A DIGITAL TRAINERS TOOLBOX TO HELP CRANE OPERATORS UPDATE THEIR SKILLS FOR INDUSTRY 4.0 ENVIRONMENTS

Didactic Manual
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MODULE 1 - Safety/Tools and Equipment
Learning Units (LU) indicative time: (5 hours)

INTRODUCTION

This Module corresponds to the normative part applicable to the handling of the different types of cranes and to the specific Legislation on Health and Safety in the workplace, as well as to the list of Regulations related to lifting equipment in each partner’s country.
All the Risks to which the worker is exposed during the handling of the crane are described, as well as the preventive measures and good practices so that the risk does not materialise.
The usual starting and stopping procedures are described below, as well as the existence of possible dangerous manoeuvres and the corresponding safety instructions. E.g. checking the state of the ground and proximity hazards. Installation of truck crane stabilisers, placing of safety notices and cordonning off the working area. All of these can be a risk for the worker himself and for third parties.

LEARNING OBJECTIVES

- Knowing the specific risks that originate in the work carried out with mobile cranes as well as the preventive measures and safety systems to be adopted for them.
- To learn about the legislation on health and safety at work in the countries of the Consortium (Romania, Malta, Greece, Spain) and the regulations concerning lifting equipment.
- Understand and know how to correctly use the procedures established for starting and stopping the crane corresponding to the beginning and end of the working day. Forbidden or dangerous manoeuvres.
- Know the manoeuvre signalling codes.
- Know the limits of use of the lifting equipment.
- Know the work instructions related to the work itself and/or the place where it is used: check the state of the ground and proximity dangers. Installing truck crane stabilisers. Placing safety notices and cordonning off the working area.
- Know the emergency response procedures.
LU 1.1 Safety

1.1.1 Health and safety legislation for working with mobile cranes

NORMATIVE REFERENCE

The safety of workers is a concern that is becoming increasingly important. As an example, the European Union has developed several directives that require its member states to maintain laws for the safe manufacture and use of equipment.

The reference standards in this field in the various countries of the participating partners are listed below:

SPAIN

Regulations applicable to self-propelled mobile cranes in Spain:

1. RD 1644/2008, of 10 October, which establishes the rules for the marketing and putting into service of machines.
2. RD 1215/1997, of 18 July, which establishes the minimum health and safety requirements for the use of work equipment by workers.
3. RD 837/2003, of 7 June, which approves the new modified and rewritten text of the Complementary Technical Instruction "MIE-AEM-4" of the Regulation on lifting and handling equipment, referring to self-propelled mobile cranes.

1) Royal Decree 1644/2008 standards for the marketing and commissioning of machines. The purpose of Royal Decree 1644/2008 is to establish the requirements for the placing on the market and putting into service of machinery in order to guarantee its safety and free movement, in accordance with the obligations established in Directive 2006/42/EC of the European Parliament and of the Council.

In order to market and use a self-propelled mobile crane in accordance with current regulations, it must follow a series of steps, which are described below. The objective will be to obtain the CE mark, which certifies that all the relevant steps to have a safe machine have been taken: According to RD 1644/2008, self-propelled mobile cranes can be included within the framework of its definitions. As they do not belong to the group of machines in annex IV of this royal decree, the way to obtain the CE marking is first to draw up a technical file to prove the conformity of the machine with the requirements of the directive. In addition to this, an internal manufacturing control must be carried out to ensure that the necessary measures are being taken to guarantee the conformity of the product. After this step, the EC declaration of conformity of the machine will be obtained, and finally the CE marking can be affixed to the machine. The characteristics of the marking have to be in accordance with the directive. When this process is completed, the machine can be placed on the market and put into service.
**Manufacturer:** Is the person who assumes responsibility for the design and manufacture of a machine or quasi-machine. He may be established in the Community or outside it. A manufacturer is someone who changes the intended use of a machine, assuming responsibility for the consequences thereof, who manufactures machines or safety components for his own use and who assembles machines, partly completed machines or parts of machines of different origin. The manufacturer’s obligations are:

- To comply with the relevant essential health and safety requirements.
- To compile the technical file.
- To provide information on the machine.
- Carry out the appropriate conformity assessment procedures.
- To draw up the EC declaration of conformity.
- Affix the CE marking and certain information on the machine.

**Machine:** In the strictest sense of the word, you can say what a machine is:

- An assembly of linked parts or components, at least one of which is mobile, associated for a specific application, provided or intended to be provided with a drive system other than human or animal power.
- An assembly as referred to in the first indent, missing only the components to connect it to sources of energy and motion. - An assembly as referred to in the first and second indents, ready for installation and able to function only if mounted on a means of transport or installed in a building or structure.
- An assembly as indicated in the first, second and third indents above or of partly completed machines which, in order to achieve the same result, are arranged and operated as a single machine.
- An assembly of linked parts or components, at least one of which moves, which are joined together for the purpose of lifting loads and whose only source of power is directly applied human effort.
- Self-propelled mobile cranes belong to this group of definitions, although it is also true that in the broadest sense, the term machine applies to interchangeable equipment, safety components, lifting accessories, cables, chains and straps and removable mechanical transmission devices.

**Technical file of the machines:** The manufacturer must demonstrate the conformity of the machine with the requirements of the directive, and in order to assess it, must refer to the design, manufacture and operation of the machine. The technical file shall consist of a manufacturing file comprising the following: General description of the machine.

- Overall drawing and drawings of the control circuits, with descriptions and explanations for understanding the operation of the machine.
- Detailed and comprehensive drawings to enable the conformity of the machine with the essential health and safety requirements to be verified (accompanied, where appropriate, by calculation notes, test results, certificates, etc.).
- Documentation relating to the risk assessment, showing the procedure followed, including a list of the essential requirements applied and a description of the protective measures applied, with an indication of any residual risks.
- Standards and other technical specifications used, indicating the essential requirements covered by these standards.
- Any technical report giving the results of the tests carried out by the manufacturer or by a body a copy of the instructions for use.
- Where appropriate, a declaration of incorporation of the partly completed machinery, with assembly instructions.
- Where applicable, a copy of the EC declaration of conformity for each machine or product incorporated into the machine.
- Copy of the EC declaration of conformity.

In the case of series production, it will also contain the internal provisions to be applied to maintain the conformity of the machines with the directive.

**Internal manufacturing control:**

- The manufacturer must take the necessary measures to ensure that the manufacturing process is carried out in such a way as to guarantee the conformity of the manufactured machine with the technical file and the requirements of the Directive.
- Essential health and safety requirements:
  - These are mandatory requirements and aim to establish a high level of safety. The manufacturer or his authorised representative must ensure that a risk assessment is carried out in order to determine which essential health and safety requirements apply to the machine. Through an iterative process of risk assessment and risk reduction, the manufacturer or his authorised representative must:
    - Determine the limits of the machine, including its intended use and reasonably foreseeable misuse.
    - Identify the hazards generated by the machine and the corresponding dangerous situations.
    - Estimate the risks, considering the severity of possible injury or damage to health and the probability of their occurrence.
    - assess the risks, in order to determine whether a reduction of risks is desirable, in accordance with the objective of the Directive.
    - Eliminate the hazards or reduce the risks arising from them, by applying preventive measures, in the following order of priority
      - Safe inherent design.
      - Protective measures.
      - Training measures (residual risks, training needs, personal protection...). The machine must be designed and manufactured taking into account the results of the risk assessment.

**EC declaration of conformity of the machines:** The content of the EC declaration of conformity is shown below:

- Company name and full address of the manufacturer and, where appropriate, his authorised representative.
- Name and address of the person empowered to compile the technical file, established within the Community.
- Description and identification of the machine including generic name, function, model, type, serial number and commercial name.
- Paragraph expressly stating that the machine complies with all the provisions applicable to Directive 2006/42/EC.
- If applicable, a paragraph declaring that the machine complies with other Community Directives and/or relevant provisions.
- If EC type-examination has been applied, the name, address and identification number of the notified body and the number of the certificate.
- If the full quality assurance procedure has been applied, the name, address and identification number of the notified body that has approved the quality system.
- Reference of the harmonised standards, or other technical standards or specifications that have been applied
- Place and date of the declaration.
- Identification and signature of the person empowered to draw up the declaration on behalf of the manufacturer or his authorised representative.

**CE marking:**

It consists of the initials CE designed as follows and accompanied by the identification number of the notified body (when applying the procedure of total quality assurance). The CE marking implies compliance with other applicable directives that require it to be affixed. This marking must be affixed next to the name of the manufacturer or his authorised representative. Where a Member State ascertains that machinery bearing the CE marking, accompanied by the declaration of conformity and used in accordance with its intended purpose or under conditions which can reasonably be foreseen, is liable to endanger the health and safety of persons and, where appropriate, domestic animals or property, it must take all appropriate measures to withdraw such machinery from the market, to prohibit the placing on the market and/or putting into service of such machinery or to restrict free movement thereof. Non-conformity would result from failure to meet the essential requirements, incorrect application of the harmonised standards and a shortcoming in the harmonised standards themselves.

**2) Royal Decree 1215/1997 on safety and health for the use of work equipment.**

RD 1215/97 (transcription of the European directive 85/665/EEC promoting measures for the improvement of workers’ safety and health conditions) in its article 3, obliges the employer since 1997, to adopt the necessary measures to make safe equipment available for use by workers. It must take account of ergonomic principles, particularly as regards the design of the workplace. Maintenance must be established in accordance with the manufacturer’s instructions so that the cranes maintain their initial safety conditions. In addition, it must also be ensured that workers and workers’ representatives receive relevant training and information on the risks arising from the use of the equipment and the preventive and protective measures to be taken.

This Royal Decree also establishes the minimum conditions that lifting equipment must have in order to be used safely, without endangering the health of workers.
Minimum requirements for work equipment for lifting loads:

- They must be firmly installed in the case of fixed equipment. Their solidity and stability during use must be guaranteed.
- Machinery for lifting loads must have a clearly visible indication of its nominal load and, where appropriate, a loading plate stipulating the nominal load for each configuration of the machine.
- Those permanently installed must be installed in such a way as to reduce the risk of the load falling, being dropped, deflecting or striking workers.
- Machinery for the lifting or moving of workers must have the appropriate characteristics for
  - Avoid the risk of falling from the carrier.
  - Avoid the risk of the user falling out of the cabin.
  - Avoid the risks of crushing and entrapment.
  - Ensure the safety of workers who, in the event of an accident, are blocked in the passenger compartment and allow them to be released.

General conditions for the use of work equipment for lifting loads:

- Removable or mobile work equipment must guarantee the stability of the equipment during use.
- The lifting of workers shall only be carried out with equipment designed for this purpose.
- However, where, exceptionally, work equipment not intended for that purpose is to be used, appropriate measures must be taken to ensure the safety of workers and to provide adequate supervision.
- The command post must always be occupied. Workers in the upper echelons must have a secure means of communication and provision must be made for their evacuation in the event of an emergency.
- The presence of workers under suspended loads must be avoided.
- Lifting accessories must be selected according to the loads being handled, the gripping points, the attachment device and the atmospheric conditions, and considering the mode and configuration of the lashing. Lifting accessory assemblies must be clearly marked so that the user is aware of their characteristics if they are not removed after use.
- Lifting accessories must be stored in such a way that they are not damaged or deteriorated

In the case of equipment for lifting non-guided loads, the following aspects must be considered:

- If two or more pieces of equipment are used in such a way that their fields of action may overlap, measures must be taken to avoid collisions between the equipment or loads.
- Measures must be taken to prevent swinging, tipping, shifting and slipping.
- If the operator is unable to observe the path of the load, a person must be appointed to signpost and give instructions to the operator. Organisational measures must also be taken to guide the operator and prevent collisions.
- A worker who is hanging or unhanging a load by hand must be able to do so in complete safety.
- All lifting operations must be properly planned, properly supervised and carried out in such a way as to protect the safety of workers. Where loads of more than one item of equipment are lifted simultaneously, a procedure must be drawn up and implemented to ensure that operators are well
coordinated.
- If any equipment cannot maintain the loads in the event of a failure of the energy supply, measures must be taken to prevent workers from being exposed to the corresponding risks.
- Suspended loads must not be left unattended unless access to the danger zone is impossible and the load has been safely suspended and is maintained in complete safety.
- Where weather conditions may pose a risk to operational safety and consequently to the safety of workers, appropriate protective measures must be taken, to prevent work equipment from tipping over.

According to Royal Decree 837/2003, of 27 June, which approves the new amended and recast text of the MIE-AEM-4 complementary technical instruction, a self-propelled mobile crane can be defined as a lifting apparatus of discontinuous operation, intended to lift and distribute in space loads suspended from a hook or any other grabbing accessory, equipped with its own means of propulsion and driving or forming part of a set with such means that enable it to be moved on public roads or land.
This Royal Decree defines the basic components of the cranes, such as rigging, crane base, cabin, counterweight, slewing ring, vane or free turning device, stabilisers, rotating structure, grabbing device limit switch and boom angle indicator, Hook load indicator, boom length indicator, load moment indicator, load limiter, lifting mechanism, boom extension mechanism, boom tilt mechanism, orientation mechanism, clamping device, boom and support bracket. It also refers to the different types of movements and types of speed it is capable of, as well as all the parameters related to the base, dimensional and load.

ITALY

Italian companies are required to adopt, in the interests of preventing accidents at work and occupational illnesses, a system of precautionary measures.
The new legal regime incorporates the content of Article 2087 of the Italian Civil Code, specifying that the employer is required to eliminate the risks present in the workplace in the light of existing technical knowledge and, where this is not possible, to reduce them to a minimum. Failure to observe the obligations imposed on the employer and on those designated in the various sectors is also made a punishable offence.
In Italy, health and safety at work are regulated by Legislative Decree Law 81/2008 (known as the “Testo Unico Sicurezza Lavoro”) recently modified. This decree transposes in Italy, the European Directive on the protection of safety and health of workers, coordinated in a single piece of legislation that provides for specific sanctions against defaulters.

The main provisions are related to the organization of thorough procedures to improve health and safety. The employer is required, in particular, to organize within the enterprise a protective and preventive service responsible for identifying risk factors and for their elimination or reduction to a minimum. The Decree also contains a number of stipulations on medical screening, establishing the person of a doctor responsible for the regular assessment and certification of employees’ physical fitness to perform the tasks assigned to them. Another of its important provisions concerns the election or appointment of a workforce representative on matters of health and safety who enjoys particular information and consultation rights.
In addition, the employer is under an obligation to provide employees with all general information on the risks present in the workplace and specific information on the risks associated with performance of the tasks assigned to individuals. Lastly, employees must receive adequate health and safety training specific to their own particular job at the time of their recruitment, in the event of a transfer or change of job, and in the event of the introduction of new work equipment or any new technology. There is also provision for special and appropriate training for safety representatives. Omission of the necessary precautions put upon the employer criminal liability and the right of the employer to ask damages.

Italian companies and subsidiaries who have not yet provided for the risk assessment, the preparation and updating of the document of evaluation of the risks, the establishment of prevention and protection service, the appointment of employees and the Service Manager Prevention and Protection, training courses, etc., risk an arrest from three (3) to six (6) months or a fine ranging from Euro 2,500 to Euro 6400 (art. 55, para. 1, TUSL) and the suspension of business (and its ban on bargaining with the Public Administration). The Legislative Decree Law n.81/2008 (TUSL) provides in Article 28 that all public and private Italian companies MUST draft and update a formal Document for the Evaluation of Risks ("Documento di Valutazione dei Rischi"), under the direct liability of the employer. The measures of prevention and protection, as well as personal protective equipment ("Dispositivi di Protezione Individuale") and the actions to be taken to update all the prevention measures will have to be implemented immediately or in a very short term if there is a matter of urgency, or will be included in the programming business when it comes to work adjustment provided for in the medium or long term.

Article 28 of TUSL sets that the Risk Assessment Document (DVR) must have the following contents:

- **Report on Risk Assessment**: containing details of all the risks to health and safety during work. This analysis is usually divided according to several risk factors, such as: workplace, machinery, equipment, chemical, physical and biological, organizational and management issues, etc. The analysis is preceded by information on the organizational chart and business. Should also indicate the criteria used for risk assessment.

- A statement of the **measures of prevention and protection** implemented in order to eliminate the above risks identified, or if it is not possible to completely eliminate them, reduce the risk to an “acceptable” level.

- **Identification of procedures for the implementation of security measures**;

- Indication of the **Service Manager for the Prevention** (Responsabile del Servizio per la Prevenzione e Protezione), of the **Protection of Workers’ Safety Representative** (Rappresentante dei Lavoratori per la Sicurezza) and the **Company’s Doctor** (Medico Competente);

- **List of personal protective equipment (DPI)**, which are protective clothing for workers to wear the personal protective equipment (e.g. safety shoes, helmet, gloves, masks, etc.).

- **Program of the measures** it considers necessary to **ensure the improvement of safety standards over time**, which means all those measures to be taken to improve levels of safety over time (maintenance, inspections, information activities and training of workers etc.).

- **Identifying the tasks that expose workers to specific risks**.
It is generally useful to integrate the Risk Assessment Document (DVR) with the following information:

- Safety procedures at work (policies, circular or written arrangements);
- Floor plans of the building/units analysed in the DVR.

The Risk Assessment Working Document (DVR) should be drafted and updated in a specific way, particularly for large and medium-sized companies. For small business with limited risk, it can be done via self-certification (up to 10 workers) or with standardized criteria’s (up to 50 workers).\(^1\)

**State-regions agreement of 22 February 2012 on work equipment**

Agreement, pursuant to Article 4 of Legislative Decree 28 August 1997, no. 281 between Government, Regions and Autonomous Provinces of Trento and Bolzano, concerning the identification of work equipment for which a specification is required qualification of operators, as well as the methods for the recognition of such qualification, the trainers, the duration, the addresses and the minimum requirements of validity of the training, in implementation of Article 73, paragraph 5, of the decree legislative 9 April 2008, n. 81 and subsequent amendments and additions. (Rep. Acts n. 53 / CSR). (Official Gazette 11.03.12 n. 60 - SO n.47).\(^2\)

**International Labour Organization (Reference Standards and Legislation).**


**Article 15(2). Lifting appliances.** The Committee also notes the information provided by the Government in reply to its previous request regarding the exceptional cases in which workers can be lifted using equipment not specifically designed for this purpose and the safety measures that must be taken in such cases.

**Article 15(2).** Lifting appliances. Raising, lowering or carrying persons in appliances constructed, installed and used for that purpose. The Committee notes that the TULS sets forth the principle that “no persons shall be raised, lowered or carried by a lifting appliance unless it is constructed, installed and used for that purpose” and that, subject to certain precautions, under the terms of paragraph 3.1.4 of Annex VI of the TULS, it is permitted not to apply that principle “in exceptional cases”. *Noting that Article 15(2) allows an exception only in “an emergency situation in which serious personal injury or fatality may occur”, the Committee requests the Government to provide information on the concept of “exceptional cases” used in the above paragraph of the TULS.*

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\(^2\) State-Regions Agreement of 22 February 2012 on work equipment “pursuant to Article 4 of Legislative Decree 28 August 1997, no. 281 between the Government, the Regions and the Autonomous Provinces of Trento and Bolzano, concerning the identification of the work equipment for which a specific qualification of the operators is required, as well as the methods for the recognition of this qualification, the trainers, the duration, guidelines and minimum requirements for the validity of the training, in implementation of article 73, paragraph 5, of legislative decree no. 81 and subsequent amendments and additions. (Rep. Acts no. 53 / CSR). (Official Gazette 11.03.12 n. 60 - SO n.47).
Health and Safety in Malta is regulated by the **Subsidiary legislation 424.09 workplaces (health, safety and welfare) regulations 9th February, 1987.**


**ARRANGEMENT OF REGULATIONS**

Regulations Preliminary
- Part I Safety - General Provisions
- Part II Health, Safety and Welfare - Special Provisions
- Part III Prevention and Control of Occupational Disease
- Part IV General Duties
- Part V Notification of Accidents
- Part VI Notices and Registers
- Part VII Enforcement
- Part VIII Offences and Penalties

Each of the above-mentioned chapters has a specific Addendum where each of the parts is regulated in more detail.

**Subsidiary legislation 424.35 work equipment (minimum safety and health requirements) regulations 6th September 2016.**

LEGAL NOTICE 293 of 2016. Citation and scope. 1.

The title of these regulations is the Work Equipment (Minimum Safety and Health Requirements) Regulations.

The scope of these regulations is to lay down minimum health and safety requirements for the use of work equipment by workers at the workplace. S.L. 424.18.

The provisions of the General Provisions for Health and Safety at Workplaces Regulations, hereinafter referred to as "the General Provisions Regulations", are fully applicable to the whole scope referred to in sub-regulation.

Without prejudice to more stringent and/or specific provisions contained in these regulations

It is a legal requirement to train workers required to operate such work equipment and machinery under legal notice 282 of 2004, regulations 3 (3.2) and 9 (a). Worker Training is also a generic requirement under Legal Notice 36 of 2003, Regulation 4 (3).

In the SCHEDULE III Reference is made to Lifting Accessories and Lifting Machines.

**Subsidiary legislation 424.03 dock safety regulations 7th September, 1953 government notice 497 of 1953, as amended by Act XLIV of 1965; Legal Notices 64 of 1966, 122 of 1977; Act XXVII of 1991; Legal Notice 114 of 1999; and Act XV of 2009.PART I Citation.1.**

It deals with specific aspects in the use of mobile cranes.

27. **Driver’s platform**

Cranes and winches shall be provided with such means as will reduce to a minimum the risk of the accidental descent of a load while being raised or lowered. In particular, the lever controlling the link motion reversing gear of a crane or winch shall be provided with a suitable spring or other locking arrangement.
28. Marking of safe working load on every crane and derrick
The driver’s platform on every crane or tip driven by mechanical power shall be securely fenced and shall be provided with safe means of access. In particular, where access is by a ladder:
(a) the sides of the ladder shall extend to a reasonable distance beyond the platform or some other suitable handhold shall be provided;
(b) the landing place on the platform shall be maintained free from obstruction;
(c) in cases where the ladder is vertical and exceeds nanometres and fifteen centimetres in height, a resting place shall be provided approximately midway between the platform and the foot of the ladder.

29. Marking of safe working load on every crane and derrick
Every crane and derrick shall have the safe working load plainly marked upon it, and every shore crane, if so constructed that the safe working load may be varied by the raising or lowering of the jib or otherwise, shall have attached to it an automatic indicator of safe working loads, provided that, in cases where the jib may be raised or lowered, provision on the crane of a table showing the safe working loads at the corresponding inclinations or radii of the jib shall be considered sufficient compliance.

30. Exhaust and live steam
Adequate measures shall be taken to prevent exhaust steam from, and so far, as it is practicable live steam to, any crane or winch obscuring any part of the decks, gangways, stages, wharf, or quay where any person is employed in the processes.

31. Foot of derrick
Appropriate measures shall be taken to prevent the foot of a derrick being accidentally lifted out of its socket or support

33. No lifting machinery to be loaded beyond safe working load
(1) No lifting machinery, chains or other lifting appliance shall be loaded beyond the safe working load, except that a crane may be loaded beyond the safe working load in exceptional cases to such extent and subject to such conditions as may be approved by the engineer in charge or other competent person, if on each occasion:
(a) the written permission of the owner or his responsible agent has been obtained;
(b) a record of the overload is kept:
Provided also that, where the load upon a single sheave pulley block is attached to the pulley block instead of to the chain or rope passing round the sheave, the load on the pulley block shall

34. Employment as driver of a crane or winch
No person under sixteen years of age and no person who is not sufficiently competent and reliable shall be employed as driver of a crane or winch, whether driven by mechanical power or otherwise, or to give signals to a driver or to attend to cargo falls on winch-ends or winch-bodies.

ROMANIA

Legislation for working with Mobile Cranes:

Order No. 1404 of 27 July 2010 approving the technical prescriptions
PT R1-2010 "Lifting machines (cranes, lifting devices, fork-lift trucks, self-propelled platforms and lifting platforms for disabled persons, vehicle lifts and special type lifting machines)",
PT R2-2010 "Electric and hydraulic lifts for persons, persons and goods or goods with internal drive", 
PT R3-2010 "In-use inspection of motion transmission elements, connecting/tightening elements/devices and load-pulling elements used in lifting installations: Cables, hooks, chains, textile straps, ropes and similar",
PT R1 / 2010 - Lifting Machines (cranes, lifting mechanisms, forklifts, self-lifting platforms including those for people with disabilities, elevators for vehicles and special type lifting machines).
PT R2 / 2010 - Electric and hydraulic elevators for people and goods with internal control
PT R3 / 2010 - Checking in use the transmission, connection and traction elements used for lifting installations

GREECE

General Occupational safety and health legislative framework

All issues concerning occupational safety and health (OSH) at national level are under the responsibility of the Ministry of Labour and Social Security. The General Directorate of Working Conditions and Health, responsible for the OSH legislation, strategy, organization, information, education, training and research issues and the Labour Inspectorate (S.E.P.E.), which is the inspection and the enforcement authority for the implementation of the labour legislation, are the principal competent state authorities.

The non-governmental OSH social partners play a crucial role to the common aim of improving the working environment and of minimizing the number of work-related accidents and occupational diseases, through the established national OSH social dialogue.

The Greek Focal Point via an enacted collaboration with the social partners and other organizations, has undertaken among other issues, the effort to coordinate and manage the operation of the National OSH Information Network.

The first legislation in Greece concerning OSH was Law 3934/1911 on Workers’ Health and Safety and Working Hours (Greek Law 3934, 1911) and Presidential Decree (PD) 14/3/1934 on Workers’ Health and Safety in Industries, Manufactures, Workshops etc. (Greek PD 14, 1934). A milestone in the development of OSH in the country was Law 1568/1985 on Health and Safety at Work (Greek Law 1568, 1985).


Given the complexity of the legislative framework, Law 3850 of 2 June 2010 has collated all the above OSH matters into a Code of Laws for the Health and Safety of Employees (Greek Law 3850, 2010). This legal document covers a wide range of issues:

- the Committees for Health and Safety at Work (EYAE) at the enterprise level (election procedure, role and number of representatives, etc.);
- the safety engineer (qualifications, duties, etc.);
- protective and preventive services (either external or internal, minimum conditions for their establishment and function);
- classification of enterprises in three different risk categories (A, high; B, medium; C, low);
- the occupational physician (qualifications, duties, minimum working time in an enterprise);
- health monitoring;
- training of employees, safety engineers and occupational physicians;
- the Council for Health and Safety at Work (SYAE) at the national level;
- Prefectural Committees for Health and Safety at Work (NEYAE);
- Special Committees for Health and Safety at Work (e.g., in shipyards);
- general requirements for buildings;
- protection of workers from physical, chemical and biological agents, fire, etc.;
- employers’ obligations (e.g., risk assessment, social dialogue).

At national level all issues concerning OSH are under the responsibility of the Ministry of Labour, Social Security and Social Solidarity, that is, the Directorate for Safety and Health at Work and the Labour Inspectorate (SEPE). According to the Regulation of Mining and Quarrying Activities, the Mines Inspectorate is responsible for the work conditions in these workplaces (Greek Ministerial Decision D7/A/12050/2223, 2011).

The Directorate for Safety and Health at Work promotes all issues related to OSH (except the inspection of the OSH legislation) (Dontas, 2014). It is the principal OSH administration agency (responsible for, among other duties, the planning, organisation, implementation, monitoring and evaluation of the national OSH strategy and policy, the national OSH system and the national OSH programme, in accordance with national priorities and the current EU OSH strategy). Its activities are mainly in the fields of OSH legislation, policy, administration, information management, training and research.

SEPE is responsible for the inspection and application of legislation on OSH either on social matters (work times, wages, social security, etc.) or on safety and health at work issues. Law 3996/2011 (Law 3996/2011) has introduced reforms to the inspectorate.

**OSH and worker participation in Greece**

Law 1568/1985 on Health and Safety at Work (Greek Law 1568/1985) has allowed the establishment of a number of institutions, such as OSH representatives and committees at the enterprise level and the Health and Safety at Work Council at the national level.

Law 3850/2010, which has amalgamated several laws and presidential decrees regarding OSH matters (Greek Law 3850/2010) includes provisions regarding consultation of workers; the right of workers and their representatives to make proposals; and balanced participation in accordance with national laws and practices.

It is important to notice that, according to legislative provisions, workers and their representatives must not incur unfavourable consequences due to OSH activities (Greek Law 3850/2010). In addition, worker representatives (trade unions and OSH representatives) are protected against dismissal (Greek Law 1264/1982).

In this context, workers and their OSH representatives shall take part or shall be consulted by the employer with regard to (Greek Law 3850/2010):

- anything which could have consequences on OSH;
- OSH training programs;
- safety and health regulation;
- persons who will undertake the duties of safety engineer and occupational physician;
- external OSH services;
- preparation of the risk assessment document;
problems associated with the interaction of a specific work environment and the wider general environment.

Workers and their OSH representatives have the right:

- to ask the employer to take appropriate measures;
- to submit proposals to him/her with the aim of mitigating OSH hazards and to remove risk sources;
- to approach the inspection authorities if they judge that the safety and health measures taken are inadequate for the protection of workers;
- to participate in visits conducted by inspection authorities at the workplace and to mention their observations.

Other regulations also include provisions for information and consultation on OSH matters. For example, such provisions are included in:

- protection of workers from noise (Greek PD 149, 2006);
- protection of workers from vibrations (Greek PD 176, 2005);
- protection of workers from artificial optical radiation (Greek PD 82, 2010);
- protection of workers from dangerous substances (Greek PD 338, 2001) and carcinogens (PD 399/1994);
- control of major-accident hazards involving dangerous substances (Greek Joint Ministerial Decision 172058, 2016);
- protection of workers from biological agents (Greek PD 186, 1995);
- working at display screen equipment (Greek PD 398, 1994);
- work equipment (Greek PD 395, 1994);
- manual handling of loads (Greek PD 397, 1994).

Health and safety legislation for working with mobile cranes

Professionals/companies that own or use lifting/work machinery are under the ‘Rules Controls Lifting Machine’ JMD, household 15085/593/2003 (Government Gazette 1186/B/ 08.25.2003), that includes the following types of machines: forklifts, wall-mounted cranes, overhead cranes, electric hoists, tower cranes, self-propelled cranes, parrots, aerial,, concrete pumps, cranes - excavators, airport equipment, lifting vehicles bridges, lifting column type garages, elevators, cargo, vehicle lifts, scissor lifting devices, automatic motor car parking systems.

Personnel and installation safety, as well as the Greek Government Gazette K 1186/B/25-08-2003, the EN and DIN 15018, 15019, 15020 standards, impose initial and periodic inspection of all equipment which execute lifting work.

The term lifting machinery includes a wide range of equipment which covers building cranes, mobile cranes, bridge cranes, monorails, forklifts, cranes on trucks and concrete pumps.

The inspection and certification procedure for the safe operation of a lifting machine, include the following steps:
- Control/review of maintenance documents, manuals etc., and certificates of previous inspection, equipment, wire ropes.
- Inspection of compliance with marking and safety requirements
- Inspection of mechanical, electrical parts prior to operation
- Operational inspection with and without load
- Operational inspection of safety devices

For professionals, owning or using forklifts - Project Control machines without certificates from recognized organizations, provided for substantial fines and removal of plates for project machinery.
1.1.2 Safety-related risks in handling on different types of cranes

<table>
<thead>
<tr>
<th>SPECIFIC RISKS</th>
<th>PREVENTIVE MEASURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overturning or collapse of the machine on objects or people due to Defective levelling of the machine.</td>
<td>General overturning</td>
</tr>
<tr>
<td>Location of the machine near slopes or unstable ground.</td>
<td>Installation conditions</td>
</tr>
<tr>
<td>Exceeding the maximum permissible load moment or the effect of the wind.</td>
<td>A crane is admitted being safe against the risk of tipping when, working on the most unfavourable tipping edge (line formed by two consecutive supports or stabilisers) it does not tip:</td>
</tr>
<tr>
<td>Use in conditions that are contraindicated by the manufacturer.</td>
<td>- When working sideways, as long as the centre of gravity of the machine plus the load is between this most unfavourable edge and the longitudinal axis of the machine.</td>
</tr>
<tr>
<td>Deficient handling of the equipment/controls.</td>
<td>- If you work in front or behind the slewing ring, provided that the centre of gravity of the machine plus the load is between the most unfavourable edge and the transverse axis.</td>
</tr>
<tr>
<td>Lack of training.</td>
<td></td>
</tr>
<tr>
<td>Lack of regular inspections.</td>
<td></td>
</tr>
<tr>
<td>Poor maintenance.</td>
<td></td>
</tr>
<tr>
<td>Lifting system failure.</td>
<td></td>
</tr>
</tbody>
</table>

**Terrain**

It should be checked that the ground is of enough consistency so that the supports (tracks, wheels or stabilisers) do not sink into it during the execution of manoeuvres or at access points.

The suitability of the ground is an essential aspect in the work of the mobile crane, as its stability depends fundamentally on the correct and adequate location or movement of the equipment.

If the transmission of the load is carried out through stabilisers and the ground is clayey or does not offer guarantees, it is preferable to extend the load distribution on the ground by increasing the support area by means of bases made up of one or more layers of railway sleepers or planks, at least 80 mm thick and 1,000 mm long, which will be placed between the ground and the stabilisers, in the second case crossing the planks of each layer in an orderly fashion over the previous one.
Supports

About tyres

When the crane is working directly on its pneumatics, the suspension should be locked, the wheels shimmed, and the handbrake applied and locked. By keeping the suspension rigid, the horizon-quality of the crane base is preserved regardless of the position of the arrow. In these cases, manufacturers recommend increasing tyre inflation pressure before moving from one situation to another.

About the stabilizers

When the mobile crane works on stabilisers, which is recommended even when the weight of the load to be lifted allows it to be done on the tyres, the support arms of the stabilisers must be extended to their maximum length and the correct horizontality of the machine must be maintained. The jacks must be raised so that the tyres are completely off the ground.

In the manoeuvre

The safe execution of a manoeuvre requires the knowledge of the weight of the load so, if it is not previously known, an approximation should be obtained by excess, cubing it and applying a specific weight between 7.85 and 8 Kg/dm3 for steels. The weight of the load will be added to that of the auxiliary elements (straps, shackles, etc.).

Once the weight of the load is known, the crane operator must verify in the worktables, specific to each crane, that the angles of elevation and range of the arrow selected are correct. If this is not the case, one of these parameters must be modified.

In operations such as rescuing accident vehicles, dismantling structures, etc., the manoeuvre must be carried out with special attention, because if the load is trapped and the traction is not exerted
vertically, the angle of pull itself can cause the working edge to have a load moment greater than the maximum admissible.

**Soil resistance**

For the maximum permissible ground pressure and soil resistance, please refer to the table (Permissible ground pressure (soil load capacity) according to DIN 1054) which shows the maximum permissible ground pressure data taken from DIN 1054:2005-1, which serves as a reference for the settlement of the crane. For its application, it is necessary to know the value of the pressures that the crane will exert (own weight plus the load to be lifted) during the manoeuvre and to verify that they are in accordance with the values reflected in the table. In all cases, it is important that the terrain on which the manoeuvre is to be carried out or on which the crane is to travel is suitably conditioned.

**Fall of the load on persons or objects due to:**

- Failure in the hydraulic circuit, brakes, etc.
- Crash of the loads or the end of the boom against an obstacle.
- Breakage of cables or other auxiliary elements (hooks, pulleys, etc.) and/or due to poorly carried out hooking or breakage.

**Knocks against objects due to:**

- Produced by the load during the manoeuvre.
- Breakage of cables in tension.

**Strobing loads and use of auxiliary elements**

The strobing must be carried out in such a way that the load distribution is homogeneous so that the suspended piece is in stable equilibrium, avoiding the contact of strobes with sharp edges by using corner pieces. The angle formed by the straps between them should not exceed 120° under any circumstances and should be less than 90°. It must always be checked, in the corresponding tables, that the useful load for the angle formed is greater than the real one.

Each of the auxiliary elements used in the manoeuvres (slings, hooks, shackles, frogs, etc.) will have enough load capacity to support, without deformation, the loads to which they will be subjected.

Cables with broken wires will be discarded, counted along a section of cable less than eight times its diameter exceed 10% of the total.
Manoeuvring area

The manoeuvring area is the entire space covered by the boom during its turn or trajectory, from the point where the cargo is tied up to the point where it is placed. This area must be free of obstacles and must have been previously signposted and fenced off to prevent the passage of personnel, while the manoeuvre is in progress.

If the passage of suspended loads over people cannot be avoided, previously established signals, generally sound, will be emitted so that they can be protected from possible detachment.

When the manoeuvre is carried out in a publicly accessible place, such as a road, the crane vehicle will be fitted with flashing or rotating lights in car yellow, located on its upper plane, which must remain lit only for the time necessary for their execution and in order to be visible from a distance, especially at night.

Personnel should not be placed in areas near moving fixtures.

The equipment must be installed in such a way as to allow correct visibility of loading and unloading operations by the operator and/or be assisted by a single signaller.

The load must not be accompanied while it is in movement.

Operators must remain or be located outside the radius of action of the load.

Different entrapment between auxiliary elements (hooks, slings, pulleys, etc.) or by the load itself due to:

Personnel located in the area of influence of the auxiliary elements in movement.

Inadequate installation of the equipment affecting the correct visibility of loading and unloading operations.

Accompanying the load while it is moving.

Electrical contacts due to:

Entering the boom or cables in contact with an electric line.

Faults in the electrical protection installation.

Previous actions

It should be checked beforehand:

If there are any overhead power lines in the vicinity of the planned work area.

The minimum distances between the line and the end of the boom in its maximum working position, as no contact is necessary for a download.

Have insulating lifting accessories (e.g. polyester slings, etc.) and insulate the hooks.
*Ground the mobile crane by means of an attached cable with a copper spike driven into the ground at a distance minimum of 3 metres from the crane.

Procedure for working in the vicinity of electrical lines.

Work in the vicinity of power lines is very dangerous because the pen can enter accidentally, in the line’s area of influence and cause an accident.

The first step to take is to request the disconnection of the line when the distance during the work is or may be less than 5 m.

If disconnection is not possible, the following measures:

Signalling and delimiting the line’s area of influence.

This can be done by using the fixed delimitations in the UNE 58151-1:2001 standard.
1.1.3 Type of crane depending on the risk group

Depending on the magnitude of the hazards that may arise in the operation of the cranes, there are four types of risk categories in which the cranes can be grouped, as follows:

<table>
<thead>
<tr>
<th>Risk group</th>
<th>Type of crane depending on the risk group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Movable cranes without tracks and those mounted on railway wagons:</td>
</tr>
<tr>
<td></td>
<td>- auto-crane</td>
</tr>
<tr>
<td></td>
<td>- crawler crane</td>
</tr>
<tr>
<td></td>
<td>- self-propelled cranes on tires</td>
</tr>
<tr>
<td></td>
<td>- towed crane</td>
</tr>
<tr>
<td></td>
<td>- cranes mounted on a railway wagon</td>
</tr>
</tbody>
</table>

Group A
https://www.freepik.com/

Group B
https://www.freepik.com/

Movable cranes on rails with arm and rotating platform:
- tower crane,
- gantry crane,
- Derrick crane.
Movable cranes on rails:

- overhead cranes,
- portal crane’s,
- suspended ceiling beams,
- cranes for casting.

Group C

https://www.freepik.com/

Special type cranes, not included in the previous groups:

- cable cranes,
- scissor cranes (Gaifer).

Group D

https://www.freepik.com/

Any type of crane (from groups A, B, C, D) operated from the ground by a button box, radio and infrared control.

Group E

https://www.freepik.com/
Regardless of the type of risk group, cranes must meet certain mandatory requirements for use, inspection, maintenance, failure reporting and measures taken for their safe operation.

It is essential to ensure resistance to the most severe stresses that may occur in operating conditions, due to the simultaneous action of mechanical stresses and environmental conditions in the work area (temperature, humidity, fog, wind; earthquakes, etc.). Ensuring security aims not only at the safety of users and exposed persons in the dangerous area but also at the environment.

