be selected and used correctly to ensure safe lifting operations.

Lifting and Hoisting Accessories

Rigging loads requires the use of various hardware items for lifting. Correct selection, inspection, and assembly of these hardware items is critical to ensuring a safe lift. Common rigging hardware includes:

- Turnbuckles
- Eyebolts
- Shackles
- Cable clips and thimbles
- Hooks
- Slings and hitches
- Spreader bars

Turnbuckles

Turnbuckles are used to adjust the lengths of slings so that loads can be lifted in a level position.

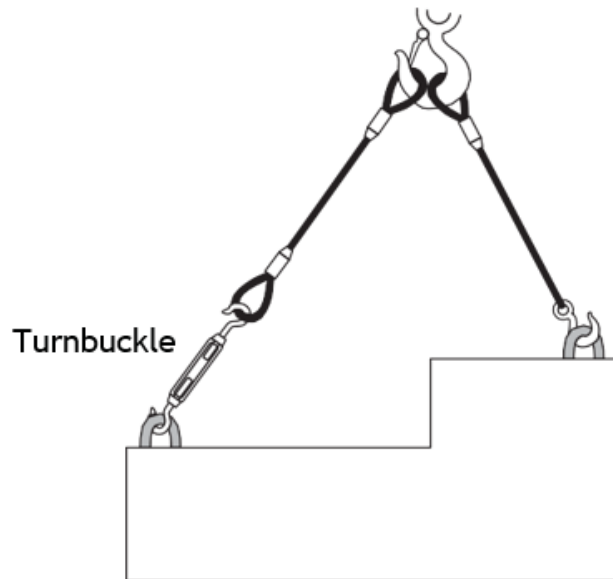


Figure 1 Adjusting leg length with a turnbuckle (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

They are metal sleeves with left-hand internal threads at one end and right-hand internal threads at the other. Threaded metal rods are fitted into each end.



Figure 2 Turnbuckle (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The ends of these threaded rods are available as eyes, jaws, or hooks. All hooks on turnbuckles must have a safety catch (Figure 3).

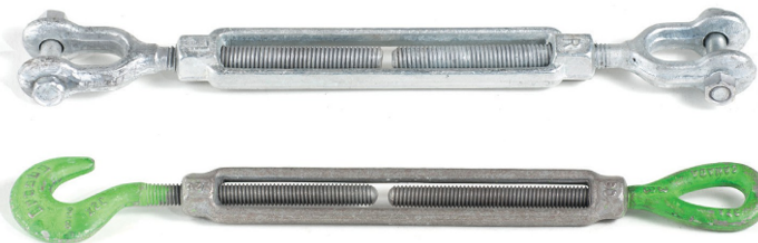


Figure 3 Turnbuckle ends (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

It is important to prevent turnbuckle ends from rotating. Rotation can be caused by vibration or by tension on the rope attached to the turnbuckle. If there is any chance that the ends of the turnbuckles could rotate within the sleeve, the ends should be secured to the sleeve using lock wire, as shown.



Figure 4—Turnbuckle end with lock wire (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Eyebolts

Eyebolts are used to provide a secure point of attachment for hoisting operations. There are two types: shoulder and shoulderless eye bolts. Shoulderless eye bolts must not be used in overhead lifting, because force applied from the side at any angle will break the stem of the bolt.

Shoulder-type eye bolts are able to withstand pulls up to 45° from vertical, providing the pull is applied along the plane of the eye. Pulling at an angle that is not in the same plane will bend or break the eye. Always make sure that the eye bolt is properly installed so that the shoulder sits tightly against the load. Do not use an eye bolt if there is any space between the shoulder and the load, because it will act like a shoulderless eye bolt and may break under stress.

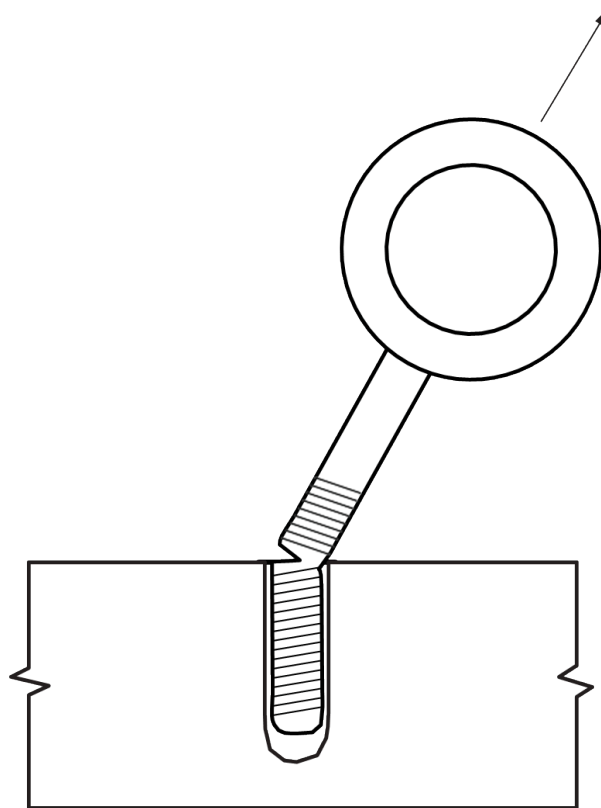


Figure 5 Shoulder-less eye bolt (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

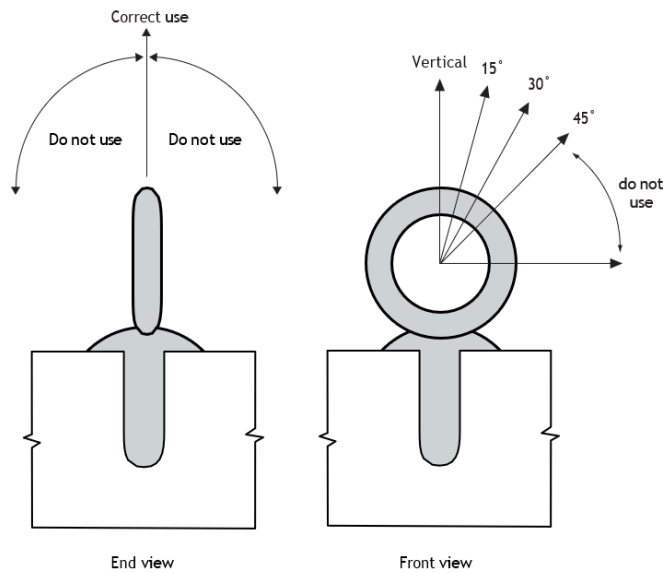


Figure 6 Angle of pull-on eyebolts (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The Working Load Limit (WLL) for eye bolts are given for vertical pulls. When lifting at an angle, you must reduce the WLL of the eye bolt as follows:

- Vertical pull = No reduction in WLL
- 15° from vertical = 45% reduction in WLL
- 30° from vertical = 65% reduction in WLL
- 45° from vertical = 75% reduction in WLL
- Over 45° from vertical = NOT RECOMMENDED

Shackles

Shackles (Figure 7) are used to connect a sling to a load. They should be used whenever two or more ropes are placed over a hook (Figure 8). The shackle should have a throat large enough to avoid crowding and pinching the ropes. The working load limit (WLL) of a shackle must be shown as a stamped or embossed number on the body of the shackle. Never use shackles that do not display a load rating.



Figure 7 Shackle (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Never replace the pin of a shackle with an ordinary bolt. Shackle pins are made of hardened steel, while ordinary bolts may bend under load and damage the shackle. In many applications, the shackle pin must be secured for safety. The pin may be wired off to prevent it from turning loose, or the pin may be seized in place.

Figure 9 shows a shackle attachment that could cause the screw pin to become loose.



Figure 9 Incorrect shackle attachment (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 8 Wire ropes on shackle over hook (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Never attach a shackle so that the load is applied to the sides of the shackle. This condition is called **crossbow loading**. Always apply the load to the pin and the curved body of the shackle. To prevent crossbow loading, never use a shackle with slings where the sling angle will exceed 45° between the two slings at the shackle.

Figure 10 shows the correct method for attaching a shackle to a lifting hook. Note that if the width of the shackle's opening is considerably greater than the thickness of the hook, packing washers should be used to centre the hook on the shackle.



Figure 10 Apply load to pin (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Shackles may be used to form a **choker hitch**, but you must make sure the pin is not bearing on any moving part of the rope. The rope could cause a screw pin to turn and become loose.



Figure 11 Using a shackle for a choker hitch (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

There are three basic types of pins available for shackles:

- *Screw pins
- Round pins
- Safety type pins

*The screw pin shackle is the most commonly used.

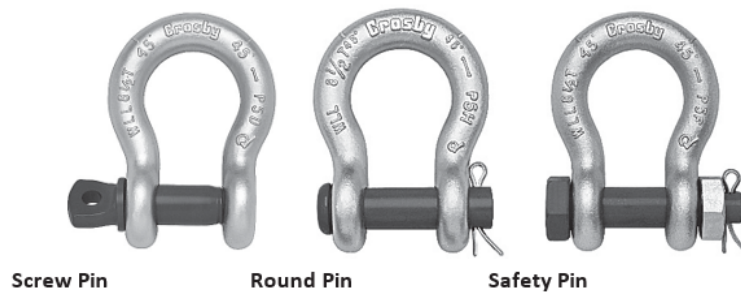


Figure 12 Pin types for anchor shackles (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Cable Clips and Thimbles

Cable clips are used to fasten the end of a wire rope back onto its standing part to form a loop. Cable clips provide a relatively quick and easy method for tying wire rope. However, the crimping action of cable clips significantly reduces the breaking strength of wire rope (by up to 20%).

The two most popular types of cable clips are the U-bolt clip and the **double saddle (fist grip) clip**, shown here. The U-portion must be installed on the dead end of the rope.

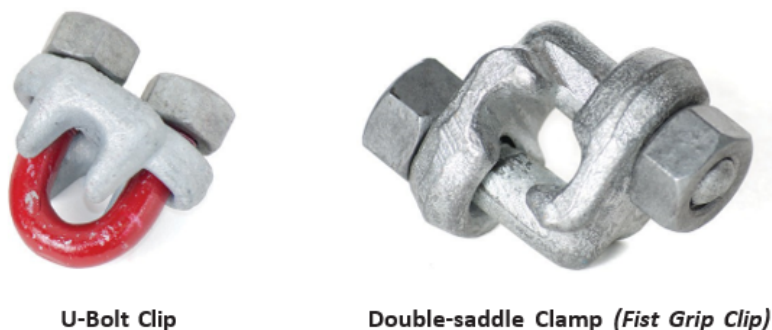


Figure 13 Cable clips (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The space between cable clips is usually equal to six or seven rope diameters. The distance from the rope end to the first cable clip should also be six or seven rope diameters. To figure out how many clips are required to make the loop, multiply the rope diameter by three and round up to the next whole number.

Wire rope has a tendency to stretch a small amount when first put into service. Wire rope reduces in diameter as it stretches. Tighten all cable clips after the first hour of service for a new connection. If the cable clip connection is under heavy strain, check the tightness of the nuts at regular intervals until no further loosening is observed.

The correct procedure for installing cable clips is as follows:

1. Calculate the length required for the loop (number of clips required multiplied by six rope diameters). Install the first clip six rope diameters from the rope end. Tighten the nuts to the recommended torque using a torque wrench.



Figure 14 Installing first cable clip (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

2. Install the second clip as near the **thimble** as possible. Tighten the nuts securely but do not apply final torque yet.



Figure 15 Installing second cable clip (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

3. Install all other clips at equal spacing. Apply tension to the rope and then tighten all nuts to the recommended torque.



Figure 16 Installing centre cable clips (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Correctly installed cable clips reduce the breaking strength of wire rope by approximately 20%; incorrectly installed, they can reduce the breaking strength by up to 50%.

Hooks

Hooks are commonly used to connect lifting devices to loads. Common types include:

- Standard eye hooks
- Slip hooks
- Grab hooks
- Sorting hooks



Figure 17 Hook types (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The standard safety eye hook is commonly used to lift loads that have been rigged, as is the variation that includes a swivel base.



Figure 18 Swivel hook (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

All hoisting hooks, except grab and **sorting hooks**, must have **safety catches**. Open hooks must not be used to lift a bucket, cage, or skip if there is a possibility the load could injure people.

Hooks are usually made of alloy steel, and their working load limit (WLL) should be stamped on them. It is important to remember that the working load limit applies only when the load sits in the saddle of the hook. If the load is off-centre or sits between the saddle and the tip, the working load limit is significantly reduced (see illustration).

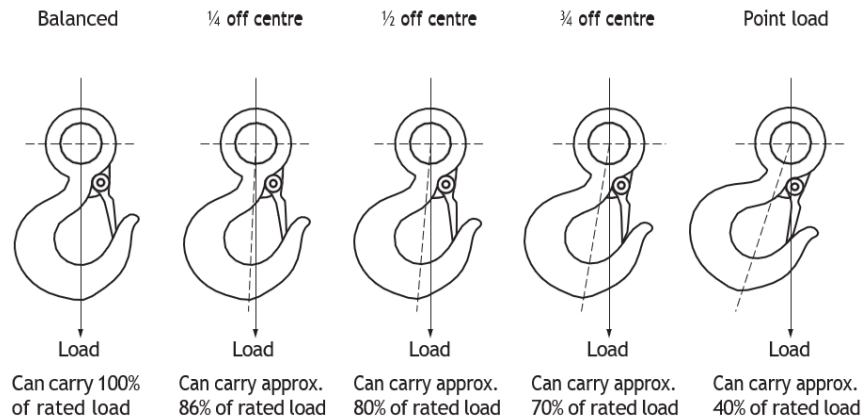


Figure 19 Effect of off centre loads on hook capacity (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Slip and grab hooks are generally attached to the ends of chains to pick up or pull a load. *Sorting hooks* are also referred to as *shake-out hooks* and are primarily used at the end of slips for picking up steel plate and other structural shapes. The long, thin hook can slide between closely stacked steel shapes. When sorting hooks are used to lift heavy loads, you must ensure that the load sits squarely in the bottom (**saddle**) of the hook.

To protect chains from the stress of twisting while under load, all hoisting chains should be equipped with **swivels**, such as those shown here.



Figure 20 Chain swivels (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Choker Hooks

Choker hooks are fittings attached to the end of a sling. The width of the hook protects connected ropes from sharp bends. When the hook is attached back onto its sling, it forms a choker hitch.

The standard choker hook shown here is attached to the end of the sling. The sling is passed around the load, and the wide surface of the hook is hooked over the standing part of the sling.



Figure 21 Standard choker hook (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

A variation of the standard choker hook, called the **adjustable or sliding choker hook** (below) is mounted on a sling that has a loop at each end. The sling is passed around a load, and the end loop is hooked over the choker hook.



Figure 22 Adjustable choker hook (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Slings and Hitches

Most items that require hoisting have no provisions for attaching a hoisting line to them. Slings are used to connect the load to the lifting device. Slings may be made of fibre rope, wire rope, chain, or webbing, and they may be attached to loads in a variety of ways.

To protect both the load and the sling, place padding between the sling and any sharp corners on the load (called **softeners**). The following simplified diagrams may not show softeners being used, but they should be applied whenever possible in the field.

Identification

All slings must have an identification tag in accordance with ANSI/ASME and CSA guidelines. This tag provides the following information:

- Name of the manufacturer
- Diameter, width, and length of the sling
- Materials
- Rated load for the given type of hitch
- Lift angle upon which the load rating is based

Sling Design Factor

One must apply a safety factor of 5:1 to every lift. This is to account for overloading, abrasion, crushing, kinking, and impact loading of slings. Some engineered lifts may have safety factors of 6:1, 8:1, 10:1 or higher.

Synthetic Web Slings

Synthetic web slings (typically made from woven nylon) are available in a variety of shapes and widths. They are softer and wider than most other slings so better protect the load against marring or scratching. The shapes most commonly found are illustrated below.



Figure 23 Synthetic web slings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Some web slings have metal end fittings instead of sewn eyes. Two types are available (see Figure 24). A basket web sling has metal triangles of equal size at each end of the webbing. A choker web sling has a larger triangle containing a slot at one end and a smaller triangle at the other end. The smaller triangle can be passed through the slot of the larger triangle to form a choker hitch.



Figure 24 (left) Basket web sling (right) choker web sling (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Metal Mesh Slings

Loads that are too abrasive or too hot for synthetic webbing yet require the wide bearing surface of a web belt are rigged with slings made of metal mesh. These metal mesh slings are usually equipped with triangle ends that permit the use of either a basket or choker hitch.

Chain

Chain slings have certain applications as they do not kink, are able to withstand rough handling, and are resistant to abrasion and corrosion. However, they have no elasticity and due to their nature, chains are less reliable than wire rope or synthetic slings and can fail without warning. The term ‘weak link’ illustrates that a single chain link can cause catastrophic failure, whereas wire rope will break progressively over time and show signs of stress or damage upon inspection.

Chain sling identification will indicate the manufacturer’s approval for hoisting. It will also show the chain’s size, WLL, length and manufacturer.

Chain slings require documented annual inspections. For a sound inspection of chain slings, clean the chain first then

inspect for wear or stretching. Any stretch over 5% requires the sling to be removed from service (OHS Regulation Part 15: Rigging (<https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-15-rigging>)). Any cracks require the entire chain to be removed from service.

Rules for safe chain use include:

- Only use alloy chain slings for hoisting.
- Always use softeners for rectangular loads.
- Avoid shock loading.
- Never repair or weld links and never shorten a chain by tying a knot or bolting two links together.
- If links bind together, this indicates stretching, and further inspection is required.
- When a chain is used for a basket hitch, always hook to the **master link**, not the chain itself.
- Store chain in a dry place.

Identification

Synthetic web slings must bear an identification tag indicating the WLL (working load limit, also known as the **safe working load**). This tag must never be removed or tampered with.



Figure 25 Sling identification tag (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Inspection

Web slings should be inspected for:

- Worn or distorted fittings
- Cuts
- Holes
- Punches (or punctures)
- Tears
- Frayed material
- Broken stitching
- Burns caused by acid, caustic chemicals, or heat

Inspect the slings carefully before use and make a decision about their safety. If you are not sure that the sling is safe, tag

it so that it will not be used by another worker and notify your supervisor. Your supervisor should make the necessary arrangements to have the sling inspected for safety and approved before it is returned to service.



Never use a sling for lifting unless it has a tag clearly indicating its working load limit!

Single Vertical Hitch

The single vertical hitch consists of a single leg of sling material with a hook or an eye at each end. The eyes on fibre or wire-rope slings should be lined with thimbles to protect the strands.

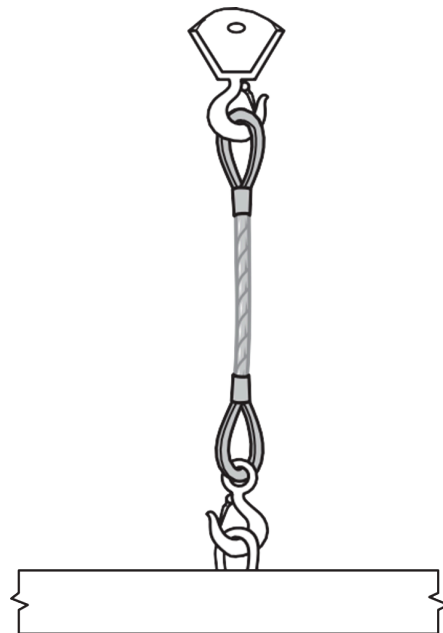


Figure 26 Single vertical hitch (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Bridle Hitch



Figure 27 A
thimble
protecting the
eye (BC Industry
Training
Authority, 2019).
CC BY-NC-SA 4.0
(<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Two, three, or more legs may be used together to form a **bridle hitch**. Bridle hitches are generally used on loads that have suitable attachment points. To keep the load stable, the attachment points must be located above the load's centre of gravity.

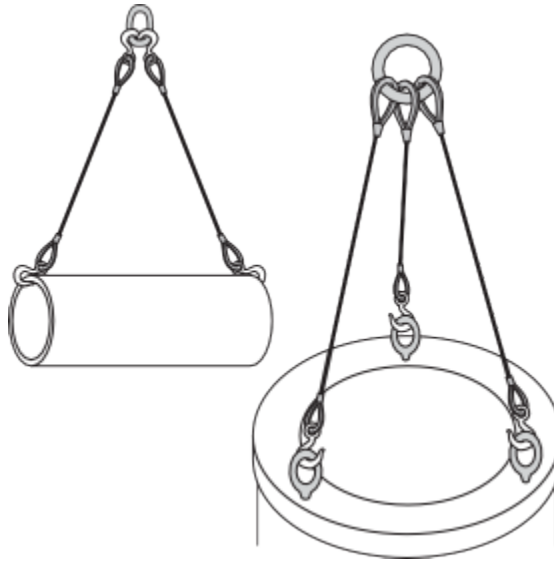


Figure 28 Bridle hitches (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

When a bridle hitch has more than two legs, do not assume that all legs are sharing the load equally. Regardless of the total number of legs, the full weight of the load might be shared by only two legs. The other legs may simply be balancing the load (see below). For this reason, each sling in a multi-leg bridle hitch must be sized so that any one sling can safely support half of the load.

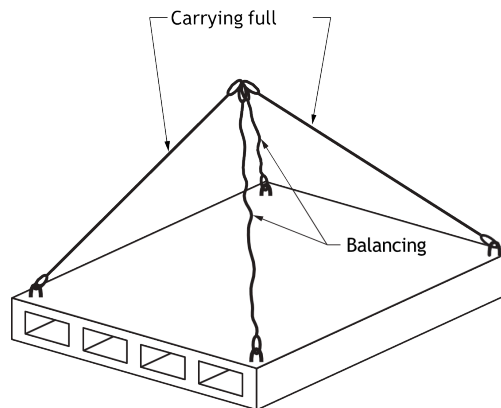


Figure 29 Load sharing (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0
(<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Single Basket Hitch

A **single basket hitch** is made from a single length of sling material passed through an opening in the load, with both ends of the sling attached to the main lifting hook.

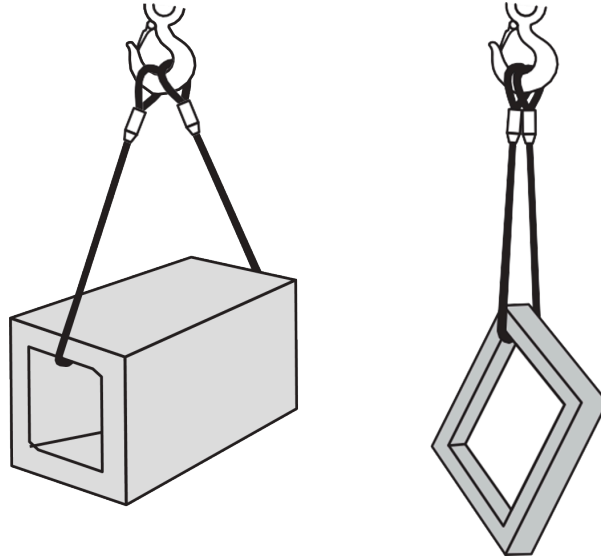


Figure 30 Single basket hitches (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Single basket hitches must not be used on loads that could tilt or slide out of the hitch.

