Tasneef

هيئة الإمارات للتصنيف
Emirates Classification Society

Rules for loading and unloading arrangements and for other lifting appliances on board ships

Effective from 1 January 2023

+971 2 6922333 +971 2 4454333 info@tasneef.ae 111155, Abu Dhabi, UAE

GENERAL CONDITIONS

Definitions:

"*Administration*" means the Government of the State whose flag the Ship is entitled to fly or under whose authority the Ship is authorised to operate in the specific case.

"IACS" means the International Association of Classification Societies.

"*Interested Party*" means the party, other than the Society, having an interest in or responsibility for the Ship, product, plant or system subject to classification or certification (such as the owner of the Ship and his representatives, the ship builder, the engine builder or the supplier of parts to be tested) who requests the Services or on whose behalf the Services are requested.

"*Owner*" means the registered owner, the ship owner, the manager or any other party with the responsibility, legally or contractually, to keep the ship seaworthy or in service, having particular regard to the provisions relating to the maintenance of class laid down in Part A, Chapter 2 of the Rules for the Classification of Ships or in the corresponding rules indicated in the specific Rules.

"Rules" in these General Conditions means the documents below issued by the Society:

(i) Rules for the Classification of Ships or other special units;
(ii) Complementary Rules containing the requirements for product, plant, system and other certification or containing the requirements for the assignment of additional class notations;
(iii) Rules for the application of statutory rules, containing the rules to perform the duties delegated by Administrations;
(iv) Guides to carry out particular activities connected with Services;
(v) Any other technical document, as for example rule variations or interpretations.

"*Services*" means the activities described in Article 1 below, rendered by the Society upon request made by or on behalf of the Interested Party.

"Ship" means ships, boats, craft and other special units, as for example offshore structures, floating units and underwater craft.

"*Society*" or *"TASNEEF"* means Tasneef and/or all the companies in the Tasneef Group which provide the Services.

"*Surveyor*" means technical staff acting on behalf of the Society in performing the Services.

Article 1

1.1. The purpose of the Society is, among others, the classification and certification of ships and the certification of their parts and components. In particular, the Society:
(i) sets forth and develops Rules;
(ii) publishes the Register of Ships;
(iii) issues certificates, statements and reports based on its survey activities.

1.2. The Society also takes part in the implementation of national and international rules and standards as delegated by various G overnments.

1.3. The Society carries out technical assistance activities on request and provides special services outside the scope of classification, which are regulated by these general conditions, unless expressly excluded in the particular contract.

Article 2

2.1. The Rules developed by the Society reflect the level of its technical knowledge at the time they are published. Therefore, the Society, although committed also through its research and development services to continuous updating of the Rules, does not guarantee the Rules meet state-of-the-art science and technology at the time of publication or that they meet the Society's or others' subsequent technical developments.

2.2. The Interested Party is required to know the Rules on the basis of which the Services are provided. With particular reference to Classification Services, special attention is to be given to the Rules concerning class suspension, withdrawal and reinstatemen t. In case of doubt or inaccuracy, the Interested Party is to promptly contact the Society for clarification.
The Rules for Classification of Ships are published on the Society's website: www.tasneef.ae.

2.3. The Society exercises due care and skill:
(i) in the selection of its Surveyors
(ii) in the performance of its Services, taking into account the level of its technical knowledge at the time the Services are performed.

2.4. Surveys conducted by the Society include, but are not limited to, visual inspection and non-destructive testing. Unless otherwise required, surveys are conducted through sampling techniques and do not consist of comprehensive verification or monitoring of the Ship or of the items subject to certification. The surveys and checks made by the Society on board ship do not necessarily require the constant and continuous presence of the Surveyor. The Society may also commission laboratory testing, underwater inspection and other checks carried out by and under the responsibility of qualified service suppliers. Survey practices and procedures are selected by the Society based on its experience and knowledge and according to generally accepted technical standards in the sector.

Article 3

3.1. The class assigned to a Ship, like the reports, statements, certificates or any other document or information issued by the Society, reflects the opinion of the Society concerning compliance, at the time the Service is provided, of the Ship or product subject to certification, with the applicable Rules (given the intended use and within the relevant time frame).
The Society is under no obligation to make statements or provide information about elements or facts which are not part of th e specific scope of the Service requested by the Interested Party or on its behalf.

3.2. No report, statement, notation on a plan, review, Certificate of Classification, document or information issued or given as p art of the Services provided by the Society shall have any legal effect or implication other than a representation that, on the basis of the checks made by the Society, the Ship, structure, materials, equipment, machinery or any other item covered by such document or information meet the Rules. Any such document is issued solely for the use of the Society, its committees and clients or other duly authorised bodies and for no other purpose. Therefore, the Society cannot be held liable for any act made or document issued by other parties on the basis of the statements or information given by the Society. The validity, application, meaning and interpretation of a Certificate of Classification, or any other document or information issued by the Society in connection with its Services, is governed by the Rules of the Society, which is the sole subject entitled to make such interpretation. Any disagreement on technical matters between the Interested Party and the Surveyor in the carrying out of his functions shall be raised in writing as soon as possible with the Society, which will settle any divergence of opinion or dispute.

3.3. The classification of a Ship, or the issuance of a certificate or other document connected with classification or certificati on and in general with the performance of Services by the Society shall have the validity conferred upon it by the Rules of the Society at the time of the assignment of class or issuance of the certificate; in no case shall it amount to a statement or warranty of seaw orthiness, structural integrity, quality or fitness for a particular purpose or service of any Ship, structur e, material, equipment or machinery inspected or tested by the Society.

3.4. Any document issued by the Society in relation to its activities reflects the condition of the Ship or the subject of certifi cation or other activity at the time of the check.

3.5. The Rules, surveys and activities performed by the Society, reports, certificates and other documents issued by the Society are in no way intended to replace the duties and responsibilities of other parties such as Governments, designers, ship builders, manufacturers, repairers, suppliers, contractors or sub-contractors, Owners, operators, charterers, underwriters, sellers or intended buyers of a Ship or other product or system surveyed.
These documents and activities do not relieve such parties from any fulfilment, warranty, responsibility, duty or obligation (also of a contractual nature) expressed or implied or in any case incumbent on them, nor do they confer on such parties any right, claim or cause of action against the Society. With particular regard to the duties of the ship Owner, the Services undertaken by the Society do not relieve the Owner of his duty to ensure proper maintenance of the Ship and ensure seaworthiness at all times. Likewise, t he Rules, surveys performed, reports, certificates and other documents issued by the Society are intended neither to guarantee the buyers of the Ship, its components or any other surveyed or certified item, nor to relieve the seller of the duties arising out of the law or the contract, regarding the quality, commercial value or characteristics of the item which is the subject of transaction.
In no case, therefore, shall the Society assume the obligations incumbent upon the above-mentioned parties, even when it is consulted in connection with matters not covered by its Rules or other documents.
In consideration of the above, the Interested Party undertakes to relieve and hold harmless the Society from any third party claim, as well as from any liability in relation to the latter concerning the Services rendered.
Insofar as they are not expressly provided for in these General Conditions, the duties and responsibilities of the Owner and Interested Parties with respect to the services rendered by the Society are described in the Rules applicable to the specific Service rendered.

Article 4

4.1. Any request for the Society's Services shall be submitted in writing and signed by or on behalf of the Interested Party. Such a request will be considered irrevocable as soon as received by the Society and shall entail acceptance by the applicant of all relevant requirements of the Rules, including these General Conditions. Upon acceptance of the written request by the Society, a contract between the Society and the Interested Party is entered into, which is regulated by the present General Conditions.

4.2. In consideration of the Services rendered by the Society, the Interested Party and the person requesting the service shall be jointly liable for the payment of the relevant fees, even if the service is not concluded for any cause not pertaining to the Society. In the latter case, the Society shall not be held liable for non-fulfilment or partial fulfilment of the Services requested. In the event of late payment, interest at the legal current rate increased by 1.5% may be demanded.

4.3. The contract for the classification of a Ship or for other Services may be terminated and any certificates revoked at the request of one of the parties, subject to at least 30 days' notice to be given in writing. Failure to pay, even in part, the fees due for Services carried out by the Society will entitle the Society to immediately terminate the contract and suspend the Services.
For every termination of the contract, the fees for the activities performed until the time of the termination shall be owed to the Society as well as the expenses incurred in view of activities already programmed; this is without prejudice to the right to compensation due to the Society as a consequence of the termination.
With particular reference to Ship classification and certification, unless decided otherwise by the Society, termination of the contract implies that the assignment of class to a Ship is withheld or, if already assigned, that it is suspended or withdrawn; any st atutory certificates issued by the Society will be withdrawn in those cases where provided for by agreements between the Society and the flag State.

Article 5

5.1. In providing the Services, as well as other correlated information or advice, the Society, its Surveyors, servants or agents operate with due diligence for the proper execution of the activity. However, considering the nature of the activities performed (see art. 2.4), it is not possible to guarantee absolute accuracy, correctness and completeness of any information or advice supplied. Express and implied warranties are specifically disclaimed.
Therefore, except as provided for in paragraph 5.2 below, and also in the case of activities carried out by delegation of Governments, neither the Society nor any of its Surveyors will be liable for any loss, damage or expense of whatever nature sustained by any person, in tort or in contract, derived from carrying out the Services.

5.2. Notwithstanding the provisions in paragraph 5.1 above, should any user of the Society's Services prove that he has suffered a loss or damage due to any negligent act or omission of the Society, its Surveyors, servants or agents, then the Society will pay compensation to such person for his proved loss, up to, but not exceeding, five times the amount of the fees charged for the specific services, information or opinions from which the loss or damage derives or, if no fee has been charged, a maximum of AED5,000 (Arab Emirates Dirhams Five Thousand only). Where the fees charged are related to a number of Services, the amount of the fees will be apportioned for the purpose of the calculation of the maximum compensation, by reference to the estimated time involved in the performance of the Service from which the damage or loss derives. Any liability for indirect or consequential loss, damage or expense is specifically excluded. In any case, irrespective of the amount of the fees charged, the maximum damages payable by the Society will not be more than AED5,000,000 (Arab Emirates Dirhams Five Millions only). Payment of compensation under this paragraph will not entail any admission of responsibility and/or liability by the Society and will be made without prejudice to the disclaimer clause contained in paragraph 5.1 above.

5.3. Any claim for loss or damage of whatever nature by virtue of the provisions set forth herein shall be made to the Society in writing, within the shorter of the following periods: (i) THREE (3) MONTHS from the date on which the Services were performed, or (ii) THREE (3) MONTHS from the date on which the damage was discovered. Failure to comply with the above deadline will constitute an absolute bar to the pursuit of such a claim against the Society.

Article 6

6.1. These General Conditions shall be governed by and construed in accordance with United Arab Emirates (UAE) law, and any dispute arising from or in connection with the Rules or with the Services of the Society, including any issues concerning responsibility, liability or limitations of liability of the Society, shall be determined in accordance with UAE law. The courts of the Dubai International Financial Centre (DIFC) shall have exclusive jurisdiction in relation to any claim or dispute which may arise out of or in connection with the Rules or with the Services of the Society.

6.2. However,

(i) In cases where neither the claim nor any counterclaim exceeds the sum of AED300,000 (Arab Emirates Dirhams Three Hundred Thousand) the dispute shall be referred to the jurisdiction of the DIFC Small Claims Tribunal; and

(ii) for disputes concerning non-payment of the fees and/or expenses due to the Society for services, the Society shall have the right to submit any claim to the jurisdiction of the Courts of the place where the registered or operating office of the Interested Party or of the applicant who requested the Service is located.

In the case of actions taken against the Society by a third party before a public Court, the Society shall also have the righ t to summon the Interested Party or the subject who requested the Service before that Court, in order to be relieved and held harmless according to art. 3.5 above.

Article 7

7.1. All plans, specifications, documents and information provided by, issued by, or made known to the Society, in connection with the performance of its Services, will be treated as confidential and will not be made available to any other party other than the Owner without authorisation of the Interested Party, except as provided for or required by any applicable international, European or domestic legislation, Charter or other IACS resolutions, or order from a competent authority. Information about the status and validity of class and statutory certificates, including transfers, changes, suspensions, withdrawals of class, recommendations/conditions of cl ass, operating conditions or restrictions issued against classed ships and other related information, as may be required, may be published on the website or released by other means, without the prior consent of the Interested Party.

Information about the status and validity of other certificates and statements may also be published on the website or released by other means, without the prior consent of the Interested Party.

7.2. Notwithstanding the general duty of confidentiality owed by the Society to its clients in clause 7.1 above, the Society's c lients hereby accept that the Society may participate in the IACS Early Warning System which requires each Classification Society to provide other involved Classification Societies with relevant technical information on serious hull structural and engineering systems failures, as defined in the IACS Early Warning System (but not including any drawings relating to the ship which may be the specific propert y of another party), to enable such useful information to be shared and used to facilitate the proper working of the IACS Early Warning System. The Society will provide its clients with written details of such information sent to the involved Classification Societies.

7.3. In the event of transfer of class, addition of a second class or withdrawal from a double/dual class, the Interested Party undertakes to provide or to permit the Society to provide the other Classification Society with all building plans and drawings, certificat es, documents and information relevant to the classed unit, including its history file, as the other Classification Society may require for the purpose of classification in compliance with the applicable legislation and relative IACS Procedure. It is the Owner's duty t o ensure that, whenever required, the consent of the builder is obtained with regard to the provision of plans and drawings to the new Society, either by way of appropriate stipulation in the building contract or by other agreement.

In the event that the ownership of the ship, product or system subject to certification is transferred to a new subject, the latter shall have the right to access all pertinent drawings, specifications, documents or information issued by the Society or which has come to the knowledge of the Society while carrying out its Services, even if related to a period prior to transfer of ownership.

Article 8

8.1. Should any part of these General Conditions be declared invalid, this will not affect the validity of the remaining provisions.

Tasneef

هيئة الإمارات للتصنيف
Emirates Classification Society

RULES FOR LOADING AND UNLOADING ARRANGEMENTS AND FOR OTHER LIFTING APPLIANCES ON BOARD SHIPS

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Chapter 3 Derrick Systems

CHAPTER 4 CRANES

CHAPTER 5 CRANES FOR OFFSHORE OPERATIONS

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CHAPTER 7 PERSONNEL LIFTING (MAN RIDING OPERATIONS)

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CHAPTER 1 GENERAL

1 Introduction

1.1 Application

1.1.1 *(1/1/2023)*

The requirements of these Rules apply to loading and unloading systems in general (hereafter referred to as systems) and to other new lifting appliances, on board ships or floating vessels, as follows:

- masts and kingposts of conventional type
- masts and kingposts of special design (derrick-cranes)
- union purchase rigs
- fixed and swinging cranes in general
- A-frames and similar
- submersible handling appliances
- lifts and loading ramps
- lifting tackle
- appliances for fish handling and fishing systems.

These Rules are relative to structural scantlings, components and ropes.

The Manufacturer is responsible for the scantlings of the machinery and the handling of the system and their qualification is to be verified as specified in Ch 14.

Irrespective of Tasneef inspections, the Designer and the Manufacturer of the system are responsible for compliance with applicable specifications and regulations, of the parts supplied and manufactured and of the suitability arrangement and components of the system even where manufactured by subcontractors.

These Rules do not consider design and construction details of structural or machine parts. The Designer and the Manufacturer are responsible for ensuring, on the basis of recognised standards and/or good engineering practice, that such details are appropriate for the static stress and strain foreseen in the environmental conditions where the structures and components are to operate. Where doubts arise, the interested parties are to ask Tasneef for confirmation of the validity, as far as applicable regulations are concerned, of the estimated design data relative to the load and environmental conditions or of specially adopted solutions. Regulations are relative to the handling of the cargo and/or ship equipment; the movement of personnel is dealt with in Ch 7 “Man Riding Cranes”.

At the request of the interested parties and for lifts in accordance with "Rules for the certification of lifts and escalators for passengers and crew members", Tasneef will issue the relative Quality Certificate.

Additional checks and requirements not specified in these Rules may be required by Tasneef for special and/or new systems.

Existing systems, for which the interested parties require Tasneef to issue the relative certificates, are to comply with these Rules, as far as deemed applicable by Tasneef according to the procedures as specified in [3.2] and are to undergo the surveys specified in Ch 2, [3].

Application of the Rules to loading and unloading systems or to lifting appliances on board ships not classed by Tasneef will be specially considered by Tasneef

In this case additional requirements may be laid down in addition or as an alternative to those given in these Rules to take account of special service conditions.

These Rules are mandatory for the purpose of the requirements issued by the Italian Government i for loading and unloading systems and for other lifting appliances on board Italian flag ships in compliance with the ILO Convention. The relative certificates are specified in [1.2].

These Rules are mandatory for the assignment and maintenance of the service notation **lifting unit** as specified in Pt A, Ch 1, Sec 2, Tab 2 of the Rules for the classification of ships, when the lifting appliance is essential for the ship's or floating vessel's service.

These Rules are also mandatory, as far as applicable, for structures and appliances used for the handling and/or supporting of loads. Where such structures and appliances are essential for the service of the ship on which they are installed, they are included in the class characteristics and do not require the assignment of the service notation lifting unit. This applies to ramps and retractable 'tweendecks of classed **ro-ro cargo ships** or to supporting and positioning sytems of dredging components of ships classed as **dredgers**.

Supporting structures of lifting appliances such as masts, posts and crane pedestals, permanently connected to the structure of the ship, and those ship structures that are subjected to the load of these systems when in operation are to be classed. The above-mentioned structures are to comply with these Rules and with the requirements of the various Parts of the Rules for the classification of ships.

Units provided with lifting arrangements complying with these Rules are assigned the additional class notation **CARGO HANDLING and/or PERSONNEL LIFTING**, according to Pt A, Ch 1, Sec 2, [6.14.31] of the Rules for the Classification of Ships.

1.2 Certification and validity

1.2.1 The following certificates relative to the system are issued by Tasneef

a) "Register of ship's cargo handling machinery and gear" ("ILO Register") as provided for by the ILO Convention for Italian flag ships or floating vessels, in accordance with the Italian Administration regulations, or for other ships on behalf of the flag Administration if authozied.

b) Certificate for loading and unloading arrangements, other lifting appliances and handling nets on board ships (Form LAS) (see Ch 2, [6.3]) in compliance with the Italian Regulations for the safety of navigation and life at sea, for Italian flag ships or floating vessels.

c) Declarations at the request of the interested parties, for purposes other than those mentioned in items (a) and (b) above, certifying the type and result of the tests and inspections performed on the basis of these Rules.

The certificates mentioned in (a) and (b) above are issued following successful preliminary survey and their validity depends on the results of periodical and occasional surveys.

The above-mentioned certificates do not exempt interested parties from the obligation of meeting other more onerous requirements and regulations issued by the flag Administration of the ship and any other requirements stipulated for the same purpose.

The duration of the validity of the certificates in (a) and (b) above cannot be extended by Tasneef except as specified in Ch 2, [5.1]. In the case of shortcomings, no instructions can be given to the interested parties before noting on the certificates that the system concerned is "out of order" or has a "lower working load" until the defect is removed.

1.3 Equivalents

1.3.1 In general, the equivalence of regulations is accepted; i.e. regulations, design and installation criteria that comply with other recognised standards equivalent to these Rules are accepted unless otherwise specified by national laws or international conventions.

In general, if fittings are correctly certified they are accepted as equivalent when in compliance with national or international standards.

Tasneef reserves the right to apply additional conditions for the approval of the above-mentioned equivalent components.

1.4 Calculations

1.4.1 As far as the examination of drawings is concerned, Tasneef may also require calculations relative to the scantlings of structures and components.

Calculations are to be performed in accordance with recognised methods appropriate to sound engineering principles.

When a computer analysis is carried out, information relative to the program and criteria used is to be submitted in order to facilitate inspection of the design.

1.5 Modifications of systems

1.5.1 When systems having the certificates mentioned in [1.1.2] (a) and (b) are modified, the interested party is to notify Tasneef without delay.

The operations involved are to be performed to the satisfaction of Tasneef and under Tasneef supervision.

Drawings relative to the modifications and including a detailed description of the latter are to be submitted to Tasneef for examination.

1.6 Operational precautions

1.6.1 These Rules assume that the cargo will be handled with the utmost care for safety reasons, taking into account the hazards that may result from mishandling. They also assume that the appliances are appropriately used by expert personnel.

Furthermore, it is assumed that prior to setting sail, all items of loose gear of the systems are appropriately stalled and where necessary lashed in order to reduce movement due to ship motion.

1.7 Tests

1.7.1 In the case of new systems, Tasneef tests are required for structural materials, derricks, fittings, items of loose gear and wire ropes as specified in the relative chapters.

Workshop tests are sufficient for machinery and equipment as specified in Ch 14.

When tests are necessary they are to comply with the requirements of the relevant Parts of the Rules for the classification of ships.

Welded connections are to be performed by certified welders and are to be in compliance with Pt D, Ch 5, Sec 1 and Pt B of the Rules for the classification of ships, as far as applicable.

1.8 Requests and fees

1.8.1 Tasneef provides for testing, calculations and checks as specified in these Rules, at the request of interested parties.

This request implies the acceptance of all relevant Tasneef requirements.

The interested party is to pay Tasneef all fees and reimburse all expenses. The applicable fees are indicated in the fee schedule in force or, failing this, by specific fees stipulated specially.

2 Definitions, abbreviations and symbols

2.1

2.1.1

The following definitions and abbreviations are additional to those given in the Rules for the classification of ships, which are reproduced here in part for ready reference:

- "Administration" is the Government of the State whose flag the vessel is flying.
- "Maritime Authorities" (MA) is the local office of the maritime Administration (Maritime Department, Port

Authorities, Regional Maritime office, etc., for all Italian flag vessels).

- "Surveyors" are Tasneef Surveyors in charge of the inspection.
- "Interested parties" are the parties requesting Tasneef certification, such as the Owner or his authorised representative, the yard or the builder.
- "Units" are ships and floating vessels. Unless otherwise specified, the word "ship" is intended to mean both ships and floating vessels.
- "Loading and unloading systems" are all systems installed on board a ship or floating vessel that are used for cargo handling, either for engine room service (e.g. including engine service travelling crane) or for handling other cargoes.

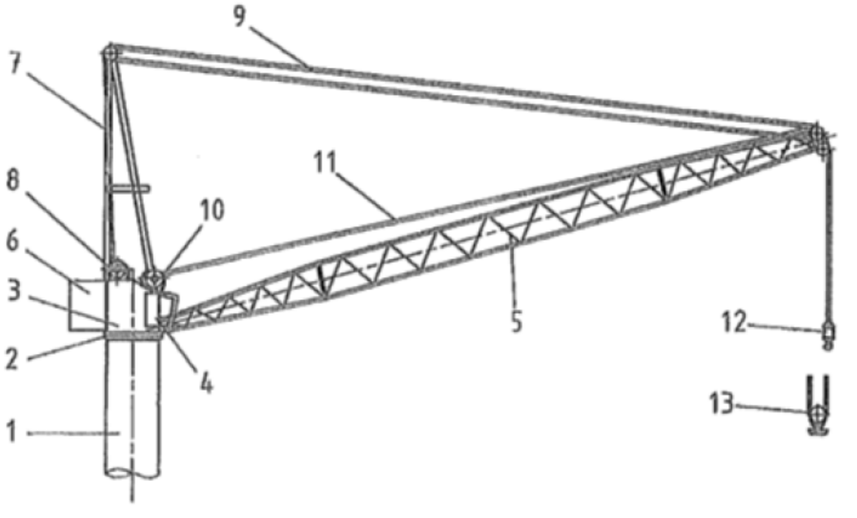
  The systems are considered:

  - "new", when of new construction or substantially modified;
  - "existing", when not "new".
- "Fixed structures" of the systems may be derrick posts and masts, derrick booms, cranes (pedestals and jibs), A-frames, lifts (platforms and associated guides) and all equipment similar to the above-mentioned systems.
- "Fittings and items of loose gear" of the systems are all parts not included in the "fixed structures". These components are considered:

  - "fittings" when they are permanently connected (e.g. derrick heel attachment, derrick head span block attachments, crane jib masthead block) or similar (e.g. derrick heel pin, mast and derrick collars, derrick eyebolts, wire ropes or stays having end connections for shrouds or span ropes, tackles with fixed end blocks);
  - "items of loose gear" when they are not fixed (hooks, shackles, swivels, blocks, chains, wire ropes or span ropes for rigging operations, e.g. for cargo runner operations).
- "Working load" (P) of a system is the maximum static load that may be handled during operation according to these Rules.
- "Safe Working Load" (SWL) of a component is the maximum load to which the component may be subjected during operation. The SWL is determined on the basis of the relevant design and the proof test to which the component was subjected.
- "Crane stiffness" is the vertical static force applied at the hook in order to produce unit vertical deflection assuming the pedestal support structure to be rigid
- "Design temperature" is the reference temperature for the area in which the system is to be installed, used as a criterion for the selection of materials. The design temperature is to be taken as the lowest mean daily air temperature in the area of operation (See also Pt B, Ch 4, Sec 1 of the Tasneef Rules for the Classification of Ships)
- "Dynamic coefficient" is the ratio between the maximum dynamic load at the hook and the actual working load for any given configuration or operating condition
- "Component" is a single part or assembly of part of a crane, which is subjected to load effects (e.g. ropes , traverse beams, pendant bars, sheaves, axles, gears, couplings, brakes, hoists, hydraulic cylinders, shafts, shackles, swivels etc.)
- "Hoisting" is the vertical movement of the cargo. If the system is equipped with two lifting appliances, the one with the greater working load, even where used to a lesser extent, is termed main appliance and the other is termed auxiliary appliance. Associated wire rope and/or tackle is called cargo runner and/or cargo runner tackle.
- "Translation" is the horizontal movement of the trolley. Where two trolleys are used in the same system, the translation movement of the trolley having the greater working load is termed main trolley and the other is termed auxiliary trolley.
- "Sliding" is the horizontal movement of the lifting equipment.
- "Rotation" is the rotatory movement of a part of the lifting equipment. This movement is also called slewing.
- "Jib hoisting" is the variation of the load outreach. This variation is also called luffing. The associated cable and/or tackle (when the jib hoisting is not obtained by means of cylinder/s) is called span rope and/or span tackle.
- "Offlead load" is the horizontal load at the boon tip caused by the radial displacement of the hook and/or the radial acceleration of the boom tip
- "Sidelead load" is the horizontal load at the boom tip caused by the lateral displacement of the boom and/or the lateral acceleration of the boom tip
- "Offshore installation" is a fixed structure supported by the sea bed or a floating unit, supported by buoyancy forces, used for the exploration, production and/or storage of hydrocarbons in a marine environmental or used for transhipping operations
- "Significant wave height" is the average height of the highest one third of the individual wave height in a short term constant state of sea (typically three hours)
- "Radius" is the horizontal distance between the crane axis of slewing and a vertical line through the hook when the axis of slewing is vertical and there is no offlead.
- "Running rigging" is meant all wire ropes passing over sheaves or guide rollers or wound on winches drums, irrespective of whether or not the ropes are moved under load.
- "Standing rigging" is meant ropes that are not turned round or wound on winches drums (e.g. guided wires, pendants, stays etc.)

In addition to the above definitions, Fig 1 to Fig 5 can be used for ready references for component’s designation:

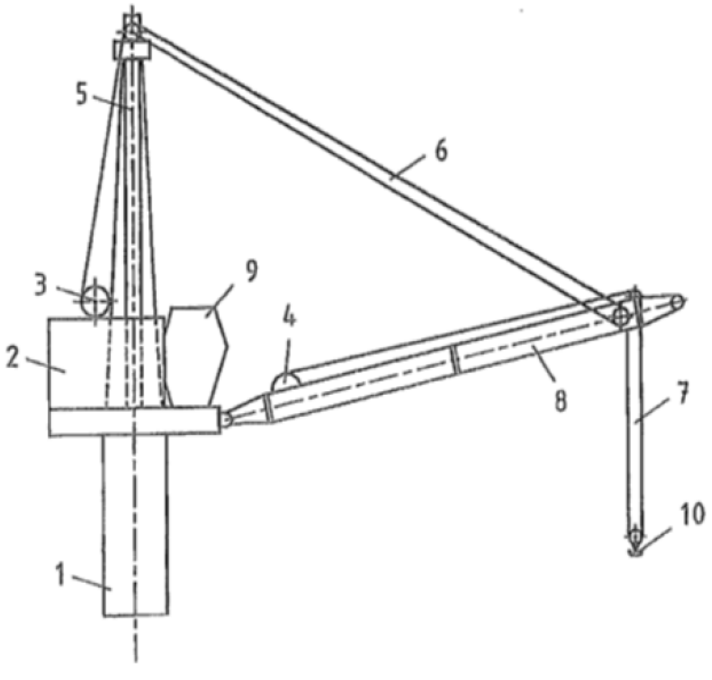
Figure 1 : Lattice boom type crane



Key

1. Pedestal
2. Slewing bearing
3. Crane frame
4. Operator's cabin
5. Lattice boom
6. Machinery house
7. A-frame
8. Luffing winch
9. Luffing rope(s)
10. Hoisting winch
11. Hoisting rope(s)
12. Hook (for single fall reeving)
13. Hook block (for multiple fall reeving)

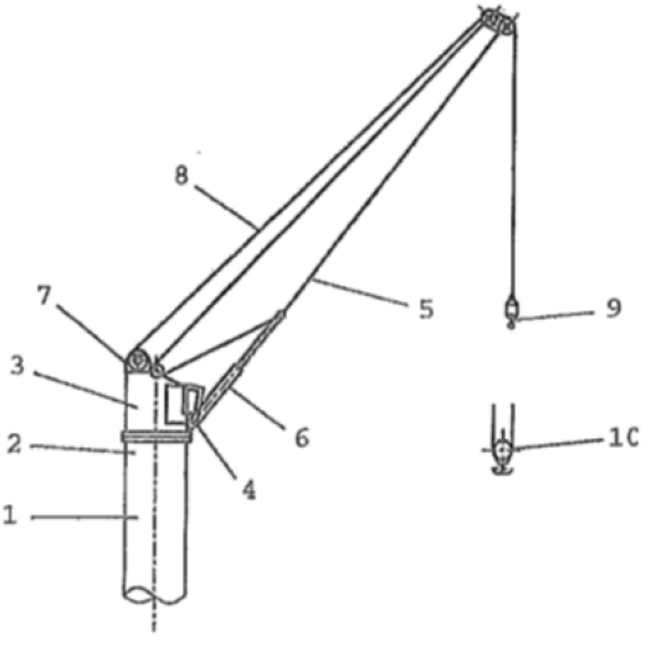
Figure 2 : Centre post-type with lattice boom



Key

1. Pedestal
2. Machinery house
3. Luffing winch
4. Hoisting winch
5. King-/centre-post
6. Luffing rope(s)
7. Hoisting rope(s)
8. Boom
9. Cabin
10. Hook block

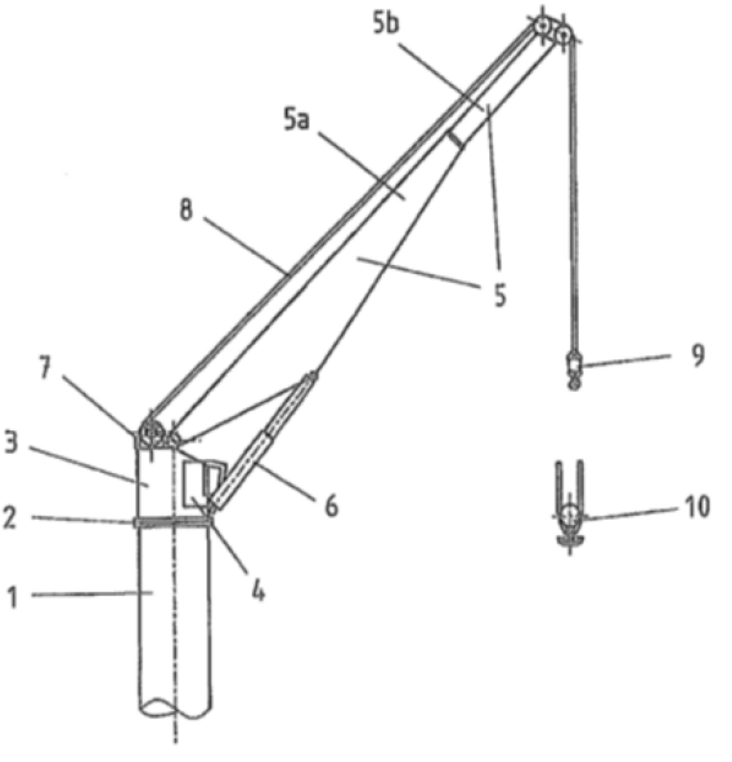
Figure 3 : Cylinder luffing type with box boom



Key

1. Pedestal
2. Slewing bearing
3. Crane frame
4. Operator's cabin
5. Box boom
6. Luffing cylinder(s)
7. Hoisting winch
8. Hoisting rope(s)
9. Hook (for single fall reeving)
10. Hook block (for multiple fall reeving)

Figure 4 : Telescopic boom type crane



Key

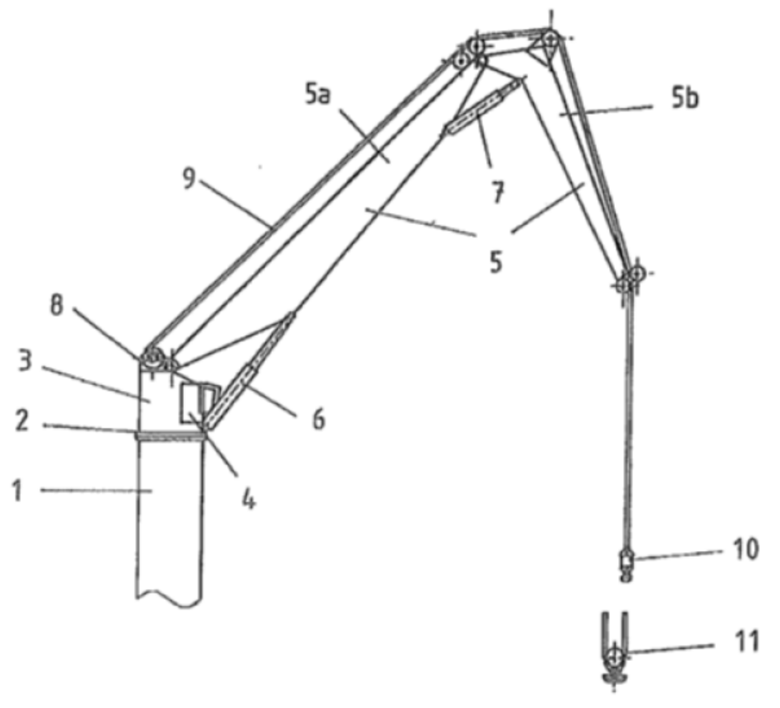
1. Pedestal
2. Slewing bearing
3. Crane frame
4. Operator's cabin
5. Telescopic boom assembly

5a. Main boom

5b. Telescopic boom

6. Luffing cylinder(s)
7. Hoisting winch
8. Hoisting rope(s)
9. Hook (for single fall reeving)
10. Hook block (for multiple fall reeving)

Figure 5 : Knuckle boom type crane



Key
1. Pedestal
2. Slewing bearing
3. Crane frame
4. Operator's cabin
5. Knuckle boom assembly
5a. Main boom
5b. Knuckle jib
6. Luffing cylinder(s)
7. Folding cylinder(s)
8. Hoisting winch
9. Hoisting rope(s)
10. Hook (for single fall reeving)
11. Hook block (for multiple fall reeving)

3 Documentation

3.1 New systems

3.1.1

The following drawings and calculations are to be submitted to Tasneef for approval for the purpose of obtaining the certification specified in [1.2] above:

a) General plan of the system.

Schematic drawings of the main fixed structures, where the following is to be indicated: working loads, structural scantlings, quality of the materials and connections, calculations.

b) Drawings and strength calculations of the components.

In the case of standards recognised by Tasneef their typical designation in the drawings specified in (a) above is sufficient.

c) Schematic drawings to be included in the ILO Register, when requested, such as:

Diagram of the general layout of on board systems, in format 297x210 mm, to be drafted according to facsimile drawings as shown in Fig 6 to Fig 13.

Drawing approval is not required if Certificate Form LA5 is issued. Motor controlled fixed tackles are to be specified in the Register of loading and unloading systems of the ship or on Certificate Form LA5.

See also Ch 9, [12] and Ch 10, [10] for lifts and ramps, respectively.

3.2 Existing systems

3.2.1 In the case of existing systems, arranged in accordance with a design that has not been approved by Tasneef the extent of the technical documentation as per [3.1] may be suitably reduced at the discretion of Tasneef taking into account the state of the system itself and the existing documentation and certification submitted by the interested party to Tasneef for examination.

In particular, the availability of valid certificates issued by recognised bodies in accordance with requirements deemed equivalent by Tasneef to those contained in these Rules is a sufficient condition for considering such systems efficient and safe; however, if doubts exist regarding the general state of loading systems or their compliance with certificates issued, such systems are to be subjected to checks and tests, irrespective of the certification obtained.

Figure 6 : Telescopic crane

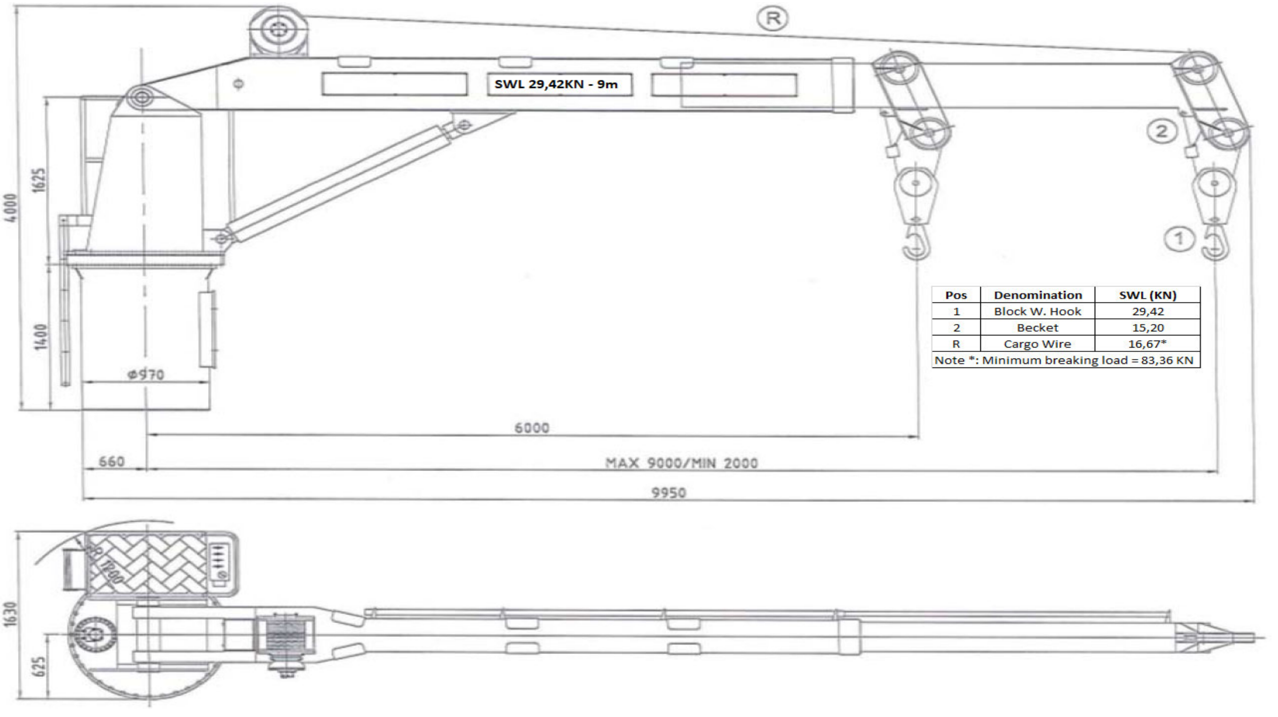
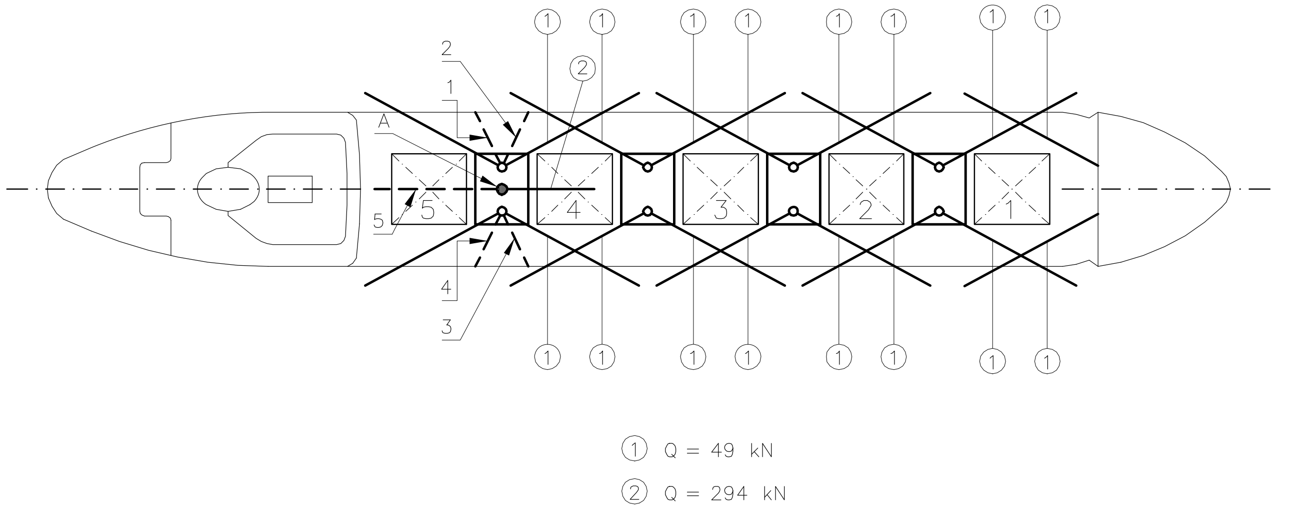


Figure 7 : Derrick system



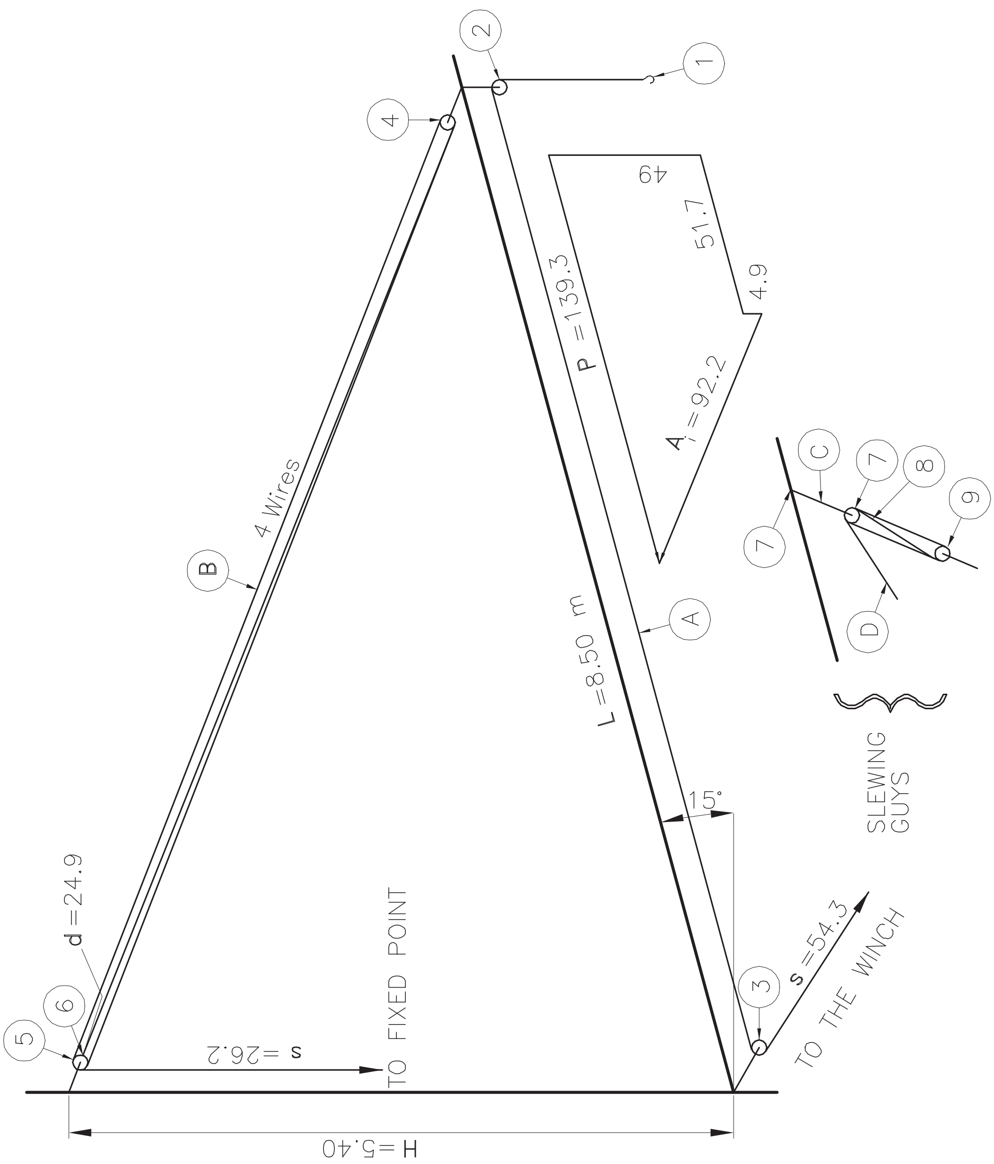
DERRICKS						
SERVICE	Q_{kN}	α	H m	L m	H/L	Notes
HATCHES 1−2−3	49	15°	5,4	8,5	0,63	SEE FIG 2
HATCH 4	294	15°	15,1	17	0,89	SEE FIG 3
HATCHES 4 − 5	49	15°	6,3	8,5	0,74	SEE FIG 2

MAST STAYS					
MAST	STAY	ø ROPE mm	No. OF WIRES	BREAKING STRENGTH OF WIRES N/mm²	BREAKING LOADS OF THE ROPE (kN)
A	1−2−3−4	32	114	1570	530
	5	46	114	1570	1079

Figure 8 : 49 kN derrick - assembly

ITEM	LOOSE GEAR	SWL (kN)
1	HOOK	49
	SHACKLE	49
2	SINGLE SHEAVE BLOCK	49
	SHACKLE	98
3	SINGLE SHEAVE BLOCK	49
4	DOUBLE SHEAVE BLOCK	92.2
	HEAD FITTING	92.2
5	DOUBLE SHEAVE BLOCK WITH BECKET	118.7
	HEAD FITTING	118.7
6	SHACKLE FOR BECKET	24.9
7	SHACKLE	29.4
	DOUBLE SHEAVE BLOCK WITH BECKET	29.4
8	SHACKLE FOR BECKET	5.65
9	SHACKLE	26.4
	DOUBLE SHEAVE	26.4

ITEM	ROPES	SWL (kN)
A	CARGO RUNNER	55.3
B	SPAN ROPE	26.2
C	SLEWING GUY PENDANT	29.4
D	SLEWING GUY ROPE	5.65



NOTE
Loads and forces in kN

Figure 9 : 294,3 kN derrick - assembly

ITEM	LOOSE GEAR	SWL (kN)
1	FOURFOLD SHEAVE BLOCK WITH BECKET	294.3
	SHACKLE	294.3
	SHACKLE FOR BECKET	39.2
2	FOURFOLD SHEAVE BLOCK	267.8
	SHACKLE	267.8
3	LEAD BLOCKS	37.77
	SHACKLES	75.5
4	LEAD BLOCKS	48
	SHACKLES	93.5
5	SIXFOLD BLOCKS	397.3
	SHACKLE OR HEAD FITTING	397.3
6	FIVEFOLD BLOCK WITH BECKET	372.8
	SHACKLE OR HEAD FITTING	372.8
7	SHACKLE	73.6
	SINGLE SHEAVE BLOCK WITH BECKET	73.6
	SHACKLE	25.8
8	SINGLE SHEAVE BLOCK	25.8
	SHACKLE	50.2
9	SNATCH BLOCKS	28.5
	SHACKLE	55.6

ITEM	ROPES	SWL (kN)
A	CARGO RUNNER	46.3
B	SPAN ROPE	48
C	SLEWING GUY PENDANT	73.6
D	SLEWING GUY ROPE	28.5

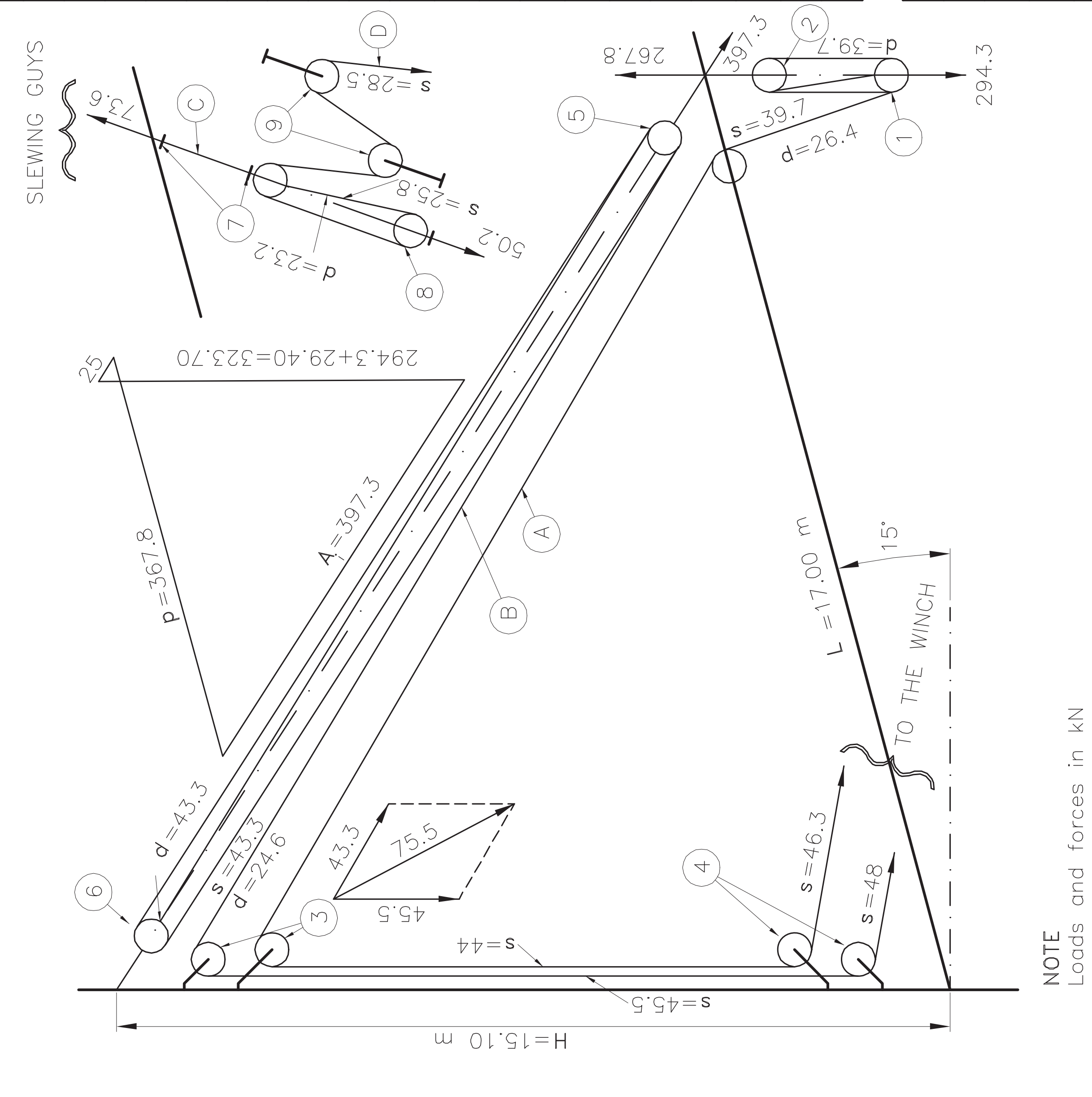


Figure 10 : 196,2 kN crane - assembly

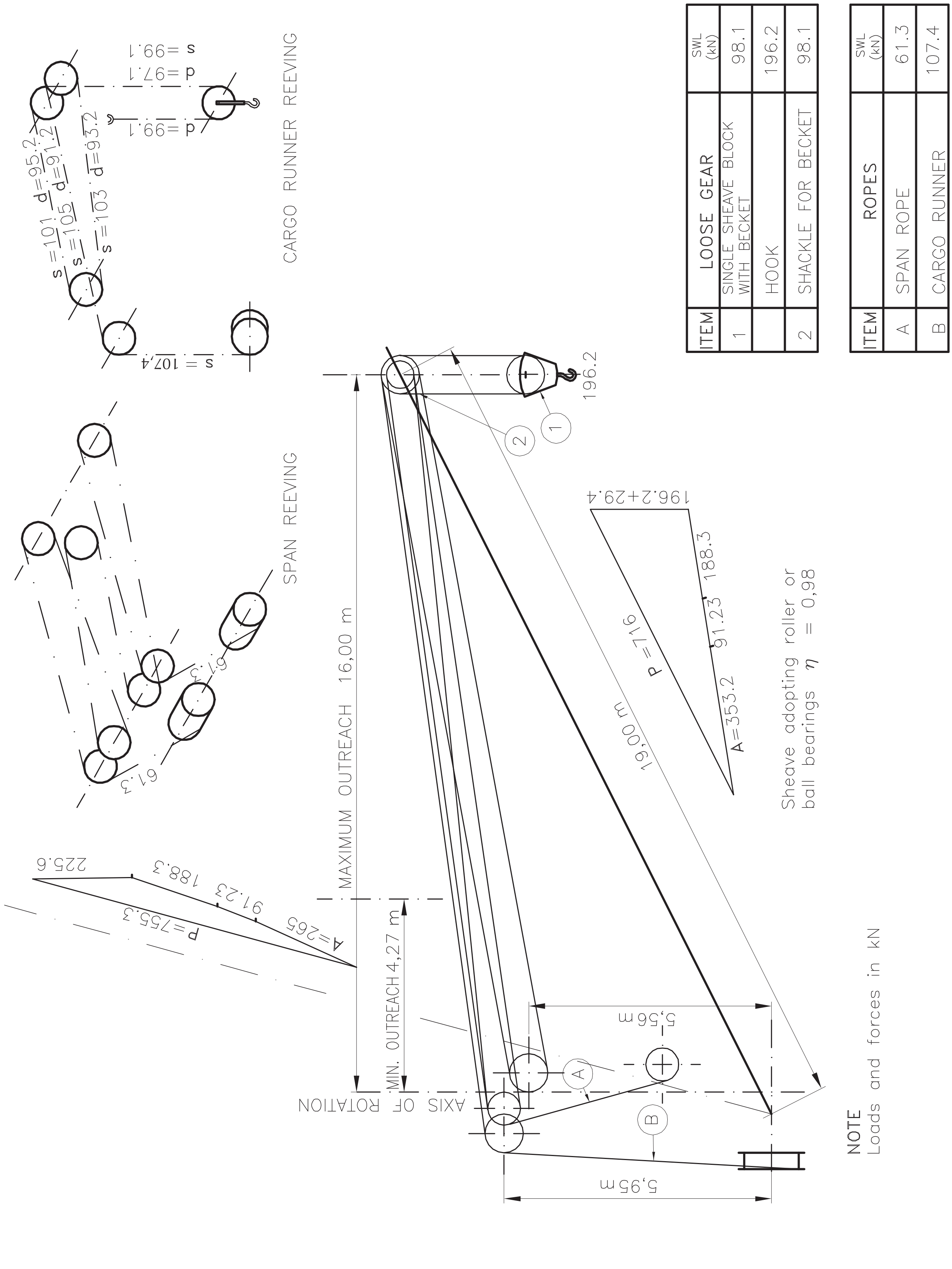
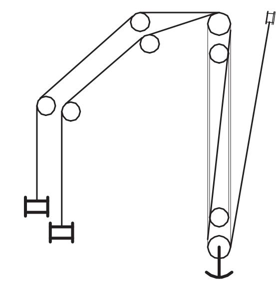