The purpose of the technical inspections is to ensure their safe operation. The evaluation of cranes and auxiliary devices is carried out periodically, according to an established program, to determine their technical condition to ensure maximizing operational safety and user protection and not to affect the environment. The periodicity and number of maintenance and overhaul works will be established depending on the complexity of the crane, the operating regime, and the environmental conditions in which they work.

1.1.4 Risks in the operation of cranes

Elimination or reduction of risks and the adoption of the necessary protection measures for risks that could not be eliminated are basic principles in the integration of safety in crane operation.

Risk factors in the operation of cranes are:

- lighting system unsuitable for the activity to be carried out;
- the manoeuvring position that allows the worker to operate in safe conditions;
- improper visibility, identification, and marking of control elements to allow safe and fast handling;
- lack of signalling means and knowledge of their significance;
- safe starting and stopping depending on the existing risks;
- emergency stop devices that prevent dangerous situations, and block them after stopping;
- failure of the power supply system that could cause an unexpected start or prevent the moving elements from being switched off;
- control circuit failure;
- carelessness in monitoring the trajectories of moving elements to avoid hitting people, targets in the danger zone;
- risks due to lightning;
- handling cranes near electrical cables.
- malfunction of the safety components used in cranes depending on the crane type.

The main components generating accidents are:

- Limit switches;
- Load and moment load limiters;
- Cylinder fluid retention devices;
- Devices to block and prevent oblique movement;
- Buffers and stops;
- Supporting parts and rail cleaners;
- Hook fuses;
- Electrical contacts at the gates or access stairs on the crane;
- Electrical contacts on the door and access hatch in the control cabin;
- Electrical contacts on the zero position of the control levers;
- Electrical contacts of rail locking devices.

1.1.5 Rules and measures to avoid risks

All documents, as well as information on crane operators’ rules and warnings, must be drawn up in the national language of the country in which the crane is used. Defect’s identification activities, repairs or replacement of defective parts, functional testing of the crane after repairs, must be performed by persons who have a certificate in this field.

The certification and attestation must be performed by an inspection body designated and recognized for the supervision and technical verification in the operation of the cranes. The cranes can only be used if they meet the technical conditions provided by the manufacturer and if the general and specific labour protection rules are observed.

- The cranes are not maintained or repaired during operation.
- It is forbidden to use cranes to lift loads greater than the maximum permissible load corresponding to the load diagram.
- It is forbidden to use cranes with ground control for the transport of molten metal if they have not been specially designed and built for this purpose.
- It is forbidden to operate outdoor cranes if the wind speed exceeds the allowed values (20 m/s for portal cranes or 15.6 m/s for other cranes), as well as if the temperature is below -20 °C.
- The use of cranes is prohibited if the visibility of the operator is affected by smoke, fog or objects placed between the crane and the field of action of the crane.
- It is forbidden to operate boom cranes if there are electrical conductors in the range of the boom. The minimum distance of 1.5 m from non-insulated conductors must be ensured, respectively 1.2 m from insulated conductors (for voltages up to 1,000V), 3 meters, for lines where the voltage is less than 57000V; 5 meters, for lines where the existing voltage is equal to or greater than 57000 V. For areas of influence of high voltage lines above 6 kV, cranes must be equipped with devices to signal the entry of the crane arm into the area of influence.
- It is forbidden to carry loads over people, inhabited rooms (buildings, offices, etc.) or industrial halls.
- It is forbidden to use rigid elements for driving the load.
- It is forbidden to lift or move loads when the cable is in an oblique position
- It is forbidden to balance the loads to place them in a point that cannot be normally served by the crane;
- It is forbidden to transport people with a crane hook or other fastening devices
- It is forbidden to lubricate, clean, maintain or repair cranes during their operation.
- It is forbidden to get on and off the crane through places other than those specially designed for it and only when the crane is stationary.
- For the handling of containers containing gases or dangerous chemicals, special supports or devices are used for their binding and transport.
1.1.6 Obligations and responsibilities of the crane operator

Persons working on the crane must be professionally qualified and authorized following the provisions of the crane’s technical prescriptions and the legal provisions in force in the country where the crane is used. **The crane operator has the following obligations and responsibilities:**

- to know the crane on which it works and the technical conditions regarding its use;
- to know and respect the signalling code;
- to participate in the maintenance works, as well as in all technical verifications;
- to record in the supervision, register of the lifting installation all the observations regarding its deficiencies in operation;
- not to operate the lifting equipment as long as the safety conditions are not met in a hazardous area.
- not to use the crane in a state of fatigue, illness, under the influence of alcohol or hallucinogenic substances;
- when climbing the access ladder to the cabin, have both hands free
- to check the existence of lubricants in the lubrication places, according to the indications in the lubrication scheme from the technical documentation;
- to check the condition, winding, and fixing of cables or chains on drums, rollers, and eyelets;
- to check the hook and load securing devices;
- to verify the operation of signalling, lighting, ventilation, and air conditioning installations;
- to verify the existence and integrity of the parts of the lifting installation;
- to check the proper operation of the safety components minus the operation of the load and moment limiter;
- not to put into operation the lifting installation with the arm near the overhead electrical conductors or in their area of influence except under the conditions provided in this technical prescription;
- to perform manoeuvres only based on orders given following the signalling code of the designated load binder; the stop signal will be considered by any other person;
- to turn on the beacon lights in case of low visibility as well as at night;
- not to carry the load on people;
- not to carry people with hooks or other fastening devices and not to allow balancing the loads by the weight of some people;
- to perform the manoeuvres for the horizontal movement of the loads so that they are at a distance of at least 1 m from the objects within the range of the crane;
- to prohibit the access of other persons in the control cabin or on the crane.
- to bring in the stop position (“zero” position) all the control devices;
- to ensure the closing of the cab after the end of the working hours, in order not to allow the crane to be started by unauthorized persons.
LU 1.2 Communications for hoisting

1.2.1 Manoeuvre signalling codes

MANUAL GUIDANCE OF LOADS. HAND-EYE COORDINATION

Ask any crane operator and they will tell you that one of the main factors for a successful project is coordination. Working in-sync with your team on the ground is not only crucial for safety but can help your project run smoothly, on schedule and keep the boss happy. With absolute precision and accuracy needed for a job, being able to clearly communicate direction is critical – but this is not always an easy task. Construction sites can be exceptionally loud and busy, meaning verbal communication is at risk of being drowned out by roaring machinery.

So how does an operator, with a load suspended in air, follow instructions from their team? Using the simple but effective method of hand signals. This age-old technique is used by crane operators across the world, aiding them to accurately receive unmistakable directions without the need for fancy equipment or even words! Although radios can be used to relay messages across the site, there are some situations when an operator will need extra assistance. There are also times when an operator’s directional visibility is obstructed or the visibility of a load area is partially blocked, conducting a lift within these types of conditions can put the operator and the workers around them at serious risk of injury. Although it recommended to use hand signals during all lifts, it is in these situations when a signal person will definitely be called upon. Easy to understand, hand signals help the operator avoid any potential hazards, completing actions in a safe and timely manner.

1.2.2 The Role of a Signal Person

As the eyes and the ears of a dedicated area or crane, a signal person carries many responsibilities. Before a person can direct the operation of a crane, they must first undergo formal training and complete a qualification in crane signalling. In training, a person will not only develop an understanding of standard hand signals, but they will also be required to become familiar with many different types of cranes, how each crane functions and any hand signals specific to particular equipment. The trainee signal person is required to grasp an understanding of the large library of signals without any memory prompts and show competence in recalling these during an examination by a third-party provider.

The signal person is also responsible for preventing injury and accidents to the best of their ability, this is done by following strict procedure during crane operation, for instance standing in clear view of the crane operator, ensuring the operating area is clear of people or hazardous objects and performing one signal at a time to avoid confusion.
1.2.3 Commonly Used Signals

The Occupational Safety and Health Administration (OSHA) standard method of signalling must be used when operating a crane. When using hand signals, the SIGNALIST or RIGGER should be positioned in front of the OPERATOR as far away from the load as possible and in a visible position where all hand signals are easily and clearly seen by the operator. The speed of hand and arm movement indicates the speed of manoeuvring for the load. The CRANE OPERATOR and the SIGNALIST or RIGGER must be trained in the theory and practice of the International Code of Hand Signs for Crane Working to safely carry out the instructions issued by the SIGNALIST.

If you cannot see the load easily, it is necessary that someone helps you with the signalling and/or when established by the company or by the characteristics of the area, it is advisable that, when manoeuvring the crane, a SIGNALIST or RIGGER should intervene. The gesture communication between the SIGNALIST and the operator will be carried out by means of a series of specific, clear and precise gestures in accordance with the universal standard code system or, if a radio telephone system is used, by means of short sentences perfectly tested and known by the SIGNALIST and the OPERATOR.

All persons involved in these activities must be aware of these rules to ensure safety and accident prevention when operating a crane. The signaller must wear the identification elements and clothing appropriate, such as jacket, sleeves, reflective armband and helmet.
Stop signals – are one the most important hand signals used on a construction site. When stop signals are used operation of the equipment must be halted.

Stop – In order to pause or stop an action, the signal person will extend a single arm and face their palm down; they will then begin to swing the extended arm back and forth.

Emergency stop – A signal person will communicate an emergency stop by extending both arms horizontal of the body with palms faced down, from this position they will swing their arms back and forth.

Dog everything – This signal will stop all activity and is performed by clasping hands together and placing them at waist level.

Boom signals – will inform the crane operator of which manoeuvre they should perform with the boom.

Raise boom – To raise the boom, a signal person will extend an arm horizontally to the side of their body and signal thumbs up, with a closed fist.

Lower boom – In order to lower the boom, the signal person will extend an arm horizontally and signal thumbs down, with a closed fist.

Swing boom – To swing the boom, the signal person will extend an arm out horizontally, using their index finger to point in the direction the boom is to swing.
Extend boom – To lengthen the boom, the signal person will place their hands at the front of their waist and point thumbs outwards with remaining fingers in a fist.

Load signals – will dictate what the operator should do with a load once it has been lifted by the crane.

Hoist load – In order to lift the load upwards the signal person will extend their arm vertically towards the ceiling/sky, point with their index finger and make small circles with their hand and index finger.

Lower load – To lower the load downward, the signal person will extend their arm horizontally, pointing their index finger towards the ground, once in this position they will make a circle motion with their finger.

The signal person can also control the pace of any movement using speed signals.

Move slowly – In order to slow the rate of an action, the signal person will place their hand above the hand which is giving the action signal.

See the full list of OSHA standard method hand signals.
LU 1.3 High voltage electrical fundamentals

1.3.1 Fundamentals of electricity and the electrical system

In order to deal with the fundamentals of electricity, it is first necessary to know what electricity is. It can be defined as the branch of physics that studies the electrical and magnetic phenomena caused by electrical charges at rest or in motion.

When electrical phenomena are manifested in a certain region of space, it is said that this region has an electric field, due to the presence of electric charges. If an electric charge is placed in such a space, it will be subjected to a force, according to Coulomb’s Law:

\[ F = K \frac{(q \cdot q')}{d^2} \]

Where d is the distance between the charges q, F is the force and K is a constant of proportionality.

The electric field has to do some work to move a charge from point A in space to another point B. This work is defined as the potential difference between A and B; and is expressed as VAB if there is a potential difference between these two points, with units in Volts (V).

We can define the current intensity as the charge that passes through a given surface per unit of time. Its unit is the Ampere (A).

\[ I = \frac{dq}{dt} \]

Once these basic concepts have been defined, it is necessary to refer to the different elements that are present in a circuit. These elements are classified as linear if their behaviour can be expressed by a linear function.

Linear elements are resistors, generators, coils or inductances and capacitors. It is important to highlight a phenomenon related to resistors: these elements produce a voltage drop between their terminals, which is directly proportional to the current passing through it; the relationship between the voltage and the current intensity is expressed as:

\[ V = R \cdot I \]

Where R, the resistance value, is the constant of proportionality between voltage and current. This is the expression of Ohm’s Law.

Non-linear elements are those whose behaviour is not determined by a linear function. Non-linear elements include diodes and transistors.

In relation to current we can distinguish two types: alternating current, in which the magnitude and direction of the current varies cyclically; and direct current, in which the flow of electric charges does not change direction over time, always circulating in the same direction.
THE ELECTRICITY SYSTEM

The four fundamental stages that make up the electricity system are:

1. Generation: which is carried out with the generating power stations, where electrical energy is obtained from different primary energies.

2. Transmission: carried out by the transmission grids. The networks are overhead lines that connect the lifting transformer stations of the power stations with the reducing transformer substations. In other words, they are responsible for transporting energy over long distances and at high voltage, which in Spain is between 220 and 400 kV.

3. Step-up transformer stations are located at the outlet of generation plants, and their mission is to raise the output voltage to a voltage value suitable for high-voltage transmission. On the other hand, step-down transformer substations perform several functions, including the reduction of voltage values to values suitable for incorporation into the distribution network.

4. Distribution: carried out by the distribution networks. These networks are made up of power lines that bring the power to the large consumption centres. The distribution networks have voltage ranges from 13.8 to 132 kV.

5. Transformation and consumption: the transformation centres transform the medium voltage values of the distribution network to values suitable for low-voltage consumption, with output values between 400 and 230 V.

1.3.2 Work in the vicinity of power lines

Carrying out a loading manoeuvre in a certain place requires taking into account the environment and the circumstances of the place where the work is to be carried out. In this regard, it is advisable to take into account the area where the work is to be carried out, use the rules for signalling manoeuvres, respect safety distances and take into account the proximity to overhead power lines.

PREVIOUS ACTIONS

As mentioned in previous sections, the following must be checked beforehand:

- If there are overhead power lines in the vicinity from the planned work area.
- The minimum distances between the line and the end of the boom in its maximum working position, as contact is not necessary for a discharge to occur.
- Provide insulating lifting accessories (e.g. polyester slings, etc.) and insulate the couplings.
- Ground the mobile crane by means of a cable connected to a copper spike driven into the ground at a minimum distance of 3 meters from the crane.
WORK PROCEDURE FOR WORK IN THE VICINITY OF POWER LINES

Working in the vicinity of power lines is very dangerous because the boom can accidentally enter the area of influence of the line and cause an accident.

The first measure to be taken is to request the disconnection of the line when the distance during the work is or can be less than 5 m. If disconnection is not possible, the following measures must be taken:

- Signpost and delimit the area of influence of the line. For this purpose, the delimitations established in standard UNE 58151-1:2001 can be used.
- Maintain a safety distance.

### RATED VOLTAGE | MINIMUM DISTANCE
--- | ---
Up to 1 Kv | 1 m
> 1 Kv up to 110 Kv | 3 m
> 110 Kv up to 220 Kv | 5 m
> 220 Kv up to 380 Kv | 5 m
Line with unknown voltage | 5 m

If it is not feasible to maintain the safety distance, the line must be protected by a protective screen. being:

D: Distance between sleepers equal to 0.5 m.
d: Distance of the screen to the power line of 5 m if the voltage is greater than or equal to 50 Kv and 3 m if it is less than 50 Kv.
1.3.3 Accidental contact procedure

In the event of accidental contact of the boom or cables with a live power line, the crane operator must remain calm and stay in the cabin until the line is taken out of service, as there is no danger of electrocution inside the cabin. If possible, he should warn all persons involved in the operations to stay away from the vicinity of the self-propelled crane and, if possible, try to move the crane to a safe area. However, if you are absolutely forced to abandon it, you should do so by jumping with your feet together, as far away from the machine as possible to avoid simultaneous contact between the machine and the ground.

1. For work in the vicinity of power lines, the following considerations must be taken into account:

- For work in an unusual area, check for the presence of any overhead conductors.
- Maintain the minimum safety distances to high-voltage lines. If this is not possible, the lines must be disconnected.
- If the line voltage is unknown, the minimum safe distance between the machine and the cables must not be less than 5 meters. This applies equally to all devices and accessories installed on the machine.
- Bear in mind that the wind can move the cables and that machine components can oscillate during sudden movements. This simple unintentional approach can cause an electric arc.
- The minimum safety distances to high-voltage lines and power lines of railways, trams, etc. must be observed.
- The machine must not be used to remove materials under power lines if any part of the machine and/or auxiliary accessories may come into contact with the power line, unless the local services of the electricity distribution company have given permission.
- If welding work is carried out on the load/basket, the screw clamp of the welding machine must be fixed to the mechanical part, so that no compensating current is transmitted.
2. The machine must be earthed before being put into service in the following cases:

- When approaching transmitting installations (radio and television stations, radio stations, etc.).
- When approaching high frequency installations.
- In the event of severe thunderstorms or a storm about to break out.

3. If, despite all care, an electric shock occurs, the following should be observed:

- Remain calm and do not move.
- Warn people in the vicinity to keep a safe distance.
- The minimum distance should be at least 10 m (zone of influence). (Zone of influence).
- Leave the zone of influence (when leaving the zone of influence, keep your legs closed and keep jumping due to the tension of the passage).
- Never leave the command post. Stay where you are and do not touch any objects.
- Immediately order the lines to be disconnected while driving.
- Before rescuing persons in the electrical circuit, the power line must be disconnected.
- In the case of a lifting platform, work must be stopped immediately, and the machine must be grounded.
- Remain in the cab and manoeuvre in such a way that contact with the power line ceases. Do not panic.
- Move the vehicle away from the site and prevent anyone from approaching the tyres that are still inflated.
  If it is not possible to stop contact (without causing the line to break), stay in the cab and keep people away until the line has been disconnected.

4. If the vehicle catches fire or is forced to abandon the vehicle:

- Check that there are no power lines on the ground or on the vehicle, in which case leave the vehicle on the opposite side.
- Jump down from the vehicle, always avoiding touching the vehicle and the ground at the same time.
- Try to fall as far away from the cab as possible, with your feet together and walk with your feet together and as close together as possible, taking small steps, jumping or keeping a single point of contact with the ground (one foot) and avoiding any objects in the area.
- Long steps should not be taken because it is possible that the potential difference between the two feet may be large enough to become lethal.

5. On the other hand, if you are present:

- Stay away from the site and do not attempt to help any possible casualties.
- If you notice that contact with the line persists or that a conductor (cable) has become detached or broken, call the electricity company to disconnect the line.
- If there are casualties, call an ambulance, ask for medical assistance.
6. If lightning strikes during a thunderstorm, proceed as follows:

- Immediately stop the operation.
- Lower the load/basket to the ground as far as possible.
- Retract the boom/arm as far as possible or lower it to a safe position. If this is not possible, the operator should remain in control of the machine.
LU 1.4 Tools and equipment

1.4.1 Limits on the use of loads and lifting equipment

Lifting accessories must be selected according to the loads to be handled, the gripping points, the coupling device and the atmospheric conditions, and taking into account the mode and configuration of the mooring. Lifting accessory assemblies must be clearly marked so that the user is aware of their characteristics if they are not removed after use. e) Lifting accessories must be stored in such a way that they are not damaged or when working with cranes, many factors are always considered to ensure the proper functioning of the machinery. One of these aspects is the calculation of the maximum load that a crane can lift without suffering complications or causing accidents.

We can say, for example, that when working with a hydraulic truck crane you cannot depend on the tyres to keep the vehicle and the load completely stable during the lifting operation. The truck uses four anchors that act as a balance and serve to prevent the crane from tipping to one side or the other. However, it is a common mistake to assume that the weight of the load on a crane will be equally distributed on each of the four platforms. Here it is necessary to calculate the potential force that will be exerted on any platform before deciding whether or not it is safe to lift the weight.

To do this, these three steps must be followed:

1. Add the weight of the crane itself to the weight of the load you are trying to lift to obtain the total weight that will be pushed down on the anchorage platforms. It does not matter if you are using the metric or English model system.
2. Multiply the square of the radius of one of the anchorage platforms by PI to obtain the surface area. The radius of the platform is equal to half its diameter. Be sure to use the same measurement system, either metric or English model, that you used in Step 1.
3. Divide the total weight used in Step 1 by the surface area calculated in Step 2 to obtain the total potential load on one of the anchor platforms, both in pounds and kilograms. If your crane is not qualified to handle that amount or more, it will not be safe to lift.

WARNINGS

Do not lift any loads unless the outriggers are properly extended, and the crane is level.

When calculating a load, it should be considered that all accessories are also counted as load, not only the material to be handled. Therefore, the weight of the rope, hook, beams, slings and shackles must also be added to the load to be lifted in order to determine the total weight of the load.

Do not assume that a configuration of different slings makes the lifting safer, as you can assume that you have the safe working load by the number of slings that make up the branch.
When lifting rigid objects with three or four sling branches, you must ensure that at least two of the slings can carry the full load alone.

1.4.2 Lifting equipment regulation

For regulatory purposes a distinction must be made between lifting accessories and other equipment used for lifting loads with lifting machinery.

LIFTING ACCESSORIES

The purpose of Directive 2006/42/EC, transposed into national law by Royal Decree 1644/2008, is to lay down the requirements for the placing on the market and putting into service of machinery, in order to ensure the safety of such machinery and its free movement. It is expressly stated in its application:

- Lifting accessories.
- Chains, cables and straps.

THE MACHINERY DIRECTIVE PROVIDES THE FOLLOWING DEFINITIONS

- **Lifting accessory**: a component or equipment which is not an integral part of the lifting machinery, enabling the load clamp, located between the machine and the load, or on the load itself, or intended to be an integral part of the load and marketed separately. Slings and their components are also considered to be lifting accessories.
- **Chains, ropes and webbing**: chains, ropes and webbing designed and constructed for lifting purposes as part of lifting machinery or lifting accessories.
Other definitions considered to be of interest are:

- **Manufacturer**: The natural or legal person who designs and/or manufactures machinery or partly completed machinery covered by this Royal Decree and who is responsible for the conformity of such machinery or partly completed machinery with this Royal Decree, with a view to marketing it under his own name or trademark or for his own use. In the absence of a manufacturer within the meaning of this Royal Decree, any natural or legal person who places on the market or puts into service machinery or partly completed machinery covered by this Royal Decree shall be regarded as a manufacturer.

- **Authorised representative**: a natural or legal person established in the European Community who has received a written mandate from the manufacturer to perform on his behalf all or part of the obligations and formalities connected with this royal decree.

- **Putting into service**: First use, in accordance with its intended use, in the European Community, of a machine covered by this royal decree.

**Additional essential health and safety requirements to offset the hazards arising from lifting operations**

Machinery presenting hazards due to lifting operations must comply with the requirements of the Machinery Directive. It is important to be familiar with certain concepts relating to the safety of lifting accessories, for example:

- **Working coefficient**: the arithmetic ratio between the load that a component can carry, guaranteed by the manufacturer or his authorised representative, and the maximum working load marked on the component.

- **Test coefficient**: the arithmetic ratio between the load used to carry out the static or dynamic tests on lifting machinery or a lifting accessory and the maximum working load marked on the lifting machinery or lifting accessory respectively.

- **Static test**: the test during which lifting machinery, or a lifting accessory is first inspected and subjected to a force corresponding to the maximum working load multiplied by the appropriate static test coefficient and then re-inspected once the load has been removed to ensure that no damage has occurred.

- **Dynamic test**: the test during which the lifting machinery is operated in all its possible configurations at maximum working load multiplied by the appropriate dynamic test coefficient taking account of the dynamic behaviour of the lifting machinery in order to check that it functions properly.
1.4.3 Protective measures against mechanical hazards

To avoid risks due to lack of stability, the manufacturer or his authorised representative must use appropriate verification methods. In addition, devices must be provided to prevent equipment, components or the load from falling. When accessories are used, they must be able to withstand the stresses to which they are subjected and lifting accessories must be designed and manufactured in such a way as to prevent failure due to fatigue or wear.

The materials used must be chosen considering the expected working environment, paying particular attention to corrosion, abrasion, impacts, extreme temperatures, fatigue, fragility and ageing. They must be designed and manufactured in such a way that they can withstand without permanent deformation or visible defect the overloads due to the static tests. Resistance calculations must ensure an adequate level of safety. The tools must be able to withstand without failure the dynamic tests carried out with the maximum working load multiplied by the dynamic test coefficient. In general, they must be carried out under the most unfavourable conditions to ensure a favourable result.

- **Pulleys, drums, rollers, ropes and chains.** Pulleys, drums and rollers must have diameters compatible with the dimensions of the ropes or chains with which they can be equipped.

  Drums and rollers must be designed, manufactured and installed in such a way that the cables or chains with which they are equipped can be wound up without leaving the intended location.

  Cables used directly for lifting or supporting the load must not have any splices except at their ends. However, splices will be tolerated in those installations which, due to their design, are destined to be modified regularly according to the needs of use.

  The working coefficient of the cable assembly and its endings is selected to guarantee an adequate level of safety; as a general rule, this coefficient is equal to 5.

  The working coefficient of lifting chains must be chosen in such a way as to guarantee an adequate level of safety; as a rule, this coefficient is equal to 4.

  In order to verify that an adequate working coefficient has been attained, the manufacturer or his authorised representative must, for each type of chain and rope used directly for lifting the load and for each type of rope ending, perform the appropriate tests or have such tests performed.

- **Lifting accessories and their components.** Lifting accessories and their components must be sized for a number of operating cycles in accordance with their intended life under the operating conditions specified for the application concerned, taking into account fatigue and ageing phenomena. In addition:

  a) The working coefficient of wire-rope/rope-end combinations must be chosen in such a way as to guarantee an adequate level of safety; this coefficient is, as a rule, equal to 5.

  b) Where chains with welded links are used, they must be of the short-link type. The working coefficient of chains must be chosen to guarantee an adequate level of safety; as a rule, this coefficient is equal to 4.
c) The working coefficient for textile ropes or slings is dependent on the material, method of manufacture, dimensions and use. This coefficient is chosen to guarantee an adequate level of safety; it is, as a general rule, equal to 7, provided the materials used are of proven excellent quality and the manufacturing process is appropriate to the intended use. Otherwise, the coefficient will, as a rule, be higher in order to provide an equivalent level of safety. Ropes or textile fibre clamps shall not be fitted with any splicing, looping or linking except at the end of the sling or in the closure of an endless sling.

d) The working coefficient of all metallic components making up, or used with, a sling must be chosen to guarantee an adequate level of safety; as a rule, this coefficient is equal to 4.

e) The maximum working load of a multi-legged sling must be determined taking into account the working coefficient of the weakest leg, the number of legs and a reduction factor which depends on the slinging configuration.

f) In order to verify that an adequate working coefficient has been attained, the manufacturer or his authorised representative must, for each type of component referred to in (a), (b), (c) and (d), perform the appropriate tests or have such tests performed.

1.4.4 Control of movements

All movements of loads must always be carried out safely, always within the specified limits. Appropriate measures must be taken if several loads converge simultaneously. It must be ensured that there will be no unexpected movements or falls of the loads.

MOVEMENT OF LOADS DURING HANDLING

The machines must be designed in such a way that the trajectory of the loads and tools can be controlled, avoiding possible collisions with people or objects.

INFORMATION AND MARKING OF CHAINS, CABLES AND STRAPS

Each lifting chain, cable or strap must bear clearly visible identification with the name and address of the manufacturer or its authorised representative and the identification of the corresponding certification. The above-mentioned certification must contain at least the following information:

a) The name and address of the manufacturer and, where appropriate, his authorised representative.

b) A description of the chain or rope, including its nominal dimensions, its manufacture, the material used in its manufacture, and any special metallurgical treatment to which the material has been subjected.

c) The test method used.

d) The maximum working load to be borne by the chain or rope.

A range of values may be indicated depending on the intended applications.
INFORMATION AND MARKING OF LIFTING ACCESSORIES

Lifting accessories must bear the following information: Identification of the material when this information is required for safety in use, the maximum working load.
In the case of lifting accessories for which marking is physically impossible, the information must be given on a plate or other equivalent means and be firmly attached to the accessory.
The markings must be legible and must be located in a place where they cannot disappear as a result of wear or compromise the strength of the accessory.

OPERATING INSTRUCTIONS FOR LIFTING ACCESSORIES

Lifting accessories must be accompanied by an instruction manual containing at least the following information:

a) The intended use.
b) The limits of use
c) Assembly use and maintenance instructions.
d) The static test coefficient used

1.4.5 Common risks of the use of the equipment or derived from other related productive processes

GENERAL RISKS

Entrapments due to:
Existence of mechanisms and gears in the open.
People located near the working area of the crane.
Placing the feet between the hydraulic jack of one of the stabilisers and the ground in the operation of lowering

Falls to different levels due to:
During the spoiling or reception of the load when it is carried out at different levels to the one where the machine is located.
Lack of collective protection elements in elevators equipped with front and side walkways.
Work carried out near slopes.
Existence of irregular, not very resistant and/or slippery terrains.

PREVENTIVE MEASURES

Mechanisms and gears must be protected by means of housings of sufficient strength.
The persons involved in the manoeuvres must not be located close to the crane’s working area, except for attachment or removal work with the crane not moving.
When lowering the lift, the operator must place the feet between the lift support arms or platforms and the ground.
The spoiling or reception of the load must be done on flat and resistant surfaces.
Lifts equipped with front walkways and sides must have protective elements collective such as complete railings.
Do not place the crane on uneven ground, which is not very resistant and/or slippery as well as in proximity of unstable slopes.
Working with poor visibility or insufficient lighting. Jumping from the cab to the ground. Placing the crane close to unevenness.

Do not jump from the cabin to the ground. Use the secure access systems to it. Do not climb on loads or objects unsuitable for improve the visibility of the operation carried out by the crane, your will look for a correct and safe location.

**Falls to the same level due to:**
Lack of order and cleanliness in the work area. Work area with puddles, mud, etc. Deficient lighting of the work area.

Keep the working area clean and free of obstacles. Place plates when there are puddles or mud. Provide adequate lighting around the crane.

**Contact with sharp objects during preparation or handling of loads due to:**
Loads with sharp edges and/or burrs, chips, etc. Existence of cutting elements present in the workplace without the corresponding PPE.

Inspect the load before it is spoiled, checking that it is packaged correctly, with no protrusions, irregularities, chips, burrs, etc. Use mechanical protection and anti-cut gloves.

**Falling objects on people due to:**
Raising loads that are badly damaged or held in place by loose objects or objects submerged in mud. Existence of badly stacked loads. Failure in the elements for lifting and transporting the load: hydraulic circuit, brakes, etc. Due to the collision of the loads or the end of the boom with an obstacle, breakage of cables or other elements.

Before starting work, check the state of the hydraulic circuit, brakes, cables, etc. Raise loads once they have been correctly spoiled, checking that there are no loose objects or that they are submerged in mud. The crane operator must always have a good visibility of the whole boom route and its load. If necessary, you should be assisted by another person (signaller), who is in communication permanent with the crane operator. The vertical of the load passage area must be free of people or vehicles.

**Crashes of the load against people and/or materials due to: Existence of personnel or materials in the area where the crane passes.**
Crane invasion of work, transit or storage areas without prior notice. Limited visibility for the crane operator.

The crane transit area must be clear of people or objects and whether an area can be invaded with persons or objects, prior notice must be given to people involved to leave it. The crane operator must be able to see the whole loading manoeuvre.

**Overexertion in manual load preparation due to:**
Assist in the manual lifting of loads. Trying to eliminate load oscillations manually. Manual handling of auxiliary material weighing more than 25 kg.

Manual force should not be used for balancing loads, control them or avoid any oscillation. Prevent the loads from oscillating and if they do occur, stop the manoeuvre until the oscillation stops.
Do not manually handle auxiliary material of weight over 25 kg.

**Burns due to:**
Contact with hot surfaces (exhaust gases).
Handling or contact with moving slings.

**Sound trauma inside the cockpit, work area, etc., due to:**
Noise generated by the engine and/or work area (construction sites, traffic, etc.), with exposure levels (daily equivalent level) above 87 dB(A).

**Poisoning by exhaust fumes due to:**
Proximity to the exhaust pipes of combustion engines, especially when their adjustment is defective.
Entry into the crane cabin of exhaust gases due to a broken pipe.
Breakage of gas conduction pipes when moving materials.

The operators involved in the operations the loading dock workers must wear protective gloves anti-abrasive.

The crane operator must wear appropriate hearing protectors to the type of noise (frequency spectrum) existing in accordance with Royal Decree 286/2006 (In Spain) and standard UNE-EN 458 (European) provided that the evaluation of risks determine the existence of risk for trauma sound. In this case, the communications between people involved in the loading operation such as the use of gesture signals.

There must be a preventive maintenance programme of the crane that contemplates the revision of all the ducts related to the evacuation of engine exhaust fumes.

The crane operator must be in a place that allows him to see the loading operations while being away from the exhaust gas outlets.
To be achieved upon learning outcome completion

Knowledge:
- Applicable legislation of the country regarding health and safety conditions
- Requirements for their use
- Procedures and instructions regarding their handling, as well as having knowledge
ASSESSMENT

1. For work in the vicinity of power lines. Identify the false answer.
   - The crane operator must remain in the cab and manoeuvre in such a way that contact with the power line ceases.
   - The first measure to be taken is to request the disconnection of the line when the distance during the work is or may be less than 10m.
   - In the event of accidental contact of the shaft or cables with a live power line, leave the area of influence only by jumping out of the way. When doing so, keep your legs closed due to the tension of the passage.
   - If it is not possible for the contact to cease (without causing the line to break), stay in the cabin, keeping people away, until the line has been disconnected.

2. The SIGNALLER or RIGGER. Mark the correct answer/s
   - Is the crane operator's assistant.
   - Does not need any special clothing
   - He/she uses a code of signals to manoeuvre safely and avoid accidents.
   - Gestural communication between the crane operator and the operator is by means of a series of specific, clear and precise gestures in accordance with the universal standard code system or, if a radiotelephone system is used, by means of a radiotelephone system.
   - He/she normally never stands in front of the Operator.

3. Identify risk factors in crane operation:
   - Inadequate lighting system for the activity to be performed;
   - Inadequate visibility, identification and signalling of control elements to allow safe and quick handling.
   - No emergency stops devices to prevent dangerous situations and to lock them after stopping;
   - Malfunctioning of safety components used on cranes depending on the type of crane.
   - All of the above

4. The crane operator's duties and responsibilities include:
   - No knowledge of the crane on which he/she is working and the technical conditions of its use; - No knowledge of the signalling code.
   - He does not know the signalling code; this is only the responsibility of the RIGGER.
   - He does not contribute to the maintenance work, nor is his presence required for all technical checks.
   - He operates the lifting installation with the boom in the vicinity of overhead electrical conductors or in their area of influence.
   - All are correct
   - All are false

5. A signalman communicates an emergency stop by;
   - By extending both arms horizontally across the body with palms downwards, from this position he/she swings the arms back and forth.
   - True
   - False
6. Lifting accessories shall be accompanied by an instruction manual containing at least the following information. Mark the correct answer

☐ The intended use.
☐ The limits of use.
☐ Instructions for assembly, use and maintenance
☐ The static test coefficient used.
☐ All of the above

7. During crane operations, the crane operator can be trapped by the existence of mechanisms and gears in the open air.

☐ True
☐ False
MODULE 2 - Rigging
Learning Units (LU) indicative time: (6 hours)

INTRODUCTION

The purpose of the second modules is to inform the crane operator regarding the main rigging operations and the pre-operational checks to be performed which include the requirements for planning and performing a lift using a crane and commonly available rigging components, such as slings, shackles, eye bolts, and turnbuckles. The Module thoroughly explores the types of wire ropes and their main use and inspection criteria. It then explains the main rigging hardware, their care, use, maintenance and disposal. The third unit will guide the learner to plan and perform a lift safely by explaining the main load calculations, main lifting notions and gravity calculation. The module then continues with sling configurations. The last two units are dedicated to rigging, hoisting and reeving. The units identify the basic hazards in rigging and hoisting, explains the main safeguarding procedures to control or eliminate these hazards.
All the information contained in the module should be used in conjunction with the applicable regulations by contractors, supervisors, operators, riggers, and others delivering or receiving instruction in the basics of safe rigging and hoisting.

LEARNING OBJECTIVES

This module aims at specifying the competences required to perform advanced rigging, including planning and preparing for work, conducting operational checks, safely and effectively performing advanced rigging activities for a range of tasks.
This module should be complemented with national regulatory requirements. After the completion of the module, the learner will be able to:

- Plan and prepare for rigging operations.
- Verify problems and equipment faults and demonstrate appropriate response procedures.
- Efficiently and safely perform advanced rigging operations.
LU 2.1 Wire rope

Wire ropes are used on all types of crane work and construction sites. There exist different kind of wire ropes which can be used for specific scopes; thus, it is important to take into consideration the following factors:

- A safety factor is put on all ropes used in industry. A sample piece of rope is tested to destruction which gives
- a Minimum Breaking Load (M.B.L.) and this breaking load is then divided by
- the Factor of Safety (relevant to the wire ropes intended use) to give the safe working load (S.W.L.) for that rope.

A test certificate is raised for each drum of rope at the manufacturers and a test certificate is issued with each length from a drum, stating the safe working load of the rope.

There are different rope constructions, each one having its own particular use. Nevertheless, there are three things to observe when examining the construction:

1. number of wires in each strand,
2. number of strands in each rope,
3. direction in which wires and strands lay (spiral) in the rope.

SELECTION OF WIRE ROPE

When selecting the equipment, a crane operator needs to take into consideration how to eliminate hazards to personnel, public and property for as long as the rope will be used and under all the conditions of exposure and operation.

The first thing to be taken into account is the workload since depending on the workload and safety factor, we will have the wire rope breaking strength.

Other factors that influence the choice of a rope are the size, grade, type and construction that are specified by equipment or rope manufacturers. We can summarise six basic requirements when selecting the rope:

- The rope must possess enough strength to take the maximum load that may be applied.
- The rope must withstand repeated bending without failure of the wire from fatigue.
- The rope must resist abrasion.
- The rope must withstand distortion and crushing.
- The rope must resist rotation.
- The rope must resist corrosion.
**TYPES OF WIRES**

The four basic constructions are:

- **Ordinary/regular lay:** all wires are the same size
- **Warrington:** outer wires are alternately larger and smaller
- **Filler:** small wires fill spaces between larger wires
- **Seale:** wires outer layer is larger diameter than wires of inner layer.

**TWISTING TORQUE AND ROTATION**

When a wire rope is bearing a load, two effects can be observed:

1. When the two ends of a wire rope are fixed, the force applied causes twisting at the fixed points.
2. When one of the ends of the wire is free and a load is attached, the wire rope tends to rotate.

If the load and the height increase, the wire rope tends to rotate more. The degree to which the rope generates twisting depends on its construction. There are two main types of wire ropes to counteract this effect: the *non-rotation* wire rope which has three layers of strands in different directions of lay to the previous one and the *rotation resistant* wire rope which has two layers of strands. In this way, the twisting torque of each layer is compensated by the twisting torque of the next layer.
FATIGUE AND ABRASION RESISTANCE

Wire ropes tend to deteriorate due to bending fatigue they are subjected to when bearing a load and flexing on the sheaves and drums. Abrasion takes place between the wire rope and the sheaves and drums. To prevent it, a wire rope with a high outer strand diameter should be used.

CRUSHING STRENGTH

In multi-layer winding applications, the wire rope should be installed with a tension between 2 and 10% of the breaking strength in order to avoid crushing between layers and deterioration.

WIRE ROPE INSPECTION

It is essential to have a well-planned program of regular inspection carried out by an experienced inspector. The wire ropes in continuous service should be checked daily during normal operations and inspected on a weekly basis. A more complete and thorough inspection of all ropes must be made at least once a month. These checks are mandatory and depends on the country regulations.

A record of each rope should report the date of installation, size, construction, length, extent of service and any defect found. The inspector will decide whether the rope should be discarded basing the decision on whether the wires are broken, worn or abraded, if the rope diameter is reduced, if the rope is stretched or corroded, and whether the strands are crushed, flattened or jammed.