When a sling is wrapped around a square object, sharp corners must be padded or protected to prevent damage to both the sling and the load.

Double Basket Hitch

Loads that require support from underneath can be lifted with a **double basket hitch**. The double basket hitch must be positioned so the load is balanced between the two points of support. The two points must be far enough apart to prevent the load from tipping or sliding out of the hitch.

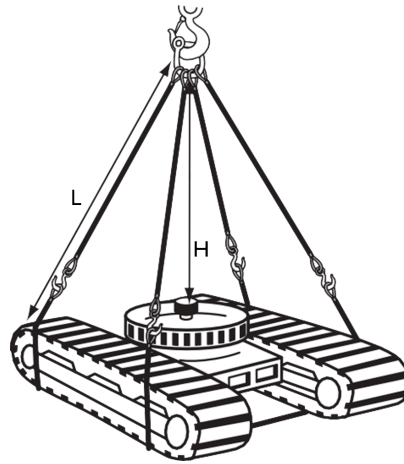


Figure 31 Double basket hitch (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The legs of a double basket hitch should be inclined at an angle of at least 60° from the horizontal to prevent the legs from sliding toward each other. By using longer slings, you can spread the legs further apart while maintaining the 60° angle. Note that the slings may slide toward each other under load, and the load may tip out of the slings unless steps are taken to secure them in place, such as placing blocks of wood to prevent movement when lifting metal pipes.

Double-Wrap Basket Hitches

Loose loads can be securely rigged for hoisting with double basket hitches by wrapping the sling completely around the load (Figure 33). This double wrapping compresses all the components together so that even the top pieces will not slide out of the rigging.

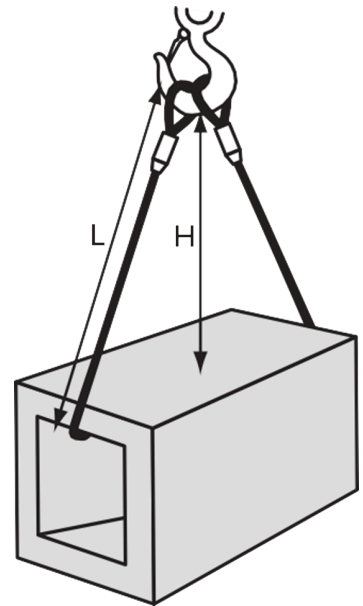


Figure 32 Necessary incline angle (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

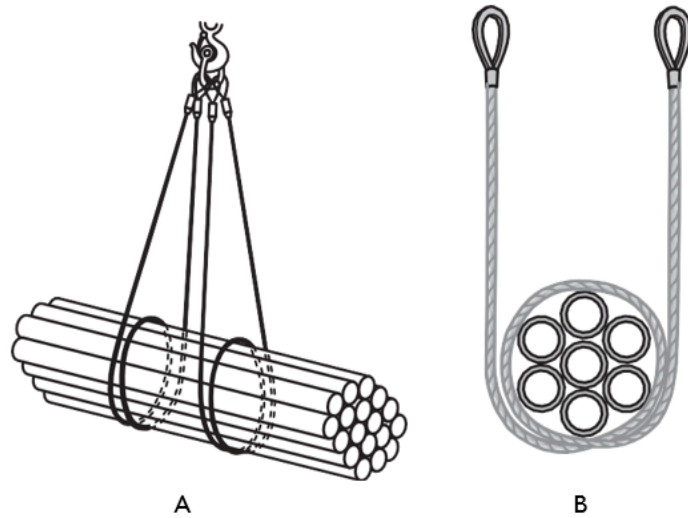


Figure 33 Double-wrap basket hitch (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Single choker hitches (below) are made by hooking a single length of sling material back onto itself just above the load. Although there are several methods for securing the sling back onto itself, none will fully secure the top of loose loads. (see Figure 34).

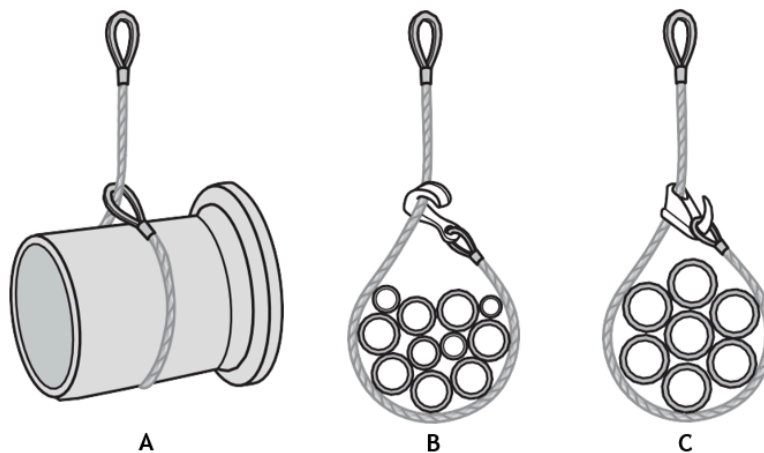


Figure 34 Single choker hitches (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Double Choker Hitch

Double choker slings must be used on all horizontal loads made up of two or more pieces of material that are over 3 m (10 ft) in length.

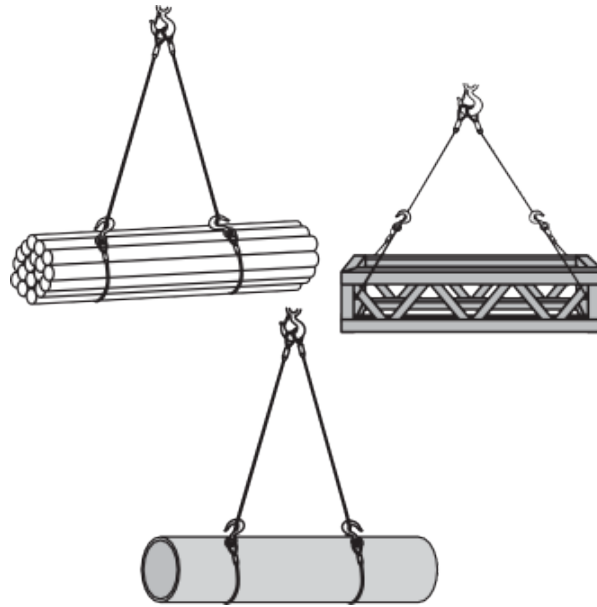


Figure 35 Double choker hitches (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Double-Wrap Choker Hitch

The double-wrap choker hitch is similar to the double-wrap basket hitch in that both squeeze the load from all sides. Double-wrap choker hitches may be used singly or in pairs.

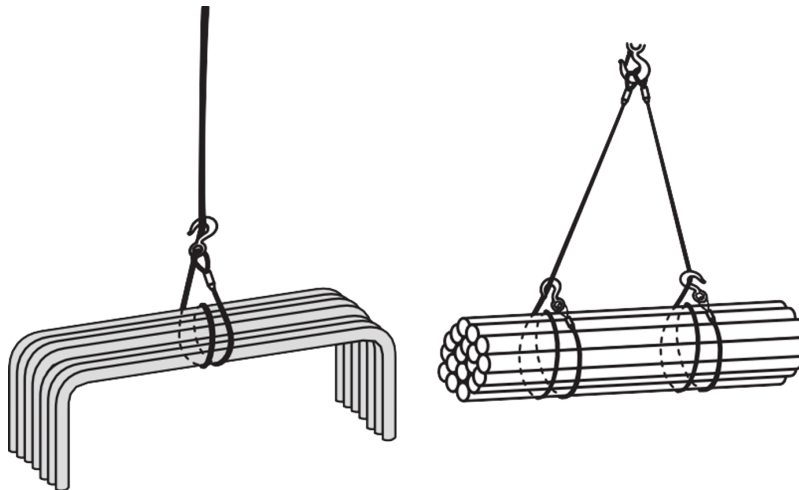


Figure 36 Double-wrap choker hitches (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Endless Slings

Endless slings (also known as grommet slings) can be used in a variety of configurations. They are simply continuous loops of the same material.

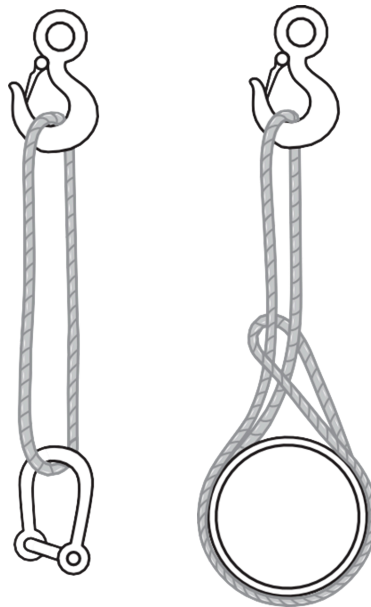


Figure 37 Endless slings (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Endless slings are usually made of fibre rope or synthetic webbing. They are light to handle and do not damage the loads, but because they are subjected to sharp bends, they tend to deteriorate more rapidly than most other types of slings.

Spreader Bars

Long loads are often attached to *[pb_glossary id="5056"]spreader bars (beams)[/pb_glossary]* before hoisting to prevent the load from tipping or sliding out of their rigging. **Equalizer bars** ensure that the load is distributed evenly between the legs of a sling or between hoist lines when more than one is used. The following figures show spreader and equalizer bars and how they are used to keep loads evenly balanced.

Equalizer bars, spreader bars, and all lifting devices must be professionally designed and manufactured. They must be certified by a registered professional engineer, stamped with the certification, and marked with a safe working load. Homemade lifting devices, such as S-hooks, are not permitted.

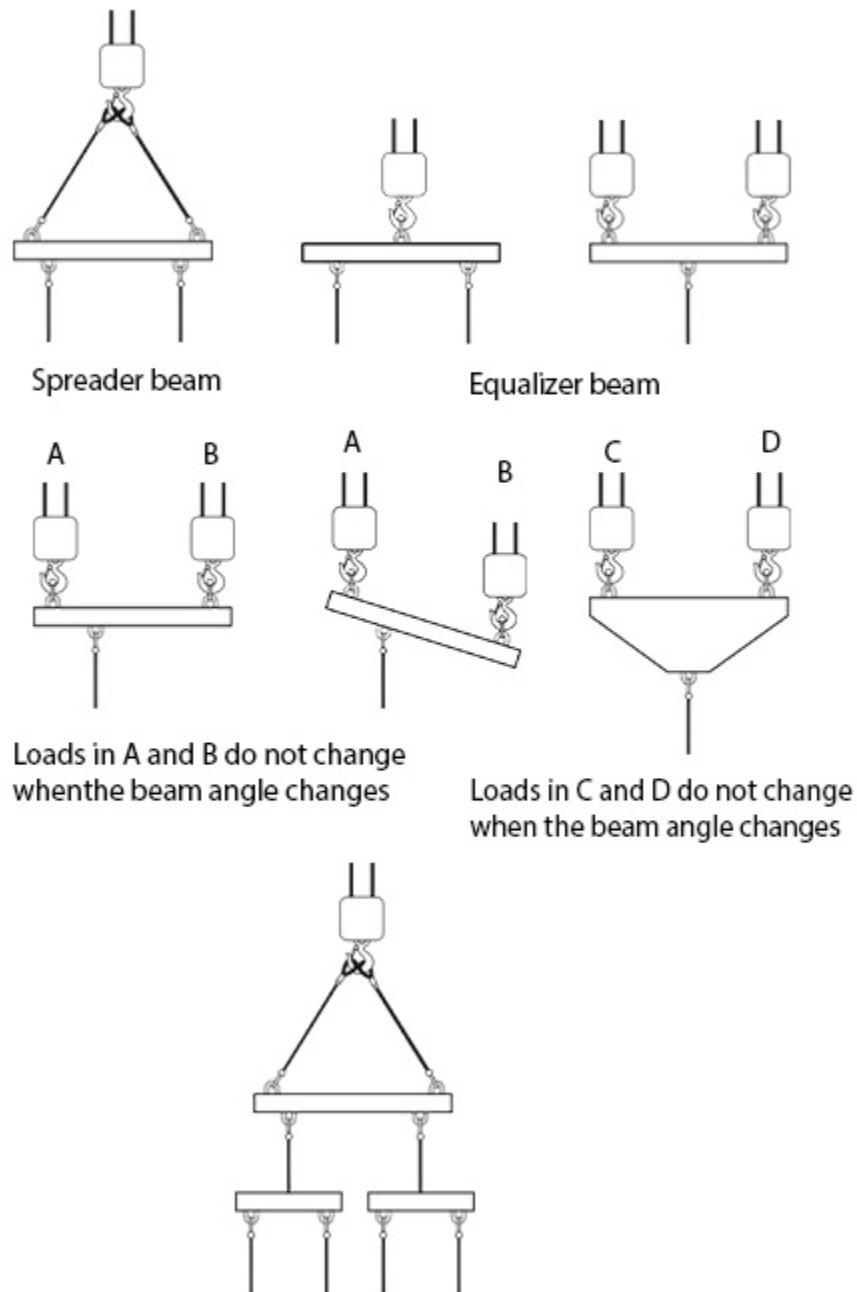


Figure 38 Spreader and equalizer beams (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Lifting and Hoisting Equipment



No person may operate lifting or hoisting equipment without proper training. All training must be provided by a qualified instructor who has received training from the original equipment manufacturer in the safe operation of the specific equipment. Only the manufacturer's operations manual may be used for training purposes.

Manual Lifting Devices

Manual lifting devices include:

- Block and tackle
- Chain hoists
- Come-alongs
- Tirfor jacks

Block-and-Tackle

A **block-and-tackle** uses fibre ropes rather than wire rope. It is capable of increasing lifting capacity. This increase can be calculated by counting the number of ropes leaving the travelling block or by counting the number of **sheaves (grooved wheels)**. For example, a with four sheaves, two on the fixed block and two on the movable block, can lift a 1000 kg load by exerting a pull of only 250 kg. This is important because the load being lifted may exceed the rope's breaking strength.

A block-and-tackle has no braking device or safety system. It cannot support a load unless the line is anchored.

Snatch Blocks

A **snatch block** is a pulley block with a side plate that swings open. Because the side plate opens, the cable does not need to be threaded through the block opening; instead the side plate is opened and the bight of the cable is placed over the pulley.



Figure 39 Block-and-tackle (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 40 Snatch Block (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Chain Hoists

Chain hoists (also known as chain falls or endless chains) are dependable and economical devices for vertical lifting. Both manually operated and electrically powered models are available. They are designed to move loads either up and down or sideways, but never both at the same time.

Chain hoists are most often used for vertical lifts but can also be used for horizontal pulls. They are hand-operated and available in a wide range of capacities, from 450 kg to 9000 kg ($\frac{1}{2}$ ton to 10 tons). The lifting capacity of a chain hoist must be clearly marked on the hoist, and must never be exceeded.

Movement is relatively slow, and the lifting distance is limited by the length of the lifting chain.



Figure 41
Chain hoist
with
“Endless”
Chains (BC
Industry
Training
Authority,
2019). CC
BY-NC-SA 4.0
(<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

“Endless” Chains

An **“endless” hand chain** turns the drive pulley. The drive pulley is connected to the lifting chain through a series of reduction gears that multiply the amount of force the operator exerts on the hand chain. To lower a load, you simply pull the hand chain in the opposite direction. Endless-chain hoists have the advantage of holding the load without requiring a separate brake.

“Come-Along”

Come-alongs (also called pullers) are similar to chain hoists but are operated by a ratchet lever rather than an endless chain. They are more convenient for horizontal pulls than chain hoists because they are compact, although they usually have a smaller lifting capacity than chain hoists. Similar to chain hoists, the rated capacity for come-alongs must be clearly marked and must never be exceeded.

Come-alongs are commonly used in repair shops to pull heavy parts into position before welding or bolting. Inspection procedures include checking the lifting medium (chain or wire rope). Safety requirements for wire rope, chain, and other attaching devices are equivalent.

Never substitute regular chain for the original lifting chain supplied with the come-along. Do not use any extensions on the handle to increase leverage.

Tirfor Jacks

Tirfor jacks (see Figure 42) are hand-operated lifting or pulling devices with an unlimited rope travel distance. They work by applying a direct pull on a wire rope that typically has a hook attached to one end and a plain end on the other (the plain end is fed through the Tirfor jack first). The pulling force is applied through two pairs of self-energizing smooth jaws that grip the rope in proportion to the load. The initial pressure that causes the jaws to grip the rope and starts the self-energizing action is provided by springs that exert a pressure of about 800 kPa (120 psi).

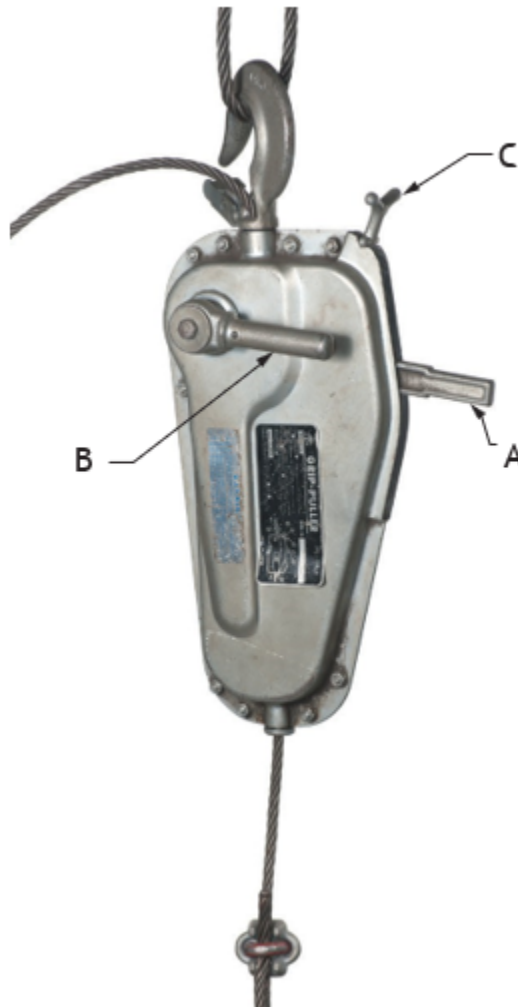


Figure 43 Tirfor jacks (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 42 Come-alongs (pullers) (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Two levers (A and B) activate the jaws to move the rope forward or backward, depending on which lever is used. The release lever (C) must **never** be left in the released position. A removable pipe handle is used to operate the levers. The jack may be attached directly to the load or anchored near the ground.



Always position the jack so that you will not be harmed or injured if the load drops.

Tirfor jacks are available in three capacities: 750 kg (1600 lb.), 1600 kg (3500 lb.) and 3200 kg (7000 lb.). All Tirfor jacks models include overload protection consisting of a shear pin in the lifting-lever connection (Figure 42B), which breaks if the load weight exceeds the rated capacity, preventing further movement of the load.

Never replace the specific wire rope used with the Tirfor jack with another piece of wire rope unless the replacement rope meets the exact same specifications as the original.

Electric Hoists

Electric hoists are much faster and more productive than manual hoists, although they are often more expensive. They usually have a push-button control suspended from a chain or wire rope. Both manual and electric hoists may be stationary or movable. Movable types are used on overhead runways, gantry cranes, jib cranes, and overhead travelling cranes.

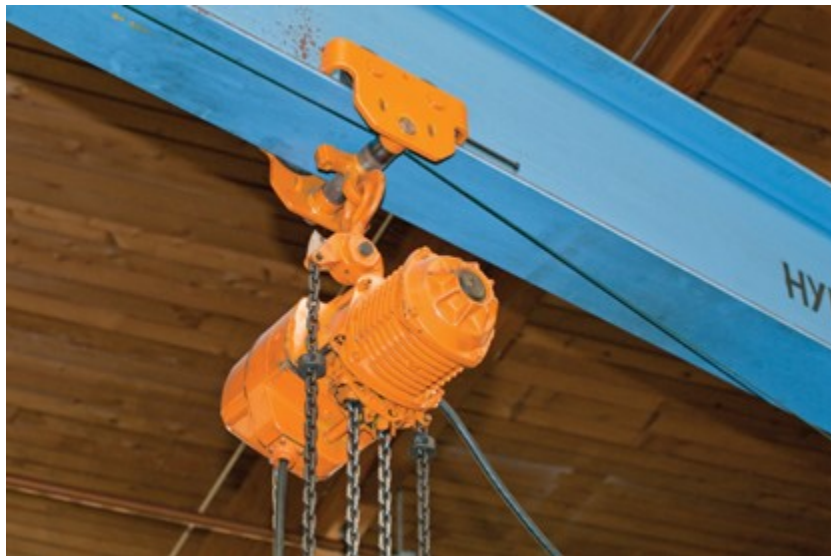


Figure 44 Electric hoist on a runway (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Some hoists are manually pulled along the overhead runway or boom, while others are motor driven. Hoists are manufactured in many capacities.

Workplace regulations typically require all trolleys to be equipped with **drop stops**, which are automatic brakes that prevent the load from falling.

Floor Hoists

A typical hydraulic floor hoist or floor crane is shown in Figure 44. The lifting reach can be adjusted by moving the boom in or out. However, as the boom extends, the lifting capacity decreases. The rated lifting capacity of these hoists is based on lifts with the boom fully extended. Floor hoists are available in various sizes and may be manually, hydraulically, or electrically powered.

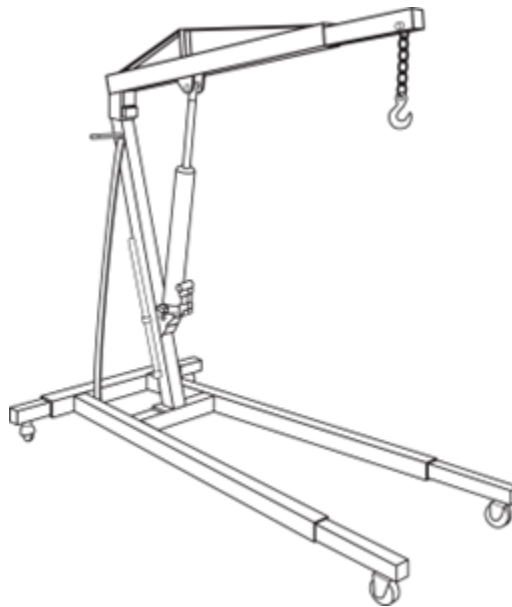


Figure 45 Floor hoist (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Superstructures for Hoists

Hoists are generally suspended from an overhead support (a **superstructure**) that may be stationary and provide for only vertical lifting or may allow the load to be moved from one area to another horizontally. These support structures must have a safe lifting capacity greater than the capacity of the hoist, and the safe capacity must be clearly marked.