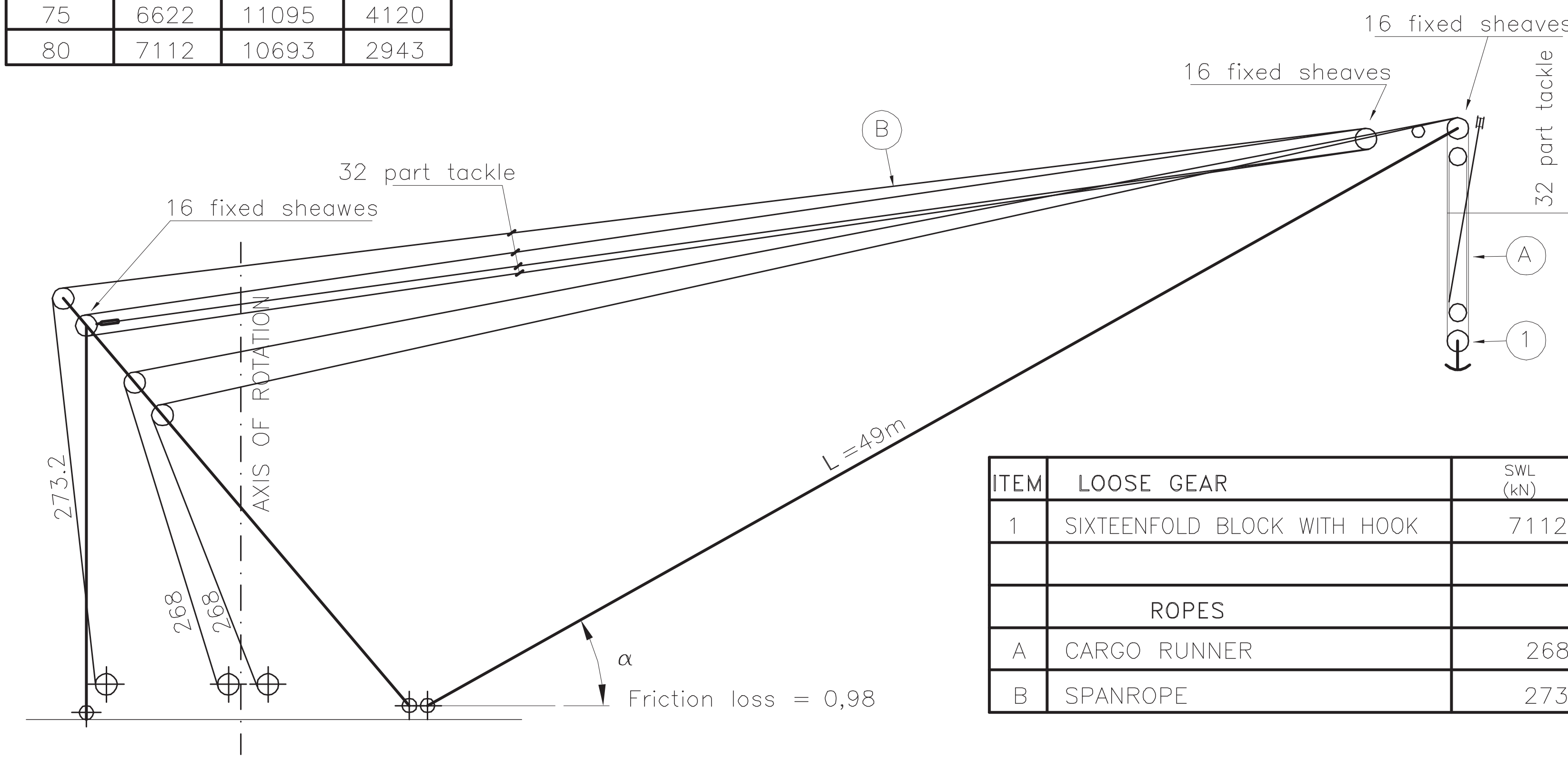
Figure 11 : 1962 kN crane - assembly

α	CAPACITY (kN)	BOOM THRUST (kN)	LOAD IN SPAN TACKLE (kN)
15	981	6425	6180
20	1177	6573	6278
25	1422	6916	6376
30	1619	7014	6229
35	1864	7210	6033
40	2158	7505	5984
45	2305	7407	5494
50	2992	8388	5788
55	3580	9123	6033
60	4365	9898	6082
65	5542	11262	5984
70	6180	11448	5150
75	6622	11095	4120
80	7112	10693	2943

NOTE
Loads and forces in kN

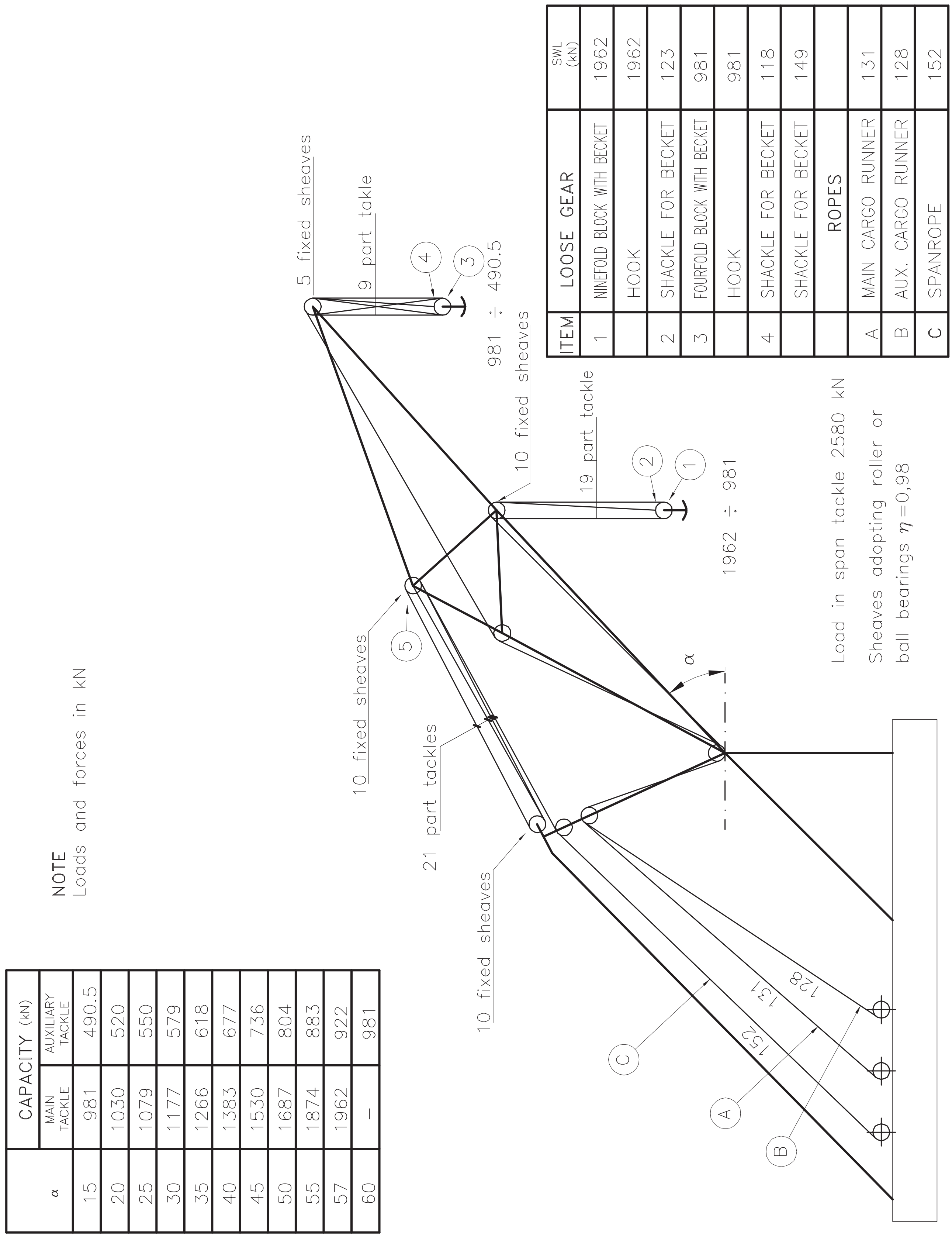
CARGO RUNNER TACKLE





ITEM	LOOSE GEAR	SWL (kN)
1	SIXTEENFOLD BLOCK WITH HOOK	7112
	ROPES	
A	CARGO RUNNER	268
B	SPANROPE	273

Figure 12 : From 1962 to 490,5 kN fixed crane



α	CAPACITY (kN) MAIN TACKLE	AUXILIARY TACKLE
15	981	490.5
20	1030	520
25	1079	550
30	1177	579
35	1266	618
40	1383	677
45	1530	736
50	1687	804
55	1874	883
57	1962	922
60	–	981

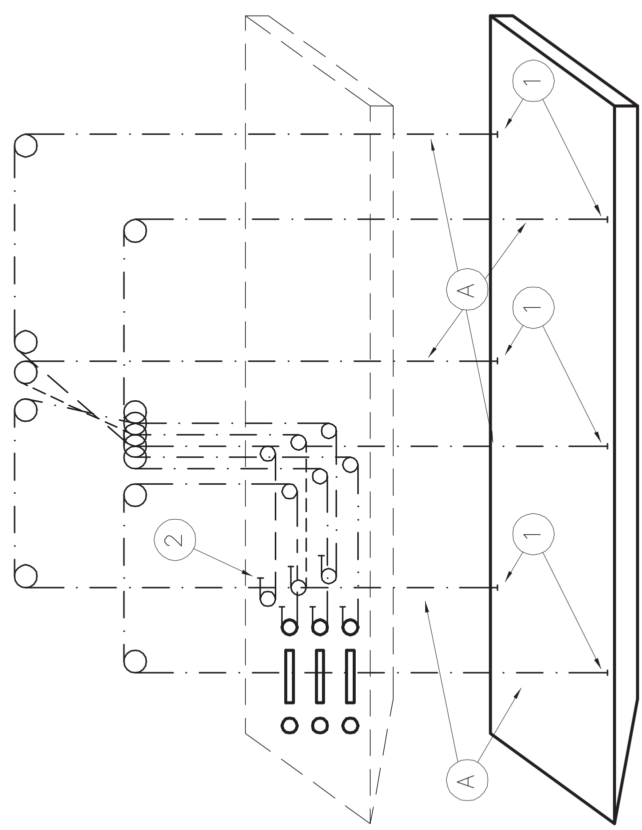
ITEM	LOOSE GEAR	SWL (kN)
1	NINEFOLD BLOCK WITH BECKET	1962
	HOOK	1962
2	SHACKLE FOR BECKET	123
3	FOURFOLD BLOCK WITH BECKET	981
	HOOK	981
4	SHACKLE FOR BECKET	118
	SHACKLE FOR BECKET	149
	ROPES	
A	MAIN CARGO RUNNER	131
B	AUX. CARGO RUNNER	128
C	SPANROPE	152

Figure 13 : Truck lift - assembly

ITEM	LOOSE GEAR	SWL (kN)
1	SHACKLE	206
	TURNBUCKLE	206
2	SHACKLE FOR BECKET	266
	ROPES	
A	HOISTING ROPE	266

LIFT WEIGHT 186.5 kN
LIFT CAPACITY 490.5 kN
TOTAL 677 kN

WORKING PRESSURE 14.71 N/mm^2



CHAPTER 2 SURVEYS AND CERTIFICATION

1 General

1.1

1.1.1 Each system is to undergo the following surveys:

- initial survey, prior to starting operation initially;
- periodical surveys, at regular intervals, every five years, every year or every six months after starting operation initially;
- occasional surveys, after every service or repair of significant parts subjected to load.

2 Initial survey of new installations

2.1 Tests and shop inspection

2.1.1

The following operations, affecting the issuance of the certificates specified in Ch 1, [1.2], are to be completed before each system begins operating:

a) survey during construction by checking compliance of fixed structures, fittings and loose gear with the approved plans;

b) Proof test of loose gear prior to initial use. A tensile test is to be carried out according to the test loads specified, for each type of lifting appliance, in the relevant chapters dealing with loose gears..

   Test loads considered for loose gear of shipboard cranes are to be used for loose gear of derricks.

   When tensile tests of components having high working load, in general greater than 4000 kN, cannot be performed due to the lack of adequate equipment or for other valid reasons, they may be omitted at the discretion of Tasneef

   The above-mentioned components are, in any case, to be subjected to the following tests with a satisfactory outcome:

   - inspections in the workshop are to be more stringent than regular inspections, e.g. non-destructive tests are to be more extensive;
   - disassembly and careful checks after overload test of system on board.

   The above checks allow the overload test of the system, carried out on board as per rules, to be considered as a replacement of the requested tensile test.

   A tensile test of each fitting is not required since it is included in the operational and overload test of the whole system once all the fitting are in operation. In particular, hull attachments of wire ropes and chains are to be suitable for the breaking load of such components.

c) Verification of the documents of the machinery inspection performed by the workshop.

2.2 Tests and inspections on board

2.2.1 General requirements

Before the test starts, suitable precautions are to be taken by the Interested Party such as to ensure the stability of the ship (or floating unit) and the adequacy of the supporting structures to bear the test loads and to guard against any difficulties which may arise during the overload test.

2.2.2 Pre-operational test

No defects are to be found for the whole working range of the system, either in lifting or slewing, in accordance with the approved plans. In the case of derricks, when the minimum acceptable angle of elevation is greater than 15°, such angle is to be used in lieu of the 15° angle.

The weight to be hoisted may be less than the working load. Nevertheless, in the case of heavy load rigs (with working load SWL = 160 kN) having new stays, it is to be at least equal to half the working load, in order to verify the efficiency of the stay tension after testing.

For derricks and derrick cranes a braking test is to be performed. This test includes lowering of the load at a normal operating speed for 3 metres, followed by an abrupt stop.

In addition, the locked winch is to be able to support the load without electrical power.

Systems and machinery are to be checked according to the requirements specified in Ch 14.

2.2.3 Operational overload test

Following the satisfactory outcome of the pre-operational test specified above, a lifting test is to be performed with overload corresponding to the working of the system as shown in Tab 1 and in accordance with the requirements specified in the following items (a) and (b):

a) Test and inspection of cranes, lifting appliances in general and fittings

   An overload test is to be performed with test loads as shown in Tab 1.

   The winch of the system is to be able to raise a test load of at least 1,1 SWL and to support the full test load even if it cannot raise it.

   When due to the pressure valve setting, hydraulic cranes cannot raise the full test load, a smaller test load may be accepted but in no case is it to be less than 1,1 SWL.

   For variable load-radius cranes, the jib is to be tested with the above-mentioned test load, for maximum and minimum jib outreach. For cranes or similar lifting appliances having variable working load as a function of the luffing, the most severe testing conditions resulting from the diagrams of the approved forces are to be considered both for structures and fittings.

   The automatic load indicator is to be switched off when it may be damaged by the overload test. In this case, at the end of the test, it must be switched on again and tested with progressively increased loads.

During the test, it is necessary to verify that each gear tooth is subjected to stress.

For travelling cranes the test load is to be traversed slowly over the full length of the track.

The suspended load is to be as lateral as possible, and it is to be tested for working on both port and starboard sides of the ship.

Following the overload test, the crane is to be subjected to testing of the brakes for all movements at maximum speed with suspended load. For cranes slewing over a range of 360°, the slewing test includes two complete turns from starting position.

All limit switches are to be tested.

b) Test and inspection of winches, derricks and associated fittings

The test weight is to be raised using the equipment of the lifting appliance and with elevation of the derrick equal to 15°. If the angle of elevation is greater, because of operational or structural requirements, the test is to be performed with the greater value.

The angle of elevation used in the test is to be indicated in Form LA2 or in Form LA5. When the test weight is hoisted, the derrick is to be slewed as far as possible in both directions.

If the winch is equipped with coupling gears, each tooth is to be subjected to the test load. Derricks with the test load are to be put in different positions so that the winches are subjected to the maximum load with the maximum length of the cable reeled up on the winch drum.

In the case of operation in union purchase, operational tests are to be performed on the whole working range and on both sides of the ship.

All tests are to be performed by hoisting weights unless Tasneef authorises the use of spring or hydraulic dynamometers, at the request of the interested party. In this case, the dynamometers are to be carefully calibrated and the loads are to be applied with an accuracy within ± 2,5% and for a suitable period of time. The test is deemed satisfactory only if the value is constant for at least five minutes.

For heavy load rigs, appropriate guy ropes are to be in place and under tension.

When two different working loads are provided for a derrick (e.g. 50 kN with double cargo runner and 30 kN with single cargo runner), the test for the smaller working load is to be repeated, even without slewing, if calculation of forces shows that some fittings or items of loose gear are more stressed with the lower working load. The test weight is to be hoisted and lowered and, depending on the type of lifting appliance, it should be slewed on the whole working range of the system. During this operation, the test weight is to be stopped with the winch brake in order to apply dynamic forces equal to those that may occur during operation. In addition, the winch electrical power is to be cut off in order to check the efficiency and safety of the locking devices.

Table 1

Safe Working load SWL, in kN	Test load, in kN
SWL ≤ 200	1,25 SWL
200 < SWL ≤ 500	SWL + 50
SWL > 500	1,10 SWL

For offshore and transhipment cranes the reference SWL in the Table is to be taken as the greatest of:

- $0{,}75 \cdot \psi \cdot SWL$
- SWL

where ψ is the dynamic coefficient as defined in the relevant chapters dealing with the mentioned types of cranes.

2.2.4 Inspection after the tests

After testing, fixed structures and associated gear are to be disassembled and examined where necessary. The tests and inspections are not to reveal deformations or unacceptable defects.

Failing this, the system is not to be used until the defects are eliminated and new tests are carried out with a satisfactory outcome. Alternatively, at the discretion of Tasneef the system may temporarily operate at reduced capacity, following the necessary checks and a possible new overload test based on the reduced capacity.

2.2.5 Marking

Following successful completion of the overload operational test, a stainless steel plate is to be permanently fixed on the crane, derrick or other lifting appliance. It is to be placed in a visible position and is to specify the following data:

- safe working load, in kN, in integers (SWL...kN); when two different safe working loads are provided for the derrick (e.g. one with single cargo runner and the other with multiple rope cargo runner), both are to be specified with a slash separating the two figures (SWL.../...kN). In the case of the union purchase rig or of variable working load cranes, working loads corresponding to the different elevations are to be indicated (e.g. for every 5° or 10°);
- minimum allowable elevation (in degrees) when the derrick exceeds 15°. This is also to be indicated on the mast;
- minimum and maximum elevation and slewing range for cranes or similar;
- abbreviation of the Office, identification number of the documentation and stamp RI;
- date of the test (month and year).

Letters and numbers indicating the safe working load are to be at least 77 mm high and painted with a bright colour on a dark background or vice versa.

3 Initial survey of existing installations

3.1

3.1.1

In general the following is required:

a) Check of compliance of the systems with relative plans.
b) Check of compliance of the details of structures and loose gear with the plans, with possible testing of the materials.
c) Check of compliance of the identification marks of the loose gear with the data specified on the certificates.
d) Check of efficiency and maintenance of structures, connections and components of the systems (fittings and loose gear, wire ropes, equipment, etc.).
e) Non-destructive tests may be required.
f) Repairs of parts and components are to be carried out to the satisfaction of the Tasneef Surveyor, inspected and subjected to overload and operational tests where deemed necessary.
g) Parts and components replacing those rejected and new components in general are to comply with all the requirements specified in [2].
h) Used components may, at the discretion of the Tasneef Surveyor, be accepted according to equivalence criteria, provided that the requirements specified in [2] are complied with.
i) Components that are not included in the existing documentation or having no markings or markings that do not correspond with those required, are to be replaced, unless accepted as used components in accordance with the requirements specified in (e) above.
j) Operational and overload tests are to be performed followed by the inspections specified in [2].
k) Acceptance markings are to be placed on the main systems and the Forms or the Certificate with the relative enclosures are to be issued.

The foregoing checks and operations may be partially extended, similar to the extension of checks for the annual survey, depending on the certification available and its validity.

The extent of the above checks depends on the state and condition of maintenance of loading systems as well as on what documents are available and whether they are certified.

4 Periodical surveys

4.1 Six-monthly surveys

4.1.1

The six-monthly survey is required for lifts and ramps and for other manned submersible lifting appliances.

The survey requirements are specified in Ch 9, [11] for lifts and in Ch 10, [9] for ramps.

Manned submersible lifting appliances are to meet the requirements specified in the following paragraph applicable to cranes in general.

4.2 Annual surveys

4.2.1

Arrangements (cranes, masts, posts, derricks and associated fittings and loose gear, lifting appliances in general and their fittings, winches and relative fittings, ropes for standing and running rigging) are to be examined every year.

The following loose gear not subject to the periodical heat treatment, is considered to be of a special category because the relative annual survey is to be complete:

- short and long link chains and gauge-checked chains;
- rings, hooks, shackles and swivels permanently connected to gauge-checked chains, to blocks or to measuring devices;
- hooks, swivels with roller bearings or hardened parts;
- connecting devices that are permanently fixed to steel wire ropes;
- nodular iron chains and steel chains, rings, hooks, shackles and swivels.

The annual survey of systems composed of derricks and their masts and posts includes inspection and tests intended to verify the absence of defects that may impair operational safety and the appropriate maintenance of systems on board, i.e. their general condition of efficiency and operation.

Depending on the type of system, disassembly is not necessary if the above may be otherwise verified.

Repaired or altered components are to be tested and, if necessary, the system is to undergo an operational overload test. If repaired or altered components may be individually subjected to an inspection bench test, an operational test is sufficient.

When the quinquennial survey is not required, e.g. for cranes, winches, lifting appliances in general and their components, the annual survey includes inspections to guarantee the appropriate maintenance of the appliances and components, i.e. their general condition of efficiency and the system operativeness.

Disassembly may be required, depending on the type of system, when needed for ensuring the above.

Certification relative to the survey is to be added to the ILO Register, in Parts I, II, III and IV as appropriate, or on Certificate Form LA5.

Certification in the above-mentioned Register is to be in Italian and English. A new Certificate is to be issued for renewed parts, when required (Forms LA2 - LA4).

4.3 Quinquennial surveys

4.3.1 Every five years, derricks and fittings permanently fixed onto derricks, posts and hull are to undergo a complete survey in lieu of the annual survey specified in [4.2].

This survey includes a complete inspection. Disassembly is to enable the necessary checks as well as inspection and complete maintenance. Operational and overload tests may be required following the above-mentioned checks and following repairs or alterations.

Every five years both derricks and cranes are to be overload tested in accordance with these Rules.

See [4.2] for certifications.

5 Occasional surveys

5.1 Surveys for alterations, renewals, repairs

5.1.1

Each alteration, repair or renewal of a system, whether or not due to damage, is to be occasionally surveyed, in order to ensure the maintenance of class condition indicated in the ILO Register or on Certificate Form LA5.

After inspection, the on board operational overload test is to be performed. The operational test alone is sufficient for components that have been modified, repaired or renewed and may be subjected to tension test. The operational test is also sufficient when one part may be subjected to the stresses to which it would be subjected in the case of testing of the whole system.

In the case of repairs to the structure of limited extension carried out without changing the original scantlings or the materials employed, Tasneef reserves the right to omit the overload test subject to the satisfactory outcome of non-destructive examinations of at least 50% of the welds of the members repaired.

Where defects are found, these are to be repaired and inspected; in such cases the structure is to be subjected to non-destructive testing involving 100% of the welded repairs.

Subject to the satisfactory outcome of the overload test or non-destructive examinations mentioned above, a new Certificate Form LA2 is to be issued, or a note is to be added to the Certificate Form LA5.

See Ch 1, [1.2] for temporary allowance of defects.

The provisions above are not applicable to renewal of wire ropes, which may be carried out under direct board officer responsibility by cutting the required length of wire rope from the existing tested reel and checking the correspondence of wire characteristics recorded on Form LA4 in the ILO Register.

If new previously untested wire is used, an occasional survey is to be carried out in order to obtain the required Form LA4.

6 Deferment of surveys or examinations

6.1 General

6.1.1

In principle, periodical surveys are not allowed to be postponed and the foreseen ascertainments are to be carried as scheduled.

However, upon Owner's request, periodical surveys as per 4, may be postponed under the conditions and within the limits as follows:

a) The lifting appliance is subjected to an accurate visual inspection by the Surveyor of the Society, or a recognized "competent person" in order to ascertain that it is in such a condition as to postpone the thorough examination; if the maintenance conditions are not verified, the Surveyor or the competent person may require dismantling of the appliance, put it out of order until the next thorough examination or refuse the postponement. In any case the survey and the relative outstanding is to be noted on the ship's Cargo Gear Register

b) The Owner has obtained, in advance, by the National Authority whose the ship is flying the flag, the authorization to postpone the survey and the relevant information is given to the Classification Society

c) The scheduled thorough examination is postponed not more than:

   1) 3 months (counted from the expiry date of the original overall tests or the last thorough quinquennial examination) for lifting appliances operating in harbour conditions

   2) 1 month for offshore or transhipment operations cranes

d) The postponement doesn't, in any case, delay the subsequent thorough examinations which are to be carried out at the dates originally scheduled

e) The deferment of the load test required every five years is not permitted. A limited deferment (typically no more than 1,5 months for lifting appliances operating in harbour conditions and 2 weeks for offshore or transhipment operation cranes) may be granted, provided that there is clear evidence of the practical impossibility to carry out that test within the expiry date. In case of deferment, an alternative test, e.g. with a dynamometer, is to be agreed with the Surveyor.

The deferment granted to the scheduled thorough examinations haven't to interfere with different determinations of the local National Authority who may disagree with the deferments themselves.

7 Instructions for the issuance of the ILO Register or of Certificate FORM LA5

7.1 General

7.1.1 This Register or Certificate is completed and submitted to the interested party by the Tasneef Office following the successful outcome of the required tests and checks. Prior to the survey, the interested party is to provide the above office with all approved plans and documentation issued by other Tasneef offices and relating to tests and surveys performed elsewhere.

A copy of the Register or Certificate is to be sent to the Office by the issuing Office, together with the survey report, except for vessels for which are dealt with exclusively by Offices.

7.2 ILO Register

7.2.1 When drafting the ILO Register (Form LA1) or the Certificate Form LA5, the following is to be taken into account:

a) Form LA1

- The "Instructions" provided at the beginning and at the end of the Form are to be complied with.
- The certification of the initial survey is to be added to the sheets relative to Parts I - II - III - IV.
- Forms LA2 - LA4, enclosed with Form LA1, are to be added to the relative flaps of Form LA1.
- The components that are to be heat treated are to be listed in Part III, with reference to the relative Form LA3.

  For steel components, the following note is to be added:

  "All gear is made of steel and does not require a periodical heat treatment".

  In the case of iron components, a note relative to each category is to be added, i.e. for each group of components having the same interval between heat treatments as follows:

  "The gear as per Certificate Form LA3 .... is to be heat treated every .... months".

b) Forms LA2 - LA4

These forms are as follows:

- Form LA2 "Testing and Survey Certificate for loading and unloading arrangements"
- Form LA3 "Testing and Survey Certificate for fittings and loose gear"
- Form LA4 "Testing and Survey Certificate for wire ropes"

Forms are to be drawn up in Italian and English and generally to be certified by the Head of the relevant Tasneef Organisational Units. When the form is signed by someone other than a Tasneef Surveyor, the above-mentioned certification is taken as authorisation.

In the case of cargo runners or span ropes with multiple rope tackles, this is to be specified in the column "Description" and the following is to be added:

"rigged as per drawing"

In the case of union purchase rigs (i.e. a pair of derricks fixed in position by their span ropes and slewing guys with cargo runners operating simultaneously for the handling of one load), the following is to be shown in Form LA2:

- if verification calculations were NOT performed for such operating conditions, the following is to be specified:

  "Union Purchase SWL equal to 1/4 of SWL indicated in column 4".

- if the above-mentioned calculations were made and if all pairs of derricks have the same union purchase SWL, the following is to be specified:

  "UNION PURCHASE SWL ... kN, with derricks positioned as indicated in the relative plan, attached to the Register".

- if the above-mentioned calculations were made and if the pairs of derricks have different union purchase SWL, Form 2bis is to be enclosed with the Register, to be filled in as indicated in Tab 2.

Forms LA3 and LA4 are to include items of loose gear relative to preventer guys.

In the case of existing systems with currently valid ILO Registration issued by recognised bodies in accordance with the ILO convention, while the necessary documentation is being prepared the existing ILO Register may be temporarily validated on the basis of successful inspections in compliance with the requirements specified in [3]. The enclosures are to be replaced, if necessary, and the following note is to be written on the cover:

"This Register and relative Enclosures bearing the modifications specified in Forms ... and including Forms ... to ... is validated by Tasneef until ... while the new Register with the relative Enclosures is being issued".

The above will be valid until the new ILO Register is completed, in general for a maximum of six months.

Table 2

Hatchway No.	Description	Working load (kN)
UNION PURCHASE SWL of derricks indicated in Certificate no.		
....	two steel derricks two steel derricks	....
Note 1: The above SWL are allowed with the derricks positioned as indicated in the relative plan attached to the Register.		

7.3 Certificate Form LA5

7.3.1 For completion of the Form, refer to the explanatory notes reported therein.

CHAPTER 3 DERRICK SYSTEMS

1 General

1.1 Application

1.1.1 The requirements of this Chapter are applicable to the following types of derrick systems:

- systems of conventional design as specified in [1.2];
- systems of special design as specified in [1.3]
- systems for operation in union purchase as specified in [1.4].

Derrick systems not mentioned above will be specially considered.

1.2 Systems of conventional design

1.2.1 Systems of conventional type include derrick systems comprising one derrick, generally tubular, equipped with a head and a heel assembly; the latter is generally connected to a derrick mast or post.

The derrick mast is fixed to the deck of the ship in way of the centreline and is intended to support derricks.

The derrick post is the derrick mast when installed outside the centreline of the ship. In general, derrick posts are arranged in pairs on a transverse section of the vessel.

Hereafter, the above-mentioned elements are referred to as masts, irrespective of their position.

The head assembly comprises attachments for connecting span rope, cargo runner lead block and slewing guys.

The derrick is raised using the span rope which is positioned between the derrick head assembly and the associated mast head attachment.

Slewing of the derrick is guaranteed by two slewing guys connected to the derrick head assembly and led to special attachments on deck.

Figures 1, 2, 3 and 4 show some of the most common conventional derrick systems.

The terminology is taken from UNAV, UNI and/or standard tables.

1.3 Systems of special design

1.3.1 Systems of special design are intended to mean all derrick systems having double span rope for slewing and raising the derrick boom without the use of slewing guys.

In general, such systems are formed by connecting the span ropes to masts having cross trees, twin masts or portal type masts.

Fig 5 shows a typical system of special design.

Systems other than those specified will be considered separately by Tasneef

1.4 Union purchase rigs

Union purchase rigs comprise a pair of derricks, held in a specific position by appropriately positioned slewing guys. Cargo runners of both derricks are connected to the load, which may be moved from the hold to the dock and vice versa with a suitable movement of the cargo runners, without slewing the derricks.

This system is considered in [7].

2 Design criteria

2.1 Loads

2.1.1 Each component is to be dimensioned on the basis of the stresses due to the maximum working load and the most severe operating conditions to which it will be subjected.

The load to be applied on the vertical axis of the cargo runner is the working load added to the weight of the fittings (hooks, blocks, etc.) that the derrick head supports plus half the weight of the derrick.

Alternatively, when the above-mentioned weights are not known, the working load of the system is to be increased by 10%.

Where necessary, consideration of the dynamic forces resulting from load handling and, depending on the mast size and geographical areas of application, the wind load, may be required for systems of special design.

Unless otherwise mentioned, see Ch 4 in such cases.

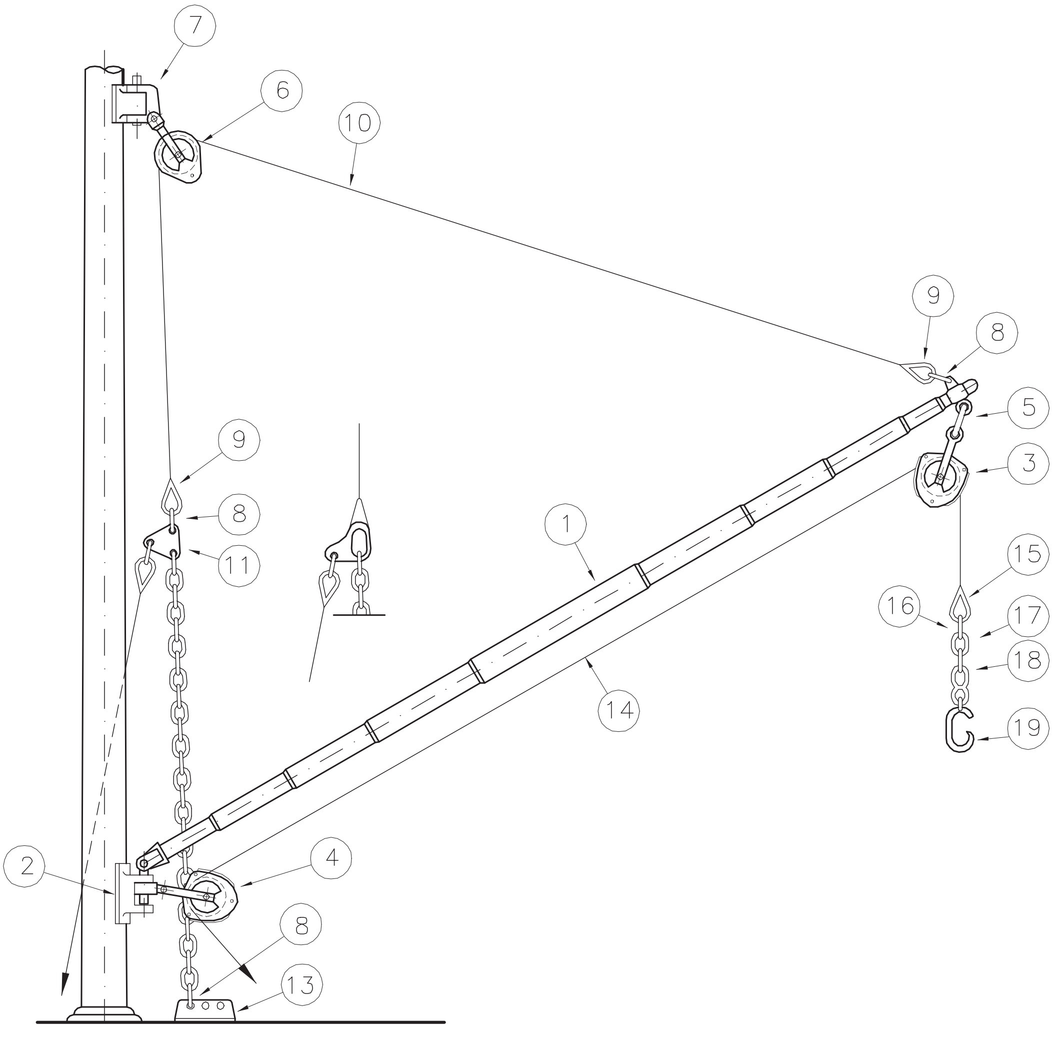
2.2 Operating angle

2.2.1 Stresses acting on the various components of a system are to be calculated in way of an angle to the horizontal equal to 15°.

For heavy load rigs (having maximum working load equal to 160 kN) or when a derrick cannot be slewed due to obstructions, stresses may be calculated considering the minimum foreseen elevation.

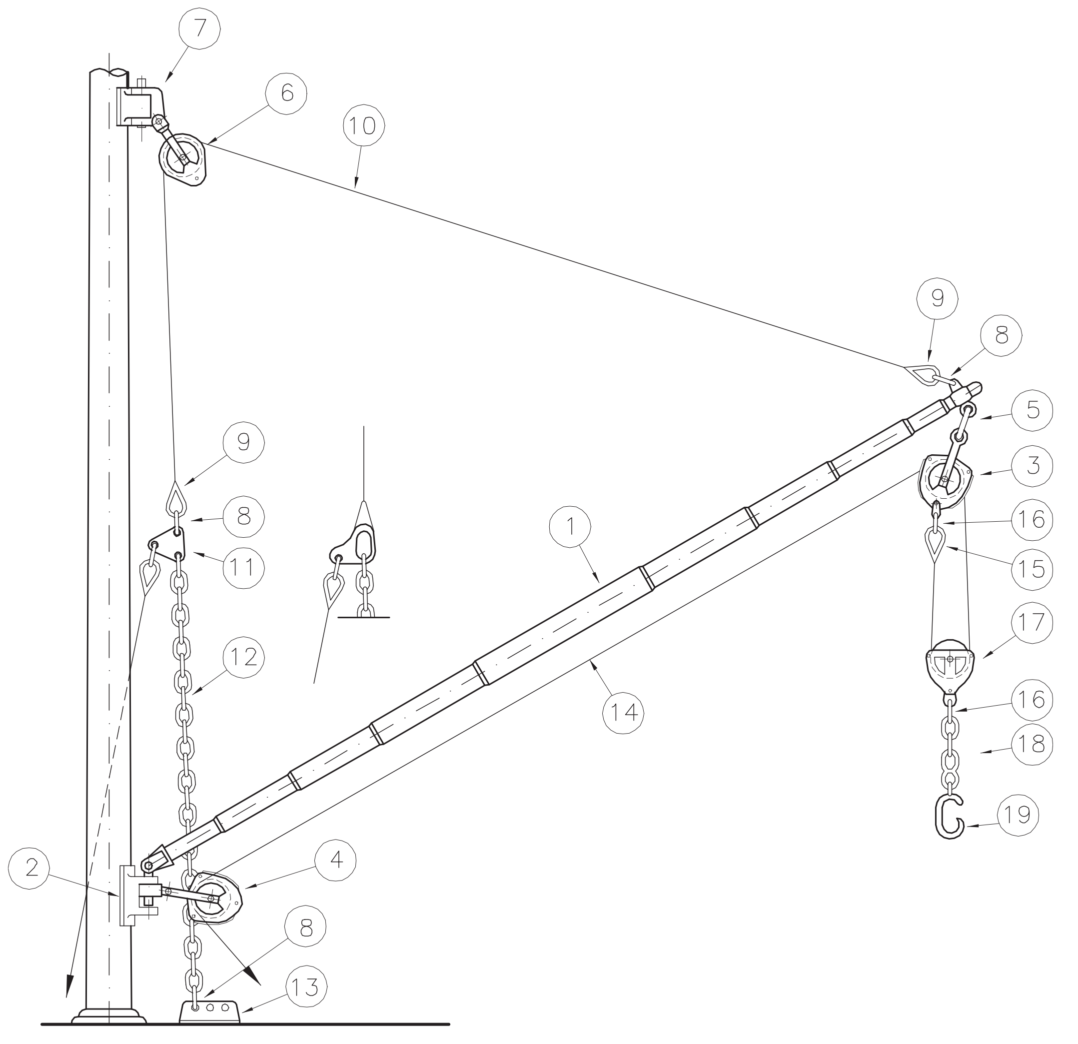
Such angle limit is to be recorded in the ILO Register.

Figure 1 : Derrick with single cargo runner



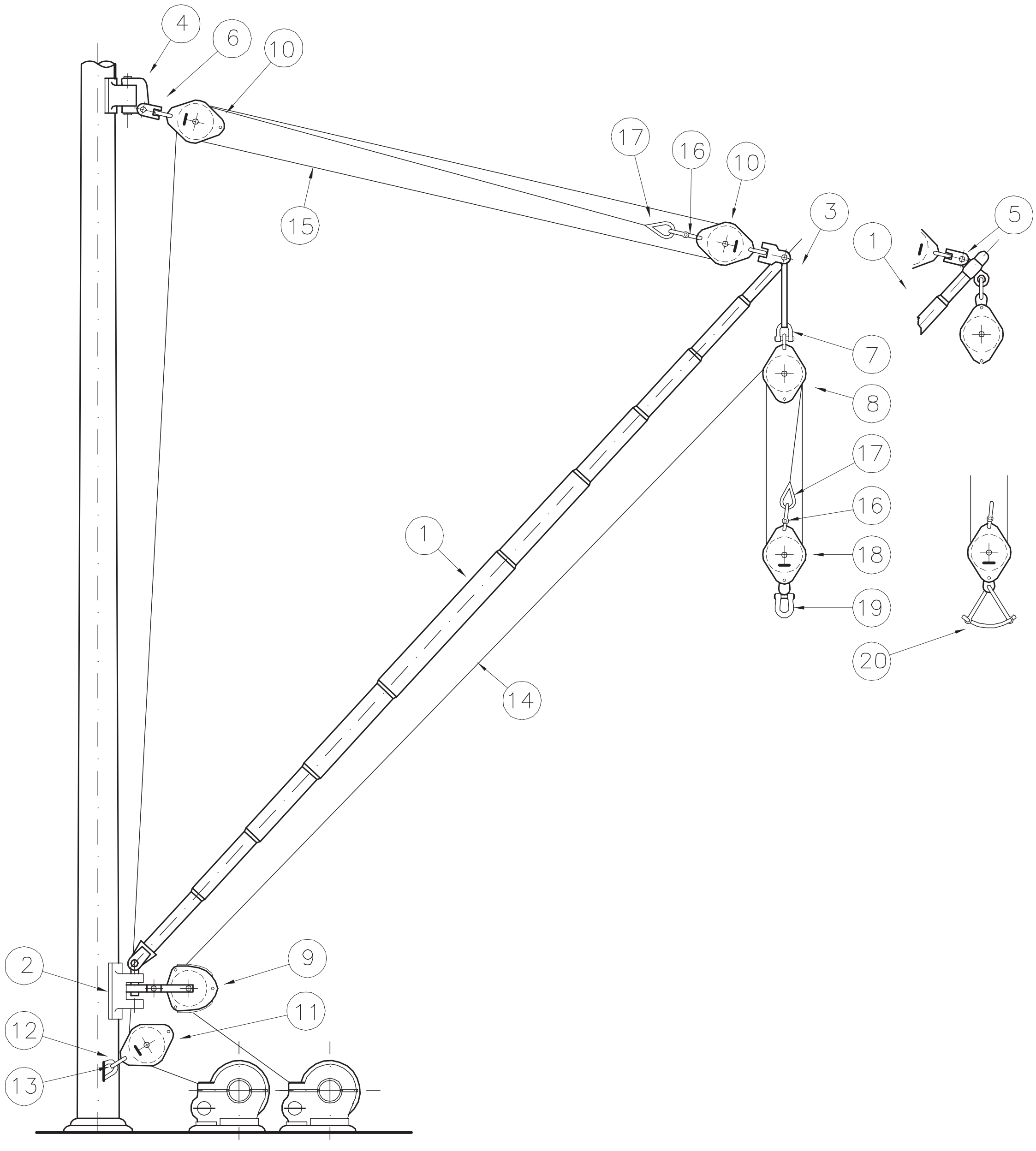
DERRIK BOOM
2 HEEL ASSEMBLY
3 HEAD CARGO BLOCK
4 HEEL CARGO RUNNER LEAD BLOCK
5 SHACKLE
6 SPAN LEAD BLOCK
7 SPAN HEAD ATTACHMENT
8 SHACKLE
9 THIMBLE
10 SPAN ROPE
11 TRIANGLE PLATE
12 LARGE LINK CHAIN
13 DECK PLATE
14 CARGO RUNNER
15 THIMBLE
16 SHACKLE
17 CHAIN
18 SWIVEL
19 DERRICK WITH TACKLE ON CARGO RUNNER

Figure 2 : Derrick with tackle on cargo runner



1 DERRICK BOOM	11 TRIANGLE PLATE
2 HEEL ASSEMBLY	12 LARGE LINK CHAIN
3 BLOCK WITH HEAD CARGO BECKET	13 DECK PLATE
4 HEEL CARGO RUNNER LEAD BLOCK	14 CARGO RUNNER
5 SHACKLE	15 THIMBLE
6 SPAN LEAD BLOCK	16 SHACKLE
7 SPAN HEAD ATTACHMENT	17 LOWER CARGO RUNNER BLOCK
8 SHACKLE	18 SWIVEL
9 THIMBLE	19 HOOK
10 SPAN ROPE	

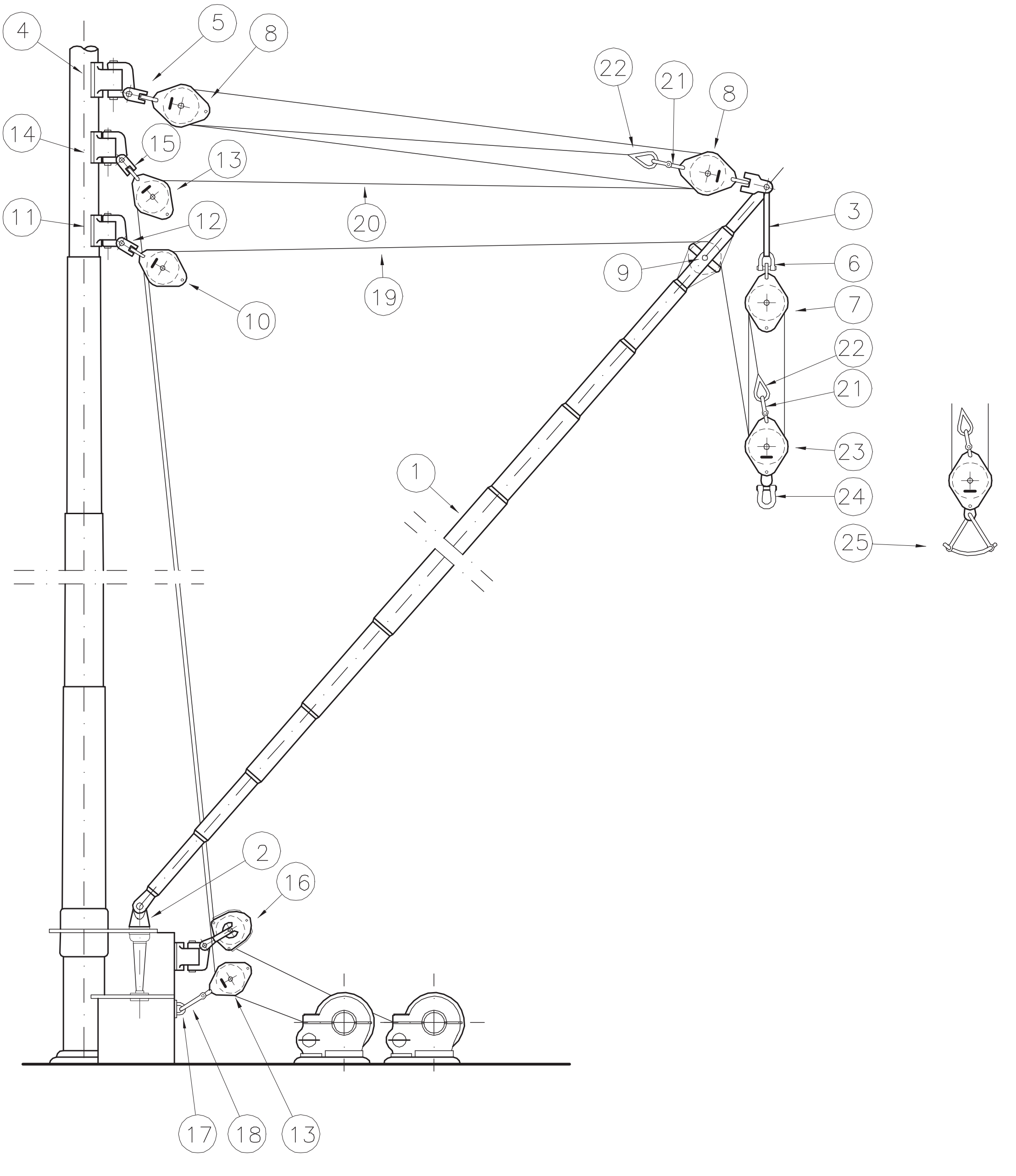
Figure 3 : Derrick with cargo and span rope tackles



Application

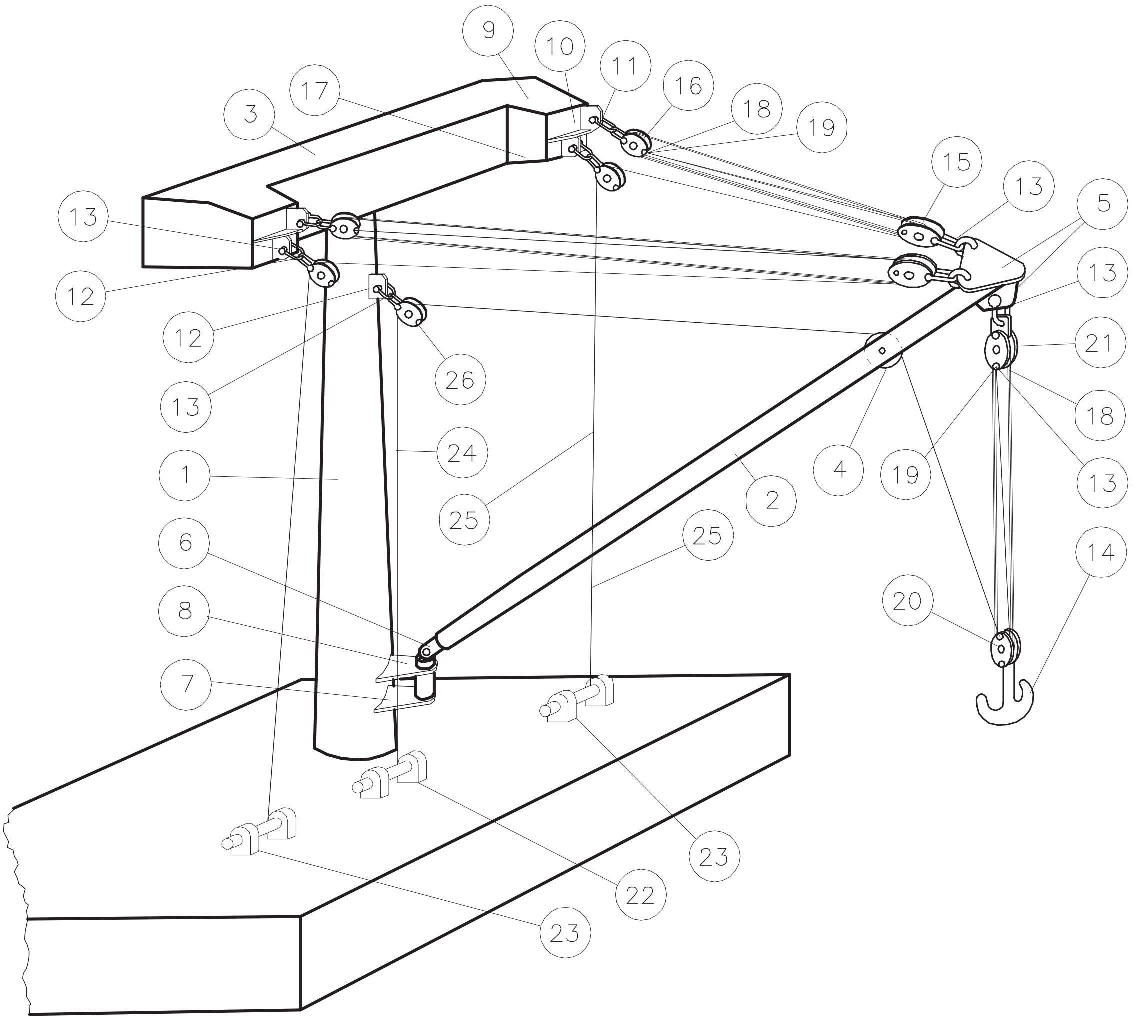
A	B		A	B	
1	1	DERRICK	10	10	HEAD SPAN BLOCK
2	2	HEEL ASSEMBLY	11	11	HEEL SPAN LEAD BLOCK
3	-	HEAD ASSEMBLY	12	12	SPAN LEAD BLOCK EYE FITTING
4	4	SPAN HEAD ATTACHMENT	13	13	SHACKLE
-	5	DERRICK SPAN EYE FITTING	14	14	CARGO RUNNER
6	6	MAST HEAD SPAN EYE FITTING	15	15	SPAN ROPE
7	7	SHACKLE	16	16	SPAN BLOCK BECKET SHACKLE
8	8	HEAD CARGO BLOCK	17	17	THIMBLE
9	9	HEEL CARGO RUNNER LEAD BLOCK	18	18	LOWER CARGO BLOCK
			19	19	LIFTING SHACKLE
			20	20	LIFTING DEVICE

Figure 4 : Derrick with cargo and span rope tackles and built-in sheave on derrick boom head



1 DERRICK BOOM
2 HEEL ASSEMBLY
3 HEAD ASSEMBLY
4 SPAN TACKLE HEAD ATTACHMENT
5 MAST HEAD SPAN EYE FITTING
6 CARGO TACKLE HOISTING SHACKLE
7 HEAD CARGO BLOCK
8 SPAN TACKLE BLOCK
9 DERRICK BOOM HEAD BUILT-IN SHEAVE
10 MAST HEAD CARGO RUNNER LEAD BLOCK
11 CARGO RUNNER LEAD BLOCK ATTACHMENT
12 DERRICK CARGO RUNNER EYE FITTING
13 MAST HEAD SPAN LEAD BLOCK
14 MAST HEAD SPAN LEAD BLOCK ATTACHMENT
15 DERRICK SPAN EYE FITTING
16 DERRICK HEEL CARGO RUNNER LEAD BLOCK
17 SPAN LEAD BLOCK EYE FITTING
18 SHACKLE
19 CARGO RUNNER
20 SPAN ROPE
21 SPAN BLOCK BECKET SHACKLE
22 THIMBLE
23LOWER CARGO BLOCK
24 LIFTING SHACKLE
25 LIFTING DEVICE

Figure 5 : System of special design



1 MAST, POST
2 DERRICK BOOM
3 CROSS TREE
4 BUILT-IN SHEAVE
5 DERRICK HEAD ASSEMBLY
6 DERRICK HEEL ASSEMBLY
7 GOOSENECK FITTING
8 GOOSENECK PIN
9 CROSS TREE SPAN ROPE FITTING
10 SPAN ROPE EYE FITTING
11 CONNECTING PLATE
12 EYEPLATE
13 SHACKLE
14 HOOK WITH SWIVEL
15 DERRICK HEAD SPAN BLOCK
16 CROSS TREE SPAN BLOCK
17 MAST HEADSPAN LEAD BLOCK
18 BECKET
19 SOCKET WITH THIMBLE
20 LOWER CARGO BLOCK
21 DERRICK HEAD CARGO BLOCK
22 CARGO RUNNER WINCH
23 SPAN ROPE WINCH
24 CARGO RUNNER
25 SPAN ROPE
26 MAST HEAD CARGO RUNNER LEAD BLOCK

2.3 Inclination of the ship

2.3.1 Force diagrams of conventional derrick systems and union purchase rigs are to include the angles of heel and trim only when these values exceed 5° and 2°, respectively.

Force diagrams of heavy load rigs or systems of special design for conventional or special derrick operation are to include the actual inclination of the ship.

Unless otherwise mentioned, the inclination of the ship is to be considered equal to 5° for heel angle and 2° for trim angle.

Greater or lesser angles may be considered only if clearly specified in the documentation submitted for approval.

These angles are to be indicated in the relative table of the ILO Register.

2.4 Wire rope tension

2.4.1 Tension acting on the tackle ropes is to be calculated according to the requirements specified in Ch 7.

2.5 Force diagram

Forces acting on the various components of the system may be calculated both analytically, on the basis of geometrical configuration, and by graphical procedure. An example of graphical calculation is given in Figures 1 to 4 where:

P_s	:	derrick working load
P_p	:	half of the weight of the derrick plus the weight of the fittings supported by the derrick head (hooks, blocks, etc.) or alternatively, 0,1 P_s as specified in [2.1]
T	:	tension on lead cargo runner
R	:	resultant acting on derrick head block pin
R_A	:	tension on span rope
R_P	:	compression on derrick
A	:	tension on lead span rope
F	:	resultant on mast head.