PROCEDURES AND PRECAUTIONS WITH WIRE ROPE

- Ensure that the right size and construction of rope is used for the job.
- Lubricate the rope regularly according to manufacturer’s guidelines.
- Never overload the rope. Minimise shock loading. To ensure there is no slack in the rope, start the load carefully, applying power smoothly and steadily.
- Never use frozen ropes.
- Take special precautions and/or use a larger size rope whenever:
  - The exact weight of the loads is unknown
  - There is a possibility of shock loading
  - Conditions are abnormal or severe
  - There are hazards to personnel.

- Use softeners to protect rope from corners and sharp edges.
- Avoid dragging rope out from under loads or over obstacles.
- Do not drop rope from heights.
- Store all unused rope in a clean, dry place.
- Never use wire rope that has been cut, kinked or crushed.
- Ensure that rope ends are properly seized.
- Use thimbles in eye fittings at all times.
- Prevent loops in slack lines from being pulled tight and kinking. If a loop forms, don’t pull it out – unfold it. Once a rope is kinked, damage is permanent. A weak spot will remain no matter how well the kink is straightened out.
- Check for abnormal line whip and vibration.
- Avoid reverse bends.
- Ensure that drums and sheaves are the right diameter for the rope being used.
- Ensure that sheaves are aligned and that fleet angle is correct.
- Sheaves with deeply worn or scored grooves, cracked or broken rims, and worn or damaged bearings must be replaced.
- Ensure that rope spools properly on the drum. Never wind more than the correct amount of rope on any drum. Never let the rope cross-wind.
LU 2.2 Rigging hardware

SAFETY DEVICES: OPERATING PRINCIPLES AND CONTROLS

Rigging skills are utilized in millions of jobs, from construction to Aerospace. Cranes and rigging are important tools in the manufacturing industry, processing Industry, and in many other industrial areas. Unfortunately, many times training for proper use and selection of rigging is taken for granted or ignored completely. Only approved methods and practices should be used for rigging. And rigging operations should only be performed by trained and experienced personnel.

Mobile crane operators must recognize any changing conditions in their work environment that could affect safety. A mobile crane operator always maintains a safe work environment and knows how to use personal protective equipment (PPE) and safety equipment.

In operations, communication is vital so that all personnel involved in the lift are aware of what is happening. Documentation such as logbooks and crane certification are essential for organizing daily operations of a crane.

Riggers and crane operators should always ensure that all components of the rigging are secure and load is balanced. They need to ensure that there is no twist in multi-leg swing and unused slings are securely stored out of the way.

Most importantly, operators and riggers need to plan their lifts and ensure they have a place to land their load safely and securely.

LIFTING GEARS

Lifting gears play an important part in the lifting operation. Their function is to tie the objects tightly and hang them on the crane. There is a great variety of lifting gears. If there is insufficient knowledge or a wrong choice is made, lifting may fail and accidents may result. All lifting gears shall be tested by qualified examiners and suitably marked with a Safe Working Load (SWL). Some lifting gears include wire rope slings, chain slings, shackles, eye bolts, hooks, rings, links and swivels.

SPECIFIC LIFTING ACCESSORIES: TYPES, USES, MAINTENANCE AND REPLACEMENT

Crane operators need to be aware of what hardware to use, how to use it, and how its working load limits (WLL) compare with the rope or chain used with it.

All fittings must be of adequate strength for the application. Only forged alloy steel load-rated hardware should be used for overhead lifting. Load-rated hardware is stamped with its WLL.

It is important to inspect hardware regularly and before each lift. Check for signs of:

- Wear,
- cracks,
- severe corrosion,
- deformation/bends,
- mismatched parts,
- obvious damage.
HOISTING HOOKS

Hooks are a vital part of lifting gear. A variety of them cater for different lifting purposes.

- Should be equipped with safety catches (except for sorting or grab hooks).
- Should be forged alloy steel with WLL stamped or marked on the saddle.
- Should be loaded at the middle of the hook. Applying the load to the tip will load the hook eccentrically and reduce the safe working load considerably.
- Should be inspected regularly and often. Look for wear, cracks, corrosion, and twisting – especially at the tip – and check throat for signs of opening.

Safety tip: Whenever two or more ropes are to be placed over a hook, use a shackle to reduce wear and tear on thimble eyes.

WIRE ROPE CLIPS

Wire rope clips are widely used for making end terminations. Clips are available in two basic designs: U-bolt and fist grip.

When using U-bolt clips, the operator should make sure to have the right type of clip. Forged alloy clips are recommended, U-bolt clips need to be attached correctly. The U-section must be in contact with the dead end of the rope.
STEP 1

APPLY FIRST CLIP one base width from dead end of wire rope. U-Bolt over dead end. Live end rests in clip saddle. Tighten nuts evenly to recommended torque.

STEP 2

APPLY SECOND CLIP as close to loop as possible. U-Bolt over dead end. Turn nuts firmly but DO NOT TIGHTEN.

STEP 3

APPLY ALL OTHER CLIPS. Space evenly between first two and 6-7 rope diameters apart.

STEP 4

APPLY TENSION and tighten all nuts to recommended torque.

STEP 5

CHECK NUT TORQUE after rope has been in operation.

SWIVELS

- Reduce bending loads on rigging attachments by allowing the load to orient itself freely.
- Should be used instead of shackles in situations where the shackle may twist and become eccentrically loaded.
SHACKLES

Hook rings are divided into two main categories: Chain ("D" type) shackle and anchor (bow) type shackle. Both are available with screw pins or round pins.

![Shackle Types]

**Shackles in use**

To be remembered:

- For hoisting, should be manufactured of forged alloy steel.
- Do not replace shackle pins with bolts. Pins are designed and manufactured to match shackle capacity.
- Check for wear, distortion, and opening up. Check crown regularly for wear. Discard shackles noticeably worn at the crown.
- Do not use a shackle where it will be pulled or loaded at an angle. This severely reduces its capacity and opens up the legs.
- Do not use screw pin shackles if the pin can roll under load and unscrew.

EYEBOLTS

Eye bolts are mainly classified into plain (shoulderless) eye bolts and shoulder type eye bolts.

- The bolt length shall be 1-1.5 times the diameter of the bolt and totally drilled on the load.
- The bolt hole shall fit into the bolt.
Eye bolt in use

- For hoisting, use eye or ring bolts of forged alloy steel.
- Use bolts with shoulders or collars. Shoulderless bolts are fine for vertical loading but can bend and lose considerable capacity under angle loading. Even with shoulders, eye and ring bolts lose some capacity when loaded on an angle.
- Make sure that bolts are at right angles to hole, make contact with working surface, and have nuts properly torqued.
- Pack bolts with washers when necessary to ensure firm, uniform contact with working surface.
- Make sure that tapped holes for screw bolts are deep enough for uniform grip.
- Apply loads to the plane of the eye, never in the other direction. This is particularly important with bridle slings, which always develop an angular pull in eye bolts unless a spreader bar is used.
- Never insert the point of a hook in an eye bolt. Use a shackle instead.
- Do not reeve a sling through a pair of bolts. Attach a separate sling to each bolt.

SNATCH BLOCKS

- A single or multi-sheave block that opens on one side so a rope can be slipped over the sheave rather than threaded through the block.
- Available with hook, shackle, eye, and swivel end fittings.
- Normally used when it’s necessary to change the direction of pull on a line. Stress on the snatch block varies tremendously with the angle between the lead and load lines.

HOIST RINGS

The rigger must be able to rig the load to ensure its stability when lifted. This requires a knowledge of safe sling configurations and the use of related hardware such as shackles, eyebolts and wire rope clips. Determining the working load limits of the rigging equipment as well as the weight of the load is a fundamental requirement of safe rigging practice.

It is extremely important not to use any equipment that is suspected to be unsafe or unsuitable until a competent person verifies its suitability.

The working load limits of all hoisting equipment and rigging hardware are based on ideal conditions which can be rarely replicated in the real field. It is important for a crane operator to recognise the factors that can affect the rated working load limits of the equipment and hardware.
TURNBUCKLES

Can be supplied with eye end fittings, hook end fittings, jaw end fittings, stub end fittings, and any combination of these.

- Rated loads are based on the outside diameter of the threaded portion of the end fitting and on the type of end fitting. Jaw, eye, and stub types are rated equally; hook types are rated lower.
- Should be weldless alloy steel.
- When turnbuckles are exposed to vibration, lock frames to end fittings. This will prevent turning and loosening. Use wire or manufacturer-supplied lock nuts to prevent turning.
- When tightening a turnbuckle, do not apply more torque than you would to a bolt of equal size.
- Inspect turnbuckles frequently for cracks in end fittings (especially at the neck of the shank), deformed end fittings, deformed and bent rods and bodies, cracks and bends around the internally threaded portion, and signs of thread damage.

THE SLINGS: TYPES, MATERIALS, SAFETY, USE, MAINTENANCE AND REPLACEMENT

The professional mobile operators need to be capable of describing the use of lifting equipment and their functions.
Wire rope slings should be inspected frequently for broken wires, kinks, abrasion and corrosion. All wire rope slings should be made of improved plow steel with independent wire rope cores to reduce the risk of crushing.

WIRE ROPE SLINGS

Wire rope consists of individual wires laid into a number of strands, which are then wrapped around a central core. Different numbers of wires in the strands and various methods of arrangement may affect the characteristics of the wire rope sling. The wire rope shall be equipped with a thimble and with pressed metal sleeve and marked with a Safe Working Load (SWL).
Inspection points

The wire rope sling shall not be used and shall be disposed if any one of the following is present.

Different types of damage possible for wire rope slings

The use of wire rope slings for lifting materials provides several advantages over other types of slings. While not as strong as chain, it has good flexibility with minimum weight. Breaking outer wires warn of failure and allow time to react. On smooth surfaces, the basket hitch should be snubbed against a step or change of contour to prevent the rope from slipping as load is applied.

The angle between the load and the sling should be approximately 60 degrees or greater to avoid slippage. On wooden boxes or crates, the rope will dig into the wood sufficiently to prevent slippage. On other rectangular loads, the rope should be protected by guards or load protectors at the edges to prevent kinking.

Loads should not be allowed to turn or slide along the rope during a lift. The sling or the load may become scuffed or damaged.

CHAIN SLINGS

Chain slings are suited to applications requiring flexibility and resistance to abrasion, cutting and high temperatures. Wherever they bear on sharp edges, chain slings should be padded to prevent links from being bent and to protect the load. Never tie a knot in a chain sling to shorten the reach. Inspect chain slings for inner link wear and wear on the outside of the link barrels.
Crane operators should check chain slings for nicks and gouges that may cause stress concentrations and weaken links. If nicks or gouges are deep or large in area, or reduce link size below allowable wear, remove the chain from service. Any repairs must be done according to manufacturers’ specifications.

**FIBRE ROPE SLINGS**

Fibre rope slings are preferred for some applications because they are pliant, grip the load well and do not mar its surface. They should be used only on light loads, however, and must never be used on objects that have sharp edges capable of cutting the rope or in applications where the sling will be exposed to high temperatures, severe abrasion or acids.

The choice of rope type and size will depend on the application, the weight to be lifted and the sling angle. Before lifting any load with a fibre rope sling, be sure to inspect the sling carefully. Fibre slings deteriorate far more rapidly than wire rope slings and their actual strength is very difficult to estimate.

Like other slings, fibre rope slings should be inspected regularly. Look for external wear and cutting, internal wear between strands, and deterioration of fibres. Open up the rope by untwisting the strands but take care not to kink them. The inside of the rope should be as bright and clean as when it was new. Check for broken or loose yarns and strands.

**SYNTHETIC WEB SLINGS**

Web slings are available in two materials – nylon and polyester. Nylon is resistant to many alkalis whereas polyester is resistant to many acids. Nylon slings are more common but polyester slings are often recommended where headroom is limited since they stretch only half as much as nylon slings.

Synthetic web slings offer a number of advantages for rigging purposes:

- Their relative softness and width create much less tendency to mar or scratch finely machined, highly polished or painted surfaces and less tendency to crush fragile objects than fibre rope, wire rope or chain slings.
- Because of their flexibility, they tend to mould themselves to the shape of the load.
- They do not rust and thus will not stain ornamental precast concrete or stone.
- They are non-sparking and can be used safely in explosive atmospheres.
- They minimize twisting and spinning during lifting.
- Their light weight permits ease of rigging, their softness precludes hand cuts, and the danger of harm from a free-swinging sling is minimal.
- They are elastic and stretch under load more than either wire rope or chain and can thus absorb heavy shocks and cushion loads. In cases where sling stretching must be minimized, a sling of larger load capacity or a polyester sling should be used.

Synthetic web slings are available in a number of configurations useful in construction.

**NYLON SLINGS**

Type 1: Triangle & Choker (TC) - Hardware on each end produces the most effective choker hitch. Can also be used in vertical and basket hitches.

Type 2: Triangle & Triangle (TT) - Hardware on each end for use in basket or vertical hitch.

Type 3: Flat Eye & Eye (EE) - Popular, versatile sling used in vertical, choker & basket hitches. Easy to remove from underneath loads.

Type 4: Twisted Eye & Eye (EE) - Eyes turned at a right angle to sling body. Forms superior choker hitch & allows better fit on crane hook in basket hitch.

Type 5: Endless (EN) - Economical & adaptable sling with no fixed wear points. Used in all hitches. Both ends of one piece of webbing lapped and sewn to form a continuous piece. They can be used as vertical hitches, bridle hitches, in choker arrangements or as basket hitches. Because load contact points can be shifted with every lift, wear is evenly distributed and sling life extended.

Type 6: Reversed Eye (RE) - Extremely strong & durable for continuous &/or abusive applications. Wear pads on both sides of body.
LU 2.3 Introduction to rigging and hoisting

Mobile crane operators are involved in rigging to ensure that it is done safely and properly. While mobile crane operators may not be doing the rigging, they must possess knowledge of rigging procedures. Mobile crane operators have the final say and responsibility for any lift done by the crane.

The crane operator should know what hardware to use, how to use it, and how its working load limits (WLL) compare with the rope or chain used with it. All fittings must be of adequate strength for the application. Only forged alloy steel load-rated hardware should be used for overhead lifting. Load-rated hardware is stamped with its WLL. The crane operators need to inspect hardware regularly and before each lift.

CHAIN USE, CARE AND INSPECTION

Use

When using the chain slings, the operators should:

- Before use, inspect chain and attachments following the instructions under ‘inspection’ below.
- Do not exceed working load limit at any time. The operator should remember that the following listed factors can reduce the load a chain will hold:
  - Acceleration in rate of load application can produce dangerous overloading.
  - Twisting, knotting or kinking subjects’ links to unusual loading, decreasing the working load of the sling.
  - Use for purposes other than those for which slings are intended can reduce the working load of the sling.
  - Variations in the angle of the load to the sling, as the angle decreases, the working load of the sling will increase.
- Free chain of all twists, knots and kinks.
- Centre load in hook(s); hook latches must not support load.
- Avoid sudden jerks when lifting and lowering.
- Balance all loads; avoid tipping of loads.
- Use pads around sharp corners.
- Do not drop load on chains.
- Match the size and working load limit of attachments, such as hooks or rings, to the size and working load limit of the chain.
- For overhead lifting, use only alloy chain and attachments grade 80 and above.

Care

The operator should always remember that:

- Chains require careful storage and regular maintenance
- Chains need to be stored in a clean, dry place.
- To avoid corrosion, chains need to be oiled before prolonged storage.
- Chains don’t have to be heated; this will alter their thermal treatment.
- The surface finish of chain cannot be altered or changed. For harsh environments special chain is available.
**Inspection**

It is important both to inspect chain slings regularly, and to keep records of all chain inspections. Before inspecting, clean chains with a non-acid/non-caustic solvent so that marks, nicks, wear and other defects are visible. Inspect each link for these conditions:

- Twists or bends.
- Nicks or gouges.
- Excessive wear at bearing points.
- Stretch.

Distorted or damaged master links, coupling links or attachments, especially spread in throat opening of hooks. Mark plainly each link or attachment showing any of the conditions listed above to indicate rejection; remove from service until properly repaired.

**NYLON SLING: USE, CARE AND INSPECTION**

**Use**

Safe Operating Practices: Damage to synthetic slings from abrasion or cutting can be prevented if proper protection is provided on the job site. Common materials used to protect the sling from abrasion damage do not provide adequate protection from cutting. If a sling is exposed to an edge under pressure cutting may occur unless a proven method of protection is provided.

Prior to making a lift, the load be raised slightly, and then lowered so that the wear pads can be inspected for damage. If pads show evidence of cutting, the lift should be tested again using a different type/style of wear pad. Damaged or misused protection can result in damage or sling failure. Inspect before each use. Inspect for cuts, tears or damage that may prevent protection of the sling. Ensure protection is the correct size and type to protect the sling. Prevent pads and sling from slipping or sliding across load edge. Death or injury can occur from improper use, maintenance and/or inspection.

- Determine weight of the load. The weight of the load shall be within the rated capacity of the sling.
- Select sling having suitable characteristics for the type of load, hitch and environment.
- Slings shall not be loaded in excess of the rated capacity. Consideration shall be given to the sling to load angle which affects rated capacity.
- Slings with fittings which are used as a choker hitch shall be of sufficient length to assure that the choking action is on the webbing, and never on a fitting.
- Slings used in a basket hitch shall have the load balanced to prevent slippage.
- The opening in fittings shall be the proper shape and size to ensure that the fitting will seat properly in the hook or other attachments.
- Slings shall always be protected from being cut by sharp corners, sharp edges, protrusions or abrasive surfaces.
- Slings shall not be dragged on the floor or over an abrasive surface.
- Slings shall not be twisted or tied into knots, or joined by knotting.
- Slings shall not be pulled from under loads if the load is resting on the sling.
- Do not drop slings equipped with metal fittings.
- Slings that appear to be damaged shall not be used unless inspected and accepted.
- The sling shall be hitched in a manner providing control of the load.
- Personnel, including portions of the human body, shall be kept from between the sling and the load, and from between the sling and the crane hook or hoist hook.
- Personnel shall stand clear of the suspended load.
- Personnel shall not ride the sling.
- Shock loading shall be avoided.
- Twisting and kinking the legs (branches) shall be avoided.
- Load applied to the hook shall be centred in the base (bowl) of hook to prevent point loading on the hook.
- During lifting, with or without the load, personnel shall be alert for possible snagging.
- The slings' legs (branches) shall contain or support the load from the sides above the centre of gravity when using basket hitch.
- Slings shall be long enough so that the rated capacity of the sling is adequate when the angle of the legs (branches) is taken into consideration.

**Care**

Slings used in environments where they are subject to continuous exposure to ultra violet light (sunlight) should be proof tested to two times rated capacity semi-annually, or more frequently, depending on severity of exposure. Testing has confirmed that Nylon Slings lose fifty to sixty percent of their strength after 36 months of continuous exposure to sunlight. Polyester loses about thirty percent over the same period.

A sling shall be removed from service if any of the following are visible:
- If sling rated capacity tag is missing or not readable
- Acid or alkalis burns
- Melting, charring or weld spatter on any part of the sling
- Holes, tears, cuts, snags or embedded particles
- Broken or worn stitching in load bearing splices
- Excessive abrasive wear
- Knots in any part of the sling
- Distortion, excessive abrasive wear
- Any conditions which cause doubt as to the strength of the sling.

**Inspections**

Written inspection records should be established and kept on file for each new Sling. Records should include all the information taken from the Sling's identification tag (type, reach, rated capacity, manufacture, and date purchased), along with its location. These records should be updated after each periodic inspection.

IMPORTANT: all inspections must be done only by trained and qualified personnel.

(a) Initial Inspection: Before any new or repaired Sling is placed in service, it shall be inspected to ensure that the correct Sling is being used, as well as to determine that the Sling meets the requirements of this specification and has not been damaged in shipment.
(b) Frequent Inspection: This inspection shall be done each time the Sling is used.
(c) Periodic Inspection: Frequency of inspection should be based on: 1. Frequency of Sling use. 2. Severity of service conditions. 3. Experience gained on the service life of Slings used in similar applications. 4. Periodic inspections should be conducted at least monthly.
Repair

Sling webbing with structural damage shall never be repaired. Type 1 and Type 2 slings, and other web slings utilizing hardware, may be re-webbed utilizing existing fittings. It shall be the responsibility of the manufacturer repairing the web sling to determine if the hardware is re-usable. All re-webbed Type 1 and Type 2, and other web slings utilizing fittings, shall be proof tested to two times their vertical rated capacity before being placed back into service. A certificate of proof testing shall be provided. Temporary repairs of webbing, fittings, or stitching shall not be permitted.

SLING WEAR PADS

When slings are cut, property damage and/or personal injury or death can result. Sling wear pads can help to reduce this problem by acting as a buffer between the load and the sling. The number one cause of synthetic sling failure is cutting. When used with wire rope and chain slings, wear pads help protect both sling and the load from damage along points of contact.

Features and Benefits

Safety: It helps prevent sling cutting that can cause property damage, personal injury and/or death
Saves Money: Protects both sling and load from damage and increases sling life

Inspection Criteria for Sling Wear Pads

If pad is damaged, the sling may also be damaged. Inspect both thoroughly and check slings for:
- Wire Rope Slings: broken wires, kinking, crushing, abrasive wear, etc.
- Chain Slings: abrasive wear, nicks, cracks, gouges, stretch, etc.
- Web Slings: visible red core warning yarns, cuts on the face or edge of webbing, holes, tears, snags or crushed web, signs of abrasive wear, broken or worn threads in the stitch patterns.

RIGGING PROCEDURES

Mobile crane operators have the final say and responsibility for any lift done by the crane. Before a lift can be planned, it must be analysed to determine the lift’s category. There are three lift categories at BNL: incidental or ordinary lifts, pre-engineered lifts, and critical lifts. The responsible manager or designee determines the type of lift by conducting a lift assessment.

If the lift has been classified as a pre-engineered lift, then additional criteria must be met prior to operation. If determined to be a critical lift, riggers or an approved contractor must be used.

Ordinary Lift Plan Elements

Once a lift has been planned and approved, the appropriate rigging equipment, including slings, shackles, turnbuckles, and the crane itself, must be selected, inspected, and connected correctly prior to beginning the lift itself. The following items must be checked and confirmed before selecting rigging components:
- Weight of lift
- Centre of gravity
- Lift points
- Crane capacity
- Speed, height, width and length of lift
- Wind, temperature, and visibility
- Crane and load foundation ratings
- Sharp corners and angles on load
- Single angles
- Load angle factors
- Travel route clearance
- Floor loading capacity
- Work zone safety.

CALCULATING THE WEIGHT OF LOAD

1. **Determine volume**
   Measure the object to get dimensions (length, width, and height) and determine volume.
   Volume formulas:
   - Rectangle/square: Volume = Length x Width x Height
   - Hollow cylinder: Volume = \(3.14 \times \text{Length} \times \text{Wall thickness} \times (\text{Diameter wall thickness})\)
   - Complex shapes
     - In some cases, it’s best to imagine that the whole object is enclosed by a rectangle and calculate the volume of that rectangle.
     - In other cases, break the object into two or more smaller rectangles
       - Calculate the weight of each part and add them or
       - Look up weight per foot for structural shapes
   - For concrete reinforcing rod, calculate as a cylinder.

2. **Determine what material the object is made of**
   Look up the weight per unit volume for that material

3. **Determine weight of object**
   Multiply the weight per unit volume times the calculated volume to get the calculated weight of the object.

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<th>Kg/m³</th>
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</table>
EXAMPLE:

Rectangular Load
The object to be lifted is a steel block, 8 meters long, 4 meters wide and 6 meters high.
Volume = Length x Width x Height
= 8m x 4m x 6m
= 192 m³

Since steel weighs 7850 kg per m³ (see table above), the load will weigh approximately:
Block weigh = 192 m³ x 7850 kg/ m³ = 78,507 kg

CALCULATING THE CENTRE OF GRAVITY

Symmetrical loads
- The centre of gravity of a rectangular, symmetrical load can be found by inspection.
- Measure each side of the rectangle.
- Divide each side in half to locate the centre of gravity for that side.
- After, combine the results to determine the overall centre of gravity.

Asymmetric loads
- The easiest method for finding the centre of gravity of an asymmetrical load is to divide the object into rectangles and determine the centre of gravity for each first, as shown in the first image.
- For the example here, the left rectangle measures 5 m by 5 m, while the right-side rectangle measures 5 m by 10 m.
- Since the right-hand rectangle is twice as large as the smaller on the left, and since both are made of the same material, we can tell that 1/3 of the object’s weight is concentrated at the left centre of gravity (labelled "A"), while 2/3 is concentrated at the right (labelled "B").
- Draw a line connecting the two centres of gravity as shown and measure 2/3 of the way from centre of gravity A to centre of gravity B, as shown by the red line at right. That is the location of the final, combined centre of gravity for the block.
Other shapes

- To find the centre of gravity of a triangle, measure 1/3 the height from the base as well as 1/3 of the base from the steepest angle, as shown in the image.

- The centre of gravity of a circle of uniform weight is located exactly at the centre.

- The centre of gravity of a semi-circle may be determined as shown at right.

EXAMPLE:

Rectangular Load

Calculate the centre of gravity of a steel plate 4 m wide x 10 m long x 1/2 cm thick.

A. Measure “h”

H1 = 10 m

CG = 5 feet

B. H2 = 4 m

CG = 2 m
LU 2.4 Sling configurations

Slings are made of various materials as illustrated before. Additionally, they also come in various configurations for different purposes. In fact, the term “sling” covers a wide variety of configurations for fibre ropes, wire ropes, chains and webs. Correct application of slings commonly used in construction will be explained here because improper application can be dangerous.

THE SINGLE VERTICAL HITCH

The single vertical hitch supports a load by a single vertical part or leg of the sling. The total weight of the load is carried by a single leg, the sling angle is 90° (sling angle is measured from the horizontal) and the weight of the load can equal the working load limit of the sling and fittings. End fittings can vary but thimbles should be used in the eyes. The eye splices on wire ropes should be Mechanical-Flemish Splices for best security.

The single vertical hitch must not be used for lifting loose material, lengthy material or anything difficult to balance. This hitch provides absolutely no control over the load because it permits rotation. Use single vertical hitches on items equipped with lifting eyebolts or shackles.

BRIDLE HITCH

The single vertical hitch must not be used for lifting loose material, lengthy material or anything difficult to balance. This hitch provides absolutely no control over the load because it permits rotation. Use single vertical hitches on items equipped with lifting eyebolts or shackles.

Because the load may not be distributed evenly when a four-leg sling lifts a rigid load, assume that the load is carried by two of the legs only and “rate” the four-leg sling as a two-leg sling.

THE SINGLE BASKET HITCH

The Single Basket Hitch is used to support a load by attaching one end of the sling to the hook, then passing the other end under the load and attaching it to the hook. Ensure that the load does not turn or slide along the rope during a lift.
THE DOUBLE BASKET HITCH

The Double Basket Hitch consists of two single basket hitches placed under the load. On smooth surfaces the legs will tend to draw together as the load is lifted. To counter this, brace the hitch against a change in contour, or other reliable means, to prevent the slings from slipping. You must keep the legs far enough apart to provide balance, but not so far apart that they create angles below 60 degrees from the horizontal. On smooth surfaces, a Double Wrap Basket Hitch may be a better choice.

DOUBLE WRAP BASKET HITCH

The Double Wrap Basket Hitch is a basket hitch wrapped completely around the load and compressing it rather than merely supporting it, as does the ordinary basket hitch. The double wrap basket hitch can be used in pairs like the double basket hitch. This method is excellent for handling loose material, pipe, rod or smooth cylindrical loads because the sling is in full 360° contact with the load and tends to draw it together.
**THE SINGLE CHOKER HITCH**

The Single Choker Hitch forms a noose in the rope. It does not provide full 360° contact with the load, however, and therefore should not be used to lift loads difficult to balance or loosely bundled. Choker hitches are useful for turning loads and for resisting a load that wants to turn. Using a choker hitch with two legs provides stability for longer loads. Like the single choker, this configuration does not completely grip the load. You must lift the load horizontally with slings of even length to prevent the load from sliding out. You should lift loosely-bundled loads with a Double Wrap Choker Hitch.

**THE DOUBLE WRAP CHOKER**

A Double Wrap Choker Hitch is formed by wrapping the sling completely around the load and hooking it into the vertical part of the sling. This hitch is in full 360° contact with the load and tends to draw it tightly together. It can be used either singly on short, easily balanced loads or in pairs on longer loads.
ENDLESS SLINGS OR GROMMET SLINGS

Endless Slings or Grommet Slings are useful for a variety of applications. Endless chain slings are manufactured by attaching the ends of a length of chain with a welded or mechanical link. Endless web slings are sewn. An endless wire rope sling is made from one continuous strand wrapped onto itself to form a six-strand rope with a strand core. The end is tucked into the body at the point where the strand was first laid onto itself. These slings can be used in a number of configurations, as vertical hitches, basket hitches, choker hitches and combinations of these basic arrangements. They are very flexible but tend to wear more rapidly than other slings because they are not normally equipped with fittings and thus are deformed when bent over hooks or choked.

BRAIDED SLINGS

Braided Slings are usually fabricated from six to eight small-diameter ropes braided together to form a single rope that provides a large bearing surface, tremendous strength, and flexibility in every direction. They are easy to handle and almost impossible to kink. The braided sling can be used in all the standard configurations and combinations but is especially useful for basket hitches where low bearing pressure is desirable or where the bend is extremely sharp.
LU 2.5 Advanced rigging and hoisting

OPERATOR RULES

1. The operator should check that all the equipment is up-to-date and in proper working condition prior to crane operation.
2. The operator shall be familiar with the crane or hoist operating characteristics and be aware of the safety rules for operators.
3. No crane, hoist or rigging hardware shall be loaded beyond the rated capacity, except for test purposes.

HANDLING SYMMETRICAL LOADS

Hoisting and rigging for ordinary lifts that require more than one person (an operator and a rigger) shall have a designated leader. The designated leader shall be present at the lift site for the entire lift operation. If the lift is being made by only one person, that person assumes all responsibilities of the designated leader. The leadership may be given by written instructions, specific verbal instructions for the particular job or clearly defined responsibilities within the crew’s organizational structure. The leader’s responsibility includes:

- Ensure that personnel involved understand how the lift is to be made.
- Ensure that the weight of the load is determined, that proper equipment and accessories are selected, and that rated capacity is not exceeded.
- Survey the lift site for hazardous/unsafe conditions.
- Ensure that equipment is properly set up and positioned.
- Ensure that a signaller is assigned, if required, and is identified to the operator.
- Direct the lifting operation to ensure that the job is done safely and efficiently.
- Stop the job when any potentially unsafe condition is recognized.
- Direct operations if an accident or injury occurs.

The operator, or a designated person, shall ensure that the crane is still within the inspection interval. The operator (or the designated person) shall examine visually the crane.

Moving the load

The signal person directing the lift (or if a signal person is not used, the operator) shall ensure the following:

- The load is well secured and balanced in the sling or lifting device before it is lifted more than a few inches;
- That the load path is clear of obstructions;
- Check the destination area for adequate clearance as well as for adequate floor strength to support the load safely once it is placed down.

Before starting to lift, the operator will ensure the following conditions are met:

- Hoist rope or chain is not kinked.
- Multiple-part lines are not twisted around each other.
- If the load line (rope or chain) is slack, ensure that the line seats on the sheaves, sprockets, etc., as the slack is removed.
- See that the load line is plumb to prevent side pull. Two degrees out of plumb is considered excessive. It introduces stresses in the crane that were not necessarily accounted for in the design of the crane or hoist. It may result in bridge or trolley brakes holding the load. Or can possibly cause damage to the rope as it runs up the side of the sheave or drum. The load centre of gravity should have the hook above it.

Ensure that the load or hook is not allowed to swing during crane travel or hoist operation. For outdoor equipment wind speed must be considered. Wind speeds in excess of 25 mph should be evaluated by a qualified person to determine if the size, shape and weight of the load can be safely lifted.

Attach slings/chains/wire ropes to the load above the centre of gravity as specified before. If the only available attachment points are below the centre of gravity, stabilize the load using taglines.

Equalize loading on multiple leg slings and maintain a balanced load. Protect rigging equipment and the load from sharp surfaces and damage.

During power hoisting, engage the load in a controlled, deliberate manner and ensure there is no sudden acceleration or deceleration of the load (quick reversals in direction should be avoided). Sudden acceleration or deceleration and quick reversals in direction creates a shock loading situation, which should at all times be avoided. A shock load can very easily cause the load to double the load tension on the crane, hoist, and rigging equipment.

Slowly lift the load until it just begins to rise off the ground. Stop to see if load will rise evenly or if it will tilt:
- If the load tilts, lower immediately and reposition rigging components to prevent the load from listing.
- Repeat the test lift. If problem recurs, stop the lift and re-examine the Lift Plan’s recommendations for rigging equipment as well as the location of the load’s centre of gravity.

After the load is balanced correctly, warn everyone in the area of the impending lift by using the facility’s notification system (sounding an alarm, etc.).

Proceed by lifting the load slowly and moving the load slowly to its destination. Keep load as low to ground as possible. Use attendants to walk with the load if needed to keep it from impacting surrounding objects.

During initial load application, lift the load only a few inches at which time brake function load balance and sling/rigging hardware integrity can be checked. There shall be no downward drift of the load during this stop.
Do not carry loads over people. All personnel including the rigger shall stay clear of the load.

Use a tag line to help control the load. Never rise the load higher than necessary.

Lower the load slowly, making sure that it lines up correctly with any blocks, timbers, or other support devices that might be needed.

Detach the rigging and secure the equipment.

**Tag lines**

The safest method for a rigger to control a load suspended from a hook is with a tagline or a restraining device. A tagline will give the rigger the distance he needs if the load shifts or moves unexpectedly.

When moving or placing machinery, it is advisable for all crew members to stay out of the path of the load as it is being maneuvered into position. Place the tagline(s) at points on the load for control during lift-off, traveling and placement. The tagline’ person should never loop the line around his arm or body. He should have a clear view of his travel path and the signaller so he can anticipate the load’s movement. The tagline person will have his best control of the load if he is trailing the load while traveling with it.

The tagline person should provide whatever control he can. He should also be aware of his abilities and limitations.

**HANDLING ASYMMETRICAL LOADS**

Check that all crane systems are up-to-date and in proper working condition prior to crane operation.

Check the travel route to ensure there is sufficient clearance for the load.

Check the destination area for adequate clearance as well as for adequate floor strength to support the load safely once it is placed down.

Determine and identify the location of the load’s centre of gravity.

Attach slings/chains/wire ropes to the load above the centre of gravity as specified on the Lift Plan. If the only available attachment points are below the centre of gravity, stabilize the load using taglines.

Equalize loading on multiple leg slings and maintain a balanced load.

Protect rigging equipment and the load from sharp surfaces and damage.

Slowly lift the load until it just begins to rise off the ground. Stop to see if load will rise evenly or if it will tilt.

If the load tilts, lower immediately and reposition rigging components to prevent the load from listing.

Repeat the test lift. If problem recurs, stop the lift and re-examine the Lift Plan’s recommendations for rigging equipment as well as the location of the load’s centre of gravity.

After the load is balanced correctly, warn everyone in the area of the impending lift by using the facility’s notification system (sounding an alarm, etc.).

Proceed by lifting the load slowly and moving the load slowly to its destination. Keep load as low to ground as possible. Use attendants to walk with the load if needed to keep it from impacting surrounding objects.

Lower the load slowly, making sure that it lines up correctly with any blocks, timbers, or other support devices that might be needed. Detach the rigging and secure the equipment.
Moving loads through vertical openings

Passing a load through a shaft, floor hole, or other vertical opening presents many challenges to the rigger. Often, because of tight clearances or the length of the opening, it is not practical to have an assistant help guide the load as it passes through. As a result, determining the size of the opening, the exact balance point, and the overall load footprint is the key to a successful operation.

Check that all crane systems are up-to-date and in proper working condition prior to crane operation.

Check the opening to ensure there is sufficient clearance for the load.

Check the destination area for adequate clearance as well as for adequate floor strength to support the load safely once it is placed down.

Determine and identify the location of the load’s centre of gravity.

Attach slings/chains/wire ropes to the load above the centre of gravity as specified on the Lift Plan. If the only available attachment points are below the centre of gravity, stabilize the load using taglines.

Equalize loading on multiple leg slings and maintain a balanced load.

Protect rigging equipment and the load from sharp surfaces and damage.

Slowly lift the load until it just begins to rise off the ground. Stop to see if load will rise evenly or if it will tilt. If the load tilts, lower immediately and reposition rigging components to prevent the load from listing. Repeat the test lift. If problem recurs, stop the lift and re-examine the Lift Plan’s recommendations for rigging equipment as well as the location of the load’s centre of gravity.

After the load is balanced correctly, warn everyone in the area of the impending lift by using the facility’s notification system (sounding an alarm, etc.).

Proceed by lifting the load slowly and lowering the load slowly to its destination. Keep load as low to ground as possible. Use attendants to guide the load if needed to keep it from impacting the walls of the opening.

Lower the load slowly, making sure that it lines up correctly with any blocks, timbers, or other support devices that might be needed.

Detach the rigging and secure the equipment.

Moving loads through horizontal openings

Check that all crane systems are up-to-date and in proper working condition prior to crane operation.

Check the opening to ensure there is sufficient clearance for the load.

Check the destination area for adequate clearance as well as for adequate floor strength to support the load safely once it is placed down.

Determine and identify the location of the load’s centre of gravity.
Attach slings/chains/wire ropes to the load above the centre of gravity as specified on the Lift Plan. If the only available attachment points are below the centre of gravity, stabilize the load using taglines.
Equalize loading on multiple leg slings and maintain a balanced load.
Protect rigging equipment and the load from sharp surfaces and damage.
Position any catch equipment, such as rollers or a second crane, on the receiving side of the wall hole.
Slowly lift the load until it just begins to rise off the ground. Stop to see if load will rise evenly or if it will tilt. If the load tilts, lower immediately and reposition rigging components to prevent the load from listing. Repeat the test lift. If problem recurs, stop the lift and re-examine the Lift Plan’s recommendations for rigging equipment as well as the location of the load’s centre of gravity.
After the load is balanced correctly, warn everyone in the area of the impending lift by using the facility’s notification system (sounding an alarm, etc.).
Proceed by lifting the load slowly and lowering the load slowly to its destination. Keep load as low to ground as possible. Use attendants to guide the load if needed to keep it from impacting the walls of the opening.
Once the load is partially through the wall opening, have an assistant ensure that it is lined up correctly with the receiving device.
Depending on the load’s shape and centre of gravity, stop the lift as needed to attach rigging devices on the receiving side.
Continue the lift until the load is on the receiving side of the wall opening, when it can be supported and controlled by that side’s rigging apparatus.
Move the load to its final position.

Moving loads around or over obstacles

Depending on the work location, it may be necessary to lift a load around or over an obstacle that is blocking the travel path. When this happens, it is especially important to determine the potential effect of the load being dropped or otherwise damaged as a result of a fall or collision. Factors to consider include, but are not limited to, the nature of the obstacle and the item being lifted, cost, programmatic impact, safety hazard, and environmental impact.
If the lift is considered incidental or pre-engineered after careful analysis, then proceed as follows:
Check that all crane systems are up-to-date and in proper working condition prior to crane operation.
Check the opening to ensure there is sufficient clearance for the load.
Check the destination area for adequate clearance as well as for adequate floor strength to support the load safely once it is placed down.
Determine and identify the location of the load’s centre of gravity.
Attach slings/chains/wire ropes to the load above the centre of gravity as specified on the Lift Plan. If the only available attachment points are below the centre of gravity, stabilize the load using taglines.

Equalize loading on multiple leg slings and maintain a balanced load.

Protect rigging equipment and the load from sharp surfaces and damage.

Slowly lift the load until it just begins to rise off the ground. Stop to see if load will rise evenly or if it will tilt. If the load tilts, lower immediately and reposition components to prevent the load from listing. Repeat the test lift. If problem recurs, stop the lift and re-examine the Lift Plan’s recommendations for rigging equipment as well as the location of the load’s centre of gravity.

After the load is balanced correctly, warn everyone in the area of the impending lift by using the facility’s notification system (sounding an alarm, etc.).