All superstructures and supports must be certified by the engineer or manufacturer for lifting capacity.

Gantry Cranes

One of the most basic support structures that can also provide mobility is the **gantry crane**. With this superstructure, the load can be lifted and the entire crane assembly and the load can be moved to another area.



Figure 46 Gantry crane (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Overhead Runways

Runways usually consist of H-type or I-type structural steel beams fastened to heavier cross beams on the ceiling or mounted on floor supports. The hoist is attached to rollers or trolleys that run along the bottom flange of the beam.

Runways are used extensively in shops to move materials. They often extend from outdoor loading, unloading, and storage areas right into the shop. Switches, loops, and drop arms can be installed to move materials to strategic locations.

Jib Crane

Another type of support structure is the **jib crane**, which features a boom attached to a vertical member that rotates. Jib cranes may be wall-mounted or pedestal-mounted. Entire jib-crane assemblies can also be mounted on rails to move materials between areas of a shop.



Figure 47 Jib crane (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Overhead Travelling Cranes

Overhead travelling cranes (also called bridge or gantry cranes) may be **top-running** or **under-running**, depending on where the hoist assembly is mounted. Top-running cranes generally have greater load-carrying capacity. The trolleys on which the hoist assembly moves is mounted on top of **bogeys (end-trucks)** that move along parallel runways. Under-running travelling cranes are used for lighter loads, usually not more than 907 kg (2000 lb.). In these systems, the hoist-carrying bridge or beam is mounted on trolleys.



Figure 48 Overhead travelling crane (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Mobile Lifting Equipment

Mobile lifting equipment used in the piping trades includes cranes, boom trucks, loaders, Tirfor jacks, and “tuggers.”

Tuggers

Tugger is a broad term that refers to an electric or hydraulic drum **winch**. Some electric winches can be bolted to a wall or floor and used with a snatch block (pulley block) to lift pipes into place in a mechanical room.

Mobile Hoists

Boom Trucks

Boom trucks are mobile hoisting units with three features:

- A hydraulic crane mounted on the truck chassis for lifting heavy loads.
- A flatbed for transporting equipment and materials.
- (Often) a personnel hoist or fibreglass basket that allows workers to reach elevated work areas.

Boom trucks are often equipped with outriggers for stability. Boom styles can vary from straight telescopic to articulating, and capacities generally range from 3 to 75 tons, with reaches of 12 to 21 metres.

Boom truck operators require proper training and certification.

Part 14: Cranes and Hoists (<https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-14-cranes-and-hoists>) of the OHS Regulation (<https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/>) requires annual inspections of boom trucks and requires that they not be used unless a professional engineer certifies that the structural, mechanical, and control components of the truck are safe for use.

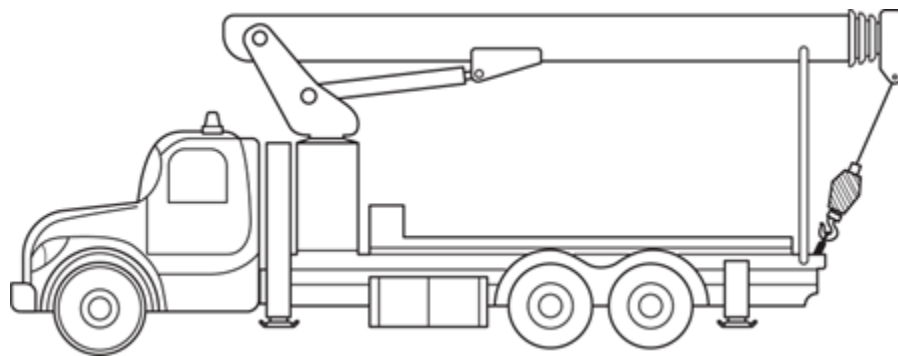


Figure 49 Boom Truck (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 50 Boom truck in action (Artaxerxes/Wikimedia Commons) CC BY 4.0
(<https://creativecommons.org/licenses/by/4.0/deed.en>)

Forklifts

No person may operate a forklift without training. All training must typically be provided in accordance with the requirements of CSA Standard B335-94 (<https://www.csagroup.org/store/product/2410931/>), Industrial Lift Truck Training.

One of the most common types of materials-handling equipment is the motorized forklift, used for lifting and transporting materials that can be stacked or placed on pallets.

The main identifying features of the forklift are the two horizontal arms (or forks) that extend from the vertical mast (Figure 49). The mast can tilt forward between 10° and 25°.



Figure 51 Forklift (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0
(<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The forklift's load-lifting capacity depends on the spacing of the forks, the height and tilt of the mast, and the floor or ground surface conditions. Lifting capacities range from 907.2 kg to 31 752 kg (2000 lb. to 70 000 lb.). Forklifts may be powered by electricity or internal combustion engines.

Manual forklifts (also called *pallet trucks* or *pallet jacks*) are hand propelled units used to lift and move palletized loads on smooth floors.

They cannot be used to stack loads one on top of the other, as their maximum lift height is only 150–200 mm (6–8 in.) above the floor. They have small steel wheels under the forks and require smooth surfaces to travel on when loaded.

The pallet jack shown here uses a hydraulic jack that is operated by pumping the handle to raise the forks. Travel is achieved by pushing or pulling. Loads can be lowered gently to the floor by using a control lever on the handle.



Figure 52 Pallet jack (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Rollers

Rollers can be used to move heavy objects by hand. Commercially available rollers can support many tons and consist of a series of roller bearings that rotate around a central core. These rollers are often used by house movers and modular-building installers.

On construction sites, large heavy items such as full skids of pipe often need to be moved. These heavy loads can be moved using a jack and several pieces of steel pipe. The pipe should be approximately 50–75 mm (2–3 in.) in diameter, and the jack must be strong enough to safely lift one end of the load. A minimum of three pipes is required, and sometimes two jacks.

To Move the Load

1. Jack up one end of the load enough to place two of the pipes under the load.
2. Position the jack at the end of the load closest to the load's final location.
3. Place one pipe past the midpoint of the load and the second pipe near the jack.
4. Lower the load onto the pipes.
5. Push the load towards its final destination.
6. As the load moves, place the third pipe in front of the load and allow the load to roll onto it.
7. As the load rolls off the last pipe, move that pipe to the front and continue the process.

This method only works if the ground is firm enough to prevent the rollers from sinking and the surface is somewhat free of small debris.

Safety Considerations

- Never allow the rollers to protrude excessively from the edge of the load.
- Keep your hands and feet clear of the rollers and the load. Watch for pinch points.
- Stay clear of the load at all times.
- Practice with light loads before applying these procedures to heavy loads.



Self-Test B-4.2: Describe Hoisting, Lifting and Rigging Equipment

Complete Self-Test 4.2 and check your answers.

If you are using a printed copy, please find Self-Test A-4.2 and Answer Key in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.



An interactive H5P element has been excluded from this version of the text. You can view it online here:
<https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2879#h5p-8> (<https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2879#h5p-8>)

References

BC Industry Training Authority. (2019). *Piping trades apprenticeship program: Use Tools and Equipment—Level 1*

harmonized [Binder]. Crown Publications, Queen's Printer for British Columbia. https://www.crownpub.bc.ca/Product/Details/7960000261_S

Camosun College. (2019). Line C: Tools and Equipment—Competency C-2: Describe Common Power Tools and Their Uses (Rev. ed.) [Learning guide]. BCcampus. <https://collection.bccampus.ca/textbook/zAYtfTec/>

Camosun College. (2015). Trades Access Common Core Competency C-2: Describe Common Power Tools and Their Uses. Victoria, B.C.: Crown Publications. Download for free from the B.C. Open Textbook Collection (<https://open.bccampus.ca/browse-ourcollection/find-open-textbooks/>).

CSA Group. (n.d.). CSA store product page (Product No. 2410931). <https://www.csagroup.org/store/product/2410931>

WorkSafeBC. (n.d.). Occupational health and safety regulation. <https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/>

WorkSafeBC. (n.d.). Occupational health and safety regulation: Part 14—Cranes and hoists. <https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-14-cranes-and-hoists>

WorkSafeBC. (n.d.). Occupational health and safety regulation: Part 15—Rigging. <https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-15-rigging>

Media Attributions

All figures are sourced from Industry Training Authority (2019) and/or Camosun College (2019) and are used under the Creative Commons Attribution 4.0 (CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/>)) licence unless otherwise noted. Images copyrighted by the BC Industry Training Authority are licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 (CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)) licence.

- **Figure 50** Boom truck Grove Street downtown Brattleboro VT April 2024 (https://commons.wikimedia.org/wiki/File:Boom_truck_Grove_Street_downtown_Brattleboro_VT_April_2024.jpg), by Artaxerxes on Wikimedia Commons is used under a CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/deed.en>) license.

B-4.3 Describe Lifting and Hoisting Communication

Communication Signals for Crane and Hoist Operations

Whenever the operator of lifting or hoisting equipment does not have a direct **line of sight** to the load, or when radio communication is not possible, a competent **signal person** must be positioned where they have a clear view of both the load and the operator. The signal person must watch the load at all times and direct all movements of the load from this vantage point. Only one person should signal to the operator of hoisting or lifting equipment at any one time.



A **STOP** signal can be given by **any** worker. This is the only signal the operator will accept from anyone other than the signal person.

Communication must consist of previously agreed-upon hand signals or radio contact. The ANSI B30.5 standard requires signal persons to be trained and tested prior to performing crane signaling. Other forms of communication may include bell, light, or horn signals.

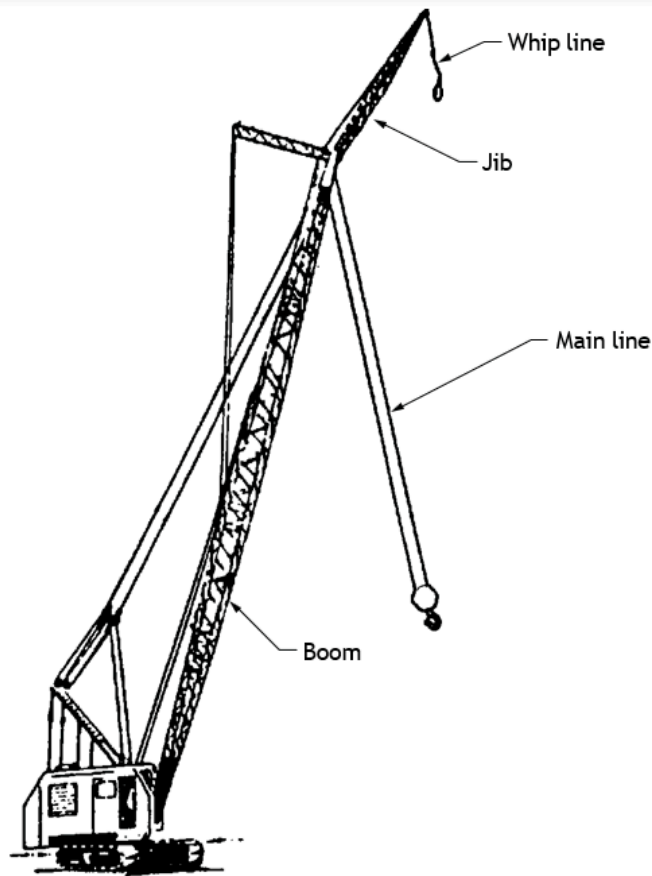


Figure 1 Mobile crane with telescopic boom (BC Industry Training Authority, 2019).
CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Audible Signals

Horn signals for traveling and mobile cranes:

One blast = STOP

Two blasts = FORWARD

Three blasts = REVERSE

Control of Platforms or Skips (Crane-Hoisted Containers):

One bell or light = STOP

Two bells or lights = RAISE LOAD

Three bells or lights = LOWER LOAD

Four bells or lights = ALL CLEAR

Hand Signals

The movement of cranes and loads is controlled using internationally recognized hand signals. These signals are used by all trades involved in lifting or hoisting operations.



If a signal is unclear or not understood, the crane operator must not respond.

“Raise the Load”

With your upper arm horizontal, forearm vertical, and your forefinger (index finger) pointing up, move your hand in small horizontal circles.

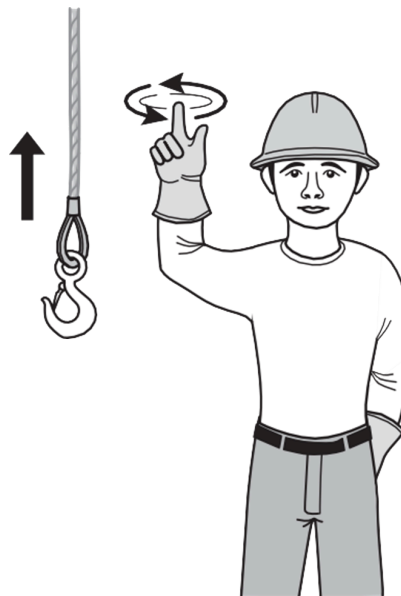


Figure 2 Raise the load (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

“Lower the Load”

With your forearm extended downward and your index finger pointing down, move your hand in small horizontal circles.



Figure 3 Lower the load (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

“Stop”

If both your hands are free, extend both arms horizontally with your fingers outstretched. If only one hand is free, face your palm toward the operator with fingers extended and wave your hand side to side.

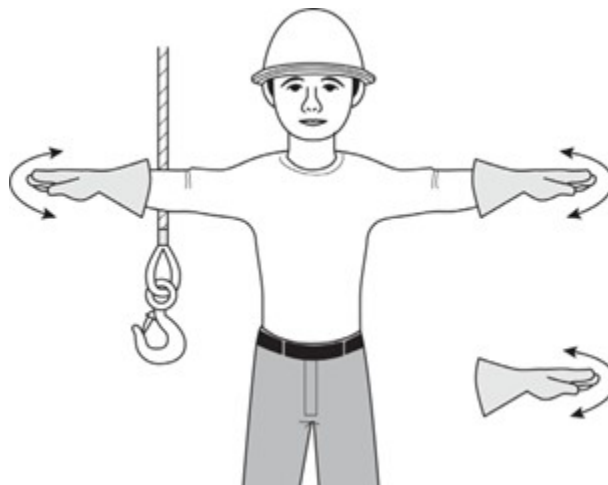


Figure 4 Stop (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Boom Signals

To signal boom movement, extend your arm with fingers closed and use your thumb to indicate whether the boom should be raised or lowered. Remember that boom movement causes the load to move laterally—toward or away from the crane—not just vertically.

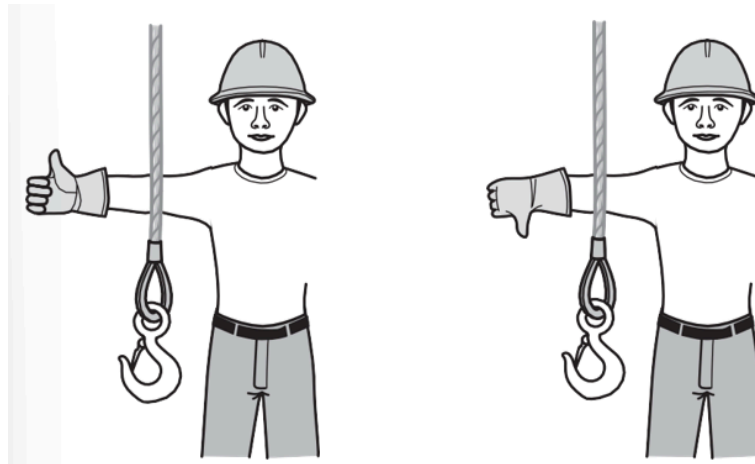


Figure 5 Raise boom and lower boom (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Cranes equipped with an extendible or telescopic boom can be signalled to extend (lengthen) or retract (shorten). This is done by holding both fists in front of the body and pointing the thumbs outward (extend) or inward (retract).

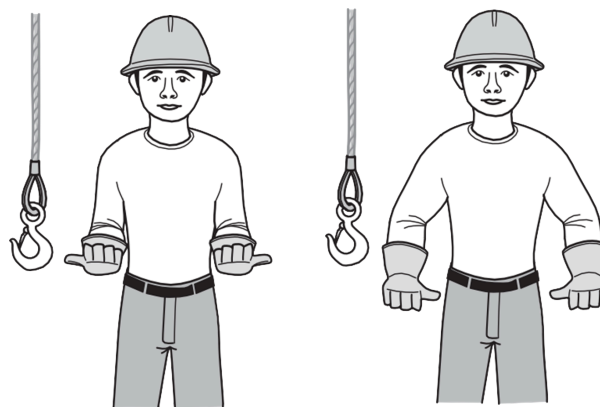


Figure 6 Extend boom and retract boom (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Note: These signals may be performed with only one hand when necessary.

To signal the crane operator to swing the boom, extend one arm and point with your index finger to indicate the direction of the swing.

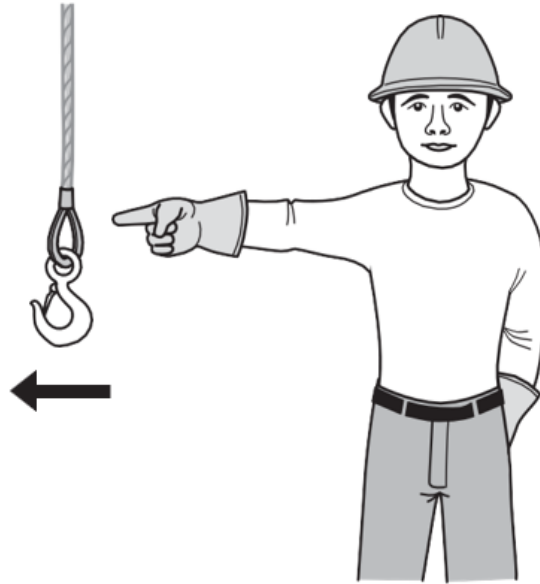


Figure 7 Swing/travel (BC Industry Training Authority, 2019).
CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Dual motions can be signaled to the crane operator when required. For example, signaling the operator to lower the boom while raising the load keeps the load at the same elevation, which is useful when avoiding an obstruction. This may be done with one or both hands. When you are using only one hand, your thumb indicates the direction of the boom, and flexing your fingers indicates the movement of the hook.

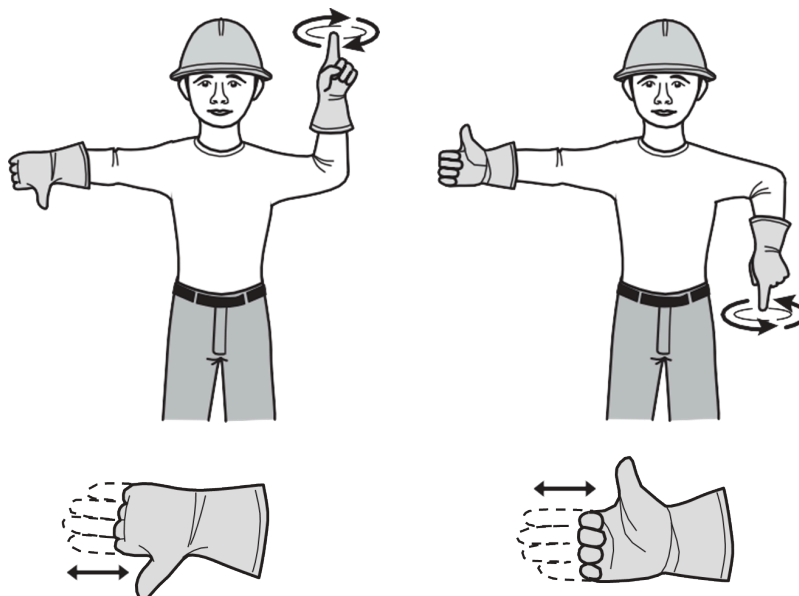


Figure 8 Left: lower the boom/raise the load; right: raise the boom/lower the load
(BC Industry Training Authority, 2019). CC BY-NC-SA 4.0
(<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Line Signals

Some cranes are equipped with a jib to extend the crane's reach for secondary loads or, occasionally, for construction personnel during installation work. From this jib, a **whip line** or **auxiliary hoist** is suspended from the jib, while the **main line** hangs from the boom.

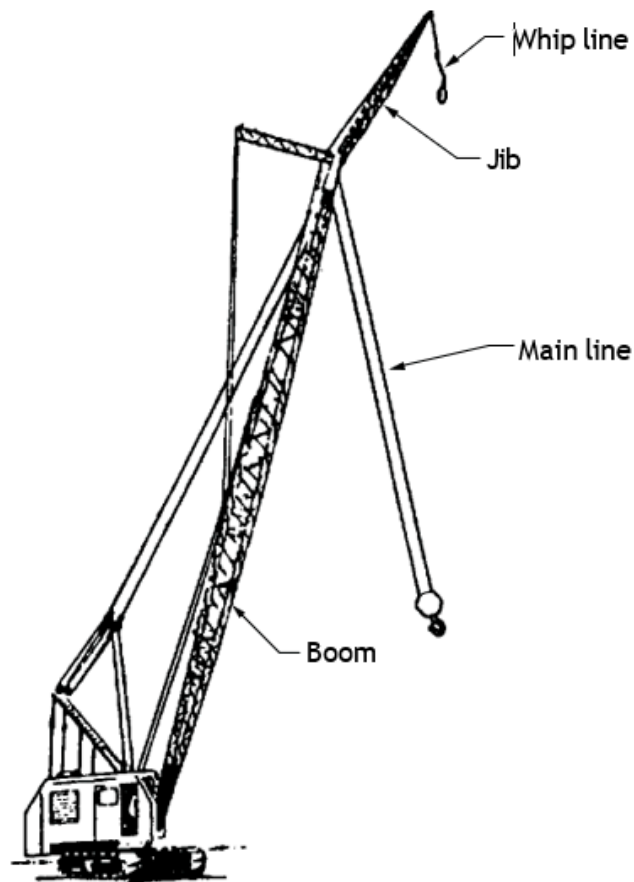


Figure 9 Crane equipped with jib (BC Industry Training Authority, 2019).
CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

The following signals indicate to the crane operator which line to use.

1. **Main line:** Tap your fist to the top of your head. Then use standard hand signals to direct further movement.
2. **Whip line:** Tap your elbow with one hand (or point to your shoulder. Confirm this variation with the crane operator before the shift. Then use standard signals to direct further motion.