Special attention is to be given where the cargo runner is led to the mast between the derrick heel attachment and the span rope attachment (see Figure 4).

In such case, the maximum tension of the span rope is to be calculated considering the tension of the cargo runner in lowering condition and referring to the factors in the relevant table in Ch 7.

In the force diagram, it is to be ensured that the component representing tension of the cargo runner does not intersect the component representing compression on the derrick.

Such a configuration could lead to a negative value of the span rope tension and therefore, when the inclination exceeds a specific angle - critical angle - an abrupt rise of the derrick could occur followed by violent striking against the mast to which it is connected (Jack-Knifing).

The critical angle ϕ is given by the following formula:

$$\mathrm{sen}\phi = 0,5\left(\frac{l}{h} - \frac{l}{n^2 \cdot h} + \frac{h}{l}\right)$$

where:

l	:	length of the derrick
h	:	height of the mast from the derrick heel and lead attachments
n	:	number of lead ropes of the load hoisting tackle
ϕ	:	angle formed by the derrick and horizontal axis passing through the derrick heel

from the above formula it is clear that the value of angle ϕ decreases when n and the ratio h/l decrease. In order to obviate the risk of jack-knifing of a rigged derrick with parallel cargo runner and span rope, h>l is to be ensured and a multiple lead rope tackle is to be used.

In the event of several derricks acting on the same mast, see Article [3].

2.6 Slewing guys

2.6.1 Appropriate slewing guys are to be used for slewing operation of the derricks. The relevant configuration and rigging are shown in Ch 7, Tab 3.

3 Derrick systems of conventional type

3.1 General

3.1.1 This Chapter is applicable to steel masts of conventional derrick systems in accordance with the requirements specified in [1.2].

Such masts are supported by hull structures having suitable strength.

See Article [4], for masts supporting derricks which are otherwise arranged.

The mast includes the following parts:

- the step, which is the mast heel connection to the hull;
- the wedging, which is the mast connection in way of the upper deck attachment;
- the rigging fixture, which is the masthead with rigged stays and shrouds.

3.2 Calculation of force F transmitted from derrick to masthead

3.2.1

Given that F_i is the force transmitted by each derrick to the masthead, F is the geometrical resultant of forces F_i in the direction considered.

Force F is to be calculated taking into account the arrangement of the derrick system generating maximum stress in the direction considered.

For masts supporting derricks with the same length and safe working load, F_i is the force of one derrick on the mast head. The maximum resultant corresponding to each direction considered may be calculated according to the following formula:

$$F = c \cdot F_i$$

where:

c : coefficient taking into account the number of derricks connected to the mast and their reciprocal position, as follows:

- when there are two derricks, one forward and one aft of the mast, the value of c is given in the first line of Tab 1 as a function of the angle θ<90° formed by the ship transverse plane with the vertical plane which passes through the mast axis and the direction considered (see Fig 10);
- when there are four derricks, two forward and two aft of the mast, the same values of c as in the previous bullet may be considered. In the case of simultaneous operation of all four derricks, the value of c is given in the second line of Tab 1;
- when there are two derricks, and both are positioned either forward or aft of the mast, the value of c may be considered as c. In the case of simultaneous operation of two derricks parallel to the centreline of the ship, the value of c is given in the third line of Tab 1.

  When simultaneous operation of the derricks of the same system is excluded, this is to be clearly specified.

3.3 Unstayed masts

3.3.1 General requirements

Scantlings of an unstayed mast supporting rigs may be verified with direct calculations, by applying force F corresponding to the maximum values of coefficient c as considered in [3.2] in way of the span rope attachments.

If the derrick heel is positioned on an independent structure, the section of the mast to be verified corresponds to the wedging. If the derrick heel is connected to the mast, the section to be verified is in way of the derrick heel.

3.3.2 Symbols

D : outside diameter of the mast in the calculation section (mm);

t : thickness of the mast in the calculation section (mm);

h : vertical distance from the derrick heel to the point of attachment of span rope (cm);

H : vertical distance from the wedging to the attachment of the span ropes (cm);

F_o : horizontal componenent of "force "F" (kN);

F_v : sum of the vertical components of F_i forces (kN);

d : horizontal distance between the point of attachment of force F and the mast axis, when the derricks are positioned on the cross bar (cm);

A : mast cross sectional area of the most stressed part (cm^2;

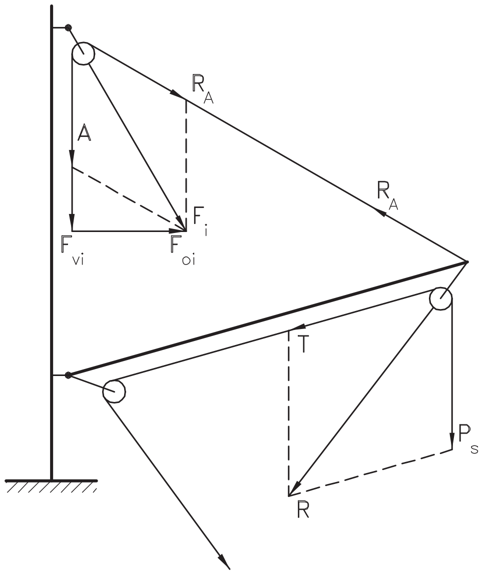
Z_f : section modulus for resistance to bending of the above-mentioned section (cm^3);

Z_t : section modulus for resistance to torsion of the above-mentioned section (cm^3).

Table 1

	θ	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°
1°	c	2,0	1,98	1,89	1,74	1,53	1,32	1,16	1,07	1,02	1,0
2°	c	2,0	2,04	2,13	2,30	2,41	2,41	2,30	2,13	2,04	2,0
3°	c	1,0	1,02	1,07	1,16	1,32	1,32	1,74	1,89	1,98	2,0

Figure 6



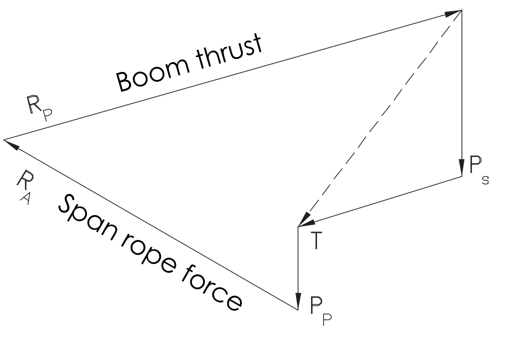
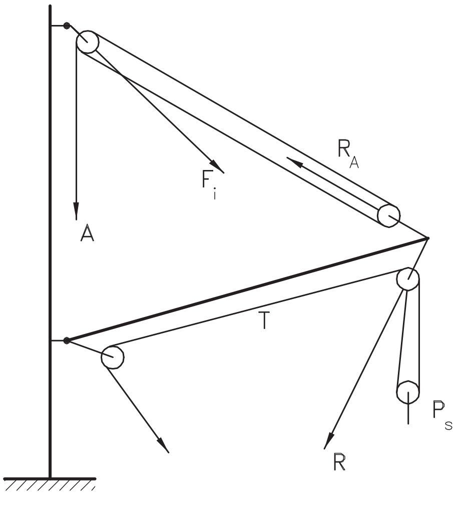


Figure 7



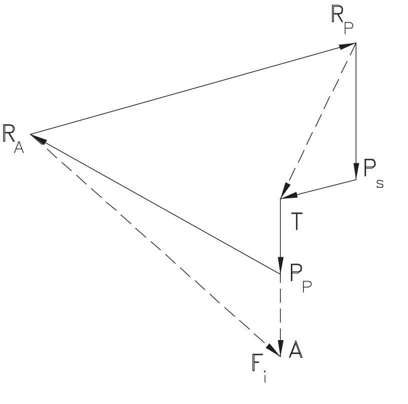
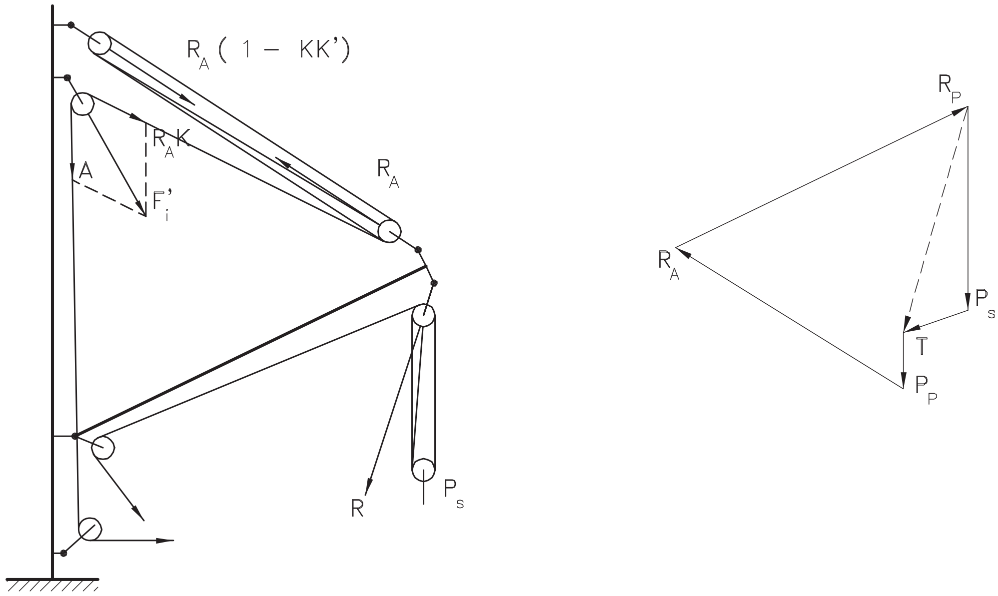


Figure 8



3.3.3 Verification of scantlings

Given:

σ_c : simple compression stress, in N/mm^2

$$\sigma_c = \frac{F_v}{A}$$

σ_f : bending stress, in N/mm2 where I = h when the derrick heel is connected to the mast and I = H when the derrick heel is not connected to the mast

$$\sigma_f = \frac{F_o I}{Z_f}$$

τ : torsion stress, in N/mm^2

$$\tau = \frac{F_o d}{Z_t}$$

than:

$$\sqrt{(\sigma_c + \sigma_f)^2 + 3\tau^2} \leq \sigma_{amm}$$

The value of σ_{amm} all is given in Tab 2 as a function of the working load P_s of the derricks. In the above mentioned table R_{eH}, in N/mm^2, is the yield point of the material, which, in any case, is to be assumed not greater than 70% of the breaking load.

For intermediate values linear interpolation is to be used.

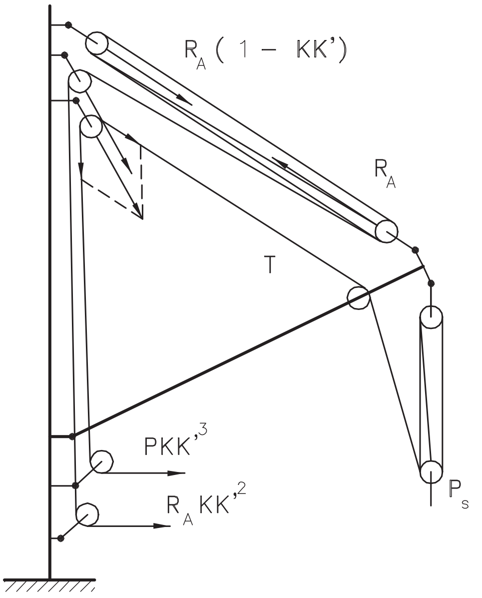
For anular section masts, the values of σ_c, σ_f e τ, in N/mm^2, may be calculated with the following formulas:

$$\sigma_c = 31,85\frac{F_v}{Dt}$$

$$\sigma_f = 1250\frac{F_o H}{D^2 t}$$

$$T = 625\frac{F_o d}{D^2 t}$$

Figure 9



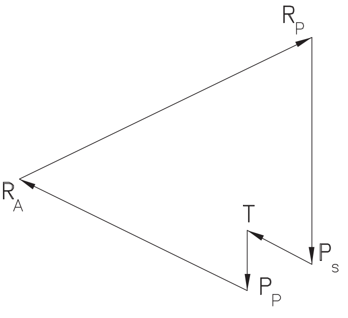


Figure 10

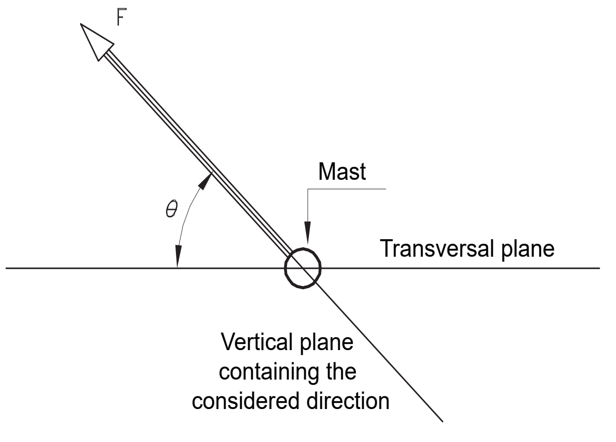


Table 2

P_s (kN)	σ_{amm} / R_{eH}
≤ 100	0,44
200	0,48
300	0,53
400	0,58
500	0,61
≥ 600	0,62

3.4 Stayed masts

3.4.1 General requirements

Scantlings of a stayed mast supporting heavy load rigs are to be verified by direct calculations. Below is an example of verification when the derrick span attachments are on the same horizontal plane as that which passes through the masthead stay assembly, where the term "stay" includes forestays, backstays and shrouds.

All configurations where the stay arrangement is such as to lead to maximum stress values, are to be considered in the verification of this type of derrick system. Verification is to be performed by taking into account the forces as shown in 2.5, with reference to Fig 11.

More accurate verification is to be carried out when the masthead cross tree is foreseen or when the span rope attachment is positioned above the rigging fixture or when the stays are connected to the mast at different heights.

Scantlings of stays are to take into account the elongation to which they are subjected due to bending of the mast in way of their point of attachment.

The distribution of forces between the mast and stays may be obtained taking into account the following:

a) equilibrium between deflection of the mast and corresponding elongations of the stays

b) equilibrium between the imposed loads on the mast and the reactions of the mast and stays.

3.4.2 Symbols

A, D, t, h, d as specified in [3.3.2].

H : vertical distance from wedging to rigging fixture (cm);

S_i : total metallic sectional area of a stay, (cm^2);

v_i : vertical distance of the heel attachment of a stay from the rigging fixture (cm);

x_i : horizontal component of the distance from the heel attachment of a stay to the line of action of force F (cm);

l_i : length subject to elastic elongation of a stay (i.e. length of the stay from the mast attachment to the turnbuckle attachment) (cm);

p_i : horizontal distance of the heel attachment of a stay from the mast axis (cm);

θ_i : angle of the stay with the horizontal plane passing through the rigging fixture (θ_i = arc. cos p_i/l_i)

ϕ_i : angle of the stay with the plane containing the resultant F_o (ϕ_i = arc sen x_i / p_i)

E'_i : modulus of elasticity of a stay (kN/cm²);

R_i : breaking load of the stay (kN);

F_o , F_v , d : as specified in [3.3.2];

K : elastic coefficient of the mast (kN/cm).

3.4.3 Verification of scantlings

Force F acting on the masthead is obtained from the load diagram and may be broken down into its horizontal and vertical components F_o and F_v, respectively.

Mast deflection and stay elongation may be considered with sufficient approximation to be due solely to force F_o.

Therefore, with reference to [3.3.3], mast verification is given by:

$$\sigma_f = \frac{F_o(K \cdot h + F_v + T_v)}{Z_f(K + K_{S1})}$$

$$\sigma_c = \frac{(F_v + T_v)}{A}$$

$$T = \frac{(F_o + T_o)d}{Z_t}$$

where:

T_v : sum of the vertical components ΣK_{S2} obtained from Tab 4 and 5

$$T_v = \frac{F_o}{K + \Sigma K_{S1}} \cdot \Sigma K_{S2}$$

T_o : horizontal component of the resultant of the span rope on the masthead

K_{S1} : sum of the elastic coefficients of working stays given in Tab 4 and Tab 5, where the term working stay includes stays forming an angle ≤ 90° with the direction of force F_o .

Tension on each stay in each position is to be compatible with the breaking load depending on the safety coefficient as specified in Ch 7.

The same verification is to be performed for components connected to the stays such as shackles, turnbuckles, etc. and for plates both for deck and for mast connection.

3.4.4 Interconnected derrick posts

Connection may be by wire rope, a very light truss or rigid beam.

Where a wire rope is used, when the derricks operate parallel to the centreline of the ship, the wire rope does not operate and each post is to be able to support its relative load.

When derricks operate abeam, the wire rope requires the second post to support the load and operation of both derricks of the same post is possible.

Where a truss or a very light structure is used and it is therefore unrealistic to expect it to behave as a rigid beam, verification may be performed as if using a wire rope.

Where the connecting structure is very strong, the rigid frame is to be considered.

3.5 Calculation of the elastic coefficient of a mast

3.5.1 For masts having anular section, the elastic coefficient K (N/cm) is given by the following formula:

$$K = 2472t(D/H)^3\frac{1}{m}$$

m : factor depending on the shape of the mast, given in Tab 3 as shown below.

3.6 Construction details

3.6.1 When masts have decreasing scantlings from the wedging to the step, and from wedging to rigging fixture, the tapering of diameter and wall thickness is to be gradual so that stress in the various sections does not exceed the allowable values.

The maximum allowable tapering of diameter and wall thickness is not to exceed 25% in the step and 15% in the rigging fixture, except in special cases to be submitted for approval.

In general, doublers or local increases in wall thickness are to be provided for in the rigging fixture in way of the points of attachment of the stays and in way of concentrated stresses, e.g. points of attachment of span or cargo runner lead sheaves, derrick heels, etc.

When the derrick heel is connected to the mast, the section between the wedging and the derrick heel is to have uniform scantlings.

Above and below this area, scantlings may be gradually reduced as mentioned above.

Hull structures in way of the mast wedging are to be suitably reinforced.

In the case of small working loads, where the mast is directly connected to the upper deck, brackets are to be arranged. The brackets are to have appropriate scantlings such as to favour stress distribution in the surrounding structures.

Cut-outs are generally to be avoided and, where necessary, they are to be well rounded and stiffened with flat bars.

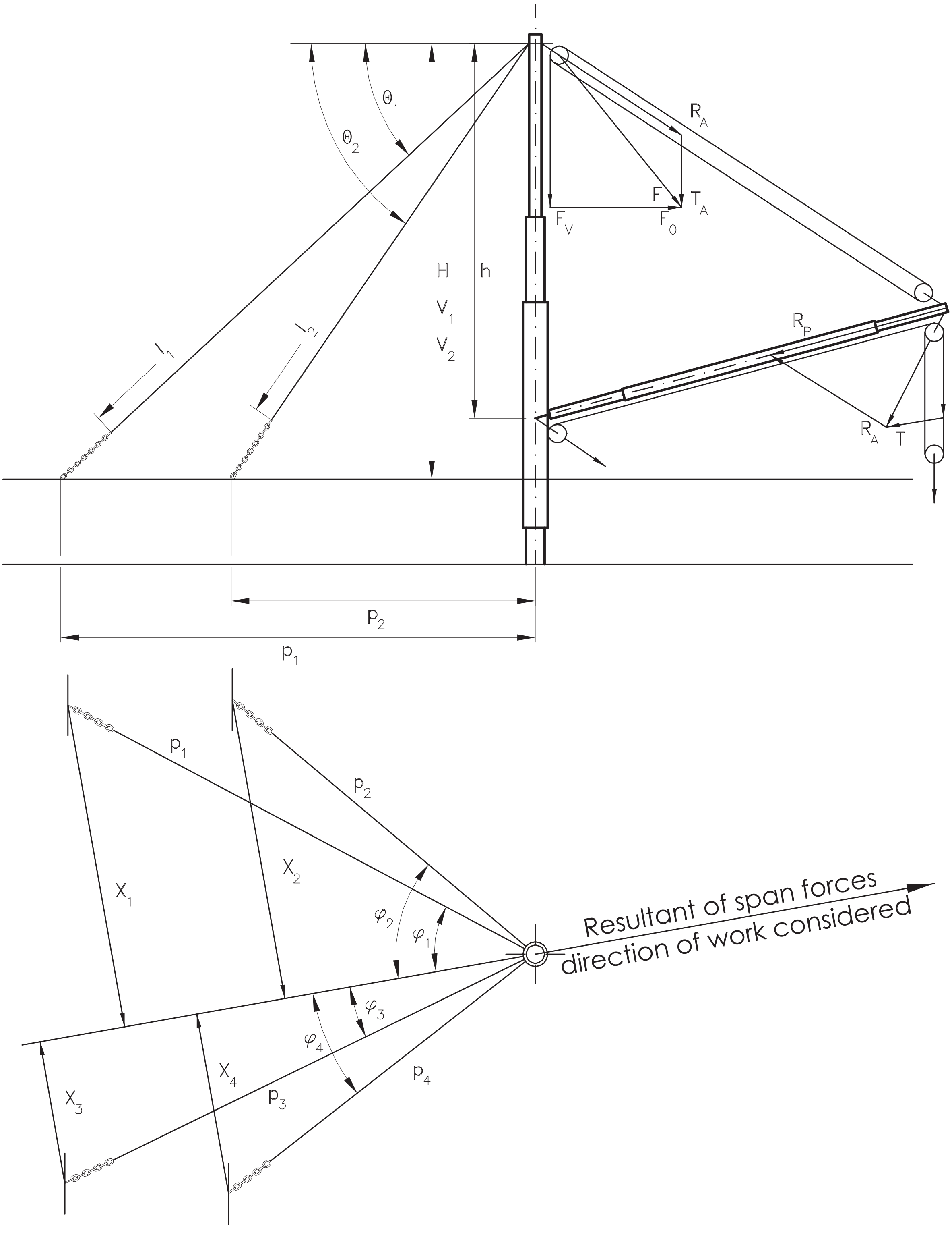
Manholes, elastic cable, holes etc. are also to be avoided in way of concentrated shear loads but, where necessary, structural continuity is to be maintained.

Appropriate reinforcements are to be fitted in way of concentrated loads. Suitable arrangements are to be made in order to avoid notch effects. All parts are to be accessible for inspection and maintenance.

Appropriate means are to be provided to remove any water which might otherwise accumulate in inaccessible parts of the structure. Where completely closed tubular masts are easily accessible for inspection and maintenance, minimum wall thickness may be 6 mm. Wall thickness less than 7,5 mm is to be avoided for sections that are not completely closed.

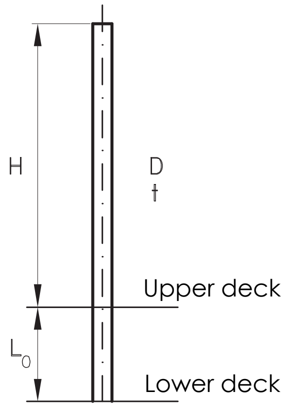
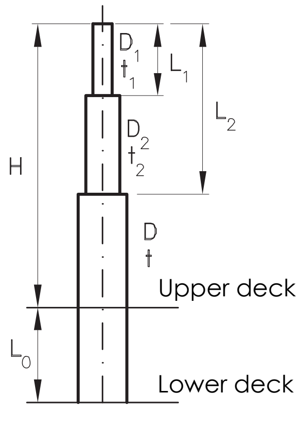
In general, the ratio diameter/wall thickness, or width/wall thickness is to range from 50 to 100 from small to large diameters (from 300 mm to 1500 mm and above) and from non-reinforced box construction to round and oval construction.

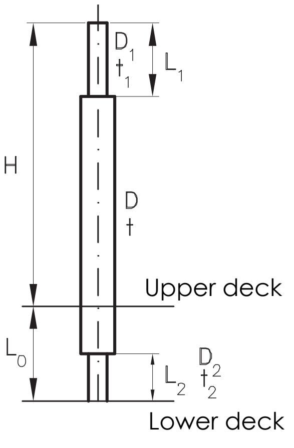
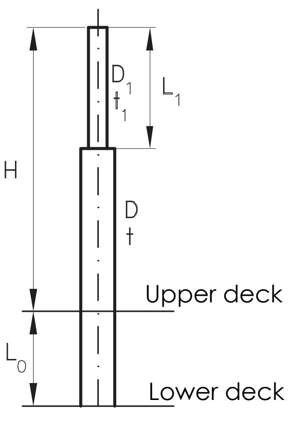
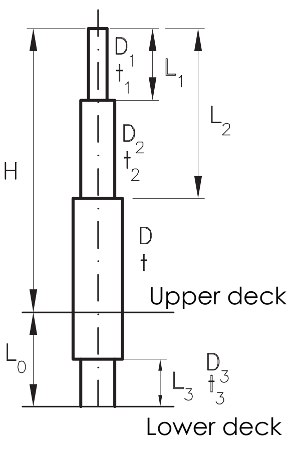
Figure 11



Θ1
Θ2
RA
F
TA
FV
F0
H
h
V1
V2
l1
l2
RP
Ps
RA
T
p2
p1
p1
p2
X1
X2
φ2
φ1
Resultant of span forces
direction of work considered
φ3
φ4
X4
X3
p3
p4

Table 3 : Factor m for the calculation of the elastic coefficient for the mast

<table>
<tr><td colspan="2">A) Mast composed of sections having constant diameter and thickness</td></tr>
<tr><td colspan="2">Where:
D_1 , D_2 , D_3: outler diameters of the mast or column in way of different sections (mm)
t_1 , t_2 , t_3 : thickness of different sections (mm)
L, L_1 , L_2 , L_3: length of different sections (mm)
$\lambda_0 = \frac{L_0}{H}, \quad \lambda_1 = \frac{L_1}{H} \quad$ etc.
$s_1 = \frac{t}{t_1}, \quad s_2 = \frac{t}{t_2} \quad$ etc.
$d_1 = \frac{D}{D_1}, \quad d_2 = \frac{D}{D_2} \quad$ etc.</td></tr>
<tr><td>
</td><td>Gives:
$m = 1 + \lambda_0$</td></tr>
<tr><td>
</td><td>$m = 1 + \lambda_0 + \lambda_2^3(d_2^3 s_2 - 1) + \lambda_1^3(d_1^3 s_1 - d_2^3 s_2)$</td></tr>
</table>

	$m = 1 + \lambda_0 + \lambda_1^3(d_1^3 s_1 - 1) + \lambda_2\left(\frac{\lambda_2}{\lambda_0}\right)^2(d_2^3 s_2 - 1)$
	$m = 1 + \lambda_0 + \lambda_1^3(d_1^3 s_1 - 1)$
	$m = 1 + \lambda_0 + \lambda_2^3(d_2^3 s_2 - 1) + \lambda_1^3(d_1^3 s_1 - d_2^3 s_2) + \lambda_3\left(\frac{\lambda_2}{\lambda_0}\right)^2(d_3^3 s_3 - 1)$

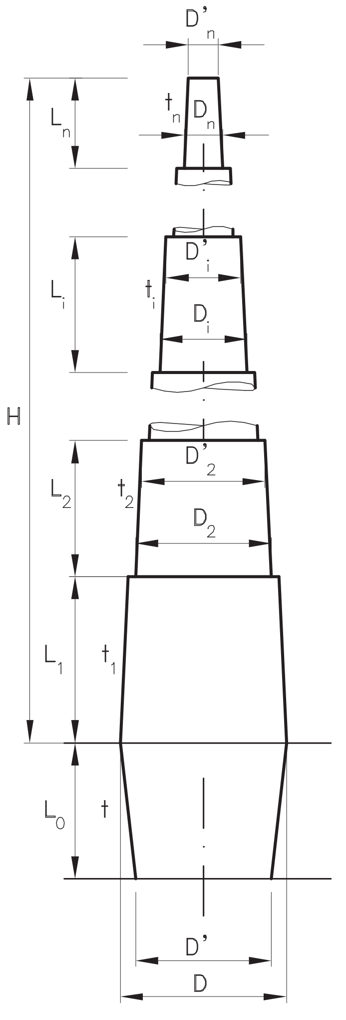
B) Mast composed of n sections having conical shape and constant thickness

Assuming:

D_i : inner diameter of each section

D'_i : upper diameter of each section

Where: $a_i = \dfrac{D_i - D'_i}{D_i}$ $\quad a_o = \dfrac{D_o - D'_o}{D_o}$



Having:

$$m = 1 + \lambda_0 c_0 + \sum_{i=1}^{n} \lambda_i d_i^3 s_i \left(\lambda_i q_i + 0,5\, r_i \sum_{k=i+1}^{n} \lambda_k \right)$$

where:

$$q_i = \lambda_i c_i + 1,5 \frac{\sum_{k=i+1}^{n} \lambda_k}{1 - a_i}$$

$$r_i = 3 \frac{\lambda_i + \dfrac{2 - a_i}{1 - a_i} \sum_{k=i+1}^{n} \lambda_k}{1 - a_i}$$

c_0 and c_i are given in Tab 7 as a function a_0 and a_i respectively.

Table 4 : Characteristics of the system

Wires	Standard type	s cm^2	l cm	q	E' kN/cm^2	$k_1 = \dfrac{E' \cdot S}{l} \cos^2\theta$	$k_2 = \dfrac{E' \cdot S}{l} \mathrm{sen}\,\theta \cos\theta$
1 2 i n							

Table 5

Stay No.	ϕ	$K_{S1} = K_1 \cos^2 \phi$	$K_{S2} = K_2 \cos \phi$
1 2 i			
n		ΣK_{S1} =	ΣK_{S2} =

3.7 Stays

3.7.1 Shrouds and stays may be constructed with wire ropes, tubular structures, steel bars or other approved systems. If wire ropes are used, they are to be in one length. If tubular structures or struts are used, they may be formed in various sections provided that they are connected with pins or hinges that allow bending on the vertical plane.

The above sections may have a maximum length such that bending stresses caused by their own weight do not exceed 1/4 of the yield point of the material used, or 1/6 of the breaking load, whichever is the lesser.

In the calculation of the bending moment, a horizontal arrangement of the stays is assumed.

Wire rope stays are to comply with the requirements specified in Ch 7.

In the calculation of stay tension, the effect of the weight of the stay itself may be ignored (deflection curve).

Systems of special design are to be considered in each case.

- For tubular or steel bar stays, the maximum allowable stress, taking into account the effect of the bending moment caused by the stay's own weight, is given in Tab 6 below as a function of the tension stress Z, on the stay R_{eH}, is the yield point of the material.
- When the value of Z is such that 200 kN < Z < 400 kN, linear interpolation is to be used.
- Where hinged connections for linking the various sections are used, their scantlings are to be calculated assuming a safety factor not less than that of the stays.

  The connection of hinges to the stay is not to cause reduction in the resistance sectional area, notch effects or stress concentrations.
- Pins are to operate with upsetting stress not exceeding 50 N/mm^2 and are to be subjected to shear stress lower than 65 N/mm^2 for mild steel and 80 N/mm^2 for higher tensile steel.

  They are to be provided with adequate and safe means for preventing any movement.
- The assembly tension of the stays is to be maintained at approximately 30 N/mm^2.

  An assembly criterion is given by the measurement of the arrow, at mid-length perpendicularly to the stay.

With reference to Fig 12, arrow f, in mm, is to be approximately as follows:

$$f \leq \frac{l^2 \cdot p}{56}$$

where:

l : length of the stay, in metres

p : horizontal distance between mast heel and attachment of the stay, in metres.

Table 6

Breaking load of stays [kN]	σ_{amm} / R_{eH}
Z ≤ 200	0,4
Z > 400	0,5

Figure 12

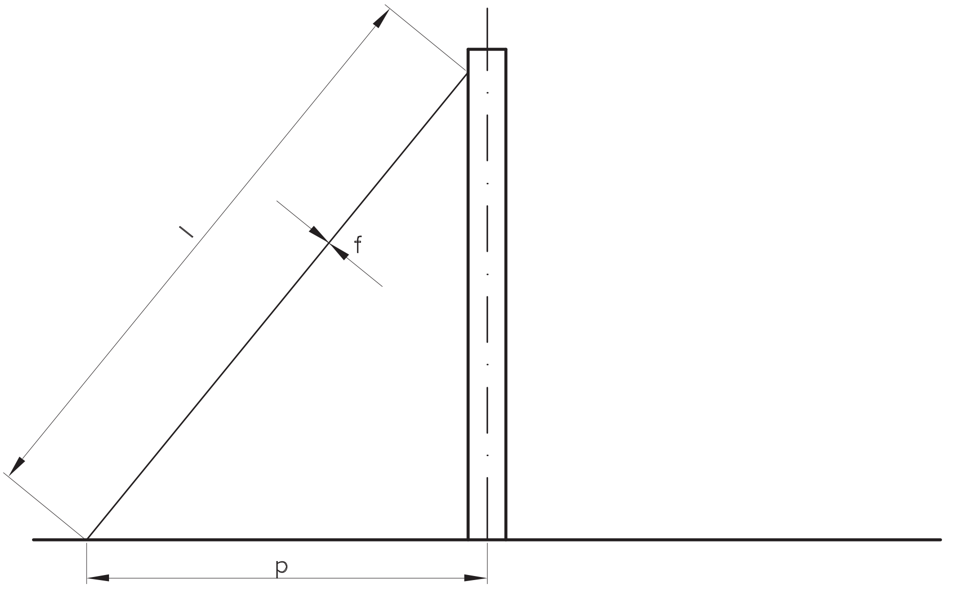


Table 7

$\frac{a_i}{a_o}$	$\frac{c_i}{c_o}$	$\frac{a_i}{a_o}$	$\frac{c_i}{c_o}$	$\frac{a_i}{a_o}$	$\frac{c_i}{c_o}$	$\frac{a_i}{a_o}$	$\frac{c_i}{c_o}$	$\frac{a_i}{a_o}$	$\frac{c_i}{c_o}$
0,01	1,008	0,08	1,064	0,15	1,128	0,22	1,201	0,29	1,284
0,02	1,015	0,09	1,073	0,16	1,138	0,23	1,212	0,30	1,297
0,03	1,023	0,10	1,082	0,17	1,148	0,24	1,223	0,31	1,310
0,04	1,031	0,11	1,090	0,18	1,159	0,25	1,235	0,32	1,324
0,05	1,039	0,12	1,100	0,19	1,168	0,26	1,247	0,33	1,338
0,06	1,047	0,13	1,109	0,20	1,179	0,27	1,259	0,34	1,352
0,07	1,056	0,14	1,118	0,21	1,190	0,28	1,272	0,35	1,367

3.8 Stay attachments

3.8.1 Stay attachments to deck and mast are to be arranged in order to allow free rotation of the stays at the points of attachment. They are to transmit no compression loads unless the stays are in steel wire rope or other flexible material that cannot be damaged by such compression.

Connections are to be provided with adequate and safe blocking means for preventing any movement.

Where tubular or steel bar stays are used, the alignment is to be taken into account for the arrangement of the attachments.

Connection plates may be forged or formed by welded plates with suitable material, such as killed fine grained practice steel.

Welded plates are to be normalised after welding. They are to ensure complete penetration of welds, to have no notches and to provide adequate accessibility for radiographic, ultrasonic or other equivalent method of examination.

Such testing is compulsory for tensile loads exceeding 200 kN.

Where details not contemplated by national standards are used, the maximum allowable stress to be considered in direct calculation is to ensure a safety factor of 4 for yield point and 5 for breaking point, taking whichever is the lesser.

Parts in reciprocal movement are to have scantlings such that upsetting stress does not exceed 25 N/mm^2.

Where different masts are used, calculation of eleastic coefficients is to be submitted to Tasneef for consideration.

4 Derrick systems of special design

4.1 General requirements

4.1.1 For systems of special design, as specified in [1.3], careful attention is to be given to the stability of the system of the two span ropes. The relevant calculations are to be submitted to Tasneef for consideration.

The design is to include the loads and the inclination of the ship and any other applicable data as specified in [2].

When the distance between the vertical plane containing the span rope line of action and the vertical axis of the derrick gooseneck fitting pin may be less than 1/9 of the length of the derrick, the stability is to be demonstrated with adequate calculations.

Suitable arrangements limiting the derrick working angle are not to induce additional bending loads on the derrick.

It is recommended that both of the span ropes should be capable of supporting the whole load with the derrick completely outboard. Each span rope is to have sufficient scantlings to support 2/3 of the total maximum tension.

For construction details of stays and attachments, see the requirements specified in [3].

4.2 Determination of forces transmitted by the derricks

4.2.1 The determination of forces transmitted by derricks to masts may be very complex, as in the case of bipod design masts, Fig 13.

This system is composed of two posts positioned athwartship, each inclined inwards so that they meet in way of the centreline of the ship slightly above a crosstree, where the span ropes are connected to support the derricks.

Each bipod design mast is equipped with four derricks. In general, two derricks are directly connected to each post, one toward the aft part of the ship and the other toward the forward part. The other two derricks are heavy load rigs and their heel assembly is connected to the upper deck on the centreline so that they may both work toward the bow and stern.

As the bipod design mast is a hyperstatic system, the relevant calculation requires the solution to equations of congruence to rotation and to movement. The calculation is further complicated by the variation of the resistant sections of the posts from heel to head.

Depending on the working derricks and their position, a mast of bipod design may be subject to:

a) longitudinal bending due to two derricks working on the same hatch;

b) longitudinal bending due to heavy load rigs positioned on the longitudinal plane and opposed by the tension of the stays;

c) transverse bending due to two derricks of the same post completely slewed outboard;

d) transverse bending for abeam heavy load rig;

e) transverse bending due to two derricks of the same post positioned on the longitudinal plane on the associated hatches;

f) torsion due to two derricks of different posts plumbing opposite hatches.

The above also applies to lifting appliances of STÜLCHENMAST type (Fig 14).

Lifting appliances of STÜLCHENMAST type include special structures for lifting very heavy loads that increase the angle of heel and trim of the ship.

The system is composed of two posts, often diverging at the head, which support heavy load rigs with two span ropes.

The operating of the two span ropes allows slewing of the load.

Structures are to be verified both for derrick hoisting and slewing in the most severe working conditions.

In the load diagram, the angles of heel and trim of the ship are to be considered for each elevation.

Unless precise indications are given in the construction of the load diagrams, the angles may be considered to be 10° and 3°, respectively.

4.3 Verification of scantlings

4.3.1 Allowable stresses, σ_{amm}, are specified in [3.3.3].

In the case of $P_s > 600$ kN the value $\sigma_{amm} = 0,8\ R_{eH}$ may be allowed on condition that:

a) detailed and complete calculations of the structural parts of the systems are submitted;

b) verification is carried out in accordance with the design criteria specified in [2].

   Dynamic forces are to be taken into account by increasing the load according to the dynamic factor indicated in Tab 8.

   Intermediate values may be obtained by linear interpolation;

c) the actual scantlings of structural elements, plates, bars, etc. are at least equal to those obtained in the calculations;

d) the manufacturing processes of steel and welded joints are considered suitable;

e) adequate measuring devices are arranged and tension of stays is checked in operation;

f) verification of the system is also carried out for navigating conditions. Several factors acting on the structures are to be considered, such as wind pressure equal to 2400 N/m² and rolling inertia of 20° with a period of 10 s.

Table 8

P_S, in kN	Dynamic factor
600	1,25
1000	1,215
1500	1,17

5 Derricks

5.1 General requirements

5.1.1 Derricks and associated fittings are to be in accordance with the Italian Standard UNAV tables or with other standards recognised by Tasneef

Special arrangements are to be approved before application.

Derricks are to have uniform diameter or are to be tapered. Tapering may be obtained by parallel, cressed, lapped or stepped construction. Derricks may be of one piece or of several welded sections.

When derricks are stepped, variations in diameter are to be minimal. The maximum allowable tapering at the ends, equal to 70% of the mid-section diameter, is not allowed in the case of derricks having only one step.

For tapered derricks, the diameter and thickness of the mid-section are to be uniform for a section equal to at least 36% of the full length of the derrick (Fig 15).

When welded lap joints are used, at least 60% of the full length of the derrick is to have uniform diameter and thickness as in the mid-section.

Where the strength of the derrick is adequate, different configurations may be accepted at the discretion of the Tasneef

5.2 Derrick scantlings

5.2.1 The scantlings of derricks are to be verified on the basis of stress of axial compression (specified in [2.5]), taking into account slewing and preventer guys and the bending moment acting on the derricks.

The bending moment is to be calculated taking into account the weight of the derricks and the eccentricity of the points of attachment.

Several examples of verification are shown below in Figures 16, 17 and 18.

Figure 13

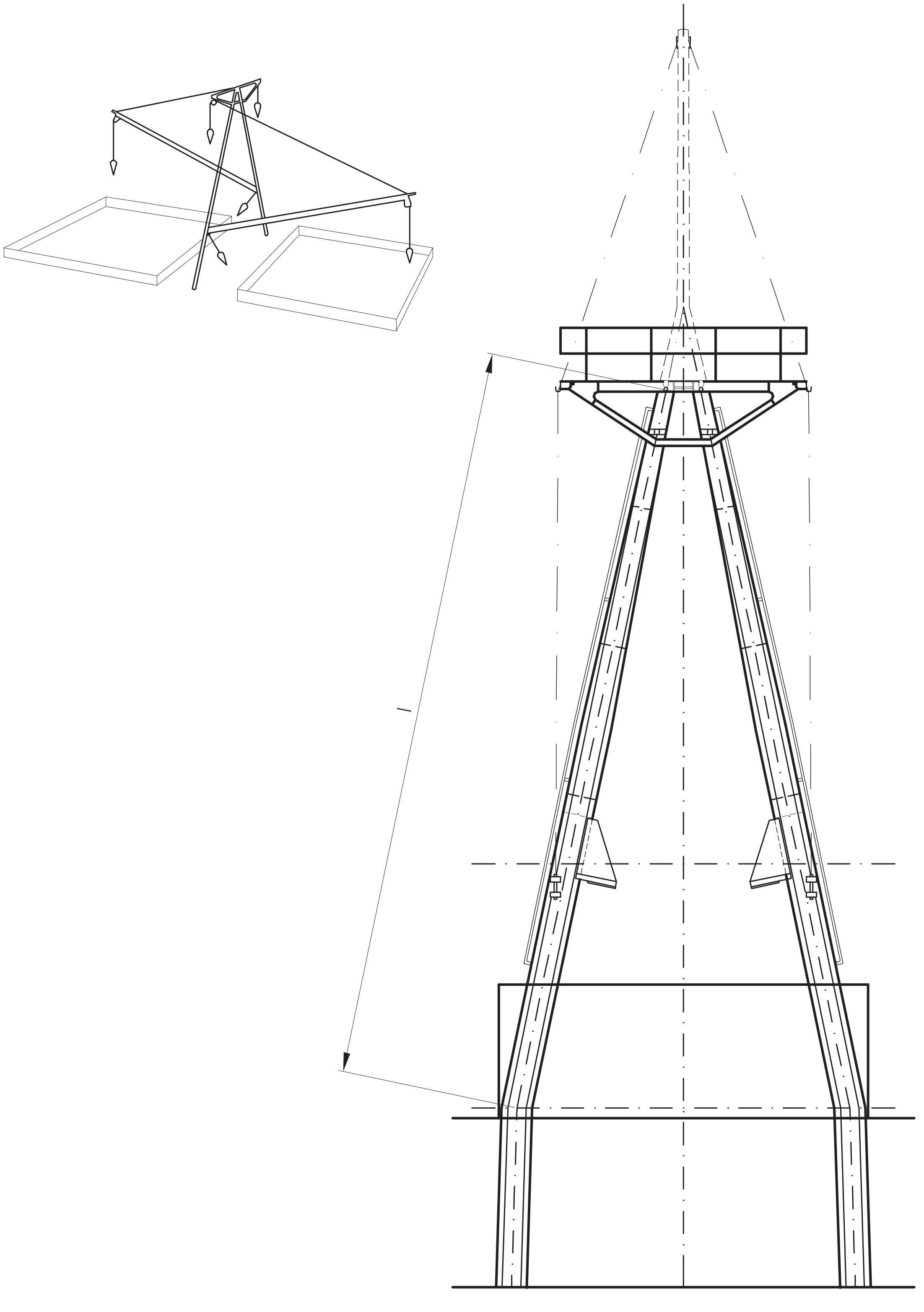


Figure 14

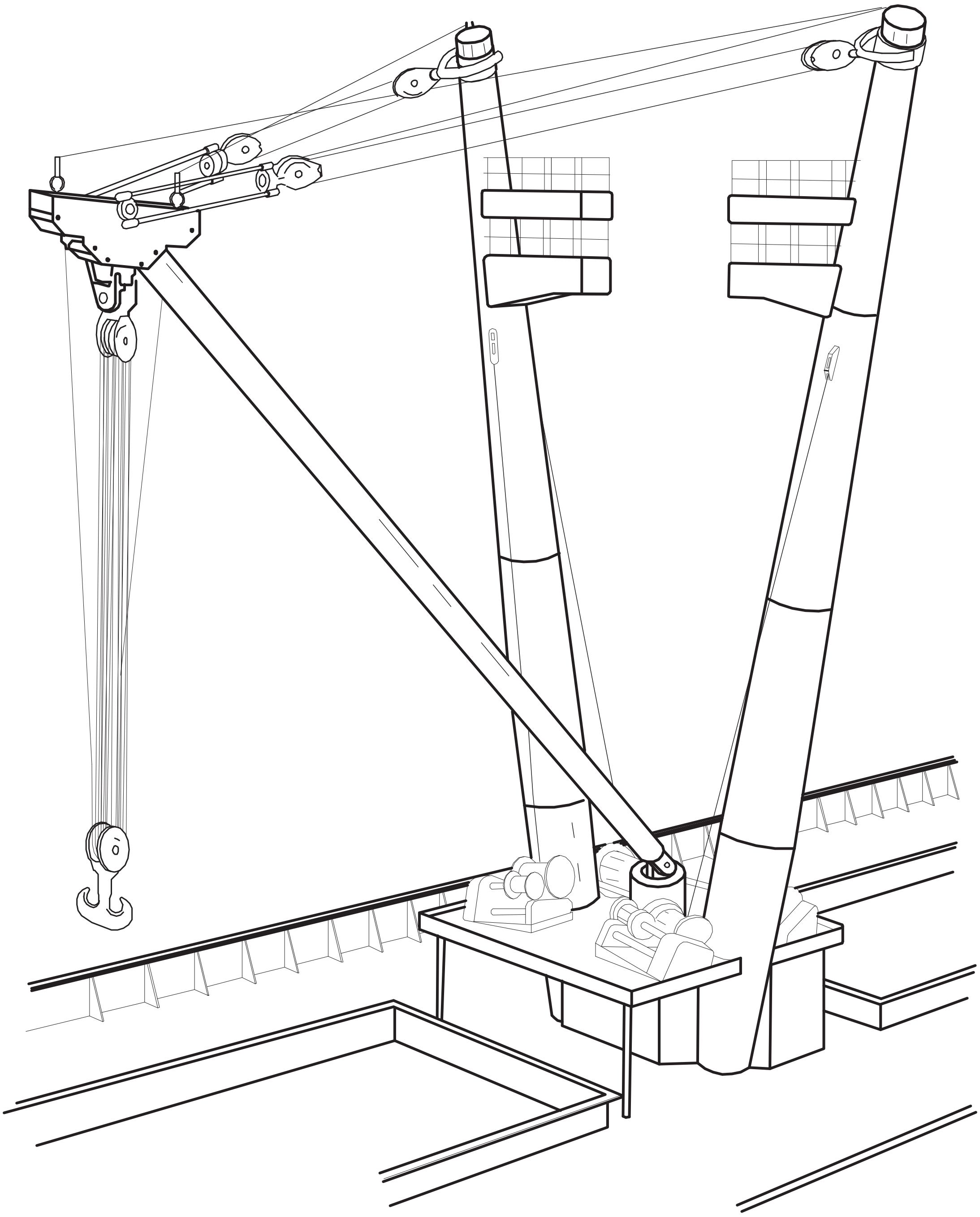


Figure 15

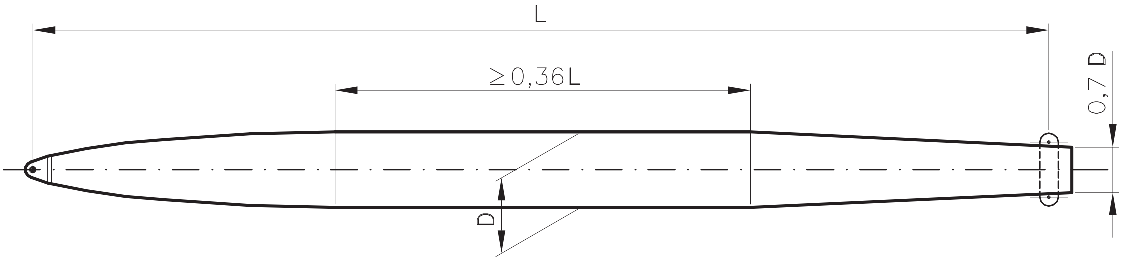
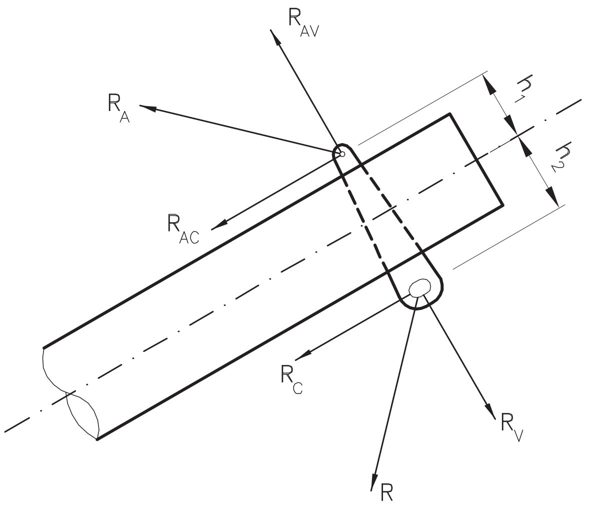


Figure 16



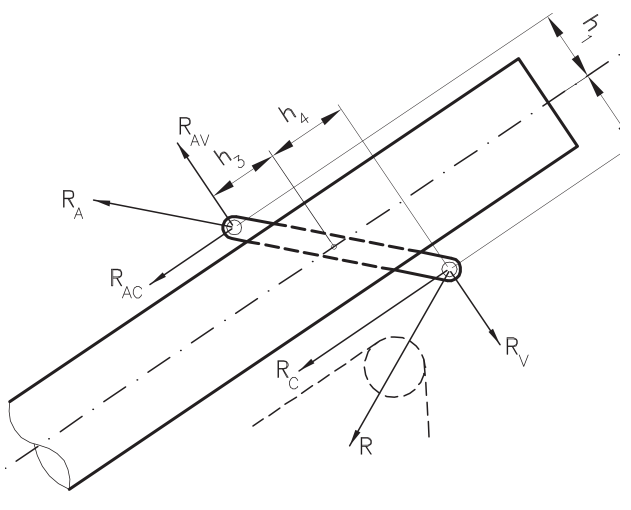
Compression:

$R_p = R_{ac} + R_c$

Bending moment

$M_f = R_{ac} \cdot h_1 - R_c \cdot h_2$

Figure 17



Compression

$R_p = R_{ac} + R_c$

Bending moment

$M_f = R_{ac} \cdot h_1 - R_c \cdot h_2 - R_{av} \cdot h_3 - R_v \cdot h_4$

5.3 Allowable stresses

5.3.1 Given:

σ_{fp} : bending stress due to the weight of the derrick

σ_{fe} : bending stress due to the eccentricity of cargo runner and/or of span rope

σ_{cp} : compression stress due to the end load

then:

$\sigma_{fp} + \sigma_{fe} + \sigma_{cp} \leq \sigma_{amm}$

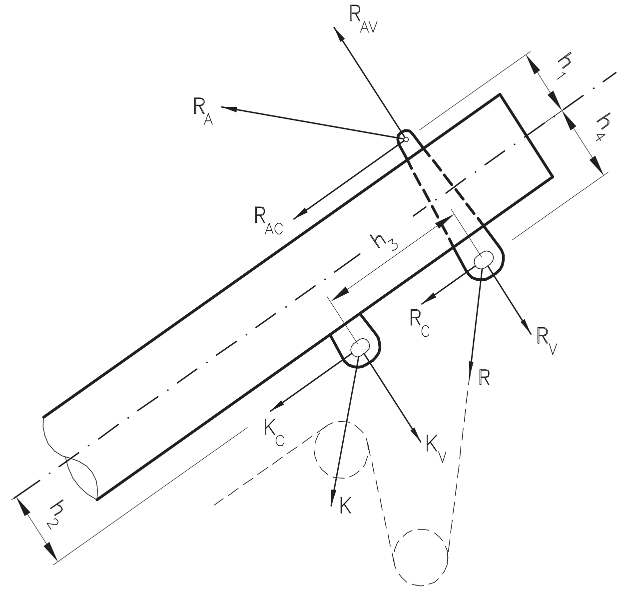
The value of σ_{amm} is given in Tab 9 as a function of the safe working load P_s of the system. In the table below, R_{eH} is the yield point of the material, not to be taken as greater than 70% of the breaking load R_m .

The stress σ_{cp} is to be calculated taking into account the slenderness of the derrick, in accordance with the relevant provisions of Ch 15.

Table 9

P_S, in kN	σ_{amm} / R_{eH}
100	0,44
200	0,48
300	0,53
400	0,58
500	0,61
600	0,62

Figure 18



Compression

$R_p = R_{ac} + R_c + K_c$

Bending moment

$M_f = R_{ac} \cdot h_1 - K_c \cdot h_2 + K_v \cdot h_3 - R_c \cdot h_4$

5.4 Construction details

5.4.1 At the ends, in way of head and heel attachments, the derricks are to have scantlings such that the cross-sectional area is equal to approximately 70% of the mid-section.

In way of the attachment of the derrick head eyeplate, the derrick is to be covered with a tube or plate doubler having thickness s_1 equal to the thickness s to which it is connected when the derrick diameter is ≥ 100 mm, or equal to 1,5% s. if the derrick diameter is < 100 mm (see Fig 19).

Adequate reinforcements are to be provided in way of the attachments of the slewing guys.

Connections between the various sections having different diameter may be obtained either by cressing the tube of greater diameter and overlapping or by interposition of welded rings as shown in Fig 20 and Fig 21.

The welded connection of the two sections of a derrick should be performed by appropriate overlapping of the derrick as shown in Fig 22 or, alternatively, by means of welded slots, at least 75mm long and having width equal to twice the thickness of the derrick (but not less than 25 mm).

6 Fitting

6.1 General requirements

6.1.1 Fittings are all those components firmly connected to masts or derricks (e.g. attachment of the derrick heel and head, span rope or cargo runner attachment to the masts, stay attachments, etc.).

In general, fittings are to comply with recognised standard tables (UNI, UNAV or equivalent) relative to the loads applied to them.

Where other fittings are to be used, standard equivalent efficiency and strength are to be demonstrated on the basis of strength calculations to be submitted for examination.

Possible water stagnation areas and abrupt variations in wall thickness of the fittings are to be avoided. All supporting surfaces are to be appropriately machined to ensure a smooth finish and a good fit.

6.2 Derrick heel assembly

6.2.1 The derrick heel assembly may be constructed in forged mild or higher tensile steel. In the case of welded structures, the design of connections is to guarantee good penetration and adequate heat treatment after welding.

When the derrick heel assembly is directly connected to the mast, appropriate stiffening and doublers are to be provided to facilitate the distribution of the stress to the surrounding structures. Where the vertical pin of the assembly is supported by roller bearings, the plans are to include the maximum value of the specific pressure allowed by the Manufacturer for the special type of bearing used.