Proceed by lifting the load slowly and lowering the load slowly to its destination. Keep load as low to ground as possible. Only raise the load when it becomes necessary to move around or over an obstacle. Use attendants and tag lines to guide the load if needed to keep it from impacting walls or other equipment.

Once the load is partially through the wall opening, have an assistant ensure that it is lined up correctly with the receiving device.

Lower the load as soon as the obstacle is cleared.

When the load is in its final location, lower it slowly, making sure that it lines up correctly with any blocks, timbers, or other support devices that might be needed.

Move the load to its final.

**Moving loads in close proximities**

Depending on the work location, it may be necessary to pass a load very near to stationary objects along the travel path. When this happens, it is especially important to determine the potential for damage to the load or nearby equipment as a result of a fall or collision. Factors to consider include, but are not limited to, the nature of the obstacle and the item being lifted, cost, programmatic impact, safety hazard, and environmental impact. If the lift is considered incidental or pre-engineered after careful analysis, then proceed as follows:

- Check that all crane systems are up-to-date and in proper working condition prior to crane operation.
- Check the clearance along the travel path to ensure there is sufficient clearance for the load.
- Check the destination area for adequate clearance as well as for adequate floor strength to support the load safely once it is placed down.

Determine and identify the location of the load’s centre of gravity.

Attach slings/chains/wire ropes to the load above the centre of gravity as specified on the Lift Plan. If the only available attachment points are below the centre of gravity, stabilize the load using taglines.

Equalize loading on multiple leg slings and maintain a balanced load.

Protect rigging equipment and the load from sharp surfaces and damage.

Slowly lift the load until it just begins to rise off the ground. Stop to see if load will rise evenly or if it will tilt. If the load tilts, lower immediately and reposition components to prevent the load from listing.
Repeat the test lift. If problem recurs, stop the lift and re-examine the Lift Plan’s recommendations for rigging equipment as well as the location of the load’s centre of gravity.

After the load is balanced correctly, warn everyone in the area of the impending lift by using the facility’s notification system (sounding an alarm, etc.).

Proceed by lifting the load slowly and lowering the load slowly to its destination. Keep load as low to ground as possible. Proceed very slowly when passing close to other equipment. Use attendants and tag lines to guide the load if needed to keep it from impacting walls or other equipment.

When the load is in its final location, lower it slowly, making sure that it lines up correctly with any blocks, timbers, or other support devices that might be needed.

**Upending, Inverting and Rolling Loads**

Upending a load refers to the process of rotating an object so that it rests on its side or end. Overhead cranes and hoists can be used to upend and invert loads, but before such an operation can be attempted, it is absolutely essential to know the load’s weight, centre of gravity, and tip point. A load’s tip point is the corner on which it will pivot when upended. Only with these three facts known can rigging be selected and placed correctly to invert a load safely without shock loading.

When upending a load, the optimum lift/hitch point is just below a line extending through the tip point and the load’s centre of gravity, as shown at right. After attaching at the lift/hitch point, a load can be tilted on its side by raising the hoist and providing a slight amount of travel.

When tipping a load, be sure to move the hoist both vertically and horizontally. If the hoist is moved vertically only, the tip point will drag across the floor, possibly damaging the load or floor as it slides. When loads must be upended without hoist travel, the tip point must be protected by placing the load on a skid or a dolly. This way, the skid or dolly slides on the floor until the load is fully raised. The skid or dolly can then be removed and the load set down.

The tip point and lift point must be located precisely to prevent the load from raising and flipping uncontrollably. If the lift point is above the line extending from the tip point through the centre of gravity, the load will flip and rise off the floor, causing it to swing uncontrollably, as shown at right.

At the same time, if the lift point is too low, the wire rope will not be held in tension, and so cannot restrain the load as it tips. When this happens, the wire rope will go slack, allowing the load to tip over suddenly and crash onto the floor. A load upended in this fashion may be damaged as it falls over and may cause collateral damage to property or personnel.
LIFTING WITH HAND-OPERATED CHAIN HOISTS

Hand-operated chain hoists come in a variety of types, shapes, sizes, lifting capacities, and diverse features/controls. These manually operated hoisting devices enable one person to lift heavy loads (multiple tons) by using a series of reduction gears to provide a mechanical advantage and thereby reduce the amount of effort (muscle energy) needed to lift a load.

There are 3 common types of hand-operated chain hoists used in rigging, shown below. Each operates on a different principle, and each has its own advantages and disadvantages to consider during the selection process.

**Differential hoist**

**Operating Principle**
Operates with multiple sheaves, each with pockets cut out to fit chain links. One sheave has more pockets than the other so as it rotates on the same shaft it takes up chain faster.

**Advantages**
Relatively inexpensive and simple to operate

**Disadvantages**
Least efficient hand-operated chain hoist
Will slip when hand loop is released
If load/hoist are jarred the load may fall.

**Screw-gear hoist**

**Operating Principle**
The mechanism inside the block is a worm and pinion arrangement. The hand chain is an endless loop that rotates the mechanism. The load chain descends directly from the block.

**Advantages**
More efficient than differential hoists
Can safely suspend a load when the hand chain is released because the worm gear cannot be driven by its pinion.

Disadvantages
Less efficient than a spur-gear hoist.
Spur-gear hoist

Operating principle
Uses a gear arrangement called a sun and planetary gear set. The hand wheel is coupled to the sun gear. As the sun gear turns, the entire group of planetary gears slowly revolves. The load wheel rotates much more slowly than the sun gear, providing the reduction in speed necessary for the hoist to operate.

Advantages
Most efficient hand-operated chain hoist. Incorporates a clutch that slips if the hoist is overload beyond its safe lifting capacity to keep the load from being raised.

Disadvantages
Requires a friction brake (usually an automatic feature/some have a manual brake release) to hold a load aloft when the hand chain is released because of the reduced amount of friction.

NOTE: If improperly used or abused, hand-operated hoists can cause major production loss, and serious injury. Safe and sound rigging practices shall be used to conjunction with hoisting operations

HOISTING GUIDANCE

Operation of a hand operated chain hoist involves more than pulling the hand chain. The use of these hoists is subject to certain hazards that cannot be met by mechanical means, but only by the exercise of intelligence, care, common sense, and experience in anticipating the motions that will occur as a result of operating the hoists.

Pre-use inspection requirements

Pre-use inspections are to be conducted by a designated person who shall determine whether conditions found constitute a hazard and whether a more detailed inspection is necessary. Records not required for frequent inspections. Inspect daily before use and frequently during use

Identification

The hoist shall be marked with the manufacturer’s name, model, serial number, and rated load capacity attached on a plate or label, or cast, forged, or stamped on the hoist or load block.

Warnings and labels

Warnings shall be affixed to the hoist or block with labels displaying information concerning operating procedures. Labels shall be in compliance with the relevant regulation and include cautionary language against:
Lifting more than rated load capacity
Operating hoist with twisted, kinked, or damaged chain
Operating damaged or malfunctioning hoist
Lifting people or lifting loads over people
Operating hoist other than with human power
Removing or obscuring labels.

Pre-use inspection checklist

The following items shall be inspected:
- Operating mechanism for proper operation, proper adjustment, and unusual sounds
- Hoist braking system for proper operation
- Hook, & latches if used
- Hoist load chain, reeving, and hoist rope for compliance with manufacturer recommendations.

Pre-hoist operations

The operator must:
- Be trained.
- Not make adjustments or repairs unless qualified.
- Report substandard conditions.
- Not operate a hoist that is tagged out of-service.
- Not use the chain or rope as a welding ground.
- Not allow welding electrodes to contact the hoist.
- Operate only manually (hand power) by one operator.

Hoist operations

- Hoist rope or chain shall not be wrapped around a load
- Before load movement, the operator shall be sure chains are not kinked or twisted around each other
- The hoist shall not be operated unless rope or chain is seated properly on the drum, sheaves, or sprockets
- The hoist shall not be operated unless centred over the load, except when authorized by a qualified person
- The operator shall not pick up a load in excess of the rated load bearing capacity on the hoist or load block, except during authorized tests or pre-engineered lifts
- A hoist overload limiting devices shall not be used to measure the maximum load to be lifted
- Each time a load approaching load capacity is handled, the operator shall check hoist brake action by lifting the load just clear of supports and continuing only after verifying the brake system is operating properly
- Unless a lower limit device is provided, the load shall not be lowered below the point where less than two wraps of rope remain on the anchorage of the hoist drum
Hoisting Tips

- Never wrap a wire rope sling completely around a hook. The tight radius will damage the sling.
- Make sure the load is balanced in the hook. Eccentric loading can reduce capacity dangerously.
- Never point-load a hook unless it is designed and rated for such use. Point-loading can cut capacity by more than half.
- Never wrap the crane hoist rope around the load. Attach the load to the crane hook by slings or other rigging devices.
- Avoid bending wire rope slings near attached fittings or at eye sections.
LU 2.6 Reieving operations

Reieving refers to the configuration of the wire rope, blocks and drum of the hoist. Reieving effects headroom, lifting speed and capacity by increasing the hoist’s mechanical advantage. Reieving also determines if the hoist has lateral hook movement or true vertical lift.

The three terms used in reieving are single, double and part. Single or double refers to the number of ropes coming from the drum. Part deals with the mechanical advantage gained by multiple reieving. For example, with two-part single reieving (2PS) the load is distributed over the two parts, and the mechanical advantage doubles the capacity of one-part reieving but reduces by one half the lifting or lowering speed of the hook.

Some applications require that the load not move right or left of the hoist centreline while being lifted. This is called true vertical lift and requires lea headroom than single reieving.

Headroom: some applications require that the distance from the bottom of beam to saddle of the hook be held to a minimum. This dimension will determine whether a standard or close headroom is required.

Lateral hook travel: Some applications require that the load, when being lifted, not move right or left from hoist centreline. If this requirement is known, a true vertical lift hoist must be used. These are described as two-part double (2PD) or four-part double (4PD) and are available in both parallel or cross mounted hoists.

REEVING METHODS

The following are several tips to help block reieving:

- If the stationary block has more than two sheaves, the lead line should be positioned in the centre sheaves to balance the block under load.
- When both blocks have the same number of sheaves, the rope dead end (becket) is attached to the stationary block. When the number of sheaves per block varies, the becket is on the block with the fewer sheaves.
- When reieving, the becket end should be fed through the blocks starting where the lead line exits, and continued on through toward the becket connection. This eliminates pulling all of the wire rope through the blocks.
Before reeving, position the blocks as close together as possible. This makes the process much easier with less wire rope to pull through.

The popular methods of arranging wire rope and sheaves to gain mechanical advantage are lacing, square reeving, and skip reeving.

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**Lacing**

Lacing is a very uncomplicated method of putting the rope through a set of blocks. The end of the wire rope is fed through the outside sheave on the top block, continue through the outside sheave on the travelling block, up to the second sheave on the top block, and down to the second sheave on the travelling block. This method is continued to the last sheave. Becket off the end, as in illustration:

- The main disadvantage of lacing is that the line travels much faster on one side, this tilts the blocks, causing the line to scrub and wear the block supports.
- The advantages to lacing are: it allows the blocks to come close together (important where headroom is at a premium) and there are no reverse bends.

Most sets of blocks can be square reeved in two types of patterns. The better method has the lead line coming off one of the centre sheaves for balance. The other has the lead line coming off an end sheave. An uneven block pull is partially offset here with the next line coming off the sheave on the opposite end.
To be achieved upon learning outcome completion

**Knowledge:**
- Numeracy to calculate capacity and working load limits
- Design and functions of lifting equipment
- Tools and equipment and the procedure for their use
- Wire rope types and slings
- Sling configurations

**Skills and competences:**
- Select advanced rigging equipment
- Connect equipment
- Remove advanced rigging equipment
- Communicate clearly, share information, listen and understand
- Read and interpret instructions, work orders and relevant documentation
- Written skills to document hazards, bad records or report faults
- Comply with legislation, regulations, standards, codes of practice
- Plan and prepare for operation
- Move, ore, remove, place, and secure loads
- Efficiently and safely perform advanced rigging operations
- Verify problems and equipment faults and demonstrate appropriate response procedures
ASSESSMENT

1. Use weights of common materials table in Learning Unit 2.3 of this Manual to calculate the weight of a steel plate 4 m wide x 10 m long x 1 m thick.
2. Calculate the centre of gravity of this concrete block.

![Concrete Block Diagram]

3. Most common synthetic web slings are made of which of the following:
   - □ Polyester
   - □ Nylon
   - □ Acetone

4. Write the four main type of wire rope

5. Which of the following statements is FALSE?
   - □ The operator should check that all the equipment is up-to-date and in proper working condition prior to crane operation.
   - □ The operator doesn’t need be familiar with the crane or hoist operating characteristics and be aware of the safety rules for operators.
   - □ No crane, hoist or rigging hardware shall be loaded beyond the rated capacity, except for test purposes.

6. TRUE or FALSE: When selecting a wire rope, the first thing to be taken into account is the workload since depending on the workload and safety factor, we will have the wire rope breaking strength.

7. TRUE or FALSE: Hoisting and rigging for ordinary lifts requiring an operator and a rigger shall not have a designated leader.

8. TRUE or FALSE: In crane operations, communication is vital so that all personnel involved in the lift are aware of what is happening.

9. YES or NO: Should a crane operator be aware of the key hazards involved in crane operations?

10. Choose the correct one:
    - The double basket hitch:
      - □ is used to support a load by attaching one end of the sling to the hook, then passing the other end under the load and attaching it to the hook.
      - □ consists of two single basket hitches placed under the load.
      - □ is a basket hitch wrapped completely around the load and compressing it rather than merely supporting it.
MODULE 3 - Load Charts and Load Weight Calculations
Learning Units (LU) indicative time: (4 hours)

INTRODUCTION

This module will look at the different aspects of crane operations, loading of cranes, handling of loads, safety when handling loads and safety of crane operations. It gives an introduction to how load limits should be calculated, as well as the possible hazards encountered when operating cranes, safety regulations that should be followed so as to ensure the safety of the personnel together with the equipment. More details about each of the units may be found by following the links to videos and resources provided as well as by carrying out further research.

LEARNING OBJECTIVES

- To introduce learners to different means and devices of securing loads
- To be able to calculate load estimates, and the best environments for handling loads
- To understand the best practices in safety of handling of loads, the importance of hand-eye coordination, and avoidance of hazards.
LU 3.1 Determining Crane load weights

Before each and every lift the person in charge must determine the total weight of the load. By doing this, one can be sure that the crane is capable of performing the operation and the health and safety of the workers is not compromised. There are several factors that need to be accounted for when calculating the lifting load, such as the type of crane used, types of lifting slings and rigging hardware, sling hitch and sling angle. In this calculation, all the lifting gear must be accounted for including cables, ropes, beams, hook and anything below it.

In some instances, the crane operator will be lifting the same load on a regular basis, in such cases the load weight does not need to be calculated every time.

The load itself may be marked by the manufacturer or has been previously weighed, so the load must always be checked to see if there are any markings or weights. Tools such as specific load cells or dynamometers can be used to find the exact weight of the load. The load cell is attached between the hook and the load and the weight of the load is read by the load cell. An example of load cells and dynamometers is shown in Figure 3.1.

![Figure 3.1 - Load cells and dynamometers used to find the weight of the lifting load.](image)

If the object is not marked with its weight, and design plans are available, these may be consulted as the weight of the assembly is generally present. For objects that were transported from another facility the bill of landing should be used as this will have an indication of the load. When carrying smaller loads industrial floor scales can be used.

If the weight is not indicated on any documents the load has to be calculated by first finding the volume. The volume can be estimated by using the formulas for basic geometric shapes such as cylinders, spheres, and cubes. After finding the rough estimate of the volume, the density of the material must be determined. The approximate weight of the load can be found by multiplying the density by the volume. The following is an example on how to calculate the density of a hollow steel pipe shown in Figure 3.2.
Figure 3.2 - Hollow steel cylinder.

Volume of cylinder = \( \pi r^2 \times h \)

Finding volume of hollow cylinder = \((\pi \times 1.5^2 \times 8) - ((\pi \times (1.5 - 0.04)^2 \times 8)\)

\[= 56.55 - 53.57 = 2.98 \text{m}^3\]

Density of steel is 8050kg/m³
So, the density is multiplied by the volume to find the mass of the cylinder: 8050 x 2.98 = 23989kg
LU 3.2 Crane capacity

The crane load capacity is essential for safe lifting operation, when neglected the safety of the workers and the integrity of the crane and load is compromised. Every time that a new lifting operation takes place the crane load capacity should be calculated as it varies depending on a number of parameters such as the lift range and type of hoist. The main procedures to follow when calculating crane capacity are the following:

**Understand the equipment:** The crane operator must be familiar with the equipment that will be used for the lift. Such as the type of crane, if the crane will be a mobile crane or stationery while carrying the load and the type of jib that will be used for the load. All these factors will provide an indication of the stability and the type of lift that will be performed.

**Measure geometric components:** The geometry of the machine should be familiar to the crane operator for a precise load calculation. Such geometrical elements include the boom, hoist and ground, which form a triangular shape. By measuring this imaginary triangle, the crane load calculation can be accurately found. The formula used for the maximum crane capacity is the following: \((r)(hC)/100\)

Where:
- \(R\) = Radius between the ground and load
- \(hC\) = Lifting height multiplied by the capacity

**Make use of a load chart:** Some cranes and lifting equipment come with a load chart which can be used to conveniently find the crane load capacity without extensive calculations. The manual or guide that comes with the crane should be always consulted before a new lift.
LU 3.3 Load charts

The load chart used should be for the particular vehicle as although cranes are similar in operation, they may vary in loading methods and capacities. By following the crane’s load chart, the safety of the crane operator and other personnel is ensured. If the crane’s load chart is ignored or the load chart from a different crane is used, overturning or structural failure may occur. An example of a load chart is shown in Figure 3.3. This chart illustrates the rated and gross capacities of a crane. The figures on the top row show the boom lengths while those on the left column represent the operating radius. By following the boom angle column and intersecting the radius/boom length column the gross capacity of this crane (of load chart shown in Figure 6) can be determined. This can also be found by following the radius column and intersecting the boom length. If the jib is stowed in the base of the boom, the row marked “Stowed jib deductions” is used to deduct the loads.

To find the crane capacity index for the load chart the following formula can be used:

\[
\frac{\text{Average (radius} \times \text{max (lifting height} \times \text{capacity)}))}{100}
\]

The load chart in Figure 3.4 is from a Liebherr crane and will be used as another example on how to read a load chart. The 200T refers to the gross capacity (in tonnes) that the crane can lift. However, the actual load capacity is referred to as the net capacity. The top row shows the lengths of boom available for this particular crane. As it can be seen from this image, the lengths vary from 13.2 to 72 metres. On the left column the operating radius of the crane is shown. This is referring to the turning ability in which the particular mobile crane can operate. The other numbers in the table represent the weight in tonnes of the load.

<table>
<thead>
<tr>
<th>BOOM LENGTH</th>
<th>Maximum Load Chart in pounds (lbs) with fully extended outrigger</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPERATING RADIUS (FT)</td>
<td>27 FT</td>
</tr>
<tr>
<td>LOADED BOOM ANGLE (DEG)</td>
<td>LOAD RATING (LB)</td>
</tr>
<tr>
<td>5</td>
<td>77</td>
</tr>
<tr>
<td>10</td>
<td>66</td>
</tr>
<tr>
<td>15</td>
<td>54</td>
</tr>
<tr>
<td>20</td>
<td>39</td>
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<td>25</td>
<td>17</td>
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<tr>
<td>30</td>
<td>16</td>
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<tr>
<td>35</td>
<td>9</td>
</tr>
<tr>
<td>40</td>
<td>9</td>
</tr>
<tr>
<td>45</td>
<td>19</td>
</tr>
</tbody>
</table>

Figure 3.3 - Load chart showing loads varying with different boom angles.
Table 3.4 - Load chart of a Liebherr LTM 1200-5.1 mobile crane.

<table>
<thead>
<tr>
<th>Net and Gross Loads</th>
</tr>
</thead>
</table>

All the loads listed in the load chart are not the actual loads that the crane can lift on its hook, they are gross/rated capacities, while the actual load that can be lifted is the net capacity. This net capacity should never be exceeded. The gross capacity includes the list of all the weights bared by the boom including those stacked, mounted or hanged from the tip. These are called capacity deductions, which include the following:

- Weight of main load block
- Effective weight of jib (this can also be stowed or open and unused)
- Weight of all the cable (hanging)
- Weight of all rigging
- Weight of load
- Weight of overhaul ball.

These are just an indication of the capacities that have to be deducted from the gross capacities and can vary from one manufacturer to another.
The chart shown in Figure 3.5 shows the gross capacity lifting on the jib which can be determined by first selecting the jib and boom angle. These values are for a 24- or 40-feet jib. When using load charts from different manufacturers, the crane operator may note different terminologies for the pinned boom extension, such terminologies include fly, jib or boom, which all refer to the same part. The load chart in Figure 3.5 is for a Link Belt crane used when lifting with the fly.

![26.5 Ft. Offset Fly](image)

**Figure 3.5 - Gross capacities chart.**

**FACTORS THAT REDUCE LOAD CAPACITIES**

There are situations when the load chart ratings do not apply for the particular lifting operation. Such operations include the pouring of concrete, erecting steel and magnet, dragline and clamshell work, the latter shown in Figure 3.6.

![Figure 3.6 - Dragline, clamshell and magnet operations using cranes.](image)
Other situations where the load chart rating does not apply are in operations with high swing rate i.e. when the crane is started and stopped in a rapid manner causing side loading. Other factors include increase in load radius; Side loading (as the boom is designed for downward strength not side); Crane setup on unlevelled ground (as all charts are based on firm level ground).
LU 3.4 Practical rules for use and safe handling of loads

The law says that all lifting operations involving lifting equipment must be:

- properly planned by a competent person
- appropriately supervised
- carried out in a safe manner

Cranes and lifting accessories such as slings must be of adequate strength, tested and subject to the required examinations and inspections. All crane operators, and people involved in slinging loads and directing lifting operations, must be trained and competent.

Tower and mobile cranes are used extensively on construction projects and present two principal hazards:

**Collapse of the crane** – such incidents present significant potential for multiple fatal injuries, both on and off-site;

**Falling of the load** – these events also present a significant potential for death and major injury.

Other incidents have involved people being struck by moving loads, cranes contacting overhead conductors and cranes colliding with each other.

**Points to keep in mind for the safe handling of loads:**

- Plan a suitable lifting route, to avoid collision with any persons, objects or overhead power lines.
- Do not drag loads.
- Move the loads as near to the ground level as possible.
- Stop people from standing in the lifting area.
- Do not ride on a load that is being lifted.
- When the crane is in operation, it must maintain a distance of at least 600 mm from any barriers or buildings.
- When visibility is blocked, the signal man shall render assistance.
- Lifting the load at a low speed so that the sling tightens slowly and maintains a balanced position.

*Figure: 3.7 - Possible hazards when using a crane.*
There are four key aspects to the safe use of cranes:

- Planning lifting operations
- Safe systems of work
- Supervision of lifting
- Thorough examination.

PLANNING LIFTING OPERATIONS

All lifting operations should be planned so they are carried out safely with foreseeable risks taken into account. The person appointed to plan the lifting operation should have adequate practical and theoretical knowledge and experience of the lifts being undertaken. The plan will need to address the risks identified by a risk assessment, the resources required, procedures and the responsibilities so that any lifting operation is carried out safely. The plan should ensure that the lifting equipment remains safe for the range of lifting operations for which the equipment might be used.

SAFE SYSTEMS OF WORK

You must plan lifting operations carefully to ensure they are carried out safely. Your plan should result in a safe system of work and this information should be recorded. This record is sometimes known as a method statement and you must ensure that everyone involved understands it. Key elements include:

- planning – including site preparation, crane erection and dismantling;
- selection, provision and use of a suitable crane and work equipment, including safe slinging and signalling arrangements;
- maintenance and examination of the crane and equipment;
- provision of properly trained and competent personnel;
- supervision of operations by personnel having the necessary authority;
- preventing unauthorised movement or use of the crane; and
- measures to secure safety of persons not involved in the lifting.

SUPERVISION OF LIFTING

The right level of supervision must be in place for lifting operations, reflecting the degree of risk and personnel involved in the particular lifting operation. The crane supervisor should direct and supervise the lifting operation to make sure it is carried out in accordance with the method statement. S/he should be competent and suitably trained and should have sufficient experience to carry out all relevant duties and authority to stop the lifting operation if it is judged dangerous to proceed.
THOROUGH EXAMINATION

There are strict legal requirements concerning the thorough examination of all cranes: Lifting equipment must be thoroughly examined at the prescribed intervals. This is a detailed and specialised examination by a competent person. The examination will usually be arranged by the crane hire company, although it is the responsibility of the crane user to ensure that all necessary examinations are carried out and that the required reports are in order. Records of thorough examinations and tests must be: readily available to enforcing authorities; secure; and capable of being reproduced in written form.
LU 3.5 Load Calculations

CENTRE OF GRAVITY FOR REGULAR AND IRREGULAR LOADS

During lifting operations, the crane operator should have a good understanding of the tipping points and the centre of gravity of the loads being lifted. The centre of gravity of the load is a central point in any object where all the mass is concentrated (also called centre of mass). It is not necessary to carry out complicated calculations for regular shaped loads, but follow this simple formula. The calculation for the crane’s leverage is shown in Figure 3.8.

First the weight of the crane is multiplied by the distance from the centre of gravity to the tipping point. Then the distance from the load (being lifted) to the tipping point is calculated, and multiplied by the weight of the load. If the result of the second calculation is larger than the first one, the crane will become unstable. In simpler terms, if the load’s leverage is bigger than the crane’s leverage, instability will follow, which can be very dangerous as it may result in property damage, injury or death. In such situation alternate methods or machinery should be used and the risk should not be taken. Trained crane operator know that one should always lift a little less load than the rated loading capacity for stability, even though reserve stability will be calculated in the load ratings.
In many scenarios the load is not uniform in shape and in others the load may be uniform in shape but not in density. These are all factors that will have an effect on the centre of gravity of the load and are considerations that should be taken carefully by the operator. Without any additional cables to secure the load the load will rotate until the load’s centre of mass is directly under the crane’s hook as shown in Figure 3.9. If the load rotates without any prior precautions from the crane operator or the setup, the situation may turn into a dangerous one.

![Figure 3.9](image)

Figure 3.9 - Lifting even (A) and uneven loads (B).

In Figure 3.9, load A has uniform centre of gravity while load B is uneven. Factors such as the object’s density or uneven loading may contribute to this overturning effect.

For regular 3D shapes such as cylinders, cubes, cuboids, cones etc. the centre of gravity can easily be found using regular mathematical equations. For irregular loads the load can be divided into smaller regular shapes and the centre of gravity of each shape can be found. A reference point in the load has to be pre-determined. All the area/volume is added and the following equation can be used to find the centre of gravity of the whole object:

\[ A_x = A_1x_1 + A_2x_2 + \ldots \]

Where:
- \( A \) = total area, \( A_1 + A_2 \ldots \)
- \( x \) = distance to centre of gravity in x direction
- \( A_1 \) and \( A_2 \) are the area/volume of each shape
- \( x_1 \) and \( x_2 \) are the distances to the centre of gravity for each shape

Note: This same formula is used in the y-direction to find the centre of gravity of the load.

**SLING ANGLE CALCULATIONS**

The sling angle is a lifting factor which should not be overlooked as it has a direct effect on the tension of the sling. The most commonly used angle by riggers is 60° as this creates an equilateral triangle and so it is quite easy to measure. However, this is not always possible due to size of the load and overhead clearance among other factors. The angle is so critical that if from 60° it is 30°, the tension factor is increase by 2 times, meaning that the rigging equipment will have double the physical load that it is carrying.
To calculate the sling angle the following steps should be followed:
First calculate the reduction factor. This can be done by using the table shown in Table 3.1. The angle from the horizontal is used to find the corresponding number of the reduction factor. Another method is to divide the sling height \( H \) by the sling length \( L \)
Then find the sling’s reduced rating by multiplying the Reduction Factor \( RF \) x sling’s rated capacity (depending on the hitch used)

An example is shown using the diagram in Figure 3.10.
Vertical Choker (VC) rating of each sling= 450kg
Measured Height \( H \) = 0.84m
Measured Length \( L \) = 0.96m
Reduction Factor \( RF \) = \( \frac{0.84(H)}{0.96(L)} \) = 0.875 Sling rating is reduced by = 0.875
450kg (VC) x .875 (RF) = 393.75kg of lifting capacity per sling

![Figure 3.10 - Finding the lifting capacity per sling.](image)

To find the required sling capacity the following steps should be taken:
- First the load that will be lifted has to be determined
- Calculate the tension factor by finding the angle from horizontal and use the angle chart to the corresponding number from the reduction factor column
- The sling length \( L \) is then divided by the sling height

An example is shown using the diagram in Figure 3.11.
Load weight = 1200kg
Rigging – 2 slings in vertical hitch
Lifting weight (LW) per sling – 600kg
Measured Length \( L \) = 1.2m
Measured Height \( H \) = 0.96m
Tension Factor \( TF \) = \( \frac{1.2m(L)}{0.96m(H)} \) = 1.25
Minimum Vertical Rated Capacity required for this lift:
600kg (LW) x 1.25 (TF) = 750kg per sling.
Figure 3.11 - Finding the required sling capacity.

Angle Chart Table

<table>
<thead>
<tr>
<th>Reduction Factor</th>
<th>Angle From</th>
<th>Tension Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90°</td>
<td>1</td>
</tr>
<tr>
<td>.996</td>
<td>85°</td>
<td>1.004</td>
</tr>
<tr>
<td>.985</td>
<td>80°</td>
<td>1.015</td>
</tr>
<tr>
<td>.966</td>
<td>75°</td>
<td>1.035</td>
</tr>
<tr>
<td>.940</td>
<td>70°</td>
<td>1.064</td>
</tr>
<tr>
<td>.906</td>
<td>65°</td>
<td>1.104</td>
</tr>
<tr>
<td>.866</td>
<td>60°</td>
<td>1.155</td>
</tr>
<tr>
<td>.819</td>
<td>55°</td>
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<td>.766</td>
<td>50°</td>
<td>1.305</td>
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<tr>
<td>.707</td>
<td>45°</td>
<td>1.414</td>
</tr>
<tr>
<td>.643</td>
<td>40°</td>
<td>1.555</td>
</tr>
<tr>
<td>.574</td>
<td>35°</td>
<td>1.742</td>
</tr>
<tr>
<td>.5</td>
<td>30°</td>
<td>2</td>
</tr>
</tbody>
</table>
FINDING THE WORKING LOAD LIMIT

The Safe Working Load (SWL) is the maximum load permitted for the wire ropes to operate in safe conditions and it is usually calculated by the manufacturer of the rigging equipment and marked on the packaging. This load limit should always be followed as exceeding it the integrity of the equipment is compromised as well as the health and safety of the workers. To find the safe working load limit the diameter of the cable or wire rope has to be measured or read from the manufacturer’s specifications. If the measurements are taken manually, it is recommended that measurements at multiple points are taken and then finding the average. The formula used is:

\[ SWL = D^2 \times 8 \]

Where:
SWL is the Safe working load in kg
D is the wire rope/cable diameter in mm

This means that for a cable which has a 30mm diameter the SWL in kg is:

\[ SWL = 30^2 \times 8 = 7200 \text{ kg} \]
To be achieved upon learning outcome completion

Determining crane load weights

Knowledge:
- Steps to determine the load
- Tools used to measure the load
- Calculation of the load

Skills and competences:
- Differentiate between different load measurement devices
- Identifying scenarios when the load should be calculated
- Calculation of the load with irregular shape and in 3 dimension using density of material

Crane Capacity

Knowledge:
- Main procedures for finding the crane capacity

Skills and competences:
- Calculating the maximum crane capacity

Load Charts

Knowledge:
- Load charts and their importance in crane safety
- Net and gross loads
- Factors that reduce load capacities

Skills and competences:
- Reading a load chart
- Finding the crane capacity index
- Differentiate between net and gross loads and how each can be found
- Identify scenarios where the load capacity of a crane is reduced

Safe handling of loads

Knowledge:
- Understand local laws and regulations on lifting equipment
- Principal hazards of mobile and tower cranes
- Basic steps for safe handling of loads
- The four key aspects for the safe use of cranes
Skills and competences:

- Applying the four key aspects of safe lifting:
  - Planning lifting operations
  - Safe systems of work
  - Supervision of lifting
  - Thorough examination.
- Understanding local legal regulations on crane loading and operation

Load Calculations

Knowledge:

- Understanding the difference between regular and irregular loads
- Importance of the centre of gravity in lifting
- Sling angle and how it can be found
- Reduction factor and uses in calculation
- Understanding the effects of sling angle on the lifting capacity
- Tension factor
- Minimum rated capacity of a sling
- Angle charts
- Safe working load

Skills and competences:

- Calculating regular and irregular loads
- Finding the centre of gravity of the load for regular and irregular load
- Finding the sling angle
- Finding the reduction factor
- Finding the lifting capacity of a sling
- Using the tension factor to find the minimum vertical rated capacity of a sling
- Using angle charts in calculations
- Finding the safe working load of cables
ASSESSMENT

1. How is the weight of the load measured/calculated before a lifting operation? And when should the weight be measured/calculated?

2. Calculate the load (actual load) for a, b and c. Use the following dimensions:
   - Outer diameter: 80cm, inner diameter: 65cm, length 3m (hollow steel)
   - Outer diameter 75cm, Inner Diameter 55cm. Length of shafts 1m and 1.5m respectively. The inner shaft is made of aluminium and the outer of steel
   - 14 copper shafts of 30cm diameter and 3m length each

3. What are the main procedures when calculating the crane capacity?

4. Load charts are an important aspect of a lifting procedure. What are the steps taken when using a load chart?

5. Outline the main differences between net and gross loads.

6. What can affect the crane’s load capacity?

7. Name the four key aspects for the safe use of cranes and explain them.

8. Differentiate between regular and irregular loads and how can the centre of gravity be found for each one of them.

9. Why is it important to understand where is the centre of gravity of the load?

10. What is the sling angle and why is it used?

11. Calculate the minimum vertical rated capacity for each load in question 2 using the following dimensions:

   Rigging – 2 slings in vertical hitch
   Lifting weight (LW) per sling – uniform (use the answer from Q.2)
   Measured Length (L) = 1.6m
   Measured Height (H) = 1.1m

12. What is the working load limit and why is it used?
MODULE 4 - Pre-Operational checks, inspections and maintenance

Learning Units (LU) indicative time: (5 hours)

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INTRODUCTION

Module 4 presents information on mandatory and periodic technical inspections and on checks at the beginning and end of the work schedule for the safe operation of mobile cranes. As cranes can only be used after obtaining operating licenses, the first inspection must be carried out by an accredited person. In this module, you will find information about the documents required for the commissioning of the mobile crane and the conditions they must meet to obtain an operating license.

For the safe use of cranes, both for crane operators and for personnel or objects in the vicinity of the work area, it is necessary to take safety measures, both before starting the crane and at the end of the work schedule. Therefore, this module describes the actions to be taken by each crane operator before and after the cessation of crane operation. The safety of the operator and the people around him depends on the observance of these measures.

The components of the cranes that undergo periodic technical inspections and the contents of the documents at the end of the inspection are also presented in this chapter.

Depending on the complexity of the crane, the operating regime, and the environmental conditions in which it operates, it is recommended to perform additional checks. In this module, you will find information about the main elements of a crane that should be subject to additional checks for the safe use of cranes.

LEARNING OBJECTIVES

- Understanding the types of technical checks;
- Understand the documents required for the commissioning of mobile cranes to apply the rules imposed in the operation of the cranes to avoid accidents;
- Recognising the effectively plan mandatory and regular checks and inspections to understand the specific terminology for the safe use of cranes;
- Knowledge of the components of cranes that undergo periodic technical inspections;
- Knowing the additional checks, depending on the complexity of the crane, the operating regime and the environmental conditions in which it operates.
- Understanding the main components of a hydraulic systems of the crane
LU 4.1 Engines and drive systems

TYPES OF TECHNICAL CHECKS OF CRANES

The following types of technical checks are mandatory for the safe operation of cranes:

The first inspection to grant operating authorizations
The first inspection is performed at the place of operation of the crane in order to grant operating authorisations. An accredited inspector shall verify the following:

- crane identification data;
- the existence of the quality file, accepted by the holder;
- the existence of the technical book and its conformity with the type of crane;
- the existence of operating instructions;
- the existence of warning instructions in cases where the crane must not be used
- the existence of information without load, under the load, static and dynamic tests;
- the existence of PV of house samples, with appropriate results;
- other documents depending on the type of crane and place where it is used.

Cranes may only be used after obtaining an operating license!

To operate safely, activities must be carried out to verify, test, maintain, and repair technical faults for the duration of the use of the cranes. Therefore, periodic checks will be carried out based on a program, by authorized persons, according to the instructions in the technical documentation of the cranes. Periodic checks of cranes can be performed by:

- holder;
- nationally accredited bodies.

THE USE OF START/STOP PROCEDURES: START AND END OF THE WORKING DAY FORBIDDEN OR DANGEROUS MANOEUVRES

Verification work before boarding a mobile crane
Before boarding the mobile crane, the operator must check that no persons or objects are in the vicinity of the machine or underneath it. Check that shoes are free of mud to avoid slipping and use the machine’s footrests to climb.
It is important that the operator uses the obligatory safety equipment such as helmet and protective glasses.

Safety measures for self-propelled mobile cranes before starting the engine
Before operating a powered mobile crane, the operator should be seated, never from outside the cabin. The controls should also be placed in neutral to prevent untimely movements during start-up.
The crane’s brakes should be correctly applied, and it should be checked that the accelerator pedal moves freely.
Safety measures for mobile cranes prior to use
The crane operator must carry out a series of preventive measures before climbing onto the machine, preferably in an area free of obstacles. In this case he must check the operation of the headlights, warning lights and safety brakes. When the crane is started up, and at each restart of work, you must also operate the machine’s limit switches to check that they are working. You will also have to check that the various crane components, mechanisms and safety devices are working properly. Check the operation of the load indicator/limiter and the different gears.
You should also check the ground where you are going to work. And the operating, technical and climatic conditions.
When starting the engine, move at a low speed to listen to the noise of the engine and mechanisms, and check that everything is correct.

Mobile crane operator verification work
Another safety measure for mobile cranes will be to control the stabilisers and support bases. The loads to be handled, distances and heights to be operated will also be recorded. These must be safe according to the tables prepared by the manufacturer. The minimum defect in these verifications must be communicated to the project manager.
Check the operation of the load limiter and the load indicator.
Check the correct and safe use of the support jacks and the placement of the support plates.
Check the operation of the crane, taking into account the effects of wind and other climatic effects on the load and the crane.
LU 4.2 Mechanical system

SAFETY MEASURES WHEN PARKING MOBILE CRANES

The land where work is to be done must be cleared of obstacles involving risks, including high and low voltage power lines with bare conductors, or, if removal is impossible, appropriate preventive measures must be taken.

Checking that the ground on which the crane is to work, and travel is sufficiently strong
It is always preferable to park the tower crane on flat ground. However, if this is impossible, you should try to park it perpendicular to the direction of the tower. The crane wheels or tracks must be on a firm and solid base. In winter try not to park on puddles or mud. In times of frost, it is preferable to park on a hard surface or planks.
Never leave a load suspended on the crane hook during a stop, whether it is a short break or the end of the day.

General safety measures for mobile cranes
During the use of this machinery the operator must not use it for any other purpose than that for which it is intended. Your safety and that of your colleagues will depend on your behaviour.
No persons shall be transported or lifted on the load or on the hook. Even when the crane is stationary, no one may park on the tracks.
The load must never be moved over other workers or over the cabin of a truck. Do not keep the load suspended on the hook at height. If the wait is prolonged, the load must be lowered to floor level, waiting for a new order to place it.