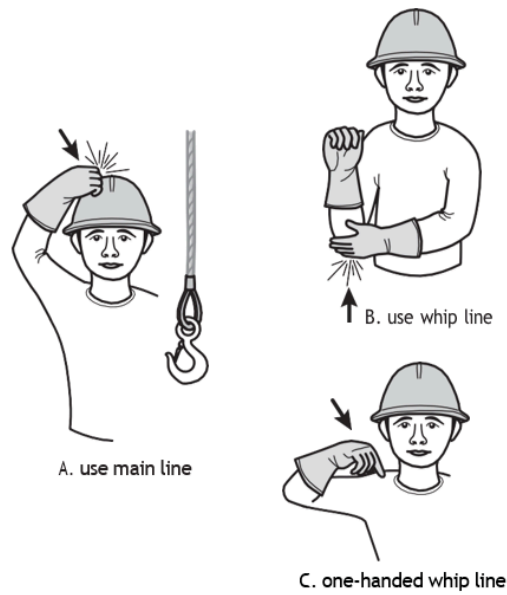


Figure 10 A: use main line B: use whip line C: (alternate) use whip line (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

“Move Slowly”

When slow movement is required, hold the palm of your free hand motionless in front of the hand giving the signal for the main line or boom (see example below).



Figure 11 Raise the load-slowly (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

“Dog Everything”

The **dog everything** signal is given by claspings both hands with thumbs and forefingers together in front of your body. At this signal, the crane operator must lock **all** crane functions until further instruction from the signal person.



Figure 12 “Dog everything” (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Vertical Hoists

Construction material hoists are used on larger construction projects where the amount of material to be moved warrants the installation of a hoist.

Material hoists must be inspected by a registered professional engineer before the first lift. Light-duty hoists and shingle hoists used for roofing do not require engineering inspection as long as they are set up according to the manufacturer’s specifications.



Workers must never ride a material hoist. Exceptions apply only in critical work environments (e.g., ironworkers or pipefitters accessing high installations) using engineered equipment under strict supervision.

Construction hoists must be inspected weekly unless the manufacturer specifies more frequent inspections.

References for Crane / Hoisting Hand Signals

Standard crane hand signals used in hoisting operations are defined in the WorkSafeBC *Occupational Health and Safety Regulation*. Similar signal systems are described in CSA and ANSI/ASME crane safety standards.

- WorkSafeBC – Occupational Health and Safety Regulation
 - Part 15—Rigging (<https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-15-rigging>)
 - Part 14—Cranes and Hoists (<https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-14-cranes-and-hoists>)
- CSA Group: B167: Overhead Cranes, Gantry Cranes, Monorails, Hoists, and Jib Cranes (<https://www.csagroup.org/store/product/2410931/>)
- OSHA: Standard Crane Hand Signals (<https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926SubpartCCAppA>)
- ANSI B30.5: Mobile and Locomotive Cranes (<https://webstore.ansi.org/standards/asme/asmeb302025-2602058>)

The video Crane Standard Hand Signals: The Complete Guide | Toolbox Talk (<https://youtu.be/1pX2a8qVjE8>) [10:18] by GotSafety (2024) provides a clear visual demonstration of commonly used signals in real-world contexts. Watching these movements in action can help reinforce the correct form and improve communication during lifting operations. Note: This video demonstrates widely used North American standard crane signals. Always follow site-specific procedures and applicable regulations, such as WorkSafeBC Occupational Health and Safety requirements, when performing lifting operations. Try practicing these signals as you watch the video.



Self-Test B-4.3: Describe Lifting and Hoisting Communication

Complete Self-Test 4.3 and check your answers.

If you are using a printed copy, please find Self-Test A-4.3 and Answer Key in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.



An interactive H5P element has been excluded from this version of the text. You can view it online here:
<https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2883#h5p-11> (<https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2883#h5p-11>)

References

- ASME. (2021). *ASME B30.2: Overhead and gantry cranes (top running bridge, single or multiple girder, top running trolley hoist)*. American Society of Mechanical Engineers.
- BC Industry Training Authority. (2019). *Piping trades apprenticeship program: Use Tools and Equipment—Level 1 harmonized* [Binder]. Crown Publications, Queen's Printer for British Columbia. https://www.crownpub.bc.ca/Product/Details/7960000261_S
- Camosun College. (2019). *Line C: Tools and Equipment—Competency C-3: Describe Rigging and Hoisting Equipment* (Rev. ed.) [Learning guide]. BCcampus. <https://collection.bccampus.ca/textbook/7c8Ymhnk/>
- Camosun College. (2015). *Trades Access Common Core Competency C-3: Describe Rigging and Hoisting Equipment*. Victoria, B.C.: Crown Publications. Download for free from the B.C. Open Textbook Collection (<https://open.bccampus.ca/browse-ourcollection/find-open-textbooks/>).
- CSA Group. (2020). *B167-20: Overhead cranes, gantry cranes, monorails, hoists, and jib cranes*. CSA Group.
- GotSafety. (2024). *Crane standard hand signals: The complete guide* [Video]. YouTube. <https://www.youtube.com/watch?v=1pX2a8qVjE8>
- Occupational Safety and Health Administration. (n.d.). *Crane hand signals*. U.S. Department of Labor. <https://www.osha.gov/cranes-derricks/hand-signals>
- WorkSafeBC. (n.d.). *Occupational health and safety regulation: Part 15—Rigging*. <https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-15-rigging>

Media Attributions

All figures are sourced from Industry Training Authority (2019) and/or Camosun College (2019) and are used under the Creative Commons Attribution 4.0 (CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/>)) licence unless otherwise noted. Images copyrighted by the BC Industry Training Authority are licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 (CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)) licence.

B-4.4 Select Slings and Tie Knots, Bends, and Hitches

Natural and Synthetic Ropes

Fibre rope may be made from either natural or synthetic fibres. Natural fibres include manila and sisal. Synthetic fibres include nylon, polypropylene, and polyester. Each of these fibres has unique properties. Fibre ropes are not the same as fibre slings, which are specifically designed and manufactured for lifting. Fibre slings are designed and commercially fabricated for lifting purposes and have their safe working load indicated on a tag sewn to the sling.

Stranding

The individual fibres in ropes, whether natural or synthetic, are relatively weak. Fibre ropes become strong only when many hundreds of these fibres are woven or twisted into *strands*.

Braided Rope

Braided ropes are generally made from synthetic materials. A braided rope has no inherent twist to it making it easy to handle. This type of rope consists of several strands of braided yarns, one inside the other.

Twisted Rope

The traditional *fibre* rope consists of three strands twisted together. The strands twist in a clockwise direction. Each strand is made up of many smaller strands called *yarns*, and each yarn is made of even smaller strands called fibres. The yarns within the strands are twisted counterclockwise, while the fibres within the yarns are twisted in a clockwise direction. By alternating the twist direction at each layer, the rope remains stable under load because the fibres stay relatively straight.

A twisted synthetic rope is preferred for *lifelines* because it stretches slightly, helping to cushion a worker's fall.

Natural Fibre Ropes



Figure 1 Three-strand twisted natural fibre rope (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Manila

Manila rope is available in six grades and is not as strong as synthetic rope. As grade and strength decrease, the colour darkens.

Table 1: Grades of Manila Rope

Grade	Description
Yacht rope	Considered the highest quality manila rope, yacht rope is pale yellow in colour. It is expensive and therefore used only on special jobs.
Bolt rope	This is a high grade, pale yellow rope. In strength, it falls between yacht rope and No. 1 grade.
No. 1 grade	No. 1 grade is light yellow and usually contains one or more coloured strands as identification. It is the lowest grade suitable for overhead lifting.
No. 2 grade	This type is slightly darker than No. 1 rope and does not have coloured identity strands. It loses strength more rapidly than No. 1 grade.
No. 3 grade	Considerably darker than either No. 1 or No. 2 grade, No. 3 loses strength very rapidly when in service.
Hardware store rope	This is the darkest and poorest grade of manila rope. Since it is constructed with a high percentage of short fibres, it has little strength, a short life, and a much rougher texture with many fibre ends sticking up from the surface.

Sisal

Sisal rope is white, coarse-textured, and rough to the touch. It is weaker than manila and should be used only when cost is more important than strength.



Natural fibre rope must **not** be used for hoisting with a powered hoist.

Synthetic Fibre Ropes



Figure 2 Twisted nylon rope with braided sheath (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Nylon

Nylon is approximately $2 \frac{1}{2}$ times stronger than manila. Nylon rope is usually pure white, soft, pliable, and smooth to the touch. It has an elastic quality and can stretch up to 40% of its length.

Nylon rope loses about 10% of its strength when wet but regains its original strength when dried. Nylon does not rot, is unaffected by mildew, and can withstand temperatures up to 150 °C (300 °F) without being damaged. It is adversely affected by acids and alkalis and can be damaged by them.

The highly elastic nature of nylon rope makes it capable of withstanding repeated *shock loads*. However, this same elasticity can be problematic if you are trying to lift loads in areas with restricted headroom.

Polyester

Polyester rope looks similar to nylon but is less elastic. It stretches only about 5% before breaking.

Polyester rope is 87% as strong as nylon. It is not as elastic as nylon and is capable of sustaining only 60% of nylon's shock load.

Polyester does not lose any strength when wet and, unlike nylon, is unaffected by acids or alkalis. For your own protection, however, you should wash polyester ropes and slings with cold water whenever they have been exposed to any chemicals.

Polypropylene

Polypropylene rope is available in a wide range of colours, but yellow is the most common. It is smooth, somewhat slippery, lightweight, and floats on water.

Polypropylene gradually softens as temperatures increase and loses up to 40% of its strength at boiling water temperature (100 °C or 212 °F). Higher temperatures will eventually cause polypropylene to melt. This rope also deteriorates rapidly when exposed to sunlight.

Polypropylene rope is about 60% as strong as nylon and is capable of absorbing only 40% of the shock load of nylon. Of all the rope types mentioned, polypropylene has the best electrical insulating properties against electrical shock, but it should be noted that only dry ropes should be used near sources of high voltage.

Working Load Limit (WLL)

The *working load limit* (WLL) is the maximum load that a rigging component may carry while meeting the safety factors set forth by workplace regulations.

Most regulations set minimum safety factors for rigging materials. The WLL is typically determined by dividing the *breaking strength* of the rigging component by the safety factor.

The minimum safety factor for rigging used to support workers is 10. For lifting materials, the safety factor varies depending upon the rigging component. For example, lifting materials with a sling made of nylon fibre rope requires a safety factor of 9, while for an alloy chain the factor is only 4.

Breaking Strength

Breaking strength is the minimum force required to break a rope, measured in Newtons (N) or pounds.

The strength of different ropes depends on the fibre being used, the diameter of the rope, and the type of stranding, that is used. For equal diameter and stranding, the strongest of the commonly used fibre rope is nylon. Polyester and polypropylene are weaker than nylon, but other conditions may make them a better choice.

For the exact breaking strength of a specific rope it is best to consult the manufacturer of the rope.

Use of Ropes

Fibre ropes are very useful in construction. They are easy to handle and, because they come in very long lengths, they can readily be adapted to many custom situations.

It is very important to use the correct knot, bend, or hitch when connecting ropes together or to material to be lifted. If the incorrect knot is tied, it may slip, causing the load to fall or jam, and may permanently damage the rope.

New fibre bulk ropes come packaged in a plastic wrapper. To remove new rope from its shipping coil, place the coil on its side, reach down inside and pull the rope up from inside the coil. Leave the outer wrapping intact.



Remember: Tying a knot reduces rope strength by approximately 50%.

Safe Use Guidelines

Ropes should not be overloaded. Ropes that have been subjected to loads beyond their working load limit should be taken out of service. For lifting materials, the maximum load should never exceed $\frac{1}{9}$ the of the rope's breaking strength.

Avoid exposing rope to direct sunlight for long periods of time. Excessive exposure causes fibres to break down due to ultraviolet rays.

Do not use frozen rope. If you must handle rope that is frozen, do so very carefully, as bending may break the strands. To prevent rope from freezing, dry it well before exposing it to cold weather.

Avoid making sharp bends in rope. Sharp bends, including those made by knots, will reduce the rope's strength by 50%. Always pad the sharp corners of a load before applying the rope.

When attaching a small-diameter object such as a hook or ring to a rope, use a **thimble** to protect the eye of the rope.



Figure 3 A thimble (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Care and Maintenance of Rope

The life of any type of fibre rope can be greatly extended if you follow the basic care and maintenance procedures listed below.

Whipping

Whipping is a wrapping applied at the end of a rope to prevent the rope strands from unravelling. Whenever a rope is cut to a new length, the ends of the rope should have whipping applied before the rope is put into service.

Whipping is more than just a tidy decoration. It prevents the strands of the rope from slipping in relation to each other. Such slipping would cause one strand to carry more or less than its fair share of the load.

To apply whipping to a rope, use a strong, non-slipping twine. If the twine tends to slip, pulling it over soft tar, beeswax or pine pitch will usually correct the problem.

Tape may be used as whipping if applied tightly. Whipping should be replaced when it shows signs of fraying or loosening.

How to Apply Whipping

1. Begin by holding one end of the twine (A) at the end of the rope. Then form a long loop along the rope.

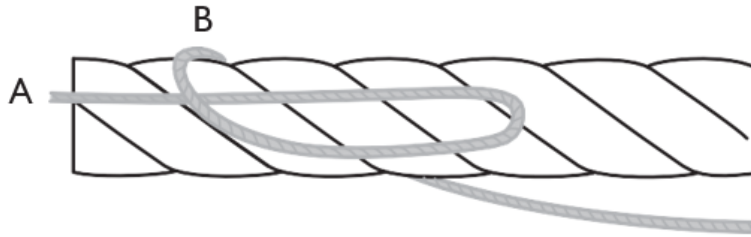


Figure 4 Loop the twine (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

2. Hold the end of the twine (A) and the left end of the loop with your left hand and begin wrapping the other end of the twine (B) around the rope over the long loop.
3. Continue to apply wraps as close to each other and as tight as possible until you have covered a distance approximately $1 \frac{1}{2}$ times the rope diameter.
4. Take the twine end (B) and pass it through the loop as shown here.

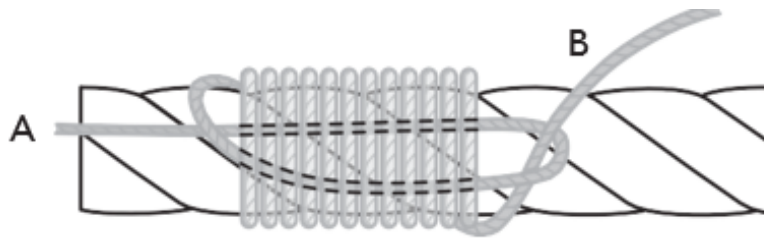


Figure 5 Pass the end through (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

5. Pull on the twine end (A) until you feel that the two ends of the twine are approximately midway under the whipping.

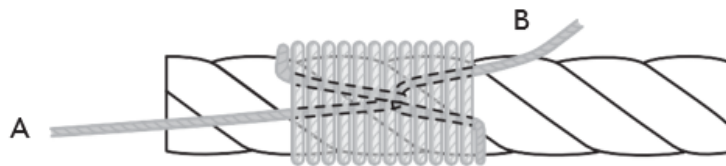


Figure 6 Pull the end to the centre (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

6. Trim the end of the twine as close as possible to the whipping; then trim the end of the rope so that a portion approximately half the rope's diameter projects beyond the whipping.

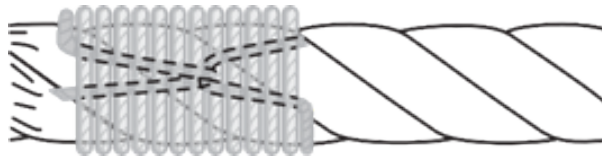


Figure 7 Trim the ends (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Instead of using whipping on nylon, polyester or polypropylene ropes, you can melt the fibres together with a hot iron or flame. Roll the end of the melted rope between two flat surfaces (scraps of wood) while the rope cools; otherwise, the end may become larger than the rope's diameter. When the ends of the rope are larger than the rope diameter, they become difficult to untie.



When you are using the hot iron or flame to melt the rope fibres, be careful to avoid burning yourself.

Storage

Rope should be kept clean. Soil embedded in the fibres acts as an abrasive, wearing the rope down. Soiled rope should be washed in cool water, loosely coiled, and hung in a well-ventilated area to dry before storage. Apart from this cleaning, rope requires very little maintenance.

Be sure to coil rope when you are preparing it for storage. The coiled rope should then be hung on large diameter pegs in a cool, dry room with good air circulation to prevent mildew. Improper storage of fibre rope leads to rot, brittleness, crushed fibres, kinks, and many other defects. Any kinks or small loops should be carefully removed before the rope is put under tension and pulled taut.

With basic care and proper storage, natural fibre rope will provide many years of service. If left lying on the ground in a damp environment, the rope will become useless in a very short time.

A thorough, visual inspection should be done before performing every lifting task. When inspecting fibre ropes, look for:

- Broken strands
- Wear and abrasion
- Heat damage or melting
- Contamination with petroleum products, which can damage the rope
- Evidence of rot or damage from exposure to the elements
- Crushing, twisting, or kinking
- Loose, broken, or damaged thimbles

Note: Any damage will affect the lifting capacity of the rope.

Tying Knots and Hitches

To use rope effectively, you must be able to select the correct knot, bend, or hitch for the task and tie it properly. Any knot, bend, or hitch must support the load imposed on it, be quick and easy to tie, and be easy to untie once the load has been removed.

Rope Work Terms

To better understand the following instructions on knot tying, you will need to identify the parts of a rope.

Figure 6 shows an overhand loop. A loop is the starting point for most knots. The portion of the rope that forms the loop is termed the “**bight**.” The long portion of the rope is termed the “**standing part**.” The end of the rope is called just that, the “**end**.”

An overhand loop is formed by passing the end of the rope over or in front of the standing part of the rope. (Figure 10).



Figure 8 Overhand loop (Camosun College/BCcampus) CC BY-NC-SA 4.0
(<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

An underhand loop is formed by passing the end of the rope under or behind the standing part (Figure 11).

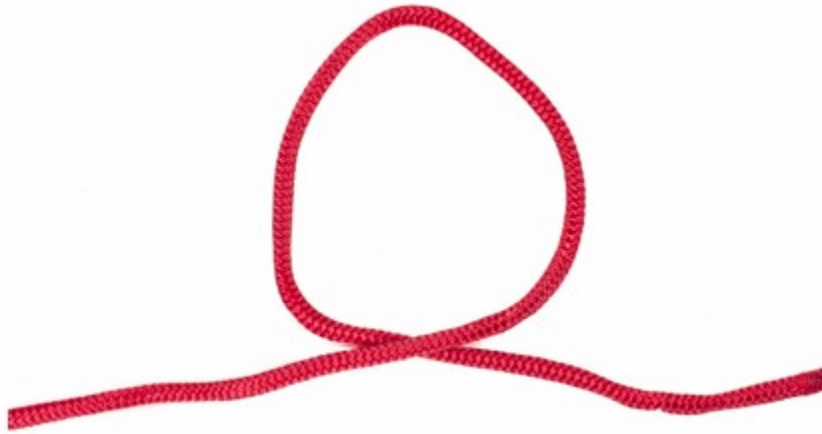


Figure 9 Underhand loop (Camosun College/BCcampus) CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

General Rules for Tying Knots, Bends, and Hitches

Bowline Knot

The **bowline knot** forms a non-slip loop at the end of a rope. It is strong, secure, and easy to untie—even after being loaded.

The bowline is used when a **slip-proof loop** is needed, such as when attaching a rope around a fixed object.

How to Tie a Bowline



Step 1: Form a small loop by passing the end of the rope over the standing part. (Camosun College/BCcampus) CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Step 2: Pass the end under the bight and pull it up through the loop. (Camosun College/BCcampus) CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Step 3: Pass the end behind the standing part. (Camosun College/BCcampus) CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Step 4: Insert the end back down through the loop (Camosun College/BCcampus) CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Step 5 Tighten the knot by holding the end of the rope and the loop in one hand and the standing part in the other hand. Then pull until the knot is tight. **Figure 10 (Steps 1-5)** Tying a bowline knot (Camosun College/BCcampus). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

To untie the bowline, loosen the knot by pushing the loop that surrounds the standing part away from the knot. Once the knot is loosened, it is easily untied.

Bowline on a Bight

The **bowline on a bight** is a knot that creates two fixed-size loops in the middle (or bight) of a rope. Its advantages are that its loops do not slip and it is also reasonably easy to untie after being exposed to a strain. This knot can be used to provide a toe hold in the middle of a rope or to make an emergency **Bosun's chair** (a device used to suspend a person from a rope to perform high work).

How to Tie a Bowline on a Bight

Start by creating a bend in the middle of the rope to double it (the doubled end now acts as the rope's "end"). Form an overhand loop.



Step 2: Pass the bent end through the backside of the loop, forming a second, larger loop.



Step 3: Spread open the bent end and pull over the larger loop.



Step 4: Continue to bring the bent end around until it encircles the doubled standing part.



Step 5: Tighten by pulling the double standing part and the bent end in opposing directions.

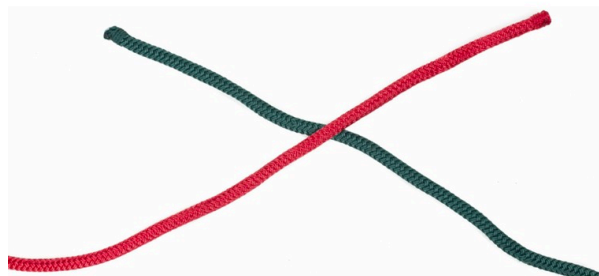


Step 6: Finished bowline on a bight
Figure 11 (Steps 1-6) Tying a bowline on a bight (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Reef or Square Knot

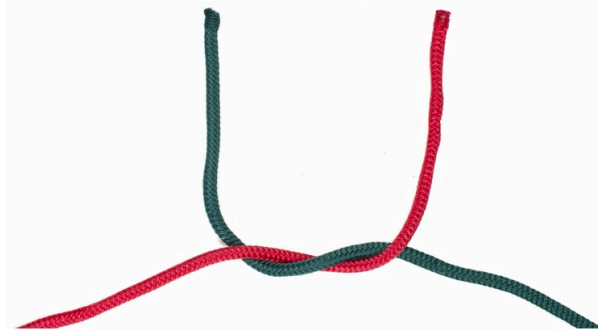
The **reef knot** or *square knot* is used to fasten together two ropes of equal diameter.

How to Tie a Reef Knot



Step 1

Cross the ends of the ropes and turn one rope around the other.



Step 2

Cross the ends again and turn one end around the other end, making sure the second turn is done in the opposite direction to the first.



Step 3

Tighten the knot.



Step 4

Figure 12 (Steps 1-4) Tying a reef or square knot (Camosun College/BCcampus). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

You can remind yourself how the reef knot is tied by using the following verse:

Left over right and under

— then —

right over left and under

The finished reef knot should have both the standing part and the end of each rope on the same side of the bight formed by the other rope.

Sheet Bend

The **sheet bend** is used to attach two ropes of unequal diameter together.