Figure 19

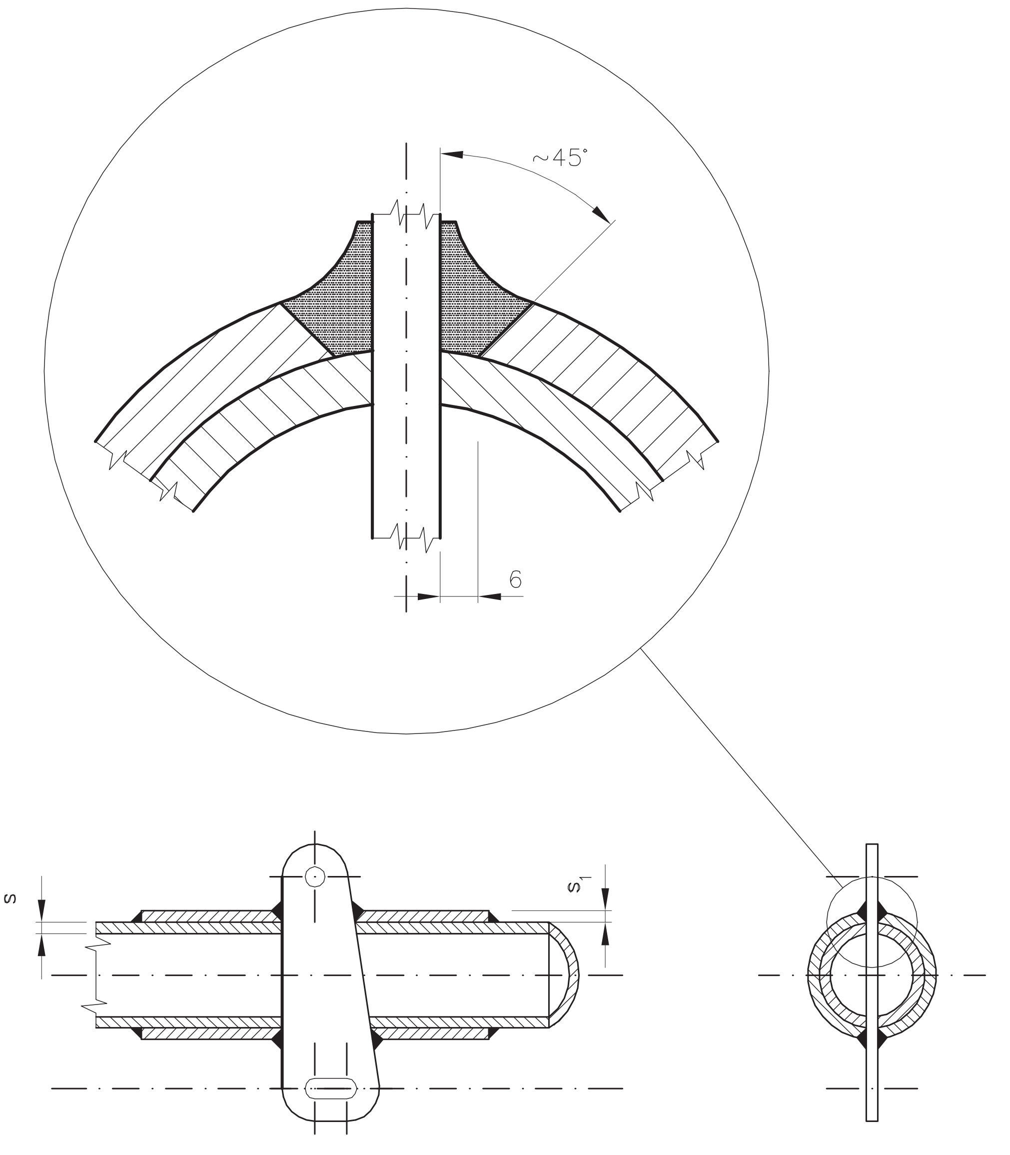
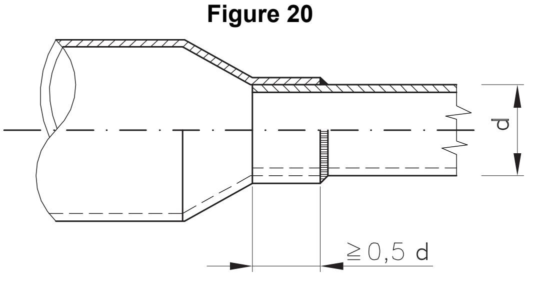


Figure 20



6.3 Derrick head assembly

6.3.1 The head assembly of light and normal load derricks is composed of an eyeplate passing through the derrick and equipped with eyes for attaching the span rope and the cargo runner lead block.

Derricks of heavy load rigs are in general of U-shaped type. The cargo runner block is connected to the U-frame by means of an elongated shackle and the lower span rope block is connected by means of the relevant attachment.

Special attention is to be paid to ensuring that even during derrick storing, assemblies do not interfere with the derricks giving rise to excessive stress concentrations in the one direction.

6.4 Head span rope attachment

6.4.1 See the requirements specified in [6.2].

Since the head span rope attachment is mainly subject to tension stress, it should be constructed with a through plate welded to the mast to which it is connected.

7 Union purchase rigs

7.1 General requirements

7.1.1 Scantlings of derricks that are arranged for single or union purchase operation are to be devised such that each component of the system is capable of supporting the stress resulting from the most severe operating conditions.

A pair of single rope derricks having strength tested for slewing may operate in union purchase without complying with any additional requirements provided that the hoisted load is no greater than 1/4 of the SWL of the derrick with the lower safe working load and the slewing guys are in the appropriate direction.

Where the system is to have a greater safe working load than that above, appropriate checks are to be performed as specified in the following paragraphs.

If a pair of derricks is arranged for operation in union purchase on one side of the ship, it may operate on the other side provided that the new arrangement is symmetrical to the old one in relation to the centreline of the ship.

In the calculations of union purchase operation, the following requirements are to be complied with:

a) the operating angle of both derricks is to be not less than 15° to the horizontal;

b) operation is to be performed with single cargo runner;

c) the height h of the headroom on the triangle plate from s is to be not less than 5 m for SWL of up to 20 kN and 6 m for SWL greater than 20 kN (where s is the greater of the height of the bulwarks and that of the hatch coamings);

d) the maximum included angle between cargo runners is not to exceed 120°;

e) the outside derrick is to have derrick head at an outreach of not less than 4 m from the ship side amidships and in forward position it is to be at a distance not less than 1/5 D or 1/4 D from the nearest hatch ends to derrick heel, where D is the length of the hatch, depending on whether the system has one or two pairs of derricks per hatch;

f) an inside derrick is normally to have the head operating at a distance of 1m from the longitudinal hatch coaming of the nearest hatch and not less than 2/3 D or 3/4 D of the transverse coaming nearest to the derrick heel, depending on whether the system has one or two pairs of derricks per hatch;

g) the aft operating derrick system is to be determined on the basis of the operating needs of the system. It is recommended that the derrick heads should be arranged not less than 1 m from the hatch coamings;

h) the operating area of the system is included between two planes defined by the vertical axis passing through the meeting point of the cargo runners in the systems specified in (e) and (f) above.

Figure 21

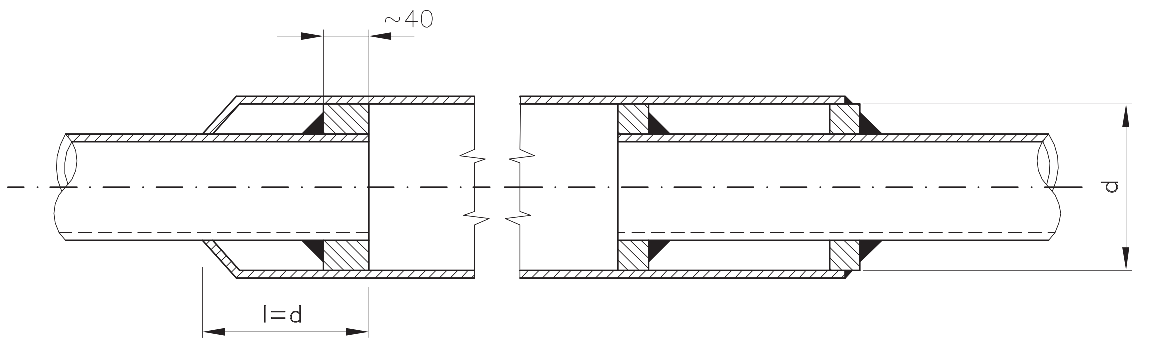
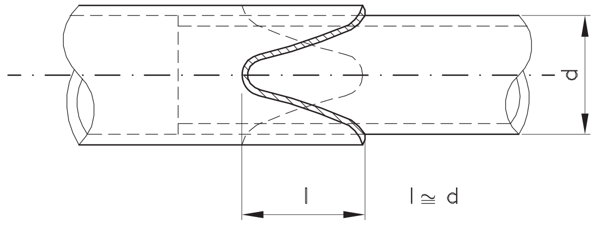


Figure 22



7.2 Details

7.2.1 Each derrick is to be equipped with slewing guys and a safety preventer guy in flexible steel wire rope on the ship side bulwark.

It is to support the maximum working load determined by the calculation of forces specified in [7.4].

The preventer guy is to be looped on the derrick head, i.e. it is to be connected to the attachment of the slewing guy by a shackle, provided that this point of attachment is designed to support the operating load of the preventer guy.

The hull attachments of the safety preventer guys are generally different from those of the slewing guys and are to have appropriate scantlings.

In way of the slewing guys, in the inner side of the ship, a tackle connecting the two derrick heads is to be positioned.

Derricks are only to be restrained by means of preventer guys. The slewing guys are to be slackened off during setting up of the rig and only the preventer guys are to be taken into account in the calculation of forces in the rig.

7.3 Characteristic data

For each pair of union purchase rigs, the following data is to be submitted:

B : midship breadth (m)

D : length of the hatch with a pair of derricks (m)

K : width of the above-mentioned hatch (m)

N : distance from the derrick heel to the transverse hatch coaming of the adjacent hatch (m)

E : position of the upper deck attachment of outside derrick preventer guy. Such attachment is to be positioned as far as possible outside and beyond the vertical plane that passes through the derrick heels. It is not to be beyond the transverse coamings of the hatch adjacent to that served by the derrick

C : position of the preventer guy of the inside derrick, lying on a plane perpendicular as far as possible to that containing the derrick and associated span rope and as far as possible outside

H_1 , H_2 : position of the derrick heels

H : distance of the span rope attachment from the derrick heel (m)

S : height (the height of the bulwarks or that of the hatch coamings, whichever is the greater) measured in way of mid-hatch length

L : length of the derricks (m)

T : height of derrick heel from deck (m) (see Fig 23).

7.4 Calculation of forces

7.4.1 The calculation of stresses acting on the different components of the system may be carried out by graphical procedure or by direct calculation.

In the first case, the diagram of forces is to be made on the basis of the characteristics of the system, according to the diagram indicated in Fig 24.

This diagram represents the projection of the system on the horizontal plane and provides information relative to the forces acting on each component, generated by a unit load and applied on the triangle plate of the two cargo runners.

Values of compressive stress on the derricks and tension on the span ropes are obtained by taking into account the effect of the horizontal and vertical components generated by preventer guys, cargo runners and by half the weight of the derrick itself.

Attention is to be paid to ensuring that force diagrams do not apply compressive forces on the span ropes so as to avoid jack-knifing conditions (see example).

In this case, deck attachments of preventer guys are to be repositioned.

8 Materials

8.1 General requirements

8.1.1

Materials are to be appropriate, at the discretion of Tasneef In general, they are to meet the testing requirements indicated in Pt D, Ch 2, Sec 1 of the Rules for the classification of ships.

Materials used for the construction of masts, posts, derricks and their components are to comply with the requirements specified below.

Materials having characteristics other than those specified in the above-mentioned Rules may be considered by Tasneef on condition that detailed information concerning their chemical, mechanical and manufacturing properties as well as their future application is submitted for consideration. If necessary, Tasneef may require additional tests.

The anticipated operating temperature of the system is to be considered in the choice of the materials used in the construction of the equipment.

In particular, for design temperatures as low as -10°C, the steel grades are as shown in Pt B, Ch 4, Sec 1, Tab 4 of Tasneef Rules for the classification of ships.

For design temperatures lower than -10°C, the steel grades are as shown in Tables 6, 7 and 8 of the aforementioned Section of the Rules for the classification of ships.

For the application of Pt B, Ch 4, Sec 1 of Tasneef Rules for the classification of ships, the classes of the structural members of cranes can be defined as follows:

- CLASS I (secondary): structures of lesser importance whose collapse would not affect the structural integrity of the crane;
- CLASS II (primary): structures of primary importance whose collapse would affect the structural integrity of the crane;
- CLASS III (special): structures of primary importance in critical zones subject to stress concentrations.

The associated Rule values of impact strength for each steel grade are shown in Tables 4 and 7 of Pt D, Ch 2, Sec 1 of Tasneef Rules for the classification of ships.

8.2 Masts, posts and derricks

8.2.1

a) Materials are to be of the type prescribed in the approved drawings or in the applicable requirements. The type of steel to be used for plates is normally indicated in Pt D, Ch 5, Sec 1 of the Rules for the classification of ships. Unless otherwise stated, tubes are to be ST category as per Pt D, Ch 2, Sec 2, [3.2] of the Rules for the classification of ships.

b) Materials are to be tested in compliance with the Section of Part D relevant to the particular type of product.

8.3 Welded connections

8.3.1 Welded connections are to comply with the requirements specified in Pt D, Ch 5 of the Tasneef Rules for the classification of ships.

Joints are to be appropriately prepared for welding and are to be suitable for the special type of structure and stresses to which they may be subjected.

In particular, butt-welded joints of masts and posts are to be appropriately chipped and back welded. Where the inner part is not accessible, welding on one side may be approved provided that adequate means for full penetration are used.

In general, intermittent fillet welds on main structural parts are not admitted.

In general, repair by welding of worn, broken or deformed parts is not allowed. Where welding is necessary, the entire procedure (edge preparation, type of electrodes and of processes, heat treatment) is subject to prior approval by Tasneef

Repair work is to be performed by qualified welders and under the supervision of a Tasneef Surveyor.

Non-destructive tests are to be performed on welded joints as specified in the above-mentioned Part D of the Rules for the classification of ships. In special cases, radiographic examination of all welded joints may be required.

Special welding sequences may be required at the discretion of Tasneef in order to improve the execution of the structure as well as to avoid anomalous shrinkage or distorsions of its parts.

Figure 23

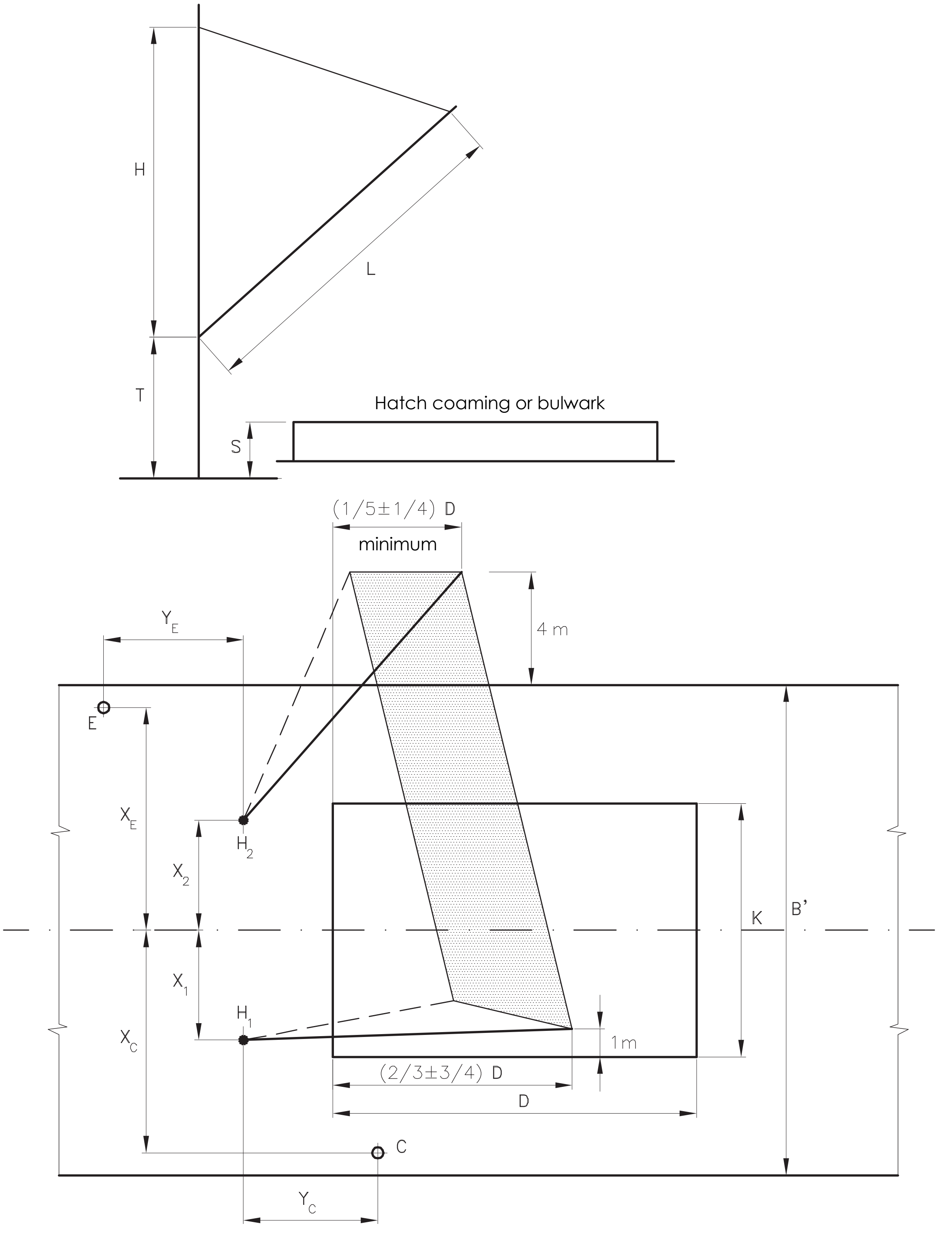
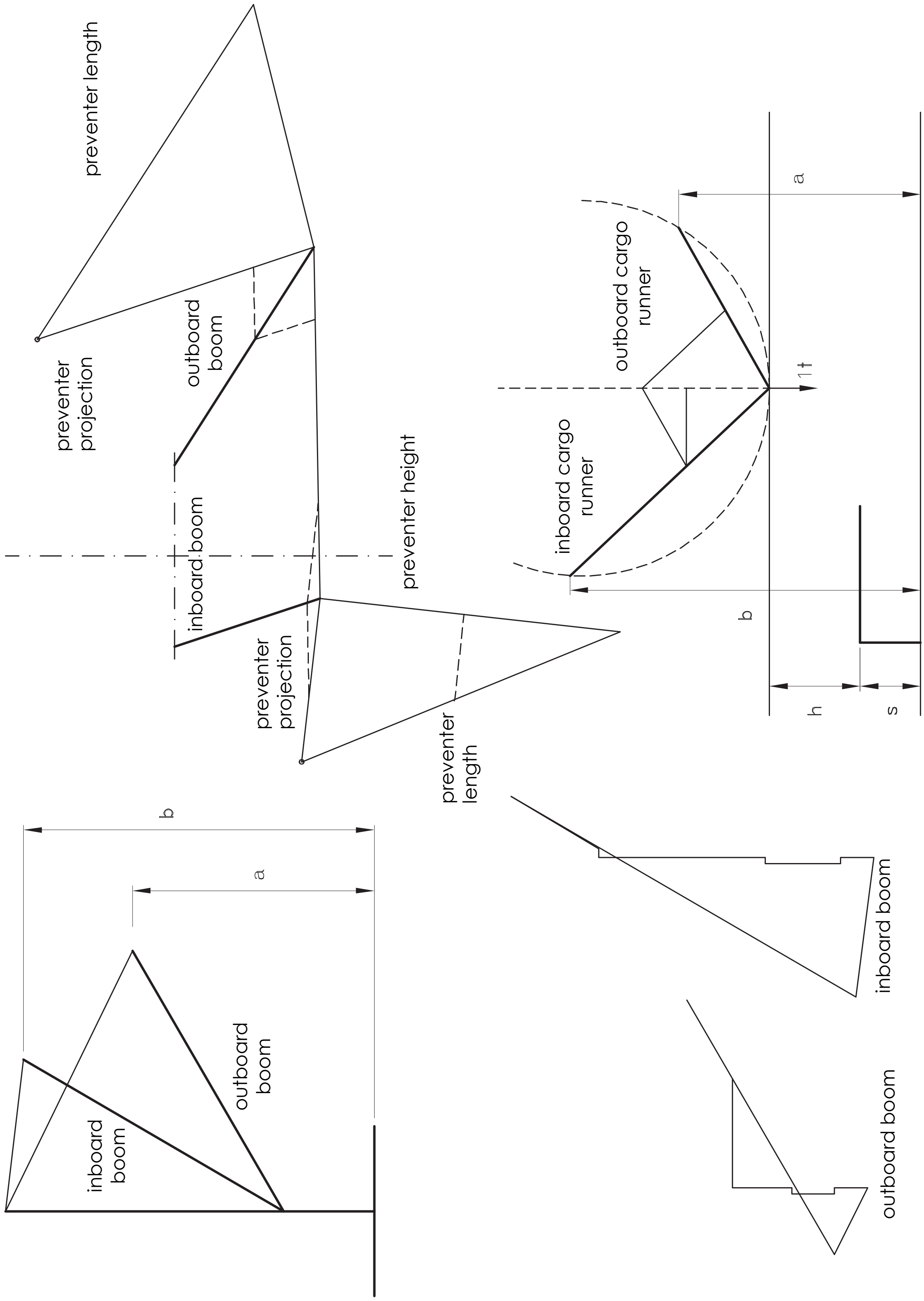


Figure 24


preventer length
preventer projection
outboard boom
inboard boom
preventer height
preventer projection
preventer length
outboard cargo runner
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b
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outboard boom
inboard boom
inboard boom
outboard boom

CHAPTER 4 CRANES

1 General

1.1 Application

1.1.1

This Chapter applies to ship cranes used for handling loads in general, in harbours and in a sheltered water environment generally. Cranes may be used for loading, for equipment handling or for engine room service.

In particular, this Chapter applies to:

a) swinging cranes and jib cranes for handling cargo and/or equipment
b) gantry or container cranes
c) fixed cranes mounted on floating vessels for handling loads with derrick, retractable jib or A-frame
d) grab cranes for dredging or for handling loads in bulk
e) special type cranes for positioning pier blocks in maritime works
f) engine room service travelling cranes equipped with motor hoists for engine maintenance
g) fixed motor hoists.

Cranes of special type other than those above will be specially considered.

Offshore cranes are to be designed according to Chapter 5 or to recognised national or international standards (e.g. API 2C or EN13852) to be agreed with the Society on a case-by-case basis.

For cranes with lifting magnet, see Ch 15, [11].

Cranes are intended to be fixed to the ship structure or firmly connected to it by means of suitable devices. See Ch 15, [10] for moving cranes with tires or tracks.

1.2 Service categories

1.2.1 As far as structural design is concerned, cranes are grouped in service categories as a function of their operating conditions and duty rating.

Operating conditions depend on the time of effective service of the crane.

The duty rating depends on the ratio of lifted working load and frequency of operation.

Assuming normal operating life equal to $6 \cdot 10^5$, three service categories are considered: light, average and heavy duty. Different values of amplification factor M of the maximum load to be lifted correspond to each category as shown in Tab 1.

Overload resulting from the service category of the crane is to be considered in the verification of the crane pedestal.

In the case of different operating conditions and duty factors, amplification factors M with relative increased values of the load are to be considered. Hereafter, they are indicated as load factors.

Cranes or lifting appliances other than those above will be considered in each case.

Table 1

Type of cranes	Service category	Amplification factor M
Swinging jib cranes for store Swinging jib cranes for general equipment Motor hoist for engine room and engine cranes	Light	1,05
Deck cargo jib cranes Container cranes Fixed cranes with derrick or retractable jib A-frame cranes	Medium	1,10
Grab cranes Gantry travelling cranes Pier blocks positioning crane	Heavy	1,20

2 Forces to be considered in the calculation

2.1 General requirements

2.1.1 The cranes considered in this section are designed to operate in a harbour or sheltered water environment where there is no significant movement of the ship due to wave action.

Different environmental conditions are to be clearly specified and the calculations are to be corrected.

When verifying crane structures, the following forces are to be taken into account:

- main static forces acting on the crane structure
- inertia forces due to the various crane and load movements
- forces due to ship inclination and motion
- environmental effects.

2.2 Main forces

2.2.1 The main forces acting on the crane structures are:

P_p : the weight of the structure and of mechanical parts connected to it, fixed and loose counterweights and any other load constantly weighing on the same component

P_s : duty load, i.e. maximum hoisting weight in the conditions under consideration

P_a : dead load, i.e. weight of items of loose gear lifted together with the load (hook, block, etc.).

2.3 Inertia forces due to the movement of the crane and load

2.3.1

a) Forces caused by vertical lifting of the load

$\Psi(P_s + P_a)$

The above is obtained by multiplying the dead load and the live load by the dynamic factor Ψ obtained from the following formula:

$\Psi = 1 + KV_s$

where:

V_s : hoisting speed in m/s, which need not be taken as greater than 1 m/s

K : coefficient to be taken as

0,3 for jib type cranes

0,6 for gantry or travelling cranes.

The value of the dynamic factor Ψ, which is to be not less than 1,15, is given by the diagram in Fig 1 as a function of the hoisting speed V_s.

Where instantaneous release of all or part of the load is foreseen, as for cranes with lifting magnet or hoisting with grabs, the resulting forces are also to be taken into account.

b) Forces caused by horizontal translation of the crane (H_t)

These forces are generated by acceleration which may occur during crane movements on board.

Such acceleration, which depends on the characteristics of the translation and braking devices, is to be specified by the Designer assuming the appropriate use of the machine.

Unless otherwise mentioned, acceleration a, in m/s^2, generating the forces under consideration may be obtained from Tab 2 as a function of the translating speed.

In general, the force to be considered is to be between 3% and 25% of the load weighing on the driving wheels or braking wheels.

c) Forces due to slewing (H_r)

Forces that depend on the characteristics of the slewing movements of the crane are to be specified by the Designer assuming the appropriate use of the machine.

In the absence of reliable data, the acceleration of the jib head at maximum outreach is to be taken as 0,6 m/s^2.

d) Forces due to hunting of the crane during translation on rails (H_s)

These forces depend on hunting and on other irregular movements during crane translation and induce transverse forces on rails.

The transverse component of the force applied by the wheel on the rail is given by the vertical load acting on the wheel, multiplied by the coefficient λ given by the diagram in Fig 2, which depends on the ratio distance between rails/trolley wheel base L/l, where l is the greater distance between the wheel axles.

Vertical forces caused by hitting uneven rails during movement may be disregarded on condition that the rail joints are level and smooth and, for existing structures, in good service condition.

e) Forces due to collision or hitting against fixed fittings H

These forces, originating from hitting against buffers or shock absorbers, are taken into account only if translation speed is at least 0,7 m/s.

For greater translation speeds, the buffer is considered capable of absorbing the kinetic energy of the crane (with no load or when load is fixed to the crane) corresponding to a speed equal to 0,7 V_t.

In general, V_t is the operating speed.

When decelerating devices are provided in addition to limit-stop switches, the reduced speed may be considered.

As a function of the deceleration applied by the buffer to the system, the stresses on the structure may be calculated.

Where systems may be subjected to hitting or hooking against fixed parts, the resulting stresses are to be taken into account.

For this purpose, application of a horizontal force capable of lifting two of the trolley wheels is to be considered in way of the load.

f) Centrifugal forces

In general, for ship cranes, the effect of centrifugal forces acting on the crane structure is limited and may be disregarded.

2.4 Forces due to ship inclination and motion

2.4.1

a) Static forces

Static forces due to ship inclination having angle of heel 5° and angle of trim 2° are considered. Alternative values are to be clearly specified under the different working conditions on the relevant documents.

b) Dynamic forces during navigation

Dynamic forces due to ship motion acting on the crane in the stowed condition and its stowage arrangements are to be taken as resulting from the combination of an acceleration normal to deck of ±1 g with an acceleration parallel to deck in fore and aft direction of ±0,5 g, or with an acceleration parallel to deck in transverse direction of ±0,5 g where the static heel is 30° in both cases.

Table 2

V, in m/s	a, in m/s²		
	Low speed	High speed	
		Acceleration usual value	Acceleration high value
0,4	0,10		
0,5	0,11		
1	0,14		
1,5	0,18	0,31	0,42
2		0,35	0,47
2,5		0,38	0,52
3		0,42	0,57
3,5		0,46	0,62
4		0,50	0,67

Figure 1

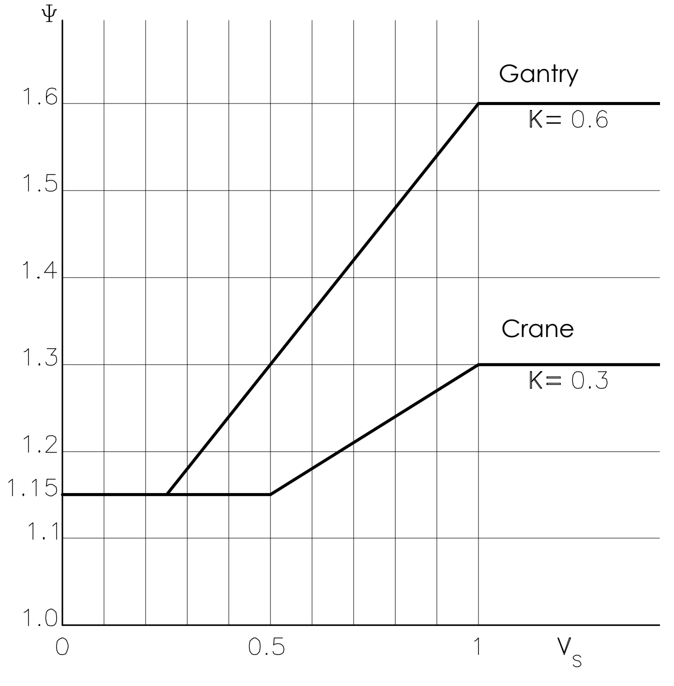
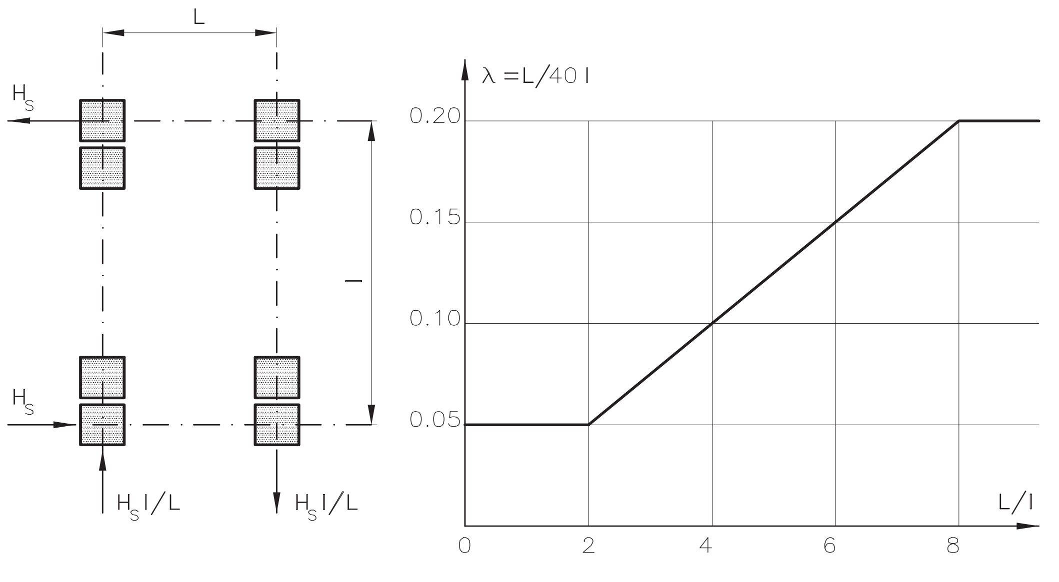


Figure 2



2.5 Forces due to environmental conditions

2.5.1

a) Wind loading

Wind pressure depends on the arrangement of the crane structure and originates from overpressure as well as depression acting on the exposed surfaces.

Wind direction is to be taken as horizontal and acting normal to the surface of the components of the crane.

Wind loading is a function of the kinetic pressure q according to an experimental coefficient c, which depends on the shape of the object subjected to wind loading and is given by the following formula:

$W = c \cdot q \cdot A$

where A is the area of the windward face (N) in m^2.

Kinetic pressure depending on the density of the air and the wind speed V is given by the following formula:

$q = 0{,}613\ V^2$

where q is in N/m^2 and V in m/s.

Unless severer weather conditions than those specified in [1.1] are considered, constant speed is to be taken as 20 m/s, irrespective of the height above sea level, with a corresponding kinetic pressure of 245 N/m.

In exceptional load condition (case III), the wind speed is to be taken as 63 m/s with a corresponding kinetic pressure of approx. 2400 N/m^2.

The coefficient c is to be obtained on the basis of aerodynamic principles. In general, for both lattice tower structures and towers of flat-sided sections, for crane systems for normal use, c may be taken as 1,6, while for towers of circular section and for the machinery box, c may be taken as 0,9 and 1,1, respectively.

For suspended loads, unless the shape of the load is known and constant, the windward face is to be taken as 0,1 m^2/kN for loads smaller than or equal to 50 kN and 0,05 m^2/kN for loads greater than 50 kN.

For loads greater than 250kN, the constant windward face is taken as 15 m^2.

The coefficient c to be used in the pressure formula p = cq is to be taken as 1,2.

b) Snow and ice loads

In general, snow and ice loads acting on the crane structures may be disregarded except where a specific design or application indicates that they are significant.

2.6 Access-way and platform loading

2.6.1 Access-ways and platforms are to be designed to carry in addition to existing loads, an accidental load of 3 kN on a square having 2500 cm^2 area in the most unfavourable spot.

Structures designed for personnel access are to be taken as supporting a concentrated load of 1 kN.

3 Design criteria

3.1 Load combinations

3.1.1 The design is to consider the ship in harbour and the crane in service as well as the ship at sea and the crane in the stowed condition. In particular, the following conditions are to be considered:

I	:	Crane operating without wind
II	:	Crane operating with wind
III	:	Crane subjected to exceptional loadings
IV	:	Crane in the stowed condition.

3.2 Loading condition I: Crane operating without wind

3.2.1 The action of the following forces operating simultaneously is considered:

- Weight of hoisted load: P_s
- Weight of the crane itself: P_p
- Dead load, load of the components lifted together with the load: P_a
- (Dynamic) Forces due to hoisting of the load and accessories:

  $\Psi(P_s + P_a)$
- Horizontal components of forces due to heel and trim:

  $\Psi(P_{so} + P_{ao})$ and P_{po}
- The most unfavourable horizontal load, H, due to slewing and hoisting of the crane and load
- Verification is to take into account the total stress S_I given by the following formula:

  $$S_I = M[P_p + \Psi(P_s + P_a) + \Psi(P_{so} + P_{ao}) + P_{po} + H]$$

where M is the factor of load amplification as a function of the service category of the crane as specified in [1.2], and the various forces are to be taken with the required configuration and direction.

If translation is applied only for the positioning of the crane but not for cargo handling, the resulting force is not to be combined with the other forces.

3.3 Loading condition II: Crane operating with wind

3.3.1 In addition to the forces specified in [3.2], the wind loading as defined in [2.5] is considered. The total stress is therefore given by the following formula:

$$S_{II} = M[P_p + \Psi(P_s + P_a) + \Psi(P_{so} + P_{ao}) + P_{po} + H] + W$$

3.4 Loading condition III: Crane subjected to exceptional loadings

3.4.1 Various conditions are taken into account:

a) "in service" system under the effect of a collision, with load P_s and weight P_p according to [2.3]
b) failure of the hoist wire and sudden release of the load simultaneously with two horizontal forces and wind loading (hoisting factor 0,2 ÷ 0,3)
c) test loading
d) crane not in service but not in the stowed condition, with maximum wind loading as specified in [2.5].

3.5 Loading condition IV: Crane in stowed condition

3.5.1 The crane is considered in the stowed condition and subjected to dynamic forces due to navigation as specified in [2.4] and to a wind speed of 80 m/s acting in the most unfavourable direction (parallel or transverse direction).

4 Verification of resistance

4.1 General requirements

4.1.1

Verification of cranes is to be performed for the load conditions specified in [3.1] according to sound basic engineering principles and to the requirements specified in Ch 15.

The arrangement and loading conditions generating maximum stresses are to be considered for each resisting element.

CHAPTER 5 CRANES FOR OFFSHORE OPERATIONS

1 Application

1.1 General

1.1.1 This Chapter applies to cranes designed to operate in offshore conditions, i.e. open sea environmental in which the waves action causes significant movement of the ship, or other offshore installation, on which the crane is fitted or from which the crane unloads goods.

The sea state will, generally, be in excess of that characterized by waves having significant height greater than 0,5 meters.

The scope of this Chapter covers jib cranes, A-frames and fixed structures used for lifting operations; travelling gantry or mobile cranes will be specially considered on the basis of these rules.

2 Dynamic Forces

2.1 Forces to be considered in the calculation

2.1.1 General requirements

The cranes considered in this section are designed to operate in unsheltered water environment where there is significant movement of the ship due to wave and wind action.

Different environmental conditions are to be clearly specified and the calculations are to be corrected.

When verifying crane structures, the following forces are to be taken into account:

- main static forces acting on the crane structure
- inertia forces due to the various crane and load movements
- forces due to ship inclination and motion
- offlead and sidelead due to supply boat motions
- out of service loads
- environmental effects.

2.1.2 Main forces

The main forces acting on the crane structures are:

- P_p : the weight of the structure and of mechanical parts connected to it, fixed and loose counterweights and any other load constantly weighing on the same component
- SWL: duty load, i.e. maximum hoisting weight in the conditions under consideration
- H: dead load, i.e. weight of items of loose gear lifted together with the load (hook, block, etc.).

2.2 Inertia forces due to the movement of the crane and load

2.2.1 Vertical factored load

The vertical factored load FL acting on the crane boom tip is the SWL, plus the weight of the hook block, thus being denoted as SWLH, multiplied by the vertical dynamic coefficient ψ:

$$FL = \psi \cdot SWLH \quad (1)$$

2.2.2 Offboard lifts

For offboard lifts, the vertical dynamic coefficient ψ is to be determined from the following expression:

$$\psi = 1 + V_r \cdot \sqrt{\frac{K}{g \cdot SWLH}} \quad (2)$$

where:

K is the vertical spring rate of the crane at the hook expressed in kN/m

SWLH is the safe working load, as defined above, expressed in kN

g is acceleration due to gravity expressed in m/s^2

V_r is the relative velocity expressed in m/s and determined from the following expression

$$V_r = V_h + \sqrt{V_d^2 + V_c^2} \quad (*)$$

being:

V_h the maximum actual steady hoisting velocity for the SWLH to be lifted and expressed in m/s

V_d the vertical velocity of the supply boat deck supporting the load and expressed in m/s

V_c the vertical velocity of the crane boom tip due to crane base motion and expressed in m/s

However, ψ is not to be less than the onboard dynamic coefficient.

Equations (1) and (2) are to be satisfied simultaneously

The vertical velocities V_d and V_c are derived from Tab 1.

Table 1 :

Supply boat velocity V_d	
Load being lifted from or placed on:	**V_d (m/s)**
Bottom-supported structure	0,0
Moving vessel (supply) with H_{sig}<3m	$V_d = 0,6 \cdot H_{sig}$
Moving vessel (supply) with $H_{sig} \geq 3$m	$V_d = 1,8 + 0,3 \cdot (H_{sig} - 3)$
Crane boom tip velocity V_c	
Crane mounted on:	**V_c (m/s)**
Bottom-supported structure	0,0
Tension leg platform (TLP)	$0,05 \cdot H_{sig}$
Spar	$0,05 \cdot H_{sig}$
Semi-submersible	$0,082 \cdot H_{sig}^2$
Drill ship	$0,164 \cdot H_{sig}2$
Floating production storage offloader (FPSO)	$0,164 \cdot H_{sig}2$
Note: H_{sig} is to be expressed in meter when used with the above formulae	

During offboard lifts, hoisting velocity at the elevation where the lift is started (i.e. supply boat deck level) is to be fast enough to prevent re-contact after the load is lifted; the minimum hoist velocity (V_{hmin}) for any particular hook load to be lifted is to be:

$V_{hmin} = 0,01 + 0,098 \cdot H_{sig}$ for $H_{sig} \leq 1,83$ m

$V_{hmin} = 0,067 \cdot (H_{sig} + 1)$ for $H_{sig} > 1,83$ m

Where:

H_{sig} is the significant wave height for the actual load to be lifted, in m and

V_{hmin} is the minimum required steady hoisting velocity, in m/s

V_h indicated in (*) to evaluate V_r, is to be the actual maximum available steady hook speed (when the hook is at the waterline) and is to be equal to or greater than V_{hmin}.

The dynamic load on the crane is clearly a function of the crane stiffness; the stiffer the crane, the larger the dynamic loading. The stiffness value K in Equation (2) is meant to describe the amount of vertical displacement of the hook block that shall occur for a given load application (kN/m). It is calculated by accounting for the combined flexibility of the loadline, boomline, pendants, boom, and kingpost or pedestal.

It should be calculated with the hook block at sea level where the supply boat lift shall be made. The crane stiffness may vary considerably with radius.

Wire rope stiffness is tipically the major contributor to crane flexibility. In the absence of wire rope manufacturer's information, the wire rope modulus of elasticity may be taken as 75000 N/mm^2 based on a cross-sectional area equal to 0,48 times the nominal rope diameter squared. This is reasonable for most independent core wire rope types commonly used for offshore cranes, but should not take place of more accurate manufacturer's information.

2.2.3 Onboard lifts

For onboard lifts, the velocities V_d and V_c are to be assumed as zero; V_{hmin} is to be assumed not less than 0,01 m/s.

The dynamic coefficient ψ is to be evaluated using the following formula:

$$\psi = 1,373 - \frac{SWLH}{5221,8} + A_v \quad (3)$$

Where:

SWLH is in kN and A_v , the vertical boom tip acceleration expressed in g, is obtained from Tab 2.

Table 2 :

Crane mounted on:	Vertical acceleration A_v
Bottom-supported structure	0,0
Tension leg platform (TLP)	$0,01 \cdot H_{sig} \geq 0,07$
Spar	$0,01 \cdot H_{sig} \geq 0,07$
Semi-submersible	$0,0075 \cdot H_{sig}^2 \geq 0,07$
Drill ship	$0,013 \cdot H_{sig}^2 \geq 0,07$
Floating production storage offloader (FPSO)	$0,013 \cdot H_{sig}^2 \geq 0,07$
Note: H_{sig} is to be expressed in meter when used with the above formulae	

Equations (1) and (3) are to be satisfied simultaneously.

However, is not to be less than $1,1 + A_v$ or greater than $1,33 + A_v$.

2.2.4 Horizontal loads

a) **General**

Horizontal loading is to be taken into consideration in establishing the crane lifting capacity. If more specific data is not available from the crane's manufacturer or purchaser, the effect of offlead, sidelead, crane static inclination and crane (ship) motions, are to be evaluated in compliance with the following provisions and are to be applied together with vertical load.

b) **Offlead and sidelead due to supply boat motion**

All offboard lifts are to include the horizontal load induced by supply boat motion. The radial offlead load, W_{offSB}, applied to the boom tip due to supply boat motion is:

$W_{offSB} = FL \cdot OL$ where:

$$OL = \frac{0,762 + 0,457 \cdot H_{sig}}{0,305 \cdot H_{tip}} \le 0,3$$

H_{tip} is the vertical distance from boom tip to supply boat deck expressed in meter and FL, in kN, is the vertical factored load already defined.

The horizontal sideload (expressed in kN) applied at the boom tip due to supply boat motion is:

$$W_{sideSB} = \frac{W_{offSB}}{2}$$

When offlead and sidelead angles are known, the offlead and sidelead forces can be regarded as a function of the mentioned angles and are expressed as:

W_{offSB} = FL · tan (offlead angle)

W_{sideSB} = FL · tan (sidelead angle)

c) **Loads due to crane inclinations (CI forces) and crane motions (CM forces)**

Both boat's inclinations (list and trim) and motions induce loads which are to be accounted for during onboard and offboard lifts. The boom tip motions resulting from the vessel crane motions can be evaluated, in the lack of specific data for the vessel, using the following Tab 3.

Vessel static inclinations (list and trim) cause offlead and sidelead depending on the crane operating direction relative to the inclination. Static offlead results in a static change in position of the hook compared to level lifting conditions. To account for this, the crane boom angle should be adjusted to bring the hook back to the correct radius and the ratings determined for this configuration. Static sidelead results in a sideload at the boom tip due to the vertical factored load equal to:

W_{sideCI} = FL · sin(static sidelead angle)

The static sidelead angle θ is defined as:

$$\theta = \sqrt{list^2 + trim^2} \cdot \sin(\text{crane swing angle})$$

The worst combination of the offload and sideload components, due to the crane swing angle, defines the safe working load to be lifted.

The crane static sidelead also causes sideload when applied to the boom and other significant crane¡¦s structural components; these sideloads are to be accounted for in evaluating the crane strength.

Crane base motions cause offloads and sideloads, to be applied to the boom tip, similar to those originated by the supply boat motions; crane base motions also cause vertical loads, offloads and sideloads to be applied to the boom and crane components in their respective centres of gravity.

The horizontal accelerations determined for the crane boom tip (from Tab 3) are to be applied to the boom and other crane components along with the boom tip horizontal load due to this acceleration times the vertical factored load.

The horizontal loads derived from crane base motions and acting on the suspended load can be expressed as:

W_{horCM} = FL · horizontal acceleration

Similar horizontal forces result from the boom and other crane components due to platform and vessel static inclinations and horizontal accelerations. These added horizontal loads shall be calculated for the various crane components and applied to the various crane components. The horizontal loads due to crane motions shall be applied in the direction of crane base motion. This results in sidelead and offlead forces due to W_{horCM} of:

W_{offCM} = W_{horCM} · cos (crane base angle)

W_{sideCM} = W_{horCM} · sin (crane base angle)

where:

crane base angle is the angle of crane base motion from the direction of boom (0° for offlead only, 90° for sidelead only)

The assumed angle of crane base motions shall be evaluated at several angles including at a minimum 0° and 90° (maximum offlead and sidelead). The lowest SWLH resulting from these angle variations shall be selected for a given lifting condition.

d) **Combination of horizontal loads**

The horizontal loads due to crane motions and supply boat motions are combined as follows.

The total horizontal dynamic sidelead and offlead forces due to the actions of the lifted load are:

1) sidelead force $W_{sidedyn}$ expressed as:

$$W_{sidedyn} = \sqrt{W_{sideSB}^2 + W_{sideCM}^2}$$

2) offlead force W_{offdyn} expressed as:

$$W_{offdyn} = \sqrt{W_{offSB}^2 + W_{offCM}^2}$$

This combined horizontal dynamic load is to be added to the horizontal loads due to static crane base inclinations and wind in order for the total design force to be considered for the crane rating conditions to be determined.

Total offload = W_{offdyn} + W_{off} (wind)

Total sideload = $W_{sidedyn}$ + W_{sideCI} + W_{side} (wind)

however the total sideload is not to be less than 0,02 times FL

e) **Loads due to crane components**

The forces and moments due to the weight of the crane components (boom, gantry, pedestal, etc.) are to be included as loads in determining allowable crane ratings and for out-of-service conditions. The vertical loads due to the component weights of the crane are to be increased by the acceleration levels given in Tab 2 for in-service offboard and onboard lifts and for out-of-service conditions by multiplying the crane component weight times (1 + A_V) from the table. This accounts for the crane dynamic motion effects acting on the vertical weight of the crane components. The horizontal dynamic effects on the crane components are also be accounted for by applying the equations in c) to the component weight instead of the factored load.

f) **Forces due to environmental conditions**

1) Wind loading

Wind pressure depends on the arrangement of the crane structure and originates from overpressure as well as depression acting on the exposed surfaces.

Wind direction is to be taken as horizontal and acting normal to the surface of the components of the crane.

Wind loading is a function of the kinetic pressure q according to an experimental coefficient c, which depends on the shape of the object subjected to wind loading and is given by the following formula:

$W = c \cdot q \cdot A$

where A is the area of the windward face (N) in m^2.

Kinetic pressure depending on the density of the air and the wind speed V is given by the following formula:

$q = 0{,}613\ V^2$

where q is in N/m^2 and V in m/s.

Constant speed is to be taken as 20 m/s, irrespective of the height above sea level, with a corresponding kinetic pressure of 245 N/m; however, if severe environmental conditions make the mentioned value not representative of the area where the crane is supposed to operate and, therefore, higher values are imposed by the manufacturer, these latter figures are to be assumed for the kinetic pressure evaluation.

In exceptional load condition (case III), the wind speed is to be taken as 63 m/s with a corresponding kinetic pressure of approx. 2400 N/m^2.

The coefficient c is to be obtained on the basis of aerodynamic principles. In general, for both lattice tower structures and towers of flat-sided sections, for crane systems for normal use, c may be taken as 1,6, while for towers of circular section and for the machinery box, c may be taken as 0,9 and 1,1, respectively.

For suspended loads, unless the shape of the load is known and constant, the windward face is to be taken as 0,1 m^2/kN for loads smaller than or equal to 50 kN and 0,05 m^2/kN for loads greater than 50 kN.

For loads greater than 250kN, the constant windward face is taken as 15 m^2.

The coefficient c to be used in the pressure formula p = cq is to be taken as 1,2.

2) Snow and ice loads

In general, snow and ice loads acting on the crane structures may be disregarded except where a specific design or application indicates that they are significant.

g) **Additional forces due to crane movements**

1) Forces caused by horizontal translation of the crane (H_t)

These forces are generated by acceleration which may occur during crane movements on board.

Such acceleration, which depends on the characteristics of the translation and braking devices, is to be specified by the Designer assuming the appropriate use of the machine.

Unless otherwise mentioned, acceleration a, in m/s^2, generating the forces under consideration may be obtained from Ch 4, Tab 2 as a function of the translating speed.

In general, the force to be considered is to be between 3% and 25% of the load weighing on the driving wheels or braking wheels.

2) Forces due to slewing (H_r)

Forces that depend on the characteristics of the slewing movements of the crane are to be specified by the Designer assuming the appropriate use of the machine.

In the absence of reliable data, the acceleration of the jib head at maximum outreach is to be taken as 0,6 m/s^2.

3) Forces due to hunting of the crane during translation on rails (H_s)

These forces depend on hunting and on other irregular movements during crane translation and induce transverse forces on rails.

The transverse component of the force applied by the wheel on the rail is given by the vertical load acting on the wheel, multiplied by the λ coefficient given by the diagram in Ch 4, Fig 2, which depends on the ratio distance between rails/trolley wheel base L/l, where l is the greater distance between the wheel axles.

Vertical forces caused by hitting uneven rails during movement may be disregarded on condition that the rail joints are level and smooth and, for existing structures, in good service condition.

4) Forces due to collision or hitting against fixed fittings H

These forces, originating from hitting against buffers or shock absorbers, are taken into account only if translation speed is at least 0,7 m/s.

For greater translation speeds, the buffer is considered capable of absorbing the kinetic energy of the crane (with no load or when load is fixed to the crane) corresponding to a speed equal to 0,7 V_t.

In general, V_t is the operating speed.

When decelerating devices are provided in addition to limit-stop switches, the reduced speed may be considered.

As a function of the deceleration applied by the buffer to the system, the stresses on the structure may be calculated.

Where systems may be subjected to hitting or hooking against fixed parts, the resulting stresses are to be taken into account.

For this purpose, application of a horizontal force capable of lifting two of the trolley wheels is to be considered in way of the load.

5) Centrifugal forces

In general, for ship cranes, the effect of centrifugal forces acting on the crane structure is limited and may be disregarded.

h) **Pedestal, kingpost and crane supporting foundation**

The actions indicated in [2.2] are also to be considered when checking pedestals, kingposts, and the crane-support structures with an additional factor, the pedestal load factor (PF), that applies to the vertical and horizontal loads due to the factored load. The PF is applied to vertical factored load and to offlead and sidelead forces due, these latter, to the vertical factored load. The PF is derived as follows:

$$PF = 1,56 - \frac{SWLH}{4003,4}$$

with $1.2 \le PF \le 1.5$

Table 3 :

Crane mounted on:	Crane static inclination angle (deg)		Crane dynamic horizontal acceleration g
	List	Trim	
Bottom-supported structure	0,5	0,5	0,0
Tension leg platform (TLP)	0,5	0,5	$0,023 \cdot H_{sig} \ge 0,03$
Spar	0,5	0,5	$0,023 \cdot H_{sig} \ge 0,03$
Semi-submersible	1,5	1,5	$0,023 \cdot H_{sig} \ge 0,03$
Drill ship	2,5	1,0	$0,037 \cdot H_{sig}^{1,1} \ge 0,03$
Floating production storage offloader (FPSO)	2,5	1,0	$0,037 \cdot H_{sig}^{1,1} \ge 0,03$
Note: H_{sig} is to be expressed in meter when used with the above formulae			

3 Strength Analysis

3.1 Design criteria

3.1.1 Load combinations

The crane design is to be considered with respect to loads resulting from the following conditions:

Case I : Crane operating without wind

Case II : Crane operating with wind

Case III : Crane subjected to exceptional loading

Case IV : Crane in stowed condition

3.1.2 Case I

For the condition of the crane operating without wind the effect of the following forces acting simultaneously is to be considered:

- Dynamic forces due to hoisting of the load and accessories: ψ (SWLH)
- Self-weight of the crane: P_p taking into account the acceleration effect, whose values are indicated in Tab 2 and Tab 3
- Horizontal components of forces: W_{offSB} , W_{sideSB}, W_{sideCI} , W_{offCM} , W_{sideCM}
- The most unfavourable horizontal loads due to slewing and hoisting of the crane and load.

3.1.3 Case II

In addition to the forces specified in [3.1.2], the wind loads W, as defined in [2.2.4], f) 1) or as specifically defined (for the particular environmental o operation), is to be considered.

3.1.4 Case III

The crane may also need to be considered with respect to the following exceptional load conditions:

a) coming into contact with buffers

b) failure of the hoist wire or sudden release of load for cranes with counterweight with two horizontal forces and wind loading (hoisting factor 0,2 ÷ 0,3)

c) test loading

d) crane not in service but not in the stowed condition, with maximum wind loads as specified in [2.2.4], f) 1) specifically for the Case III.

3.1.5 Case IV

The crane is considered in the stowed condition and subjected to dynamic forces due to navigation as specified in Ch 4, [2.4] b) and to a wind speed of 80 m/s acting in the most unfavourable direction (parallel or transverse direction).

When out of service, the crane is subjected to loads due to its own weight, the environment, and motions of the vessel. In the out-of-service condition, the crane has no load suspended from the hook. For extreme conditions (hurricane) the crane shall be in the stowed position, and the crane and boom rest or other stowage arrangement shall be designed to withstand the combination of motions and environmental forces resulting from the most extreme design conditions for the vessel. For lesser operating conditions, the crane may be out of service with the boom not stowed. In this condition, the crane is to be designed to withstand the combination of motions and environmental forces without benefit of the stowage arrangement. The manufacturer has to specify maximum non-stowed and stowed out-of-service conditions including wind speed, list and trim, and vessel accelerations.

3.2 Strength checks

3.2.1 General requirements

Verification of cranes is to be performed for the load combinations specified in [3.1.1] according to sound basic engineering principles and to the requirements specified in Ch 15.

The arrangement and loading conditions generating maximum stresses are to be considered for each resisting element.

CHAPTER 6 CRANES FOR TRANSHIPPING OPERATIONS

1 Application

1.1 General

1.1.1 This Chapter applies to cranes used for unit-to-unit handling of dry bulk loads in environmental conditions in which there are significant wave induced motions of the unit on which the crane is mounted or from which the crane is off loading. In particular the following types of units, on which the cranes are mounted, are considered:

- transhipment units, generally small units intended to tranship the cargo from one delivering unit to one receiving unit
- transhipment floating terminals, generally larger units intended to tranship the cargo between more than one delivering and receiving units simultaneously
- ship shaped terminals.

The scope of this Chapter covers jib cranes, A-frames and fixed structures used for lifting operations; travelling gantry or mobile cranes will be specially considered on the basis of these requirements.