Work in the vicinity of power lines
One of the main causes of accidents in a self-propelled mobile crane is contact with a power line. In these cases, the procedure to be followed is as follows:

- Stay in the cabin and manoeuvre, trying to stop the contact with the electrical line.
- Move the vehicle away from the place and prevent anyone from approaching the tyres that remain inflated.
- If it is not possible for you to stop the contact (without causing the line to break) you must remain in the cabin, keeping
- to people who are far away, until the line has been disconnected.

If the vehicle catches fire or the situation forces, you to abandon it:
- Check that there are no line cables on the ground or on the vehicle

Maintain minimum safety distances from power lines. If this is not possible, the lines must be disconnected. It is not possible to deduce the voltage of the power lines from their layout and height. If the line voltage is not known, the minimum safety distance between the crane and the cables should not be less than 5 metres. This applies equally to all devices and accessories installed on the crane.
Bear in mind that the wind can move the cables and that the crane arms can swing (also upwards) when making sudden movements. This simple unintentional approach can cause a flashover.

Minimum safety distances to high-voltage lines and power lines of railways, trams, etc. must be observed. The safety distances to high voltage overhead power lines are defined in the Technical Guide of Royal Decree 614/2001 on minimum requirements for the protection of the health and safety of workers from electrical risks. In the event of accidental contact of the cable with a live electric line, as a safety rule, the crane operator must:

- Remain calm, do not move.
- Warn the people around him and encourage them to keep a safe distance.
- The minimum distance to the vehicle, apparatus, load or downed lines must be at least 10 m. (zone of influence).
- Leave the zone of influence only by jumping. When doing so, keep your legs closed due to the strain of passage.
- Do not leave the elevated operator’s platform, the raised seat, the driver’s cabin or the loading area under any circumstances. Stay where you are and do not touch any objects.
- Do not touch the appliance, the load or downed lines.
- Immediately order the lines to be disconnected while driving.
- Before rescuing people, who are in the electrical circuit, the line must be disconnected.

**Checking and maintenance of cranes and auxiliary device**

Cranes are work machines that are used to handle objects over short distances. There are several construction solutions for cranes, that causes different risks in operation, depending on the type of loads handled, the maximum height and horizontal distance allowed, the ratio between time spent in use and total time used, auxiliary devices used with the crane, etc.
**LU 4.3 Hydraulic systems**

Mobile cranes incorporate different hydraulic systems used in lifting and moving the loads. Before working on a crane with a hydraulic system, it is vital for operators to have some basic knowledge about the essential components that allow it to carry heavy materials. The basic equipment on a hydraulic crane [1]:

- **Boom** – It is the most easily distinguished component, the large steel telescoping arm that is responsible for lifting loads.
- **Jib** – Mounted at the end of the boom, it is the telescopic section that is described as a lattice-like structure. The jib provides the boom with additional length.
- **Wire Ropes** – These are reinforced steel cables that extend from the operator’s cab and over the end of the boom arm and jib. Each wire rope is capable of holding approximately 14,000 pounds. At the end of the cable is a 285-pound metal ball that keeps the line straight when there is no load.
- **Rotex Gear** – Located underneath the cab, this is a turntable bearing that enables the device to rotate in both directions. The swivel-like movement is controlled by a foot pedal in the cab.
- **Outriggers** – These foot-like devices provide balance and stability to the machine during the lifting process.

Hydraulic systems allow cranes to be lightweight and easy to operate. The hydraulic systems are generally made up of the following components:

- reservoir - holds hydraulic fluid.
- hydraulic pump - moves the liquid through the system and converts mechanical energy and motion into hydraulic fluid power.
- electric motor - powers the hydraulic pump.
- valves - control the flow of the liquid

Hydraulic systems are essential for the safe operation of cranes. Operators must understand the hydraulic principles and functions of the components.

Because the hydraulic systems use oil under pressure to generate energy, checking the oil level in the reservoir is necessary to ensure proper operation of the piston in the cylinder. The pressure required to move the piston is generated by a pump. The hydraulic system must ensure fast and precise control of the crane’s running mechanism. Wind can affect the load distribution, especially when heavy loads are involved. Cranes equipped with hydraulic systems allow load handling by preventing the crane from tipping over while working. Prevention of overturning is ensured by a hydraulic pump that moves the fluid to rotate the crane arm, thus allowing the lateral movement of the load. Hydraulic pressure, often from the same steering pump, is used to extend and retract the stabilizers that support the crane base so that the load can be removed further from the base.
SAFETY MEASURES

Due to the large size and power of a crane with hydraulic systems, operators must be trained to operate safely and reduce the risk of accidents. A crane with faulty systems could put operators or nearby people in danger of fire or falling objects. Improperly mounted cranes can even tip over.

Measures to take in account when using cranes with hydraulic systems [2]:

- operators must readjust the counterbalance valve each time the load weight is changed
- the boom is lowered without a load, pump pressure ramped up to the compensator setting and the arm run very slow when lowering.
- adjusting the counterbalance valve so that it does not fall into an uncontrolled movement.
- all hydraulic systems have designed and consequential clearances that result in internal leakage that increases as a function of the pressure differential. Some of the designed leakage is necessary for lubrication while other leakage is undesirable.
- as hydraulic oil temperature increases, its viscosity thins out. Thinner will leak quicker with the same pressure differential. Without some external feedback to adjust the command signal, all hydraulic systems will slow down as the oil heats up. Using an oil with a higher viscosity index number would reduce the leakage.
- maintain a proper temperature inside the system.
- control all crane movements with gradual and progressive speed variations.
- gradual movements to protect valve.
- clean the hydraulic system filters. Using dirty oil filters can cause damage of the components.
LU 4.4 Continual checks

PERIODIC CHECKS

During the entire operation of a crane, the following elements will be checked periodically:

- oil level;
- system tightness;
- lubrication, cooling, lubrication and braking system;
- wear condition of parts subject to friction;
- wear of gaskets;
- mechanical, electrical, or hydraulic operating systems;
- wear of cables or traction chains and their fixing;
- the condition of the security components and their regulation;
- the functionality of the lifting installation mechanisms;
- the condition of the fastening or handling elements of the load;
- operation of the electric power, control and lighting, and signalling system;
- checking the condition of the tracks and the wheels;
- other elements subject to mechanical stress depending on the type of crane.

After the periodic technical inspection, a document must be drawn up that will include the following information:

- equipment identification code;
- registration number;
- the name of the equipment;
- series and year of manufacture;
- maximum load;
- maximum opening;
- maximum height;
- maximum length;
- due date;
- date of verification;
- other information specific to the type of equipment.

PAY ATTENTION TO:

- The date of the periodic technical inspection of the crane shall not exceed the inspection period.
- Technical checks of the cranes are required after repairs.
- These aim at verifying the execution of repairs and technical repair documents.
- The repair documents must specify the work performed, the parts used and their certificates of conformity, the test methods used and the procedures and test results (if applicable), the certificate of conformity of the repair activity.
ADDITIONAL CHECKS

For safe operation of the cranes, it is recommended to perform additional checks, depending on the complexity of the crane, the operating regime and the environmental conditions in which it works. Additional checks consist of:

- oil level control;
- checking the bearing condition of the bearings and the proper functioning of the lubrication system;
- lubrication of parts subject to friction according to the lubrication scheme;
- checking the wear of cables and traction chains and their fixing;
- checking the operation of security components and adjusting them;
- checking the operation of the crane mechanisms and repairing or replacing worn subassemblies;
- checking the fastening or handling elements of the load;
- tightening the joining elements, the joints, checking the fixing of the buffers and the stops;
- checking the operation of the electric power, control and signalling system;
- checking the operation and tightness of hydraulic and pneumatic circuits.
To be achieved upon learning outcome completion

**Knowledge:**
- Type of inspection
- The contents of the documents after the periodic technical inspection
- Safety measures for mobile cranes before use
- Safety measures for mobile cranes during use
- Safety measures for mobile cranes after use

**Skills and competences:**
- Understanding the type of inspection
- Understanding the documents for technical inspection
- Knowing the safety measures for mobile cranes
- Problem solving
- Decision making
- Managing risk
ASSESSMENT

1. Cranes can be used without an operating license?
   - Yes
   - No

2. In order to grant the operating license to a crane, check:
   - crane identification data;
   - the existence of the quality file and the technical book
   - the existence of instructions for use and warning
   - invoice
   - warranty certificate

3. Periodic checks of cranes can be performed by:
   - holder;
   - nationally accredited bodies
   - any person employed in the company

4. Before boarding the mobile crane, the operator must check
   - no persons or objects are in the vicinity of the machine
   - shoes are free of mud
   - safety equipment is new

5. The people can be carried or lifted on a load or on a hook?
   - Yes
   - No

6. The load can be moved over other workers or over the cab of a truck?
   - Yes
   - No

7. The load can be suspended on the hook at height?
   - Yes
   - No

8. In the event of accidental contact of the cable with a live power line, the crane operator must:
   - to stay calm
   - to leave the area of influence just by jumping
   - ask other people to disconnect the line

9. The elements of the crane will be checked periodically:
   - wear and tear of cables or traction chains;
   - the state of the security components and their regulation;
   - the functionality of the lifting installation mechanisms;
   - validity of the guarantee certificate
   - the cost of periodic repairs

10. The date of the periodic technical inspection of the crane shall not exceed the inspection period.
    - Yes
    - No
MODULE 5 - Mobile crane set-up
Learning Units (LU) indicative time: (6 hours)

INTRODUCTION

Module 5 provides the main information about setting up the mobile crane. Finding the right compromise between balance, gravity and leverage is crucial to ensure that all operations are carried out with the appropriate precautions and in complete stability. As our entire course is dedicated to mobile cranes, the assembly and disassembly of the two types of boom crane, lattice and telescopic, is explained in detail. Subsequently, a description is also given to the transport phase of the crane tools, with references to existing European legislation.

Once all the parts have arrived at the worksite, it is essential to carry out the part known as "pre-lift", which involves a preventive check by means of a check list of a series of minimum requirements. When preparing the worksite, it is necessary to take into account the ground conditions, which are often uneven or simply sloping, and which can require the use of crane mats or outrigger pads that are sufficient to provide the necessary foundation support for maximum crane safety.

LEARNING OBJECTIVES

- Understanding the right crane setup;
- Be confident with gravity, balance and leverage main functioning in lifting actions;
- Be aware of ground conditions;
- Understand the main features of the lattice boom crane and how to assemble and disassemble;
- Understand the main feature of the telescopic boom crane and how to assemble and disassemble;
- Be aware of the safety requirements during assembly and disassembly;
- Be aware of the transport regulation in order to comply with national legislation and not to damage roads and the mobile crane;
- Recognising the main risks when planning a job and be able to classify them;
- Recognise which types of lift require the support and supervision of specialised personnel as “critical lifts”;
- Recognise the risks involved in setting up the right worksite and soil conditions.
LU 5.1 Crane set-up

It can be difficult to know if the ground beneath your crane will support the weight and pressure under your outriggers, yet knowing this is critical to safe crane setup. In response to this need, U.S. standards and regulatory bodies now place greater emphasis on understanding ground conditions and using crane mats or outrigger pads that are sufficient to provide the necessary foundation support for maximum crane safety.

Here are some mobile crane safety tips and topics for successful crane setup:

- Know your responsibilities. Every country has regulation that states that cranes must be assembled on ground that is firm, drained and graded sufficiently, in conjunction with supporting materials, such as blocking, cribbing, pads, mats, to provide adequate support and levelness.
- Moreover, states that outrigger blocking or cribbing must have sufficient strength to prevent crushing, bending or shear failure. And it needs to be of such thickness, width and length as to completely support the float, transmit the load to the supporting surface, and prevent shifting, toppling or excessive settlement under the load.
- Know the bearing strength of the ground and soils. Because this is an extremely complex combination, it’s a good idea to seek the advice of a geotechnical engineer. A low-cost way to determine ground conditions is to use a Dynamic Cone Penetrometer, which is portable and easy-to-use. This information can be compared to ground bearing pressure charts for different soil types.
- Identify any sub-surface hazards and avoid if possible.
- Evaluate and improve the ground if needed. Ways to improve the ground include compaction, removing un-compacted surface layers, or bringing in rock or other dense inorganic material. If the ground is wet, allow time to get the moisture out.
- Know the maximum pressure the crane will exert on each outrigger during the operation, or the maximum outrigger reaction force. Crane manufacturers provide this information for each crane model, and generally, it can be found in your operation manual. Many also offer free software solutions that allow you to input the lift data, which then outputs the outrigger reaction forces that will be generated.
- Select the right size outrigger pad or crane pad. Undersized pads can put you in an unstable condition, but oversized pads are inefficient in terms of purchase, labour, and transportation costs. Several methods are commonly used in the industry. DICA has evaluated each of these and have found that various methods produce widely varying conclusions and most methods don’t take into account the ground condition. DICA strongly suggests that you should use a sizing method that takes into account ground conditions (ground bearing capacity), and actual outrigger loads.
- Choose crane pads or outrigger pads that are designed and constructed to meet or exceed the bearing, flex and shear strength required. Their purpose is to distribute the load from the outrigger float over a large enough area that the bearing pressure to the ground surface is acceptable. They must be stiff enough that the crane will not go out of level as the load swings.
- Never place blocking, cribbing, pads or mats under the outrigger beam. For safer mobile crane setup, only use them under the outrigger floats or pontoons.
- Monitor every lift. If the outrigger pad or crane mat is showing significant deflection or bending, stop the lift. The outrigger force is greater than the pad and ground can support. Additional appropriate blocking or cribbing should be added. If the pad or mat is being driven into the ground, stop the lift. The pressure under the pad exceeds the ground bearing capacity. A larger pad, blocking or cribbing is needed to spread the load over a larger area, or the ground needs to be improved to adequately support the load.

- Use common sense. If it doesn’t look right, stop. If it doesn’t act right, stop. If it doesn’t feel right, stop. Products are never a replacement for common sense. Use your common sense. You never know the life you save may be your own.

HARD GROUND SETUPS

When working in very hard ground conditions with strict load reduction requirements, using an intermediate layer as a buffer can help you get optimum performance out of your outrigger pads or crane mats.

A common misconception regarding the load distribution of crane pads and mats is that outrigger loads are evenly distributed across the entire mat area in all ground conditions — no matter what the pad is or what the loads or pressures are from the equipment. There will always be some level of peak loading, and actual load distribution will be the result of how the load, ground and pads influence each other.

As the ground conditions become harder or ground bearing capacities increase, pads and mats become less effective in spreading load. In very hard ground conditions such as a slab of concrete, load typically distributes at an angle of 45-60 degrees through the thickness of the pads. This results in higher peak pressures and higher overall ground bearing pressures because of the reduced area of distribution. Often the interaction between the ground and pad is not recognized or understood, which results in higher ground bearing pressures than are intended.

To reduce ground bearing pressure in very hard ground conditions, consider introducing a softer buffer layer that allows for managed pad deflection to occur. The objective is to soften the ground to make the existing pad more effective as opposed to stiffening the pad to overcome the hard ground conditions. Softening the ground is a counterintuitive approach, however making pads stiffer can significantly increase costs and weight. Commonly used intermediate buffer materials include sand, or materials with high compaction strength, such as neoprene or rubber.
Beyond softening the ground to enhance load distribution, an additional benefit of using an intermediate layer is to fill any inconsistencies or voids between the pad and the ground that helps to eliminate point loading on small areas of the ground, and it helps protect the ground surface under heavy loads.

**Ground Bearing Capacity Table**

<table>
<thead>
<tr>
<th>GROUND TYPE</th>
<th>DENSITY OF STATE</th>
<th>Approximate Ground Bearing Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Tons/ft ($^2$)</td>
</tr>
<tr>
<td>Rock (not shale unless hard)</td>
<td>Bedrock</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Layers</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Soft</td>
<td>8</td>
</tr>
<tr>
<td>Hardpan, cemented sand or gravel</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Gravel or sand</td>
<td>Compact</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Firm</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Loose</td>
<td>4</td>
</tr>
<tr>
<td>Sand, coarse to medium</td>
<td>Compact</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Firm</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>Loose</td>
<td>3</td>
</tr>
<tr>
<td>Sand, fine, silty, or with trace of clay</td>
<td>Compact</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Firm</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Loose</td>
<td>2</td>
</tr>
<tr>
<td>Silt</td>
<td>Compact</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Firm</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Loose</td>
<td>2</td>
</tr>
<tr>
<td>Clay</td>
<td>Compact</td>
<td>4</td>
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<tr>
<td></td>
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<td>2.5</td>
</tr>
<tr>
<td></td>
<td>Loose</td>
<td>1</td>
</tr>
</tbody>
</table>

*Source: Cranes and Derricks, Fourth Edition. Author Jay Shapiro*
GRAVITY, BALANCE & LEVERAGE

A mobile crane is built around the design principals of balance and leverage. In short, a crane must be capable of lifting heavy loads, through the use of leverage, while remaining in balance.

Before we dig into these concepts, we need to talk about gravity. We know from Newton and Einstein that the natural phenomenon of gravity is alive and well, all you have to do is drop a small object on your foot to be a believer. In material handling, we have to consider the Centre of Gravity (or CG) of a load. The “centre of gravity symbol”, illustrated by the black and white circles on the illustrations below is used to show the location where an object’s CG lies. The CG of any object is said to be the point in the object where the weight is evenly distributed. Meaning the leverage on one side of the object must be equal to the leverage derived by the other side of the object.

Now let’s look at a balance beam, which is similar to a basic crane model. The beam, balanced on a fulcrum, remains in balance as long as the leverage on one side of the fulcrum is equal to the leverage on the opposite side of the fulcrum. If either of the weights placed on the beam is larger than the other, the beam will tip in the direction of the heavier object. The only way to keep the beam in balance is to move the fulcrum closer to the heavier object, as illustrated below. By moving the fulcrum, the beam remains in balance and each object counterbalances the other.

![Balance beam illustration]

Now let’s apply this to a mobile crane. In the illustration below, the right side of the balance beam is raised up, much like the boom of a crane. As long as each object’s leverage remains equal, the beam remains in balance.

![Mobile crane illustration]

Now let’s take it a step further and suspend the load below the beam like it would be from a crane. In the illustration below, the beam can remain in balance if the leverage derived from each object remains equal.
This example is great, as long as nothing changes, but we know this is not likely to happen. As soon as the weight of the object on the right is increased (like picking up a heavier load) you must compensate by increasing the leverage on the left side of the beam. If the object on the right moves closer to the fulcrum (like retracting a boom), you must compensate by decreasing the leverage of the object on the left side of the beam.

Before we go any further on mobile crane stability, we need to look at the mobile crane itself. Pulling it apart and looking at how the crane is constructed gives us a different perspective on balance than looking at the machine as a whole. So, let’s de-construct it.

- The superstructure, upper structure or upperworks, is the revolving frame of equipment on which the operating machinery are mounted along with the operator’s cab.

- The carrier, chassis or car body is the under carriage of the crane and depending on the type would typically include the carrier cab, wheels/tracks, outriggers, etc. It is designed for transporting the rotating crane superstructure.

- The third component to consider is the boom. They have a CG too. However, as you increase or decrease the length of a hydraulic crane boom, you change the boom’s CG. A lattice boom crane’s CG will remain unchanged, unless a jib or other ancillary item is added.
The example below puts these concepts into action, by looking at the leverage derived by a crane and load.

In the crane field, the fulcrum of the balance beam is replaced by the term “Tipping Axis” and we call the centre of gravity the “CG”. The equation above illustrates how a crane is similar to a balance beam. However, when working with cranes, and one side of the equation equals the other side of the equation, the crane is considered to be in a balanced condition and tipping is ready to occur at any moment.

It would be unsafe to operate a crane where the load’s leverage was equal to the crane’s leverage, so “Reserve” stability is built into crane stability load ratings. Reserve stability can be best illustrated by looking at a crane that has hoisted its maximum safe working load in the area of stability.
Mobile crane stability
They say a picture is worth a thousand words, so this post will use illustrations to indicate some of the various configurations and quadrants of operation where there may be stability concerns and include images of where something went wrong.

Lifting on Rubber
Crane manufacturer’s that allow “on rubber” lifts will provide a load rating chart specifically for this configuration.

Over the Side
Not only are fully set outriggers recommended for the full capacity of the load chart, the image to the right illustrates a telescopic boom truck crane with the boom over the side quadrant. Lifting over the side is the least stable location for most cranes.

Over the Front
Crane manufacturer’s that allow “over the front” lifts will provide a load rating chart specifically for this configuration.
Over the Rear
While this is usually where the most capacity is provided, you must still follow the load chart, and know your load weight for your lift to ensure the crane will remain stable and upright.

Boom Length
Many times, tipping is a result of the boom being extended beyond the necessary length.

Hopefully by now we can all agree that the loss of stability resulting in a tipping incident or accident shouldn’t be a common occurrence. They are costly and can be avoided. Remember the following key points:

- Make sure the operator is a qualified mobile crane operator with the education, knowledge and experience to operate the machine and make the lift.
- There are many crane designs, read the crane manufacturer’s operation manual to make certain the operator fully understands the operating quadrants, superstructure positions and operating characteristics of the crane.
- Make sure the operator fully understands the load capacity chart for the crane they are operating.
- Make sure the operator fully understands how to use the crane’s load weighing device (LMI, RCI, RCL, etc.).
- NEVER lift loads where the load chart does not provide ratings.
- NEVER lift more weight than what’s posted in the load chart.
- Outriggers are to be fully extended and set at all times when practical.
- Never allow the operator to “lift by the seat of their pants” if they can start to feel the crane tipping, then it is already too late, the crane has been overloaded.
GROUND CONDITIONS AND ASSESSMENTS

Before setting up the crane and extending the outriggers a site assessment must be carried out by a competent person to make sure that it can support the load of the crane and the carrying loads. To reduce the risk of having the crane outriggers going into the ground due to the pressures of the loading, spreader plates are used. These enlarge the surface area of the outriggers and thus spread the forces acting on the ground on a larger surface area, making the crane more stable. If the ground conditions are not ideal, other measures such as timber mats, steel grillages or concrete pads should be used. Such example is shown in Figure 11.

There are some common hazards that crane operators must look out for before going on the work site or before starting. Soft uncompacted soil or filling material can be dangerous as it may not always be visible but can be detrimental to the vehicle’s stability and safety.

Setting up the crane close to an excavation site is quite hazardous and industry guidelines advises against such practices as there is a greater risk of the ground giving in without notice. However, in cases where this cannot be avoided a geotechnical engineer should carry out an assessment of the surrounding areas. In residential areas the crane operator has to be aware of any cellars or basements and the type of flooring beneath the crane as the strength of such structures can be compromised with the load o the crane. The same can be said for paved areas, as these are designed to take on the weight of pedestrians and not a loaded crane. The ground underneath may be relatively soft or services such as plumbing and electricity may be passing beneath. Crane operators must also pay attention to the weather conditions, as prolonged rain can cause the ground underneath to become softer and cause instability or collapse.

WIND INFLUENCE

Wind can be a very dangerous hazard when operating a crane as it can easily render the whole structure unstable and cause it to tip over. Crane risk assessment sheets for mobile cranes advise the operator to retract the boom, turn off the machine and get out of the crane if the wind gust has a speed of more than 10m/s. A wind gust is the average wind speed measured on a span of three seconds. The wind speed is the average wind speed measured at a height of 10m over a period of 10 minutes. The crane operator must keep in mind the wind pressure acting on the crane as this increase by a factor of four if the wind speed doubles. Such an abrupt change in wind load pressure can cause the crane to tip over.
The crew operating the crane should always pay attention to the load chart wind speed that the manufacturer suggests for the particular crane. A risk assessment should be carried out to ensure the safety of the crew when operating at higher wind speeds if the crew is experienced enough to control the load in such conditions. Then, determining a safe wind speed can be broken down to three simple things:

- Firstly, the wind speed at which the crew feels safe operating. This should be judged by experience and risk assessment. The risk assessment may include how much a load may move about, the ability to control the load by tag lines, site restrictions and other factors.
- Secondly, the load chart wind speed that the crane manufacturer specifies as the maximum wind speed. The load chart wind speed may vary by configuration, boom length, sequence, etc.
- Thirdly, the permissible wind speed may need to be reduced below the load chart wind speed due to the surface area of the load.

The wind load can be calculated using the following equation:

\[ F = A \times P \times C_d \]

Where:
- \( F \) is the wind load
- \( P \) is the wind pressure
- \( C_d \) is the drag coefficient (which depends on the shape of the object)

**Gust versus average wind speed**

The load chart wind speed and permissible wind speed are based on the instantaneous maximum wind speed inclusive of any gusts. This is the so called “three second gust” measured at the highest point of the boom system, and not the average wind speed measured at a 10m elevation over a time period of 10 minutes as given by most weather stations. The three second gust wind speed can easily be higher by a factor of two and more i.e., taking into account the average wind speed at 10m elevation may significantly underestimate the real conditions.
LU 5.2 Lattice boom crane

The major components of a lattice boom crane are shown in figure 1. Inspecting each of these components is part of the operator’s prestart inspection. The lattice boom supports the working load and is the most common boom used in the NCF. It is used on all types and makes of cranes and is mounted at the boom butt on the revolving superstructure. On a crane, the boom supports the weight of the load as well as providing lift and reach. The basic boom consists of a boom base section and a boom tip section. Its length is increased by assembling additional sections, as in the case of the lattice boom, or by hydraulically extending sections, as in the case of the telescopic boom.

![Figure 1 - Lattice boom crane components.](image)

**Boom sections**

Lattice boom sections are made of lightweight, thin wall, high strength alloy tubular or angle steel, designed to take compression loads. The most common type of boom section is tubular, shown in Figure 2, consisting of four main chords connected with lattices also known as lacing. At the very bottom, where it becomes attached to the boom base section, are four pin connection lugs and a bracing member referred to as the diagonal. The square frame at each end of the boom insert is commonly referred to as the picture frame.
Manufacturers recommend not using a crane if it has rust, bent lacings or cords, cracked welds, and other problems that affect the strength of the lattice boom. These zero tolerances require crane crews to use extreme care when handling unused sections with forklifts, storing unused sections away from traffic areas, transporting and securing sections on tractor-trailers, and preventing equipment or obstacles from running into the boom while mounted on the crane during transport, performing operations, or when parked. The NCF uses sections that are normally 10 to 20 feet in length. When adding several sections of different lengths, check the operator’s manual for boom section configuration. If this information is not in the operator’s manual, a rule of thumb used when mixing short boom sections with long sections is to install the shorter sections closest to the boom base section; for example, if you use two 10-foot sections and one 20-foot section, install the two 10-foot sections closest to the boom base section. The boom sections are bolted by plate (flange) connections (Figure 3A) or pin and clevis connections (Figure 3B). The most common is the pin and clevis. All boom sections that come with a crane will have an attachment identification number attached that assigns the boom section to a specific crane.

Figure 2 - Tubular boom section.

Figure 3 - (A) Bolt connection and (B) Pin connection.
Boom angle indicator

The capacities that are listed on the crane load charts are also based on and vary with the boom angle of the crane. The boom angle, on lattice boom cranes is between the centre line of the boom (from the boom base section pins to the head machinery) and the horizontal while the boom is under load (Figure 4). Some cranes are equipped with boom angle indicators that are fluid type, mounted on the left of the operator’s cab on the boom base section visually readable by the operator (Figure 5). This type of indicator must be adjusted properly, free from binding, and the crane must be level or it to accurately indicate boom angles. Even under these conditions its readings are only approximate.

On other type of cranes, the boom angle indicator consists of a metal plate with degree numbers (0 to 90 degrees) and a freely swinging arm that reacts as the boom angle changes. On such indicators, the numbers and arms should remain clean and visually readable at all times. To check the accuracy of the boom angle indicator, place a 3-foot builder’s level on the centre boom section as shown in Figure 21-13. Raise and lower the boom until the level shows the boom is at zero degrees.

Although the boom angle indicator is a quick reference for the operator to know what angle the boom is at, do not rely on the boom angle indicator for radius accuracy especially when the lift exceeds 75 percent of the rated capacity. Use the radius measurement to determine the capacity of the crane from the load rating charts and to avoid any possibility of error.

Figure 4 - Boom angle on a lattice boom crane.  
Figure 5 - Fluid type boom angle indicator.
Sheaves

Sheaves are located in the gantry, boom mast, bridle, and hook block. An arrangement of sheaves located at the very top of the boom tip section is referred to as the head machinery. Sheaves rotate on either bearings, or bushings, and are installed basically anywhere wire rope must turn or bend.

Boom pendants

A pendant is a fixed-length of wire rope forming part of the boom suspension system. Each section of boom has two pendants. Both pendants must stay with the section of the boom they came with. When storing a boom section, secure the two pendants to the boom section with tie wire or rope. If one pendant is bad, always replace both. If you only replace the one bad pendant, the new or replaced pendant could be different in length or manufacture. This difference will cause an uneven pull or twist on the boom when the boom is put under a load or strain.

Gantry

The gantry, or A-frame, is a structural frame, extending above the revolving superstructure. The gantry supports the sheaves in which the boom hoist lines are reeved. The height of the gantry provides an angle between the pendants and boom that reduces the compression forces placed on the boom during raising and lifting operations; therefore, always raise the gantry before raising the boom or lifting a load. On some models of cranes, the gantry is adjustable, allowing it to be lowered so the crane can travel under bridges.

Boom mast

Some models of cranes are equipped with a boom mast instead of a gantry, as shown in Figure 7. The boom mast, sometimes called live mast, consists of a structural frame hinged at or near the bottom of the boom base section that is lowered by gravity solely under the control of the boom hoist drum brake. The tip of the boom mast supports the boom hoist sheaves and pendants. The boom mast works like the gantry, as it increases the angle between the pendants and boom, decreasing the compression forces placed on the boom.
This project has been funded with support from the European Commission. This communication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Bridle assembly

The bridle assembly is part of the boom suspension system. It may be connected to the boom mast or serve as a floating harness on a crane equipped with a gantry. The bridle assembly is the connection point between the pendants and is an assembly of sheaves in which the boom hoist wire rope reeves through.

Boom hoist reeving

Rigged to the rear winch drum, the boom hoist reeving is part of the boom suspension system used to raise and lower the boom.

Boom stops

Boom stops are designed to prevent the boom from going over backwards if a load line breaks. They will not stop the boom if the operator forgets to disengage the boom hoist control lever. However, some models of cranes are equipped with a boom upper limit switch that prevents the operator from raising the boom past a pre-set boom angle. This switch also prevents operators from raising the boom into the boom stops. Most cranes that are equipped with the upper limit switch also have a bypass switch that allows the operator to raise the boom past the pre-set boom angle. One type of boom stop is shown in Figure 8.
5.2.1 Assembly and disassembly lattice boom crane

CONTEXT

Mobile crane operators need to disassemble cranes in order to transport them to and from jobsites. Disassembly of the crane may be necessary to comply with road regulations. Mobile crane operators assemble the cranes once on site. When assembling or disassembling a lattice boom always observe the following points:

- Obtain, read, and understand the step-by-step instructions outlined in the approved AEP specific to the type of crane.
- Do not stand inside, on, or under the boom at any time while assembling or disassembling the boom.
- Do not climb, stand, or walk on the boom. Use a ladder or similar device to reach necessary areas.
- When removing or installing the boom section, drive the connection pins from the outside of the boom toward the inside, as shown in Figure 9.

![Figure 9 - Drive connection pins from outside in.](image)

- When removing the boom section, be sure the pendants are tight and located at or behind the boom connection. Only the lower pins located behind the pendants may be removed; the boom must be straight, and head machinery rested on blocking, all of which are shown in Figure 10.

![Figure 10 - Correct way of removing lattice boom section.](image)
Always wear proper eye protection, hard hat, safety glasses or goggles and safety shoes when removing or installing the boom section.

Stay clear of pinch points when aligning boom section connection lugs. Never place your fingers in connection pin holes.

Use caution when disconnecting the dead end of wire ropes. Reeve ropes can become twisted on the sheaves. When the dead-end pin or socket is removed, the rope may spin.

ASSEMBLY LATTICE BOOM CRANE

The following are general steps for assembling a boom section on a lattice boom that is equipped with either a gantry or boom mast, mounted on either a crawler or truck carrier:

Step 1. Have a forklift align the boom section with the boom base section.
Step 2. Reverse the crane until the boom base top pin connection lugs are connected with the top pin connection lugs on the boom section. The boom breakdown performed over the side requires a forklift to manoeuvre the boom section until the pins are aligned.
Step 3. Once the top lugs are aligned, drive the boom connection pins into the top lugs from the inside out and insert the cotter pins.
Step 4. Engage the boom hoist control lever to raise the boom base section. This allows the top pins to perform as a hinge that draws the bottom pin connection lugs together.
Step 5. Once the bottom lugs are aligned, drive the boom connection pins into the bottom lugs from the inside out and insert the cotter pins.
Step 6. Raise both the boom base and section several inches to clear the ground. Reverse the crane until the top connection lugs of the boom section align with the top connection lugs of the boom tip. Final alignment of the lugs might require the use of a crowbar.
Step 7. Once the lugs are aligned, drive the boom connection pins into the top lugs and insert the cotter pins.
Step 8. Engage the boom hoist control lever to raise the boom section and tip. This results in the top pins performing as a hinge, drawing the bottom pin connection lugs together.
Step 9. Once the bottom lugs are aligned, drive the boom connection pins into the bottom lugs from the inside out and insert the cotter pins.
Step 10. If the crane is mounted on a truck carrier, reset the outriggers.

The procedures for connecting the bridle to the pendants are as follows:

Step 1. Engage the boom hoist control lever to lower the bridle or boom mast to produce slack in the boom hoist wire rope.
Step 2. The next step is to connect the bridle assembly to the boom section pendant lines. To do this, disconnect the bridle assembly from the boom base section and manually manoeuvre the bridle assembly to connect with the pendants of the boom section. Producing slack in the bridle assembly may require manually feeding the boom hoist wire rope through the sheaves.

NOTE: if the crane is equipped with a boom mast, lower the boom mast to connect the pendants.
Step 3. When the pendants are connected to the bridle, it is a good practice to insert the pins from the inside out. This practice allows for an easier visual inspection of the cotter pins inserted in the pendant line pins when the boom is in the air.

Step 4. The next step is to connect the boom section pendants to the boom tip pendants. This usually requires manual labour to align the boom section pendants to the boom tip pendants. You may also have to engage the boom hoist control lever to provide slack in the boom hoist reeving to align the pendants. Once the pendants are aligned, insert the pendant connection pins and cotter pins.

Step 5. Next, engage the boom hoist control lever to raise the bridle assembly and pendants. Before doing this, go back through and visually inspect all boom and pendant pin connections and cotter pins. Have someone watch the boom hoist drum to ensure the wire rope does not cross wind, causing it to be crushed or kinked. Additionally, ensure all of the boom hoist wire rope is properly running on all of the sheaves. Once everything checks out, engage the boom hoist control lever and raise the bridle and pendants until they are tight.

Step 6. Visually check the boom’s suspension system before raising it off the ground. As the boom is being raised, visually check the boom hoist wire rope.

Step 7. Once the boom is erected, check the hoist wire rope reeving. You want to ensure the wire rope is correctly flowing through the head machinery and hook block sheaves and winding properly on the hoist drum.

DISASSEMBLY LATTICE BOOM CRANE

When disassembling a lattice boom, take the opportunity to inspect thoroughly items such as the connection pins, cotter keys, and inside the connection lugs for wear, rust, and surface cracks.

The following are general steps for disassembling a boom section on a lattice boom that is equipped with either a gantry or boom mast, mounted on either a crawler or truck carrier.

Step 1. If the crane is mounted on a truck carrier, set outriggers and swing the superstructure over the rear or side, depending on the make and model of the crane.

Step 2. Lower the hook block(s) to the ground and provide slack in the hoist line(s). Next, lower the boom and set the head machinery on blocking.

Step 3. Engage the boom hoist control lever to lower the bridle assembly or boom mast to slacken the pendants.

Step 4. To prevent the pendants from falling to the ground, use tie wire or rope to secure them to the boom. Then, remove the cotter pins and drive out the main pins from the bridle assembly connections in the pendants.

Step 5. Position the bridle assembly on top of the boom base (Figure 11). The operator does this by engaging the boom hoist control lever to tighten the boom hoist lines until the bridle is positioned on top of the boom base. To align the pinholes, manually position the bridle assembly using a crowbar. The pins that are used for the pendant line connections are normally the pins used to connect the bridle assembly to the boom base. If the crane is equipped with a boom mast; the boom mast normally has a short set of pendants that connect to the boom base pinholes (Figure 12).
NOTE: visually check the boom hoist drum to ensure the boom hoist wire rope does not loosen and cross wind on the hoist drum, resulting in crushing or kinking the wire rope.

**Step 6.** Tighten the boom hoist lines to support the weight of the boom, but not so tight that the head machinery is lifted off the blocking.

**Step 7.** Remove the cotter pins from the boom connecting pins and drive out the lower boom connection pins.

**Step 8.** After removing the lower pins, engage the boom hoist control lever and lower the bridle assembly or mast, allowing the boom to separate at the bottom by hinging on the top pins. Then, lower the boom on blocking.

**Step 9.** Remove the top connection pins. Once they are removed, engage the boom hoist enough to separate the boom connection lugs.

When performing the boom breakdown over the rear of the crane, separate the boom by raising the outriggers enough to move forward with the carrier and by releasing the brakes on the hoist line(s) to slacken the hoist wire rope, as the carrier moves forward to allow space to add a section(s).