How to Tie a Sheet Bend

1. To tie the sheet bend as shown, form a bight in the larger diameter rope.
2. Pass the end of the smaller diameter rope up under and through the bight; wrap it around the back of the bight's end and standing part of the larger rope.
3. Pass the end under the section of the smaller rope where it first came through the bight and continue with the small end until it lies across the top or face of the bight formed by the larger rope.
4. Hold both the standing part and the end of each rope in each hand and pull in opposite directions to tighten.



Step 1

To tie the sheet bend as shown, form a bight in the larger diameter rope.



Step 2

Pass the end of the smaller diameter rope up under and through the bight; wrap it around the back of the bight's end and standing part of the larger rope.



Step 3

Pass the end under the section of the smaller rope where it first came through the bight and continue with the small end until it lies across the top or face of the bight formed by the larger rope.



Step 4

Hold both the standing part and the end of each rope in each hand and pull in opposite directions to tighten.

Figure 13 (Steps 1-4) Tying a sheet bend (Camosun College/BCcampus). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

For additional holding strength, pass the running end around and under the bight an second time to create a double sheet bend.



Figure 14 Double sheet bend (Camosun College/BCcampus). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

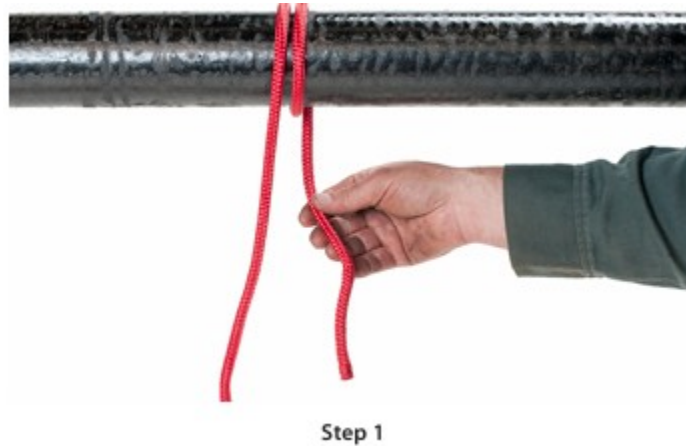
Round Turn with Two Half-Hitches

The *round turn and two half-hitches* is a hitch used to secure the end of a rope to a fixed object. The name refers to the components used to form the knot: A round turn wraps the rope around the object (completely encircling it), and the two half-hitches secure the end around the standing part.

How to Tie It

1. To make this round turn with two half-hitches, you must as mentioned wrap the rope completely around the object (a full round turn).
2. Pass the end of the rope around the standing part and pull the end between the object and the rope to form the

first half hitch.



3. Make a second loop around the standing part of the rope in the same direction as the first loop. (If one loop is clockwise and the other is counter-clockwise, the hitch will be difficult to untie.)
4. Finish by passing the end of the rope between the standing part and the two loops. As the standing part is pulled tight, the loop around the object will slip until the two half-hitches have jammed tightly to the object. They will not come untied if the pull on the standing part is relaxed.



Step 3



Step 4

Figure 15 (Steps 1-4) Round turn and two half hitches (Camosun College/BCcampus). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Rolling Hitch

The **rolling hitch** is a knot used to attach a rope to a rod, pole, or other rope. A simple friction hitch, it is used for lengthwise pull along an object rather than at right angles. The rolling hitch is designed to resist lengthwise movement for only a single direction of pull.



Step 1



Step 2



Step 3



Step 4



Step 5

Figure 16 (Steps 1-5) Tying a rolling hitch (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Clove Hitch

The **clove hitch** is used to secure a rope to a fixed object, such as a post.

How to Tie a Clove Hitch

1. Wrap the rope around the object once, with the wrap passing to one side of the standing part.
2. Make a second wrap around the object, this time passing to the opposite side of the standing part.
3. Pass the end of the rope between the object and the second wrap.
4. Pull the two wraps together and tighten by pulling the standing part and the end in opposite directions.

Note: The clove hitch can be made even more secure by tying the end to the standing part with a single half-hitch.



Step 1



Step 2



Step 3



Step 4

Figure 17 (Steps 1-4) A clove hitch tied in position (Camosun College/
Bccampus). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Figure 18 Clove hitch pre-tied to slip over end of pipe (Camosun College/BCcampus). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Timber Hitch

The **timber hitch** is used to secure a rope to a plank, timber, post, or pipe when the object must be lifted in an upright position. The timber hitch is a series of modified half-hitches.

How to Tie a Timber Hitch

1. Wrap the rope around the object with an overhand loop and tie a single half-hitch around the object. (Steps 1 and 2)
2. Pass the free end of the rope between the object and rope two more times.
3. Pull the hitch tight by pulling the standing part of the rope at 90° to the object.
4. Using the standing part of the rope tie one or more half-hitches along the length of the pipe or object to make the pipe secure and allow it to be hoisted vertically.



Step 1

Wrap the rope around the object with a overhand loop.



Step 2

Tie a single half-hitch around the object.



Step 3

Pull the hitch tight by pulling the standing part of the rope at 90° to the object.



Step 4

Using the standing part of the rope tie one or more half-hitches along the length of the pipe or object.



Tie two half hitches to make the pipe secure and allow it to be hoisted vertically.
Figure 19 (Steps 1-5) Tying a timber hitch (Camosun College/BCcampus). CC BY-NC-SA 4.0
 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Trucker's Knot (or Trucker's Hitch)

The **trucker's knot** is a very useful knot for tying loads down. The knot forms a slip-resistant loop that acts like a pulley in a system. You can generate almost three times as much tension on a rope using the trucker's knot as you would if you just pulled on a straight rope.

You may find this video Truckers Hitch (https://media.bccampus.ca/media/Truckers%20Hitch/0_x4iyzc34) by Camosun College (2022) helpful.

How to Tie a Trucker's Knot

1. Form a small loop in the rope and twist the loop formed by the bend three times.
2. Take a bend in the standing (dead) end and pass this new doubled bend through the loop formed by the three twists to form a second loop. This second loop becomes your "pulley" used to apply tension to the rope tying down your load.
3. Pass the dead end of the rope through a tie-down point or hook on the truck, then through the second loop formed by the trucker's knot.

4. Pull to apply tension, then secure with a double half-hitch.



Step 1



Step 2



Step 3



Step 4

Figure 20 (Steps 1-4) Tying a trucker's knot (Camosun College/BCcampus).
CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure Eight Knot

The simple *figure eight knot* is used to form a stopper on the end of a rope. This “stopper” is used to prevent the rope from running through a sheave or pulley or to stop the rope from slipping through another knot.

How to Tie a Figure Eight Stopper

1. Form a loop.
2. Pass the end around the standing part.
3. Bring the end back through the loop.
4. Tighten.



Step 1



Step 2



Step 3



Step 4

Figure 21 (Steps 1-4) Tying a figure eight knot or “stopper”
(Camosun College/BCcampus). CC BY-NC-SA 4.0
(<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Figure Eight Loop

A figure eight knot can also be tied into a non-slip loop. This loop could be used to secure the end of a lifeline around a solid object.

Tying a Figure Eight Loop

1. Tie a regular figure eight but leave a long tail.
2. Wrap the tail around the object.
3. Take the end of the tail and retrace the path of the rope back through the figure eight.
4. Pull the knot snug.



Step 1



Step 2



Step 3

Figure 21 (Steps 1-4) Tying a non-slip loop (Camosun College/BCcampus). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Do not join ropes for overhead lifting! Use only single-piece ropes.

Video Resources

The following videos by Camosun College (2022) demonstrate important rope knots used in rigging operations.

- Knots and Hitches (https://media.bccampus.ca/media/Knots%20and%20Hitches/0_1zyju8c0) [10:03]– Demonstrates several common knots used to secure loads and rigging equipment.
- Trucker's Hitch (https://media.bccampus.ca/media/Truckers%20Hitch/0_x4iyzc34) [3:00]– Shows how to tie a trucker's hitch to create mechanical advantage when tightening rope.
- How to Whip the End of a Rope (https://media.bccampus.ca/media/How%20to%20Whip%20the%20End%20of%20a%20Rope/0_rhafq2j5) [2:57] – Demonstrates how to apply whipping to prevent the end of a rope from fraying and to extend the rope's service life.



Self-Test B-4.4: Select Slings and Tie Knots, Bends and Hitches

Complete Self-Test 4.4 and check your answers.

If you are using a printed copy, please find Self-Test A-4.4 and Answer Key in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.



An interactive H5P element has been excluded from this version of the text. You can view it online here: <https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2887#h5p-12> (<https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2887#h5p-12>)

References

- BC Industry Training Authority. (2019). *Piping trades apprenticeship program: Use Tools and Equipment—Level 1 harmonized* [Binder]. Crown Publications, Queen's Printer for British Columbia. https://www.crownpub.bc.ca/Product/Details/7960000261_S
- Camosun College. (2019). *Line C: Tools and Equipment—C-4: Describe Ladders and Work Platforms* (Rev. ed.) [Learning guide]. BCcampus. <https://collection.bccampus.ca/textbook/7c8Ymhnk/>
- Camosun College. (2015). *Trades Access Common Core Competency C-4: Describe Ladders and Work Platforms*. Victoria, B.C.: Crown Publications. Download for free from the B.C. Open Textbook Collection (<https://open.bccampus.ca/browse-ourcollection/find-open-textbooks/>).
- Camosun College. (2022a). *Knots and hitches* [Video]. BCcampus Media. https://media.bccampus.ca/media/Knots%20and%20Hitches/0_1zyju8c0

Camosun College. (2022b). Trucker's hitch [Video]. BCcampus Media. https://media.bccampus.ca/media/Truckers%20Hitch/0_x4iyzc34

Camosun College. (2022c). How to whip the end of a rope [Video]. BCcampus Media. https://media.bccampus.ca/media/How%20to%20Whip%20the%20End%20of%20a%20Rope/0_rhafq2j5

Media Attributions

All figures are sourced from Industry Training Authority (2019) and/or Camosun College (2019) and are used under the Creative Commons Attribution 4.0 (CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/>)) licence unless otherwise noted. Images copyrighted by the BC Industry Training Authority are licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 (CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)) licence.

B-4.5 Use Hoisting, Lifting and Rigging Equipment

High-Voltage Line Clearance

Use extreme caution when working with a crane near high-voltage power lines. Although you may not be the operator of the crane, you may be rigging or handling the load that the crane lifts.

Keep your distance from power lines! Surrounding every live power line is an area referred to as the “**absolute limit of approach**.” **DO NOT**, under any circumstance, move any crane boom, load line, or load into this area unless the power line has been *de-energized*. There are no exceptions.

This *limit of approach* varies according to local, provincial, and federal laws and the crane manufacturer's recommendations, but the generally accepted clearances are shown in Figure 1.

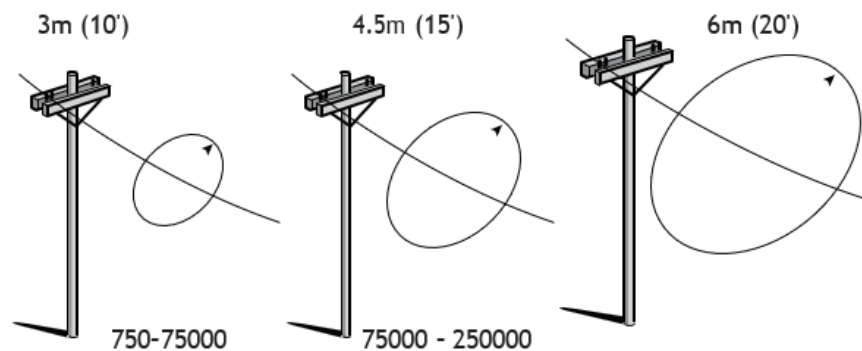


Figure 1 Limits of approach to power lines, according to voltage (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Safety Precautions

- Whenever your work involves moving heavy loads, wear steel-toed safety boots.
- If there is any risk of your hands suffering cuts or abrasions, wear gloves.
- Be alert! Try to anticipate load movements.
- Plan ahead: have an escape route planned in the event something goes wrong.

Care of Slings and Wire Rope

Wire rope and fibre slings should be stored in a dry location off the ground. The strength of a nylon sling is reduced when it becomes wet.

Lubricate wire rope regularly with a light oil to prevent corrosion. You can brush the oil on or pass the wire rope through an oil bath. In either case, it is important to ensure complete penetration of the oil into the inner wires.

Wire Rope Safety

When working with wire rope slings, always wear gloves and eye protection. The following safety precautions should be followed when handling wire rope:

1. Use the correct rope for the job.
2. Inspect the wire rope regularly.
3. Never overload the rope.
4. Minimize shock loads by lifting or hoisting and stopping loads slowly.
5. Avoid sudden loading in cold weather.
6. Take special precautions and/or use a larger rope when:
 - The exact load is unknown
 - There is a possibility of shock loading
 - The conditions are abnormal or severe, or
 - There is a hazard to personnel
7. Protect rope from sharp corners or edges with padding (use **softeners**).
8. Avoid dragging the rope from under loads or over obstacles.
9. Avoid dropping wire rope slings from heights.
10. Avoid rolling loads over the slings.
11. Store all unused ropes in a clean, dry place.
12. Prevent loops in slack lines from being pulled tight and forming **kinks**. Once a kink has formed in a wire rope, the damage is permanent. A weak spot will always remain even if the kink appears to have been straightened.
13. Never use wire rope that has been cut, badly kinked, or crushed. Obtain approval to destroy and discard any slings or hoisting equipment found to be unsafe.
14. Use metal **thimbles** in eye fittings at all times.

Damage to Wire Rope and Wire Rope Inspection

Individual wire breakage may be found in almost any rope. In most cases, broken wires do not require rope removal if they are at well-spaced intervals. Note the area and watch carefully for any further wire breaks. Clean up broken wires by bending the wire back and forth until the wire breaks off. This allows the broken end to remain inside the rope where it will do less harm. Cutting broken wires with pliers may leave jagged ends that can damage other wires.

A wire rope used for lifting must be permanently removed from service if there are six or more randomly distributed broken wires in one **rope lay**, or three or more broken wires in one strand in one rope lay.

A rope must also be permanently removed from service if there is more than one broken wire near an attached fitting. Breaks that occur near attached fittings are usually the result of fatigue stresses concentrated in these localized sections. Wire breaks of this type should be cause for replacement of the rope or renewal of the attachment to eliminate the locally fatigued area.

Once broken wires appear in a rope operating under normal conditions, many more will show up within a relatively short period. Attempting to use a rope beyond the allowable number of broken wires will create a hazard.

Worn and Abraded Wires

Each individual wire in a rope, when new, is a complete circle in cross-section. Wear due to friction on sheaves, rollers, drums, etc., eventually causes the outer wires to become flat on the outside, reducing the circle to a segment that gradually becomes smaller as the “flat” increases. These worn areas become void of lubrication and are characterized by their bright appearance. This is part of normal service deterioration and, in most installations where operating conditions are not particularly severe, relatively even abrasion will occur on the outer wires.

Peening

When wire rope strikes against a structural part of the machine or beats against a roller or itself, the wires and strands are flattened and distorted and become brittle. This continuous pounding is called “**peening**.” Often, this can be avoided by placing protectors between the rope and the object it is striking.

Another common cause of peening is continuous working, under high loads, over a sheave or drum. Where peening action cannot be controlled, it is necessary to have more frequent inspections and to prepare for earlier rope replacement.

Scrubbing

Scrubbing refers to the displacement of wires and strands as a result of wire rope rubbing against itself or another object. This, in turn, causes wear and displacement of wires and strands along one side of the rope.

Fatigue Fractures

Wires that break with square ends and show little surface wear have usually failed as a result of fatigue. In almost all cases, these failures are related to bending stresses or vibration. **Fatigue fractures** in wire ropes are most often found near a fitting.

Corrosion

Corrosion, while difficult to evaluate, is a more serious cause of wear than abrasion. Usually it signifies a lack of lubrication. Corrosion will often occur internally before there is any visible external evidence on the rope surface. *Pitting* of wires is cause for immediate rope removal.

Usually a slight discolouration because of rusting merely indicates a need for lubrication. Severe rusting, on the other

hand, leads to premature fatigue failures in the wires, necessitating the rope's immediate removal from service. To retard corrosive deterioration, the rope should be kept well lubricated. In situations where extreme corrosive action can occur, it may be necessary to use *galvanized* wire rope.

Strands

Replace the rope if the strands are crushed, flattened, or jammed. These conditions usually occur when there are multiple layers on drums. Independent steel wire-cored ropes should be used to prevent crushing. Crushing can also occur if the hoist rope becomes slack and cross-coiled on the drum or trapped in the machinery. No further operations should be carried out until the rope has been paid out, examined for possible damage and correctly re-spoiled.

If the rope displays **high stranding or unlaying (unwinding)**, replace the rope or renew the end connection to reset the rope lay. In cases such as this, excessive wear and crushing take place and the other strands become overloaded.

Bird Caging, Kinks and Bulging

“Bird caging” is damage that can result from either a sudden stop, winding on too small a drum, or where the rope is being pulled through tight sheaves. This is cause for rope replacement unless the affected section can be removed.



Figure 2 “Bird caging” (BC Industry Training Authority, 2019).
CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Kinks are usually caused by faulty handling or **reeving** (where the rope is passed through a hole and stressed). The strands become **dog-legged** and, where running on sheaves, are subject to excessive wear at the kink. Replace the rope or the affected section of the rope.

Bulging is indicative of core slippage or “turns” being put into or taken out of the rope. Replace the rope, particularly if it is of rotation-resistant construction.

If the rope has gaps, excessive clearance between strands, or core protrusion, replace the rope.

Heat Damage

After a fire or exposure to elevated temperatures, there may be metal discoloration, an apparent loss of internal lubrication or damage to fibre cores. Under these circumstances, the rope should be replaced.

Electric Arcs

Rope that has either been in contact with a live power line or been used as “ground” in an electric welding circuit will have wires that are fused, discoloured, and/or **annealed**, and must be removed from service.

Hook Safety

Hooks, like all rigging hardware, must be inspected frequently. You must be alert for signs of wear, particularly in the saddle and the throat opening. Measure the throat’s opening to make sure it is not widening (a sign that the hook has been overloaded and weakened). Check for cracks, corrosion, and distortion. If you discover evidence of wear, immediately discard the hook. Destroy the hook before throwing it away to prevent someone else from attempting to use it.

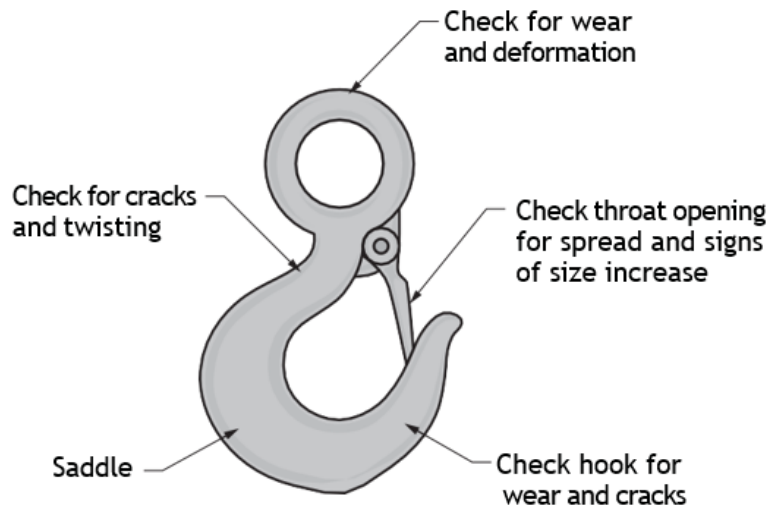


Figure 3 Parts of a hook to check (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Safety of Other Hardware

The *Workers’ Compensation OHS Regulation* requires that every piece of rigging hardware must be tagged with the working load limit (WLL).

Rings, Links and Swivels: Inspect rings, links and swivels regularly for wear, cracks and abrasion.

Eye Bolts and Ring Bolts: Inspect eye bolts and ring bolts regularly for wear, cracks and abrasion. The angle that the sling forms with the eye bolt affects the WLL of the eye bolt considerably. Always try to keep the pull of the sling as close to in-line with the shank of the eye bolt as possible. Use a spreader bar, if necessary, to reduce the angle at the eye bolt.

Turnbuckles: Inspect **turnbuckles** regularly for wear, cracks, abrasion and deformation.

Shackles: Inspect shackles regularly for wear, cracks and abrasion.

Synthetic Web Slings: Inspect web slings for worn eyes and worn fittings, cuts, holes, punches, tears, frayed material, broken stitching and burns caused by acid, caustics or heat. If a damaged sling is found, remove the sling from service immediately. Do not attempt to repair a damaged sling yourself.

Safe Rigging Practices

Whenever you are handling materials, remember that you are responsible for your own safety and for the safety of others. The best form of personal protection is to stay alert. Before you lift a load, check the rigging components to make sure that they meet the lifting requirements and that the rigging has been safely attached to the load. You must assure that your personal safety and the safety of other workers has not been compromised.

Each circumstance will require that different precautions be taken and the following information should be considered as the minimum safety requirements in any situation.

Personal Protection

Wear safety headgear at all times, but specifically if there is any risk of falling objects or injury to your head.

If the materials you are handling could injure your hands, wear gloves for protection. Gloves should have short cuffs. Gauntlet-type gloves are not safe because the cuffs tend to catch on projections and also serve to funnel dirt and small objects into the glove. If you are handling corrosive or irritating chemicals, wear rubber gloves to prevent skin contact.

When working with materials that are rough and abrasive, wear a protective apron to protect your clothing from becoming worn or ripped.

Your feet should be protected by CSA-approved safety footwear. Always wear safety glasses or safety goggles.

Clothing

The clothing you wear should protect you from dirt, scrapes and abrasions. Your clothing should be loose enough to allow free movement, yet not so loose that it poses a danger of being caught on or in any materials or equipment. All jewellery should be removed, and long or loose hair should be tied back and tucked under a hat or hair net.

Housekeeping

Job-site housekeeping habits can make material handling safe or dangerous. Keep all traffic areas clear to prevent tripping. Spills should be cleaned up immediately to prevent slipping and falling.

Safe Handling of Loads Supported By Cranes

When using slings to attach a load to a crane, ensure that the slings are secure and the load is balanced. Often, when the crane begins to lift the load, the load shifts to one side or the other. If the load shifts, make sure you will not be trapped. Be especially careful to avoid getting your fingers caught between the load and the slings.

If you must apply a sideways force to a suspended load, always push the load away from you. Loads that cannot be adequately controlled must have tag lines attached.