2 Static and Dynamic Forces

2.1 Forces to be considered in the calculation

2.1.1 General requirements

When verifying crane structures, the following forces are to be taken into account:

- main static forces acting on the crane structure
- inertia and dynamic forces due to the crane and load movements
- forces due to ship inclination and motion in stored/waiting condition
- forces due to wind, snow and ice
- access-way and platform loads.

2.1.2 Main forces

The main static forces acting on the crane structures are:

- P_p : the weight of the structure and of mechanical parts connected to it, fixed and loose counterweights and any other load constantly weighing on the same component
- SWL: duty load, i.e. maximum hoisting weight in the conditions under consideration
- H: dead load, i.e. weight of items of loose gear lifted together with the load (hook, block, etc.).

2.2 Inertia and dynamic forces due to the crane and load movements

2.2.1 Forces caused by vertical lifting of the load

The forces caused by vertical lifting of the load are to be evaluated by the formula:

$$FL = \psi \cdot SWLH \quad (1)$$

The dynamic effect due to the relative vertical motion of the crane and the vessel, from/to which the load is hoisted, is taken into account with the dynamic factor, to be calculated according to the following formula, and to be assumed not less than 1,4:

$$\psi = 1 + V_r \cdot \sqrt{\frac{K}{g \cdot SWLH}} \quad (2)$$

where:

K is the vertical spring rate of the crane taking into account all elements from the hook to the pedestal support structure, expressed in kN/m

SWLH is the safe working load, as defined above, expressed in kN

g is acceleration due to gravity expressed in m/s^2

V_r is the relative velocity expressed in m/s and determined from the following expression:

$$V_r = V_h + \sqrt{V_d^2 + V_c^2}$$

being:

V_h the actual steady hoisting velocity for the SWLH to be lifted where the lift is started (i.e. supply boat deck level) and expressed in m/s. The hoisting velocity at the elevation is to be fast enough to prevent re-contact after the load is lifted and in no case to be taken less than 0.5 V_L

V_L maximum steady hoisting speed for the rated capacity to be lifted, expressed in m/s

V_d the vertical velocity of the supply boat deck supporting the load and expressed in m/s

V_c the vertical velocity of the crane boom tip due to crane base motion and expressed in m/s

Note 1: Typical cranes involved in transhipment operation generally hoists from both barges and ships; consequently the dynamic factor should in general be calculated with the combination that gives the maximum of velocity.

The above velocities V_h , V_d and V_c are to be determined from direct calculations, assuming specific environmental conditions for the site where the vessel on which the crane is fitted is designed to operate. The values of ship velocities are to be calculated considering the maximum significant wave height assumed for the operation of the crane.

2.2.2 Forces due to slewing (H_r)

Forces that depend on the characteristics of the slewing movements of the crane are to be specified by the Designer assuming the appropriate use of the machine.

In the absence of reliable data, the acceleration of the jib head at maximum outreach is to be taken as 0,6 m/s^2.

2.2.3 Forces due to collision or hitting against fixed fittings H

These forces, originating from hitting against buffers or shock absorbers, are taken into account only if translation speed is at least 0,7 m/s.

For greater translation speeds, the buffer is considered capable of absorbing the kinetic energy of the crane (with no load or when load is fixed to the crane) corresponding to a speed equal to 0,7 V_t.

In general, V_t is the operating speed.

When decelerating devices are provided in addition to limit-stop switches, the reduced speed may be considered.

As a function of the deceleration applied by the buffer to the system, the stresses on the structure may be calculated.

Where systems may be subjected to hitting or hooking against fixed parts, the resulting stresses are to be taken into account.

2.2.4 Centrifugal forces

In general, for ship cranes, the effect of centrifugal forces acting on the crane structure is limited and may be disregarded.

2.3 Forces due to unit inclination and motion in stored/waiting condition

2.3.1 static and dynamic inclinations and horizontal motions

The effect caused by static and dynamic inclinations and horizontal motions of the vessel is to be taken into account, considering:

- Static forces due to ship inclination having angle of heel 5° and angle of trim 2° are considered. Alternative values are to be clearly specified under the different working conditions on the relevant documents.
- Dynamic sidelead and offlead effects taking into account the effect due to motions of the unit/ship on which the crane is fitted and of the barge/ship offloaded, to be determined from direct calculations assuming specific environmental conditions for the site where the vessel on which the crane is fitted is designed to operate. The values of ship velocities to be calculated are those which can be reached with a probability of 10^{-8} per cycle.

2.4 Forces due to wind, snow and ice

2.4.1 Wind loads

Wind pressure depends on the arrangement of the crane structure and originates from overpressure as well as depression acting on the exposed surfaces.

Wind direction is to be taken as horizontal and acting normal to the surface of the components of the crane.

Wind loading is a function of the kinetic pressure q according to an experimental coefficient c, which depends on the shape of the object subjected to wind loading and is given by the following formula:

$W = c \cdot q \cdot A$

where A is the area of the windward face (N) in m^2.

Kinetic pressure depending on the density of the air and the wind speed V is given by the following formula:

$q = 0,613\ V^2$

where q is in N/m^2 and V in m/s.

Constant speed is to be taken as 20 m/s, irrespective of the height above sea level, with a corresponding kinetic pressure of 245 N/m; however, if severe environmental conditions make the mentioned value not representative of the area where the crane is supposed to operate and, therefore, higher values are imposed by the manufacturer, these latter figures are to be assumed for the kinetic pressure evaluation.

In exceptional load condition (case III), the wind speed is to be taken as 63 m/s with a corresponding kinetic pressure of approx. 2400 N/m^2.

The coefficient c is to be obtained on the basis of aerodynamic principles. In general, for both lattice tower structures and towers of flat-sided sections, for crane systems for normal use, c may be taken as 1,6, while for towers of circular section and for the machinery box, c may be taken as 0,9 and 1,1, respectively.

For suspended loads, unless the shape of the load is known and constant, the windward face is to be taken as 0,1 m^2/kN for loads smaller than or equal to 50 kN and 0,05 m^2/kN for loads greater than 50 kN.

For loads greater than 250kN, the constant windward face is taken as 15 m^2.

The coefficient c to be used in the pressure formula p = cq is to be taken as 1,2.

2.4.2 Snow and ice loads

In general, snow and ice loads acting on the crane structures may be disregarded except where a specific design or application indicates that they are significant.

2.5 Access-way and platform loads

2.5.1

Access-ways and platforms are to be designed to carry in addition to existing loads, an accidental load of 3 kN on a square having 2500 cm^2 area in the most unfavourable spot.

Structures designed for personnel access are to be taken as supporting a concentrated load of 1 kN.

3 Strength Analysis

3.1 Design criteria

3.1.1 Load combinations

The crane design is to be considered with respect to loads resulting from the following conditions:

Case I : Crane operating without wind

Case II : Crane operating with wind

Case III : Crane subjected to exceptional loading

Case IV : Crane in stowed condition

3.1.2 Case I

For the condition of the crane operating without wind the effect of the following forces acting simultaneously is to be considered:

- Dynamic forces due to hoisting of the load and accessories: ψ (SWLH)
- Self-weight of the crane: P_p taking into account the acceleration effect, whose values are indicated in Ch 5, Tab 2 and Tab 3.
- Horizontal components of forces: W_{offSB} , W_{sideSB}, W_{sideCI} , W_{offCM} , W_{sideCM}

  For further details, see relevant definitions in Ch 5
- The most unfavourable horizontal loads due to slewing and hoisting of the crane and load.

3.1.3 Case II

In addition to the forces specified in [3.1.2], the wind loads W, as defined in [2.4.1] or as specifically defined (for the particular environmental o operation), is to be considered.

3.1.4 Case III

The crane may also need to be considered with respect to the following exceptional load conditions:

a) coming into contact with buffers
b) failure of the hoist wire or sudden release of load for cranes with counterweight with two horizontal forces and wind loading (hoisting factor 0,2 ÷ 0,3)
c) test loading
d) crane not in service but not in the stowed condition, with maximum wind loads as specified in [2.4.1] specifically for case III..

3.1.5 Case IV

The crane is considered in the stowed condition and subjected to dynamic forces due to navigation as specified in Ch 4, [2.4] b) and to a wind speed of 80 m/s acting in the most unfavourable direction (parallel or transverse direction).

3.2 Strength checks

3.2.1 General requirements

Verification of cranes is to be performed for the load combinations specified in [3.1.1] according to sound basic engineering principles and to the requirements specified in Ch 15.

CHAPTER 7 PERSONNEL LIFTING (MAN RIDING OPERATIONS)

1 General

1.1

1.1.1 Cranes intended for lifting or moving of personnel are to comply with the specific requirements given in this chapter, in addition to the other requirements of these Rules.

1.1.2 Rated capacity

The rated capacity are not to exceed 50% of the rated capacity for lifting of loads at the actual radius and wave height. This information are to be given in the instructions, load chart and by the rated capacity indicator whenever the mode for lifting of personnel is selected (see [1.1.6])

1.1.3 Secondary brake

In addition to the normal working brake, hoisting and luffing winches are to be equipped with a mechanically and operationally independent secondary brake, with separate control circuits.

The secondary brake is to, preferably, act directly on the winch drum being, however, a fully independent load path considered acceptable. Means are to be provided for the user to conduct an individual test of the secondary brake. The secondary brake is to fulfil the requirements given in Ch 14, [6.2] for the rated capacity for lifting of personnel.

1.1.4 Cylinders

Where cylinders are used for luffing, folding or telescoping they are to be provided with a "mechanical" brake in accordance with Ch 14, [6.2].

Alternatively each motion is to be allowed by two independent cylinders where each cylinder is independently able to hold the rated capacity for personnel lifting.

1.1.5 Basket

Lifting of personnel is to be only performed using equipment especially designed for the purpose, e.g. baskets according to EN 14502-1 or equivalent standards.

Specifications of baskets are to be according to following provisions:

- Baskets are to be preferably of soft type construction
- The rated load of the basket is calculated as:
  - 165 kg for the first person
  - 100 kg for the following ones
- The design of the basket is to be such that personnel can stand on the periphery and can hold the basket
- The dimensions of the basket are to be such that it is stable when lowered on the deck
- The allowed number of persons is to be affixed on the basket.

1.1.6 Controls, indicators and safety systems *(1/1/2023)*

The lifting appliances used for personnel lifting shall be fitted with means to luff down and lower load at controlled speed in case of electrical power failure, rupture of any hydraulic fluid pipe under pressure or in the event of failure in the control system.

The control station is to be equipped with a manual key selections witch for the purpose of lifting personnel.

The switch is to be lockable in both positions with a removable key and have an adjacent warning light continuously indicating when it is activated. The key may only be removed in normal operation (no personnel lifting) and the light is not to illuminate unless selection for personnel lifting is made.

Selection of mode is only to be allowed without load on the hook.

When the mode for personnel lifting is selected, the following is to be fulfilled:

a) All brakes are automatically to be activated when the controls are in neutral position and in case of emergency stop being activated or when power failure occurs
b) The automatic and manual overload protection systems (AOPS and MOPS respectively) are to be overridden, i.e. it is to be impossible for them to be activated
c) When fitted, the following:
   - active heave compensation system (AHC)
   - active rope tensioning system (ART)
   - passive heave compensation system (PHC)
   - passive rope tensioning system (PRT)

   are to be overridden, i.e. the activation of these systems is not to be allowed.

1.1.7 Information for use

Operational procedures, including any conditions, precautions and limitations for the lifting of personnel are to be reported in the instruction for use provided by the crane's manufacturer to the purchaser.

Except for emergency conditions, the operational limitations to be fulfilled, when lifting personnel and unless otherwise stated by the crane's manufacturer, are the following:

- mean wind velocity: 10 m/s
- significant wave height: 2 m
- visibility: daylight
- in case of movable crane, no travelling of the crane is allowed when moving of personnel is being carried out.

The crane operator is to be provided with means for continuous communication with the personnel to be lifted or a designated person, who has direct view to the personnel being lifted, is to be available nearby.

1.1.8 Testing and certification

In addition to the certification usually issued for the crane when used to lift and move goods (see Ch 2), the following activities are to be performed for the certification of the crane used for moving personnel:

a) visual and dimensional inspection to ascertain the compliance of the basket with the adopted recognized standard, unless structural drawings have been previously approved
b) review of the material certificates provided by the manufacturer
c) overload test of the basket according to the figure suggested by the manufacturer but, in any case, not less than 2,2 times the rated load of the basket
d) review of the rope (if any) test certificate where the safety factor is certified to be not less than 10; if the test certificate is not available, the rope is to be tested in the presence of the attending Surveyor

On satisfactory completion of the above, a statement allowing the use of the crane for personnel lifting operation can be issued to the interested party.

A draft of the statement, whose content may be modified according to the specific needs, is indicated hereafter:

STATEMENT No..

This is to certify that, on Client's request, Messrs..
....

the cranes type……...........................intended for use on board the ……......................……………and whose structural drawings have been previously approved by ……..on satisfactory completion of the following activities:

(Note: the testing activities carried out are to be listed)

- ....
- ....
- ....
- ....
- ....
- ....
- ....
- ....
- ....
- ....

have been deemed suitable also for movement of personnel on board the above mentioned unit.

The operating limitations of the cranes, when used for man riding service, are the following:

- Maximum lifting capacity:...kN
- Mean wind velocity:...m/s
- Maximum significant wave height:...m
- Visibility:..
- Travelling of crane:...

Issued at ……………………........on...........……………………………………

The validity of the statement is strictly connected to the validity of the Cargo Gear issued for the crane intended for lifting of goods.

CHAPTER 8 SUBSEA CRANES

1 General

1.1 Application

1.1.1 This Chapter provides additional requirements for the certification of lifting appliances intended to perform subsea lifting operations at sea and installed on ships, floating units or fixed offshore facilities.

1.1.2 The requirements of Ch 5 and Ch 15 are to be complied with unless otherwise specified in the present Chapter.

1.1.3 The specific ship requirements for the Launch and Recovery Systems used to handle a diving bell are specified in Pt F, Ch 13, Sec 14 of Tasneef Rules for the classification of ships containing the criteria for the assignment of the additional class notation **DIVINGSUPPORT**.

1.2 Documents to be submitted

1.2.1 The following documents are to be submitted in addition to those listed in Ch 1, Art 3:

- Load charts for subsea lifting based on the prescriptions of this Chapter.

2 Design loads

2.1 General

2.1.1 For the purpose of application of Ch 5, the provisions of this Article are to be considered in addition to the ones of Ch 5, [2].

2.1.2 The SWL to be used for submersible handling systems is to be taken as the greater of:

a) The maximum in-air weight of the submersible and exposed length of hoisting rope

b) The maximum weight of the exposed length of hoisting rope, together with the combined in-water weight of the submersible and submerged length of rope.

2.1.3 When using a subsea lifting appliance, the possible overweight of water and solids swept along during ascent so as suction resistance due to the sea ground is to be anticipated and accounted for.

2.2 Vertical dynamic amplification factors

2.2.1 The amplification factors for subsea lifting shall be based on the sea & operating conditions justified by an analysis of the accelerations or model predictions taking into consideration the ship/offshore unit motions and the effects of the load passing through the air/water interface (also called splash zone).

2.2.2 Normally, for operations up to a significant wave height of 2,0 m, the dynamic amplification factor ψ as defined in Ch 5, [2], is not to be less than 2,1.

For operations with a significant wave height of more than 2,0 m, the dynamic amplification factor is to be further increased and evaluated on a case by case basis.

2.3 Out of plane motions

2.3.1 In general, for operations up to a significant wave height of 2.0 m, the offlead and sidelead angles are assumed to be 10° and to be acting simultaneously while the submersible is in the water, passing through the air/water interface or splash zone. The offlead and sidelead angles to be applied to the suspended load.

3 Controls, indicators and safety systems

3.1 General

3.1.1 Lifting appliances intended to perform subsea lifting are to be provided with indicators of the length of the paid-out rope.

4 Testing

4.1 Testing of subsea cranes employed for unmanned submersible systems

4.1.1 The requirements of Chapter 2 are to be applied.

4.2 Testing of subsea cranes employed for manned submersible systems

4.2.1

a) A ‘static’ load test according to Chapter 2 is to be applied. In the case of cranes or A frames, this load is to be lifted at the maximum and minimum radii or inboard/outboard positions and at an intermediate position.

b) A ‘dynamic’ load test equivalent to 1,1 x SWL. This test is to demonstrate that the hoist brake system is capable of stopping the load whilst being lowered at maximum speed to simulate a power failure.

c) An ‘operational’ load test equivalent to 1,25 x SWL. This test is to be carried out over the full range of operation of the lifting appliance.

d) review of the rope (if any) test certificate where the safety factor is certified to be not less than 10; if the test certificate is not available, the rope is to be tested in the presence of the attending Surveyor.

CHAPTER 9 LIFTS FOR CARGO HANDLING

1 Application

1.1 General

1.1.1

This Chapter applies to on board lifts for cargo handling, including vehicles without persons on board, in harbour or a sheltered water environment. See Ch 14 for machinery and systems.

The conditions for total or partial extension of these requirements to systems designed to operate in offshore conditions will be considered in each case.

Lifts which are part of the deck structure are to comply with the requirements relative to structural strength and, if necessary, to watertightness as specified in the relevant regulations as applicable (Load Line or SOLAS Conventions).

Where systems are to be subjected to heavy duty cycles, Tasneef may stipulate requirements additional to those specified in the following Articles.

2 Design criteria

2.1 General

2.1.1 The design is to consider operation of the lift with ship in harbour and lift in the stowed condition with ship is at sea.

In the first case, the following forces are acting:

- weight of lift and associated components;
- applied loading (working load);
- dynamic forces due to lift movement;
- static forces due to inclination of the ship.

In the second case, the following forces are acting:

- weight of lift and associated components;
- applied load due to cargo loading;
- dynamic forces due to ship motion.

The most unfavourable load conditions due to asymmetric loading are to be considered by the Designer during the movement phases of the lift. Forces relative to specific conditions, such as initial acceleration of the lift, end of run, special characteristics of the system and anomalous operation, which are not considered in the plans are to be identified.

Where the above forces generate more severe conditions, they are to be given special consideration.

Such conditions are to be specified in the documentation to be submitted to Tasneef for approval. In any case, the Designer is responsible for the compliance of the design with these Rules.

Operational allowance, operational limits and maintenance requirements are to be detailed in the specification/s issued by the Designer and/or Manufacturer, who is/are to submit them to the user of the system. A copy is to be submitted to Tasneef for information purposes.

The above-mentioned specification/s are to indicate the limit conditions of the system's reliability on the basis of design and evaluation criteria under the responsibility of the Designer and/or Manufacturer.

Tasneef may require other more onerous and restrictive operational limitations in addition to those required by these Rules, on the basis of the above specifications.

Therefore, it is recommended that the above reliability limits should be specified at the time of submission of the initial documentation.

Tasneef may take these limits into account when establishing the conditions on which approval of the system is based.

For the purposes of Tasneef certification and its validity, the above-mentioned specifications are intended to be binding for the user, who is responsible for correct operation of the system.

2.2 Loads

2.2.1 The weight of the lift and associated fittings, the weight of the load to be hoisted and the applied load when the lift is in the stowed condition are to be clearly indicated in the plans submitted for approval.

The above-mentioned loads are to correspond with those taken for the structural verification of the ship. In the case of vehicles, the loads are to include all necessary details for correct identification (vehicle weight, axle loading, distance between the axles, number of wheels, tyre print dimensions).

In the stowed condition, the evenly distributed load considered for the verification of the deck is to be considered as acting on the lift.

2.3 Dynamic forces

2.3.1 In the absence of more accurate data, an increase in weight equal to 20% may be assumed in considering the dynamic forces resulting from the movement of the lift.

Dynamic forces due to the ship motion acting on the lift in the stowed condition and its stowage arrangements are to be taken as resulting from the combination of an acceleration normal to deck of ± 1 g with an acceleration parallel to deck in fore and aft direction of ± 0,5 g, or with an acceleration parallel to deck in transverse direction of ± 0,5 g and a static heel of 30° in both cases.

2.4 Inclination

2.4.1 Unless otherwise specified, in the calculation of static forces due to ship inclination, the angle of heel and angle of trim are to be taken as 5° and 2°, respectively.

Values other than the above are to be specified in the documents relative to lifts.

3 Allowable stresses

3.1 General

3.1.1 For calculations carried out with the traditional beam theory, the values of allowable stresses σ_{amm}, τ_{amm} in N/mm^2 and of the allowable deflection f_{amm} in metres for verification relative to the first and second cases as specified in [2.1] are, respectively, as indicated in Tab 1.

Table 1

	1st case	2nd case
σ_{amm}	140 / K	175 / K
τ_{amm}	80 / K	100 / K
f_{amm}	0,0025 l	0,0025 l

where:

K : coefficient of higher strength steel as defined in Pt B, Ch 4, Sec 1 of the Rules for the classification of ships

l : beam span.

The above-mentioned allowable stresses are valid for steels having a ratio yield point/breaking load not greater than 0,7. Other ratios will be given special consideration.

Deflection may be limited to the need to ensure watertightness when required. Ideal stress σ_{id} is given by the following formula:

$$\sigma_{id} = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x \cdot \sigma_y + 3\tau_{xy}^2}$$

where:

σ_x , σ_y : normal tensions in two perpendicular directions

τ_{xy} : tangent tension.

The bulkling check of the plating member considered may be carried out by means of direct calculation.

4 Plating

4.1 General

4.1.1 The plating thickness of lifts intended to support heavy load vehicles or fork-lifts is to be not less than the value t, in mm, obtained by the following formula:

$t = 4,5 \cdot (c \, . \, P \, . \, K)^{0,5}$

c : coefficient given in Tab 2 as a function of the dimensions u and v of the tyre print (see Fig 1)

P : load on the tyre print, in KN.

Where there are double wheels, the tyre print consists of both.

For fork-lifts subject to tipping where the load on the print is not specified, the value of P is to be calculated considering the total mass of the vehicle, including the cargo handled, applied to one axle only.

The Designer is to supply details of the tyre pressure, wheel dimensions, loads on wheels and tyre print dimensions. Where these data are not available, an approximate value of the thickness t, in mm, may be calculated by the following formula:

$t = 0,32 \; K_1 \cdot (P_1.K)^{0,5}$

where:

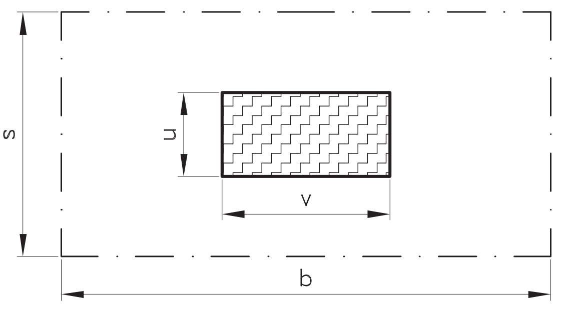
K_1 : 3,6 for 4 wheels-per-axle vehicles

4,45 for 2 wheels-per-axle vehicles

P_1 : axle load, in kN.

Where it is intended to use vehicles with steel wheels or tracked vehicles, the plating thickness will be specially considered by Tasneef on a case-by-case basis.

Figure 1



5 Gaskets

5.1 General

5.1.1 The material for gaskets is to be resistant to saline environmental conditions and sea water; gaskets are to be fixed to the panels of the lift so as to maintain watertightness.

Steel parts in contact with gaskets are not to have sharp edges.

Forces due to the weight of the lift and applied loadings as well as sea loading are to be transferred to stiffening structures around the openings of the lift or to deck by direct contact by means of suitable devices capable of supporting the above-mentioned forces. Watertightness is ensured by means of a suitable soft gasket.

Metal contact between the lift and the hull is to be achieved, if necessary, by means of a suitable connection for grounding.

The gasket and the locking and supporting devices are to be efficient even during movement between deck and coamings. If necessary, appropriate arrangements are to be provided in order to limit this movement.

Locking devices are to be installed so as to apply a sufficient compression on the gaskets between the lift and the coamings.

Locking devices are to be fixed in place with suitable means and are not to be easily removed.

When hydraulic devices are used, they are to be blocked in the closed position by mechanical devices in the event of failure of the hydraulic system.

6 Blocking devices

6.1 General

6.1.1 Blocking devices are to be capable of supporting loads generated by the loading condition specified in [2.1].

During the various operational phases of the lift, the blocking devices are to be automatically connected whenever the lift stops on deck for loading and unloading.

Loading and unloading of the lift is not allowed if these devices are not connected. Where of retractable type, the connection of such devices enables the supply of power to the lift to be cut off, while disconnection enables the lift to be lowered. In the case of hydraulic movement, the devices are not to be able to be disconnected until the system has reached sufficient pressure.

If the blocking devices are remote controlled, direct control is also to be possible.

7 Guides and braking devices

7.1 General

7.1.1 Guides are to be provided to restrict horizontal movement of the platform during operation. These guides are to allow free vertical movement of the lift without obstruction and without stopping. They are to be of suitable strength.

Breaking devices are to be provided to hold the lift in position in the event of damage to the hoisting system.

8 Safety devices

8.1 General

8.1.1 Suitable safety devices are to be provided to prevent the lift from moving until covers, where fitted, or closed barriers are removed, or when the load is greater than the allowed values.

Suitable devices are to be provided to keep the stresses in the structures and components of the system within the design values, in particular in the initial acceleration, end of run and in other specific individual operating conditions.

During movement of the lift in the area concerned, suitable audible and visual alarms are to be activated.

The area concerned with movement of the lift and deck openings is to be protected by suitable safety barriers. The relevant closing control is to be positioned in way of the operating station of the lift and is to enable:

- the lift to be manoeuvred only when the barrier is closed;
- barriers to be opened only when the lift is at deck level.

Where some obstruction prevents movement, the lift is to stop and maintain its position.

The Designer is to provide for automatic devices that stop movement in the event of anoperational a nomaly or irregular operation.

Table 2

b / s	u / s → v / s ↓	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
1	0,5	0,242	0,174	0,138	0,113	0,094	0,080	0,077	0,060	0,052	0,045
	1	0,222	0,160	0,122	0,099	0,079	0,066	0,055	0,045	0,037	0,030
	2	0,198	0,134	0,098	0,073	0,053	-	-	-	-	-
	3	0,175	-	-	-	-	-	-	-	-	-
1,4	0,5	0,228	0,189	0,158	0,128	0,111	0,096	0,083	0,073	0,064	0,056
	1	0,217	0,177	0,143	0,116	0,098	0,082	0,070	0,060	0,051	0,043
	2	0,196	0,153	0,119	0,092	0,072	0,058	0,046	-	-	-
	3	0,178	0,134	0,100	0,072	-	-	-	-	-	-
≥ 2,5	0,5	0,232	0,196	0,163	0,135	0,117	0,100	0,087	0,077	0,067	0,059
	1	0,219	0,184	0,150	0,123	0,105	0,088	0,076	0,066	0,056	0,048
	2	0,199	0,161	0,129	0,101	0,082	0,067	0,055	0,046	0,037	0,031
	3	0,185	0,142	0,108	0,083	0,064	0,051	0,038	0,028	0,019	0,012

9 System for moving the lift

9.1 General

9.1.1 In the case of hydraulic movement of lifts, the requirements specified in Pt C, Ch 1, Sec 10 of the Tasneef Rules for the classification of ships are to be complied with.

Scantlings of wire rope and chains used in raising the lift are to correspond with the requirements specified in Ch 11 and Ch 12.

10 Materials and welded connections

10.1 General

10.1.1 Materials used in the construction of lifts are to comply with the requirements specified in Pt B, Ch 4, Sec 1 of the Tasneef Rules for the classification of ships. In general, such materials are to satisfy the testing requirements specified in Part D of the Rules for the classification of ships.

Other materials and procedures may be approved if considered to be suitable for the specific application.

11 Tests and inspections on board

11.1 General

11.1.1 The requirements specified in Ch 2 are to be complied with as far as applicable.

In particular, after installation on board, after major repair work that may affect the safety or tension strength of the system and every 5 years, the lift is to be subjected to the following tests:

Operational overload test, with load equal to:

- 25% of SWL for safe working loads less than or equal to 200 kN
- SWL with an increase of 50 kN for 200 < SWL < 500 kN
- 10% of SWL for safe working loads greater than 500 kN.

In addition, every 6 months, with no possibility of deferment, lifts are to be inspected in order to verify the satisfactory condition of all components and correct operation of the equipment.

In particular:

- the hoisting arrangements are to correspond with the drawings and the marking plates are to indicate lift performance;
- all loose items are to be examined and the Surveyor may require disassembly depending on the state of maintenance of the system as a whole;
- the hydraulic system is to be examined, including piping;
- operation of safety devices is to be tested;
- the integrity of all loaded fittings and of guides is to be examined;
- the watertightness of gaskets is to be checked by means of a hose test;
- an operational test and, if necessary, an overload test are to be performed.

At the request of the interested party, an annual survey may replace the six-monthly survey, without further deferment, on condition that a maintenance and inspection procedure is provided. This procedure is to include completion of the six-monthly survey and recording of the operations carried out by the ship personnel in a register provided for the purpose.

12 Documentation to be submitted for examination

12.1 General

12.1.1 The following is to be submitted to Tasneef for examination:

a) design calculation with complete indication of all necessary components for testing as well as of the properties of the materials used;

b) main plans of the structure;

c) detailed drawings of the hoisting systems with the details of components for connection to hull and the characteristics of all items of loose gear, including any wire ropes and/or chains;

d) detailed diagrams of any hydraulic or compressed air systems;

e) detailed plan of the electrical system with indication of the load, type and characteristics of wire cables, nominal data for calibration of switches, protection and manoeuvering devices;

f) calculation of short-circuit currents in the most important parts to test the characteristics of the protection equipment;

g) testing certificate for motors.

CHAPTER 10 VEHICLE RAMPS

1 Application

1.1 General

1.1.1 This Chapter applies to mobile ramps used for loading and unloading vehicles as well as for manoeuving in harbours or sheltered water.

Ramps designed to operate in conditions other than those above will be specially considered.

As regards their position, ramps are to comply with the structural strength and watertightness requirements of the relevant Rules as applicable.

Ramps that are not subjected to movement in loaded conditions are not to be noted in the Register of loading and unloading systems of the ship.

2 Design criteria

2.1 General

2.1.1 The design is to take into consideration the following conditions:

a) loaded condition

b) manoeuvring condition

c) stowed condition.

In case (a) above, the ramp is to be considered in the worst possible condition and supporting arrangement (either supported by the quay or its hoisting mechanism), and subjected to the following forces:

- its own weight
- load of vehicles
- dynamic forces due to vehicle movement
- static forces due to ship inclination and slope of the ramp.

For manoeuvring of the ramp, the ramp is subjected to its own weight, dynamic forces due to manoeuvring and forces due to ship inclination.

In the stowed condition at sea, the ramp and its locking mechanisms are subjected to their weight and dynamic forces due to ship motion.

2.2 Loads

2.2.1 The plans submitted for examination are to clearly specify the following data: weight of the ramp, design applied loading, operating angles and speeds, loads applied to the ramp in the stowed condition.

The above-mentioned loads are to correspond with those taken for the structural verification of the ship. In the case of vehicles, the loads including all necessary details for correct identification are to be specified (vehicle weight, axle loading, distance between axles, number of wheels, tyre print dimensions).

2.3 Dynamic forces

2.3.1 Unless otherwise specified, the weight of the ramp is to be multiplied by 1,2 in order to take account of the dynamic forces due to ramp manoeuvring.

The applied load due to vehicles is to be multiplied by 1,1 to take account of dynamic forces due to vehicle movement.

Unless otherwise specified, dynamic forces due to the ship motion acting on the ramp in the stowed condition and its stowage arrangements are to be taken as resulting from the combination of an acceleration normal to deck of ± 1 g with an acceleration parallel to deck in fore and aft direction of ± 0,5 g, or with an acceleration parallel to deck in transverse direction of ± 0,5 g, where the static heel is 30° in both cases.

2.4 Inclination

2.4.1 The ramps are to be designed to operate safely and efficiently at an angle of heel of 5° and an angle of trim of 2° acting simultaneously.

The slope of the ramp during operation is not to exceed 10%. Greater slopes will be the subject of special consideration.

3 Allowable stress

3.1 General

3.1.1 The requirements specified in Ch 9 are to be complied with. In the event of exceptional loadings, greater allowable stresses may be accepted in each case at the discretion of Tasneef

4 Plating and gaskets

4.1 General

4.1.1 The requirements specified in Ch 9 are to be complied with.

5 Blocking devices

5.1 General

5.1.1 Blocking devices are to be capable of supporting loads applied by the inertia force generated by the ship motion specified in [2.3].

6 Safety devices

6.1 General

6.1.1 An alarm is to be provided indicating when the slope of the ramp is greater than the design value.

Suitable devices are to be provided to prevent manoeuvring the ramp when blocking devices are not disconnected.

Suitable end-of-run devices are to be provided in order to prevent undue stress on the structures of the ramp, hinges and cables.

7 System for moving the ramp

7.1 General

7.1.1 The requirements specified in Ch 9 are to be complied with.

8 Materials and welded connections

8.1 General

8.1.1 The requirements specified in Ch 9 are to be complied with.

9 Tests and checks on board

9.1 General

9.1.1 Ramps manoeuvred with applied loading are to be tested in compliance with the requirements specified in Ch 9.

Ramps that are to be manoeuvred only without load are to undergo an operational test and all equipment and safety devices are to be tested after installation on board, as well as after major renewal, alteration or repair work, at the discretion of the Surveyor in charge of the inspection, and during the ordinary hull survey.

In addition, during special surveys, ramps are to be inspected in order to verify the satisfactory condition of all elements and correct operation of the equipment; in particular:

- the hoisting arrangements are to comply with the plans;
- all loose items are to be examined and the Surveyor may require disassembly depending on the maintenance condition of the system as a whole;
- the hydraulic system is to be examined, including piping;
- operation of safety devices is to be tested;
- the integrity of all loaded fittings is to be examined;
- the watertightness of gaskets is to be hose tested;
- an operational test is to be performed.

At the request of the interested party, an annual survey may replace the six-monthly survey, with no deferment, on condition that a maintenance and inspection procedure with completion of the survey every 6 months is provided.

This procedure is to include recording of the operations carried out by the ship personnel in a register provided for the purpose.

10 Documentation to be submitted for examination

10.1 General

10.1.1 The following is to be submitted to Tasneef for examination:

a) design calculation with complete indication of all necessary components for testing as well as of the properties of the materials used;

b) main plans of the structure;

c) detailed drawings of the hoisting systems with the details of the components for connection to hull and the characteristics of all items of loose gear, including any wire ropes and/or chains;

d) detailed diagrams of any hydraulic or compressed air systems;

e) detailed plan of the electrical system with indication of the load, type and characteristics of wire cables, nominal data for calibration of circuit breakers, protection and manoeuvring devices;

f) calculation of short-circuit currents in the most important parts to test the characteristics of the protection equipment.

In addition, for ramps having greater size and weight and generally formed by various sections, diagrams of all opening and closing phases with the relative position of the various elements and sequence of the manoeuvres and stresses on the supports in the various phases are to be submitted.

CHAPTER 11 ROPES FOR RUNNING AND STANDING RIGGING

1 Wire ropes

1.1 General requirements

1.1.1

Wire ropes are generally to comply with the requirements of an international or recognised national standard and are to be suitable for the use for which they are proposed in accordance with manufacturer's recommendations.

Wire ropes are to comply with the requirements specified in Pt D, Ch 4, Sec 1 of the Tasneef Rules for the classification of ships.

2 Fibre ropes

2.1 Running rigging

2.1.1

Steel wire ropes of "Seale", "Warrington" or "Filler" type with not less than 6 strands over a wire core are recommended for running rigging.

A fibre core is generally to be used in all applications for running rigging; cables intended for leading sheaves or to lay around cleats or similar fittings may have both steel or fibre core.

Each strand is generally to consist of not less than 19 wires and may have a fibre or a wire core as mentioned above.

For load manoeuvring, it is recommended that wire ropes consisting of not less than 24 wires should be used.

Where the strand has a fibre core, the wires are to be laid round it in not less than two layers.

With an increase in the diameter of the cable there should be an increase in the number of wires in order to obtain greater flexibility.

The span rope and the cargo runner are to be of steel wire rope. Other constructions will be considered in each case.

Steel wire ropes used with sheaves are to be in one length. Lengthening by splicing of ropes is not permitted.

Steel wire ropes of span ropes fixed to tackles are to be fixed to adequate small bits having a radius not less than 5 times the diameter of the rope. Other fixing systems may be taken into account.

Dimensioning of the fixed span rope is to be verified on the basis of:

a) effective tension on the span rope, if of simple rope
b) tension acting on the becket during lowering phase if the span rope includes a tackle.

Dimensioning of the mobile span rope is to be on the basis of the tension acting on the section of the rope that goes to the winch.

Cargo runners are to be equally dimensioned on the basis of the tension that goes to the winch.

2.2 Standing rigging

2.2.1

Cables for standing rigging are in general to be constructed of 6 or 7 strands over a main wire core.

2.3 Slewing guys

2.3.1

The slewing guy is composed of a preventer (parent), which connects the upper end of the derrick to the upper block of the manoeuvring tackle, and the manoeuvring tackle itself.

Scantlings of the slewing guy are given in Tab 3 as a function of the load of the derrick.

2.4 Splicings

2.4.1 Splicings for wire ropes

Wire ropes are to be suitably prepared at their ends in order to prevent the unwinding of strands and wires.

Traditional splicings are to be performed with not less than three tucks with each whole strand of the rope and not less than two tucks for one half strand.

With the exception of the first, tucks are to be tucked against the lay of the rope. Protective covers for splicings are not allowed in as much as they hinder inspection.

2.4.2 Splicings for fibre ropes

Spliced ends are in general layed on a thimble.

Where the rope is manufactured from natural fibres, splicings are to be performed with not less than three tucks with each whole strand of the rope and not less than two tucks for one half strand.

Where the rope is manufactured from polyamide or polyester, splicings are to be performed with not less than four tucks with each whole strand of the rope and one tuck for one quater strand.

Where the rope is manufactured from polypropylene, not less than three tucks with each whole strand are to be performed.

All strands are to be tucked against the lay of the rope. Length of ends leaving the ropes are to be not less than three times the diameter of the rope. Ropes are to be in one length.

Lengthening by splicing of ropes is not permitted.

Mechanical terminals are to be approved. In general, fibre ropes are permitted for slewing guys having working load not greater than 40 kN also for connection of the head of union purchase rigs.

2.5 Terminal connections

2.5.1 Splicings fitted by pressed sleeves

The application of a sleeve is to be carried out by a company previously authorised by Tasneef this company will be responsible for the application of sleeves having the same scantlings, mechanical and chemical characteristics found in the previously tested samples.

The testing operations of a sleeve are as follows:

a) visual inspection

b) checking of workshop certification concerning sleeves

c) bench testing to double working load as specified below:

- the testing is to be carried out on all sleeves for which application was not witnessed by a Tasneef Surveyor. In the case of a large number of homogeneous sleeves, bench tests may be partially extended to the Surveyor's satisfaction;
- the testing in (c) is not required if the Tasneef Surveyor witnesses the sleeve application and verifies the correct procedure.

In order to determine the safe working load of the wire-sleeve connection, taking into account that the pressed sleeve produces an efficiency loss of the wire caused by a notch, a modified coefficient is to be applied to the breaking load of the wire equal to:

- 0,95, for wires having diameter less than or equal to 26 mm
- 0,925, for wires having diameter > 26 mm.

2.5.2 Sockets

The application of sockets is to be carried out by an authorised company in compliance with recognised standards (ex. UNI EN 13411-4) and by specialised personnel, using melted material (lead, tin and zinc alloy).

The testing operation of sockets is as follows:

a) Rule testing of sockets and acceptance on the basis of standard type or in compliance with approved drawings

b) visual examination

c) bench testing.

The testing in (c) is not required if the Tasneef Surveyor witnesses the socket application and verifies the correct procedure.

In order to determine the working load of the wire rope socket connection, no correction coefficient is to be applied.

2.5.3 Terminal connection forming eye or loop splices adopting clamps or hand splicing

Clamps are to be placed correctly according to the wire Manufacturer's recommendations; correct hand splicing is to be carried out according to recognised standards.

In order to determine the working load of the wire terminal connection arranged by clamps or splicing, the following correction coefficients are to be adopted:

- 0,90, for wire up to 10 mm
- 0,75, for wire equal to or greater than 40 mm
- for intermediate wire diameters, correction coefficients are to be derived by linear interpolation between 0,90 and 0,75.

The turnbuckles are to have a working load not less than 1/5 of the breaking load of the wire rope to which they are to be connected; in any case, it is not necessary that such fittings have a safe working load exceeding that required in relation to their intended position.

2.5.4 Other kinds of terminal connection

For other kinds of terminal connection, the testing procedure and correction coefficients to be adopted in order to determine the working load of the wire will be stipulated in each case, according to criteria analysis similar to the provisions of the previous paragraphs.

2.5.5 Terminal connection fitted on lifting appliances on board ship coming from foreign flag

In the case of arrangements of ships coming from foreign flags having a cargo gear certificate, a pressed sleeve without any marks may be accepted on condition that the cargo gear certificate is valid and following thorough visual inspection of the wire connection. Following satisfactory outcome of the above checks, the pressed sleeve can be marked with the personal stamps of the Tasneef Surveyor responsible for the survey, without any issuing of Form3 for the connection.

2.5.6 Terminal connection filled with resins

Wire connection using resins, in compliance with standards recognised by Tasneef (ex. UNI ISO/TR 7596), may be accepted subject to special conditions stated in each case by Tasneef

2.6 Renewal of steel wire ropes

2.6.1

A steel wire rope is to be renewed in the following cases:

- where there are signs of corrosion, tendency to form empty spaces, separation of the strands and/or wires;
- where there are signs of wear, indicated by flattening of the wire;
- where the number of broken or damaged wires exceeds 5% of the total over a 10 metre length of rope;
- where there are broken wires concentrated in one strand or in a section of rope shorter than 10 times the diameter;
- where there are broken wires in way of the splicing or near terminal connections (during inspection of the rope, clamps, thimbles and similar fittings are to be removed).

2.7 Stresses in the various parts of a tackle

2.7.1 General

The tension p of a tackle for suspending load Q (see Fig 1) is given by the following formula:

$$p = Q \cdot K \cdot K'$$

where:

K : coefficient given in Tab 1 depending on the number of wires n supporting the load and on the efficiency of the sheaves:

$$K = \frac{1 - \mu}{1 - \mu^n}$$

K′ : coefficient given in Tab 2 depending on the position of the section of cable considered and on the efficiency of the sheaves.

Table 1

n Numer of wires supporting the weight	μ^n	$K = \frac{1-\mu}{1-\mu^n}$	μ^n	K	μ^n	K
1	0,98	1	0,95	1	0,90	1
2	0,9604	0,5050	0,9025	0,513	0,81	0,5263
3	0,9412	0,3401	0,8574	0,351	0,729	0,369
4	0,9224	0,2577	0,8145	0,270	0,6561	0,2907
5	0,9040	0,2083	0,7738	0,221	0,5904	0,2441
6	0,8859	0,1752	0,7351	0,189	0,5313	0,2133
7	0,8682	0,1517	0,6983	0,166	0,4781	0,1916
8	0,8508	0,1340	0,6634	0,149	0,4302	0,1755
9	0,8338	0,1203	0,6302	0,135	0,3871	0,1631
10	0,8171	0,1093	0,5987	0,125	0,3483	0,1534
11	0,8008	0,1004	0,5688	0,116		
12	0,7848	0,0929	0,5404	0,109		
13	0,7691	0,0866	0,5133	0,103		
14	0,7537	0,0812	0,4877	0,0976		
15	0,7386	0,0765	0,4635	0,0932		
16	0,7238	0,0724	0,4401	0,0893		
17	0,7093	0,0687				
18	0,6951	0,0655				
19	0,6812	0,0627				
20	0,6676	0,0601				

Table 2

Wire position	K′ (hoisting)	K′ (lowering)	K′ (hoisting)	K′ (lowering)	K′ (hoisting)	K′ (lowering)
	μ = 0,98		μ = 0,95		μ = 0,90	
0	μ^{n-1}	1	μ^{n-1}	1	μ^{n-1}	1
1	1	μ^{n-1}	1	μ^{n-1}	1	μ^{n-1}
2	1,0204	μ^n	1,053	μ^n	1,111	μ^n
3	1,0412	μ^{n+1}	1,108	μ^{n+1}	1,234	μ^{n+1}
4	1,0624	μ^{n+2}	1,166	μ^{n+2}	1,372	μ^{n+2}
5	1,084	μ^{n+3}	1,228	μ^{n+3}	1,524	μ^{n+3}
6	1,1061	μ^{n+4}	1,292	μ^{n+4}	1,693	μ^{n+4}

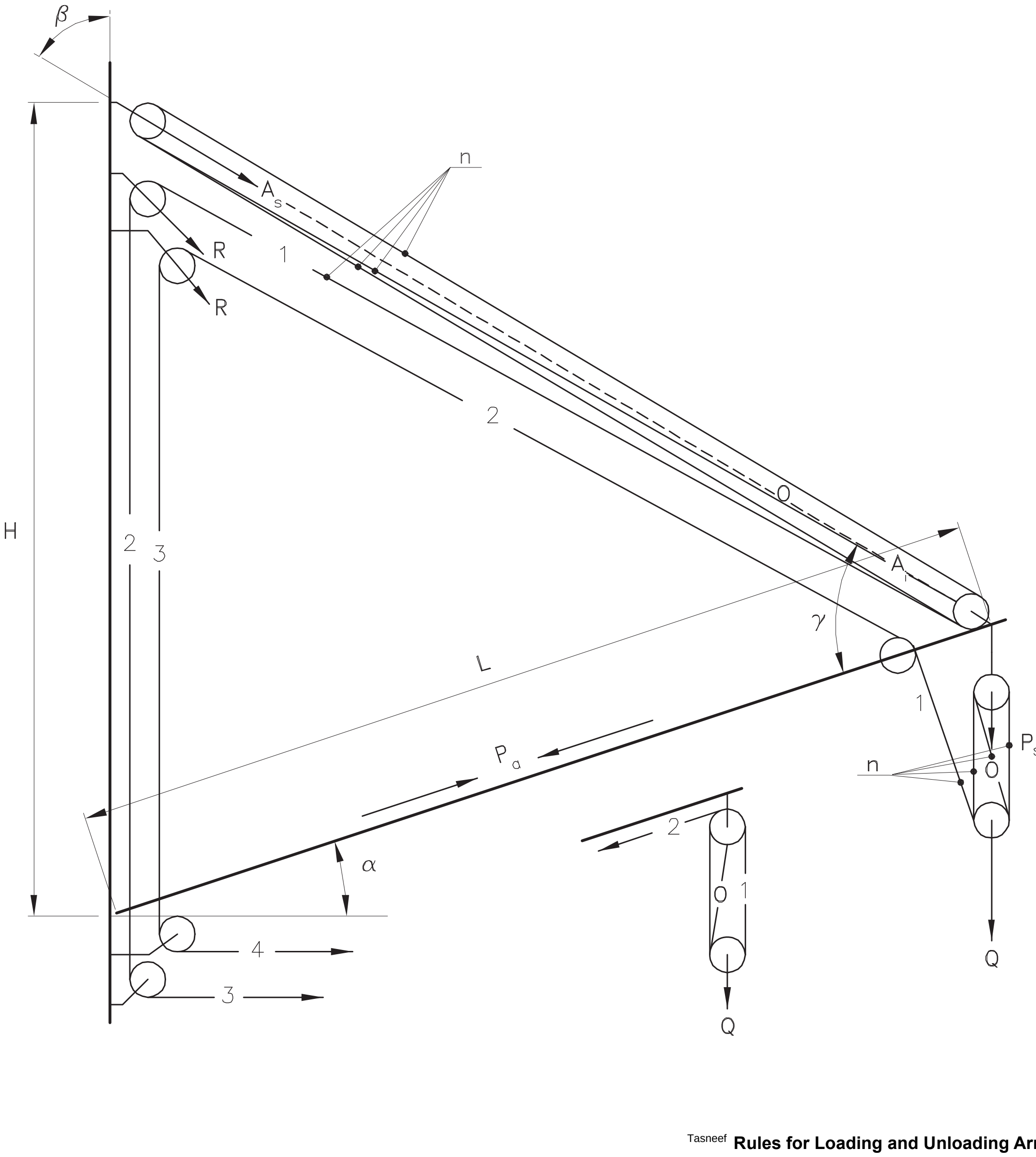
Note 1: In general, the efficiency coefficient μ is to have the following values:
μ = 0,98 for sheaves assembled on bearings
μ = 0,95 for sheaves assembled on ferrules
μ = 0,90 for sheaves of wooden blocks rigged with fibre ropes.

Table 3 : Slewing guys

Capacity of derrick P kN	Working load of guy C L kN	Slewing guy pendant in steel Minimum diameter mm	Tackle				
			Number of sheaves	Wire strair kN	Breaking load C R kN	Wire diameter	
						Hemp rope quality II	Manilla quality II
10 [1]	10	10	1 + 1	3,6	25,3	20	18
≤ 20	15	12	1 + 2	4,3	30,0	22	20
≤ 29	20	14	2 + 2	4,8	33,4	22	22
≤ 39	25	15	3 + 2	5,3	36,6	24	24
≤ 49	29	17	3 + 3	5,7	39,4	24	24
≤ 59	32	18	3 + 3	6,2	42,7	26	24
69 ÷ 93	34	18	3 + 3	6,7	46,0	26	26
98 ÷ 123	37	19	3 + 3	7,1	49,2	28	26
128 ÷ 147	39	20	3 + 3	7,6	52,6	28	28
157 [2]	0,25 P	5 C L	-	-	-	-	-

Note 1: For derricks with SWL less than 10 kN, the working load of the slewing guy may be assumed to be not greater than the SWL
Note 2: Steel wire rope is required

Figure 1



2.8 Working load of ropes

2.8.1 General requirements

The allowable working load for ropes depends on their breaking load according to a safety factor that is a function of the type and working load of the lifting appliance or of its diameter as specified in [2.8.2] and [2.8.3] below for steel wire ropes and fibre ropes, respectively.

Different criteria in compliance with recognised standards may be taken into account.

2.8.2 Steel wire ropes

The breaking load of steel wire ropes is to be determined using recognised procedures.

In particular, it may be obtained by tensioning either a section of the wire rope to fracture or each of the wires of the rope to tension strength until it breaks. In the second case, a suitable laying coefficient is to be taken into account for calculation of the breaking load. Where doubts arise, the test is to be performed on the section of wire rope.

Ropes for running and standing rigging, including preventer guys, are to have a breaking load equal to or greater than n times the maximum tension acting on them, where n is the safety factor which is a function of the SWL, in kN, of the lifting appliances (also including the weight of the hook and load block) and the relative values are as follows:

a) Safety factor n for cranes intended for shipboard operations:

SWL < 100 kN n = 5

$100\,kN \le SWL \le 1570\,kN$ $n = \frac{10^4}{0,902\,SWL + 1893}$

SWL > 1570 kN n = 3

For ropes used for the shrouds of masts, for derrick posts and for fixed span wires of cranes, socketed at ends, the value n is generally to be not less than the above-mentioned values, but may be assumed not greater than 4.

b) Safety factor n for cranes intended for offshore and transhipping operations:

- Running rigging

$$n = \frac{10^4}{0,902\,SWL + 1893}$$ but need not be > 5

or

$n = 2,25\ \psi$

whichever is greater, but shall not be less than 3.

ψ is the vertical dynamic coefficient

- Standing rigging

$$n = \frac{10^4}{0,902\,SWL + 1893}$$ but need not be > 4

or

$n = 2,0\ \psi$

whichever is greater, but shall not be less than 3.

For goods lifts, lifting platforms, ramps and car decks the following loads shall be applied:

- operation without useful load: dead load
- operation with useful load: dead load + nominal load

c) Safety factor n for cranes intended for man riding operations:

Wire ropes used on cranes intended for man riding operations shall have a safety factor not less than 10.

2.8.3 Fibre ropes

The coefficient for man-made or natural fibre ropes by which the breaking load is to be divided in order to obtain the working load depends on the diameter of the rope according to Tab 4.

Table 4

Wire diameter mm	Coefficient
12	12
14 ÷ 17	10
18 ÷ 23	7
24 ÷ 39	7
40	6

CHAPTER 12 LOOSE GEAR

1 General

1.1

1.1.1

These Rules consider the following items of loose gear: shackles, hooks, swivels, lifting eyes, connecting plates, master links, rings, tackles and blocks, etc., through which loads may be connected to the lifting appliance but which are not an integral part of it and which may be easily disassembled.

A hoist, when fitted on particular lifting appliances such as, for example, an engine travelling crane, is not to be considered as loose gear but rather as a built-in/fixed component of the lifting appliance as a whole; therefore the relevant structural checks are to be carried out according to the requirements stipulated in these rules for cranes.

Before initial operation and/or following each repair or alteration affecting the strength, the hand operated pulley blocks are to be subjected to a load test where the test load is to be equal to 1,5 times the hoist SWL.

Items used for connecting the load to the hook, e.g. slings, which are not part of the ship's equipment are not considered as items of loose gear for the purposes of these Rules and are not included in the ILO Register.

Loose gear are, in general, to be designed and manufactured in accordance with international or recognised national standards.

Where the above-mentioned loose gear are not in compliance with recognised standards, their constructional drawings, with indication of the materials used and the heat treatments to which the various components were subjected, are to be submitted for examination.

In general, strength checks of loose gear are to be carried out considering a minimum safety factor of 4 compared with the minimum tensile strength of the material the loose gear is made of.

The safe working load of an item of loose gear is to be not less than the maximum stress to which it is subjected in the system.

Before initial operation and following each repair or alteration of the items of loose gear subjected to the load, they are to be tested and certified as specified in Ch 2.

1.1.2 Design load of loose gears of cranes intended for offshore and transhipping operations

Design load of such loose gear is to be the greatest of:

- $0.75 \cdot \psi \cdot SWL$
- SWL

being ψ the dynamic coefficient for which the crane is designed.

In any case, the safe working load of a loose gear is to be not less than the maximum static design load to which it is subjected once fitted in the lifting arrangement.

2 Materials and heat treatment

2.1 General requirements

2.1.1 Materials used for manufacturing items of loose gear are to comply with the requirements of Part D of the Rules for the classification of ships.

The above-mentioned materials are to be of suitable type, quality and characteristics for the intended purpose, and are subject to Tasneef approval in each case.

Materials used for items manufactured according to design, standards or specifications approved by Tasneef are to comply with the relevant requirements.

Materials that are not covered by the Rules for the classification of ships in force may be accepted at Tasneef discretion following adequate tests and inspections.

Suitable heat treatments are to be provided for the various items depending on their operating characteristics and on the material.

Flame cut items from plates are to be machined, or forged and machined, to ensure a smooth surface. In addition, the arrangement of fibres of the material is to be compatible with the direction of the force acting.

All rotating parts are to be supported with bushed bearings or ball or roller bearings and suitably lubricated.

Items in steel castings or forgings are to be normalised or heat treated after completion of all welding, if any.

Items of loose gear are not to be repaired but are to be replaced as soon as possible.

2.2 Heat treatment

2.2.1

Where the heat treatment is required, it is to be carried out in a closed furnace and with adequate means for controlling temperature and for preventing absorption of impurities in the gaseous state.

If the heat treatment of existing item is not known or if the item may not have been subjected to the required temperature, it is to be normalised at 950/1.000°C and subsequently cooled uniformly before operation.

3 Blocks

3.1 Sheaves

3.1.1

Sheaves may be forged or fabricated from thick steel plates. Castings in steel or spheroidal graphite iron may be accepted.

Grey cast iron or malleable cast iron may be used for sheaves in the following cases:

- Blocks made by one sheave with a maximum load not greater than 100 kN
- Blocks made by more than one sheave having a maximum load on each sheave not greater than 100 kN.

A review of the material certificate issued by the material Manufacturer is to be carried out.