When performing the boom breakdown over the side of the crane, separate the boom by releasing the brakes on the hoist line(s) to slacken the hoist wire rope and using a forklift to pick up the boom tip carefully and manoeuvre it enough to provide adequate space to insert a boom section(s).
REQUIRED KNOWLEDGE

1. lifting points
2. component weight
3. pinch points
4. blocking procedures
5. rigging and hardware
6. component preparation (cleaning debris and contaminants from surfaces)
7. installation and removal of bridle and boom stops
8. boom composition chart and blueprints
9. space requirements for assembling
10. capabilities and limitations of auxiliary lift equipment
11. reeving and lacing (including self-reeving)
12. hook block and overhaul ball capacity
13. result of using defective hardware
14. remote control procedures
15. ground conditions
16. assembly and disassembly procedures according to manufacturers’ specifications

Key competencies to assemble lattice boom crane

To install tracks on car body:

- ensure car body is level
- remove any blocking between drive sprockets and pads
- extend/retract tracks
- position track onto the car body using auxiliary lift equipment or manufacturers’ procedures for self-erecting
- install fasteners according to manufacturers’ specifications to secure track on car body
- join hydraulic/mechanical connections to complete drive/outrigger circuits
- adjust track and chain tension according to manufacturers’ specifications

To install house:

- check for defects such as worn bolts, pins and bushings
- clean all surfaces and apply lubricant to pins and connection points to allow assembly
- position house onto the car body/crrier using assist crane or manufacturers’ recommended procedure for self-erecting cranes
- install fasteners according to manufacturers’ specifications to secure house on car body/crrier
- connect hydraulic lines and electrical connections to complete circuits
To install outrigger boxes:

- position outrigger box using auxiliary lift equipment such as forklifts, boom trucks or assist cranes depending on type of crane or manufacturers’ procedure for self-erecting
- check for defects such as damaged hoses, fittings and cylinders
- clean fittings to avoid oil contamination and ensure ease of installation
- connect hoses and wiring according to manufacturers’ specifications to complete hydraulic and electrical circuits
- install fasteners such as bolts and pins according to manufacturers’ specifications to secure the outrigger box to the car body/carrier

To install boom base:

- clean and lubricate pins and bushings to allow assembly
- raise gantry and/or live mast to working position
- position boom base onto house using assist crane or live mast depending on type of crane or manufacturers’ procedure for self-erecting
- install fasteners such as heel pins, keeper pins and bridle connections to secure boom base onto house
- connect hoses and electrical wiring according to manufacturers’ specifications to complete circuits

To assemble boom and jib:

- check for defects such as damaged chords, lacings and pendants
- determine installation sequence of boom/jib sections according to manufacturers’ specifications
- use blocking to suit ground conditions
- lay out and connect boom/jib sections (including pendants and wiring) according to manufacturers’ instructions

To install counterweights:

- check for defects such as broken bolts, and damaged threads and pins
- determine installation sequence and placement of counterweights according to manufacturers’ specifications
- place counterweights on crane (tray or deck) for final installation of assembly
- raise and lower assembled counterweights into position according to manufacturers’ specifications
- install fasteners such as pins and bolts to secure assembled counterweights according to manufacturers’ specifications
To install hoist lines, hook blocks and overhaul ball:

- spool out stored hoist line off of winch while maintaining adequate tension to avoid damaging hoist line
- cut and seize wire rope lines using cable cutting equipment according to manufacturers’ specifications
- reeve hook block with required parts of line to lift calculated weight
- terminate wire rope ends using connections such as wedge sockets
- install fasteners to secure the hoist line to boom head or block/ball

Key competencies to disassemble lattice boom crane

To remove hoist lines, hook blocks and overhaul ball:

- remove and store fasteners
- dismantle end connections (wedge sockets)
- remove wire rope from hook block
- spool in hoist line onto winch while maintaining adequate tension to ensure proper spooling
- secure line on drum to preserve spooling

To disassemble boom and jib:

- lower boom/jib onto blocking that suit ground conditions
- dismantle boom/jib sections (including pendants and wiring) according to manufacturers’ instructions
- remove and store hardware and accessories

To remove counterweights:

- remove and store fasteners such as pins and bolts
- raise and lower counterweight assembly out of position according to manufacturers’ instructions
- disassemble counterweight assembly

To remove boom base:

- disconnect hoses and electrical wiring according to manufacturers’ specifications
- support base using auxiliary lift equipment
- remove and store fasteners such as heel pins, keeper pins and bridle connections
- lift boom base off house using assist crane or live mast depending on type of crane
- lower gantry and/or live mast to stowed position
To remove house:

- support with blocking suitable for ground conditions and level the crane using equipment such as jacks and assist cranes to facilitate removal of house
- secure house with auxiliary lift equipment
- disconnect hydraulic lines and electrical connections
- remove and store fasteners according to manufacturers’ specifications
- lift house off car body/carrier using assist cranes or manufacturers’ recommended procedure for self-erecting cranes

To remove tracks from car body:

- disconnect hydraulic/mechanical connections for drive/outrigger systems
- extend/retract tracks
- support with blocking and level the crane using equipment such as jacks and auxiliary lift equipment to facilitate removal of track
- ensure weight of track is supported using auxiliary lift equipment before removing fasteners
- remove and store fasteners according to manufacturers’ specifications
- lift track off the car body using auxiliary lift equipment

To remove outrigger boxes:

- ensure weight of outrigger box is supported, using auxiliary lift equipment such as forklifts or assist cranes depending on type of crane, before removing hardware
- remove fasteners such as bolts and pins according to manufacturers’ specifications to release the outrigger box from the car body/carrier
- disconnect hoses and electrical wiring according to manufacturers’ specifications
LU 5.3 Telescopic boom crane

Telescopic boom cranes are typically called hydraulic cranes. The booms are composed of a series of rectangular, trapezoidal, or other shape of symmetrically cross-sectional segments, fitting into each other. The largest segment, at the bottom of the boom, is called the base section or boom butt. The smallest section, at the top of the boom, is called the tip section or boom tip. In between there can be one or more sections called the first, second, and so forth, sections. With the boom fully retracted, the telescopic boom crane is highly manoeuvrable and easy to transport to jobsites. Telescopic boom crane nomenclature is shown in Figure 13.

![Figure 13 - Telescopic boom crane nomenclature.](image)

**Boom sections**

Telescopic booms may be a pinned boom, full-powered boom, or a combination of both. A "pinned boom" means sections are pinned in the extended or retracted position. A "full-powered boom" means sections extend or retract hydraulically. Some models have a full-powered main boom with a pinned boom tip section. Read the operator’s manual for the proper operation of the type of boom that is equipped on the crane you are assigned to operate.

On a full-powered boom, the sections are extended and retracted (except for the base section) by hydraulic cylinders, called extension cylinders. The cylinders are mounted parallel to the boom centre line within each section. The boom extension cylinders on most telescopic booms have sequencing valves that allow the sections to extend (telescope) by equal amounts. These cranes usually have a single telescope control lever in the cab. However, on cranes not equipped with sequencing valves, the operator will have to extend each section equally. (The crane will have two or three boom telescope control levers in the cab, each controlling only a single boom section.) If the boom sections are extended unequally, the most fully extended section of boom could bend to uneven stresses. Additionally, the load chart will be invalidated for determining rated capacity of the crane. Boom sections that are marked off in equal increments, as shown on the boom in figure 4, make it easier for the operator or signalman to make sure each section is extended equally.
When a load is placed on a telescopic boom, the load weight on the boom causes the hydraulic rams within the boom to stiffen up and slightly curve. As the load is removed from the boom, the rams return straight. Because of this, do not extend the boom while it is under load. Read the operator’s manual for boom extension information.

**Boom angle indicator**

The boom angle indicator is located on the boom base section, on same side as the superstructure operator’s cab. The boom angle on a telescopic boom crane is between the boom base section and the horizontal while the boom is under load (Figure 14). Checking the accuracy of a boom angle indicator on a telescopic boom is similar to doing so on a lattice boom.

![Figure 14 - Boom angle for a telescopic boom crane.](image)

**Hoisting mechanism**

The hoisting mechanism for a telescopic crane is a hydraulically powered hoist drum. The hoist drum is mounted behind the boom on the crane house or revolving turntable. Some hydraulic cranes are equipped with two hoist drums: one for the main hoist and the second for the auxiliary or whip line.

**House assembly**

The house assembly is a revolving unit that supports the boom. Some small hydraulic cranes have the operator’s cab and counterweight attached to the revolving unit.
**Operator’s cab**

The telescopic crane will have hoist, swing, and boom control levers similar to the cab of the lattice boom crane. Control lever(s) is/are also provided to extend and retract the boom. The hoist system does not require foot-controlled brakes. When the hoist control lever is returned to the neutral position, the hydraulic system holds the load in place.

**Counterweight**

The counterweight on a telescopic crane provides greater stability when lifting loads. When you are performing near-capacity lifts at high boom angles using a telescopic crane, about 60 percent of load weight is placed on the outriggers away from the load. When you are performing the same lift with a lattice boom crane, about 60 percent of the load is placed on outriggers close to the load.

**Operating Machinery**

Similar to the lattice boom, the operating machinery on the telescopic boom consists a front and a rear winch drum, mounted one behind the other and located behind the boom.

**Power source**

The power for a telescopic crane comes from hydraulic fluid. In most cases, the main carrier engine drives the hydraulic pump that supplies the hydraulic fluid to hydraulically controlled components. Power is diverted to hydraulic motors or cylinders by the valve body at the operator’s control station. The hydraulic power provides positive control of all crane functions.
5.3.1 Assembly and disassembly telescopic boom crane

CONTEXT

Mobile crane operators need to disassemble cranes in order to transport them to and from jobsites. Disassembly of the cranes may be necessary to comply with road regulations. Mobile crane operators assemble the cranes once on site. Any configuration changes require inspection. Effective communication skills are essential to ensure safety and efficiency when assembling and disassembling telescopic cranes.

REQUIRED KNOWLEDGE

1. lifting points
2. component weight
3. hydraulic pressure
4. reeving of hook block and attachment of overhaul ball
5. result of using defective hardware
6. capabilities and limitations of auxiliary lift equipment
7. component preparation (cleaning debris and contaminants from surfaces)
8. rigging and hardware
9. rigging procedures
10. assembly and disassembly procedures according to manufacturers’ specifications

Key competencies to assemble telescopic boom crane

To install outrigger boxes:

- position outrigger box using auxiliary lift equipment such as forklifts or assist cranes depending on type of crane or manufacturers’ procedure for self-erecting
- check for defects such as damaged hoses, fittings and cylinders
- clean fittings to avoid oil contamination and ensure ease of installation
- connect hoses and electrical wiring according to manufacturers’ specifications to complete hydraulic and electrical circuits
- install fasteners such as bolts and pins according to manufacturers’ specifications to secure the outrigger box to the car body/carrier

To install main boom:

- operate boom launcher or use assist cranes to position main boom for correct installation
- install fasteners such as pins, bolts and other hardware to secure boom
- connect hydraulic lines and electrical connections to complete circuits
To install hoist lines, hook blocks and overhaul ball:

- spool out stored hoist line off of a winch while maintaining adequate tension to avoid damaging hoist line
- cut and seize wire rope lines using cable cutting equipment according to manufacturers’ specifications
- reeve/lace hook block with required parts of line to lift calculated weight
- terminate wire ropes ends using connections such as wedge sockets
- install fasteners to secure the hoist line to boom head or block/ball

To install counterweights:

- check for defects such as broken bolts, and damaged threads and pins
- determine installation sequence and placement of counterweights
- place counterweights on crane (tray or deck) for final installation of assembly
- raise and lower assembled counterweights into position according to manufacturers’ specifications
- install fasteners such as pins and bolts to secure assembled counterweights

To install swing-away jibs and inserts:

- manually retract telescopic jib extensions
- remove and store fasteners according to manufacturers’ specifications
- disconnect electrical components such as anemometer, anti-two block and lights
- disconnect hydraulic components such as luffing cylinders
- remove inserts using an assist crane
- return offset to stowed position
- stow and secure jib for travel according to manufacturers’ specifications
- ensure weight of swing-away jib and inserts are supported by auxiliary equipment before removing any hardware

Key competencies to disassemble telescopic boom crane

To remove counterweights:

- remove fasteners such as pins and bolts according to manufacturers’ specifications
- raise and lower counterweight assembly out of position
- disassemble counterweight assembly

To remove hoist lines, hook blocks and overhaul ball:

- remove and store fasteners
- dismantle end connections such as wedge sockets
- remove wire rope from hook block
- spool hoist line onto winch while maintaining adequate tension to ensure proper spooling
- secure line on drum to preserve spooling

**To remove main boom:**

- ensure weight of main boom is supported by auxiliary equipment or boom launcher before removing any hardware
- remove fasteners such as pins, bolts and other hardware
- disconnect hydraulic lines and electrical connections

**To remove outrigger boxes:**

- ensure weight of outrigger box is supported, using auxiliary lift equipment such as forklifts or assist cranes depending on type of crane, before removing hardware
- remove fasteners such as bolts and pins to release the outrigger box from the car body/carrier
- disconnect hoses and electrical wiring
LU 5.4 Safety during assembly and disassembly

Accidents during assembly and disassembly of lattice boom and tower cranes are one of the major causes of crane-related fatalities. These sections are designed to prevent such accidents by requiring safe assembly/disassembly procedures for lattice boom and tower cranes. Hydraulic-boom cranes (such as telescopic boom crane) are not generally assembled on site, but these sections contain some provisions, such as the requirement for proper setting of outriggers and stabilizers, that apply to cranes with hydraulic booms.

Required procedures

When assembling or disassembling a crane, you must comply with either:

- manufacturer procedures, or
- your own employer procedures, which must be developed by a qualified person. Such procedures must, at a minimum (1) prevent unintended dangerous movement or collapse of any part of the equipment; (2) provide adequate support and stability of all parts of the equipment; and (3) position employees involved in the assembly/disassembly operation so that their exposure to unintended movement or collapse of part or all of the equipment is minimized.

Regardless of which of these options you choose, you must follow any manufacturer prohibitions that apply to the assembly/disassembly operation.

The A/D Director

All assembly/disassembly operations must be directed by an individual who meets the criteria for both a competent person and a qualified person, or by a competent person who is assisted by one or more qualified persons. The A/D director must understand the applicable assembly/disassembly procedures. The A/D director must take the following precautions to protect against potential hazards associated with the operation, including:

- site and ground conditions must be able to support the equipment during assembly/disassembly;
- blocking material must be the correct size, amount, and condition. The blocking must be stacked so as to sustain the loads and maintain stability;
- when used to support lattice booms or components, blocking must be placed appropriately to protect the structural integrity of the equipment, and prevent dangerous movement and collapse;
- when using an assist crane, the loads that will be imposed on the assist crane at each phase of assembly/disassembly must be verified as being within its rated capacity;
- the point(s) of attachment of rigging to a boom must be suitable for preventing structural damage and facilitating safe handling of these components;
- the centre of gravity of the load must be identified, if necessary, for the method used for maintaining stability. Where there is insufficient information to accurately identify the centre of gravity, measures designed to prevent unintended dangerous movement resulting from an inaccurate identification of the centre of gravity must be used;
- the boom sections, boom suspension systems (such as gantry A-frames and jib struts), and components must be rigged or supported to maintain stability upon the removal of the pins;
- suspension ropes and pendants must not be allowed to catch on the boom or jib connection pins or cotter pins (including keepers and locking pins);
- steps must be taken to prevent unintended movement from counterweights that are inadequately supported or are being hoisted;
- each time reliance is to be placed on the boom hoist brake to prevent boom movement during assembly/disassembly, the brake must be tested prior to such reliance to determine if it is sufficient to prevent boom movement. If it is not sufficient, a boom hoist pawl, other locking device/back-up braking device, or another method of preventing dangerous movement of the boom (such as blocking or using an assist crane) from a boom hoist brake failure must be used;
- backward stability must be assured before swinging the upperworks, travel, and when attaching or removing equipment components;
- the effect of wind speed and weather on the equipment must be taken into account.

The crew

Before the operation begins, the A/D director must ensure that the crew members understand all of the following:

- their tasks;
- the hazards associated with their tasks;
- the hazardous positions/locations that they need to avoid.
- Before a crew member goes to a location that is out of view of the operator and is either in, on, or under the equipment, or near the equipment (or load) where the crew member could be injured by movement of the equipment (or load), the crew member must inform the operator that he/she is going to that location. Whenever the operator knows that a crew member is in such a potentially dangerous position, the operator must not move any part of the equipment (or load) until the operator is informed in accord with a prearranged system of communication that the crew member is in a safe position.

The rigger

When rigging is used for assembly/disassembly, the employer must ensure that the rigging work is done by a qualified rigger, i.e., a rigger who meets the definition of a qualified person.

Working under the boom, jib or other components

When pins (or similar devices) are being removed, employees must not be under the boom, jib, or other components, unless site constraints require one or more employees to be in such a position. In such a case, the A/D director must implement procedures that minimize the risk of unintended dangerous movement and minimize the duration and extent of exposure under the boom.
**Synthetic slings**

When using synthetic slings during assembly or disassembly, you must follow the synthetic sling manufacturer’s instructions, limitations, specifications and recommendations. Synthetic slings must be protected from abrasive, sharp or acute edges, and configurations that could cause a reduction of the sling’s rated capacity, such as distortion or localized compression.

**Outriggers and stabilizers**

When the load to be handled and the operating radius require the use of outriggers or stabilizers, or at any time when outriggers or stabilizers are used:

- the outriggers or stabilizers must be either fully extended or, if manufacturer procedures permit, deployed as specified in the load chart;
- the outriggers must be set to remove the equipment weight from the wheels, except for locomotive cranes. This provision does not apply to stabilizers;
- when outrigger floats are used, they must be attached to the outriggers. When stabilizer floats are used, they must be attached to the stabilizers;
- each outrigger or stabilizer must be visible to the operator or to a signal person during extension and setting;
- outrigger and stabilizer blocking must be the correct size, amount, and condition. The blocking must be placed only under the outrigger or stabilizer float/pad of the jack or, where the outrigger or stabilizer is designed without a jack, under the outer bearing surface of the extended outrigger or stabilizer beam.

**Dismantling booms and jibs**

The following precautions must be taken to prevent dangerous movement of boom and jib sections that are being dismantled.

- none of the pins in the pendants are to be removed (partly or completely) when the pendants are in tension;
- none of the pins (top or bottom) on boom sections located between the pendant attachment points and the crane/derrick body are to be removed (partly or completely) when the pendants are in tension;
- none of the pins (top or bottom) on boom sections located between the uppermost boom section and the crane/derrick body are to be removed (partly or completely) when the boom is being supported by the uppermost boom section resting on the ground (or other support);
- none of the top pins on boom sections located on the cantilevered portion of the boom being removed (the portion being removed ahead of the pendant attachment points) are to be removed (partly or completely) until the cantilevered section to be removed is fully supported.
LU 5.5 Transportation

Transport is a fundamental phase in the setting up of a construction site, involving the logistics of vehicles and materials. The aspect of safety during transport is by no means negligible and in fact, according to the U.S. Bureau of Labor Statistics\(^3\), transportation incidents - along with falls to a lower level - made up 14 percent of the fatal injuries involving cranes, just after the other cause of being struck by a falling object or equipment. In 60% of these cases, the worker was struck by an object falling from a crane\(^4\).

Today’s heavy lift cranes weigh almost as much as the loads they lift, which means getting them to the job site can be a challenge. For this reason, not only do crane companies need to be experts in the field, they need to be experts also in federal and state Department of Transportation requirements for getting equipment to the job site. Even a small company traveling within its own state has to deal with load limits on roads and bridges. They have to know about special vehicle registration and when permits are required. They need to know when to remove weight from the crane, and how to transport the boom and counterweights separately. Larger companies, traveling over state lines, need to know the subtle differences in requirements from state-to-state or may be faced with large fines, travel delays, or accidents.

Extra planning is required if any part of the travel is off-road or on non-paved roads. The travel plan could call for removing weight from the crane in order to stay within weight requirements on public-paved roads. When going off-road, it may be necessary to use wood, metal or cement matting over the full route of travel, or in extreme cases, building a road that can handle the weight of a crane\(^5\).

Throughout Europe, each European Member State has its own rules for the professional competence and certification of crane operators\(^6\). These rules range from compulsory to optional and even to no rules at all. Regarding the certification scheme, the European Association of Abnormal transport and Mobile Cranes is currently developing the European Crane Operators License (ECOL) which is a European Operator Licensing System aimed at the operators of mobile cranes\(^7\). The training for the ECOL is delivered by training institutes and a precondition for taking part in an ECOL training and examination is that participants are at least 18 years old, and hold of a valid EU Class-C driving license (truck driving license).

From a legislative point of view, the main reference is the Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC.

In details, here are some specific points for the regulation of the driver and the machinery also during the transport:

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\(^6\) European Association of Abnormal Transport and Mobile Cranes (2020).

\(^7\) [https://ecol-esta.eu/](https://ecol-esta.eu/)
“1.3. PROTECTION AGAINST MECHANICAL HAZARDS

1.3.1. Risk of loss of stability Machinery and its components and fittings must be stable enough to avoid overturning, falling or uncontrolled movements during transportation, assembly, dismantling and any other action involving the machinery.

If the shape of the machinery itself or its intended installation does not offer sufficient stability, appropriate means of anchorage must be incorporated and indicated in the instructions.

3. SUPPLEMENTARY ESSENTIAL HEALTH AND SAFETY REQUIREMENTS TO OFFSET HAZARDS DUE TO THE MOBILITY OF MACHINERY.

3.1. GENERAL 3.1.1. Definitions (a) “Machinery presenting hazards due to its mobility” means — machinery the operation of which requires either mobility while working, or continuous or semicontinuous movement between a succession of fixed working locations, or — machinery which is operated without being moved, but which may be equipped in such a way as to enable it to be moved more easily from one place to another. (b) ‘Driver’ means an operator responsible for the movement of a machine. The driver may be transported by the machinery or may be on foot, accompanying the machinery, or may guide the machinery by remote control.

3.2. WORK POSITIONS

3.2.1. Driving position Visibility from the driving position must be such that the driver can, in complete safety for himself and the exposed persons, operate the machinery and its tools in their foreseeable conditions of use. Where necessary, appropriate devices must be provided to remedy hazards due to inadequate direct vision. Machinery on which the driver is transported must be designed and constructed in such a way that, from the driving positions, there is no risk to the driver from inadvertent contact with the wheels and tracks. The driving position of ride-on drivers must be designed and constructed in such a way that a driver’s cab may be fitted, provided this does not increase the risk and there is room for it. The cab must incorporate a place for the instructions needed for the driver.

3.2.2. Seating Where there is a risk that operators or other persons transported by the machinery may be crushed between parts of the machinery and the ground should the machinery roll or tip over, in particular for machinery equipped with a protective structure referred to in section 3.4.3 or 3.4.4, their seats must be designed or equipped with a restraint system so as to keep the persons in their seats, without restricting movements necessary for operations or movements relative to the structure caused by the suspension of the seats. Such restraint systems should not be fitted if they increase the risk.

3.2.3. Positions for other persons If the conditions of use provide those persons other than the driver may occasionally or regularly be transported by the machinery or work on it, appropriate positions must be provided which enable them to be transported or to work on it without risk. The second and third paragraphs of section 3.2.1 also apply to the places provided for persons other than the driver.”
Specifically, with regard to the moment of transport:

"3.3.3. Travelling function

Without prejudice to road traffic regulations, self-propelled machinery and its trailers must meet the requirements for slowing down, stopping, braking and immobilization so as to ensure safety under all the operating, load, speed, ground and gradient conditions allowed for. The driver must be able to slow down and stop self-propelled machinery by means of a main device. Where safety so requires, in the event of a failure of the main device, or in the absence of the energy supply needed to actuate the main device, an emergency device with a fully independent and easily accessible control device must be provided for slowing down and stopping. Where safety so requires, a parking device must be provided to render stationary machinery immobile. This device may be combined with one of the devices referred to in the second paragraph, provided that it is purely mechanical. Remote-controlled machinery must be equipped with devices for stopping operation automatically and immediately and for preventing potentially dangerous operation in the following situations: — if the driver loses control, — if it receives a stop signal, — if a fault is detected in a safety-related part of the system, — if no validation signal is detected within a specified time. Section 1.2.4 does not apply to the travelling function.

4.1.2. Protection against mechanical hazards

4.1.2.1. Risks due to lack of stability Machinery must be designed and constructed in such a way that the stability required by section 1.3.1 is maintained both in service and out of service, including all stages of transportation, assembly and dismantling, during foreseeable component failures and also during the tests carried out in accordance with the instruction handbook. To that end, the manufacturer or his authorized representative must use the appropriate verification methods.

4.1.2.3. Mechanical strength

Machinery, lifting accessories and their components must be capable of withstanding the stresses to which they are subjected, both in and, where applicable, out of use, under the installation and operating conditions provided for and in all relevant configurations, with due regard, where appropriate, to the effects of atmospheric factors and forces exerted by persons. This requirement must also be satisfied during transport, assembly and dismantling."

LU 5.6 Pre-lift planning

Pre-lift plans can run from a brief informal plan to a detailed process involving many parties such as companies, engineers, customers and sub-contractors. Coordinating lift responsibilities with crew members and other tradespeople at pre-lift meetings is a crucial step in planning lifts. Lift plans are used as a precautionary means of protecting your load, your people, and surrounding property during a lift. Lifting can be performed safely, but this very much depends on the unique characteristics of the lift and how it is planned out.

The international society has basically adopted a boilerplate approach to load handling, in particular for what concerning the pre-lift planning, the use of a verification sheet is quite common. Standards such as “CSA Z150” Safety Code on Mobile Cranes, and the new American standard “ASME P30.1” are both helpful resources. Each standard has a list of best practices you can use to exercise due diligence in your lift planning.

PRACTICAL LIST OF PRE-CHECK

Below are stated some common activities you can consider when deciding if a lift plan is necessary for whatever project you are working on. These recommendations are based on a summary of the control sheets issued by the main construction companies and the percentage of activities that led to higher risk factors. The following are a list of the main questions that should be asked when organizing a construction plan:

1) **When there are potential hazards to the work area**
   Is the soil/ground stable enough for the crane and the load? Can the outriggers be properly stabilized? Are there power lines or other structures obstructing the delivery? Can you obtain a minimum safe distance from potential obstacles? Is there an environmental impact if you strike any nearby pipelines, tanks, storage facilities, etc.?

2) **When there is a potential risk to people**
   This could relate to any potential hazard involving persons. Are personnel being lifted? Is the load being moved or suspended over areas of the general public? Is overhead protection needed to protect the public? Is there an environmental or chemical risk to the public if the load drops?

3) **When there is a risk inherent in the load itself**
   Can the load be potentially unstable due to dynamic forces? Does the shape, size, or weight of the load create a risk in some way? Does the nature of the load (i.e., is it flammable?) pose a risk?

4) **When the environment has an adverse effect on the lift**
   Is there an adverse risk of heavy wind, rain or snow? Can ambient temperature affect the load handling? Is this a daytime or night-time lift? Is the lift being moved from one type of surface to another (i.e., water to land, land to water, water to water)?

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*Based on Article by Ahmed Ali, When Do I Need a Critical Lift Plan? December 2016, LinkedIn.*
5) **When load handling and rigging capacity are a concern**

Is the load weight significant compared to the crane and rigging capacity? Is there a risk of dynamic loading? Is the load weight information accurate/reliable? Do you need multiple cranes to handle the load, and if so, how do you sequence the lift? Is the equipment properly certified and safe to use?

6) **When failure can have a financial impact**

If the load fails, how will it affect your deadline? Is the load easily replaceable? What is the potential cost of accidentally damaging any nearby structures?

**Certainly, the first step is to determine the lift category.** In general, before a lift can be planned, it must be analysed to determine the lift’s category. The Brookhaven National Laboratory – BNL lists three lift categories: incidental or ordinary lifts, pre-engineered lifts, and critical lifts. The responsible manager or designee determines the type of lift by conducting a lift assessment. The flow chart here, adapted from the SBMS Lifting Safety Subject Area, will help to determine if a lift should be classified as incidental (ordinary), pre-engineered, or critical.

More in details, critical lifts require confirmation of engineering, or merit additional engineering input because of an items or location’s size, weight, close-tolerance installation, or high susceptibility to damage. These lifts could be either ordinary lifts or pre-engineered lifts, but with additional hazards that could result in significant delays to a program, undetectable damage resulting in future operational or safety problems, a significant release of radioactivity or other hazardous material, present a risk of injury personnel. Critical lifts must be made by Facilities & Operations riggers or by approved contractors, and as such are not covered in this program. On the other hand, pre-engineered lifts are repetitive lifts that meet the definition of a critical lift, defined below. If, however, the BNL Lifting Safety Committee determines that through the use of tooling, fixtures, sketches, analyses, and written procedures, the possibility of dropping, upset, or collision is reduced to an acceptable level, the lift may be designated as a pre-engineered lift.

**Practical information to be used in planning a critical lift**

**Request for additional planning resources and personnel**

When it comes to a standard lift plan, it’s likely your company has its own managers, operators, riggers, flaggers, and field personnel to safely plan the lift. However, if during your assessment you determine your lift is a critical one, you may consider the need to bring on additional resources to tackle the unique challenges of your project. These additional resources may range from extra lift equipment and lift operators (i.e., multi-crane lifts) to engineering capability (i.e., geotechnical, marine engineers, structural, etc.) who can check things like load stability, soil stability, and potential environmental risks.

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10 Basic Rigging Workbook, Brookhaven National Laboratory, Training and Qualifications Program Office, 2016.
Provide a detailed lift plan

Provide you with a comprehensive, detailed drawing package which includes instruction on the proper equipment needed, lift sequencing, rigging, matting, planning and elevations to deliver the load. Instruct you on the correct travel path of the load so as to ensure proper boom, load, rigging, and swing clearances during the erection and lifting phases. If required, will perform a pre-lift visit to ensure the set-up of the cranes and rigging is according to the lift plan.

Analyse your load

Help calculate the load’s centre of gravity, and identify factors that can dangerously shift or alter the load while in transit. Help determine the proper lift points, load attachments, or contact points to ensure they handle and maintain the load’s integrity. Ensure the outrigger and crawler loads don’t exceed soil capacity. Specify the crane location(s) and the initial position of the load.

Check your rigging setup

Make sure your rigging is suitable for the weight and geometry of the load, keeping in mind all dynamic effects, potential adverse weather, and centre of gravity. Engineered critical lifts help to ensure the safe delivery of any heavy load. Critical lift plan studies include: provide plan, elevation, rigging, and matting drawings as required.

Size up rigging (rigging studies)

Rigging hardware should be used to lift items only within its lifting capacity\(^\text{11}\). The Inspection Tag is a permanent tag attached to slings, hooks, and below the hook lifting devices. It indicates the safe working load (SWL), inspection date and serial number. It should be inspected prior to using the item to assure it is within compliance. The process is outlined in SOP – Standard Operating Procedure – 15-29, “Inspection of Non-Mechanized Rigging Components”.

Practical example of rigging and lifting

The primary function of lifting and rigging is to transport essential equipment and materials into locations where they are easily accessible for workers. This process helps eliminate the risks of having to manually transport equipment and materials up scaffolding, which can be difficult and dangerous. Furthermore, lifting and rigging are designed to lift extremely heavy loads that would otherwise be impossible to perform manually. To illustrate, a heavy portable generator needs to be lifted up ten floors where workers can use it to provide power. Transporting the generator manually is not feasible due to the weight of the generator. In addition, the generator must be rigged correctly to allow for offsets in load-bearing limits that change based upon the angle of the generator as it is lifted up ten stories.

\(^{11}\) Hoisting and Rigging Fundamentals for Riggers and Operators, TR244C, Rev. 5 December 2002.
Ensure that the outrigger / crawler loads do not exceed the soil capacity

Many factors need to be considered when safely setting-up mobile cranes on site\textsuperscript{12}. Crane stability often depends on the integrity of the ground on which it stands. Effective assessment of ground conditions is essential to assist with safe set up and operation of cranes. To reduce the risk of crane accidents as a result of improper crane set-up, planning activities shall be carried out by a competent person(s) to assess the capability of the ground to withstand the loads and pressures imposed by the lifting equipment. All parties who are involved in the planning, set up and use of cranes on site must be aware of the fundamental criteria, planning issues and risk assessments that are needed to ensure lifting operations proceed in a safe and stable manner.

Certificates of the crane and the rigging equipment

The world of certification is diverse and encompasses many certification companies. The NCCCO – National Commission for the Certification of Crane Operators – for example, frequently uses abbreviations (or “codes”) for more than 30 certifications they count.

Check boom, load, rigging, and swing clearances during the erection and lifting phases

For this point, it is advisable to thoroughly review the previous modules, recalling the main guidelines on the procedure to be followed for the inspection of individual parts.

Provide safety precautions related to wind, communications or other site-specific hazards (using a Task Risk Assessment)

Risk assessment is a term used to describe the overall process or method where you:

- Identify hazards and risk factors that have the potential to cause harm (hazard identification).
- Analyse and evaluate the risk associated with that hazard (risk analysis, and risk evaluation).
- Determine appropriate ways to eliminate the hazard, or control the risk when the hazard cannot be eliminated (risk control).

A risk assessment is a thorough look at your workplace to identify those things, situations, processes, etc. that may cause harm, particularly to people. After identification is made, you analyse and evaluate how likely and severe the risk is. When this determination is made, you can next, decide what measures should be in place to effectively eliminate or control the harm from happening.

This could have different formats but generally look presented as follow:

\textsuperscript{12} For further information about the ground condition and the crane stability please consult the “CICA & CANZ Guidance Note Crane Stability and Ground Pressure”, The Crane Industry Council of Australia, 30/01/2017.
<table>
<thead>
<tr>
<th>Job Name &amp; Description of Work:</th>
<th>DATE:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of Load:</td>
<td>Method by Which Weight was Determined:</td>
</tr>
<tr>
<td>Estimated or Known?</td>
<td>Center of Gravity determined by:</td>
</tr>
<tr>
<td>Type of communication (Verbal, Radio or hand):</td>
<td>Estimated or Calculated?</td>
</tr>
<tr>
<td>Site Safety:</td>
<td>Contact Number:</td>
</tr>
</tbody>
</table>

### CONTACT INFORMATION

<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
<th>Phone Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designated Lift Supervisor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crane Operator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Designated Rigger</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SAFETY REVIEW

**CRANE**

- 1. Was a pre-lift operations meeting held? [Yes] [No] [NA]
- 2. Is the yearly crane/hoist inspection current? (Is it documented?) [Yes] [No] [NA]
- 3. Has the daily visual inspection been completed? [Yes] [No] [NA]
- 4. Are safety devices installed and tested? [Yes] [No] [NA]
- 5. Is the wind speed below 30 mph? (Wind speed >20 mph require reassessment of Work Risk, if wind speed >30 mph, lifting operation shall not proceed.) [Yes] [No] [NA]
- 6. Have precautions been taken to keep other personnel out of the area? [Yes] [No] [NA]
- 7. Was the need to protect the swing area and landing zones considered? [Yes] [No] [NA]
- 8. Has the ground stability been assessed, and is the ground stability adequate for this lift? [Yes] [No] [NA]

**RIGGING**

- 9. Has the rigging been inspected? (shackles, chains, wire, rope, etc.) [Yes] [No] [NA]
- 10. Is the rigging of proper capacity? [Yes] [No] [NA]

**LOAD**

- 11. Has the need for taglines been evaluated? [Yes] [No] [NA]
- 12. Is the load to be lifted stable? (no liquid or other resulting load) [Yes] [No] [NA]
- 13. Have the lifting lugs and pad eyes been inspected? [Yes] [No] [NA]

**CRITICAL LIFT ASSESSMENT**

- 14. Are people being lifted? [Yes] [No] [NA]
- 15. Are power lines within twice the maximum boom swing radius plus the equaled clearance? [Yes] [No] [NA]
- 16. Are two or more lifting machines being used to simultaneously lift one load? [Yes] [No] [NA]
- 17. Is this a lift that presents a risk of significant property damage, high potential of personal injury or designated by customer to be critical in nature? [Yes] [No] [NA]
- 18. Will the crane or hoist operator lose sight of the lead original person at any time during the lifting operation? [Yes] [No] [NA]
- 19. Is the weight of the load more than 75% of the dynamic or static capabilities of the lift equipment? [Yes] [No] [NA]
- 20. Is the lift being conducted over energized or pressurized equipment? [Yes] [No] [NA]
The position of mobile lifting equipment or the location of fixed installations can have a dramatic effect on the risks involved in a lifting operation. It is vital to take all practical steps to avoid people being struck by loads or the equipment itself during use. The equipment should also be positioned to minimize the need to lift over people. Measures should be taken to reduce the risk of load drift (e.g., spinning, swinging, etc.); and of the load falling freely or being released unintentionally. Many different methods have been developed to prevent falling loads, including the use of multiple ropes or chains, hydraulic check valves and nets for palletized loads.

13 https://www.hse.gov.uk/work-equipment-machinery/planning-organising-lifting-operations.htm
Measures must be taken to ensure that people cannot fall down a shaft or a hoist way. At access points to these areas, effective means to prevent access should be in place, such as gates, barriers or doors. Where access is required to enter the area, when a platform or car is present (e.g., a lift), the doors or gates should be interlocked to allow the gates to open only when the car is present.

When positioning lifting equipment, care must be exercised to avoid hazards arising from proximity, for example: coming into contact with overhead power lines, buildings or structures; coming too close to trenches, excavations or other operations; and coming into contact with buried underground services, such as drains and sewers.
LU 5.7 Worksite preparation

There are many reasons why cranes fall. One of the most common causes is land subsidence. What measures can we take to prevent this needless misfortune?

Today’s cranes are geometrically designed to be extremely stable. So why do they still tip over? Studies show that one crane accident occurs for every 10,000 hours of use in the United States.

A common and reliable method of determining soil capacity is to have a reputable geotechnical company survey and determine soil capacity. Then it is possible to compare the allowed soil capacity with the crane’s ground reaction and design a suitable load distribution or matting system. In some cases, the matting is not enough, and it will be necessary to make improvements to the ground. Soil improvements could consist of a modest layer of compacted crushed stone backfill or they could be as complex as installing piles tied to a supporting concrete slab.

Radar Sounding of the set-up area should be considered when working in older industrial facilities and if there is a possibility of underground voids, tanks, abandoned structures or natural cavities.

For smaller cranes with lower ground pressure reactions, you still need to check the ground capacity. We read about accidents almost daily, where a small crane tipped over because the ground failed. Geotechnical companies have some less expensive methods that measure density and work well for smaller temporary loading situations. Alternatively, if the crane is working on new construction, the building foundation design is based on the allowable ground pressure. You may find the soil capacity has already been determined in the area where the crane will be set up. If you use this method, make sure the borings were done in the immediate area of the crane pad and beware of recent excavations where the backfill may not be properly compacted.
Pay special attention to slopes and sharp drop offs. Don’t set up too close to the edge. An industry rule of thumb is to set the crane up on a one-to-one ratio from the edge. That is as far back from the edge as the void is deep. I suggest you consult a geotechnical engineer before setting up near any slope or vertical edge.

In conclusion, be proactive when it comes to managing ground bearing pressure. Use the proven technology available and don’t assume anything.

SITE CATEGORIES AND UNDERGROUND HAZARDS

Sites can be split into a number of categories to highlight the most likely hazards that need to be considered and risk assessed. More attention is required to establish the strength of the ground where ground conditions are poor or where there is a lack of data on the nature of the subsoil. Typical categories include:

- **Greenfield sites**: particular problem areas are adjacent to rivers, estuaries and floodplains where soft alluvial deposits and high groundwater tables can be expected.
- **Beaches**: low sand density and a variable groundwater level can create difficult conditions.
- **Brownfield sites**: unknown previous use including basements, storage tanks, poorly-filled open pits and poorly-compacted fill, etc.
- **Paved areas**: tarmacked or paved areas can appear deceptively strong but lead to outriggers punching through weak surfacing. Lightly trafficked car parks, estate roads and footpaths should be scrutinised. The edge of paved areas is usually weak.
- **Town centre sites**: expect underground hazards including services, drainage pipes, buried cables, basements and tunnels, etc. beneath paved areas. This can lead to outriggers punching through to the void below.
Ground capacity

Prior to setting up a crane on site, the ground condition should be reviewed in the risk assessment process to determine whether the ground is suitable to operate the crane safely. It is recommended that the ground condition is inspected by a geotechnical engineer to provide accurate permissible ground pressure. Crane lift study results should be provided to the geotechnical engineer and a geotechnical report should be issued by the geotechnical engineer with instruction of the suitability of the ground at the time of the lifting activity conducted.

Table 2 below listed typical maximum permissible ground pressure for different ground types as a reference:

<table>
<thead>
<tr>
<th>Ground type</th>
<th>Maximum permissible ground pressure (t/m²)</th>
<th>Maximum permissible ground pressure (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard rock</td>
<td>200</td>
<td>2000</td>
</tr>
<tr>
<td>Shale rock and sandstone</td>
<td>80</td>
<td>800</td>
</tr>
<tr>
<td>Compacted gravel—with up to 20% sand</td>
<td>40</td>
<td>400</td>
</tr>
<tr>
<td>Asphalt</td>
<td>20</td>
<td>200</td>
</tr>
<tr>
<td>Compacted sand</td>
<td>20</td>
<td>200</td>
</tr>
<tr>
<td>Stiff clay (dry)</td>
<td>20</td>
<td>200</td>
</tr>
<tr>
<td>Soft clay (dry)</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Loose sand</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Wet clay</td>
<td>Less than 10</td>
<td>Less than 100</td>
</tr>
</tbody>
</table>

Table 2 Typical maximum permissible ground pressure for different ground types [1]

Ground conditions can vary dramatically from one workplace to another and even within one workplace. Failure to address poor ground conditions to ensure crane stability may cause the crane to overturn resulting in serious injury to the crane operator and other people near the crane. Factors affecting ground support of cranes include:

- surface water, water mixed with soil e.g., mud and underground water like springs or streams
- the type of ground e.g., clay, sand, rock or a mixture of these
- backfilled ground from a previous excavation or trench
- covered underground cavities or penetrations which still exist
- continued operation of the crane in one location, and
- the location of pressurized underground services e.g., a shallow fire hydrant main which may burst if an outrigger is located directly above it.
Decisions on the suitability of the ground conditions can only be made based on visual inspection. Where it is difficult to work out if the ground conditions are suitable, documented information on the ground bearing pressure should be obtained from a geo-technical engineer. Rock usually provides the most stable supporting surface for a mobile crane. Although rock may be present on the surface it may not extend far below the surface. One way to establish how far rock may extend below the surface is to examine nearby excavations or trenches at the workplace. Rock that extends far below the surface provides an indication of the ground’s integrity. Extra risks created when outriggers are positioned close to an excavation must be managed.