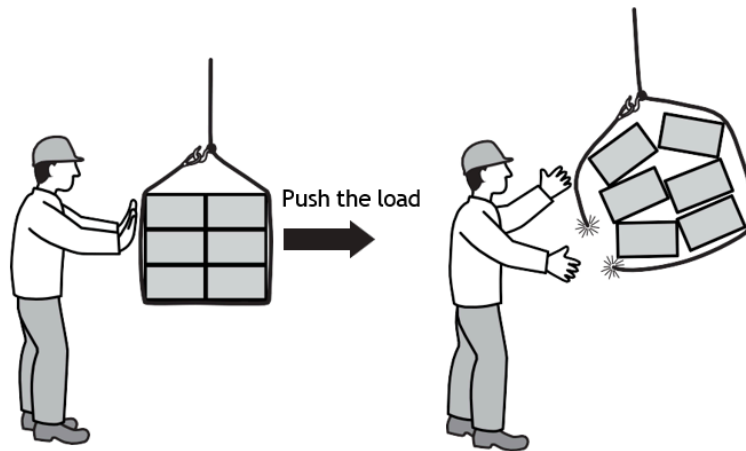


Figure 4 Push a load (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pulling a suspended load could result in back strain or, much worse, entrapment (as shown in Figure 5) should the load come loose.

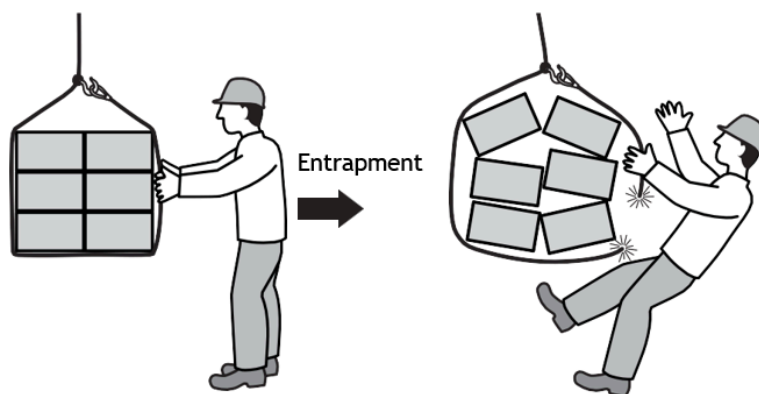


Figure 5 Never pull a load (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Be familiar with the standard signals used in hoisting operations so that even if you are not directly involved, you can anticipate the movement of the load.



Never work under a suspended load. Have a plan of action, including an escape route to safety, in case a suspended load falls.

Tag Lines

Always use tag lines to control the load. Tag lines permit you to control the load from a safe distance. Should the load shift or drop, you will be out of danger.

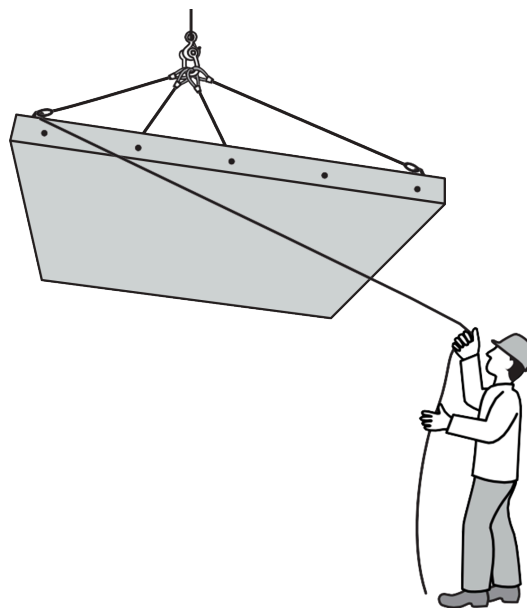


Figure 6 Use tag lines (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



When working with large cranes moving objects near power lines, use a power-line spotter to avoid moving the crane or the load within the safety zone. Electric shock can kill!

Rope for Tag Lines

Every effort should be made to keep away from energized power lines. But if accidental contact is made, the tag line must not conduct the current to the worker guiding the load. Wire rope should not be used, and because nylon lines absorb water, they should not be used.

The preferred rope for a tag line is polypropylene rope. Polypropylene does not conduct electricity and is inexpensive.

Length of Rope

The length of the tag line should be long enough to allow a worker to control the load while it is near the ground or any other structure.

Two Tag Lines

Use two tag lines when the load needs to be maneuvered between or around objects or structures. Use a spreader bar when lifting long pipes with a crane. Use two tag lines, one at each end, to guide longer pipes into place.

Location of Attachment for Tag Lines

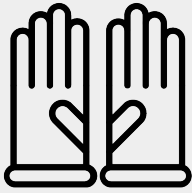
Locate tag lines near the end of a long load. Tie the tag line to the load using a bowline. The tag line should be attached to the load so that it will not become trapped when the load is landed.

Safety When Using a Tag Line

The tag line is used to allow the worker to guide the load and still stay out from under it.



Do not stand under the load at any time.



Wear gloves to protect your hands.

Do not double wrap the tag line around your hand or body to avoid entanglement. Keep the tag line clear of your feet.

Note: If there is a sudden movement of the load, do not attempt to hold the load with the tag line.

Do not use the tag line to move the load into position. The tag line is used only for guiding the load. If the crane cannot reach the landing position with the load, the crane will have to move.

Unsafe Rigging Practices

1. Never wrap or choke the load with the hoisting line.
2. Avoid impact loading caused by sudden jerking when lifting or lowering. Lift the load gradually until the slack is eliminated.
3. Never ride the load that is being lifted.
4. Never allow the load to be carried over the heads of any personnel.
5. Never work under a suspended load.
6. Never leave the load suspended in the air when the hoist or crane is unattended.
7. Never make temporary repairs to a sling.
8. Never lift loads with one leg of a multi-leg sling until the unused legs are made secure.
9. Never lift a load with the point of a hook.

Use of Faulty Equipment

Examine all hardware, equipment, tackle, and slings before using it. DESTROY defective components so that discarded equipment may not be used by someone who is not aware of the hazards or defects.

Rigging Structural Shapes

Structural shapes are manufactured with several different configurations and require careful attention when rigging for lifting, turning, stacking, and blocking.

Loose bundles of round stock should be double wrapped with slings prior to lifting to secure those pieces on top of the load. When setting the load down, set it on blocking that has side-restraining chocks (Figure 7) to prevent the pieces from spreading.

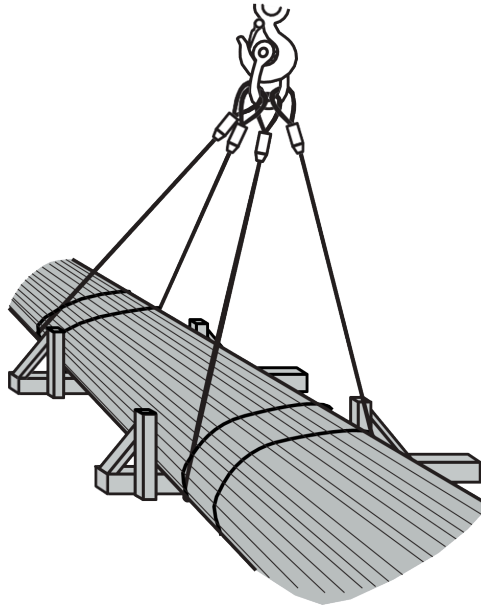


Figure 7 Blocking for pipe (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

When rigging long loads, use slings with sufficient length that the dimension L is always greater than dimension S . This will ensure that your sling angles are always greater than 60° from horizontal.

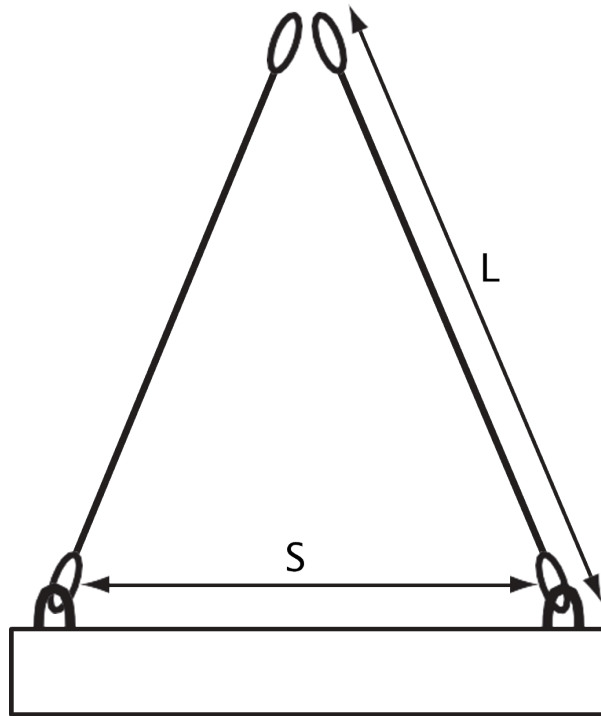


Figure 8 Correct sling angle (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Never wrap the sling on the lifting hook to prevent movement. This weakens the sling considerably and may render it useless.



Figure 9 Never wrap a hook (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

You can form a choker hitch from a looped rope, provided that the loop contains a metal thimble. Rope loops without thimbles can suffer severe abrasion by the cutting section of the line running through the eye.



Figure 10 Choker hitch (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

If you are rigging a choker with the aid of a shackle, you must make sure the shackle pin bears on the eye of the sling. DO NOT allow the pin to bear on the running line. The movement of the running line could loosen the shackle pin, causing the load to drop.

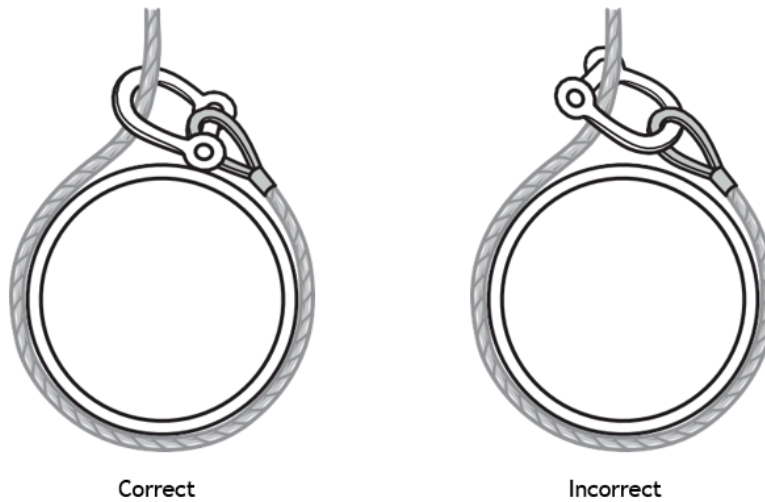


Figure 11 Shackle use (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0
<https://creativecommons.org/licenses/by-nc-sa/4.0/>

When working with large cranes that are moving objects near power lines, use a power line spotter to avoid hitting the lines with the crane or the load. **Electric shock can kill!**



Figure 12 Use shackles (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0
<https://creativecommons.org/licenses/by-nc-sa/4.0/>

When connecting two or more ropes to the lifting hook, use a shackle to attach the ropes to the hook. The shackle should have the pin bearing on the hook.

Many structural shapes have sharp edges and corners that can damage slings. To prevent damaging the slings, always provide padding between the sling and the sharp corners of the load.

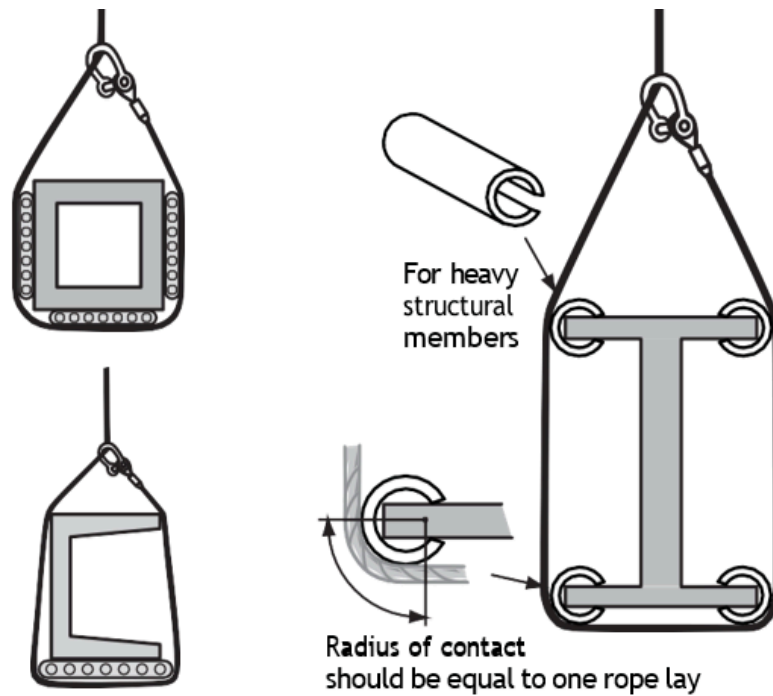


Figure 13 Protective padding (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Turning Loads

When using a crane or hoist to turn heavy structural shapes, you must attach your rigging so that you have full control of the load at all times. Avoid violent or jerky movements because these could cause severe injury to bystanders.

By rigging a load as shown in Figure 14, start the roll by lifting the load. Then by gently lowering the load, continue the roll while maintaining full control.

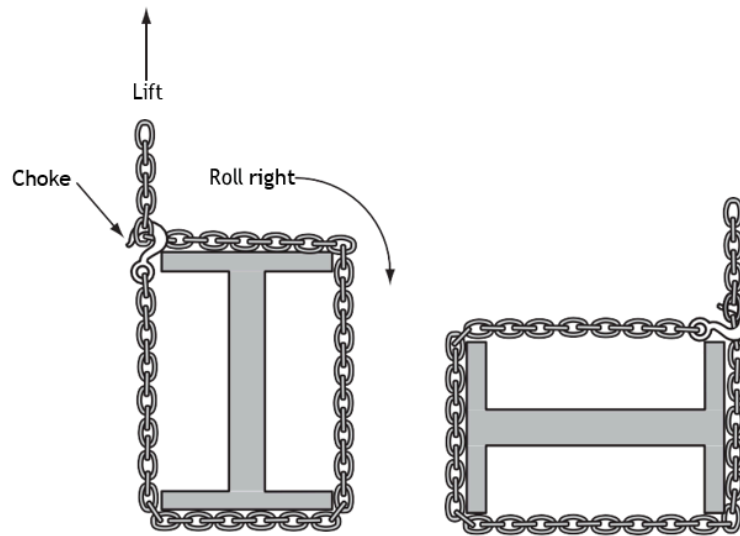


Figure 14 A controlled turn (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

If you were to rig a structural shape, the load would flip violently regardless of how slow you made the lift. The load would then rock back and forth several times before it could be lowered.

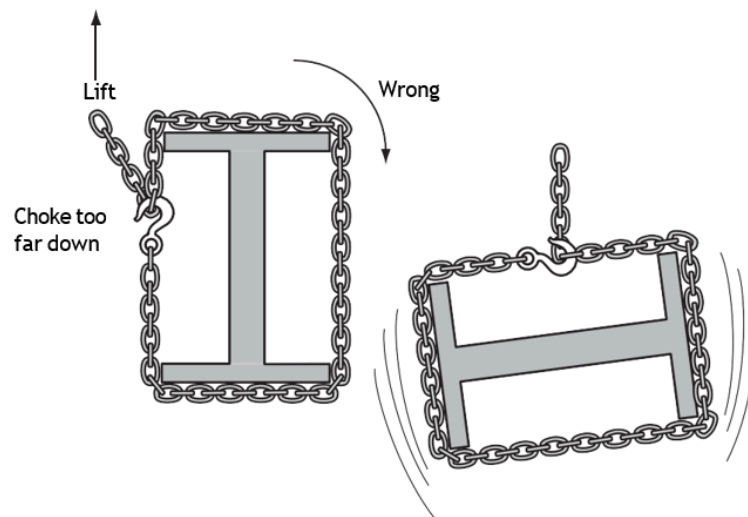


Figure 15 Unsafe flip (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Correct Storage Practices

Store materials in such a manner that they are easily accessible and protected from harm. Piles or stacks of material must be securely stacked and pose no threat to people in their vicinity.

To allow cranes or forklifts access to materials, store the materials on **dunnage** (pieces of lumber for support) blocks or pallets.

Materials that can be damaged by bending or buckling should be stored on adequate supports to prevent such damage. If materials will be exposed to rain, store them at a slight slope to permit the rainwater to run off.

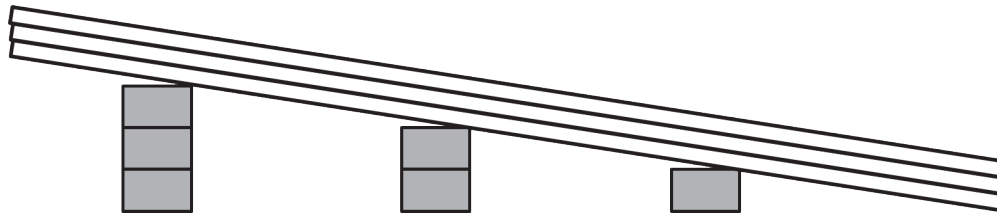


Figure 16 Slope for water run-off (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Pipe should be piled with the bottom row of each stack well blocked, as illustrated in Figure 17. The blocking prevents the bottom row from being spread apart by the weight of the subsequent rows. Nail or screw blocking whenever possible. Narrow wedges may be sufficient for small stacks of small diameter pipe, but larger diameter pipe will roll right over them, so use blocking adequate for the situation. Continue to stack rows in a pyramid pattern for stability.

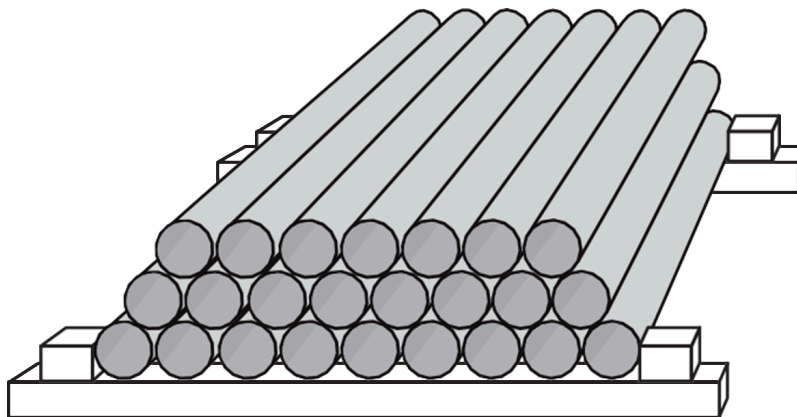
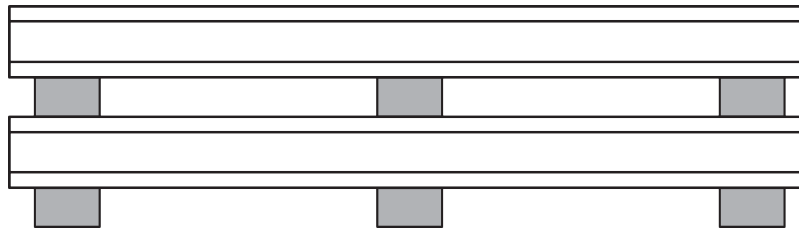


Figure 17 Blocking stacks of pipe (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

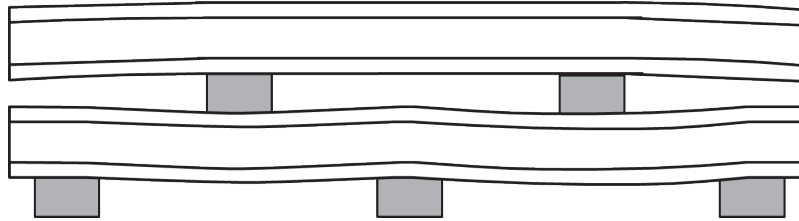
Loose materials should be banded together and stored in containers or bins.

Blocking and Stacking

When stacking structural shapes, you must provide blocking under the first row and cross-sticks between each successive row. The cross-sticks must be positioned directly above the previous row to prevent the materials from buckling and kinking.



Correct blocking



Incorrect blocking

Figure 18 Correct and Incorrect Blocking (BC Industry Training Authority, 2019).
CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)



Self-Test B-4.5: Use Hoisting, Lifting and Rigging Equipment

Complete Self-Test 4.5 and check your answers.

If you are using a printed copy, please find Self-Test A-4.5 and Answer Key in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.





An interactive H5P element has been excluded from this version of the text. You can view it online here:
<https://b-handmeasuringtools-bcplumbingappr1.pressbooks.tru.ca/?p=2891#h5p-13> (<https://b-handmeasuringtools-bcplumbingappr1.pressbooks.tru.ca/?p=2891#h5p-13>)

References

- BC Industry Training Authority. (2019). *Piping trades apprenticeship program: Use Tools and Equipment—Level 1 harmonized* [Binder]. Crown Publications, Queen's Printer for British Columbia. https://www.crownpub.bc.ca/Product/Details/7960000261_S
- The competencies **Use hoisting, lifting and rigging equipment** and **Rig loads for cranes** (our sections B-4.5 and B-4.6) align with and are adapted from the *Piping Trades Apprenticeship Program: Use Tools and Equipment—Level 1 Harmonized* curriculum (Industry Training Authority, 2019). See: SkilledTradesBC. (2025). *Plumber program outline (harmonized)*. <https://skilledtradesbc.ca>

Media Attributions

All figures are sourced from Industry Training Authority (2019) and/or Camosun College (2019) and are used under the Creative Commons Attribution 4.0 (CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/>)) licence unless otherwise noted. Images copyrighted by the BC Industry Training Authority are licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 (CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)) licence.

B-4.6 Rig Load for Cranes

Cranes are mechanical hoisting equipment designed to lift, move, and land a load deemed too heavy to move safely by hand. The potential of modern cranes is immense, with some having a capacity in the hundreds of tons. As a tradesperson, it is important to be familiar with the many different types of cranes and derricks, and to understand how to select the appropriate crane to perform a hoist safely and effectively.

If you are working with a crane, your responsibilities include the following:

- Use safe behavior around a crane.
- Be able to identify basic crane components and types.
- Ensure the crane site is safe and ready for use and that the landing spot or lay-down area is ready for the hoisted load.
- Ensure the load is stable.

Industry employs cranes to move everything from bundles of pipe to sections of buildings, from vehicles to personnel. Because of the potential for catastrophic consequences when a lift goes badly, crane operations and crane components are heavily controlled and regulated. OHS Regulations, Part 15: Rigging (<https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-15-rigging>) describes minimum safety standards, referring to Canadian Standards Association (CSA), American National Standards Institute (ANSI), and American Society of Mechanical Engineers (ASME) standards for the design, inspection, maintenance, and repair of all cranes.

Describe Crane Procedures

Crane Component and Terms

Block: A collection of sheaves that provide a mechanical advantage in a lift. Blocks are often found at the hook.