Cast nylon sheaves may also be used subject to prior approval of the manufacturing process and on condition that they have shown satisfactory service experience on shore applications. However, particular attention is to be addressed to the fact that, while tests have revealed greater endurance for ropes used with cast nylon sheaves, the ropes themselves show no apparent external tearing or breaking of elementary wires but may break due to fatigue of the inner wires; consequently, the use of a steel sheave is recommended in the equipment of the system.

The diameter of sheaves with steel ropes is to be measured to the base of the rope groove and is to be not less than 14 times the rope diameter for running rigging and 10 times for standing rigging.

The depth of steel groove in the sheave is to be as far as possible of the same diameter as the rope but, in any case, not less than three-quarters of the rope diameter.

The contour at the bottom of the groove is to be circular and its radius is to be greater than the rope diameter of the sheave.

The diameter of sheaves with fibre ropes measured to the base of the rope groove is to be not less than 5,5 times the terminal diameter of the rope. The depth of the groove is to be not less than 1/3 the diameter of the rope. The radius of the rope groove is to be at least 1mm greater than the radius of the rope.

Blocks intended for use with fibre ropes are not to be fitted with more than three sheaves and a becket or four sheaves and no becket.

If, as outcome of periodical survey or damage occurred, the replacement of sheaves is deemed necessary, the following procedure is to be adopted:

- identification of the sheaves based on the figures reported on the manufacturer's certificates
- visual and dimensional inspection to ascertain the compliance of the sheaves with recognized standards adopted
- review of the materials certificates issued by the manufacturers
- check of the welding procedure specifications (WPS) if applicable
- magnetic and ultrasonic inspections
- once the sheaves have been installed, a running functional test is to be carried out

No I.L.O. Form is to be issued but the replacement of the sheave is to be noted on the Ship's Cargo Register.

3.2 Straps

3.2.1 The corners of the straps are to be radiused. The straps are to project beyond the sheaves to provide ample protection for the rope and are to be at least 2 mm away from the sheaves.

The through holes of supporting and connecting pins are to be machined and are to be perfectly aligned.

Lightening holes are not allowed.

3.3 Pins

3.3.1 Block pins are to be equipped with suitable devices to secure against rotation.

Where the pins are threaded on one end, they are to be secured with a nut and a lock nut.

Other securing systems may be adopted provided that they are safe and easily removable in the event of disassembly for inspection.

Suitable arrangements are to be provided for lubrication also when the tackle is in service.

Axle pins are to be positively secured against rotation and lateral movement. In any event, the surface finish of the pin is to be suitable for the type of coupling (bearing or ferrule) to be used.

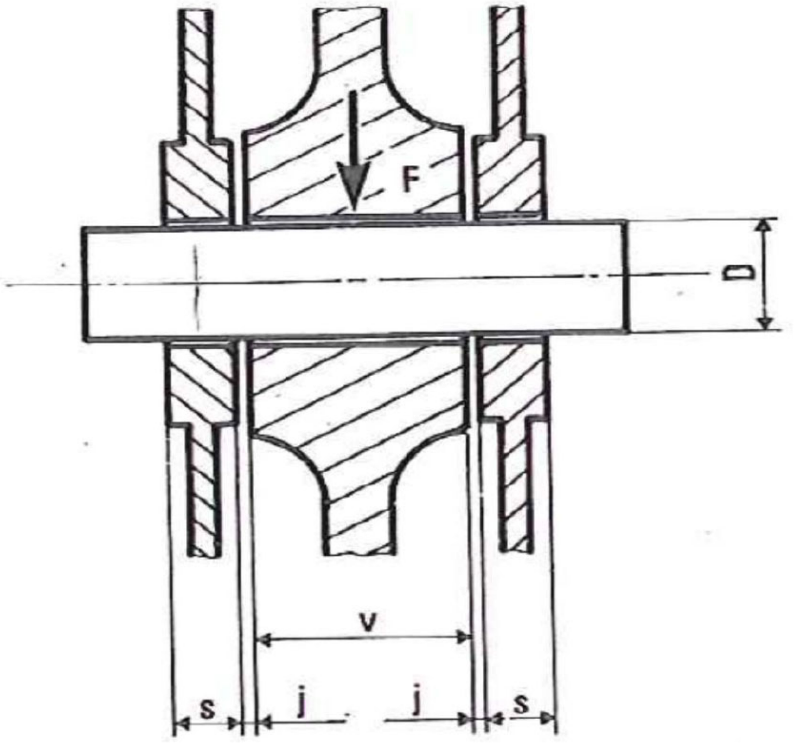
Suitable arrangements are to be provided for lubrificating all bearings without dismantling the block.

3.4 Scantling rules

3.4.1

The sheave axels are designed by direct calculation; with reference to Fig. 1 the following calculation might be adopted.

Figure 1



F is the maximum force, in KN, acting on the axle pin in operational condition.

Dimensions D, s, v and j are in mm

The bending moment is:

$$M_f = \frac{F}{4} \cdot \left(s + 2 \cdot j + \frac{v}{2}\right) \cdot 10^3$$

with v not taken as greater than 2D.

The shear force is:

$$T = \frac{F}{2}$$

The shear stress is:

$$\tau = \frac{16 \cdot T}{3 \cdot \pi \cdot D^2} \cdot 10^3$$

The allowable stresses for the axle pins are:

- bending stress:

  $0{,}45 \cdot R_e$ when $F \leq 250$

  $0{,}45 \cdot \left(\frac{F}{0{,}6 \cdot F + 100}\right) \cdot R_e$ when $250 < F < 1600$

  $0{,}68 \cdot R_e$ when $F \geq 1600$

- shear stress:

  $0{,}25 \cdot R_e$ when $F \leq 250$

  $0{,}25 \cdot \left(\frac{F}{0{,}6 \cdot F + 100}\right) \cdot R_e$ when $250 < F < 1600$

  $0{,}38 \cdot R_e$ when $F \geq 1600$

R_e is the yield stress of the axle material.

3.5 Safe working load

3.5.1 The safe working load (SWL) of a simple sheave block without becket is the maximum allowable tension on the rope (see Tab 3, Fig 1).

Following UNAV requirements, two values are indicated on the straps: above is the SWL and below is the maximum allowable load S on the head fitting.

For the safe working load (SWL) of a simple shear block, without becket, with hook the following is to be assumed:

- for block

  the maximum allowable tension T on the rope (see Tab 3, Fig 1) as foreseen in the previous paragraph;

- for hook

  the maximum allowable load S on the head fitting (see Tab 3, Fig 1).

The safe working load (SWL) of a simple sheave block with becket or of a multi-sheave block is the maximum allowable load S on the head fitting. For the calculation of the above-mentioned load S on the head fitting of the blocks forming a tackle, the outgoing section of rope is considered to be always parallel to the direction of the load even when it forms an angle with it (see Tab 3, Fig 2).

The figure in the lower position indicated on the strap specifies the safe working load.

Sheave blocks without becket used as lead blocks and where the rope on the sheave forms a minimum angle that cannot be reduced because of service limitation are to have scantlings on the basis of the minimum effective resultant load S, which, on the basis of calculation, acts on their head fitting; the blocks are to have SWL equal to half of the effective stress S.

The following blocks are considered to meet the conditions of invariability of the angle of the rope leading to them:

- the lead block at mast head of a single span rope (see Tab 3, Fig 3)
- the lead block at mast head of a span rope (see Tab 3, Fig 4 a) or a cargo runner with tackle (see Tab 3, Fig 5 a).

Simple sheave blocks without becket used as lead blocks and where the ropes on the sheave form a minimum angle that may vary because of service limitation are to be designed as if the outgoing and incoming sections of rope were parallel.

The tension T to be applied to the rope for calculation of the dimensions will be as follows:

a) cargo runner simple sheave lead blocks arranged on derrick head, derrick heel and on deck (see Tab 3, Fig 6): T = Q (SWL of derrick); blocks having SWL = Q are to be used

b) cargo runner simple sheave lead blocks (with becket at derrick head) arranged on derrick head, derrick heel and on deck (see Tab 3, Fig 7): T = 1/2 Q; blocks having SWL = 1/2 Q are to be used

c) cargo runner or span rope lead blocks with tackle arranged on derrick heel (see Tab 3, Fig 4 and 5 b): T = maximum rope tension; blocks having SWL = maximum rope tension are to be used

d) lead blocks after those specified in (c) above are to have SWL equal to the SWL of the block specified in (c).

For calculation of stress on hoisting arrangements of blocks with tackle, the incoming section of rope of the tackle is considered to be always parallel to the direction of the load even when it forms an angle with it.

When both the cargo runner and the span rope are with tackle, both the lead blocks at mast head, at mast heel and on deck are to be designed for the greater load needed, such that either one may be used for the same purpose.

4 Hooks

4.1 General

4.1.1 The end part of the cargo runner with which the load is suspended may be formed by a C hook, a hook with closing plate, a ramshorn hook, a lifting hook or a special lifting device in accordance with the relative standards.

Where the hook to be used is not in accordance with a recognised standard but the equivalence can be demonstrated, it is to be designed so as to avoid catching on obstructions during loading and unloading manoeuvres as well as sliding and slipping off of the hoisting slings.

Hooks may be made of mild or higher tensile strength steels. After forging, hooks in mild steel are to be normalised while those in higher tensile steel are to be subjected to a suitable heat treatment.

The same treatment is to be used for forged shackles.

In general, hooks in cast steel or from plate are not allowed.

5 Special lifting items

5.1 General requirements

5.1.1

Special lifting items such as spreaders and lifting beams are to have scantlings for the safe working load they are intended for. The calculation of the SWL of lifting appliances using these items has to account for the weight of the latter.

Special attention is to be paid to structural continuity and abrupt changes of section are to be avoided. Adequate reinforcement is to be fitted in way of concentrated loads at lifting points.

5.2 Allowable stresses and loads

5.2.1

The hoisting item is to be designed for the load for which it is intended.

Ideal stress σ_{id}, bending stress σ_f and shear stress τ are to be not greater than the following values, as a function of the SWL of the item:

$$SWL \le 100 \text{ kN}: \quad \sigma_f = 0,45\sigma_y \quad \tau = 0,30\sigma_y \quad \sigma_{id} = 0,50\sigma_y$$

$$SWL \ge 1600 \text{ kN}: \quad \sigma_f = 0,67\sigma_y \quad \tau = 0,40\sigma_y \quad \sigma_{id} = 0,90\sigma_y$$

where σ_y is the yield point of the material.

For intermediate values, allowable stresses may be determined by interpolation.

Bearing strength on pins is to be not greater than 0,50 σ_y for SWL ≤ 100 kN and 0,90 σ_y for SWL ≥ 1600 kN

Where the item is subjected to compression loads, it is to be verified for resistance to buckling. The ratio critical stress/effective compressive stress is to be not less than 1,3.

6 Chains

6.1 General

6.1.1

Requirements relative to steel chains without link stud as specified in Part D of the Tasneef Rules for the classification of ships, are to be complied with.

7 Lifting eyes

7.1 Scantling rules

7.1.1

Usual engineering calculations, based on the geometry of the lifting eye, or compliance with recognized standards, may be adopted to evaluate the suitability of the device for the design working load acting on it.

8 Testing items of loose gear

8.1 General

8.1.1 Items that are not permanently attached to the lifting appliance, including lifting beams and spreaders, are to be subjected to an overload test with the loads specified in Tab 1 for cranes intended for shipboard operations and in Tab 2 for cranes intended for offshore and transhipping operations prior to initial operation and/or after any repair or alteration of parts that may be subjected to loading. The test is to be carried out in a recognised workshop and, where the necessary test load is not available, a hoisting test is to be performed.

Smaller test loads are not permitted. Exceeding value is to be not greater than 2%.

Where items of loose gear (hooks, rings, etc.) are used with spreaders and lifting beams, such items are to be subjected to preliminary separate testing.

After testing, all items are to be thoroughly examined to verify the absence of defects and check that all moving parts rotate freely.

The test load of ramshorn hooks is to be suspended with two slings where each forms a 45° angle with the vertical axis passing by the centreline of the hook. Equivalent testing arrangements may be accepted on request. In addition to the above-mentioned test, chains are to be subjected to a breaking test. A sample having adequate length is to be taken from the chain and subjected to a load equal to 4 x SWL.

For lifting appliances for the handling of manned submersibles, the above-mentioned test loads are to be multiplied by 1,5.

Table 1

Loose gear	SWL, in kN	Testing load, in kN
Simple sheave block without becket	SWL = maximum allowable tension on the rope	4·SWL
Note 1: For intermediate values of SWL foreseen by standard tables for loose gear, the item with lesser SWL may be adopted on condition that its SWL is not less than 95% of that requested.		

Loose gear	SWL, in kN	Testing load, in kN
Simple sheave block with becket multi sheave block with hook	SWL ≤ 250	2·SWL
	250 < SWL < 1600	0,933·SWL + 267
	SWL ≥ 1600	1,1· SWL
Hooks, shackles, chains, rings, turnbuckles	SWL ≤ 250	2·SWL
	SWL > 250	1,22·SWL + 195
Hoisting device	**SWL, in kN**	**Testing load, in kN**
Beams, spreaders, and similar devices	SWL ≤ 100	2·SWL
	100 < SWL < 1600	1,04·SWL + 96
	SWL ≥ 1600	1,1·SWL
Note 1: For intermediate values of SWL foreseen by standard tables for loose gear, the item with lesser SWL may be adopted on condition that its SWL is not less than 95% of that requested.		

Table 2: Loads for cranes intended for offshore and transhipping operations

Loose gear	SWL, in kN	Testing load, in kN
Simple sheave block without becket	SWL = maximum allowable tension on the rope	Maximum between: 3·ψ·SWL and 4·SWL
Simple sheave block with becket multi sheave block with hook	SWL ≤ 250	Maximum between: 1,5·ψ·SWL and 2·SWL
	250 < SWL < 1600	Maximum between: 0,7·ψ·SWL+267 and 0,933·SWL+267
	SWL ≥ 1600	Maximum between: 0,825·ψ·SWL and 1,1·SWL
Hooks, shackles, chains, rings, turnbuckles	SWL ≤ 250	Maximum between: 1,5·ψ·SWL and 2·SWL
	SWL > 250	Maximum between: 0,915·ψ·SWL+195 and 1,22·SWL+195
Note 1: For intermediate values of SWL foreseen by standard tables for loose gear, the item with lesser SWL may be adopted on condition that its SWL is not less than 95% of that requested. **Note 2:** ψ is the dynamic coefficient for which the crane is designed		

Loose gear	SWL, in kN	Testing load, in kN
Hoisting device	**SWL, in kN**	**Testing load, in kN**
Beams, spreaders, and similar devices	SWL ≤ 100	Maximum between: 1,5·ψ·SWL and 2·SWL
	100 < SWL < 1600	Maximum between: 0,78·ψ·SWL+96 and 1,04·SWL+96
	SWL ≥ 1600	Maximum between: 0,825·ψ·SWL and 1,1·SWL
Note 1: For intermediate values of SWL foreseen by standard tables for loose gear, the item with lesser SWL may be adopted on condition that its SWL is not less than 95% of that requested. **Note 2:**ψ is the dynamic coefficient for which the crane is designed		

9 Testing of existing lifting eyes already welded on board

9.1 General

9.1.1

When the certification of existing lifting eyes, already previously welded and used, is requested and no material certificates are available on board, the following acceptance procedure can be adopted.

- Evaluation of the strength and suitability of the lifting eyes as per [7].
- Mean value of significant number of hardness tests
- Correlation between the above hardness mean value and the corresponding material ultimate tensile strength reported on recognized standards (i.e. EN ISO 18265)
- Non-destructive inspections on welding seams are to be carried out
- Load test (to be performed drawing particular attention to the safety of the operation) of the lifting eyes applying a load equal to 1,25 times its SWL

On satisfactory result of what above stipulated, a declaration stating the activities carried out is to be issued.

10 Marking of items of loose gear

10.1 General

10.1.1 Items of loose gear are to be permanently and clearly marked with:

- safe working load in kN (e.g., SWL = 100 kN)
- the notation of the Office with the number of the test certificate, the circular marking of Tasneef and the mark of the Surveyor in charge of the test
- for blocks, the maximum rope diameter for which the block is designed
- for lifting beams and/or spreaders, the tare weight in KN

For items having different working loads depending on the hoisting position, the safe working load of the item at each hoisting position is also to be marked.

Particular attention is to be addressed to verifying that test marks on the item of loose gear are noted on the relevant test certificate; where there is no evidence of this, the item concerned is to be subjected to a further test.

Test marks are to be in a visible position and are not to affect the tension strength of the item.

Dimensions of marks are not to exceed the following values:

- 3 mm, for safe working load SWL ≤ 20 kN or for round sections having diameter d ≤ 12,5 mm
- 4,5 mm, for safe working load 20 < SWL ≤ 80 kN or for diameter 12,5 < d ≤ 26 mm
- 6 mm, for safe working load SWL > 80 kN or for diameter d > 26 mm.

Where marking is performed on a plate permanently linked to the item, the plate is to be resistant to corrosion and the marks may be of greater dimensions than the above.

Marking of the safe working load on spreaders, lifting beams and similar items is to be such as to be clearly visible for the operators.

11 Certification

11.1 General

11.1.1

a) For items of loose gear for lifting appliances requiring the ILO Register, the following document:

   - Certificate LA3: Test and inspection of items of loose gear

   is to be submitted in the required number of copies to the office in charge of issuing the ILO Register.

b) Testing documents of items of loose gear to be used in systems that require the ILO Register are generally speaking:

   - Certificate LA3 - Test and inspection of items of loose gear
   - Certificate LA4 - Test and inspection of steel wire ropes

   Refer to Ch 2, [7] Survey and Certification for explanation on how test certificate is to be filled in.

Table 3

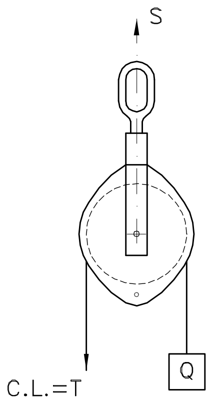


Figure 1

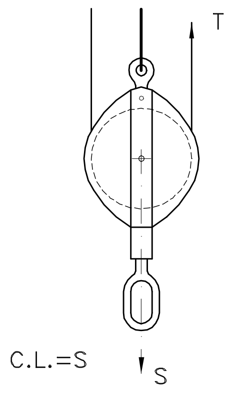


Figure 2

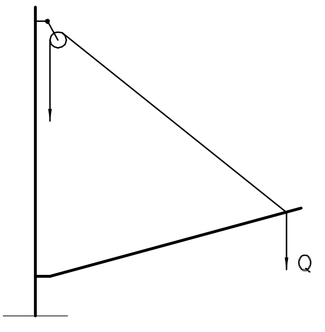


Figure 3

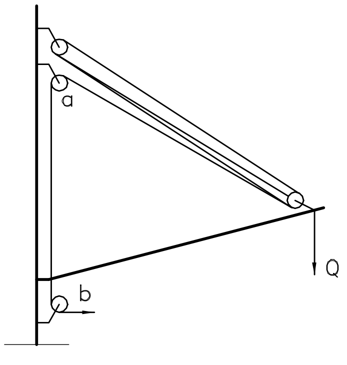


Figure 4

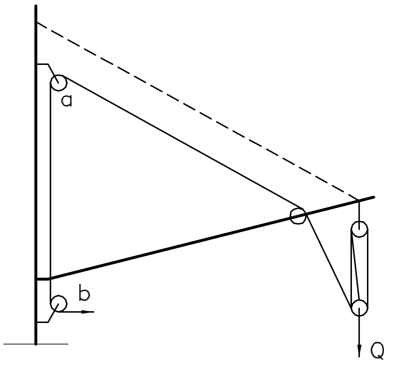


Figure 5

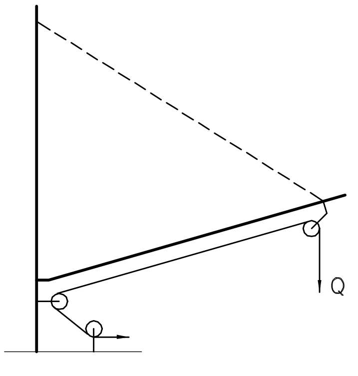


Figure 6

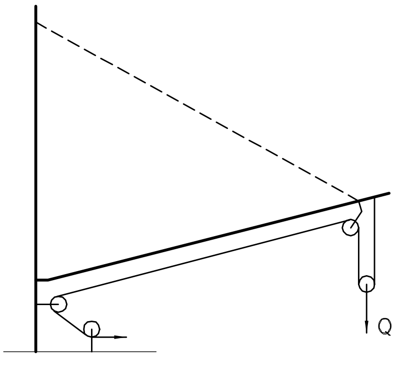


Figure 7

CHAPTER 13 CARGO SUPPORTING DEVICES

1 General

1.1 Application

1.1.1 *(1/10/2022)*

This chapter applies to those portable/removable devices used to support cargo units stowed on the decks/holds of the ships with design vertical accelerations at any point not greater than 1g (e.g. displacing ships). The devices may be stands, pillars, frames, trestles and other similar devices intended to bear the direct loads exerted by the cargo units by spreading them on the underlying hull structures. This chapter applies to devices built in steel only, whilst devices built in materials other than steel will be specially considered.

1.1.2 *(1/10/2022)*

The efficiency and the functionality of the devices are left to the designer's responsibility.

2 Design criteria

2.1 Working loads

2.1.1 *(1/10/2022)*

The working loads of the devices are to be specified by the designer, in terms of force and moment (if any) components.

2.2 Design loads

2.2.1 *(1/10/2022)*

A dynamic coefficient equal to 2 is to be applied to all the working loads to obtain the design loads for the strength checks of the devices.

3 Strength checks

3.1 General

3.1.1 *(1/10/2022)*

The structural verification of the devices is to be performed according to sound basic engineering principles and to the requirements specified for the load case I in Ch 15, [2.2] and [2.3].

4 Testing and materials

4.1 General

4.1.1 *(1/10/2022)*

The steel plates and the steel profiles used for the construction of the devices are to be supplied together with 3.1 mill certificates (EN 10204 Standard).

The devices are to be inspected to check the compliance of the structures with the approved plans.

Critical welds are to be checked by non-destructive tests to detect any possible defect.

The devices are to be subject to an overload test reaching the 110% of the relevant safe working load; after the overload test, the devices are to be thoroughly examined to detect deformations or unacceptable defects.

When an overload test with working load greater than 250 kN cannot be performed due to the lack of adequate equipment or other valid reasons acceptable to Tasneef it may be omitted provided that all the welds are checked by non-destructive tests.

5 Documents to be submitted

5.1 General

5.1.1 *(1/10/2022)*

The following plans are to be submitted to Tasneef

a) General plans of the device for information:

   Drawings showing the shape and the general dimensions of the device and the working loads.

b) Structural plans of the device for approval:

   Drawings showing the geometry, the scantlings, the material identification according to a recognized standard and the weld type/size of the device.

CHAPTER 14 MACHINERY AND ELECTRICAL SYSTEMS

1 General

1.1

1.1.1 Components and equipment for lifting appliances are to be designed in compliance with recognised standards, to be specified by the designer, and sound engineering principles; consideration is to be given during design to the additional loads imposed by dynamic and environmental effects when they affect the machinery.

Where other requirements are complied with, Tasneef reserves the right to accept them on condition that the Designer demonstrates relative equivalence.

2 Tests and documentation

2.1 General

2.1.1 For the machinery of lifting appliances, testing by Tasneef is not required; an internal workshop certificate is sufficient [See Note1]. In addition, the following tests are to be performed on board:

- parts designed to withstand pressure (piping, pumps, valves) are to be subjected to Rule hydrostatic test;
- electrical parts are to be subjected to tests as specified in Part C of the Tasneef Rules for the classification of ships;
- operational tests are to be carried out, unless already performed by the Manufacturer in the presence of a Tasneef Surveyor.

During the operational test, the efficiency of machinery braking and stopping equipment designed for normal operation as well as for emergency situations is to be verified.

The tests have also the purpose to ascertain that the system is of fail-safe type in case of failure; in this regard, the acceptability of the operating and control system is subjected to the satisfactory results of a suitable failure mode affect analysis (FMEA).

Following the test, disassembly and inspection of parts may be required, at the discretion of the Tasneef Surveyor in charge of the test.

Note 1: For electrical parts, workshop certification is to include all tests for approval (in particular, test of applied voltage) as required by the CEI regulations in force.

Hydraulic cylinders, which are to be manufactured in accordance with approved plans, are to be subjected to hydrostatic test, as per rules, in the presence of a Tasneef Surveyor.

3 Winches

3.1 General

3.1.1 Where a speed change gear is fitted and the hoisting drum is free to rotate when the gear is in the neutral position, a blocking device is to be provided to prevent the gear from accidentally disengaging during operation. An automatically applied brake is to operate on the drum side of the change gear when neutral is selected.

Where steam powered winches are fitted, blocking of the reversal lever in the resting position is to be possible.

The blocking valve of steam output from pipe to deck is to be positioned near the winch and, if manually controlled, to be suitably insulated.

The steam pressure is to be kept constant in order to guarantee the continuity of the work of the winch.

Where two cables are wound on the same drum, this latter is to ensure their effective separation, for example by means of adequate flanges. The drum, or the part of the drum that contains the span rope, is to be suitably connected to the winch by means of pinions or teeth on both sides, with control pawls for simulatenous operation. Pawls and teeth are to be designed for supporting torsion not less than 1,5 times maximum torsion under the worst operating conditions.

4 Drums

4.1 General

4.1.1 Drums for rope reeling as well as end flanges are to have the greatest possible diameter.

Where the drum is grooved, reeling up of the rope is allowed in several loops not exceeding 3 complete layers.

For all operating conditions, the distance between the top layer of the wire rope on the drum and the outer edge of the drum flanges is to be at least 2,5 times the diameter of the wire rope; in case wire rope guards are fitted to prevent over spilling of the wire, the above mentioned distance may be slightly reduced.

Where the drum is not grooved, reeling up of the rope more than once is to be avoided.

Span rope drums are to be designed to reel enough length of rope to allow the system to achieve maximum and minimum rangein the former case, at least three complete "rounds" of rope are to remain on the drum. Where the drum is grooved, two complete "rounds" of rope may be left..

The radius of the groove is to exceed by at least 10% the radius of the rope and the slot on the bottom is to be circular for an arc of 120°. The space between two grooves is to be adequate and the edges are to be rounded.

The cable is to be firmly connected to the drum as appropriate in order to avoid any additional stresses.

The angle between the cable and the plane perpendicular to the drum axis is not to exceed 1/16 radian for the cargo runner and 1/12 radian for the span rope.

Special attention is to be given where only one motor is used for both the span rope and the cargo runner. In this case, when the motor operates the cargo runner the span rope is blocked by the corresponding pawl of the drum. An adequate blocking device is to prevent the pawl from disconnecting from the drum until the motor is connected to the drum of the span rope.

4.1.2 Drum scantlings

See Appendix 1.

5 Control station

5.1 General

5.1.1 The control station is to be installed so as to allow an ample view of the working area.

Where this is not possible, suitable means of communication are to be provided.

The control station is to be sufficiently comfortable.

The station is to be fireproof and a suitable fire extinguisher is to be easily accessible.

The operating, stop and standby conditions of each item of machinery are to be clearly indicated.

6 Alarm and control devices

6.1 General

6.1.1 In addition to the provisions of laws and regulations in force and irrespective of the type of document required, lifting appliances for cargo handling are to be provided with the appropriate controls, alarms and safety arrangements specified below or with alternative arrangements providing equivalent safety at the discretion of Tasneef

Suitable means are to be provided to ensure for all movements safe and effective control of speed, direction and stopping of the lifting appliance also in the event of an emergency.

The load is to be able to be held in position in the event of a sudden cut in operating power. The subsequent emergency lowering is to be signalled by an alarm provided for the purpose.

Drums are normally to have a slack wire rope detection device which is to be automatically activated if the wire rope becomes slack during lowering; the device, in addition to an indication, has to cut off the operating power to the winch.

The device may be omitted if the crane operator has a full view of the drums from its operating position.

In electrical machinery, the motor for lifting the load is to be activated only when controls have passed through the resting position.

Where auxiliary current is supplied, short-circuits on this line that could activate the lifting motor or release the brake are to be avoided.

In machinery with internal combustion, falling of the load because of gravity when the motor is disengaged is to be prevented.

6.2 Brakes

6.2.1 All movements are to be controlled by means of controlled or automatic traction brakes.

Automatic brakes are to operate when control is in the resting position, in the event of an emergency stop due to power reduction including the absence of one phase or for voltage reduction beyond the allowed value; means are, however, to be provided for overcoming brake mechanisms if, for sake of safety, this should be desirable..

In the case of an electric motor, the possibility of excitement of the rotor due to reversal of electric and motor force of any auxiliary motor or due to stray current, of current dispersion or breaking of insulation, is to be avoided.

Irrespective of the type of brake (hand, foot pedal or automatic brake), it is to be capable of applying a force 25% greater than that required in the worst operating conditions, considering the ship inclination and disregarding mechanical loss in the transmission.

The winch is to be provided with a band brake. It is to be capable of holding the jib of a crane in position when it is at the maximum range with the maximum allowed load and with wind as considered for cranes in operation.

The brake is to be capable of holding a static load of 1,5 times the rated load of the winch.

Brakes relative to rotation are to be provided with a device capable of preventing abrupt stopping of rotation.

When load lowering is by gravity, in addition to the normal brake, an automatic speed limiting device is to be installed so that the speed of the load does not increase excessively.

6.3 Moving warnings

6.3.1 In the case of portal cranes, a continuous audible warning is to sound when the crane is moving along its track. In addition, the operator of the crane is to be provided with another sound warning device to be operated when necessary.

6.4 Automatic limit stop switches

6.4.1 Cranes in general are to be provided with automatic devices for controlling movements that interrupt the supply of current when designed operational limits (for movement of load hoisting, jib manoeuvring, rotation when not allowed over a 360° angle, sliding on rails and trolley translation) are exceeded.

It is recommended that similar devices should also be installed in derricks and fix-jib derrick cranes.

6.5 Automatic overload switches

6.5.1 Lifting appliances, except for derricks or derrick cranes, are to be provided with automatic devices that interrupt the power supply when the load to be handled exceeds the capacity by 10%.

It is recommended that an alarm, calibrated for 95% of the load before switch activation, should be installed.

6.6 Maximum capacity indicator

6.6.1 Where lifting appliances have fixed safe working load, this is to be clearly indicated on the appliance.

In the case of variable SWL, an automatic device is to be installed in a visible position for the operator. This device is to indicate the maximum allowable load at the various ranges or positions of the trolley.

The indicator may be replaced by a table arranged in the control station.

6.7 Level indicators

6.7.1 When there are operational limitations of the lifting appliance with regard to the angle of heel or trim of the ship, suitable devices indicating these angles are to be provided.

6.8 Wind speed indicators

6.8.1 Wind speed indicators (anemometers) applied to the crane in a suitable position are to provide the crane operator with a visual indication of the wind speed and an audible alarm is to sound when the allowed limits are exceeded.

6.9 Stop indicators

6.9.1 In the case of container cranes, a device is to be provided for automatic blocking of the lifting movement of the load when one of the twist locks has not ensured coupling of the spreader to the container.

6.10 Noise reduction

6.10.1 Noise reduction at source by design

The main noise sources to be found in off-shore or transhipment cranes are:

a) Engines used for the crane functions

b) Winches, gears and transmissions

c) Hydraulic and pneumatic components and circuits

d) Brakes and other mechanical components

The following measures are to be used to reduce noise at source of off-shore or transhipment cranes:

- Selection of low-noise hydraulic and mechanical components
- Use of anti vibration systems to reduce structure borne sound
- Encasement of noise-radiating parts
- Appropriate adjustment of operating speeds

Recommended suggestions to reduce operating noise are to be reported in the manufacturer's instruction manual.

APPENDIX 1 DRUM SCANTLINGS

1 General

1.1

1.1.1 Should the scantlings of the drum are requested to be verified, the following simplified calculation method is suggested being, however, equivalent evaluations accepted The minimum thickness, in millimeters, of the drum is obtained from the following expression:

$$t = \sqrt{t_f^2 + t_f \cdot t_c + t_c^2}$$

where:

$$t_f = \frac{1250 \cdot M}{D_m^2 \cdot \sigma_{admf}}$$

$$t_c = \frac{1000 \cdot K_{RL} \cdot T}{p \cdot \sigma_{admc}}$$

K_{RL} = coefficient of rigidity to be assumed as specified in Tab 1.

Table 1 : coefficient of rigidity K_{RL}

Number of layers	Fiber core wire rope	Other types of wires
1	1,0	1
2	1,4	1,3
3	1,6	1,5
4	1,8	1,6

M (N·m) is the bending moment induced by the maximum static load T, in kN, on the drum considered as a beam.

D_m is the mean diameter of the drum (D_e – t), in millimeters. D_e is the nominal diameter of the drum and it corresponds to the external diameter in case of not grooved drums and to the diameter at the roots of the grooves in case of grooved drums).

p, in millimeters, is the pitch between two adjacent rounds of wire.

Both bending allowable stress $\sigma_{adm\ f}$ and compressive allowable stress $\sigma_{adm\ c}$, are related to N_e equivalent number of cycles and are to be evaluated according to the following procedure.

2 Classification and fatigue allowable stresses

2.1 Classification

2.1.1 The classification of the barrel is based on the equivalent number of cycles N_e supposed to be performed during its operating life; the equivalent number of cycles by multiplying the real (effective) number of cycles by the spectrum factor K_m.

For bending stresses the effective number of cycles is to be evaluated on the basis of the rotation speed of the drum (one cycle for each revolution) and the corresponding duration of the lifting class to which the drum belongs and the relevant spectrum factor K_m.

For compressive stresses the effective number of cycles is to be evaluated on the basis of the lifting cycles.

2.2 Fatigue allowable stresses

2.2.1 For given number of cycles and type of material used, the fatigue allowable stresses, in MPa, are as specified in Tab 2.

Table 2 : fatigue allowable stresses, in MPa

Type of materials	$2 \cdot 10^6$ cycles	$5 \cdot 10^6$ cycles	$1 \cdot 10^8$ cycles
	σ_{lf1}	σ_{lf2}	σ_{lf3}
Grey cast iron, spheroidal and carbon steel	125	92	51
Rolled carbon steel, with welding seams accurately checked	150	110	60
Rolled carbon steel, with welding seams checked, and grey cast iron	125	92	50

According to the equivalent number of cycles N_e, the fatigue allowable stress is evaluated by means of the following expressions:

a) if N_e is less than 5 x 10^6 cycles:

$$\sigma_{adm\ fat} = \sigma_{lf1} \cdot \left(\frac{2 \cdot 10^6}{N_e}\right)^{\frac{1}{3}}$$

b) if N_e is between 5 x 10^6 and 1 x 10^8 cycles:

$$\sigma_{adm\ fat} = \sigma_{lf2} \cdot \left(\frac{5 \cdot 10^6}{N_e}\right)^{\frac{1}{5}}$$

c) if N_e is greater than or equal to 1 x 10^8 cycles:

$\sigma_{adm\ fat} = \sigma_{lf3}$

2.3 Allowable stresses

2.3.1 For both bending allowable stress $\sigma_{adm\ f}$ and compressive allowable stress $\sigma_{adm\ c}$ the lower figure between static allowable stress, to be evaluated as stated below, and fatigue allowable stress, as per [2.2], is to be considered.

2.3.2 Bending allowable stress

The static allowable stress $\sigma_{adm\ fs}$ is to be calculated as follows:

a) Grey cast iron castings

$0,185 \cdot f_t$

b) Grey and spheroidal castings

$0,2 \cdot f_t$ if elongation A < 12 %

$0,67 \cdot f_t$ if elongation A ≥ 12 %

c) Castings and rolled steel

$0,67 \cdot f_y$

where f_t and f_y are the ultimate tensile strength and the yield point of the material respectively.

2.3.3 Compressive allowable stress

a) Grey cast iron castings

$0,36 \cdot f_t$ if elongation A < 12 %

b) Grey and spheroidal castings

$0,5 \cdot f_y$ if elongation A ≥ 12 %

CHAPTER 15 STRENGTH ANALYSIS

1 Symbols

1.1

1.1.1 For the purpose of this Chapter the following symbols applies:

σ_{amm}: allowable stress, in N/mm^2

F: stress factor

σ: failure stress, in N/mm^2

σ_y: yield stress of the material, in N/mm^2

σ_u: ultimate tensile of the material, in N/mm^2

σ_{CR}: critical compression stress of the material, in N/mm^2

2 Verification of resistance

2.1 General requirements

2.1.1 Verification of cranes is to be performed for the load conditions specified in Ch 4 [3.1], Ch 5 [3.1] or Ch 6 [3.1], as applicable, according to sound basic engineering principles and with allowable stresses as specified in [2.2].

The arrangement and loading conditions generating maximum stresses are to be considered for each resisting element.

2.2 Allowable stresses

2.2.1 Materials

The allowable stress σ_{amm} is to be taken as the failure stress of the component concerned multiplied by a stress factor F which depends on the load case considered. The allowable stress is therefore given by the general expression:

$\sigma_{amm} = F\sigma$

The stress factor, F, for steels in which $\sigma_y/\sigma_u \le 0,7$ is given in Tab 1.

Table 1 : stress factor, F

Load case	I	II	III and IV
Stress factor, F	0,67	0,75	0,85

For steel with $\sigma_y/\sigma_u > 0,7$ then σ_y is to be considered not greater than 75% of the minimum ultimate strength of the steel.

2.2.2 Shear-resistant connections with bolts and rivets

In general, shear-resistant connections with bolts and rivets are not recommended, except for accessory structures such as stairs, rails and access-ways, for which gauged bolts are to be used and holes are to be reamed.

Normal and high strength bolts are classed as defined in Tab 2 which also defines the nuts to be associated to them.

Table 2 : classification of nuts and bolts

	Usual			High strength		
Bolt	4,6	5,6	6,6	8,8	10,9	12,9
Nut	4	5	6	8	10	12

2.2.3 Friction connections with bolts

Only high strength bolts are to be used.

Washers, one located under the nut and the other under the bolt head, are to be 45° bevelled on one inner edge and the same bevel is to be made on the corresponding outer edge; when fitted, the bevel is to be towards the bolt head or towards the nut allowable stresses for bolts are reported in Tab 3.

Bolts are to be duly tightened. It is recommended to apply a tightening moment as to create an axial force N_s:

$N_s = 0,8 f_{k,N} A_{res}$ in KN

Where A_{res} is the net area of the bolt.

The tightening moment T_s to be applied to create the axial force N_s is:

$T_s = 0,2 N_S d$ in Nm

Where d is the nominal thread diameter of the bolt.

Table 3 : Allowable stresses for bolts

Allowable stresses					
Bolt	f_t N/mm^2	f_y N/mm^2	$f_{k,N}$ N/mm 2	$\sigma_{ab,amm}$ N/mm^2	$\tau_{b,amm}$ N/mm 2
4,6	400	240	240	160	113
5,6	500	300	300	200	141
6,6	600	360	360	240	170
8,8	800	640	560	373	264
10,9	1000	900	700	467	330
12,9	1200	1080	840	560	395

Where:
$f_{k,N}$ is assumed as the lower value between $f_{k,N}$ = 0,7, f_t and $f_{k,N}$ = f_y being f_t and f_y the ultimate and yield stress according to ISO 898-1 or equivalent Standard.
$\sigma_{ab,amm}$, $\tau_{b,amm}$ are the axial and shear allowable stress

Tab 4 shows the values of the net area A_{res}, the axial force N_s and the tightening moment T_s for the different classes of bolts.

Table 4 : A_{res} and N_s for the different classes of bolts

d in mm	A_{res} in mm^2	T_s in Nm					N_s in kN				
		4,6	5,6	6,6	8,8	10,9	4,6	5,6	6,6	8,8	10,9
12	84	39	48	58	90	113	16	20	24	38	47
14	115	62	77	93	144	180	22	28	33	52	64
16	157	96	121	145	225	281	30	38	45	70	88
18	192	133	166	199	309	387	37	46	55	86	108
20	245	188	235	282	439	549	47	59	71	110	137
22	303	256	320	384	597	747	58	73	87	136	170
24	353	325	407	488	759	949	68	85	102	158	198
27	459	476	595	714	1110	1388	88	110	132	206	257
30	561	646	808	969	1508	1885	108	135	161	251	314

2.2.4 Rivets

The allowable stresses to be considered for rivets are those reported in Tab 5.

Table 5 : allowable stresses for rivets

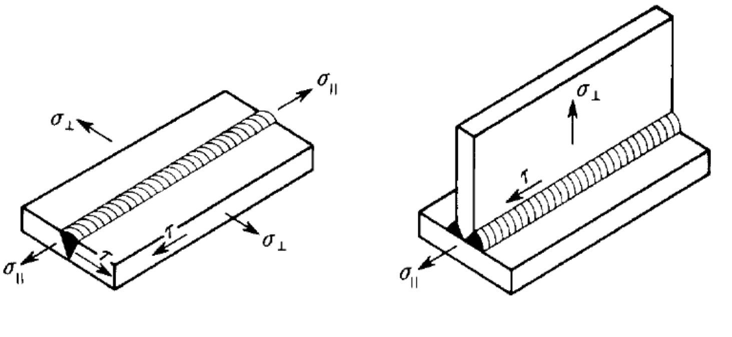
Allowable stresses	
$\sigma_{ab,amm}$ N/mm2	$\tau_{b,amm}$ N/mm^2
50	120

2.2.5 Welded connections

- **Butt joints or full penetration T joints**

  When evaluating the stresses originated by axial forces acting perpendicularly to the welding axis or by shear forces, the longitudinal section of the welding is to be considered as the "resistant" section; for calculation purposes, its length is the total length of the welding seam and its width is the lowest thickness of the two welded elements, evaluated close to the welding seam, for butt joints and the thickness of full penetration welded element for T joints (see Fig 1):

Figure 1



The "resistant" section to be considered, when evaluating the stresses originated by axial forces parallel to the welding axis, is the orthogonal section of the welded component (i.e. the section of the parent metal plus the weld metal)

The equivalent stress given by the following formula:

$$\sigma_{id} = \sqrt{\sigma_{\perp}^2 + \sigma_{||}^2 - (\sigma_{\perp} \cdot \sigma_{||}) + 3 \cdot \tau_{||}^2}$$

Where:

$\sigma_{\perp}$ is the axial stress perpendicular to the longitudinal section of the welding

$\sigma_{||}$ is the axial stress parallel to the welding

$\tau_{||}$ is the shear stress in the longitudinal section of the welding

is to be lower or equal to the values reported in the Tab 6.

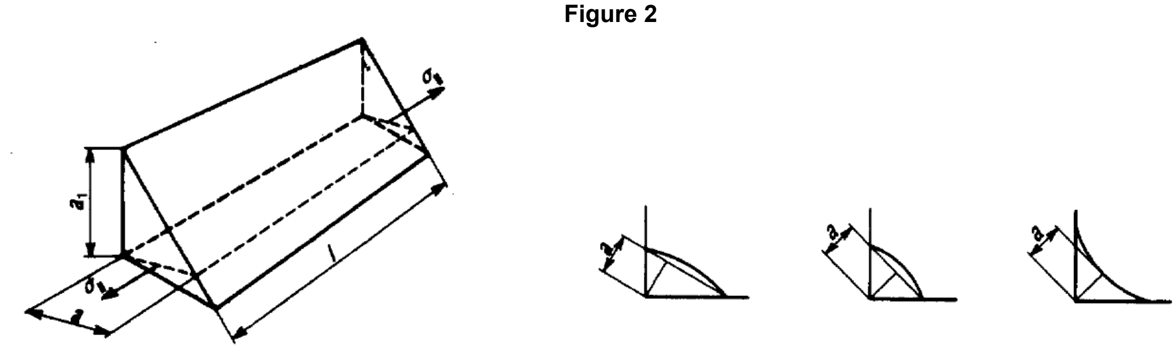
Table 6 : allowable stresses for butt joints or full penetration T joints

Allowable stresses in N/mm^2	
Joint	$\sigma_{id} \leq$
I Class	σ_{amm}
II Class	$0{,}85\sigma_{amm}$
Where: σ_{amm}: allowable stress of base material	

- **Fillet joints**

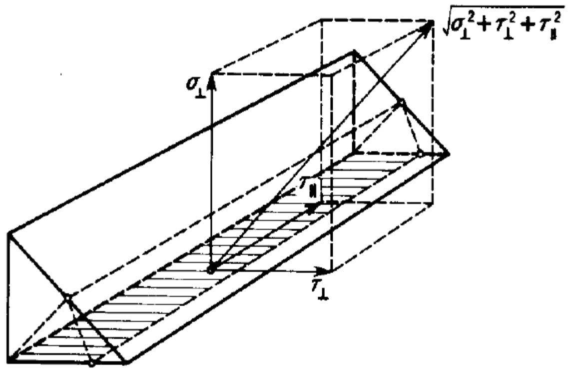
  When evaluating the stresses induced by axial forces, acting perpendicularly to the axis of the welding, or by shear forces acting along the same axis, the "resistant" section to be considered is the throat section of the welding seam; for calculation purposes its length L is the seam total length, providing the ends of the seam are not clearly missing or defective, while the width a is the height of the triangle inscribed in the transversal section of the welding seam (see Fig 2).

Figure 2



The stress evaluation is to be performed by overturning the throat section on one of the side of the seam. The stress originated by the external forces on the throat section is to be split into three orthogonal components $\tau_{\perp}$, $\tau_{||}$ and $\sigma_{\perp}$ as shown in the Fig 3 below:

Figure 3



In case all the three above mentioned components are acting, the following conditions are to be verified:

$$(1)\ \sqrt{\tau_{\perp}^2 + \sigma_{\perp}^2 + \tau_{||}^2} \leq \begin{cases} 0,85 f_d & \text{for steel S235} \\ 0,70 f_d & \text{for steel S275 and S355} \end{cases}$$

$$(2)\ |\tau_{\perp}| + |\sigma_{\perp}| \leq \begin{cases} f_d & \text{for steel S235} \\ 0,85 f_d & \text{for steel S275 and S355} \end{cases}$$

In case only the stress components $\sigma_{\perp}$ and $\tau_{\perp}$ are acting, the expression (2) is to be verified together with the following:

$$|\tau_{\perp}| \leq \begin{cases} 0,85 f_d & \text{for steel S235} \\ 0,70 f_d & \text{for steel S275 and S355} \end{cases}$$

$$|\sigma_{\perp}| \leq \begin{cases} 0,85 f_d & \text{for steel S235} \\ 0,70 f_d & \text{for steel S275and S355} \end{cases}$$

In case only the stress components $\tau_{\perp}$ and $\tau_{||}$ or $\sigma_{\perp}$ and $\tau_{||}$, are acting, the expression (1) is to be verified.

In case only one of the stress components $\tau_{\perp}$, $\sigma_{\perp}$ or $\tau_{||}$, is acting, it is sufficient to verify the following:

$$|\tau_\perp|, |\sigma_\perp|, |\tau_{||}| \le \begin{cases} 0,85 f_d & \text{for steel S235} \\ 0,70 f_d & \text{for steel S275 and S355} \end{cases}$$

2.2.6 Supports and hinges

- **General**

All support devices, with particular reference to plates, are to be design to withstand the bending and shear stresses they undergo; the device is to be still efficient even for a stress level equal to 1,5 times the allowable stress as indicated in [2.2.1].

- **Hinged supports**

Hinges are to be designed to limit the bending stress of the pin whose length is to be such as to guarantee a full support to all the connected parts/components.

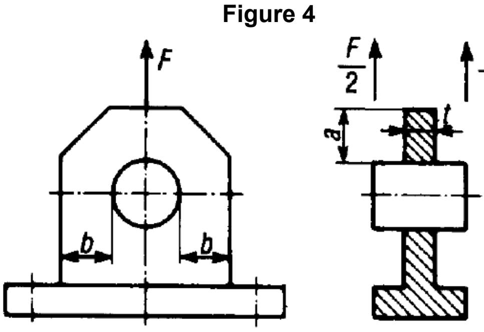
Pins are to be duly secured so as to maintain their original assembling position

When the straps of hinges are subjected to tension, the resistance sections, opposite located with respect to the diameter, perpendicular and parallel to the tension direction, are to fulfil the following limitations (see Fig. 4):

$2bt \ge 1{,}4F/\sigma_{amm}$

$ta \ge F/\sigma_{amm}$

Figure 4



Thickness t, in general, is to be neither less than 12 mm nor greater than 50 mm; moreover the following is to be verified:

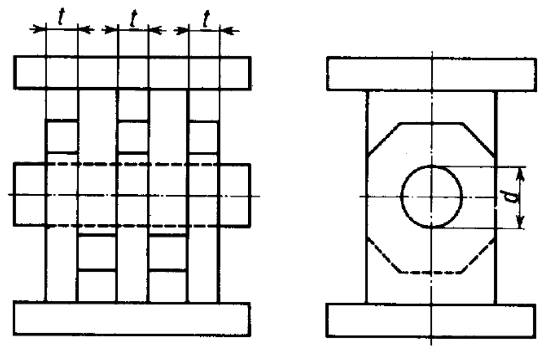
$b / t \le 8$

Pins of hinges are to be designed for the maximum values of shear and bending stress.

The supporting area A of the pin is to be evaluated as the product of the diameter d times the total sum of the thicknesses Σt of resistant elements of a strap, as per Fig 5:

$A = d\ \Sigma t$

Figure 5



On the outline of the hole, the tension referred to the diametral projection of the cylindrical surface as defined above, is to fulfil the following expression:

$\sigma_{rif} \le 1{,}35\ \sigma_{amm}$

2.2.7 Sections weakening due to holes

Verification of tension and bending strength is to be performed with reference to the net sectional area, i.e. deducting the area of the holes.

The check of the bending of beams is, in general, performed taking into account the second moment of area of the section once the holes have been deducted; the calculation is carried out by deducting the second moment of area of the holes, respect to the neutral axis of the gross section.

2.3 Verification of resistance to buckling

2.3.1 General requirements

In addition to individual members of the jib structure being examined with respect to buckling, crane jibs are to be considered with respect to critical compressive failure of the jib as a whole.

Verification is to be performed for all load cases considering the allowable stresses specified in [2.2] and assuming the values specified below for the safety factor $\nu = \sigma_{CR} / \sigma_{amm}$:

ν = 1,5 for load case I

ν = 1,33 for load case II

ν = 1,2 for load case III and load case IV

Gross sections, i.e. including the holes for the connections, may be considered for the verification of resistance to buckling.

2.3.2 Compressed members

What stated below applies only to members subjected to a compressive stress acting along their own axis; it is not, therefore, applicable when the compressive stress acts with fixed eccentricity or when the members are bent or when the members, in addition to a compressive action, have to withstand also bending stresses.

Components of crane jibs and the jib itself, as a whole, are to be verified in the two main planes of deflection.

The effective (deflection) length of the jib is, in general terms, defined as $L_c = \beta L$ where L is the actual length of the jib and β is a factor which depends on the end constraint conditions of the jib in the considered deflection plane.

When more detailed evaluations are not required, the values of the factor β can be assumed as follows:

$\beta = 1$ when translations only are constrained at both ends of member

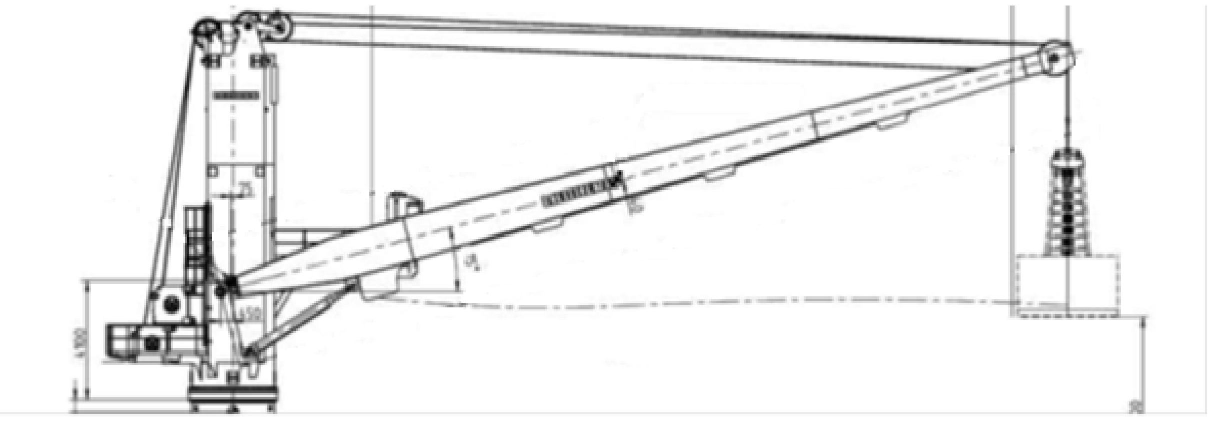
$\beta = 0{,}7$ when rotations and translations are constrained at both ends of member

$\beta = 0{,}8$ when rotations and translations are constrained at one end of member and translations only at the other end

$\beta = 2$ when rotations and translations are constrained at one end of member and the other one is free to rotate and translate.

A typical crane's arrangement is shown by in Fig 6 where the boom is mainly supported by cylinder(s).

Figure 6



In the particular case of rope supported jib (span rope and/or cargo runner at its head), the jib is considered to be constrained in the elevation plan at both ends against vertical translation while it can rotate freely; the effective deflection length may be, therefore, considered as the actual length of the jib ($\beta = 1$).

In the horizontal plan, the lower end of the jib is to be considered as constrained against translation and rotation by the jib pivot and the head is to be considered as partially constrained with respect to translation by the hoist and luffing ropes, the constraint varying with the tension in these ropes.

The constant β is given by the following expression:

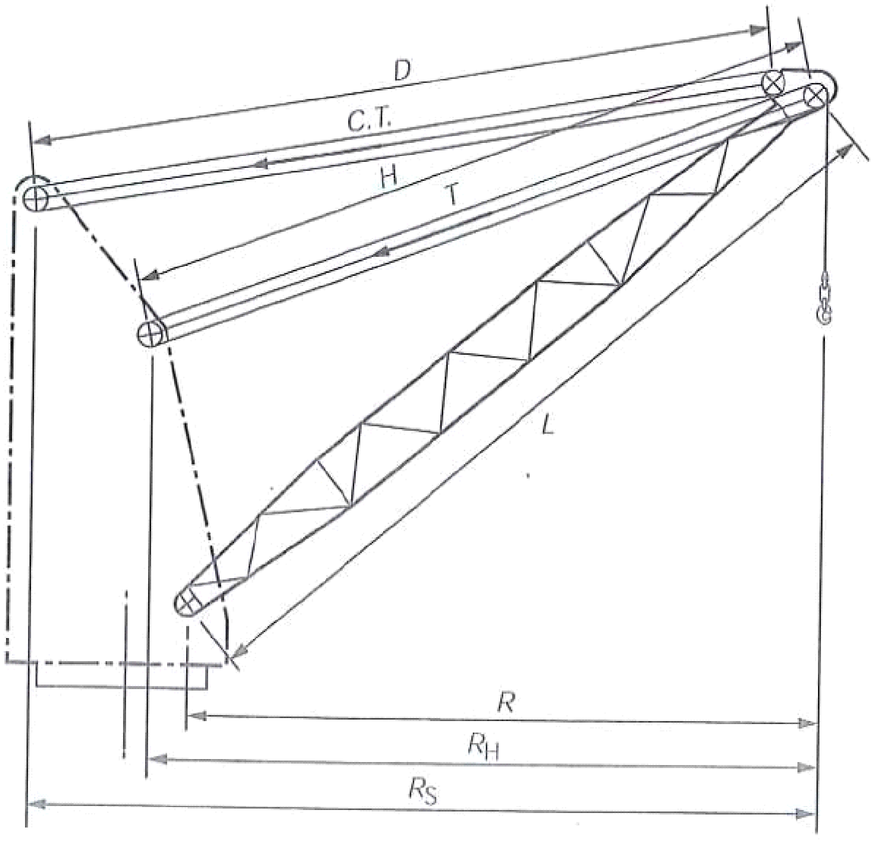
$$\beta = 2 - \frac{R \cdot (D + C \cdot H)}{R_H \cdot D + C \cdot R_S \cdot H}$$

Where:

C is the ratio of load applied to the jib head by the luffing rope to that applied to the non-vertical part of the hoist rope; and

R, R_H, R_S, D and H are dimensions, in mm, as shown in Fig 7

Figure 7



2.3.3 slenderness ratio of a prismatic member

The ratio $\lambda = L_c / I$ is defined as the slenderness ratio of a prismatic member in its own main inertia plan, where:

L_C is the effective length of the member as defined in [2.3.2] and I is the radius of gyration of the transversal section laying in the same plan with respect to which L_C is evaluated.