Whether the ground has a ‘crust’ on its surface should be checked. The surface of this type of ground is usually firmer than the ground underneath. The firm surface may give the impression that the ground is more stable than it actually is. If the ground is punctured by an outrigger or the end of a crawler track, the softer ground will be exposed which may cause the crane to overturn.

**Sloping ground**

Crane roll over can occur when a mobile crane travels along a side slope. Working on a slope has the effect of either increasing or decreasing the working radius of the crane, which may in turn affect the stability of the crane and cause the crane to overturn either forward, backwards or sideways. Most manufacturers of mobile cranes with moiling capability specify the cranes should only be operated on firm level ground. Working or travelling on sloping or uneven ground should be avoided where possible. If working on slopes is unavoidable the crane should be used within the manufacturer’s specified capacity for operating on the relevant degree of slope. Travel on a slope should be up or down the slope not across the slope.

Where the centre of gravity of the mobile crane is high above the ground, a minimal ground slope can be a major factor in causing the crane to overturn. This particularly applies when:

- the boom has a high luff angle
- the boom is telescoped out
- the centre of gravity of the suspended load is high, and
- there is articulation of an articulated crane.
A side slope of only 2 or 3 degrees can have a drastic effect on the stability of the crane. Soft ground, pneumatic tires and suspension movement will also tend to increase the side angle of the crane and increase the risk of overturning.

**Crane proximity to excavations and trenches**

When cranes are set up close to excavations or trenches there may be an increased risk of the sides of the excavation or trench wall collapsing causing the crane to overturn. This risk increases with softer ground and the presence of groundwater. The risk of collapse is greater for vertical cuts in the excavation wall compared to walls that have been battered back at an angle. The presence of ‘slippery back’ where there is a naturally occurring slip plane, for example a fracture in the ground, can also increase the risk of excavation or trench collapse.

The following principles should be applied when setting up mobile cranes near excavations:

1) Where the ground is compact and not crumbling, the distance of any part of the crane outrigger support dunnage from the excavation should be at least equal to the depth of the excavation (general 1:1 rule).

2) Where the ground is loose or backfilled i.e., crumbling, the distance of any part of the crane outrigger support dunnage from the excavation should be determined by a competent person e.g., a geotechnical engineer.

**HOW TO PREPARE YOUR JOBSITE**

Typically, you can’t leave your construction as is before your crane arrives. Among other things, the terrain and layout on location might not be suitable. Instead, you need to prepare for both its arrival and the job that needs to be done. The very first thing you should do when you are making arrangements for a crane is to schedule an initial consultation. During this consultation with the crane operator, several things will be covered including:

- Who will be responsible for bringing necessary tools and crane attachments?
- How the terrain should be prepared for the crane ahead of time
- Clearance of the route for the crane to get to the property, such as trees and electrical lines
- Assessing what obstructions will have to be eliminated before the work can take place
In populated areas, the crane operations can become a bit more complicated. You should ensure that you obtain the necessary permits ahead of time to ensure you are not penalized or fined for bringing in heavy equipment without permission. In some cases, the crane operator will make these arrangements, but this should be discussing during the initial consultation.

After that, the following steps must be followed to prepare your job site for the crane installation:

**Ensuring access**

In some cases, the chief obstacle is not getting the crane close enough to the load but to get it on-site at all. Remember, they are pieces of heavy-duty equipment and come with the bulk to match their roles. Therefore, you need to check that there is a gate or other entrance which they can fit through. Ask your company for the precise dimensions. Keep in mind that bumps or rises in the road can also be an issue. Anything that will get in the way of the crane as it manoeuvres the sections of the modular home will need to be either removed or relocated until the job is complete. For example, large tree limbs, telephone lines, and even rocks may inhibit the full range of motion the crane will need in order to accomplish smooth movement. A stable terrain will also be a necessity as the crane will need stability in order to safely move modular sections. Keep safety clearances in mind, and make sure the initial route into the property is ample for the crane delivery.

**Preparing the terrain**

One of the critical steps is to do all you can to adjust the terrain for the crane. You need to make sure that it can safely navigate around the site.

On your end, you should check whether there is space for the vehicle to move around and get close enough to the load. Aside from this, you should pay attention to potential hazards, including these:

- Power lines
- Ditches or drop-offs
- Unstable ground
- Hidden obstacles
- Scaffolding
- Other overhanging objects like branches

If you can, take the appropriate steps to remedy the situation. Otherwise, warn all the personnel and clearly mark out the danger zones. Depending on the specifics of the job and site, you might also need permission from the stakeholders to allow the crane onsite.
Use appropriate cribbing/mats

- Cribbing may fail if the load is not spread over the full area of the mat
- Cribbing/mats may fail if the ground crushes or extensive settling appears
- Cribbing/mats may fail when the mat bends
- Cribbing/mats may fail by horizontal splitting

Secure the loads

Next, you have to secure the loads. Unfortunately, improper loading is one of the leading causes of accidents involving cranes. Make sure that nothing can come loose and that nothing is protruding unnecessarily. We recommend that you have an experienced hand oversee this process. Plus, have the crane operators do one final check before they lift.

Put safety measures in place

Overall, one of your top priorities should be the safety of everyone on the job. Typically, you should try to implement some or all of the following measures:

- Compile and distribute a safety plan for the whole crew.
- Watch the weather forecast for high winds or heavy rains.
- Ask the crane company for their safety records.
- Put up relevant warning signs.
- Work out safety checklists to review carefully beforehand and during the job.
- Make sure that everyone is wearing their protective gear.
- Minimize distractions on the job site.
- Complete a risk assessment.

Most significantly, be sure to optimize communication on location between all the personnel.

Start preparing early

Preparing the jobsite beforehand can help you streamline the whole process. There may be significant delays if the operators arrive but can’t access the location or find differences from what was planned. Even more importantly, adequate preparation can help you avoid accidents and damage to property.
To be achieved upon learning outcome completion

Sets up crane

**Knowledge**
- Setup procedures according to manufacturers’ specifications
- Applicable standards and guidelines such as jurisdictional regulations and CSA Z150
- Hazards such as overhead obstructions, power lines and underground obstacles
- Recommended controls to minimize or eliminate risks and hazards
- Requirements of the job such as radius, crane dimensions, and load weight and dimensions
- Engineered drawings
- Types of specialty lifts such as engineered, multi-crane lifts and personnel lifts
- Jurisdictional and site requirements for issues such as soft and unstable ground conditions
- Factors affecting the lift such as tail swing, load path and clearances

**Skills and competences**
- Ensure site hazards have been minimized or eliminated and no new hazards have been introduced since completing pre-lift planning
- Identify and report any variations in the engineered drawings such as an obstacle introduced into the lift path, or a change in the size or weight of the lift
- Measure radius and refer to manufacturers’ load chart specifications
- Follow engineered drawing and establish points of reference
- Determine crane location according to factors such as load size, load weight, obstacles, clearance dimensions and type of operation
- Orientate crane for placement of outriggers and crawlers
- Determine setup such as outrigger position, crawlers extended or retracted, and boom length, according to manufacturers’ specifications and lift plan
- Determine blocking and crane matting requirements based on ground conditions
- Level crane using outriggers or shimming/blocking tracks
- Confirm crane is level using tools and equipment such as level or crane’s computerized display
Lattice boom crane

Knowledge
- Lifting points
- Component weight
- Pinch points
- Blocking procedures
- Rigging and hardware
- Component preparation (cleaning debris and contaminants from surfaces)
- Installation and removal of bridle and boom stops
- Boom composition chart and blueprints
- Space requirements for assembling
- Capabilities and limitations of auxiliary lift equipment
- Reeving and lacing (including self-reeving)
- Hook block and overhaul ball capacity
- Result of using defective hardware
- Remote control procedures
- Ground conditions
- Assembly and disassembly procedures according to manufacturers’ specifications

Skills and competences to assemble:
- Install tracks on car body
- Install house
- Install outrigger boxes
- Install boom base
- Assemble boom and jib
- Install counterweights
- Install hoist lines, hook blocks and overhaul ball

Skills and competences to disassemble:
- Remove hoist lines, hook blocks and overhaul ball
- Disassemble boom and jib
- Remove counterweights
- Remove boom base
- Remove house
- Remove tracks from car body
- Remove outrigger boxes
Telescopic boom crane

Knowledge
- Lifting points
- Component weight
- Hydraulic pressure
- Reeing of hook block and attachment of overhaul ball
- Result of using defective hardware
- Capabilities and limitations of auxiliary lift equipment
- Component preparation (cleaning debris and contaminants from surfaces)
- Rigging and hardware
- Rigging procedures
- Assembly and disassembly procedures according to manufacturers’ specifications

Skills and competences to assemble:
- Install outrigger boxes
- Install main boom
- Install hoist lines, hook blocks and overhaul ball
- Install counterweights
- Install swing-away jibs and inserts

Skills and competences to disassemble:
- Remove counterweights
- Remove hoist lines, hook blocks and overhaul ball
- Remove main boom
- Remove outrigger boxes
Transportation

Knowledge

- As per the workplace documents, mobile crane operators
- use logbooks, load charts, hazard assessments and workplace policies and procedures to carry out their job.
- be familiar with regulations relating to hoisting, rigging and safe work environments.
- to have the ability to read and interpret manufacturers’ specifications and load charts for the model of crane they are using
- to obtain information from engineered and construction drawings and plans
- to be familiar with the possibility to communicate the particularly for lifts that require technical explanation and advice from other engineers and dedicated staff
- to have the ability to graphically represent the logistics

Skills and competences

- Mathematical and physics concepts such as conversions, geometry, algebraic calculations, measurement and calculation of load and lift requirements
- To use code books, load charts and manufacturers’ specifications to further determine procedures, limits and the necessary equipment for rigging and hoisting
Performs pre-lift planning

**Knowledge**
- Applicable standards and guidelines such as jurisdictional regulations and CSA Z150
- Factors affecting the lift such as tail swing, load path and clearances
- Roles and responsibilities of all persons involved with the lift
- Hazards such as overhead obstructions, power lines and underground obstacles
- FLRA
- Recommended controls to minimize or eliminate risks and hazards
- Types of specialty lifts such as engineered, multi-crane lifts and personnel lifts
- Jurisdictional and site requirements such as JSA
- Engineered drawings
- Manufacturers’ specifications such as load charts

**Skills and competences**
- Confirm requirement for engineered drawings according to client/company policies and site-specific requirements
- Interpret and verify engineered drawings and site-specific requirements to ensure lift proceeds as planned
- Verify lift conditions such as wind, potential hazards, crane configuration and setup, and signalling responsibilities
- Identify hazards such as overhead power lines, underground infrastructure, underground utilities, obstacles impacting clearances, ground conditions and environmental conditions
- Consult local utilities to verify location and safe limit of approach to utilities
- Recommend controls to eliminate or minimize risks and hazards
Worksite preparation

Knowledge

- Site inspection procedures and protocols
- Relevant road rules, regulations, permit and license requirements pertaining to mobile crane operation and safety
- Relevant OH&S and environmental procedures and regulations
- Mobile crane applications, capacities, configurations, safety hazards and control mechanisms
- Site inspection procedures and protocols
- Operational procedures for crane crews for the conduct of a site inspection for a lift using a mobile crane
- Guidelines relating to the safe use of machinery and equipment
- Focus of operation of work systems and equipment
- Application of relevant agreements, codes of practice or other legislative requirements

Skills and competences

- Communicate effectively with others when conducting a site inspection for a lift using a mobile crane
- Read and interpret instructions, procedures, information and signs relevant to a site inspection for a lift using a mobile crane
- Interpret and follow operational instructions and prioritise work
- Complete documentation related to a site inspection for a lift using a mobile crane
- Work collaboratively with others when conducting a site inspection for a lift using a mobile crane
- Plan own work including predicting consequences and identifying improvements
- Prioritise and multi-task work
- Adapt appropriately to cultural differences in the workplace, including modes of behaviour and interactions with others
- Promptly report and/or rectify any identified problems that may be identified when conducting a site inspection for a lift using a mobile crane in accordance with regulatory requirements and workplace procedures
- Implement contingency plans for unexpected events that may occur when conducting a site inspection for a lift using a mobile crane
- Apply precautions and required action to minimise, control or eliminate hazards that may exist during work activities
- Monitor work activities in terms of planned schedule
- Modify activities depending on differing operational contingencies, risk situations and environments
- Work systematically with required attention to detail without injury to self or others, or damage to goods or equipment
- Operate and adapt to differences in equipment in accordance with standard operating procedures
- Identify and correctly use equipment, processes and procedures
- Select and use required personal protective equipment conforming to industry and OH&S standards
ASSESSMENT

1. What are the differences between lattice and telescopic boom crane?
2. How many degrees of slope can compromise the stability of a crane?
   - 0.5 – 1.0
   - 2.0 – 3.0
   - 10.0 – 12.0
3. What are the factors that can generate hazards on construction sites in city centre?
4. What should be considered when determining a safe wind speed?
5. When calculating the wind impact, is it better to consider the intensity of the gust or the average wind speed? And why?
6. Describe the law governing the balance of a crane with an extended boom and loaded weight, as shown in the figure.

7. What are the six steps to connect the bridle to the pendants in the assembly of a lattice boom crane?
8. What to do when a crane boom breakdown?
9. What does it mean “Machinery presenting hazards due to its mobility”?
10. Why can’t a mobile crane always be driven on public roads?
11. What is the “CSA Z150”?
12. Why is so important to determine a lift category?
13. What is a task risk assessment?
14. What are the 5 main actions to assemble telescopic boom crane?
15. What are the 4 main actions to disassemble telescopic boom crane?
MODULE 6 - Mobile Crane Operations

Learning Units (LU) indicative time: (14 hours)

INTRODUCTION

The Module is divided into 6 sections. The first one deals with Lifting Theory and forces, and then, in the second chapter, introduces the student to the different types of crane operations and the different jobs in the self-propelled crane sector. Chapter three informs the learner about the different types of cranes and what are the different tasks that can be carried out. Chapter 4 explains how the hydraulic telescopic boom works. Chapter 5 informs about the operation of hydraulically operated lattice boom cranes and covers both crawler cranes and truck-mounted cranes. Finally, Chapter 6 describes the operation of the hydraulically operated lattice boom.

LEARNING OBJECTIVES

- Providing students with the necessary knowledge to be able to carry out all operations and load transport with self-propelled mobile cranes safely, as well as the maintenance and conservation of the machinery according to the plan established by the manufacturer.
- To inform and raise awareness of the risks involved in the handling of this equipment.
- To provide knowledge of the strategies, procedures and techniques necessary to develop good driving, crane positioning and assembly and disassembly of jibs with technical and safety guarantees.
- To provide knowledge of the signals made by the Signaller or Rigger during the handling of the load.
- To provide knowledge of the different types of cranes and the different operations that can be carried out by each of them.
- To explain how the load is calculated and what the load limits are.
- Introduce the operation of hydraulically operated lattice boom cranes, including both crawler and truck-mounted cranes.
- To provide knowledge of the elements that make up the machine, its components and how to carry out the inspections and checks necessary for the execution of work with a mobile crane in full safety conditions.
- Establish references for the practical handling of the different types of cranes.
LU 6.1 Lifting theory and forces

When planning a loading manoeuvre with cranes, several factors must be taken into account in order to carry out the work successfully, as these factors will determine how the manoeuvre is to be carried out. Especially if we take into account that handling loads has a certain degree of risk and not knowing them can cause accidents.

A. The weight of the load:
It is important to know the weight of the load to identify the equipment (self-propelled crane or truck crane) to be used. Trying to guess the weight or doubting the weight can lead to accidents, which can be fatal. Thus, we define weight as the force with which it is attracted by the earth due to the action of the earth’s gravity.

\[
\text{Weight} = \text{Volume (m}^3\text{)} \times \text{Density of material (kg/m}^3\text{)}
\]

Remember that the weight of a body depends on the material it is made of and its dimensions. To define the weight, we can calculate the approximate volume of the object and multiply it by the approximate density of the material it is made of.

\[
\text{Volume} = \text{Width} \times \text{Height} \times \text{Length}
\]

\[
\text{Density} = \frac{\text{Mass}}{\text{volume}}
\]

BOTH DISTANCE AND WEIGHT ARE DETERMINANTS OF BALANCE.
If the load is asymmetrical, the load can be divided geometrically, i.e. into several parts for which the formula for calculating the volume is known. Then all the parts must be added together and multiplied by the density of the material. In this way the weight of the object will be known.

B. Volume:
Knowing the volume of the load will be important because it will help us to determine the weight of the load and to identify the type of crane to be used. We will now look at the formula for determining the volume of the object.

\[
\text{Volume} = \text{width} \times \text{height} \times \text{length}
\]

C. The centre of gravity:
At this point, the first thing to know is that the centre of gravity of a body is the point where all the mass of the body can be considered to be concentrated. With this information it will be easier to position the slings to balance the load.

If the object is symmetrical, the centre of gravity will be at the midpoint. But if it is not symmetrical, or if it is composed of materials of different nature, we have to calculate its centre of gravity by breaking it down into other objects whose centres of gravity are known.

D. The balance:
To determine the equilibrium of a body it is necessary to know its centre of gravity, which must not change when changing position. To bring an object into equilibrium, a vertical force must be applied whose line of action passes through the centre of gravity and neutralises the weight of the body. In the case of suspended bodies, we can see three types of equilibrium:

- **Stable equilibrium**: this is when the centre of gravity of the object is below the point of suspension, so it tends to verticality when removed from it.
- **Unstable equilibrium**: This is when the centre of gravity of the object is above the point of suspension, so that the body rotates around the point of attachment when removed from it.
- **Indifferent equilibrium**: When the object is suspended just above the centre of gravity.

Remember that both the weight of the load and the distance of the manoeuvre are determining factors in balance.

E. Material of manufacture: It is important to know if the load is of rough and rough material to consider when breaking down or slinging the load. This is to prevent the implements from being worn or damaged during movement, which could cause accidents.
Tips to avoid accidents with lifting equipment

- Train personnel
- Before each start of activity inspect that all controls and controls are working properly.
- If cranes are used, ensure that they are stable and that they are on a firm and level surface.
- Carry out regular inspections of lifting equipment.
- Do not exceed the maximum stipulated load.
- Check that the braking system works correctly before lifting completely.
- Do not handle loads on people.
- Avoid keeping loads suspended unnecessarily.
- Do not make sudden movements or sudden changes of direction.
- Do not handle loads directly with your hands, use handles or hooks.
- Assign a person to guide the operator.
- Do not transport people.
- The load must be lifted vertically.
- Ensure that the distribution of loads is balanced, checking that all slings are equally taut when lifting the load.
- Train personnel on the signalling of hands used.
- Use of personal protective equipment at all times.
- Do not use hooks or lifting accessories in poor condition.
LU 6.2 Introduction to crane operations

6.2.1 Self-propelled mobile crane operator

The position consists of handling the controls and correct operation of the self-loading truck and self-propelled crane, both the general mechanics of transport and the specific mechanics of the boom or crane and including the elements, tools, materials, auxiliary means, collective and individual protections necessary to carry out the work. Works both in industrial environments and on construction sites (building sites) and in the transport, loading and unloading of materials, machinery, etc.

The three usual operations in the services of a self-propelled mobile crane. These manoeuvres are:

1. Driving
2. Settling of the crane
3. Assembly and disassembly of jibs

The workplace of a mobile crane, as defined by its name, is mobile, which means that the circumstances of the workplace are changeable over time, thus requiring special attention to each workplace with respect to its conditions, as the change of location limits the in-depth knowledge, from the point of view of Occupational Health and Safety.

Operations carried out in the work of self-propelled mobile cranes

DRIVING

The driving operation with a self-propelled mobile crane can be visualised in two ways: 1) The movement of the crane from the crane hire company to the customer’s premises, where the work is to be carried out. 2) The movement of the crane within the customer’s facilities, when the crane has to be moved as a requirement of the service. The displacement to be studied will be the first case, the displacement of the crane operator with his machinery to the place where he will set it down and carry out the lifting.
Description of work

Movements on public roads, private roads and/or workplaces whose activities are varied.
The following dangerous situations may occur during this activity and must be taken into account:

Entrapment by overturning machinery or vehicles
- Terrain conditions: - Inequalities. -Slippery terrain. -Sloping ground.
- Incorrect pressure.
- Inappropriate speeds.
- Or by the fasteners. -Wheels. -Wrinkles.

Collisions or collisions with vehicles
- Insufficient machine capacity for deceleration.
- Stopping and immobilisation due to failure/failure of the control system.
- Stopping and immobilisation due to failure/failure of the braking system for travel movements: -Transverse brake. - Parking or emergency brake.
- Weather conditions (rain, snow, hail, fog, etc.).

Falls of persons to different levels
- Defects in support and grip points.
- Slips.
- Tripping.
- Falls when getting in and out of the cabin.

Collisions with stationary objects
- Collisions with fixed installations as a result of insufficient capacity of the machine to decelerate.
- Stopping and immobilisation due to failure/failure of the control system.
- Stopping and immobilisation due to failure/failure of the braking system for travel movements: - Travel brake - Parking or emergency brake.
- Stop and immobilisation due to failure/malfunction due to not being in travel mode (with boom retracted).

Collisions with moving objects
- Insufficient machine capacity for deceleration, stopping and immobilisation.

Direct electrical contacts
- Contacts with uninsulated live elements or with insulation defects (underground overhead power lines).
- Adverse weather conditions.
CRANE SETTLEMENT

On arrival at the work site with the crane, the surrounding conditions prior to setting down must be analysed so that the crane can be set down safely.

1. **Ground conditions**
   - Inspection of the ground to ensure that the soil is sufficiently strong and able to withstand the pressure of the crane.
   - Absence of underground conduits: pipes, etc.
   - Location away from excavations, pits, slopes, etc.

2. **Both the radius and the working height:**
   - The radius and working height must be taken into account in accordance with the load tables provided by the manufacturer.
   - To avoid risks associated with power lines:
     - It is important that prior to settlement, the electricity company has been asked to cut off the power supply. If this is impossible, the power line must be protected by a protective screen, the area must be signposted, and the crane operator must be informed of the risks and the preventive measures to be taken. If this proves impossible, settlement work must be carried out at a distance of at least 3 to 7 metres, taking as a reference point the end of the boom as far as the power line.

3. **It is also advisable to use insulating lifting accessories, to insulate couplings and to have voltage detectors.**

Job description


The following dangerous situations may occur during this activity and must be taken into account:

**Entrapment by or between objects**

- Danger of settling due to moving machine parts:
  - Support plate-floor by extension of the outrigger cylinder.
  - Superstructure outrigger cylinder due to retraction of the sliding beam.
  - Fixed installation by extension of the sliding beam.
  - Pneumatic-floor by retraction of the stabiliser cylinder.
Entrapment due to machine or vehicle overturning

- Loss of crane stability:
  - Overloading.
  - Collapse of the ground (proximity of slopes, pits or uncompacted ground).
  - Supporting structure (special works on slabs or bridges).
  - The effects caused by elastic deformation of the crane (elastic deformation of the carrier, crawler tracks or stabilisers).
  - Maximum permissible inclination in the plane of rotation.
  - Exceeding the overturning lines of the mobile crane.

Collisions or impacts with vehicles

- Collision of motor vehicles and stabiliser beams due to proximity to roadways.
- Operations to identify the terrain prior to the installation of the equipment and inspection of auxiliary elements.
- Collision due to the proximity of motor vehicle traffic lanes.

Collisions with stationary objects

- Collisions with accessible parts of the machine in normal operation, at protruding points:
  - Hook.
  - Stabiliser.
  - Struts.
- During the installation of distribution plates, blows with cylinders and beams.

Collisions with moving objects

- Knocks with cylinders or beams during jacking or jack assembly.
- Oscillatory movement when releasing the hook.

Electrical contacts

- Direct contact with live parts.
- Accidental indirect contact with live metal part.
- Unprotected or beaconed overhead lines when raising the boom to release the hook.
- Underground power lines when stabilising the crane.
- Storms with electrical discharge

Knocks/cuts by objects or tools

- Cutting or shearing with accessible parts of the machine: with the snatch block and pulley head.
- Sharp edges or points.
- Deteriorated protection.
- Wire strands.
- Fouling of parts.
- Whiplash when handling cables.

**Projection of fragments or particles**

- Projection or injection of pressurised fluid due to excess pressure in pipes or hydraulic hoses.
- Failure of hydraulic cylinder protection valves such as boom lift, telescoping or stabiliser valves.
- Failure of hydraulic tank protection valves.
- Absence of deflectors in hydraulic installation located at a distance of less than 1 metre from the control station.
- Pressure vessels.
- Gases in fuel tanks.
- Battery fluids.

**Risk of explosion**

- Overpressure of pipes.
- Overpressure in hydraulic hoses.
- Failure of hydraulic cylinder protection valves (boom lift, telescopic or stabiliser cylinders).
- Hydraulic tank failure.

**Falls of persons to different levels**

- Slips.
- Tripping.
- Falls when getting in or out of the cabin.
- Defects in support and grip points.
- Crane platforms or handrails.

**Falls of persons on the same level**

- Skidding.
- Loss of balance.
- Falls at zero level during stabiliser assembly operations.
- Placement of distribution plates.
- Obstacles and fixed elements in areas of passage or access to assembly, disassembly, inspection and control stations.

**Stepping on objects**

- Stepping on stones.
- Abandoned objects.
- Irregularities in the ground.
- Nails, rebar, etc.
ASSEMBLY AND DISASSEMBLY OF JIBS

Jibs are the ultimate extension of the boom; this boom accessory can allow the crane operator to achieve the necessary radius of reach required by his machinery to perform a service. The jib is therefore an extension of the boom that allows you to lift light loads to great heights. Jibs can be of two types, Fixed and Folding. The operation under study is specific to the assembly and disassembly of the jib, so we will analyse the situations with the folding type of jib.

**Folding jib**: This is an extension at the upper end of the boom or close to it to provide it with an additional boom length, made up of one or more sections, which is articulated to allow it to rotate in the vertical plane.

**Job description**

Manual handling of the crane’s moving parts: structure and support of boom components, cable guide pulley, tilting cylinder.

Assemble/disassemble various elements of the machine: cable safety tubes, cables, chains, "hook up" limit switch counterweight, cable latch, auxiliary boom support. Filling/unfilling and securing various bolts.

Manipulation of drive components from the crane control stations: tensioning/untensioning of wire rope, configuration of load table appropriate to a manoeuvre.

The following dangerous situations may occur during this activity and must be taken into account:

**Entrapment by or between objects**

- Crushing between moving machine parts.
- Support plate-floor by extension of the stabiliser cylinder.
- Floor by retraction of the stabiliser cylinder.
- Beam-fixed installation by extension of the sliding beam.
- Hook-cab by pendulum movement of the hook.

**Falling objects in handling**

- Falling machine elements.
- Cable safety tubes.
- Counterweight of end-of-stroke limiter of pulley head and snatch block, etc.
- Falling tools.

**Falling objects due to collapse or collapse**

- Collapse of boom components.
- Failure of anchor bolts.

**Collisions with stationary objects**

- Collision with accessible parts of the machine in operation due to protruding points (snatch blocks and hook, overhanging cable).

**Collisions with moving objects**

- Possible impact during bolt removal due to uncontrolled movement of the nib.

**Electrical contacts**

- Direct electrical risk.
- Indirect electrical risk.
- Risk with unprotected or unmarked overhead lines.
- Accessible parts of the machine in operation with sharp edges or points.
- Moving parts with damaged protection.
- Cable wires.

**Blows/cuts by objects or tools**

- Access to the driving position.
- Defects in gripping and support points.
- Defects in platforms.
- Defects in the crane railing.
- Unloading and assembly of lattice sections.

**Falls of persons to different levels**

- Skidding.
- Loss of balance.
- Falls at zero level in stabiliser assembly operations.
- Obstacles in passage areas

**Falls of persons on the same level**

- Contact with elements that reach high temperatures.

**Thermal contacts**

- Getting in and out of the cab.
- Stepping on stones, objects, uneven ground.

**Stepping on objects**

6.2.2 Signaller or rigger

The signaller or rigger is in charge of informing, signalling and directing manoeuvres to the crane operators inside the services and also controls the traffic around the manoeuvre. The signalman may be a collaborator of the crane operator or the manoeuvre leader. He/she uses hand and hand signals, signalling paddle or racket and “witnesses”, as well as intercommunication systems when the terrain reduces visibility between the people in charge of this activity. The signaller must wear the appropriate identification elements and clothing, such as jacket, sleeves, reflective armband and helmet.

The work of the signalman is essential for the safe lifting of loads, as is communication between the crane operator and the signalman, which must be clear, simple and known to both.

Radiotelephone systems can be used to carry out operations, although it is true that sometimes this is not feasible or is cumbersome due to the noise generated by the work itself, so communication is generally carried out by means of gestures.

However, depending on the operation being carried out, there will be no choice but to communicate via walkie-talkies.
6.2.3 Manoeuvring director

This is the person who directs the manoeuvre, indicating, by means of clear communication, what the crane operator has to do. Avoid causing situations of great insecurity.

Their functions during assembly operations, among others, are shown below:
Verifying that the installation has been carried out correctly and checking the operation of the capacity indicator/limiter, as well as all the crane’s safety devices.
Check the correct location of the crane on the basis of the data on ground resistance, weights, load balance and distances, heights and depths to be operated during manoeuvres, duly provided by the lessee.
Verify the correct positioning and checking of the support plates and stabilisers.

6.2.4 Security manager

The safety manager is the person with sufficient safety knowledge to be able to act and assess what is being done, and with the authority to stop a hoist. In no case should it be the crane operator himself.
This is the person designated to ensure the safety of the crane operators and the person in charge of ensuring that the established safety regulations are complied with. In addition, he/she has the power to stop the work if he/she considers that it may be dangerous for the health and safety of people.

6.2.5 Strobe

He is responsible for choosing the type of tool (sling, chain, cable, shackle, etc.), suitable for the load to be lifted, placing the tool correctly and securing the load, checking that there is no danger of falling, overturning or sudden movement of the secured load when the lifting work is being carried out.

6.2.6 Quality certifier

This professional profile verifies and certifies the quality for the correct maintenance of the crane and its accessories.
LU 6.3 Introduction to mobile cranes

6.3.1 Crane Introduction

A crane is described as a piece of equipment designed to lift, transport and land a load. When deciding on the type and size of crane that is suitable for a specific job, these are the characteristics that need to be taken into consideration:

- The dimension, weight, and lift radius of the heaviest and largest load.
- The maximum lift height.
- The number of lifts to be made.
- The type of lifting.
- If using a mobile crane, the type of carrier required. This will depend on ground conditions and the location of the lift.
- Whether the loads have to be walked or carried by the crane.
- Another factor is the road ban situation in the spring of the year in colder climates.
- Many cranes cannot travel on side roads unless partially disassembled.

A Crane means a powered device that is equipped with mechanical means for raising or lowering loads suspended by means of a hook or other load handling device. It can, by the movement of the whole device or of its boom, jib, trolley or other such part, re-position or move suspended loads both vertically and horizontally; and includes all parts of the crane down to and including the hook or load-handling device, and all chains, rails, ropes, wires, or other devices used to move the hook or load-handling device. A crane also includes the attachments, fittings, foundations, mountings and supports but it does not include lifting gear that is not an integral part of the crane.

6.3.2 Crane types

Mobile cranes are characterized by the fact that they are designed to move, or travel, about the jobsite relatively easily. They are mounted on either wheels or crawlers. Crane mobility permits a minimum amount of time for move-in, setup, and move-out.

Wheel-mounted mobile cranes can also propel themselves to the jobsite. Such site-to-site moves are called transit moves. Once on the jobsite, mobile cranes can be quickly moved to wherever they are needed. The size between the largest and smallest mobile cranes differs widely. In general, size is directly proportional to mobility.

THE BOOM

Mobile cranes can be further classified by boom type and carrier type. Booms are either conventional lattice truss boom or telescopic boom. All telescopic boom cranes in use today use hydraulic cylinders to extend and retract the boom, therefore, they are commonly referred to as hydraulic cranes. Each of these types of booms carries the load weight differently.
The **lattice boom** and its pendants, or backstays, form a triangle. The boom is a compression member, and the pendants are tension members. The structural system thus formed is very strong, rigid, and relatively light. Boom length can be increased significantly with little penalty in capacity for the added dead weight. Telescopic booms, on the other hand, carry their load as flexible, cantilevered box beams, much like fishing poles. As such, they are extremely strong and have a high lift capacity when almost vertical. However, at low boom angles, the telescopic boom’s capacity decreases rapidly because of limited bending capacity. In addition, at low boom angles, the dead weight of the boom contributes significantly to overturning. As with a fishing pole, deflection of a telescopic boom is significant even with low loads.

The primary advantages of the telescopic boom cranes are portability and rapid setup time. Telescopic cranes are almost always mounted on wheeled carriers. The boom segments nest inside one another and are easily retracted to roadable lengths. Once at the site, the boom can be extended to full length in a matter of minutes. To extend reach height even further, lattice boom extensions are frequently added manually to the tip of the telescopic boom.

Size effects play an important role in the time required for setting up a telescopic boom crane. The larger the crane, the longer the setup time required and the less mobile it is on site. The setup time is still significantly shorter than that required for comparable lattice boom cranes. The largest telescopic cranes (800 tons and up) require additional trucks to carry boom, outriggers, and counterweight.

**The carrier**

A carrier is what makes a mobile crane mobile and basically consists of a special truck chassis, turntable, and wheels. Strictly speaking, crawler "carriers" are not usually referred to as carriers but rather crawler bases and consist of a structural frame called a car body, a turntable, and crawler treads. The upperworks consist of the hoisting mechanisms, swing mechanisms, hoist engine, and boom mounting - all of which are fastened to a structural frame called the machinery deck. Via the machinery deck, the upperworks are mounted to the carrier’s (or crawler base’s) turntable. The upperworks of smaller cranes are permanently mounted to the carrier. For larger cranes, the upperworks or house is designed to be detached or undecked from the carrier to facilitate transit moves.

**Crawler carriers**, or bases, are ideally suited for rugged jobsite situations. Their large footprint provides a large ground-bearing area that is ideal for traveling along unfinished site roads or paths, especially with sandy soil conditions. Crawlers need to be trucked in and assembled on site. Smaller crawler-mounted cranes can be loaded on a truck fully assembled (excluding boom).

The largest land-based mobile cranes available today are crawler mounted. These large cranes are not very manoeuvrable and take extensive time to assemble and transport.

*Illustration 1 - Crawler carrier*
Wheeled carriers come in three basic types. The first is called a truck carrier and has the ability to travel long distances on public highways. Its heavy-duty suspension and power train are designed primarily for highway travel and for graded jobsite roads. This carrier type has proven to be the most diverse. It provides a base for both lattice boom and telescopic boom cranes ranging in capacities from 5 tons to well over 500 tons.

A second type of truck carrier is the rough terrain (RT). The type of carrier has four oversized wheels and is designed strictly for off-road use because it does not have a separate driver’s cab. The rear axle of a rough terrain carrier has an oscillating hydraulic suspension that gives it superior off-road travel capabilities. During pick and carry operations, the rear axle must be locked.

Finally, the most technically advanced type of carrier is the all-terrain (AT) carrier. As its name implies, it is suitable for traveling on both highways and ungraded jobsite roads. This feature is achieved by a fully hydraulic, computer-controlled suspension and all-wheel steering for its multiple axles. It offers high manoeuvrability in confined urban settings.

All truck carriers are supplied with outriggers that must be fully extended when the boom of the crane is manipulated, whether it is loaded or unloaded. When setting the out riggers, all of the tires must be completely free of contact with the ground. The tires are considered part of the counterweight and are not effective as ballast if touching the ground.

The following are the main crane types:
Carrier-mounted Lattice Boom Crane

This type of crane is chosen for energy projects and large-scale construction works because of the long herald. The lattice boom crane is a heavy-duty machine that can move prodigious weights. They usually possess multifunction jibs that augment the crane’s lift reach and mobility.

Crawler-mounted Lattice Boom Crane

Crawler cranes in construction are used when the project requires a heavy load to be lifted over long distances or at great heights. They are often used for construction in hard-to-reach areas and in new instalments, or for jobs in poor weather conditions.
Carrier-mounted Hydraulic Telescoping Boom Crane

Truck mounted crane with telescopic boom is widely used in the lifting and transportation of municipal construction, mining engineering, landscaping and other infrastructure materials and other equipment. The truck mounted crane can operate to left and right, can be both positive and negative 360-degree rotation, can also be a full range of rotation.

Crawler-mounted Hydraulic Telescoping Boom Crane

The automatic boom extender/retractor easily adjusts the length of the boom to match working conditions, making the crane ideal for material handling and other jobs that required coordinated movement with other workers.

6.3.3 Crane movements

Cranes are machines that are designed and used to lift loads. Most cranes can also move and position loads. It can be said that most cranes can lift loads vertically and move loads horizontally.
LU 6.4 Hydraulic telescopic boom operation

To operate a crane, crane operators must conform to national qualifications, as specified in the previous modules. Prior to beginning work at a job site, the crane operator should understand:

- Crane Safety
- Crane Controls
- Crane Load Limits
- Operating Procedures.

The operator must understand emergency measure execution and be prepared to take emergency action at any time. Safe operation is the responsibility of the operator, maintenance and inspection personnel. Safety has been a major consideration in the design and manufacture of this equipment but only the operator and maintenance personnel can insure a safe work environment.

6.4.1 Starting Crane operations

THE POWER TAKE-OFF (PTO)

NOTE: Follow manufacturer instructions to engage the PTO in your vehicle. The instructions in this manual may not be accurate for all PTO’s.

A. Automatic Transmission
1. Set the vehicle parking brake.
2. Turn on the vehicle engine.
3. Put the vehicle in “Park” or “Neutral”.
4. Engage the PTO according to the manufacturer’s instructions. With an electrical “Hot Shift” PTO, press the switch to the “ON” position. NOTE: A light will come on to show the PTO is engaged.
5. Warm the engine to operating temperature.

B. Manual Transmission
1. Set the vehicle parking brake.
2. Place the transmission in “Neutral”.
3. Make certain the PTO lever is in the “OFF” position.
4. Start the vehicle engine.
5. Fully depress the clutch.
6. Engage the PTO. With a cable-shift PTO, move the lever to the “ON” position. With an air shift PTO, move the valve to the “ON” position.
7. Release the clutch gradually.
8. Warm the engine to operating temperature.
Disengaging the PTO

1. Fully depress the vehicle’s clutch pedal (if manual).
2. Disengage the PTO (OFF).
3. Release the clutch pedal gradually

DANGER: DO NOT COME IN CONTACT WITH THE PTO. DEATH OR SERIOUS INJURY MAY OCCUR

WARNING: DISENGAGE THE PTO PRIOR TO MOVING THE VEHICLE. FAILURE TO DO SO MAY CAUSE PUMP AND PTO DAMAGE, AND INADVERTENT OPERATION OF THE CRANE DRIVE TRAIN, WHICH COULD CAUSE AN ACCIDENT.

CRANE CONTROLS

Telescopic cranes may be equipped with either a radio or tethered remote control. All controls have decals which indicate operating directions for the function desired. Prior to operating the crane:

1. Make sure the individual crane functions are labelled with function control decals. If decals are missing or illegible, replace them.
2. Hydraulic valve control levers should be moved in a slow, smooth fashion for the even flow of hydraulic fluid. Excessively sudden or sharp movements of the control levers causes excessive wear and dangerous lifting hazards.
3. DO NOT operate controls with oily or greasy hands. Wear clean gloves for best results.
4. Each operator should test crane controls at the start of his shift.

Radio remote controls

The telescopic radio remote control functions include boom extensions, loader rotation, winch, engine speed, and crane and compressor power.