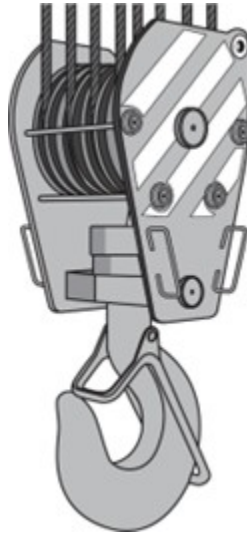


Figure 1 Crane block and hook (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Boom: The primary arm of a crane. It acts as a lever and positions the block and hook directly above the load.

Boom cylinder: The hydraulic control of a boom.

Boom radius: Also referred to as the operating radius, this is the horizontal distance from the centre of rotation to the hook and is a function of boom angle and length. This concept is crucial to understanding safe crane capacity.

Counterweight: A supplementary ballast added to the weight of a crane to provide additional stability during a lift.



Figure 2 Counterweights (Cjp24/Wikimedia Commons)
CC BY-SA 3.0 (<https://creativecommons.org/licenses/by-sa/3.0/deed.en>)

Cribbing: Material used for dunnage or blocking under a load to allow for the attachment and removal of rigging.

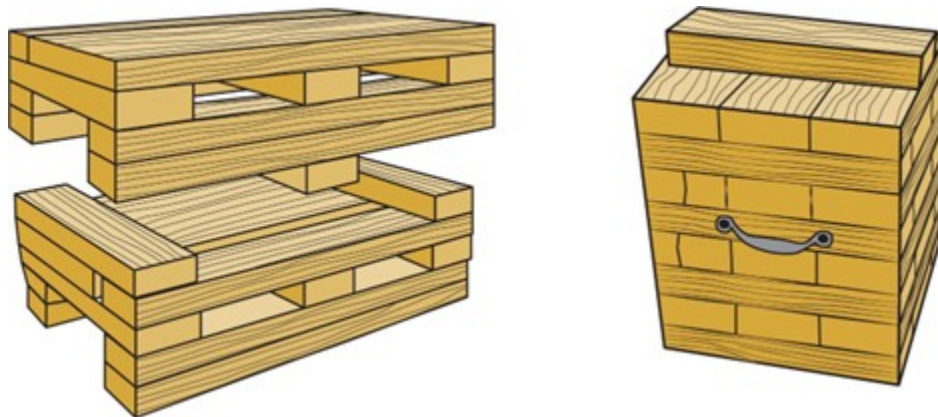


Figure 3 Cribbing or support blocks (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0
(<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Gantry: A fabricated structural, bridge-like crane operating on tracks or wheels at or near ground level.



Figure 4 Gantry crane (Haakman/Wikimedia Commons) CC BY 3.0 (<https://creativecommons.org/licenses/by/3.0/deed.en>).

Headache ball: A crane hook, generally without a block.

Hoist line: The wire rope that controls the main block, jib block, or hook.

Jib: A secondary arm of a crane, used to extend the boom for specific lifts.

Lashing: An arrangement of wire rope and securing hardware such as U-bolt clips, used to secure two or more objects together. It is often used to temporarily secure a load, prior to a hoist.

Load chart: Manufacturer's documentation or literature that describes a crane's lift capacity under all possible operating configurations.

Outrigger: A support member that projects beyond the natural outline of a crane to provide additional support and to prevent toppling.



Figure 5 Boom truck with outriggers (PhilaFrenzy/Wikimedia Commons) CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/deed.en>)

Pendant: Also called a stay, a supporting line that maintains a constant distance between two points of attachment, such as a counterweight and a gantry or mast.

Sheave: A grooved wheel or pulley used to redirect force along a hoist line.

Side-loading: A dangerous condition in which a portion of a crane hoist acts horizontally, placing force on the boom other than the true vertical lift that the boom is designed for.

Swing: The hazard area associated with the swing radius of the crane's carrier and counterweights. This area should be flagged off during crane operation and considered a no-go zone.

Tagline: Guy wires used to control crane loads and prevent unwanted rotation or swinging, allowing ground workers to control the load from a safe distance.

Whipline (auxiliary hoist): A secondary hoist line from the main hoist, usually lighter and faster.

Crane Selection

There is an incredible variety of cranes, so crane selection must consider a number of factors, including:

- Weight, shape and size of the load. Important: include all slings, spreaders, other lifting equipment used, and hook block in load weight calculations. Consider anything below the boom tip as load.
- Lift parameters, including boom or operating radius and height
- Number of lifts required
- Required mobility of the crane
- Site and terrain conditions

Crane Identification

You will find crane identification and user information permanently attached to the crane. Clear identification of all detachable components such as the boom, jib, counterweight, etc., indicates that these components are connected to that particular crane. In addition, permanently affixed, easily located, and clearly written capacity rating charts, or load charts, are required. These describe safe capacity loads at permissible boom lengths and angles. For example, a crane may have a capacity of 110 tons, but this capacity decreases as the boom extends or moves closer to horizontal. This information is provided in the rated capacity literature.

Industry categorizes cranes by lift capacity (rated in tons), boom style, and mobility.

Boom Style

- Telescoping
- Lattice
- Fixed
- Articulating

Mobility

- Rough terrain
- Crawler
- Truck mount
- Carrier mount
- Tower, stationary
- Tower, rail mounted

Ensure the load is stable whenever you are lifting loads with a crane. Start the initial lift very slowly, watching the load for any signs of tilting or shifting. If the load tilts more than 5°, lower the load and rearrange the rigging.

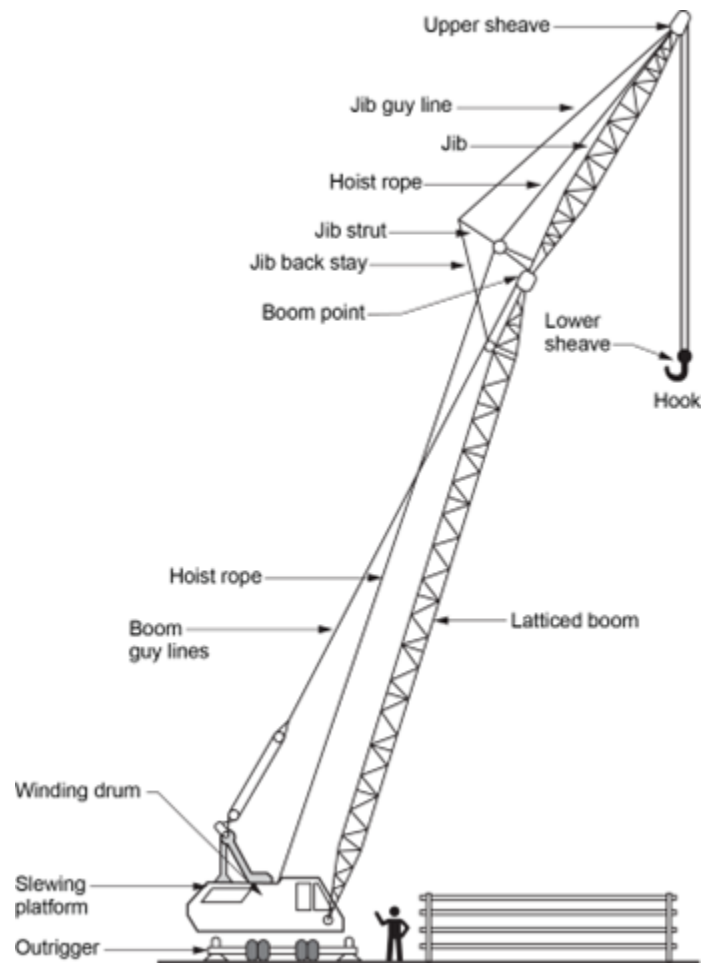


Figure 6 Carrier mounted lattice boom crane (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

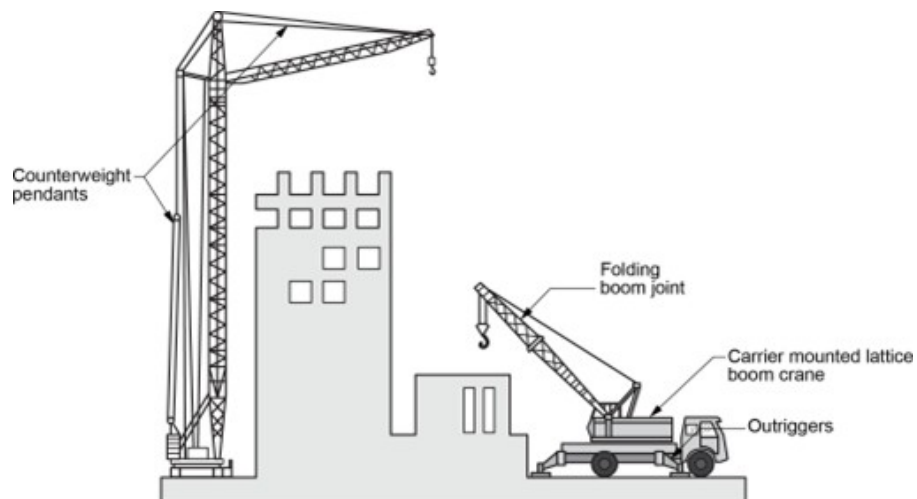


Figure 7 Crawler crane with luffing boom (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

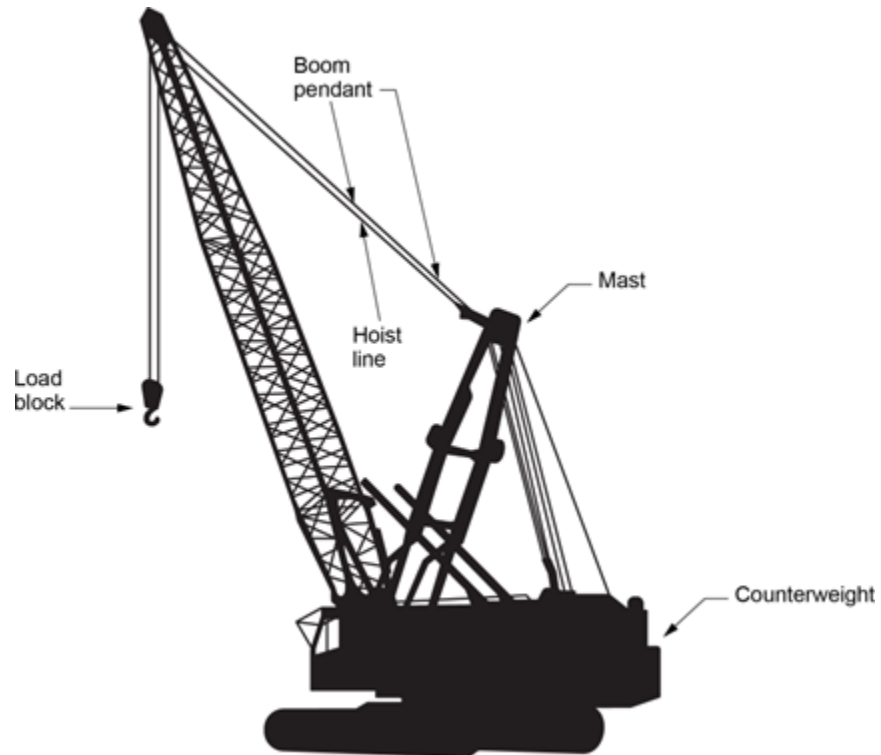


Figure 8 Crawler mounted lattice boom (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

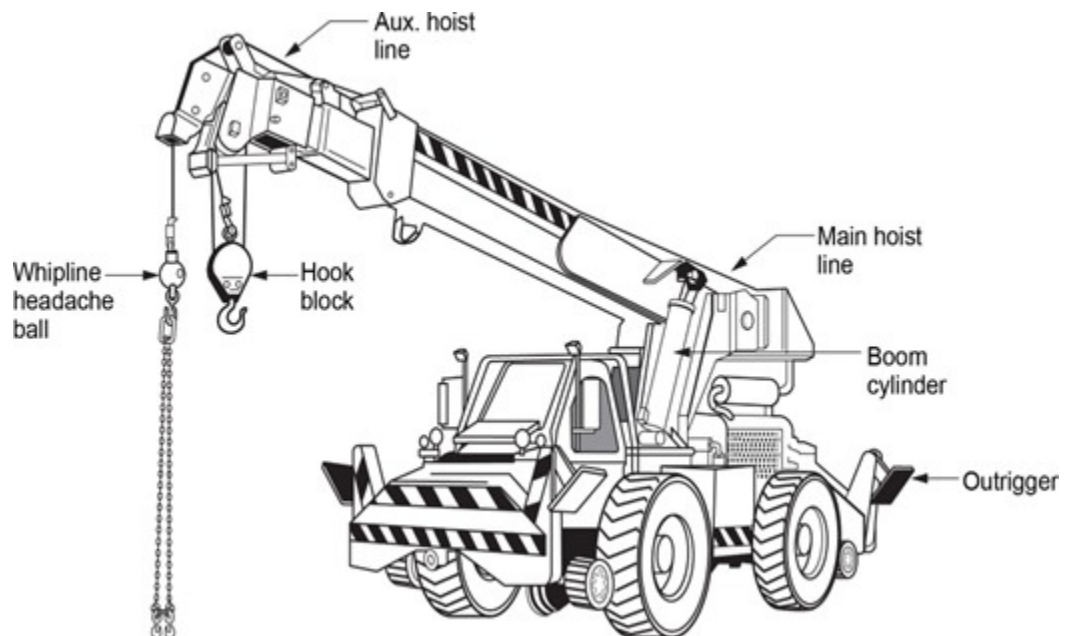


Figure 9 Rough terrain crane with telescoping boom (BC Industry Training Authority, 2019). CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Load Chart

Load chart, shown below, informs the user of a crane's safe capacity in all permissible configurations of boom lengths and angles, base conditions, load radius, boom point elevation, and whether outriggers are used or not. The boom angle refers to the angle of the boom to the horizon. The load radius describes the measurement from the crane centreline to load centre at its most distant. The boom point elevation describes the distance from the ground to the centre of the outermost part of the boom. The term outriggers describes equipment attached to the base of a crane designed to increase the base area and provide a great deal more stability, especially when the load is to the side of the crane.

Typically, as the boom lowers and approaches horizontal, and the centreline of the lift moves away from the centre of the crane, crane capacity diminishes. This is termed the *load radius*. When describing a 100-ton crane, this capacity rating describes the safe capacity with the boom near vertical or the minimum boom radius and the load directly to the rear of the crane with little to no swing.

Carrier Mounted Lattice Boom

Table 1: Load Charts for Two Different Types of Cranes

Boom length	Radius	Boom angle	Side pick- up, no outriggers	Rear pick- up with outriggers	Side pick- up with outriggers	Rear pick- up with outriggers
50 m	8 m	83°	32,226 kg	39,975 kg	99,135 kg	99,135 kg
50 m	15 m	75°	17,670 kg	18,656 kg	39,970 kg	47,261 kg
50 m	45 m	27°	1,875 kg	2,125 kg	7,305 kg	10,156 kg

Crawler Mounted Lattice Boom

Table 2: Load Charts for Two Different Types of Cranes

Boom Length	Radius	Boom Angle	Boom Point Elevation	Crawlers retracted	Crawlers Extended
21m	4.8 m	80°	23 m	177,968 kg	181,600 kg
21m	21m	19.5°	9.2 m	21,247 kg	23,880 kg

Note the extreme differences in load capacity as crane conditions change in the tables above. There may also be additional charts included to account for added counterweights.

Site Preparation

The crane operator, project engineer, or supervisor will select and oversee site preparation for a selected crane. Your involvement in this could involve any of the following tasks:

- Assess access roads in the area.
- Assess whether there is sufficient space to assemble the crane, if necessary.
- Level and compact the site.
- Identify and account for powerlines, and power down (de-energize them), if necessary
- Identify and make provisions for trenches, shoring, buried utilities, etc.
- Restrict public access and set up a perimeter using safety ribbon or barricades.
- Ensure proper clearances for the crane's swing radius.
- Provide outrigger mats and cribbing for soft ground conditions. Cribbing is material used for dunnage under a load to allow for the attachment and removal of rigging.
- Prepare a lay-down area for the load. This may include dunnage or other site preparation.

Certain conditions may require extra precautions, including avoiding the leading edge of a trench, underground sewer mains, and ground beside recently constructed buildings that may have uncompact backfill. If in doubt, consult a soil engineer.

Outriggers require mats that are at least three times larger in area than the floats and should be rigid and rated for the load. Never block the arm of an outrigger, only the float. Bearing mats can be made of wood or steel and offer more stability than native soil.

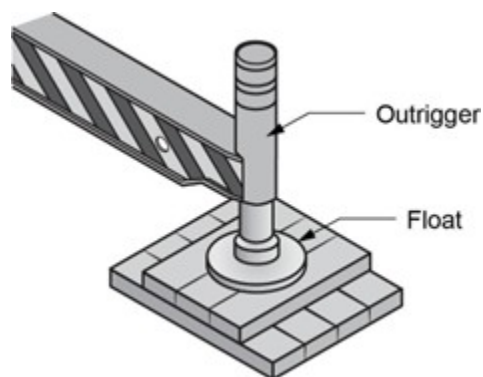


Figure 10 Float and outrigger

Once the crane is in place, perform a walk-around, paying particular attention to overhead hazards and crane support.

Crane Leveling

Cranes require a level base. Most safety standards require a grade of 1% or less, with some manufacturers requiring $\frac{1}{2}$

%. A 1% grade means a base with a length of 20 feet or 240 in. may only have an elevation change of $2 \frac{3}{8}$ in. from one

end to the other. This requirement prevents side-loading on the boom, a condition where force is applied to the boom at an angle, which the boom is not designed to withstand. The *IPT Crane and Rigging Training Manual* shows that a short-boom crane at the minimum hoist radius can lose 10% of its capacity for every 1% angle of side-load.

Level a crane with calibrated measuring tools, such as a *four-foot carpenter's level* or the *bird's-eye levels* found in the crane's cab.

After levelling the base, check the crane's level using the following method: raise the boom to its highest angle and hoist a small, compact load just off the ground. The hoist line should fall within the centreline of the boom. Do this for each of the four quadrants: front, side, and corners. If the hoist line is outside the boom, the crane is not level. This method is less accurate in windy conditions.

Secure Load for Rigging Attachment and Removal

Once the chosen crane is in place, a lift plan has been completed, and the crane site has been prepared, the worker can prepare for the lift. Preparation of a load before and after a hoist requires an understanding of proper material handling and a familiarity with hoisting and jacking equipment. Pipe trades workers need to learn the safety precautions required to prepare material and equipment prior to a lift, and to safely remove rigging equipment once the lift is complete.

Pre-Hoist Preparation

OHS Regulation 15.2 states: "*Rigging and slinging work must be done by or under the direct supervision of qualified workers familiar with the rigging to be used and with the code of signals authorized by the Board for controlling hoisting operations.*"

At this point, a trained and qualified individual should have established the weight of the load, confirmed the distance, height, and swing of the lift, and selected the appropriate tackle and hardware.

To prepare a load for hoisting, the load must be on dunnage or cribbing to allow for the application of slings or other approved hoisting equipment. If necessary, jack or pry the load and position cribbing beneath it. Distribute the weight evenly on the cribbing while leaving enough vertical clearance to apply the rigging equipment. This process creates a high risk of pinching injuries. **Remember: never place any part of your body under a load!**

At this point, if the load is not accessible to the crane hook, use appropriate equipment to move or position the load across the floor. Some options include:

- Roller jacks, steel dollies, air castors, or skates
- A forklift or pallet jack
- A chain fall, come-along, or chain hoists

Rig the load while it is supported by cribbing or dunnage. Always rig using the appropriate slings and equipment, and never wrap the hoist rope directly around the load.

Apply the rigging equipment with the centre of gravity (C of G) identified. The centre of gravity will always move directly under the hook when lifted, so anticipate load swing or shifting. Consider using a turnbuckle or come-along at the hook

to help centre and balance the load beneath the hook. Test the load by lifting it approximately one foot. If the load is more than 5° off level, lower the load and re-rig.

Attach taglines to adequately control swing and load rotation. Ensure that taglines are made of non-conductive material to reduce the risk of electric shock. Taglines should be long enough to allow workers to control the load from a safe distance. Use more than one tagline if necessary. Remove taglines after the lift is complete and the load is in its final position.

Post-Hoist Procedures

OHS Regs 15.3 states, *“Loads to be unhooked by a worker must be safely landed and supported before the rigging is detached.”*

This may mean lashing the load to a structural member or landing the load on prepared cribbing before releasing the hook.

Consider what will happen next. Is the load in the correct location, or will you need to rig it across the floor? Is the lay-down area sufficiently clear and ready? Is the load a piece of equipment that must be accurately placed on a pad? Be sure you are satisfied with the position of the load before removing the hook.



Self-Test B-4.6: Rig Load for Cranes

Complete Self-Test 4.6 and check your answers.

If you are using a printed copy, please find Self-Test A-4.6 and Answer Key in the Appendix at the end. If you prefer, you can scan the QR code with your digital device to go directly to the interactive Self-Test.





An interactive H5P element has been excluded from this version of the text. You can view it online here:
<https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2895#h5p-14> (<https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/?p=2895#h5p-14>)

References

BC Industry Training Authority. (2019). *Piping trades apprenticeship program: Use Tools and Equipment—Level 1 harmonized* [Binder]. Crown Publications, Queen's Printer for British Columbia. https://www.crownpub.bc.ca/Product/Details/7960000261_S

The competencies **Use hoisting, lifting and rigging equipment** and **Rig loads for cranes** (our sections B-4.5 and B-4.6, respectively) align with, and are adapted from, the Piping Trades Apprenticeship Program: Use Tools and Equipment—Level 1 Harmonized curriculum (Industry Training Authority, 2019). See: SkilledTradesBC. (2025). Plumber program outline (harmonized). <https://skilledtradesbc.ca>

WorkSafeBC. (n.d.). *Occupational health and safety regulation: Part 15—Rigging*. <https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-15-rigging>

WorkSafeBC. (n.d.). *Occupational health and safety regulation: Part 15—Rigging, s. 15.2 Qualified riggers*. <https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-regulation/part-15-rigging#SectionNumber:15.2>

Media Attributions

All figures are sourced from Industry Training Authority (2019) and/or Camosun College (2019) and are used under the Creative Commons Attribution 4.0 (CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/>)) licence unless otherwise noted. Images copyrighted by the BC Industry Training Authority are licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 (CC BY-NC-SA 4.0 (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)) licence.