The slenderness ratio is to be not greater than 200 in case of main members and 250 in case of secondary ones; when significant dynamic actions are experienced, the mentioned figures can be limited to 150 and 200 respectively.

2.3.4 uniformly compressed transversal section of members

When the transversal section of the member is uniformly compressed, the following expression is to be verified:

$$\frac{\sigma_c}{\sigma} \geq \nu$$

Where:

$\sigma_c = N_c/A$ is the critical stress value originated by the force N_c responsible for the lateral deflection of the member

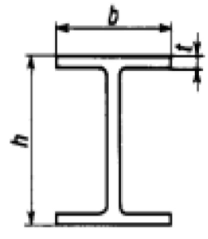
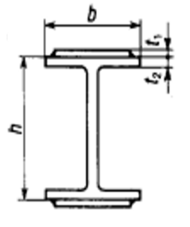
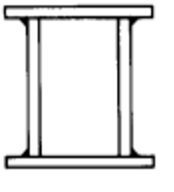
$\sigma = N/A$ is the axial compression stress value related to the section where the axial load N acts.

For doubly symmetric sections or for section with only one symmetric orthogonal axis, the σ_c values are reported, as a function of the material yield point, in the following Tab 7.

The Table shows the ratios σ_c/f_y for 4 different types of sections and with respect to the ratio λ/λ_c being λ_c the slenderness corresponding to the ultimate elastic behaviour of the member as follows:

$$\lambda_c = \pi \sqrt{\frac{E}{f_y}}$$

Table 7 : σ_c values for doubly symmetric sections or for section with only one symmetric orthogonal axis

λ/λ_c	σ_c/f_y				Members	Shape of Section	Curve
	Curve **a**	Curve **b**	Curve **c**	Curve **d**			
0,00	1,000	1,000	1,000	1,000	Simple	Welded or rolled squared, rectangular or round hollow sections: t≤40mm	**a**
0,10	1,000	1,000	1,000	1,000			
0,20	1,000	1,000	1,000	1,000			
0,30	0,978	0,965	0,951	0,917	Simple	Rolled Sections: h / b ≥ 1,2 t≤40mm 	**b**
0,40	0,953	0,925	0,900	0,841			
0,50	0,923	0,885	0,843	0,769			
0,60	0,885	0,838	0,783	0,699			
0,70	0,844	0,785	0,719	0,633			
0,80	0,796	0,727	0,655	0,572			
0,90	0,739	0,633	0,593	0,517			
1,00	0,674	0,599	0,537	0,468			
1,10	0,606	0,538	0,486	0,424			
1,20	0,540	0,481	0,439	0,385		Rolled Sections reinforced by flat bars: t_1≤40mm t_2≤40mm 	
1,30	0,480	0,429	0,395	0,350			
1,40	0,427	0,383	0,357	0,319			
1,50	0,381	0,343	0,323	0,290			
1,60	0,341	0,308	0,293	0,265			
1,70	0,306	0,277	0,266	0,242			
1,80	0,277	0,250	0,241	0,222			
1,90	0,251	0,226	0,219	0,204			
2,00	0,228	0,205	0,200	0,188		Welded hollow section: t≤40mm 	
2,10	0,208	0,188	0,183	0,173			
2,20	0,190	0,173	0,169	0,160			
2,30	0,175	0,159	0,158	0,148			
2,40	0,162	0,147	0,147	0,138			
2,50	0,149	0,137	0,137	0,129			
2,60	0,138	0,128	0,128	0,120			
2,70	0,128	0,119	0,119	0,112	Simple or welded	Generic — t≤40mm	**c**
2,80	0,119	0,110	0,110	0,105			
2,90	0,112	0,103	0,103	0,098		All — t>40mm	**d**
3,00	0,105	0,096	0,096	0,092			

The same values σ_c/f_y are represented in terms of curves in Fig 8 where:

- the curve a refers to hollow section (squared, rectangular or round)
- the curve b refers to single members such as:

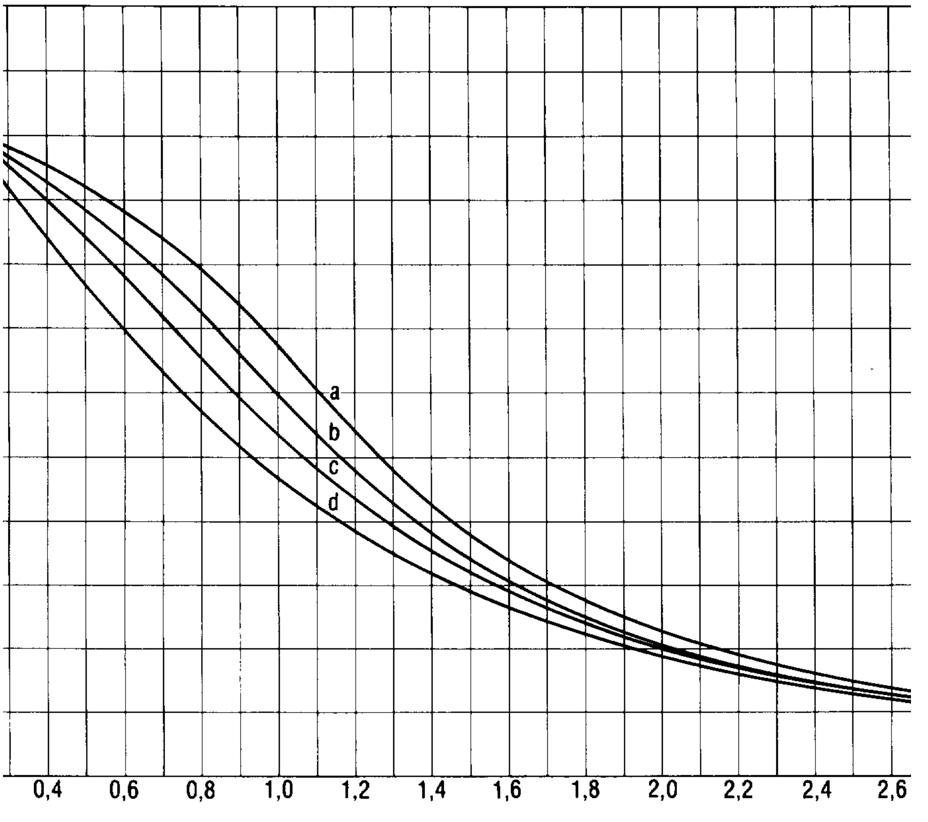
  1) rolled double T sections where the ratio between the height h and the wing width b_f is h/b_f >1,2 (i.e. HE with h>360mm and IPE sections);

2) rolled double T sections where the wings are reinforced by means of welded flat bars;

3) welded hollow sections.

- the curve c refers to single members different from those above mentioned or to open sections made with welded elements and to sections consisting of more than a single member
- the curve d refers to single or multiple members having thickness > 40 mm.

Figure 8



In case welded flat bars are used to reinforce the wings of a rolled double T section, the greatest between the thickness of the wing and the flat bar is to considered as the thickness t to be assumed for the calculation.

2.3.5 Lateral deflection along a direction different from that of the symmetrical axis perpendicular to the section

For the verification of the lateral deflection along a direction different from that of the symmetrical axis perpendicular to the section, when more detailed consideration with respect to the combined effects of both bending and torsion are not required, the values of the critical stress, as per the curves c and d of Fig 8 can be still assumed; in this case, however, the equivalent slenderness λ_{eq} is to be considered as follows:

$\lambda_{eq} = \lambda$ for $\lambda \geq 100$

$\lambda_{eq} = 1,2\lambda - 20$ for $100 \leq \lambda \leq 220$

2.3.6

In compliance with what stipulated in [2.3.7] the verification of a compressed member can be performed assuming that the transversal section is subjected to a compressive action N increased by the coefficient ω.

2.3.7

The following expression is to be verified:

$$\frac{\omega N}{A} \leq \sigma_{amm}$$

$$N_c = \frac{\sigma_{amm} A}{\omega}$$

The values of ω coefficients, as a function of the slenderness ratio λ are shown in App 1, Tab 1 for steel S235, App 1, Tab 2 for steel S275 and App 1, Tab 3 for steel S355 when the member is a squared, rectangular or round pipe.

In case the member has sections for which curve b of Fig 8 is to be considered, ω coefficients are shown in App 1, Tab 4, App 1, Tab 5 and App 1, Tab 6 for the steels above mentioned respectively.

In case the member has sections for which curve c of Fig 8 is to be considered, ω coefficients are shown in App 1, Tab

7, App 1, Tab 8 and App 1, Tab 9 for the steels above mentioned respectively.

In case of sections whose thicknesses are greater than 40 mm, ω coefficients, as shown in App 1, Tab 10, App 1, Tab 11 and App 1, Tab 12 for the steels above mentioned respectively.

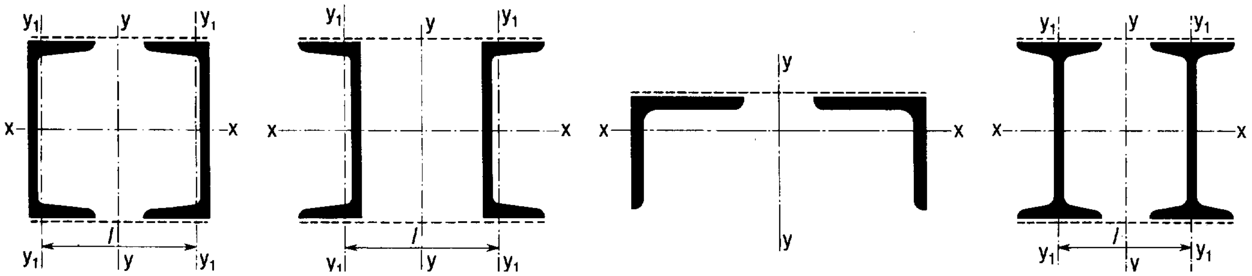
2.3.8 Multiple members

- **General**

In case of members consisting of two identical components, the verification can be performed in compliance with the procedure adopted for single members, as indicated in [2.3.7] considering for ω coefficients those reported in Appendix 1 Tables according to the material's yield point, with the only exception of evaluating the slenderness as suggested below.

Fig 9 summarizes the most recurrent situations faced when performing the verification of a section.

Figure 9



- **battened members**

In case of battened members, when the deformability of battens is negligible with respect to that of the lacings, the ideal slenderness ratio is defined as follows:

$$\lambda_{eq} = \sqrt{\lambda_y^2 + \lambda_1^2}$$

Where:

$\lambda_y = \beta L_0 / i_y$ being i_y the radius of gyration of the whole section with respect to the YY axis

$\lambda_1 = L_1 / i_{1\,min}$ being L_1 the distance between the axis of the battens and $i_{1\,min}$ is the minimum radius of gyration of the single member section.

For the expression of the ideal slenderness ratio to be applied, the following conditions are to be verified:

$$\frac{L_1}{i_{1y}} \le \frac{\lambda_x}{2}\left(4 - 3\frac{N}{N_c}\right) \quad \text{When} \quad \frac{\lambda_x}{2}\left(4 - 3\frac{N}{N_c}\right) > 50$$

$$\frac{L_1}{i_{1y}} \le 50 \quad \text{When} \quad \frac{\lambda_x}{2}\left(4 - 3\frac{N}{N_c}\right) \le 50$$

Where N is the total load acting on the multiple member and N_c is as defined in [2.3.7].

- **members whose main elements are connected by lacings**

In case of members whose main elements are connected by lacings, the usual configurations are as represented in the sketches in Fig 10.

The equivalent slenderness ratio is given by the following formula:

For sketches a) and c):

$$\lambda_{eq} = \sqrt{\lambda_y^2 + \frac{10A}{L_0 L_1^2} \cdot \left(\frac{L_d^3}{A_d} + \frac{L_1^3}{A_t}\right)}$$

For sketch b):

$$\lambda_{eq} = \sqrt{\lambda_y^2 + \frac{10A}{L_0 L_1^2} \cdot \left(\frac{L_d^3}{A_d}\right)}$$

Where:

λ_y is the slenderness ratio as defined before for battened members

A is the total section of both chords

A_d is the section of a diagonal strut for sketches a) and b) and the section of two diagonals struts for sketch c)

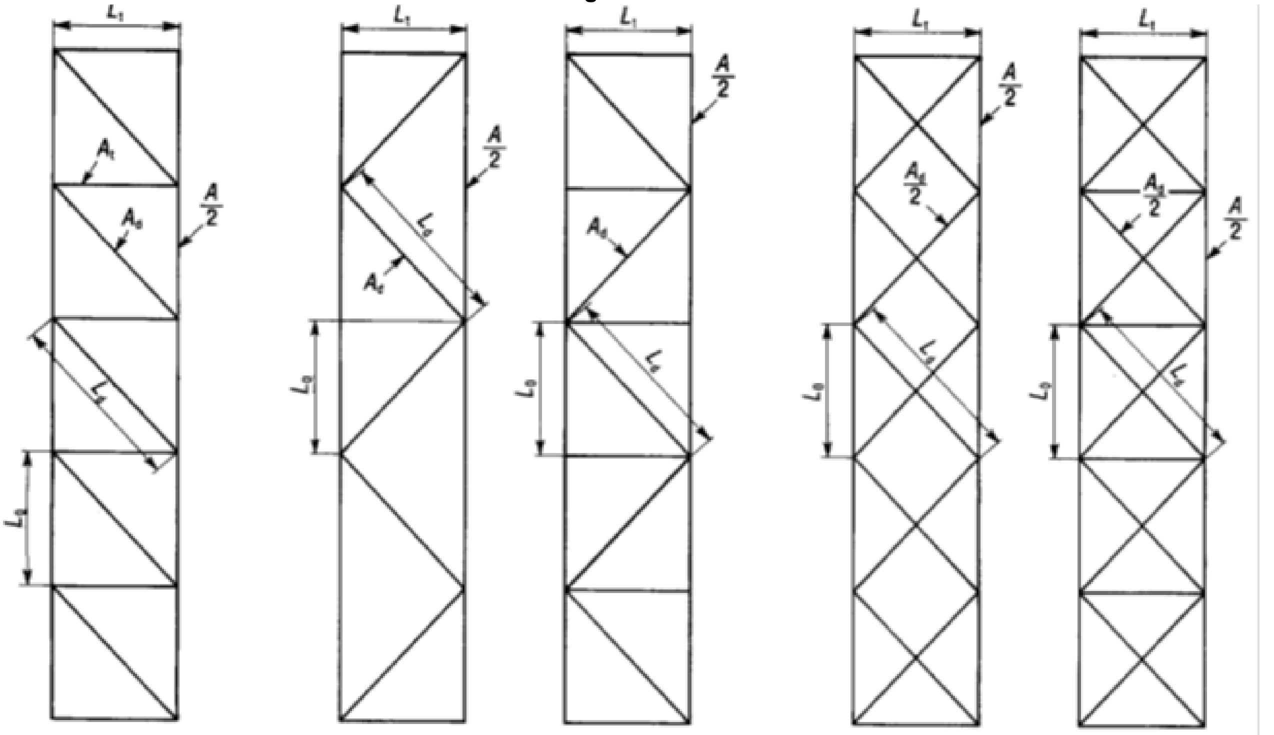
A_t is the section of the horizontal strut

L_d is the length of a diagonal strut

L_t is the distance between centroidal axis of chords

L_o is the length of a diagonal strut projected on the chord axis

Figure 10



Sketch a) Fig. I

Sketch b) Fig. II

Sketch c) Fig. III

- **design of connections**

Transversal connections of compressed multiple members and their connections to chords, may be designed assuming the force V as follows.

$$V = \frac{\omega N}{100}$$

Where:

ω coefficient is reported in App 1 Tab 7, App 1 Tab 8 and App 1 Tab 9 (or in App 1 Tab 10, App 1 Tab 11 and App 1 Tab 12 for thickness t > 40mm) as a function of the member

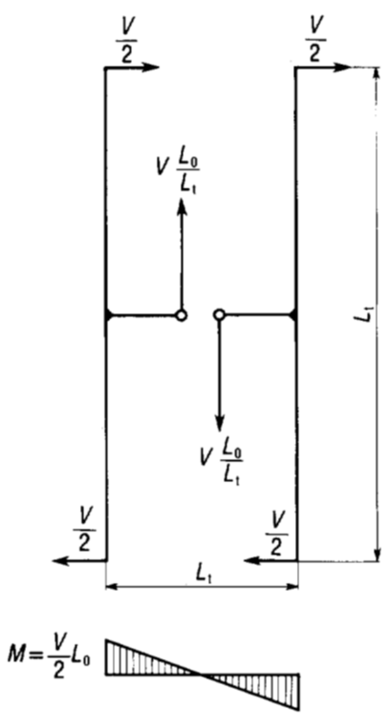
N is the axial force acting on the member

When dynamic actions are to be considered, the value of the force V is to be increased by 25%

In case of battened connections, the force V is to be increased by $5(L_t / i_{1\ min} - 20)$ % when the maximum distance L_t between the chords is greater than $20\ i_{1\ min}$

The scantling of the connecting battens is carried out assuming that the force V splits into two equal parts between the chords as shown in Fig 11.

Figure 11

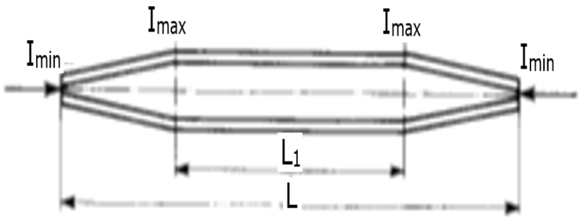
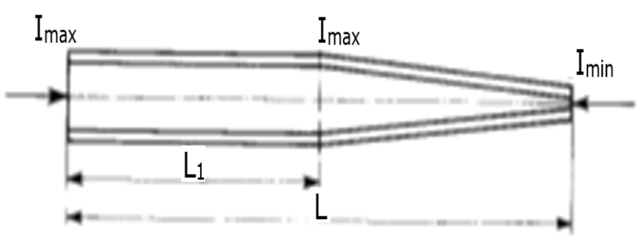
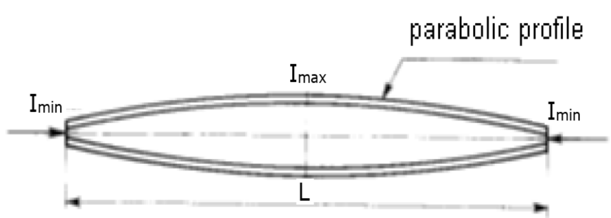
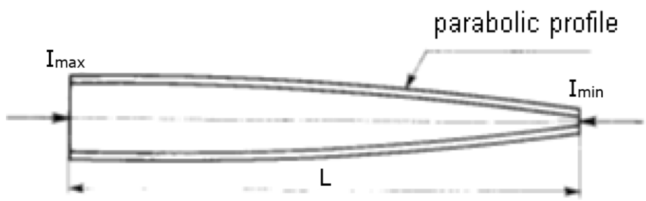


2.3.9 Members with non-constant section

Members with area of transversal section approximately constant, but with varying height, can be verified adopting the procedure detailed for members with constant section, providing a suitable equivalent inertia moment $I_{ed} = \gamma I_{max}$ is taken into consideration.

In case of both ends hinged members and $0,1 < \gamma < 1$, γ values are indicated in Tab 8.

Table 8 : γ values for both ends hinged members and $0,1 < \gamma < 1$

Cases	Shape of Section	γ values
a		For $\frac{L_1}{L} \le 0,5$ $\gamma = 0,17 + 0,33k + 0,5\sqrt{k} + \frac{L_1}{L} \cdot (0,62 + \sqrt{k} - 1,62k)$
		For $\frac{L_1}{L} \ge 0,8$ $\gamma = 1$
		For $0,5 < \frac{L_1}{L} < 0,8$ γ is to be obtained by linear interpolation between γ corresponding to $L_1/L = 0,5$ and $\gamma = 1$
b		For $\frac{L_1}{L} \le 0,05$ $\gamma = 0,08 + 0,92 + \left(\frac{L_1}{L}\right)^2 \cdot (0,32 + 4\sqrt{k} - 4,32k)$
		For $\frac{L_1}{L} \ge 0,5$ see Case **a**
c		$\gamma = 0,48 + 0,02k + 0,5\sqrt{k}$
d		$\gamma = 0,18 + 0,32k + 0,5\sqrt{k}$

Where:

$k = \sqrt{\frac{I_{min}}{I_{max}}}$

2.3.10 Members subjected to compression and bending

- **Prismatic members subjected to compressive axial force N and to a constant bending moment M**

  In case of prismatic members subjected to compressive axial force N and to a constant bending moment M, affected or not by N and acting in one of the main inertia plans, it is sufficient to verify the following:

$$\omega\frac{N}{A}+\frac{M}{\psi W\left(1-\nu\frac{N}{N_{cr}}\right)}\le\sigma_{amm}$$

Where:

ψ is the form factor (adaptation plastic factor) which preliminarily for the sake of safety can be assumed as equal to 1

υ is the safety factor for buckling as defined [2.3.1]

$N_{cr} = \sigma_{cr}A$ where σ_{cr} is the critical stress, in N/mm^2, reported in Tab 9 and evaluated by means of the Euler expression (even if the deformation of the member exceeds the elastic field) for the slenderness ratio relevant to the actual bending plan.

Table 9 : σ_{cr} values for the slenderness ratio relevant to the actual bending plan

λ	0	1	2	3	4	5	6	7	8	9
10	20331	16803	14119	12030	10373	9036	7942	7035	6275	5632
20	5083	4610	4201	3843	3530	3253	3008	2789	2593	2418
30	2259	2116	1985	1867	1759	1660	1560	1485	1408	1337
40	1271	1209	1153	1100	1050	1004	961	920	882	847
50	813	782	752	724	697	672	648	626	604	584
60	565	546	529	512	496	481	467	453	440	427
70	415	403	392	382	371	361	352	343	334	326
80	318	310	302	295	288	281	275	269	263	257
90	251	246	240	235	230	225	221	216	212	207
100	203	199	195	192	188	184	181	178	174	171
110	168	165	162	159	156	154	151	149	146	144
120	141	139	137	134	132	130	128	126	124	122
130	120	118	117	115	113	112	110	108	107	105
140	104	102	101	99	98	97	95	94	93	92
150	90	89	88	87	86	85	84	82	81	80
160	79	78	77	77	76	75	74	73	72	71
170	70	70	69	68	67	66	66	65	64	63
180	63	62	61	61	60	59	59	58	58	57
190	56	56	55	55	54	53	53	52	52	51
200	51	50	50	49	49	48	48	47	47	47
210	46	46	45	45	44	44	44	43	43	42
220	42	42	41	41	41	40	40	39	39	39
230	38	38	38	37	37	37	37	36	36	36
240	35	35	35	34	34	34	34	33	33	33
250	33	32	32	32	32	31	31	31	31	30

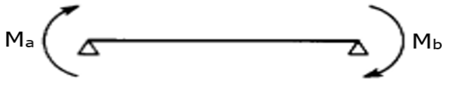
- **Bending moment varying along the member**

  When evaluating the bending stress of a member originated by a bending moment varying along the member, the value $M_{eq} = 1,3\ M_m$ is to be considered with the limitation $0,75M_{max} \le M_{eq} \le M_{max}$ where M_m is the medium value of the bending moment varying along the member and M_{max} is its maximum value. For the particular case of a member constrained at both its ends and subjected to a bending moment linearly varying between the end moments M_a and M_b (see Fig 12), the value of M is given by the following expression:

$$M_{eq} = 0,6M_a - 0,4M_b \quad \text{with} \quad |M_a| \geq |M_b|$$

providing $M_{eq} > 0,4\ M_a$

Figure 12



- **Prismatic members subjected to compressive axial force N and to bending moments M_x and M_y**

  In case of prismatic members subjected to compressive axial force N and to bending moments M_x and M_y acting in two main inertia plans, it is sufficient to verify the following:

$$\frac{\omega N}{A} + \frac{M_{x,eq}}{\psi_x W_x\left(1 - \frac{\nu N}{N_{cr,x}}\right)} + \frac{M_{y,eq}}{\psi_y W_y\left(1 - \frac{\nu N}{N_{cr,y}}\right)} \leq \sigma_{amm}$$

2.3.11 Plated beams subjected to deflection

Plated beams are to be verified for resistance to buckling and warping in accordance with relevant recognized standards

2.3.12 Buckling of plated beams

- **General**

  Web plates of walled members are to be verified with respect to buckling and, locally, in way of concentrated loads applied between stiffeners.

When performing the check, the web plate is considered as divided into rectangular fields whose length and height are defined as a and h respectively; the figure a is the distance between the transversal fasteners whilst b is the clear distance between adjacent longitudinal. When there are no fasteners, the length a of the plate coincides with the length of the member.

The buckling check of each field (a, h) as above defined, is performed considering the value of the stress c at the compressed edge and the medium value of the shear stress τ originated by the maximum value of the bending moment, the axial and shear force therein acting. Should the maximum value of the bending moment or of the shear force is found at one end of the field (a, h), the values they have at the middle of the field can be assumed for the evaluation of the stresses σ and τ.

When the axial force acting on the cross section of the web plate is always a tensile force, uniformly distributed or linearly varying, only the shear stress is to be taken into consideration for the verification of the buckling, being therefore $\sigma_1 = 0$. When, on the contrary, the axial force is a compressive force, uniformly distributed or linearly varying according to a law defined by the ψ coefficient (see Tab 10), the maximum value of the tension normal to the edge of the field under consideration is assumed as σ_1.

For the purposes of buckling verification, the shear stress τ is evaluated assuming that the shear force is uniformly distributes on the web section plate only.

Table 10 : compressive force, uniformly distributed or linearly varying according to a law defined by the ψ coefficient

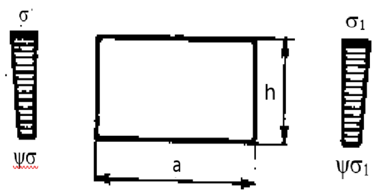
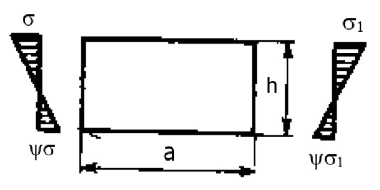
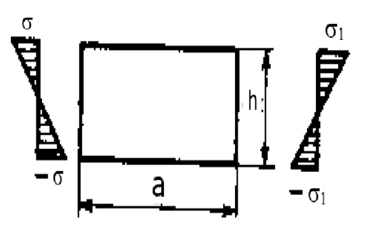
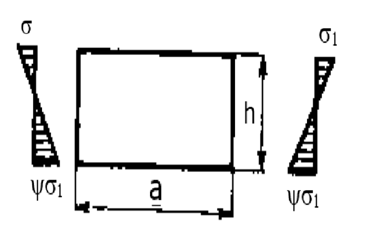
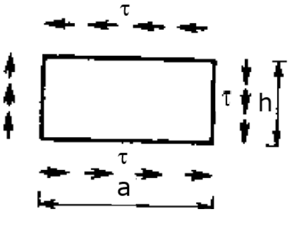
Ordinal	Panel load assumptions		Ideal buckling stress *	$\alpha = a / h$	buckling coefficient
I	linearly varying compression stress $0 \le \psi \le 1$		$\sigma_{cr} = k_\sigma \sigma_{cr,\,0}$	$\alpha \ge 1$	$k_\sigma = \dfrac{8,4}{\psi + 1,1}$
				$\alpha < 1$	$k_\sigma = \left(\alpha + \dfrac{1}{\alpha}\right)^2 \cdot \dfrac{2,1}{\psi + 1,1}$
II	Compressive and tensile stress linearly varying with compressive stress greater in value $-1 \le \psi \le 0$		$\sigma_{cr} = k_\sigma \sigma_{cr,\,0}$		$k_\sigma = 1 + \psi k_1 - \psi k_3 + 10\psi(1+\psi)$ Where: k_1 is derived from Ordinal I for $\psi = 0$ k_3 is derived from Ordinal III for $\psi = -1$
III	Compressive and tensile stress linearly varying with same values of compressive and tensile stresses $\psi = 1$ or with tensile stress greater in value $\psi < 1$		$\sigma_{cr} = k_\sigma \sigma_{cr,\,0}$	$\alpha \ge 2/3$	$k_\sigma = 23{,}9$
				$\alpha < 2/3$	$k_\sigma = 15{,}87 + (1{,}87/\alpha^2) + 8{,}6\alpha^2$
IV	Uniformly distributed shear stress		$\tau_{cr} = k_\tau \sigma_{cr,\,0}$	$\alpha \ge 1$	$k_\tau = 5{,}34 + (4/\alpha^2)$
				$a < 1$	$k_\tau = 4 + (5{,}34/\alpha^2)$
* For critical stress $\sigma_{cr,\,0}$ see Tab 11					

Table 11 : $\sigma_{cr,\,0}$ reference values in N/mm^2

h cm	t mm													
	3	4	5	6	8	10	12	14	15	16	18	20	22	24
30	18,62	33,11	51,72	74,44	132,41	206,89	297,92							
40	10,47	18,62	29,06	41,88	74,48	116,38	167,58	228,09	261,84					
50	6,70	11,92	18,62	26,81	47,67	74,48	107,25	145,98	167,58	190,67	241,32			
60	4,65	8,28	12,93	18,62	33,10	51,72	74,48	101,38	116,38	132,41	167,58	206,89	250,34	
70	3,42	6,08	9,49	13,68	24,32	38	54,72	74,48	85,50	97,28	123,12	152,00	183,92	218,88
80	2,62	4,65	7,27	10,47	18,62	29,09	41,89	57,02	65,46	74,48	94,26	116,38	140,81	167,58
90	2,07	3,68	5,75	8,28	14,71	22,99	33,10	45,06	51,72	58,85	74,48	91,95	111,26	132,41
100	1,68	2,98	4,65	6,70	11,92	18,62	26,81	36,50	41,89	47,67	60,33	74,48	90,12	107,25
110	1,39	2,46	3,85	5,54	9,85	15,39	22,16	30,18	34,62	39,39	49,86	61,55	74,48	88,64
120	1,16	2,07	3,23	4,65	8,28	12,93	18,62	25,34	29,09	33,10	41,89	51,72	62,58	74,48
130	0,99	1,76	2,75	3,97	7,05	11,02	15,87	21,59	24,79	28,21	35,70	44,07	53,33	63,46
140	0,86	1,52	2,38	3,42	6,08	9,50	13,68	18,62	21,38	24,32	30,78	38	45,98	54,72
150	0,74	1,32	2,07	2,98	5,30	8,26	11,92	16,22	18,62	21,19	26,81	33,10	40,05	47,67
160	0,65	1,10	1,82	2,62	4,65	7,27	10,47	14,26	16,37	18,62	23,57	29,09	35,20	41,89
170	0,59	1,03	1,61	2,32	4,12	6,44	9,28	12,63	14,50	16,49	20,88	25,77	31,18	37,11
180	0,52	0,92	1,44	2,07	3,68	5,75	8,28	11,26	12,93	14,71	18,62	22,99	27,82	33,10
190	0,46	0,83	1,29	1,86	3,30	5,16	7,43	10,11	11,61	13,20	16,71	20,63	24,96	29,71
200	0,42	0,74	1,16	1,68	2,98	4,65	6,70	9,12	10,47	11,92	15,08	18,52	22,53	26,81
210	0,38	0,68	1,05	1,52	2,70	4,22	6,08	8,28	9,50	10,81	13,68	16,89	20,44	24,32
220	0,35	0,62	0,96	1,39	2,46	3,85	5,54	7,54	8,66	9,85	12,46	15,39	18,62	22,16
230	0,32	0,56	0,88	1,27	2,25	3,52	5,07	6,90	7,92	9,01	11,40	14,08	17,04	20,27
240	0,29	0,52	0,81	1,16	2,07	3,23	4,65	6,34	7,27	8,28	10,47	12,93	15,65	18,62
250	0,27	0,49	0,74	1,07	1,91	2,98	4,29	5,84	6,70	7,63	9,65	11,92	14,42	17,16
260	0,25	0,44	0,69	0,99	1,76	2,75	3,97	5,40	6,20	7,05	8,92	11,02	13,33	15,87
270	0,23	0,41	0,64	0,92	1,63	2,55	3,68	5,01	5,75	6,54	8,28	10,22	12,36	14,71
280	0,21	0,38	0,59	0,86	1,52	2,38	3,42	4,65	5,34	6,08	7,69	9,50	11,50	13,68
290	0,20	0,35	0,55	0,80	1,42	2,21	3,19	4,34	4,98	5,67	7,17	8,86	10,72	12,75
300	0,19	0,33	0,52	0,74	1,32	2,07	2,98	4,06	4,65	5,30	6,70	8,28	10,01	11,92
310	0,17	0,31	0,48	0,70	1,24	1,94	2,79	3,80	4,36	4,96	6,28	7,75	9,38	11,16
320	0,16	0,29	0,45	0,65	1,16	1,82	2,62	3,56	4,09	4,65	5,89	7,27	8,80	10,47
330	0,15	0,27	0,43	0,62	1,09	1,71	2,46	3,35	3,85	4,38	5,54	6,84	8,28	9,85
340	0,14	0,26	0,40	0,58	1,03	1,61	2,32	3,16	3,62	4,12	5,22	6,44	7,80	9,28
350	0,14	0,24	0,38	0,55	0,97	1,52	2,19	2,98	3,42	3,89	4,92	6,08	7,36	8,76
360	0,13	0,23	0,36	0,52	0,92	1,44	2,07	2,82	3,23	3,68	4,65	5,75	6,95	8,28
370	0,12	0,22	0,34	0,49	0,87	1,36	1,96	2,67	3,06	3,48	4,41	5,44	6,56	7,83
380	0,12	0,21	0,32	0,46	0,83	1,29	1,86	2,53	2,90	3,30	4,18	5,16	6,24	7,43
390	0,11	0,20	0,31	0,44	0,78	1,22	1,76	2,40	2,75	3,13	3,97	4,90	5,93	7,05

400	0,10	0,19	0,29	0,42	0,74	1,16	1,68	2,28	2,62	2,98	3,77	4,65	5,63	6,70
410	0,10	0,18	0,28	0,40	0,71	1,11	1,60	2,17	2,49	2,84	3,59	4,43	5,36	6,38
420	0,10	0,17	0,26	0,38	0,68	1,06	1,52	2,07	2,38	2,70	3,42	4,22	5,11	6,08
430	0,09	0,16	0,25	0,36	0,64	1,01	1,45	1,97	2,27	2,58	3,26	4,03	4,87	5,80
440	0,09	0,15	0,24	0,35	0,62	0,96	1,38	1,89	2,16	2,46	3,12	3,85	4,65	5,54
450	0,09	0,15	0,23	0,33	0,59	0,92	1,32	1,80	2,07	2,35	2,93	3,68	4,45	5,30
460	0,08	0,14	0,22	0,32	0,56	0,88	1,27	1,72	1,98	2,25	2,85	3,52	4,26	5,07
470	0,08	0,13	0,21	0,30	0,54	0,84	1,21	1,65	1,90	2,16	2,73	3,37	4,08	4,86
480	0,07	0,13	0,20	0,29	0,52	0,81	1,16	1,58	1,82	2,07	2,62	3,23	3,91	4,65
490	0,07	0,12	0,19	0,28	0,50	0,78	1,12	1,52	1,74	1,99	2,51	3,10	3,75	4,47
500	0,07	0,12	0,19	0,27	0,48	0,74	1,07	1,46	1,68	1,91	2,41	2,98	3,60	4,29

- **Checking for point loads**

  When longitudinal fasteners are not fitted, local checking of the web, subjected to loads applied between two adjacent transversal fasteners, is satisfied providing the following expression, often largely conservative, is verified:

$$\frac{F}{t_w \cdot b_{eff}} \le \frac{230000}{\nu}\left[1 + 2\left(\frac{h_w}{a}\right)^2\right]\left(\frac{t_w}{h_w}\right)^2 \qquad \text{in } \frac{N}{mm^2}$$

Where:

F is the applied concentrated load

h_W is the web height

a is the distance between two adjacent fasteners

b_{eff} is the smallest value between a and h

t_W is the web thickness

ν is the safety factor against buckling as defined in [2.3.1]

The checking is to be implemented by ascertaining that, in way of the point load application (see Fig 13), the following expression is verified:

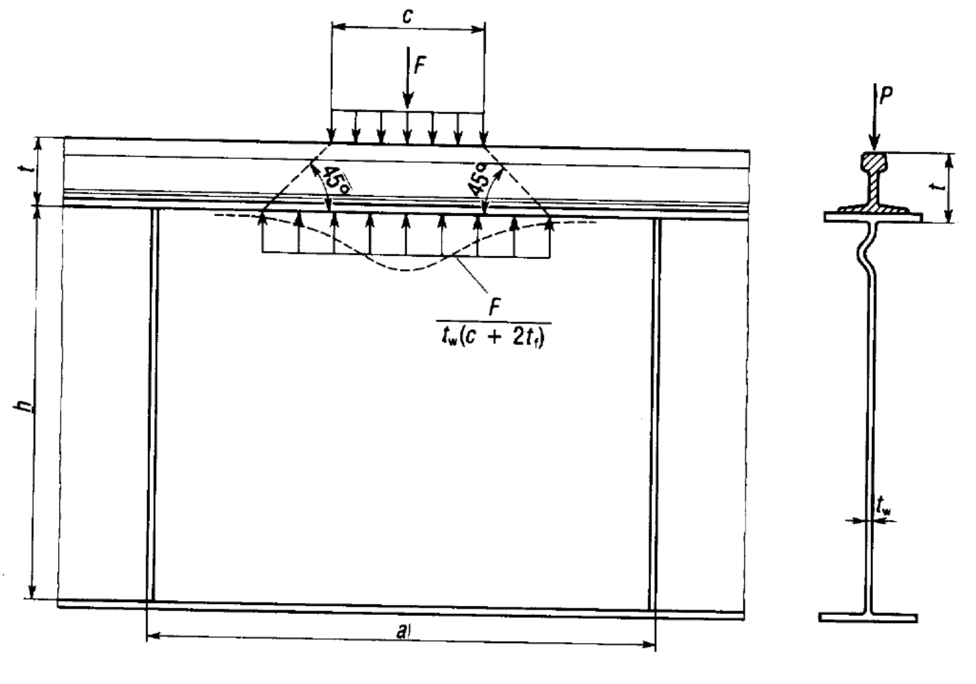
$$\frac{F}{t_w \cdot (c + 2t)} \le 1,15\sigma_{amm}$$

Where:

c is the length of the section on which the load F is applied

t is the total thickness through which the load distribution occurs

Figure 13



2.4 Verification with respect to fatigue

2.4.1 General

The fatigue strength, expressed as the critical amplitude of a fluctuating or alternating stress, is to be determined on the basis of the following information:

a) Service categories and duty factor of the crane

b) The material used and the notch effect at the point being considered

c) The fluctuation factor = $\sigma_{min}/\sigma_{max}$

d) Whether the maximum stress is tension or compression

Regarding detailed procedure for the determination of the critical stress amplitude, see Appendix 2 or other specialized recognized literature.

3 Slewing ring and slewing ring bolting

3.1

3.1.1 General requirements

The crane manufacturer is to submit plans of the slewing ring, the bolting arrangement, crane and pedestal structure in way of the slewing ring; calculations giving static and fatigue design loads and allowable stresses for the ring and bolting arrangement are to be submitted too.

the crane is equipped with a conventional forged slewing bearing, material properties are to be specified by the manufacturer such as chemical composition, mechanical properties, heat treatment, depth and hardness of surface hardened layer and surface finish of fillets.

Slew rings are to be constructed of steel having an average Charpy V-notch impact value, at – 20°C, of 42 J taken from three samples with a lowest single value not less than 27 J.

Position of test specimen is to be indicated. The method and extent of non-destructive testing is to be specified and the testing procedures are to be defined.

Detailed information about the method of manufacture is to be recorded by the manufacturer in the technical construction file. For every new material of which the manufacturer has no previous experience and for any change in heat treatment of a material previously used, a detailed material examination, including NDE, is to be carried out.

In general, the ring is to be manufactured from steel having an ultimate tensile strength of range 820 to 1100 N/mm2 and an elongation, based on a gauge length of five diameters, of not less than 15%.

Bolts are to be according to ISO 898-1 material Grade 8.8, 10.9 or 12.9, or equivalent, whose impact values are those indicated in this standard with the following exceptions:

- for cranes for offshore operations: the impact values are those indicated in Tab 12
- for cranes for transhipping operations: the impact values are those indicated in ISO 898-1 or Tab 12 depending on the site where the crane will be installed.

Table 12 : impact values for bolts

Grade	Charpy V notch at test temp. -20 °C		Minimum elongation
	average value in Joule	minimum single value in Joule	gauge lenght 5d in %
8,8	42	27	14
10,9	42	27	12
12,9	42	27	10

Bolts are to be pre-tensioned by controlled means, as prescribed by the crane manufacturer, to at least 70% of their yield stress or in accordance with calculations which demonstrate that their fatigue life is either equal to that of the crane or such lesser value is stated in the maintenance manual.

Bolts are to be subjected to visual and magnetic particle inspection according to ISO 898-1 at least 48 hours after completion of the quenching and tempering process.

Bolts, in general, should have rolled threads, in order to improve fatigue strength, and be supplied in black condition, be well greased and sealed against corrosion; if plated, the treatment should be such as to preclude the occurrence of hydrogen embrittlement.

The axial tensile load, due to external loading, on the most heavily loaded bolt, is given by the following expression:

$$N = \frac{4 \cdot M_t}{n \cdot d} - \frac{H}{n}$$

Where:

M_t is the design overturning moment, in N/mm^2

H is the design axial load, in N

D is the pitch circle diameter of bolts, in mm

N is the number of bolts

The force N is to be lower to the axial force acting on the bolt when pre-tensioned as described in [2.2.3]

3.1.2 Flange connection with pre-stressed bolts

For constructional purposes, the following provisions are to be fulfilled:

- bolt holes may be larger than the shaft diameter d_s by a value Δ given by the expression:

  $\Delta < 0,1 \quad d_s \leq 3$ mm
- bolt spacing is not to be greater than 6 d_s
- in general the span length of bolts is to be, at least, 3 d_s

The suitability of the flange with respect to the forces transmitted by the tensional loads of the bolts is to be verified on the basis of current sound engineering practice or standard recognized calculation procedures

However, the thickness tf of the flanges is to be, in general, not lower than 3 times the required thickness of the upper part of the crane's column (that means that no contribute of the slewing ring is to be considered)

The bending stress in the flange may be calculated according to formula contained in [7.1.2].

3.1.3 Flange flatness

Flatness of the connecting flange mating surface to the slewing ring is to comply with the slewing ring manufacturer's specification.

No surface levelling compound is to be used in order to fulfil the required evenness; in case of repair needs only the use of compound may be accepted providing, however, previous agreement with the Classification Society and the slewing ring manufacturer

4 Stability against overturning

4.1

4.1.1 General

Mobile cranes are to be examined for stability against overturning in the worst operating conditions.

Rails and guides are assumed to be rigid.

The maximum inclination of the crane in relation to ship inclination is considered.

The following conditions are to be taken into account:

a) crane operating with wind as specified in loading condition II

b) failure of the hoist wire and sudden release of the load as specified in loading condition III, b)

c) crane in the stowed condition during navigation as specified in loading condition IV

d) crane not in operation with maximum load suspended in the most unfavourable position.

The safety factor considered as the ratio of stabilising moments and overturning moments is to be at least 1,25 for the conditions in (a), (b) and (c) above and at least 1,50 for (d) above.

Blocking devices or lashings may be considered for calculation of the overturning moment provided that their efficiency does not depend on friction and the anchoring structure has suitable scantlings.

Suitable lashing arrangements are to be provided for supporting the forces acting when the crane is in the stowed condition.

Travelling cranes on rails are to be provided with efficient stops at both ends of travel and are to be designed so that, after contact, the crane will remain stable under the most severe operating conditions.

Travelling cranes on wheels are to be designed to prevent complete derailment or loss of stability in the event of wheel or axle failure.

Jib cranes are to be designed so as to obviate jack-knifing.

Where ballast is necessary to ensure stability, this is to be clearly indicated on a plate permanently fixed onto the crane structure in a suitable position.

5 Safety against crane dragging by the wind

5.1

5.1.1 General

In the most unfavourable conditions of inclination of the ship, the crane is to be verified against dragging by the wind having a maximum force plus 10%.

This verification may be performed assuming a factor of adherence of the braked wheels equal to 0,14, and resistance to movement of the idle wheels equal to 10 N/kN if assembled on roller bearings or equal to 15 N/kN if assembled on bushed bearings.

Where dragging of the crane is possible, an anchoring device (chains, rail tongs, manual or automatic bolts, etc.) is to be arranged.

For calculation of tongs, a friction factor between the rail tongs and the rails is to be taken as 0,25.

6 Guides and tracks

6.1

6.1.1 General requirements

Guides and tracks are to comply with the requirements specified in the previous paragraphs.

All vertical and horizontal forces transmitted to the deck by the travelling wheels of the crane and all forces caused by hitting against the end of run devices as specified in either Ch 4 [2.3.1] (e) (for cranes), Ch 5 [2.2.4], g), 4) (for offshore cranes) or Ch 6 [2.2.3] (for transshipment cranes) are to be considered.

6.1.2 Vertical forces

Vertical forces are to be calculated in relation to loads considered in the different loading conditions.

6.1.3 Transverse horizontal forces

Horizontal forces, normal to the direction of movement, may be taken as 1/10 of the vertical static load in order to consider "hunting" and the inertia forces of the trolley.

6.1.4 Longitudinal horizontal forces

Unless otherwise indicated, longitudinal horizontal forces may be taken as 1/7 of the vertical load on the drive wheels. The forces due to hitting against the end of run devices are not considered.

6.1.5 Elastic deformation

Unless otherwise specified by the Manufacturer, the maximum vertical deflection and horizontal transverse deflection are to be not greater than 1/800 and 1/1600, respectively, of the span of the track or rails.

6.1.6 Allowable stresses

See the requirements specified in [2.2].

7 Crane pedestals and foundations

7.1

7.1.1 General requirements

Crane pedestals and foundations concern the hull and are therefore to comply with the requirements of structural strength and watertightness in accordance with the relevant Rules as applicable.

In general, supporting structures of the crane are to be suitably connected to the upper deck (wedging) as well as to the lower deck (step).

Connecting flanges of removable parts are to have suitable thickness so as to ensure sufficient rigidity for bearings or bolts.

Where flanges are stiffened by brackets, the latter are to be positioned along the circumference and are generally to be installed every two bolts.

7.1.2 Verification of resistance

Resistance is to be verified with regard to loads that result from the most severe operating conditions as specified in Ch 4, [3.1.1] (for cranes), Ch 5, [3.1.1] (for offshore cranes), Ch 6, [3.1.1] (for transhipment cranes).

The bending stress σ_f in a pedestal flange, connected to a cylindrical pedestal, may be calculated as follows:

$$\sigma_f = \frac{5 \cdot \sigma_t \cdot t_p \cdot e}{t_f^2}$$

Where:

σ_t is the total stress acting in the pedestal wall below the flange (i.e. bending and tension/compression)

t_f is the flange wall thickness

t_p is the pedestal wall thickness below the flange

e is the distance between bolt holes and centre of pedestal wall

In general it is recommended the ratio t_f / t_p to be ≥ 3.

The allowable stresses are those considered for the hull structures to which crane pedestals and foundations are connected.

Materials are to be chosen depending on wall thickness as specified in Part B of the Tasneef Rules for the classification of ships.

8 Construction requirements

8.1

8.1.1 General requirements

The general requirements specified in recognized international Standards are to be complied with; requirements for constructional particulars specified below are to be complied with as well.

8.1.2 Structural elements

In general, rolled angle bars smaller than 50 x 50 mm, thicknesses less than 5 mm and bolts or rivets having diameter smaller than 14 mm are not allowed.

Lesser values are only approved for secondary members, at the special request of the Designer.

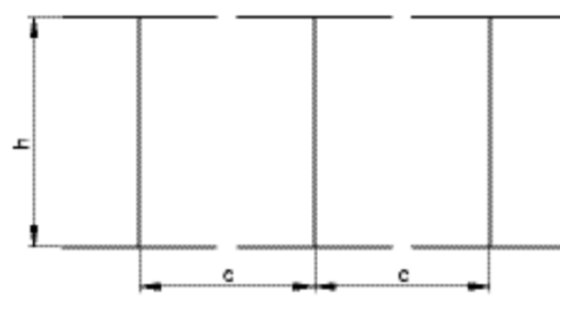
8.1.3 Composite bars under compression

The slenderness ratio of each bar composing the latticework is not to exceed 50 if the effective bending length is considered to be the distance between two knots (i.e. considering the bars to be hinged at their ends).

Tripping plates are to be arranged at one third of the effective deflection length of the composite bar.

In general, in case of sectioned bars of three or more sections (see Fig 14), the distance between the sections is to be not greater than the height of the bar ($c \leq h$).

Figure 14



8.1.4 Main members

In general for main members, the slenderness ratio is to be less then or equal to 120 (in special cases less then or equal to 150).

For secondary members is to be less then or equal to 200 (in special cases less then or equal to 250).

8.1.5 Bars under tension

Where bars under tension are composed of two or more rolled bars, they should be connected to each other at least every 1,5 m in order to prevent vibrations.

8.1.6 Crane head

The design of the crane head is to be such as not to generate load concentrations while avoiding wear of ropes and permitting ease of access for inspection of the sheaves and pins.

Span rope and cargo runner connections are to be arranged in order to generate the smallest bending moment on the crane jib.

8.1.7 Design of the Crane

The crane is to be designed so that each part may be easily inspected. The elements to be lubricated are to be easily accessible and disassembly and maintenance are to be facilitated as far as possible.

Where possible, bending of main components is to be avoided; failing this, such components are to have a long radius and are to be obtained on suitable mandrels.

Notches are to be avoided. Cut-outs are to be rounded off. Continuous elements are to be well rounded and are to have as large a connecting radius as practicable.

If hollow sections where water may accumulate cannot be eliminated, suitable drainage holes are to be provided.

In the case of compound structures, hollow spaces where maintenance may not be easily carried out are to be filled with suitable material.

9 Materials

9.1 Application

9.1.1 General requirements

Materials are to be appropriate, at the discretion of Tasneef and, in general, they are to meet the testing requirements indicated in Pt D, Ch 2, Sec 1 of the Rules for the classification of ships.

Materials used for the construction of cranes and their components are to comply with the requirements specified below.

Materials having characteristics other than those specified in the above-mentioned Rules may be considered by Tasneef on condition that detailed information concerning their chemical, mechanical and manufacturing properties as well as their future application is submitted for consideration. If necessary, Tasneef may require additional tests.

The anticipated operating temperature of the system is to be considered in the choice of the materials used in the construction of the equipment.

In particular, for design temperatures as low as -10°C, the steel grades are as prescribed in Pt B, Ch 4, Sec 1, Tab 6 of Tasneef Rules for the classification of ships.

For design temperatures lower than -10°C, the steel grades are as prescribed in Pt B, Ch 4, Sec 1, Tab 8, Tab 9 and Tab 10 of the Rules for the classification of ships.

For the application of Pt B, Ch 4, Sec 1 of Tasneef Rules for the classification of ships, the classes of the structural members of cranes can be defined as follows:

- CLASS I (secondary): structures of lesser importance whose collapse would not affect the structural integrity of the crane;
- CLASS II (primary): structures of primary importance whose collapse would affect the structural integrity of the crane
- CLASS III (special): structures of primary importance in critical zones subject to stress concentrations.

The associated Rule values of impact strength for each steel grade are shown in Tables 4 and 7 of Pt D, Ch 2, Sec 1 of Tasneef Rules for the classification of ships.

10 Mobile cranes

10.1

10.1.1 General requirements

A crane with tires or tracks is allowed to work on board, to be rigged in its fixed position and to move on deck with the suspended load on condition that:

a) deck structures are suitable for supporting the loads transmitted by the crane during transit. Deck areas where the crane may travel and move are to be clearly indicated, with suitable means. These areas are also to be specified in the "Diagram of the general arrangement on board of lifting appliances" to be enclosed with the ILO Register. The transit area is to include at least 1 m between the crane and any fixed structure

b) from the "Trim and Stability booklet" the heel and trim angles of the ship resulting from the crane moving with the suspended load do not exceed the limit values taken for the scantling verification of the crane

c) the inertia forces generated by a sudden stop during translation are taken into account for the verification of the crane structures. Where such inertia forces are unknown but the translation speed v is known, the acceleration a generating these forces may be obtained from Ch 4, Tab 2;

d) the tipping moment of the crane is less than 80% of the stabilising moment

e) all tests during motion of translation of the crane with the load suspended on the hook corresponding to minimum and maximum safe working load are performed with a satisfactory outcome

f) cranes are provided with automatic working load indicators capable of giving a visual alarm for loads having from 90% to 97% of the maximum load allowed in the specific condition and an audible alarm for loads having more than 103% of the working load.

11 Cranes with lifting magnet

11.1

11.1.1 General requirements

The use of cranes with lifting magnet on board is subjected to the following conditions in addition to those indicated above, as far as applicable:

a) the electrical system is to be designed so that overload of the system sets off an alarm on the main electrical panel before demagnetisation of the lifting magnets occurs

b) the electrical system is to be kept in operation with a power equal to twice the operating power and subdivided into two parallel groups

c) variation of the supply voltage is to be not greater than 10%;

d) an alternative power source, i.e. batteries that start operating as soon as the main power supply is cut off, is to be provided.

The crane is to be marked with the maximum operating load as determined by tests using loads having the same characteristics as those to be lifted "in service".

When the load to be lifted "in service" is different from that used in the test, it is to be reduced by 60% of the maximum operating load.

APPENDIX 1 COEFFICIENT ω AS A FUNCTION OF THE SLENDERNESS RATIO

1 General

1.1 Aim of the Appendix

1.1.1 The following Tables show the ω coefficient, as a function of the slenderness ratio of the member, for the different grades of steel used.