To operate the radio remote:
1. Make sure the large red “Emergency Stop” button is not pressed in. This button must be pulled out for the remote to operate. If the Emergency Stop button is pulled out, you will hear a small beeping noise with activation of any toggle switch. If the Emergency Stop button is pressed in, the crane will not function and you will not hear any beeping noises with toggle switches.

2. Toggle and hold switches to the desired crane function. Pull the trigger to move the crane.

3. When you have finished crane operation, return the crane to the transport position.

**ELECTRIC CRANES**

Electric cranes have no PTO or pumps, but they do have tethered remote controls which are similar in operation to the hydraulically controlled cranes.

The telescopic remote controls operate the crane boom extensions, crane rotation, winch, engine speed, and crane and compressor power. The remote controls also have an ENGINE STOP function which is a safety feature required on all cranes with remote controls that use a PTO driven pump. To operate the crane:

1. Turn on the power via the on/off switch of the tethered remote handle. Press the “Engine Start” toggle to start the vehicle engine to power the crane.

2. Pull back on the trigger until the power unit begins to run.

3. Using the decal as a guide, select the required function on the crane handle to move the crane as desired, making sure not to release tension on the trigger assembly. You must hold both the trigger and the crane function toggle switch at the same time to make the crane move.

4. When done with the function, continue to hold the trigger assembly in until all immediate movements of the crane have been completed.

5. If no further work with the crane is needed, or if all immediate movements of the crane have been completed, then release the trigger assembly to return the power unit back to a rested state.

6. Turn off power to the handset.
6.4.2 Crane capacity and load limits

Most telescopic boom cranes have a sequencing valve that extends the sections of a hydraulic boom equally. Booms on machines with several boom extension levers will have to be equally extended by the operator. The load chart is based on the boom sections being equally extended. If the boom sections are not equally extended, the chart readings are not accurate and the longest extended section may be overloaded.

The telescopic cranes are designed to lift specific loads. These loads are defined on the capacity placard mounted near the operator’s station and on the crane. Exceeding the limits presented on the capacity placard will create severe safety hazards and will shorten the life of the crane. The operator and other concerned personnel must know the load capacity of the crane and the weight of the load being lifted!

**WARNING:** NEVER EXCEED THE CRANE’S RATED LOAD CAPACITIES. DOING SO WILL CAUSE STRUCTURAL DAMAGE AND DAMAGE TO WINCHES AND CABLES WHICH CAN LEAD TO SERIOUS INJURIES OR DEATH.

**NOTE:** LOAD LIMIT INFORMATION ON THE CAPACITY PLACARD IS FORMULATED ON 85% OF TIPPING. “TIPPING REFERS TO THE CRANE ACTUALLY TIPPING WITH ITS OPPOSITE OUTRIGGER AND TIRES HAVING BROKEN CONTACT WITH THE SURFACE.

Prior to lifting a load:

1. Determine the weight of the load.
2. Determine the weight of any load handling devices.
3. Add the weight of the load and the weight of the load handling devices. The sum will be the total weight of the load being lifted.
4. Determine the distance from the centreline of crane rotation to the centreline of the load being lifted.
5. Determine the distance from the centreline of crane rotation to the centreline of where the load is to be moved to.
6. The actual distance used should be figured as the larger of points 4 and 5 above.
7. Determine at what angle the crane will be operated (for example 30°, 45°, etc.) by referencing the angle indicator on the lower boom.
8. Make certain that 2-part line is used for any lift which requires 2-part line. (Note: The two-part line weight is noted in a box on the capacity chart.)
REDUCED CAPACITY

In some cases, the capacity of a crane is reduced when lifts are performed on the sides of the truck. If your vehicle cannot lift full capacities when the crane is positioned on the side of the truck, you will see a Reduced Capacity Lift Chart on your vehicle. This chart uses a green, yellow, and red color-coding system to show you the level of capacity the crane can lift when the crane is positioned in various sectors. The color-coded Reduced Capacity Lift Chart (RCLC) corresponds to a visual indicator on the base of the crane, and displays the percentage of the full hydraulic crane capacity to be lifted in each sector.

ANTI-TWO BLOCKING SYSTEM

“Two-Blocking” is the condition in which the lower load block or hook assembly comes in contact with the upper load block or boom point sheave assembly. This can cause winch cable and sheave damage. An anti-two-blocking system can help prevent cable damage by sensing the position of the winch cable end attachments with respect to the sheave case and shutting down the functions that cause two blocking.
Telescopic cranes can have two types of anti-two-blocking systems; a rod and weight system and a switch activation mechanism.

The crane operator should check the anti-two block system daily as follows:

1. Examine flexible rod and weight / switch activation mechanism to insure free unrestricted mechanical operation
2. Examine cord for damage, cuts or breaks. Grasp cord and pull to check operation of cord reel. The cord should retract on reel when released.
3. Start vehicle, engage PTO and slowly winch the load line up until anti-two-block weight / switch activation mechanism comes in contact with the hook end of the load line cable. At the moment the weight is fully supported, the winch up function should become non-functioning. Slowly increase truck engine speed while simultaneously actuating the winch up function. The winch should not function. If operation other than as described occurs, stop immediately and investigate. Failure to do so will risk damage to the cable or the crane.

If all is well at this point, actuate the boom extend function slowly, and gradually increase to full actuation. Once again, the function should be non-existent with no tightening of the winch cable. If operation other than described occurs, stop immediately and reverse the function.

The final check involves actuating both the winch up and extend functions together and checking for proper operation of the anti-two blocking circuit. Once again, start slowly and stop if it appears the cable is being tensioned.

**WARNING:** ANY ANTI TWO BLOCKING SYSTEM CONSISTS OF A SERIES OF MECHANICAL COMPONENTS AND CANNOT BE 100% FAILSAFE.
If the anti-two block function appears to be functioning normally, winch the cable down until the sensing weight swings free or the switch activation mechanism returns to the normal position.

**NOTE:** TWO-BLOCKING IS THE CONDITION IN WHICH THE SNATCH BLOCK OR HOOK ASSEMBLY COMES IN CONTACT WITH THE UPPER LOAD BLOCK OR BOOM POINT SHEAVE ASSEMBLY.

**CHANGING FROM DOUBLE TO SINGLE-PART LINE**

Initially, your crane is set up with two-part line. Single-part line gives you a closer load distance and faster line speed.

If you require a closer load distance or a faster line speed, first check that you have the capacity to lift your load using single part line. If you do, change the crane to one-part line using the following steps:

1. Disconnect the pin which holds the hook/ snatch block assembly in place. Set aside the pin and the snatch block.
2. Disconnect the double-line anchor pin.
3. Remove the downhaul weight from the crane boom tip.
4. Slide the downhaul weight onto the wire rope. Drop it into place on the hook. **NOTE:** Some cranes have two hooks. Use the hook rated for your load.
5. Lift your load. When finished, return the boom tip to two-part line, or stow the snatch block and pin.

**TASK PERFORMANCE**

To operate the crane:

1. Position the crane as close to the job as possible on a firm, dry and level surface. Avoid overhead obstructions on the work side of the unit.
2. Set the auxiliary (parking) brake.
3. Depress the clutch pedal. Engage the PTO.
4. Before conducting any boom operations, extend outriggers and level the crane side to side, using the power down outrigger function. Use a signal person if the outriggers are not in view from the operator’s station when extending or lowering the outriggers. Provide blocks if necessary to level the unit on sloping ground or bearing pads if the outriggers tend to sink into soft terrain or hot asphalt. Some concrete or asphalt surfaces are relatively thin and cannot withstand the outrigger loading. Concrete can break through and cause instability.
5. Raise the inner boom.
6. Rotate the boom to the selected location. Lower the hook block to an adequate length to allow for extended boom length before extending any telescoping boom sections. Firmly set the outriggers, but do not lift tires from the ground. Stability over the front (without front stabilizers) can be hampered by raising the vehicle excessively. Be very careful when operating in areas around the truck not supported by outriggers because of cushion of tires and springs. When swinging loads from areas

**WARNING:** DO NOT ATTEMPT TO HANDLE A LOAD IF OUTRIGGERS ARE UNABLE TO MAKE SOLID
supported by outriggers, use extreme caution due to potential sudden shifting of the support point. Always keep the load as close to the ground as possible.

**CAUTION:** DO NOT ATTEMPT TO ROTATE THE CRANE BEFORE PLACING IT IN THE DEPLOYED POSITION. DAMAGE TO EQUIPMENT AND INJURY TO PERSONNEL MAY RESULT.

### 6.4.3 Crane shutdown

1. Retract the extension booms (and cable if applicable). Be sure to retract the manual extensions prior to the hydraulic extensions.
2. Secure the hook.
3. Stow the crane in its travel configuration with the boom in the boom support. Make sure the winch line is SLACK. After stowing, tighten the winch line just enough to keep the cable from contacting the boom. Excessive cable tension may cause the boom to bounce out of the rest during transit and may put damaging loads on the extension cylinder.

**CAUTION:** EXCESSIVE DOWNWARD PRESSURE ON THE BOOM SUPPORT MAY DAMAGE THE BOOM SUPPORT OR THE BODY.

Once the boom is in the transport position, shut off the truck engine and toggle the inner and extensions functions on the handset to relieve any trapped pressure. This will ensure the boom does not move out of the boom rest during transit.

1. Stow the outriggers.
2. Disengage the throttle control.
3. Depress clutch pedal (if applicable) and disengage PTO.
4. Secure loose items on truck bed.
5. Release the auxiliary brake.
OPERATORS

Personnel permitted to operate a crane must have certain minimum qualifications, conform to conduct and physical requirements and possess certain abilities. Be aware of and follow all national and state regulations.

6.4.4 Operation in adverse conditions

DUSTY AND SANDY AREAS

Operating in dusty or sandy areas presents special problems due to the abrasive action of dust which shortens the life of parts. Make every effort to keep dust and sand out of the moving parts of the crane machinery and engine.

1. All lubricants and lubricating equipment must be kept clean. Service breathers and air cleaners frequently to remove accumulated sand and dust. Lubricate more frequently to keep a supply of clean lubricant in the moving parts. Clean all lubrication fittings thoroughly before attaching the grease gun.
2. Keep the fuel tank filler cap tight to prevent sand and dust from entering the fuel tank. Service fuel filters frequently to keep them free of sand and dust.
3. Keep the hydraulic oil reservoir caps tight to prevent sand and dust from entering the hydraulic systems. Service the hydraulic oil filters frequently to keep the system free of sand and dust.
4. Use wood blocking or mats under the outrigger pads when operating in sand. See that the carrier vehicle does not shift during operation.
5. Before performing service on the crane, such as replacing hoses, thoroughly clean hose connections and surrounding area. Failure to do so will allow sand particles into the hydraulic system which will damage the pump, holding valves, valve bank and cylinders, leading to costly repairs.

HIGH HUMIDITY OR SALT AIR CONDITIONS

Moisture and salt will cause deterioration of paint, cables, wiring and all exposed metallic parts. Keep parts dry and well lubricated in high humidity or salt air conditions.

1. Completely remove rust and corrosion as soon as it appears on any part of the machine. Wash off salt water and dry all parts thoroughly. Paint the exposed surfaces immediately. Place a film of lubricant or grease on all polished or machined surfaces and other surfaces which cannot be painted.
2. Keep parts thoroughly lubricated to repel water from polished metal surfaces and to prevent the entry of water into bearings. Keep lifting cables well lubricated.

HIGH ALTITUDE

Operation at high altitudes presents special problems due to lower atmospheric pressure and wide temperature ranges. Consult the vehicle owner’s manual regarding operating the vehicle at high altitudes.
COLD WEATHER

For cold weather operation with temperatures of -25°F or lower, the following procedures must be followed:

1. Start the truck and run at manufacturer’s recommended idle speed for proper warm up.
2. After approximately 45 minutes of truck warm up time, engage the PTO.
3. With the PTO fully engaged and the truck engine running at idle speed, let the hydraulic system oil circulate.
4. If at any time during oil circulation, and especially during the initial warm up time, any hydraulic pump noise such as metal grinding, or a popping noise is heard, shut down the unit immediately. Check that the hydraulic oil line leading to the suction port on the pump is not clogged, or that the hydraulic oil itself does not have a gelling condition.
5. After the 45-minute warm up period, begin crane operation as follows:
   a) Slowly extend horizontal outrigger cylinders out approximately 6 inches and retract, extend out again approximately half way and retract, and then extend full stroke.
   b) Follow the procedure above on crane deployment, and extend cylinders.
   c) When completed, begin crane swing operation by rotating slowly approximately one eighth revolution one way, return to previous position and rotate in opposite direction. Do this several times, then rotate 90° and return.
   d) If equipped with a winch, begin winch operation by slowly opening the control valve allowing several revolutions in one direction. Then reverse the control valve and operate several revolutions in the opposite direction. Repeat several times allowing longer operation intervals.
LU 6.5 Operating hydraulic drive lattice boom cranes encompasses both crawler-mounted and truck-mounted cranes

The hydraulic system that allows the operation of the crane, in addition to the cylinders, is mainly composed of:

- pump,
- tank containing the hydraulic fluid,
- flexible hoses.

Each hydraulic circuit must have means for controlling the pressure. The pump must be able to feed the flow rate of the hydraulic system at the pressure indicated by the crane manufacturer and must be suitable for the fluids used by the system. The tank must have sufficient capacity for the crane to function properly both when all cylinders are fully extended and when they are retracted; in addition, it must have: an access opening, a drain valve equipped with a cap to allow cleaning of the tank and suitable devices for monitoring the minimum and maximum level of fluid.

All the circuits concerning the load support must have automatic devices (for example valves) that limit the pressure to a maximum design value.
Flexible hoses, other pipes and fittings must be designed considering a bursting pressure much higher than the maximum working pressure; the pipes must be arranged and, where necessary protected, so as not to be damaged by movements due to normal use of the crane. The guards must be able to deflect a possible jet of fluid.

All circuits relating to the support of the load must be equipped with automatic means installed near the cylinders (for example load support valves) sensitive to pressure, necessary to avoid uncontrolled movements of the crane in case of breakage of the circuit. The rotation mechanism must be able to withstand the maximum rotation and stopping forces to carry the load under the most disadvantageous working conditions.

RISK FACTORS

**Chemical agents:** the risk of contact with chemical agents can occur during maintenance and refuelling operations on the hydraulic crane and truck, due to the use of mineral oils, grease and fuel; furthermore, contact, even in the form of jets and splashes, can occur during normal use of the crane in case of failure of the hydraulic pipes containing high pressure fluid. To cope with these risks, routine maintenance operations must be carried out with equipment suitable for the purpose and efficient (e.g. containers, funnels, grease guns), checks and the necessary replacements of the hydraulic system pipes must be carried out and checked the effectiveness of the relative protections.

**Required Knowledge**

- K 1 manufacturers’ recommended procedures and working practices as described in the operator’s manual
- K 2 basic hydraulic systems
- K 3 crane manufacturers’ procedures for computer setup
- K 4 freefall mode and how to operate and disengage freefall mode
- K 11 effect of weather on operations such as wind, rain, snow and lightning
- K 12 heavy lift operations and procedures
Key Competencies (Operates hydraulic drive crawler-mounted lattice boom cranes)

- G-20.01.01 perform function test to ensure crane operation
- G-20.01.02 engage swing, boom, hoist and travel functions at various speeds in any given direction simultaneously taking into consideration changing site conditions
- G-20.01.04 maintain control of load during all functions such as changing radius, using the hoist, boom, swing and travel controls in combination while taking into consideration changing site conditions

Key Competencies (Operates hydraulic drive truck-mounted lattice boom cranes)

- G-20.02.01 perform function test to ensure crane operation
- G-20.02.02 engage swing, boom and hoist functions at various speeds in any given direction simultaneously
LU 6.6 Hydraulic drive lattice boom operation

Long heralded as the crane of choice for energy projects and large-scale construction works, the lattice boom crane is a heavy-duty machine that can move prodigious weights. Crawler cranes, in particular, are usually kept on-site for extended periods, given their enormous size. Yet these are famously stable machines. Their total mass is balanced over a tracked platform, which allows them to handle jobs on a great variety of ground surfaces — even on soft terrain. They’re also adaptable. Most are designed with multifunction jibs that augment the crane’s lift reach and mobility.

There are many different sectors in which mobile cranes are increasingly in demand:

The energy sectors and the construction and maintenance of major public facilities, bridges, and other infrastructure projects keep the demand for crawler cranes steady. Renewable energy projects raise the game for these powerful cranes, which play indispensable roles in installing and decommissioning wind turbines. At the same time, the need for cranes in energy applications will drive market growth for the larger machines, which allow for more clearance for the jib or boom.

For example, Global Market Insights has researched the future demand as Chinese, Indian and Southeast Asian markets augment their infrastructure development. All told, the need for crawler cranes is on track to top $3 billion by 2024. South American demand will also be vital in light of projected spending on transit and energy. Other non-residential infrastructure needs include renovations for emergency service sites, installing street lights and event setups for major commercial and music events and festivals.

Some companies opt to rent crawler cranes at a lower price than buying. For new and older models, crane maintenance and reconfiguration are also finding brisk demand.
As we have seen on this course plan, crane makers are going high tech. Today’s new models feature more straightforward self-assembly, user-friendly controls and in-cab information display panels. Flexibility matters too, and the giant cranes are becoming easier to use on small sites.

Crawler crane makers are embracing telematics as well. Telematics is the systems that generate work reports, supporting appropriate maintenance. Predicting total uptime is as critical as extending the working life of a crane. With proper care, lattice boom cranes are a decades-long investment that impressive model performance every working day.

Consider the benefits of the Remote Observation Satellite System – KCross, now a standard feature throughout the Kobelco’s G-2 series. KCross offers remote machine monitoring straight from a user’s desktop. Daily reports show the crane’s hours in use, fuel consumed, idle time, winch use, travel time and other key details.

Technological adaptations often entail significant changes, which can also lead to the discontinuation of specific crane models. The frictions crane – a lattice boom crane that uses clutches and foot brakes for load control instead of a hydraulic system as with modern lattice boom cranes – are no longer manufactured. However, many are still in use on job sites. Since these cranes are still in service and their operation is entirely different from their modern counterpart, accrediting agencies need to test operator skills on the crane types they are expected to operate.
Cranes are machines that are designed/used to lift loads. This is their main purpose. Most cranes can also move and position loads. It can be said that most cranes can lift loads vertically and move loads horizontally. As we saw, there are many different types and sizes of cranes from many different manufacturers. The type of crane which this module deals with is known as the boom type crane, sometimes called jib crane. There are also different types of booms. Many manufacturers have their own special equipment or systems to achieve the way in which the crane works but, whatever the method used, cranes perform only three basic functions, namely:

- VERTICAL Movement is carried out by the crane’s hoist (and lowering) function
- HORIZONTAL fore and aft movement are carried out by the crane’s boom hoist function, sometimes called derricking or luffing.
- HORIZONTAL movement is also carried out using the crane’s swing (or slewing) function.

They are resume in the draw below:
As we have seen in the dedicated module, wheel-mounted mobile cranes can also propel themselves to the job site. Such site-to-site moves are called transit moves. Once on the job site, mobile cranes can be quickly moved to wherever they are needed. The size between the largest and smallest mobile cranes differs widely. In general, height is directly proportional to mobility.

If we overview the existing lattice boom crane types, a 500-ton crawler-mounted mobile crane (not the biggest) may take several days to erect on-site and travel to the lift location. However, a 45-ton truck-mounted telescopic boom crane is ready when it arrives on-site and can execute many lifts that same day. Mobile cranes can be further classified by boom type and carrier type. Booms are either conventional lattice truss boom or telescopic boom. Virtually all telescopic boom cranes in use today use hydraulic cylinders to extend and retract the boom. Therefore, they are commonly referred to as hydraulic cranes. Each of these types of booms carries the load weight differently.

The lattice boom and its pendants, or backstays, form a triangle. The boom is a compression member, and the pendants are tension members. The structural system thus formed is very strong, rigid, and relatively light. Boom length can be increased significantly with little penalty in capacity for the added dead weight. The lattice boom is modular, and the length between the butt section and the tip section is increased by manually inserting short boom segments known as inserts. Inserts range in length from 10 to 40 feet and install quickly with pins. This procedure, however, must be completed with the boom laying horizontally on the ground and takes one or two ironworkers and a small assist crane.

Heavy loads with high mobility – these are the two main characteristics of lattice boom mobile cranes. Whilst the boom on the wheeled crane is a lattice version similar to a crawler crane, the undercarriage has been adopted from all-terrain cranes.
The lattice boom ensures that it can hoist heavy loads. On the other hand, the undercarriage with wheels provides the required mobility, enabling it to move quickly and easily from site to site. All cranes are designed to comply with current road regulations to be suitable for use throughout the world. The boom is erected at the site.

A friction crane operator has to engage the clutch and control the load with the foot brake and levers simultaneously. As we said, while manufacturers no longer produce friction cranes, some lattice boom models are still friction operated and controlled using friction clutches and brakes instead of hydraulics.

Comparing the operation of friction and hydraulic cranes, Hans Merkel, president of Kissimmee Crane School, said, “It’s like night and day”. On a friction crane, the load is controlled by mechanical means, and failure to maintain the brake will result in losing the load. Hydraulic controls automatically return to neutral, which brings load movement to a stop. CIC – Crane Institute Certification – has always certified operators of friction cranes but is now offering a special notation designating "Friction" on certification cards for operators who take their practical exam on friction cranes. The purpose is to identify the operators who have demonstrated skill in operating these unique, complex cranes. A lattice boom crane may be hydraulically or friction controlled. Therefore, CIC is taking this extra measure to provide greater clarity to employers and recognition for operators.
To be achieved upon learning outcome completion

**Knowledge:**
- Demonstrate knowledge of the different types of cranes and its components
- Demonstrate knowledge of the structure, components and assembly of lattice boom friction cranes
- Demonstrate knowledge of load tables and load calculations for lattice boom friction cranes
- Demonstrate knowledge of lattice boom friction jib crane servicing and maintenance procedures
- Demonstrate knowledge of the theory of crane lifting forces
- Demonstrate knowledge of how to identify each of the working operations performed with self-propelled mobile cranes and strictly comply with the specific safety regulations in full safety conditions
- Demonstrate ability to carry out the operations of driving, crane positioning and boom assembly and disassembly, with safety guarantees
- Demonstrating knowledge of each of the workstations in the sector and the tasks to be carried out by each of them
- Demonstrating knowledge of the different types of cranes and the operations they can perform according to their type
- Demonstrate knowledge of crane capacity and load limits, carrying out loading and unloading operations safely
- Demonstrate knowledge of the practical operation of hydraulically operated lattice cranes

**Skills and competences:**
- Basic skills in physics, mathematics, calculus
- Forces and calculation vectors for lifting
- Uses clutches and foot brakes in the case of friction crane
- Knowledge of the hydraulic principles
- Basic calculations of heights, areas, volumes and grades
- Commonly used construction symbols and abbreviations
- Construction terminology
- Features of plans and elevations, including direction, scale, key, contours, symbols and abbreviations
- Job safety analysis (JSA) and safe work method statements
- Key features of formal job specifications
- Processes for application of scales in plan preparation and interpretation
- Project quality requirements
- Site and equipment safety (OHS) requirements
- Techniques for orienting/confirming the orientation of a plan.
- Boom manoeuvring practice
- Manoeuvring loads in the workplace
- Stability of the crane and the load
- Recording and maintaining accurate information relating to crane operations
- Reporting to relevant person/s on site risk control measures that are not in place or deficient
- Setting up and validating an exclusion zone
1. How can we calculate the weight and volume of the load?

2. What is the centre of gravity of a load and why is it important?

3. In the case of suspended bodies, we can see three types of equilibrium:

4. What are the three basic usual operations in the services of a self-propelled mobile crane.

5. What are the functions of the signaller or rigger?
   - Clean the area where the crane is set down.
   - Driving the crane
   - Control the people entering and leaving the site.
   - Informing, signalling and directing the manoeuvres to the crane operators within the services and also controlling the traffic around the manoeuvre.

6. To carry out his work, the signaller
   - Communicates by means of gestures
   - Communicates by means of a signalling paddle or racket.
   - Communicates by radiotelephone systems.
   - All are correct

7. When deciding on the type and size of crane suitable for a particular job, what features should be taken into account? Name any of them.

8. Describe the 8 steps to be taken before lifting a load.

9. What anti-locking systems can telescopic cranes have?

10. What are the three basic types of crane movements?

11. What distinguishes a friction crane from a hydraulic crane?

12. What makes lattice crane booms so robust?

13. What are the main movements of the crane?
Glossary

**Abrasion**: Surface wear on the wires of a wire rope.

**A/D Director**: (Assembly/Disassembly director) means an individual who meets this subpart’s requirements for an A/D director, irrespective of the person’s formal job title or whether the person is non-management or management personnel.

**Allowable Ground Bearing Pressure**: The maximum permissible pressure, typically expressed in pounds per square foot (psf) or Pascals (Pa), that may be imposed on the supporting surface. This value may be equal to the Soil Bearing Capacity divided by a suitable safety factor or it may be a lesser value as limited by other considerations, such as the strength of the subsurface pipes. See Ground Bearing Pressure; see Soil Bearing Capacity.

**Angle Indicator**: Device on the crane used to determine the angle at which the boom is situated relative to the horizontal plane.

**Anti-two Block System**: A system of electromechanical devices used to prevent the crane operator from two blocking the crane.

**Assembly/Disassembly**: Means the assembly and/or disassembly of equipment covered under this standard. With regard to tower cranes, “erecting and climbing” replaces the term “assembly” and “dismantling” replaces the term “disassembly”. Regardless of whether the crane is initially erected to its full height or is climbed in stages, the process of increasing the height of the crane is an erection process.

**Asymmetrical Load**: An object with an off-centre centre of gravity due to the object’s irregular shape and/or composition.

**Average Ground Bearing Pressure (AGBP)**: \[
\text{Force/Area} = \text{AGBP}.
\]
The average pressure exerted onto the ground under a specified area.

**Boom**: Part of the crane that extends above the upperworks or superstructure and supports the line or lines to which the load is attached.

**Bumper Outrigger**: A hydraulic cylinder or manual jack located on the front bumper of a truck crane carrier to provide additional stability and extend the crane’s working range over the front of the carrier. Also: Fifth Outrigger.

**Capacity**: The actual ability to carry that a crane has.

**Car Body**: Frame of a chassis for a crawler crane to which the tracks and upperworks attach.

**Carrier**: The portion of the crane located below the turntable bearing.

**Centre of Gravity**: The point in an object or person where their weight is balanced. With mobile cranes, there are three basic components that have individual centre of gravity points. These are the superstructure, carrier and boom. Each of these components has its own centre of gravity. Depending on how each piece is positioned, it can affect the other’s centre of gravity.

**Centre Gravity of a Load**: Single point on the load at which it can be hoisted perfectly balanced. Some riggers like to think of it somewhat in reverse: it is the point at which all of a load’s weight.

**Chassis**: Part of the carrier that includes the steering and braking mechanisms, suspension, drive train and tracks or wheels.

**Composite**: A composite material (also called a composition material or shortened to composite, which is the common name) is made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics...
different from the individual components. The individual components remain separate and distinct within
the finished structure, differentiating composites from mixtures and solid solutions.

**Counterweight:** Heavy metal or concrete attachments secured to the back of the upperworks to offset the
weight of the extended boom and load and increase lift capacity.

**Crane Load Chart:** Each crane has a load chart that, in short, specifies the crane’s capabilities — detailing its
features and how its lift capacity varies when considering distance and angle.

**Crane Mat:** An assembly of structural members, arranged or connected and used to support crawler cranes,
and/or equipment for load distribution and stability.

**Crane Pad:** Manufactured single piece or unibody solutions used for outrigger support under outrigger
enabled equipment for load distribution and stability. See DICA’s crane pads.

**Crawler Crane:** Mobile crane that uses a track-driven carrier.

**Cribbing:** Blocking materials that are used to increase the bearing area and height. See DICA’s plastic cribbing
blocks.

**Critical Lift:** A crane lifting operation judged to involve an exceptional level of risk, due to factors such as load
weight, lifting height, procedural complications, or proximity to situational hazards. Critical lifts may be
identified by conditions exceeding a specified percentage of the crane’s rated capacity; however, many more
complex issues may be involved.

**Crush Rating:** The allowable amount of pressure that an outrigger pad, crane outrigger pad, cribbing or
crane pad is rated to carry, based on the strength of the material.

**Deflection:** The bending of supporting materials as downforce is applied. See Downforce.

**Derrick:** A lifting device consisting of a vertical mast secured at the top by guy lines or braces and utilizing
hoist machinery and operating ropes. A derrick may or may not utilize a boom.

**Derricking or Luffing:** Operation of changing boom angle by varying the length of the boom suspension ropes.
It is imparted to the inclined member or the jib to move in a vertical plane so that the angle of the jib may be
changed in order to bring the load line nearer to or further off from the centre of the crane.

**Displacement:** The difference between the unloaded horizontal positions of the outrigger pad, compared
with the fully loaded horizontal position of the outrigger pad.

**Downforce:** The force that is generated in a downward direction from the outriggers through the outrigger
float and onto the outrigger pads.

**Drum:** Cylindrical flanged barrel, either of uniform or tapering diameter, on which rope is wound either for
operation or storage. Its surface may be smooth or grooved. It is a cylindrical component on the mobile crane
that is used to store and dispense line; the line is wound or spooled into the drum when the operator causes
the drum to rotate.

**Equalizing Sheave:** The sheave at the centre of a rope system over which no rope movement occurs other
than equalizing movement. It is frequently overlooked during crane inspections with disastrous
consequences. It can be a source of severe degradation.

**Extend the boom:** Hydraulic cranes, in most cases, have one or more telescoping sections to the main boom;
this is one feature that allows the operator to control the length of the boom.

**Fatigue Resistance:** The characteristic of a wire rope which allows it to bend repeatedly under stress.

**Filler Wire:** A strand construction that has small auxiliary wires for spacing and positioning other wires.

**Gantry:** A bridge-like overhead structure with a platform supporting equipment such as a crane, signals, or
cameras.

**Ground Bearing Capacity** (GBC): The strength of the ground, or its ability to support a pressure.
Ground Bearing Pressure (GBP): The pressure, typically expressed in pounds per square foot (psf) or Pascals (Pa), that a crane imposed on the supporting surface. See Allowable Ground Bearing Pressure.

Grounding Mat: Grounding device used when a crane will be working in a relatively fixed location which is near electrical hazards. Equipment is placed on that mat and bonded to it. The grounding mat area is usually enclosed with a fence to prevent personnel from stepping on and off the mat during operation of the machine.

Grounding Rod: Grounding device used when a crane will be working in a relatively fixed location which is near electrical hazards. The ground lead is connected to the rod and to the machine, with the rod placed as close to the machine as possible.

Hardware: Usually refers to rigging hardware, which can be any of a wide range of bolts, hooks, chains, shackles, clamps, and other mechanical devices used to secure or attach to loads in preparation for hoisting.

Hoist: A hoist is a device used for lifting or lowering a load by means of a drum or lift-wheel around which rope or chain wraps. It may be manually operated, electrically or pneumatically driven and may use chain, fibre or wire rope as its lifting medium.

Hoist Line: Single line attached to a ball, lift hook or other assembly; the term hoist line may also be used to describe the compound assembly of lines running through the hook block.

Hoisting: Act of manipulating the crane controls in order to move a load.

Hook Block: Heavy metal block containing sheaves or pulleys, located at the end of the hoist line on some cranes; the hook block is equipped with a hook for attachment of loads.

Hydraulic System: System that relies on pressurized oil to make it function; the boom on hydraulic cranes is manipulated through the use of oil under pressure.

Incidental or Ordinary Lifts: Involve the use of basic hoisting equipment directly above the load. The load must also have certified lifting points or be relatively easy to sling.

Inspection: Activity of examination, measurement, or testing to determine whether the specified requirements are met.

Jack: A mechanical or hydraulic device for lifting heavy weights short distances. RELATED: Outrigger Jack.

Jib: A long horizontal frame that sticks out from a crane and from which the hook hangs. It is the horizontal or near-horizontal beam used in many types of cranes to support the load clear of the main support.

Lattice Boom: A boom of lattice-type construction, usually fabricated of steel angles or tubing.

Lifting: To move or bring (something) upward from the ground or other support to a higher position.

Load: A quantity of something carried at the same time.

Maintenance: Totality of operations to ensure that the crane/auxiliary equipment is maintained in safe operating parameters.

Mat: Individual timbers fastened together into units, steel plates, or woven wires placed under crawler tracks, wheels, or outrigger pads to prevent sinking by increasing the bearing area contacting the ground thereby reducing bearing pressures.

Maximum Outrigger Reaction Force: The maximum amount of weight that the equipment can exert through its outriggers.

Non-rotation-resistant Wire Rope: Stranded wire rope, the design of which is not intended to reduce load induced torque. Also known as standard wire rope.

On Outriggers: (1) The condition where a crane operates with all outriggers fully extended and set to level the crane body with its tires or crawlers free of the ground. (2) Rated capacities for a crane which are applicable when the crane is operating with all outriggers fully extended and set to level the crane body with its tires or crawlers free of the ground. Related: On Rubber.
On Rubber: (1) The condition where a crane operates with any of its tires in contact with the ground. (2) Rated capacities for a crane which are applicable when the crane is operating with any of its tires in contact with the ground. Also: On tires. Related: On Outriggers.

Operating Machine: Controlling the working action of a machine and accepting responsibility for the observance of the manufacturing specifications of the process. This shall not be taken to mean the sole process of starting or stopping a machine.

Outrigger: A beam which extends from the lower works of a crane to increase the crane’s stability. The beams may be either extendible/retractile or fixed length and typically utilize some type of pad to distribute loads to the ground surface.

Outrigger Beam: The part of an outrigger system which extends horizontally from the outrigger box to support the vertical outrigger jack.

Outrigger Jack: The hydraulic cylinder on the outrigger beam which extends vertically to raise and lower the crane.

Outrigger Pad: A wood, metal, or synthetic structural element that is placed on the supporting surface and on which bears the crane’s float that is used to distribute the outrigger load over a larger area. See DICA’s outrigger pads.

Outrigger Pin System: A hydraulic system available to facilitate outrigger box removal by means of hydraulic cylinders used in place of the standard outrigger box mounting pins.

Overhaul: Activity, usually planned, which consists of all the operations performed on the cranes / auxiliary equipment in order to identify the defects and remedy them according to the technical prescriptions.

Pad: Compacted soil, concrete, wooden timbers or mats, or steel plates assembled into a system for supporting a crane with minimal settlement.

Periodic Inspection: Mandatory inspection activity performed at a certain time interval, after the start of crane operation.

Periodic Technical Inspection: Activity that is required by the crane owner, at predetermined intervals or whenever the owner deems it necessary, to ensure that the crane meets the requirements for safe operation.

Person-in-charge: Person appointed by the responsible manager or designee to direct critical or pre-engineered lifts. The person-in-charge must be present during the entire lifting operation and must have experience in handling similar types of equipment. The designated person-in-charge may be either a supervisor familiar with critical lift operations, or a person with special knowledge of the equipment and handling.

Pontoon: (1) A pan type structure which attaches to the bottom of vertical outrigger jack to distribute loads over the supporting surface. SEE: Float. (2) Large steel pads usually fabricated to support crane tire or outrigger loads on soft soil. Pontoon is the steel equivalent of wooden crane mats.

Power Take-Off (PTO): Device used for the transfer or transmission of engine power to the operating functions of the crane

Pre-engineered Lifts: Repetitive lifts that meet the definition of a critical lift, defined below. If, however, the BNL Lifting Safety Committee determines that through the use of tooling, fixtures, sketches, analyses, and written procedures, the possibility of dropping, upset, or collision is reduced to an acceptable level, the lift may be designated as a pre-engineered lift.

Radius: Horizontal distance from the centre of rotation of a crane to the centre of gravity of load with the load suspended.
**Reeving**: Method of installing parts of line, in a multiple part line system; each sheave turns at a different speed; helps balance the sheave speed across the block; therefore, the block travels level as it is hoisted up and down.

**Rigger**: Designated individual whose duty it is to ensure that loads are appropriately attached or rigged to the hoist line of the crane.

**Rigging**: is defined as the set of manoeuvres that are carried out by a crane.

**Rotation-resistant Rope**: A wire rope consisting of at least two layers of strands where the lay direction of the outer layer is opposite of its underlying layer.

**Seale**: A strand construction having one size of cover wires with the same number of one size of wires in the inner layer.

**Seize**: To bind securely the end of a wire rope or strand with seizing wire or strand.

**Shaves**: Wheels or pulleys located in a hook block, boom heads, or other parts of the crane boom on which the line runs. They are used in tandem with a rope, belt, or cable to lift items with a crane. Essentially, a sheave is a wheel with an open groove that a rope or cable fits around so it can rotate around the exterior. One end of the cable is attached to an item that needs to be moved, while the other is attached to a fixed object, like the base of a crane. The cable smoothly moves over the wheel of the sheave as it is wound up on the fixed object, lifting the other object into the air.

**Signal**: Approved signs given to the operator by the signaller; the signaller may use hands and arms to relay the information, or may rely on a radio to give verbal cues to the operator.

**Signaller**: Designated individual who relays information to the crane operator.

**Site Supervisor**: Exercises supervisory control over the worksite on which a crane is being used and over the work that is being performed on that site.

**Slewing Motion**: It is imparted to the whole super structure of the crane including the jib, so that it can turn about a central pivot shaft with regard to the non-revolving parts. This motion enables the crane to shift the load line to revolve round the crane.

**Slings**: Wire ropes made into forms, with or without fittings, for handling loads and made to permit the attachment of an operating rope. The sling is a flexible lifting attachment used with crane hook, bucket, shovel or similar to hoist and move materials or equipment.

**Strand**: An arrangement of wires helically laid about an axis, or another wire or fibre centre to produce a symmetrical section.

**Spooling**: Process of winding line either onto or off of a drum on which it is stored.

**Stabilizer**: An extendable or fixed member(s) attached to the mounting base to increase the stability of the crane, but which may not have the capability of relieving all of the weight from wheels of tracks.

**Swing (slewing)**: Rotating the upperworks horizontally through part or all of the radius or circle.

**Symmetrical Load**: An object that, because of its uniform shape and composition, has its centre of gravity located exactly in its middle.

**Technical Condition Assessment**: Set of technical examinations, verifications and tests carried out on the basis of a program approved, in order to evaluate the technical condition of the crane in operation.

**Technical Verification**: totality of the examinations and/or tests that will be performed, based on the technical documentation applicable to cranes / auxiliary equipment, in accordance with the provisions of the technical prescriptions, in order to assess the extent to which they meet the specified requirements for safe operation.

**Telescopic Booms**: A serial work platform with boom sections that extend telescopically. They are also commonly known as “stick” booms because of their straight appearance.
**Telescopic (hydraulic) crane:** Telescopic cranes are equipped with a boom (arm) outfitted with a hydraulic cylinder that allows it to change length, like a telescope. Hydraulic cranes are heavy-duty equipment used for lifting and hoisting. Unlike smaller cranes, which rely on electric or diesel-powered motors, hydraulic cranes include an internal hydraulic system that allows the crane to lift heavier loads. This fluid-filled hydraulic system enables the crane to transport objects such as heavy shipping containers and tractor trailers, which are well beyond the size and scope of any other lifting device.

**Tracks:** Carrier system used to move certain cranes that require the use of tracks rather than wheels.

**Upperworks (house):** Part of the mobile crane above the carrier which rotates and supports the boom, winches, cylinders and other components.

**Warrington** A strand construction in which the outer layer of wires is composed of alternating large and small wires.

**Wire Rope:** A plurality of strands laid helically around an axis or core. Material made of many extremely strong and flexible metal alloy wires wound in various configurations to suit a range of conditions; often referred to as cable.

**Wire:** A single, continuous length of metal cold-drawn from a rod.

*Main source: A Glossary of Common Crane and Rigging Terms. Specialized Carriers & Rigging Foundation.*
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LIFTING MACHINES (cranes, lifting mechanisms, forklifts, self-lifting platforms including those for people with disabilities, elevators for vehicles and special type lifting machines).
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