- **Figure 2** Potain tower crane2-Counterweight (https://commons.wikimedia.org/wiki/File:Potain_tower_crane2-Counterweight.jpg) [Counterweights] by Cjp24 on Wikimedia Commons is licensed under the a CC BY-SA 3.0 (<https://creativecommons.org/licenses/by-sa/3.0/deed.en>) license.
- **Figure 4** GTAISUN with SCARABEO (https://commons.wikimedia.org/wiki/File:TAISUN_with_SCARABEO_9.JPG) [Gantry crane], by Haakman on Wikimedia Commons is used under a CC BY 3.0 (<https://creativecommons.org/licenses/by/3.0/deed.en>) license.
- **Figure 5** Replacing an advertising poster in London using an articulated platform 01 (https://commons.wikimedia.org/wiki/File:Replacing_an_advertising_poster_in_London_using_an_articulated_platform_01.JPG) [Boom truck with outriggers] by Philafrenzy on Wikimedia Commons is licensed under CC SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/deed.en>)

Self-Test B-4.1: Describe the Principles of Lifting and Hoisting

Complete Self-Test B-4.1 and check your answers.

1. State the formula for mechanical advantage of a lever.
2. Where should the slings attach to the load, in relation to the centre of gravity?
3. Where will the centre of gravity of a load be positioned after it is lifted off the ground?
4. Does the position of the centre of gravity depend upon how the load is rigged?
5. Which safety factor determines the working load limit of a rigging system designed as a crew lift?
 - a. 1:1
 - b. 5:1
 - c. 10:1
 - d. 15:1
6. Who decides whether a rigger is qualified or not?
 - a. Worker
 - b. Employer
 - c. Foreman
 - d. WorkSafeBC

Answer Key: Self-Test B-4.1 is on the next page.

Answer Key: Self-Test B-4.1

1. $MA = \text{length of effort arm} / \text{length of resistance arm}$.
2. The point of attachment must be above the centre of gravity, or the load may roll over.
3. Regardless of the rigging, the load will shift to put its center of gravity directly below the hook.
4. If rigged improperly, the shifting may cause the load to become unstable and result in an accident.
5. c. 10:1
6. b. Employer

Self-Test B-4.2: Describe Hoisting, Lifting and Rigging Equipment

Complete Self-Test B-4.2 and check your answers.

1. Turnbuckles are used to adjust the length of slings so that loads can be lifted in what way?
 - a. In a level position
 - b. Higher
 - c. Vertically
 - d. From below
2. The screw threads at each end of a turnbuckle's sleeve must be designed in what fashion?
 - a. Locking at one end and non-locking at the other
 - b. Identical
 - c. A larger diameter at one end than at the other
 - d. Left-handed at one end and right-handed at the other
3. When several ropes are to be attached to a single hook, the connection to the hook must be made with a _____.
 - a. Turnbuckle
 - b. U-bolt
 - c. Shackle
 - d. Series of cable clips
4. The U-bolt part of a cable clip must be installed so it bears on which of the following?
 - a. Thimble
 - b. Live end of the rope
 - c. Dead end of the rope
 - d. Whipping
5. What does the number of cable clips required for a connection depend upon?
 - a. Diameter of the rope
 - b. Type of clip used
 - c. Mass of the load
 - d. Strength of the rope
6. Correctly installed cable clips will reduce the breaking strength of wire rope by what factor?
 - a. 10%
 - b. 20%
 - c. 30%
 - d. 40%
7. What is the safe working capacity of a jib or overhead travelling crane?
 - a. Equal to that of the hoist assembly
 - b. Not more than 10 Mpa (1450 psi) less than the hoist assembly
 - c. Greater than that of the hoist assembly
 - d. Displayed visibly on the device
8. The load-lifting capacity of motorized forklifts depends on the spacing of the forks, the floor or ground surface and _____.
 - a. Height and tilt of the mast

- b. Whether it is equipped with a torque converter
 - c. Size of the rear wheels
 - d. Steering capacity of the front wheels
9. How is the mechanical advantage of a hydraulic jack determined?
- a. Length of the pump piston
 - b. Length of the lifting piston
 - c. Ratio of the pump piston's force to the lifting piston's force
 - d. Ratio of the pump piston's diameter to the lifting piston's diameter
10. To lower a load supported by a hydraulic jack, you must do which of the following?
- a. Flip the lever downward
 - b. Set the pump to reverse
 - c. Lift the handle as high as possible
 - d. Open the valve
11. Which pulling device can use either chain or cable?
- a. Chain fall
 - b. Block and tackle
 - c. Come-along
 - d. Gin pole
12. A Tirfor jack is a hoisting device that uses a ____
- a. Nylon rope
 - b. Metal chain
 - c. Wire rope
 - d. Fibre rope
13. How are Tirfor jacks made to travel in the opposite direction?
- a. Flipping the gear lever
 - b. Turning the handle in the opposite direction
 - c. Releasing the ratchet
 - d. Re-locating the pipe handle

Answer Key: Self-Test B-4.2 is on the next page.

Answer Key: Self-Test B-4.2

1. a. In a level position
2. d. Left-handed at one end and right-handed at the other
3. c. Shackle
4. c. Dead end of the rope
5. a. Diameter of the rope
6. b. 20%
7. d. Displayed on the device
8. a. Height and tilt of the mast
9. d. Ratio of the pump piston's diameter to the lifting piston's diameter
10. d. Open the valve
11. c. Come-along
12. c. Wire rope
13. d. Re-locating the pipe handle

Self-Test B-4.3: Describe Lifting and Hoisting Communication

Complete Self-Test B-4.3 and check your answers.

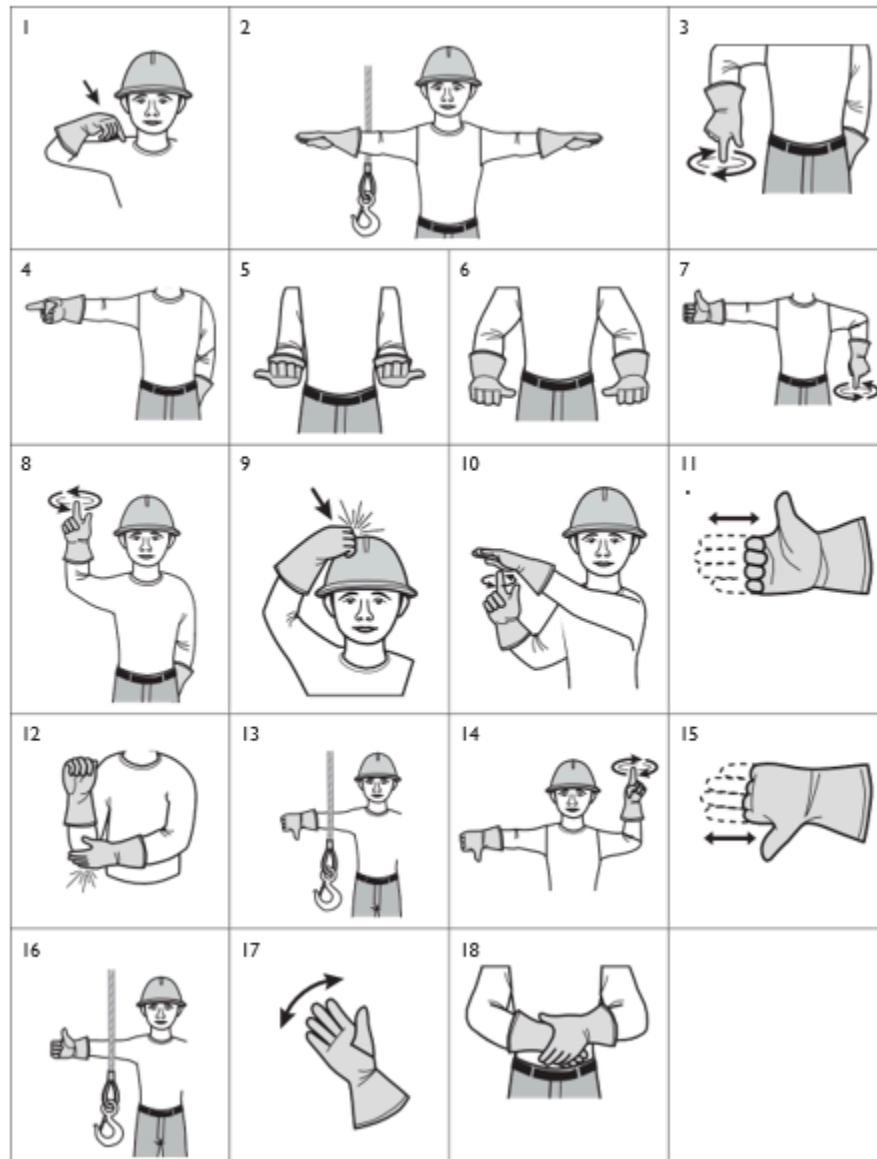


Figure 1 Image for Question 1

1. Using the illustrations above, fill in the corresponding number(s) on the next page for each of the hand signals listed below:

_____A. "USE THE MAIN LINE"

_____B. "STOP" (two signals)

_____C. "RETRACT BOOM"

- _____D. "LOWER THE LOAD"
- _____E. "HOIST SLOWLY"
- _____F. "LOWER THE BOOM AND RAISE THE LOAD" (two signals)
- _____G. "EXTEND THE BOOM"
- _____H. "USE WHIP LINE" (two signals)
- _____I. "SWING THE BOOM"
- _____J. "RAISE THE BOOM AND LOWER THE LOAD" (two signals)
- _____K. "HOIST"
- _____L. "LOWER THE BOOM"
- _____M. "DOG EVERYTHING"

Answer Key: Self-Test B-4.3 is on the next page.

Answer Key: Self-Test B-4.3

- a. 9
- b. 2, 17
- c. 6
- d. 3
- e. 10
- f. 14, 15
- g. 5
- h. 1, 12
- i. 4
- j. 7, 11
- k. 8
- l. 13
- m. 18

Self-Test B-4.4: Select Slings and Tie Knots, Bends and Hitches

Complete Self-Test B-4.4 and check your answers.

1. What type of Manila rope has one or more coloured strands?
 - a. Number 1 grade
 - b. Yacht rope
 - c. Hardware store rope
 - d. Bolt rope
2. Which is the strongest of the ropes listed below?
 - a. Polypropylene
 - b. Sisal
 - c. Polyester
 - d. Manila
3. Which type of dry rope has the best electrical insulating properties?
 - a. Manila
 - b. Polypropylene
 - c. Polyester
 - d. Nylon
4. When loaded to the breaking point, nylon rope will stretch up to what percent of its original length?
 - a. 10%
 - b. 20%
 - c. 30%
 - d. 40%
5. The portion of the rope which forms the loop is called the _____.
 - a. Middle
 - b. Standing part
 - c. Circle
 - d. Bight
6. Which of the knots listed below forms a non-slip loop?
 - a. Square knot
 - b. Bowline
 - c. Reef knot
 - d. Timber hitch
7. The knot, hitch or bend illustrated in Figure 1 is a _____.

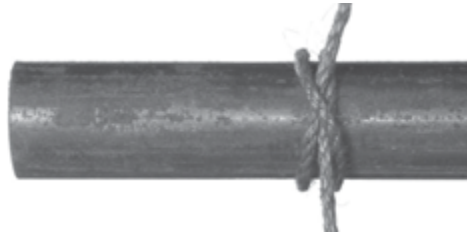


Figure 1 Image for Question 7

- a. Carrick bend
 - b. Timber hitch
 - c. Clove hitch
 - d. Trucker's knot
8. Which knot multiplies the tension you apply to a rope?
- a. Timber hitch
 - b. Bowline
 - c. Sheet bend
 - d. Trucker's knot
9. When joining a large diameter rope to a small diameter rope, what should be used?
- a. Square knot
 - b. Carrick bend
 - c. Sheet bend
 - d. Half-hitch
10. When joining two ropes of the same diameter together, what should be used?
- a. Double half hitch
 - b. Reef knot
 - c. Sheet bend
 - d. Timber hitch

Answer Key: Self-Test B-4.4 is on the next page.

Answer Key: Self-Test B-4.4

1. a. Number 1 grade
2. c. Polyester
3. b. Polypropylene
4. d. 40% its original length
5. d. Bight
6. b. Bowline
7. c. Clove hitch
8. d. Trucker's knot
9. c. Sheet bend
10. b. Reef knot

Self-Test B-4.5: Use Hoisting, Lifting and Rigging Equipment

Complete Self-Test B-4.5 and check your answers.

1. How should slings and wire rope be stored?
2. What should be done with a wire rope sling that has a kink in it?
3. What should be done if there is a possibility of shock loading when using a wire rope sling?
4. What should be done with a broken wire in a wire rope sling?
5. Is it safe to replace a lost pin in a shackle with a high-strength bolt? Explain.
6. If a danger of stepping on protruding nails exists, what type of footwear will protect you from injury?
 - a. Steel-toed boots
 - b. Cowboy boots
 - c. Steel insoles
 - d. Non-skid rubber soles
7. When a crane starts taking up the slack in the slings around a load, what should be avoided?
 - a. Standing back from the load
 - b. Getting your fingers pinched
 - c. Checking the loads balance
 - d. Planning an escape route
8. When moving a suspended load,_____.
 - a. Pull the load towards yourself
 - b. Stand under the load
 - c. Guide and follow the load
 - d. Stand on the load
9. How should loose materials be stored?
 - a. Tied together
 - b. Stacked on shelves
 - c. In containers or bins
 - d. According to length
10. When rigging loose bundles of pipe what should be used?
 - a. Double-wrapped basket hitches
 - b. Two-leg bridle hitch
 - c. Four-leg bridle hitch
 - d. Single choker hitch
11. Tag lines should be used to control loads because they allow control from _____.
 - a. Directly under the load
 - b. A safe distance
 - c. Above the load
 - d. Within the crane
12. What loads should padding be applied to?
 - a. Excessive weight
 - b. Slippery surfaces

- c. Irregular surfaces
- d. Sharp corners

Answer Key: Self-Test B-4.5 is on the next page.

Answer Key: Self-Test B-4.5

1. Wire rope and fibre slings should be stored in a dry location off the ground.
2. Destroy and discard a kinked wire rope sling.
3. Take special precautions and/or use a larger-sized rope.
4. The broken wire ends should be removed as soon as possible by bending the broken ends backward and forward by hand or with a pair of pliers.
5. No. The bolt is not designed to support the loads required.
6. c. Steel insoles
7. b. Getting your finger pinched
8. c. Guide and follow the load
9. c. In containers or bins
10. a. Double-wrapped basket hitches
11. b. A safe distance
12. d. Sharp corners

Self-Test B-4.6: Rig Load for Cranes

Complete Self-Test B-4.6 and check your answers.

1. Which term best describes supportive material intended to keep a load off the ground and allow for proper and safe application of slings?
 - a. Blocks
 - b. Cribbing
 - c. Sheaves
 - d. Counterweights
2. Which term best describes an auxiliary hoist line, which is typically lighter and faster than the main hoist?
 - a. Tagline
 - b. Pendant
 - c. Forestay
 - d. Whipline
3. Which term best describes the horizontal distance from the centreline of the hook to the centreline of crane rotation??
 - a. Swing
 - b. Whipline
 - c. Hoist line
 - d. Boom radius
4. Which terms best describes the dangerous condition of force applied to the boom at an angle from vertical?
 - a. Side-loading
 - b. Side-stressed
 - c. Boom-torque
 - d. Non-vertical lift
5. Which term best describes support members that project beyond the natural outline of the crane to prevent toppling?
 - a. Side-loads
 - b. Outriggers
 - c. Gantry masts
 - d. Headache ball
6. Where would a worker find a crane's capacity rating chart?
 - a. In the main office
 - b. With the foreman
 - c. Affixed to the crane
 - d. On the manufacturer's website
7. Which of the following terms best describe a bridge-like crane often found affixed to rails or on wheels?
 - a. Gantry

- b. Crawler
 - c. Boom truck
 - d. Telescoping
8. The load weight calculations does not include the rigging equipment such as spreader bars, slings, and block hooks as these are integrated within load calculations.
- a. True
 - b. False
9. Which of the following term is not a boom style?
- a. Fixed
 - b. Lattice
 - c. Telescoping
 - d. Rough terrain
10. Which phrase best describes how a crane's load capacity changes as the boom radius increases?
- a. Increases
 - b. Decreases
 - c. Is not affected
 - d. Depends on side-loading
11. Which term best describes a supplementary weight added to the base of a crane?
- a. Ballast
 - b. Gantry
 - c. Load chart
 - d. Counterweight
12. What size should outrigger pads be?
- a. Outriggers should never use pads
 - b. Three times the area of the floats
 - c. Size of the pads is not relevant
 - d. Approximately the size of the floats

Answer Key: Self-Test B-4.6 is on the next page.

Answer Key: Self-Test B-4.6

1. b. Cribbing
2. d. Whipline
3. d. Boom radius
4. a. Side-loading
5. b. Outriggers
6. c. Affixed to the crane
7. a. Gantry
8. b. False
9. d. Rough terrain
10. b. Load capacity decreases
11. d. Counterweight
12. b. Three times the area of the floats

Version History

This page provides a record of changes made to this learning resource, Plumbing Apprenticeship Level 1, Block B (<https://b-handmeasuringtools-bcplumbingapprl1.pressbooks.tru.ca/>). Each update increases the version number by 0.1. The most recent version is reflected in the exported files for this resource.

Important Notice: This book contains content used with permission from Skilled Trades BC, Trades Training BC, and various third-party contributors, with all third-party content identified and attributed throughout. To create your own version, you must obtain explicit permission from Skilled Trades BC and the respective third-party content owners.

If you identify an error in this resource, please report it using the TRU Open Education Resource Error Form.

Version	Date	Change	Details
1.0	May 2026	Plumbing Apprenticeship Level 1 Block B learning resource from STBC content converted to open and freely accessible digital platform and published at TRU.	

Plumbing Apprenticeship & Trade Resources in BC

A successful career in plumbing requires a strong foundation of skills, knowledge, and workplace safety awareness. Below are key resources to support plumbing apprentices in BC, including educational pathways, trade certifications, workplace safety guidelines, and mental health and wellness support.

Plumbing Apprenticeship & Certification Resources

- **SkilledTradesBC – Plumbing Apprenticeship** (<https://skilledtradesbc.ca/plumber>) – Overview of plumbing training, certification requirements, and apprenticeship pathways in British Columbia.
- **Red Seal Program – Plumber** (<https://www.red-seal.ca/eng/trades/plumbers/overview.shtml>) – National certification program with exam prep guides and trade mobility information.
- **BC Building Codes & Standards** (<https://www.bccodes.ca/>) – Official building and plumbing codes for British Columbia.

Workplace Safety & Regulations

- **WorkSafeBC** (<https://www.worksafebc.com/en>) – Essential safety resources for plumbers, including:
 - Health & Safety – WorkSafeBC (<https://www.worksafebc.com/en/health-safety>)
 - Report Unsafe Working Conditions (<https://www.worksafebc.com/en/contact-us/departments-and-services/health-safety-prevention>)
 - Report a Workplace Injury or Disease (<https://www.worksafebc.com/en/claims/report-workplace-injury-illness>)
 - Submit a Notice of Project Form (<https://www.worksafebc.com/en/for-employers/just-for-you/submit-notice-project>)
 - Get Health and Safety Resources (Videos, Posters, Publications, and More) (<https://www.worksafebc.com/en/resources-health-safety>)
 - Search the OHS Regulations (and Related Materials) (<https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation>)
 - Conduct an Incident Investigation (<https://www.worksafebc.com/en/health-safety/create-manage/incident-investigations/conducting-employer-investigation>)
- **CCOHS: OHS Answers Fact Sheets – Plumber** (https://www.ccohs.ca/oshanswers/occup_workplace/plumber.html) – Safety guidelines and best practices for plumbers in various work environments.

Financial Supports

- **Financial Support (SkilledTradesBC)** (<https://skilledtradesbc.ca/financial-support>) – Information about grants, tax credits, Canada apprentice loans, employment insurance, and the Indigenous Skills and Employment Training

(ISET) program.

- **StudentAidBC** (<https://studentaidbc.ca/>) – Complete post-secondary education through student loans, grants, and scholarships. There is also programs that help with loan repayment.
- **WorkBC (Government of BC)** (<https://www.workbc.ca/find-loans-and-grants/students-and-adult-learners/services-apprentices-and-employers>) – Services for apprentices and employers.

Mental Health & Wellness Support

- **HealthLink BC – Mental Health and Substance Use** (<https://www.healthlinkbc.ca/mental-health-and-substance-use>) – HealthLink BC resources for mental health and wellness support.
- **Here2Talk** (<https://here2talk.ca/>) – Free and confidential counseling services available to all post-secondary students registered at a BC school.
- **Help Starts Here** (<https://helpstartshere.gov.bc.ca/>) – A database with over 2,500 listings of services related to mental health and substance use supports.
- **Hope for Wellness Helpline** (<https://www.hopeforwellness.ca/>) – 24/7 online chat and phone line with experienced and culturally competent counselors available to all Indigenous people in Canada.
 - First Nations Health Authority Mental Health Supports Info Sheet [PDF] (<https://www.fnha.ca/Documents/FNHA-mental-health-and-wellness-supports-for-indigenous-people.pdf>) by First Nations health Authority – List of culturally safe services for Indigenous people.
- **HeretoHelp – BC** (<https://www.heretohelp.bc.ca/>) – Mental health resources, including videos, articles, and support services in BC.
- **BC Construction Industry Rehabilitation Plan** (<https://www.constructionrehabplan.com/>) – Mental health and substance use services for CLRA and BCBT members and their families.
- **Virtual Mental Health Supports (Government of BC)** (<https://www2.gov.bc.ca/gov/content/health/managing-your-health/mental-health-substance-use/virtual-mental-health-supports>) – Virtual services are available for British Columbians who are experiencing anxiety, depression, or other mental health challenges.

Crisis Support

- **Interior Crisis Line Network** – Call 1-888-353-2273 (tel:+1-888-353-2273) for 24/7 emotional support, crisis intervention, and community resource information.
- **Talk Suicide Chat Service** (<https://talksuicide.ca/>) – An alternative if calling is difficult; available for crisis intervention.
- **310Mental Health Support** – Call 250-310-6789 (tel:+1-250-310-6789) for emotional support, information, and resources specific to mental health.
- **1-800-SUICIDE** – Call 1-800-784-2433 (tel:+1-800-784-2433) if you are experiencing feelings of distress or despair, including thoughts of suicide.
- **Opioid Treatment Access Line** – Call 1-833-804-8111 (tel:+1-833-804-8111) between 9 am and 4 pm to connect with a doctor, nurse, or healthcare worker who can prescribe opioid treatment medication that same day.
- **KUU-US Crisis Response Service** – Call 1-800-588-8717 (tel:+1-800-588-8717) for culturally-aware crisis support for Indigenous peoples in BC.
- **Alcohol and Drug Information and Referral Service** – Call 1-800-663-1441 (tel:+1-800-663-1441) to find resources and support.



Emergency Services — For life-threatening situations, call 911 or visit your nearest emergency department.