Table 1 : Steel S235 (curve a)

λ	0	1	2	3	4	5	6	7	8	9
0	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
10	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
20	1,00	1,01	1,01	1,01	1,01	1,01	1,02	1,02	1,02	1,03
30	1,03	1,03	1,03	1,04	1,04	1,04	1,05	1,05	1,05	1,06
40	1,06	1,06	1,07	1,07	1,07	1,08	1,08	1,09	1,09	1,1
50	1,1	1,11	1,11	1,12	1,12	1,13	1,13	1,14	1,14	1,15
60	1,16	1,16	1,17	1,17	1,18	1,18	1,19	1,2	1,2	1,21
70	1,22	1,23	1,24	1,24	1,25	1,26	1,27	1,28	1,29	1,29
80	1,31	1,32	1,33	1,34	1,36	1,37	1,38	1,4	1,41	1,42
90	1,44	1,45	1,47	1,48	1,5	1,52	1,53	1,55	1,57	1,59
100	1,61	1,63	1,65	1,67	1,69	1,71	1,73	1,75	1,77	1,79
110	1,82	1,84	1,86	1,89	1,91	1,94	1,96	1,99	2,01	2,04
120	2,06	2,09	2,12	2,14	2,17	2,2	2,22	2,25	2,28	2,31
130	2,34	2,37	2,4	2,43	2,46	2,49	2,52	2,55	2,58	2,61
140	2,65	2,68	2,71	2,74	2,78	2,81	2,84	2,88	2,91	2,95
150	2,98	3,02	3,05	3,08	3,12	3,16	3,19	3,23	3,27	3,3
160	3,34	3,38	3,41	3,45	3,49	3,53	3,56	3,6	3,64	3,68
170	3,72	3,76	3,8	3,84	3,88	3,92	3,96	4,01	4,05	4,09
180	4,14	4,18	4,22	4,27	4,31	4,35	4,4	4,44	4,49	4,53
190	4,58	4,62	4,67	4,72	4,77	4,81	4,85	4,9	4,94	4,99
200	5,03	5,08	5,13	5,18	5,22	5,27	5,32	5,37	5,42	5,47
210	5,52	5,57	5,62	5,67	5,72	5,77	5,82	5,87	5,92	5,98
220	6,03	6,08	6,14	6,19	6,24	6,3	6,36	6,41	6,46	6,52
230	6,57	6,63	6,69	6,74	6,79	6,84	6,9	6,96	7,02	7,08
240	7,14	7,19	7,25	7,31	7,38	7,44	7,5	7,55	7,61	7,67
250	7,73									

Table 2 : Steel S275 (curve a)

λ	0	1	2	3	4	5	6	7	8	9
0	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
10	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
20	1,01	1,01	1,01	1,01	1,02	1,02	1,02	1,03	1,03	1,03
30	1,04	1,04	1,04	1,04	1,05	1,05	1,05	1,06	1,06	1,07
40	1,07	1,07	1,08	1,08	1,09	1,09	1,1	1,1	1,11	1,12
50	1,12	1,13	1,13	1,14	1,14	1,15	1,16	1,16	1,17	1,1B
60	1,18	1,19	1,2	1,2	1,21	1,22	1,23	1,24	1,25	1,26
70	1,27	1,28	1,29	1,3	1,31	1,32	1,33	1,35	1,36	1,37
80	1,39	1,4	1,42	1,43	1,45	1,46	1,48	1,5	1,52	1,54
90	1,55	1,57	1,59	1,62	1,64	1,66	1,68	1,7	1,72	1,75
100	1,77	1,8	1,82	1,84	1,87	1,9	1,92	1,95	1,98	2
110	2,03	2,06	2,09	2,12	2,15	2,17	2,2	2,23	2,26	2,30
120	2,33	2,36	2,39	2,42	2,46	2,49	2,52	2,56	2,59	2,62
130	2,66	2,69	2,73	2,77	2,8	2,84	2,87	2,91	2,95	2,99
140	3,02	3,06	3,1	3,14	3,18	3,22	3,26	3,29	3,33	3,37
150	3,41	3,45	3,49	3,54	3,56	3,62	3,66	3,7	3,74	3,79
160	3,63	3,88	3,92	3,97	4,01	4,06	4,11	4,15	4,2	4,25
170	4,29	4,34	4,39	4,44	4,48	4,53	4,58	4,63	4,68	4,73
180	4,75	4,83	4,88	4,93	4,98	5,03	5,08	5,13	5,18	5,23
190	5,28	5,34	5,39	5,44	5,5	5,55	5,61	5,66	5,72	5,77
200	5,83	5,88	5,93	5,99	6,05	6,1	6,16	6,22	6,28	6,34
210	6,4	6,46	6,52	6,58	6,64	6,7	6,75	6,81	6,87	6,93
220	7	7,06	7,12	7,18	7,25	7,31	7,38	7,45	7,51	7,57
230	7,64	7,7	7,76	7,83	7,9	7,97	8,04	8,11	8,17	8,24
240	8,31	8,37	8,44	8,51	8,57	8,64	8,71	8,78	8,85	8,92
250	8,98									

Table 3 : Steel S355 (curve a)

λ	0	1	2	3	4	5	6	7	8	9
0	1, 00	1,00	1,00	1,00	1,00	1, 00	1,00	1,00	1,00	1,00
10	1, 00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,01	1,01
20	1,01	1,02	1,02	1,02	1,03	1,03	1,03	1,04	1,04	1,04
30	1,05	1,05	1,06	1,06	1,06	1,07	1,07	1,06	1,08	1,09
40	1,1	1,1	1,11	1,11	1,12	1,13	1,13	1,14	1,15	1,15
50	1,16	1,17	1,18	1,18	1,19	1,20	1,21	1,22	1,23	1,24
60	1,25	1,26	1,27	1,28	1,29	1,31	1,32	1,33	1,35	1,36
70	1,38	1,39	1,41	1,43	1,45	1,47	1,48	1,5	1,53	1,55
80	1,57	1,59	1,61	1,64	1,66	1,69	1,71	1,74	1,77	1,79
90	1,82	1,85	1,88	1,91	1,94	1,97	2	2,03	2,06	2,1
100	2,13	2,16	2,19	2,23	2,26	2,3	2,33	2,37	2,41	2,44
110	2,48	2,52	2,56	2,6	2,63	2,67	2,71	2,75	2,79	2,83
120	2,88	2,92	2,96	3	3,05	3,09	3,13	3,18	3,22	3,27
130	3,31	3,36	3,4	3,45	3,49	3,54	3,59	3,63	3,68	3,73
140	3,78	3,83	3,88	3,93	3,98	4,03	4,09	4,14	4,19	4,24
150	4,3	4,35	4,4	4,46	4,51	4,57	4,63	4,68	4,74	4,8
160	4,86	4,91	4,96	5,02	5,07	5,13	5,19	5,25	5,31	5,37
170	5,43	5,49	5,56	5,62	5,68	5,74	5,8	5,86	5,93	5,99
180	6,05	6,12	6,19	6,25	6,32	6,39	5,45	6,52	6,59	6,66
190	6,72	6,78	6,85	6,92	7	7,07	7,14	7,21	7,28	7,36
200	7,43	7,5	7,57	7,65	7,72	7,79	7,87	7,95	8,03	8,1
210	8,15	8,26	8,33	8,41	8,48	8,56	8,64	8,72	8,79	8,87
220	8,95	9,02	9,1	9,18	9,26	9,33	9,42	9,49	9,57	9,65
230	9,73	9,81	9,90	9,99	10,08	10,17	10,25	10,33	10,42	10,5
240	10,6	10,67	10,76	10,85	10,94	11,03	11,11	11,21	11,3	11,4
250	11,49									

Table 4 : Steel S235 (curve b)

λ	0	1	2	3	4	5	6	7	8	9
0	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
10	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
20	1,01	1,01	1,01	1,02	1,02	1,02	1,03	1,03	1,04	1,04
30	1,05	1,05	1,06	1,06	1,07	1,07	1,08	1,08	1,09	1,09
40	1,1	1,1	1,11	1,11	1,12	1,12	1,13	1,13	1,14	1,15
50	1,15	1,16	1,17	1,17	1,18	1,19	1,2	1,2	1,21	1,22
60	1,23	1,24	1,25	1,25	1,26	1,27	1,28	1,29	1,3	1,31
70	1,33	1,34	1,35	1,36	1,37	1,38	1,4	1,41	1,42	1,44
80	1,45	1,47	1,46	1,5	1,51	1,53	1,55	1,56	1,58	1,6
90	1,62	1,63	1,65	1,67	1,69	1,71	1,73	1,75	1,77	1,79
100	1,81	1,83	1,86	1,88	1,9	1,92	1,95	1,97	1,99	2,02
110	2,04	2,07	2,09	2,12	2,14	2,17	2,2	2,23	2,25	2,28
120	2,31	2,34	2,37	2,4	2,42	2,45	2,48	2,51	2,54	2,58
130	2,61	2,64	2,67	2,7	2,74	2,77	2,8	2,84	2,87	2,91
140	2,94	2,97	3,01	3,04	3,08	3,11	3,15	3,19	3,22	3,26
150	3,3	3,34	3,37	3,41	3,45	3,49	3,53	3,57	3,62	3,66
160	3,7	3,74	3,79	3,83	3,86	3,9	3,94	3,99	4,03	4,07
170	4,11	4,15	4,2	4,24	4,28	4,33	4,37	4,42	4,47	4,51
180	4,56	4,6	4,65	4,7	4,74	4,79	4,84	4,88	4,93	4,98
190	5,02	5,07	5,12	5,16	5,21	5,26	5,31	5,36	5,41	5,46
200	5,51	5,56	5,6	5,65	5,7	5,76	5,81	5,87	5,92	5,97
210	6,02	6,07	6,12	6,18	6,24	6,29	6,35	5,41	6,46	6,52
220	6,57	6,63	5,69	6,74	6,8	6,86	6,91	6,97	7,02	7,08
230	7,13	7,19	7,24	7,3	7,36	7,42	7,48	7,54	7,59	7,64
240	7,69	7,75	7,82	7,89	7,95	8,02	8,07	8,12	8,18	8,23
250	8,29									

Table 5 : Steel S275 (curve b)

λ	0	1	2	3	4	5	6	7	8	9
0	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
10	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,01
20	1,01	1,02	1,02	1,02	1,03	1,03	1,04	1,04	1,05	1,05
30	1,06	1,06	1,07	1,07	1,08	1,08	1,09	1,1	1,1	1,11
40	1,11	1,12	1,12	1,13	1,14	1,14	1,15	1,16	1,16	1,17
50	1,18	1,19	1,2	1,21	1,21	1,22	1,23	1,24	1,25	1,26
60	1,27	1,28	1,29	1,3	1,32	1,33	1,34	1,35	1,36	1,38
70	1,39	1,41	1,42	1,43	1,45	1,47	1,48	1,5	1,52	1,54
80	1,55	1,57	1,59	1,61	1,63	1,65	1,67	1,69	1,71	1,73
90	1,75	1,76	1,8	1,82	1,85	1,87	1,89	1,92	1,94	1,97
100	1,99	2,02	2,05	2,07	2,1	2,13	2,16	2,19	2,22	2,25
110	2,28	2,31	2,34	2,37	2,4	2,43	2,46	2,5	2,53	2,56
120	2,60	2,63	2,66	2,7	2,73	2,77	2,81	2,84	2,88	2,92
130	2,95	2,99	3,03	3,07	3,11	3,14	3,18	3,22	3,28	3,3
140	3,34	3,39	3,43	3,47	3,51	3,56	3,6	3,65	3,69	3,74
150	3,79	3,83	3,87	3,91	3,96	4	4,05	4,09	4,14	4,19
160	4,23	4,28	4,33	4,38	4,43	4,48	4,53	4,57	4,63	4,68
170	4,73	4,78	4,83	4,88	4,93	4,98	5,03	5,08	5,13	5,18
180	5,23	5,29	5,34	5,4	5,45	5,5	5,55	5,6	5,68	5,71
190	5,77	5,83	5,89	5,94	5,99	6,05	6,11	6,17	6,23	6,29
200	6,35	6,41	6,47	6,53	6,59	6,65	6,71	6,78	6,84	6,9
210	6,96	7,02	7,08	7,14	7,2	7,25	7,32	7,39	7,45	7,51
220	7,57	7,62	7,68	7,75	7,82	7,89	7,96	8,03	8,08	8,14
230	8,2	8,26	8,33	8,39	8,46	8,53	8,59	8,65	8,73	8,81
240	8,87	8,94	9,02	9,09	9,16	9,24	9,31	9,39	9,46	9,53
250	9,61									

Table 6 : Steel S355 (curve b)

λ	0	1	2	3	4	5	6	7	8	9
0	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
10	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,01	1,01	1,02
20	1,02	1,03	1,03	1,04	1,04	1,05	1,05	1,06	1,07	1,07
30	1,08	1,08	1,09	1,1	1,1	1,11	1,12	1,12	1,13	1,14
40	1,15	1,15	1,16	1,17	1,18	1,19	1,2	1,21	1,22	1,23
50	1,24	1,25	1,26	1,27	1,28	1,3	1,31	1,32	1,34	1,35
60	1,37	1,38	1,4	1,41	1,43	1,45	1,46	1,48	1,5	1,52
70	1,54	1,56	1,58	1,61	1,63	1,65	1,67	1,7	1,72	1,75
80	1,77	1,8	1,82	1,85	1,87	1,9	1,93	1,96	1,99	2,02
90	2,05	2,08	2,11	2,14	2,17	2,21	2,24	2,28	2,31	2,34
100	2,38	2,42	2,45	2,49	2,53	2,56	2,60	2,64	2,68	2,72
110	2,76	2,8	2,84	2,88	2,93	2,97	3,01	3,05	3,1	3,14
120	3,19	3,23	3,28	3,32	3,37	3,42	3,46	3,51	3,56	3,62
130	3,67	3,72	3,77	3,83	3,87	3,92	3,97	4,02	4,07	4,12
140	4,17	4,23	4,28	4,34	4,39	4,45	4,5	4,56	4,62	4,67
150	4,73	4,79	4,84	4,9	4,96	5,01	5,07	5,13	5,19	5,25
160	5,31	5,37	5,43	5,49	5,55	5,61	5,67	5,73	5,8	5,87
170	5,93	5,99	6,05	6,12	6,19	6,26	6,33	6,4	6,46	6,53
180	6,6	6,67	6,74	6,81	6,88	6,94	7,01	7,08	7,15	7,21
190	7,29	7,36	7,43	7,5	7,57	7,63	7,69	7,77	7,85	7,93
200	8,01	8,08	8,14	8,21	8,28	6,36	8,43	8,51	8,58	8,66
210	8,74	8,82	8,9	8,98	9,06	9,15	9,23	9,31	9,4	9,48
220	9,57	9,65	9,74	9,83	9,92	10	10,09	10,18	10,27	10,36
230	10,45	10,54	10,63	10,73	10,83	10,92	11,02	11,11	11,2	11,3
240	11,4	11,49	11,58	11,69	11,78	11,88	11,99	12,09	12,2	12,3
250	12,4									

Table 7 : Steel S235 (curve c)

λ	0	1	2	3	4	5	6	7	8	9
0	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
10	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
20	1,01	1,01	1,02	1,02	1,03	1,04	1,04	1,05	1,05	1,06
30	1,06	1,07	1,08	1,08	1,09	1,1	1,1	1,11	1,12	1,12
40	1,13	1,14	1,15	1,16	1,16	1,17	1,18	1,19	1,2	1,21
50	1,22	1,23	1,24	1,25	1,26	1,27	1,28	1,29	1,3	1,32
60	1,33	1,34	1,35	1,36	1,38	1,39	1,4	1,42	1,43	1,45
70	1,46	1,48	1,49	1,51	1,52	1,54	1,56	1,57	1,59	1,6
80	1,62	1,64	1,66	1,67	1,69	1,71	1,73	1,75	1,77	1,79
90	1,81	1,83	1,84	1,86	1,88	1,9	1,92	1,95	1,97	1,99
100	2,01	2,03	2,05	2,08	2,1	2,12	2,15	2,17	2,19	2,22
110	2,24	2,27	2,29	2,32	2,35	2,37	2,4	2,43	2,45	2,48
120	2,51	2,54	2,56	2,59	2,62	2,65	2,68	2,71	2,74	2,77
130	2,8	2,83	2,86	2,89	2,92	2,96	2,99	3,02	3,05	3,08
140	3,11	3,15	3,18	3,21	3,25	3,28	3,32	3,35	3,39	3,42
150	3,46	3,5	3,54	3,58	3,62	3,65	3,69	3,73	3,77	3,81
160	3,85	3,89	3,95	3,98	4,02	4,06	4,1	4,14	4,18	4,22
170	4,28	4,3	4,35	4,39	4,43	4,47	4,52	4,56	4,6	4,64
180	4,69	4,73	4,77	4,82	4,86	4,9	4,95	4,99	5,04	5,08
190	5,13	5,17	5,22	5,26	5,31	5,36	5,4	5,44	5,49	5,54
200	5,6	5,65	5,7	5,75	5,8	5,85	5,91	5,96	6,01	6,06
210	6,11	6,16	6,21	6,27	6,32	6,35	6,43	6,49	6,54	6,6
220	6,65	6,71	6,76	6,81	6,87	6,93	6,98	7,04	7,09	7,14
230	7,2	7,25	7,3	7,36	7,41	7,47	7,53	7,59	7,65	7,7
240	7,75	7,81	7,89	7,96	8,02	8,07	8,12	8,17	8,23	8,3
250	8,36									

Table 8 : Steel S275 (curve c)

λ	0	1	2	3	4	5	6	7	8	9
0	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
10	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,01
20	1,02	1,02	1,03	1,03	1,04	1,05	1,05	1,06	1,07	1,07
30	1,08	1,09	1,09	1,1	1,11	1,12	1,12	1,13	1,14	1,15
40	1,16	1,17	1,18	1,19	1,2	1,21	1,22	1,23	1,24	1,25
50	1,26	1,27	1,28	1,29	1,31	1,32	1,33	1,35	1,36	1,37
60	1,39	1,4	1,42	1,43	1,45	1,46	1,48	1,5	1,51	1,53
70	1,55	1,57	1,58	1,6	1,62	1,64	1,66	1,68	1,7	1,72
80	1,74	1,76	1,78	1,8	1,82	1,84	1,86	1,88	1,91	1,93
90	1,95	1,97	2	2,02	2,04	2,07	2,09	2,12	2,14	2,17
100	2,19	2,22	2,25	2,27	2,3	2,33	2,36	2,39	2,42	2,45
110	2,48	2,5	2,54	2,57	2,6	2,63	2,66	2,69	2,72	2,76
120	2,79	2,82	2,85	2,89	2,92	2,96	2,99	3,02	3,06	3,09
130	3,13	3,16	3,2	3,24	3,27	3,31	3,35	3,39	3,43	3,47
140	3,51	3,55	3,59	3,63	3,68	3,72	3,76	3,8	3,85	3,89
150	3,93	3,98	4,02	4,07	4,11	4,15	4,2	4,24	4,29	4,33

160	4,38	4,43	4,47	4,52	4,56	4,61	4,66	4,7	4,75	4,8
170	4,84	4,89	4,94	4,99	5,03	5,08	5,13	5,18	5,23	5,28
180	5,33	5,38	5,43	5,47	5,53	5,59	5,85	5,7	5,75	5,81
190	5,86	5,92	5,98	6,03	6,08	6,14	6,20	6,26	6,32	5,38
200	6,43	6,49	6,55	6,61	6,67	6,73	6,79	6,85	6,91	6,96
210	7,03	7,08	7,14	7,2	7,26	7,32	7,37	7,44	7,5	7,56
220	7,63	7,68	7,74	7,81	7,88	7,97	8,03	8,08	8,13	8,19
230	8,26	8,33	8,4	8,46	8,52	8,59	8,65	8,72	8,79	8,85
240	8,93	8,99	9,06	9,13	9,2	9,27	9,34	9,41	9,48	9,55
250	9,62									

Table 9 : Steel S355 (curve c)

λ	0	1	2	3	4	5	6	7	8	9
0	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
10	1,00	1,00	1,00	1,00	1,00	1,00	1,01	1,01	1,02	1,03
20	1,03	1,04	1,05	1,05	1,06	1,07	1,08	1,08	1,09	1,1
30	1,11	1,12	1,13	1,13	1,14	1,15	1,16	1,18	1,19	1,2
40	1,21	1,22	1,23	1,24	1,26	1,27	1,28	1,3	1,31	1,33
50	1,34	1,36	1,37	1,39	1,41	1,42	1,44	1,46	1,48	1,5
60	1,51	1,53	1,55	1,57	1,59	1,62	1,64	1,66	1,68	1,7
70	1,72	1,75	1,77	1,79	1,82	1,84	1,87	1,89	1,92	1,94
80	1,97	1,99	2,02	2,05	2,07	2,1	2,13	2,16	2,19	2,22
90	2,25	2,28	2,31	2,34	2,38	2,41	2,44	2,47	2,51	2,54
100	2,58	2,61	2,65	2,68	2,72	2,76	2,79	2,83	2,87	2,91
110	2,95	2,98	3,02	3,06	3,1	3,14	3,18	3,22	3,27	3,31
120	3,35	3,4	3,44	3,49	3,53	3,58	3,63	3,68	3,72	3,77
130	3,82	3,87	3,92	3,97	4,02	4,07	4,12	4,17	4,22	4,27
140	4,32	4,38	4,43	4,48	4,53	4,58	4,64	4,69	4,74	4,79
150	4,85	4,9	4,95	5,01	5,06	5,12	5,17	5,23	5,29	5,35
160	5,4	5,45	5,51	5,58	5,64	5,71	5,77	5,83	5,89	5,96
170	6,02	6,08	6,14	6,21	6,27	6,34	6,41	6,47	6,54	6,61
180	6,67	6,74	6,81	6,88	6,94	7,01	7,08	7,15	7,21	7,28
190	7,34	7,41	7,48	7,55	7,63	7,69	7,76	7,83	7,93	8,01
200	8,07	8,13	8,2	8,27	8,35	8,43	8,5	8,57	8,64	8,72
210	8,8	8,87	8,95	9,03	9,11	9,19	9,27	9,35	9,43	9,5
220	9,58	9,67	9,75	9,83	9,92	10	10,09	10,17	10,27	10,36
230	10,45	10,54	10,63	10,73	10,83	10,92	11,02	11,11	11,2	11,3
240	11,4	11,49	11,58	11,69	11,78	11,88	11,99	12,09	12,2	12,3
250	12,4									

Table 10 : Steel S235 (curve d)

λ	0	1	2	3	4	5	6	7	8	9
0	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
10	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
20	1,00	1,01	1,02	1,03	1,04	1,05	1,05	1,05	1,07	1,09
30	1,09	1,1	1,11	1,12	1,13	1,14	1,15	1,16	1,17	1,18
40	1,19	1,2	1,21	1,22	1,24	1,25	1,26	1,27	1,28	1,29
50	1,3	1,32	1,33	1,34	1,35	1,37	1,38	1,39	1,41	1,42
60	1,44	1,45	1,47	1,48	1,49	1,51	1,52	1,54	1,56	1,57
70	1,58	1,6	1,62	1,64	1,65	1,67	1,69	1,7	1,72	1,74
80	1,76	1,78	1,79	1,81	1,83	1,85	1,87	1,89	1,91	1,93
90	1,95	1,97	1,99	2	2,02	2,05	2,07	2,09	2,11	2,13
100	2,15	2,17	2,19	2,22	2,24	2,26	2,28	2,3	2,33	2,35
110	2,37	2,4	2,42	2,44	2,47	2,48	2,51	2,54	2,56	2,59
120	2,61	2,64	2,66	2,69	2,72	2,74	2,77	2,8	2,82	2,85
130	2,88	2,9	2,93	2,96	2,99	3,02	3,04	3,07	3,1	3,13
140	3,18	3,19	3,22	3,25	3,28	3,31	3,35	3,38	3,41	3,44
150	3,47	3,49	3,54	3,57	3,61	3,64	3,67	3,7	3,74	3,77
160	3,81	3,84	3,88	3,91	3,95	3,99	4,02	4,05	4,09	4,13
170	4,17	4,2	4,24	4,28	4,32	4,36	4,39	4,43	4,47	4,51
180	4,55	4,59	4,63	4,67	4,72	4,77	4,79	4,83	4,88	4,92
190	4,96	5	5,04	5,08	5,13	5,17	5,21	5,25	5,3	5,34
200	5,39	5,43	5,48	5,52	5,57	5,61	5,65	5,7	5,75	5,79
210	5,84	5,89	5,93	5,98	6,03	6,08	6,12	6,17	6,22	6,27
220	6,31	6,36	6,41	6,46	6,51	6,55	6,61	6,65	6,71	6,76
230	6,81	6,86	6,91	6,96	7,01	7,07	7,12	7,17	7,22	7,28
240	7,33	7,36	7,43	7,49	7,54	7,6	7,65	7,7	7,76	7,81
250	7,87									

Table 11 : Steel S275 (curve d)

λ	0	1	2	3	4	5	6	7	8	9
0	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
10	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,01
20	1,02	1,03	1,04	1,05	1,06	1,07	1,08	1,09	1,1	1,11
30	1,12	1,13	1,14	1,15	1,17	1,18	1,19	1,2	1,21	1,22
40	1,24	1,25	1,26	1,27	1,29	1,3	1,31	1,33	1,34	1,35
50	1,37	1,38	1,4	1,41	1,43	1,44	1,46	1,48	1,49	1,61
60	1,53	1,54	1,56	1,58	1,6	1,61	1,63	1,65	1,67	1,69
70	1,71	1,73	1,75	1,77	1,79	1,81	1,83	1,85	1,87	1,89
80	1,91	1,93	1,95	1,97	1,99	2,01	2,04	2,05	2,09	2,11
90	2,13	2,16	2,19	2,2	2,23	2,25	2,28	2,3	2,33	2,35
100	2,39	2,4	2,43	2,45	2,48	2,51	2,53	2,55	2,59	2,62
110	2,64	2,67	2,70	2,73	2,76	2,79	2,82	2,85	2,88	2,91
120	2,94	2,97	3	3,03	3,06	3,1	3,13	3,16	3,19	3,23
130	3,26	3,3	3,33	3,36	3,4	3,43	3,47	3,49	3,54	3,58
140	3,61	3,65	3,69	3,72	3,76	3,8	3,84	3,88	3,92	3,96
150	4,00	4,04	4,08	4,12	4,16	4,2	4,24	4,28	4,32	4,36
160	4,41	4,45	4,49	4,54	4,58	4,62	4,67	4,72	4,77	4,80
170	4,85	4,89	4,94	4,99	5,03	5,08	5,12	5,17	5,22	5,27
180	5,32	5,36	5,41	5,46	5,51	5,56	5,61	5,66	5,71	5,76
190	5,81	5,86	5,91	5,97	6,02	6,07	6,12	6,17	6,23	6,28
200	6,33	6,39	6,44	6,49	6,55	6,6	6,66	6,71	6,77	6,83
210	6,89	6,94	7	7,06	7,11	7,17	7,22	7,25	7,34	7,4
220	7,46	7,52	7,58	7,63	7,69	7,75	7,81	7,87	7,94	7,99
230	8,06	8,12	8,18	8,24	8,3	8,36	8,43	8,49	8,55	8,62
240	8,68	B,75	8,81	8,88	8,94	9	9,07	9,14	9,2	9,27
250	9,34									

Table 12 : Steel S355 (curve d)

λ	0	1	2	3	4	5	6	7	8	9
0	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
10	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,01	1,02	1,03
20	1,04	1,05	1,06	1,08	1,09	1,1	1,11	1,12	1,13	1,15
30	1,16	1,17	1,18	1,2	1,21	1,22	1,24	1,25	1,26	1,28
40	1,29	1,31	1,32	1,34	1,35	1,37	1,39	1,4	1,42	1,44
50	1,45	1,47	1,49	1,51	1,53	1,55	1,56	1,58	1,6	1,62
60	1,64	1,67	1,69	1,71	1,73	1,75	1,77	1,79	1,82	1,84
70	1,86	1,89	1,91	1,93	1,96	1,98	2	2,03	2,06	2,09
80	2,11	2,13	2,16	2,19	2,21	2,24	2,27	2,29	2,32	2,35
90	2,38	2,41	2,44	2,46	2,49	2,52	2,55	2,58	2,61	2,65
100	2,68	2,71	2,74	2,77	2,81	2,84	2,87	2,91	2,94	2,97
110	3,01	3,04	3,08	3,12	3,15	3,19	3,22	3,26	3,3	3,34
120	3,38	3,42	3,46	3,49	3,53	3,57	3,62	3,66	3,7	3,74
130	3,78	3,82	3,87	3,91	3,95	4	4,04	4,09	4,13	4,18
140	4,22	4,27	4,31	4,36	4,41	4,45	4,5	4,55	4,6	4,65

150	4,7	4,77	4,8	4,85	4,9	4,95	5	5,05	5,11	5,16
160	5,21	5,27	5,32	5,37	5,43	5,48	5,53	5,59	5,65	5,7
170	5,76	5,82	5,87	5,93	5,99	6,04	6,1	6,16	6,22	6,28
180	6,34	6,4	6,46	6,52	6,58	6,64	6,7	6,76	6,82	6,89
190	5,95	7,01	7,08	7,14	7,20	7,27	7,33	7,39	7,46	7,53
200	7,59	7,66	7,72	7,79	7,86	7,93	7,99	8,06	8,13	8,2
210	8,27	8,33	8,4	8,47	8,54	8,62	8,69	8,76	8,83	8,9
220	8,97	9,05	9,12	9,19	9,27	9,34	9,42	9,5	9,57	9,65
230	9,74	9,81	9,89	9,97	10,05	10,13	10,22	10,3	10,39	10,48
240	10,56	10,65	10,73	10,83						
250										

APPENDIX 2 CHECKING WITH RESPECT TO FATIGUE

1 General

1.1

1.1.1

The way of variation of the stresses and, as a consequence, of the load spectrum which creates the tensions, are to be known in order to perform the checking with respect to fatigue; this means that a relation between loads and number of times they stress the crane is to be defined

2 Definitions

2.1

2.1.1 Cycles of tension - Δ of tension

With reference to the diagram time-oscillations of the stress in a well-defined point of the crane structure, when the oscillation amplitude can be considered constant, the section between two subsequent minimum values of stress is defined as “cycle of tension”.

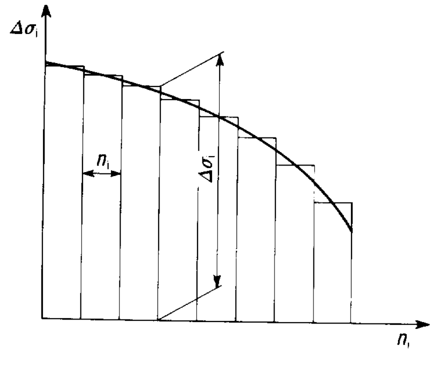
The algebraic difference between the maximum and minimum value of the tension within the cycle considered, is defined as the differential Δ of tension; indexes σ or τ will be used when Δ is referred to axial or shear stresses respectively.

In case of non-constant oscillation, cycles and differentials of tension will be evaluated in compliance with the procedure stipulated in [4.2].

2.1.2 Spectrum of Δ tension

Fig 1 relates the differential of tensions $\Delta\sigma_i$ which occur in a fixed point of the crane structure with the relevant number of cycles; the maximum abscissa of the diagram represents the total number of cycles to which the structure is subjected.

Figure 1



3 Strength to fatigue of structural components

3.1

3.1.1 Class of structural details

Tab 2 shows the details which more frequently are encountered in a crane construction along with their relevant allowable differential of tension $\Delta\sigma_a$

$\Delta\sigma_a$ identifies the detail considered and is defined as “category” of the detail itself; it corresponds to stresses of constant amplitude at 2 x 10^6 cycles. Details to be verified with respect to fatigue are grouped as follows:

- Group I Non welded details subjected to tension-compression.
- Group II Welded details subjected to tension-compression.
- Group III Details subjected to shear forces
- Group IV Details of tubular structures

The fatigue allowable differential of the details is its nominal differential Δ and already takes into account for the reduction of strength due to the details local over stresses. However, if local reduction of section or joints not adequately designed make the differential Δ to be greater than expected, the design differential (to which the allowable differential is to be compared) is to be increased by means of suitable coefficients.

All butt joints or full penetration joints, as per Tab 2, are to be of First Class as defined by the applicable literature.

3.1.2 SN curves of structural details

Each structural detail has its own SN curve which, for Δ of constant amplitude, gives the variation of the number of maximum allowable cycles as a function of the variation of Δ.

The set of curves SN relevant to details subjected to tension-compression and shear forces are reported in Fig. 2 and Fig. 3 respectively.

Figure 2 SN curves for details subjected to tension-compression forces

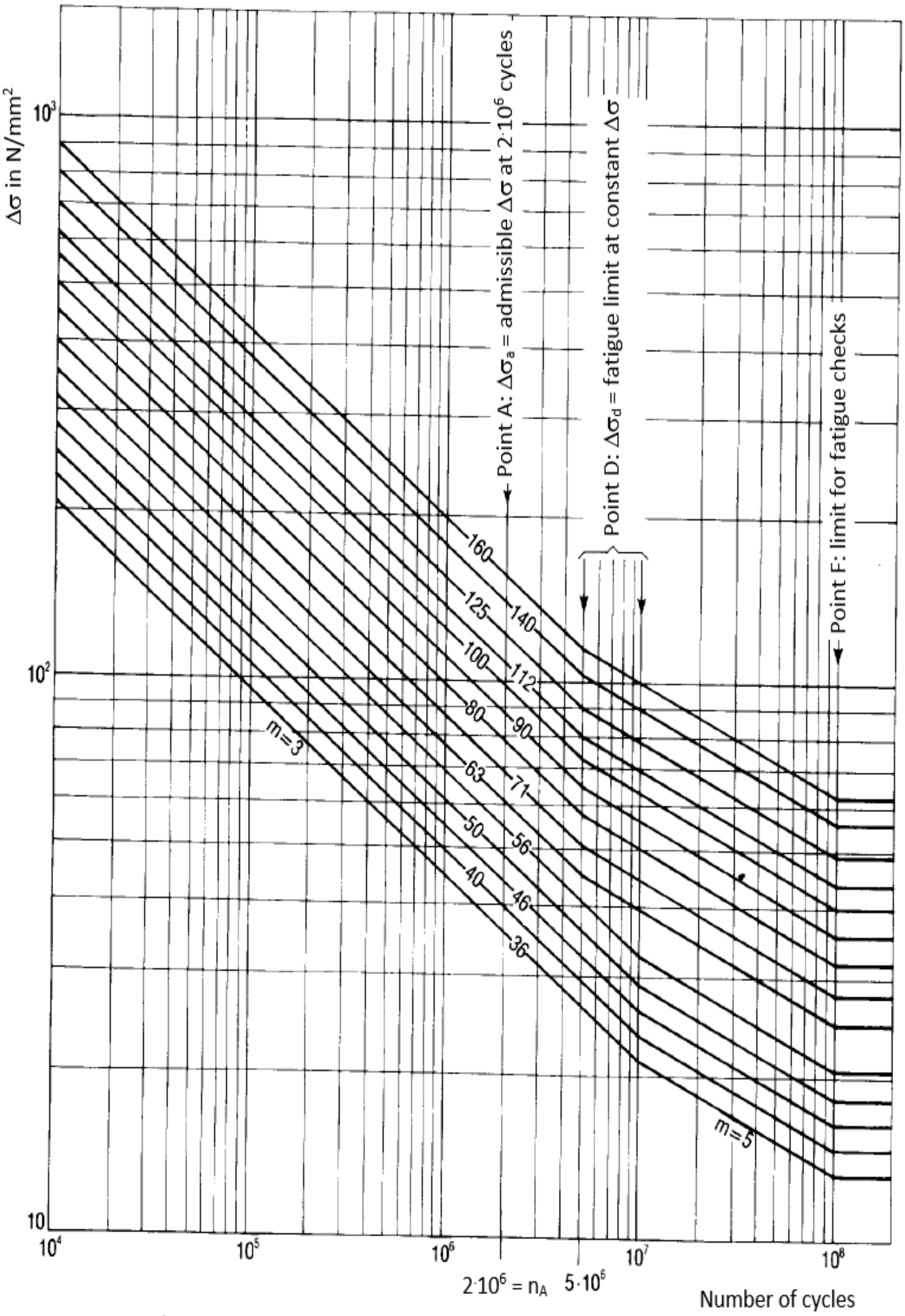
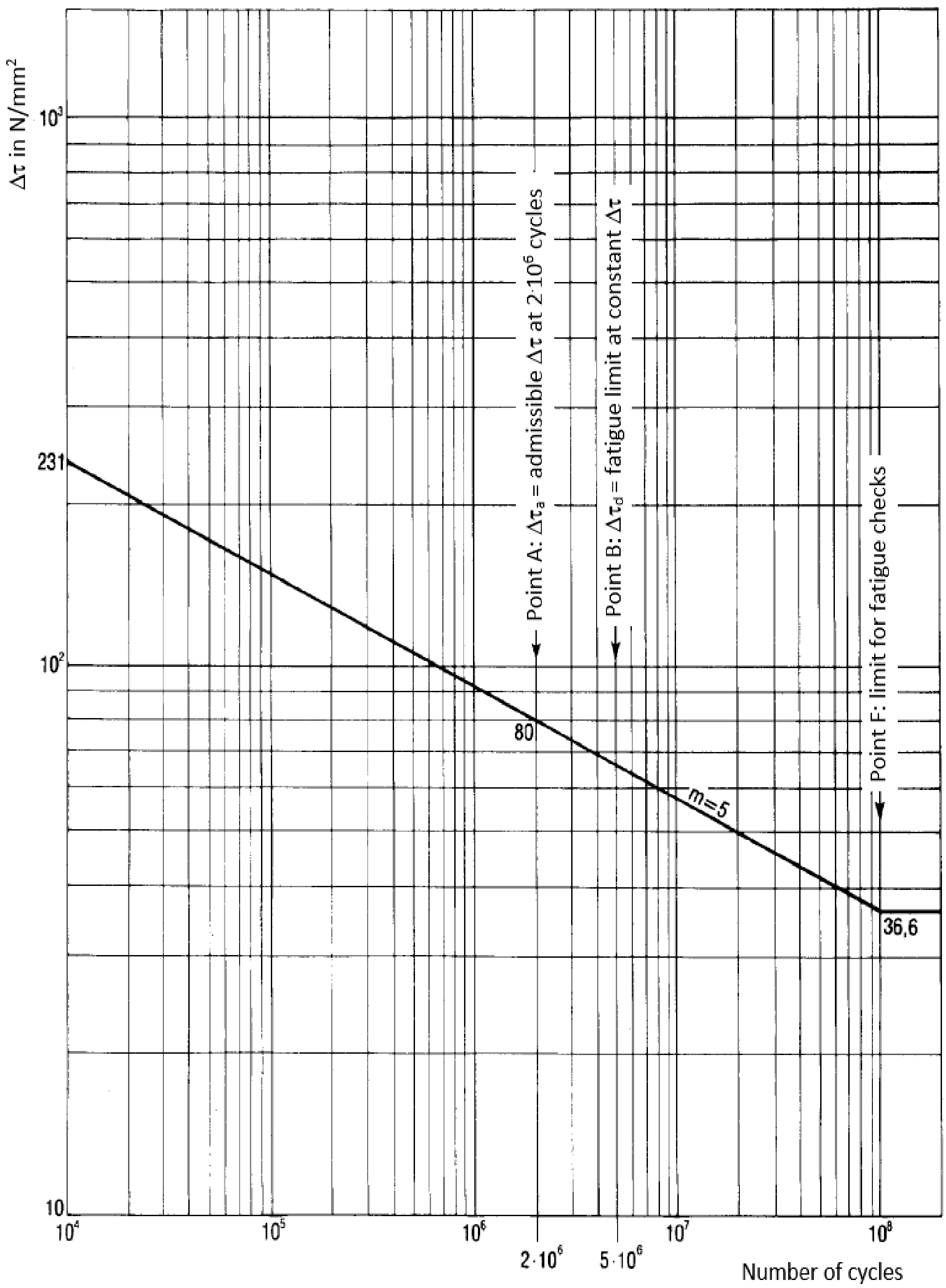


Figure 3 SN curves for details subjected to shear forces



- **Details subjected to tension-compression force**

With reference to Fig. 2, curves SN are represented by the equation $\Delta\sigma^{m} \cdot n$ = constant, where m has different values according to the type of the stress and the number of cycles.

Curves are represented as follows:

a) a set of parallel straight lines, relevant to m=3, in the range of cycles $10^4 \leq n \leq 5 \cdot 10^6$

b) a knuckle point D in way of $N_D = 5 \cdot 10^6$ for curves with allowable $\Delta > 56$ N/mm²; $N_D = 10^7$ for curves with allowable $\Delta \leq 56$ N/mm²; $\Delta\sigma_d$ related to the point D, is defined as the limit of fatigue having constant amplitude (i.e. limit, below which, for Δ of constant amplitude, the life of the detail is indefinite)

c) a further set of parallel straight lines, relevant to m=5, in the range of cycle $N_D < n < 10^8$

d) a further knuckle point F in way of $1 \cdot 10^8$; all values lower than Δ, related to F, state that every Δ of fatigue can be neglected

On each curve a further point A is indicated, with its corresponding $\Delta\sigma_a$ as defined in [3.1.1].

The curves with m=3 are obtained through a statistic analysis of the experimental values relevant to the different structural details and represent mean values decreased by two standard deviations.

The SN curves are valid for steels having minimum yielding strength less than or equal to 690 MPa and fulfilling the requirements of relevant applicable recognized standards.

3.1.3 Strength to fatigue for thicknesses t > 25 mm

The strength to fatigue effect of structural details in [3.1.2] refers to thicknesses ≤ 25 mm; in case of thicknesses greater than 25 mm, the strength is to be reduced and its value evaluated by means of the following expression:

$$\Delta\sigma_{a,t} = \Delta\sigma_a \cdot \sqrt[4]{\frac{25}{t}}$$

Where:

$\Delta\sigma_a$ is the value Δ assumes when the number of cycles is equal to $2 \cdot 10^6$

t is the thickness (greater than 25 mm) of the most stressed part of the structural detail

$\Delta\sigma_{a,t}$ is the correct value of Δ based on the thickness t

4 Checking with respect to fatigue

4.1

4.1.1 General

No checking with respect to fatigue is requested if:

- all Δ values, when the stress is due to tension-compression forces, are lower than 26N/mm^2 or $\Delta\sigma_d$ whichever is the higher
- all Δ values, when the stress is due to shear forces, are lower than 35 N/mm^2
- the total number of cycles is lower than 10^4.

For all different cases, the checking with respect to fatigue, relevant to a limit service (operation) status is to be performed. For this purpose, $\Delta\sigma_i$, $\Delta\sigma_a$and $\Delta\sigma_d$, are subjected to the following considerations:

a) if rules/specifications assumed for the checking do not foresee an amplification factor $\gamma_s > 1$ to be used, the design values of Δ are to be evaluated assuming $\gamma_s = 1$

b) Δ derived from tables or diagrams (with, therefore, safety relevant to two standard deviations) are to be considered during the checking when it is assured that the breakdown of the structural detail leads only to local failure of the structure and the particular type of the structure itself allows redistribution of the stresses

c) When redistribution of stresses is not allowed and the breakdown of the structural detail leads to the global failure of the structure, more restrictive values of Δ (which correspond to the mean experimental value decreased by 3.5 standard deviations) are to be assumed; the above is obtained decreasing the values of Δ by means of a coefficient γ_m =1,3

d) For intermediate situations between b) and c), Tab 1 gives the values that the coefficient γ_m assumes with relation to the adopted number of standard deviations.

Table 1 : coefficient γ_m

Number of standard deviations	2	2,5	3	3,5
coefficient γ_m	1,0	1,1	1,2	1,3

The checking with respect to fatigue can be performed in compliance either with Miner method or Δ equivalent method described in [4.1.3] and [4.1.4] respectively.

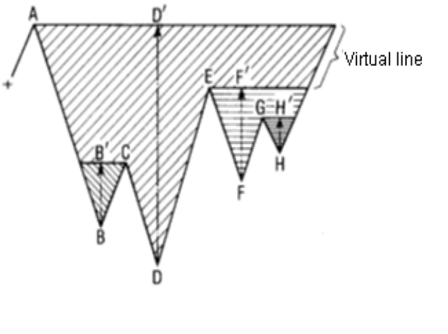
4.1.2 Evaluation of the spectrum of tension Δ

The evaluation of the spectrum of tension can be performed using the “reservoir” method.

The diagram of the stresses, relevant to the detail under consideration, versus the time is assumed as the bottom profile of a reservoir filled with water (see Fig. 4); the end parameters of the diagram are represented by the line which converges towards the maximum absolute point of the diagram (point A) and by a corresponding line, real or virtual, located at the end of the diagram itself (and which “close” the diagram on the abscissa axis). The evaluation of the different cycles in which the diagram is split and its relevant Δ, is performed as follows:

- It is assumed to empty the reservoir draining the water from the lowest point D; the first cycle corresponds to the void of water so determined and the relevant Δ is represented by the segment DD’
- Due to the shape of the reservoir, secondary simple or multiple basins are created; multiple basins, like that one whose vertices are the points F and H, are empty starting from their lower point (F in the case of Fig. 4) and the second cycle, whose Δ is represented by the segment FF’, corresponds to the void of water so created. Simple basins, like those whose vertices are the points B and H, are empty so each one originating a cycle having Δ the segment BB’ and HH’ respectively.

Figure 4



4.1.3 Method of Miner's Rule

The following expression is to be verified:

$$\sum \frac{n_i}{n_i^*} \leq 1$$

Where:

n_i is the actual number of cycles relevant to $\Delta\sigma_i$ or $\Delta\tau_i$

n^*_i is the number of cycles that, on the reference curve SN, corresponds to $\Delta\sigma_i$ or $\Delta\tau_i$

The number of cycles n^*_i is given by:

$$n_i^* = \frac{1}{(\gamma_s \cdot \gamma_m \cdot \Delta\sigma_i)^3} \cdot \Delta\sigma_a^3 \cdot 2 \cdot 10^6 \quad \text{for } \Delta\sigma_i \geq \Delta\sigma_d$$

$$n_i^* = \frac{1}{(\gamma_s \cdot \gamma_m \cdot \Delta\sigma_i)^5} \cdot \Delta\sigma_d^5 \cdot 5 \cdot 10^6 \text{ for } \Delta\sigma_i < \Delta\sigma_d \text{ and } \Delta\sigma_a > 56 \text{ N/mm}^2$$

$$n_i^* = \frac{1}{(\gamma_s \cdot \gamma_m \cdot \Delta\sigma_i)^5} \cdot \Delta\sigma_d^5 \cdot 10^7 \text{ for } \Delta\sigma_i < \Delta\sigma_d \text{ and } \Delta\sigma_a \leq 56 \text{ N/mm}^2$$

$$n_i^* = \frac{1}{(\gamma_s \cdot \gamma_m \cdot \Delta\tau_i)^5} \cdot \Delta\tau_a^5 \cdot 2 \cdot 10^6 \text{ for shear stress}$$

$\Delta\sigma_a$ or $\Delta\tau_a$ are obtained from Fig. 2 and Fig. 3 for SN curves and $\Delta\sigma_d$ the limit of fatigue with constant amplitude of SN curve.

4.1.4 Δ equivalent method

The range of constant amplitude of a spectrum of stress, which acts during a number of cycles equal to the total n cycles of the spectrum and originates the same damage with respect to the fatigue, is defined as "equivalent field" of a spectrum; according to the regime of stress, the equivalent field is indicated as follows:

$\Delta\sigma_{ef}$ or $\Delta\tau_{ef}$

The equivalent field is given by the following expressions:

- for spectra relevant to tension-compression stress:

$$\Delta\sigma_{ef} = \sqrt[3]{\frac{\sum \Delta\sigma_i^3 \cdot n_i}{n}}$$

- for spectra relevant to shear stress:

$$\Delta\tau_{ef} = \sqrt[5]{\frac{\sum \Delta\tau_i^5 \cdot n_i}{n}}$$

The checking with respect to fatigue is performed by comparing $\Delta\sigma_{ef}$ or the $\Delta\tau_{ef}$ with the $\Delta\sigma$ or the $\Delta\tau$ respectively obtained from Fig. 2 or Fig. 3 for the same number of cycles n; in particular is to be verified the following:

$$\gamma_s \cdot \Delta\sigma_{ef} \leq \frac{\Delta\sigma}{\gamma_m} \quad \text{or} \quad \gamma_s \cdot \Delta\tau_{ef} \leq \frac{\Delta\tau}{\gamma_m}$$

4.1.5 Multi-axial stresses

When simultaneous cycles of axial and shear stress act in each range step of a spectrum, the following procedure is to be followed:

a) the calculation of principal stresses in way of minimum and maximum stresses is to be performed for each step of the spectrum

b) the relevant Δ of tension is to be evaluated

c) the checking with respect to fatigue is to be performed considering the spectrum of Δ of tension so obtained.

If the value of the shear stresses is less than or equal to 15% of the value of the simultaneous axial stress, its influence can be neglected. When the cycles of axial and shear stresses are not simultaneous, the damages $\Sigma n_i/n_i^*$, originated by the associated spectra, are to be evaluated separately and the sum of the results so obtained are to be equal to 1 or less.

4.1.6 Structures not affected by internal stress

For not welded structures, or welded structures with thermal releasing treatment afterwards, when the design Δ has both tension and compression components, a reduced virtual Δ can be used for calculation purposes; Δ can be assumed as the tension component increased by 60% of the compression component.

As an alternative, the values of resistance fatigue capacity $\Delta\sigma$ or $\Delta\tau$ can be increased by a coefficient k reported in Fig. 5 as a function of the ratio $R = \sigma_{min}/\sigma_{max}$

Figure 5

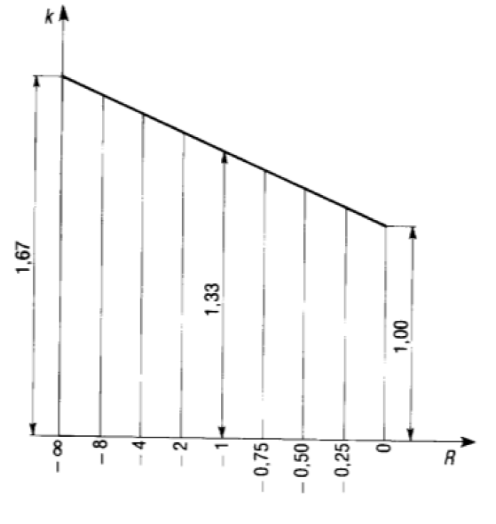
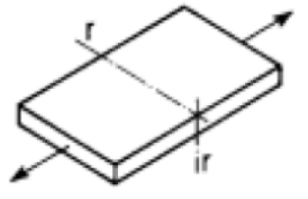
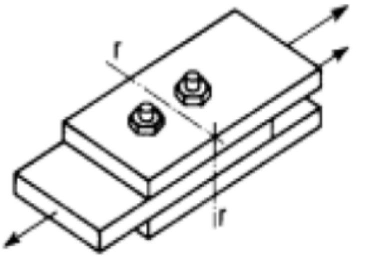
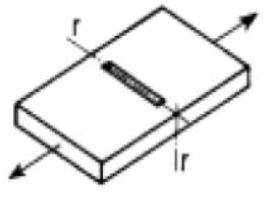
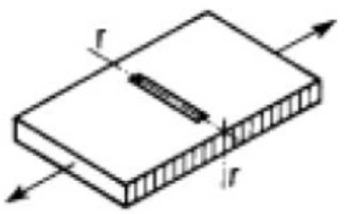
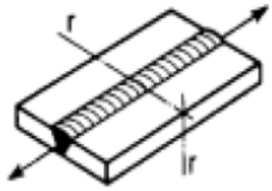
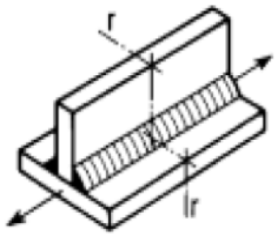
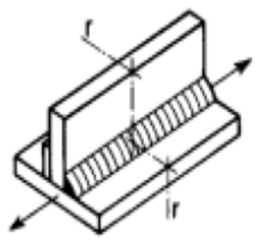
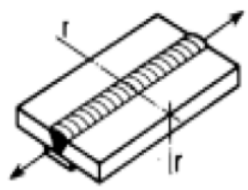
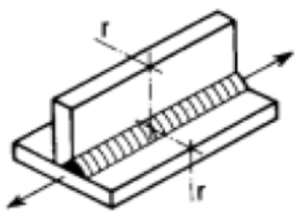
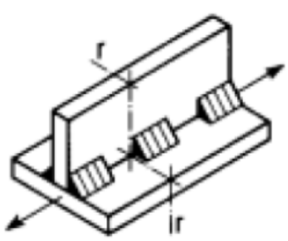
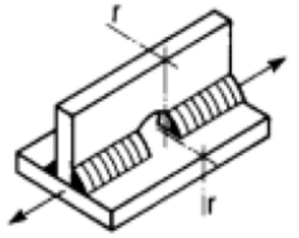
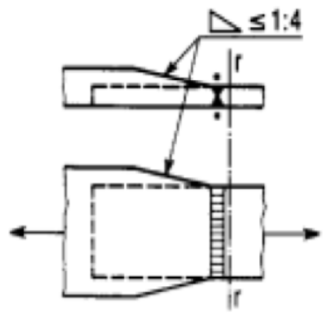
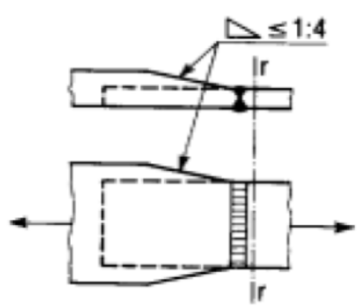
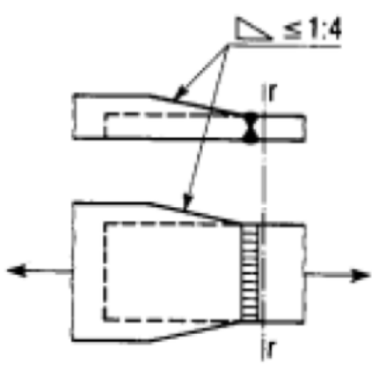
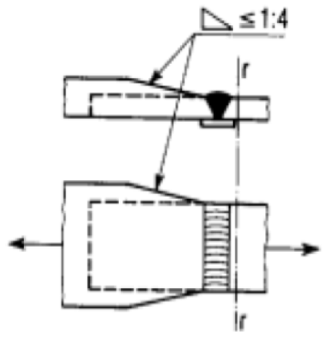
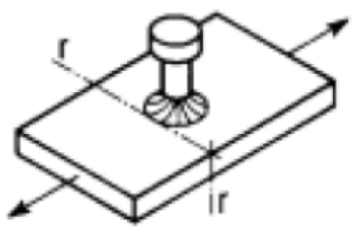
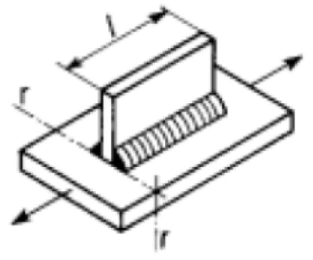
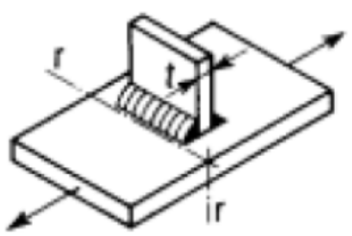
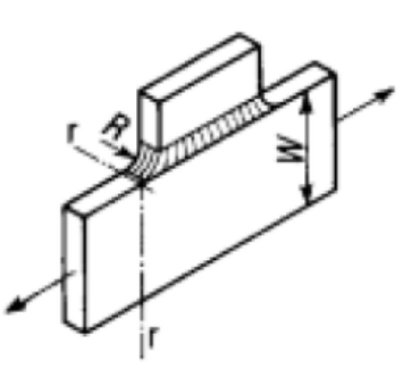


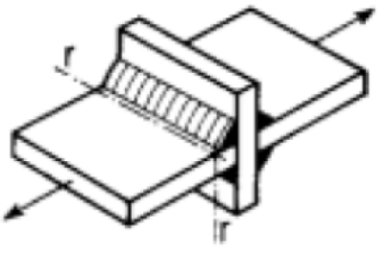
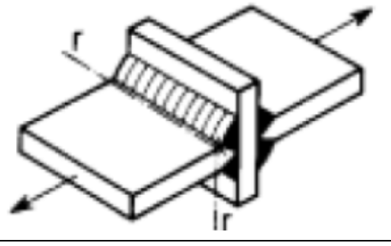
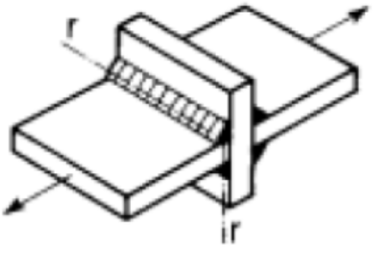
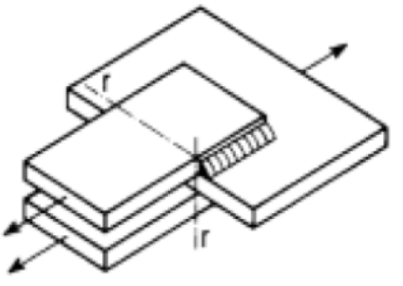
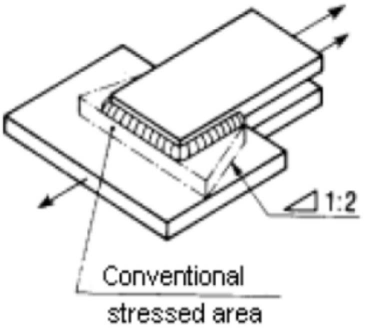
Table 2 : Structural components

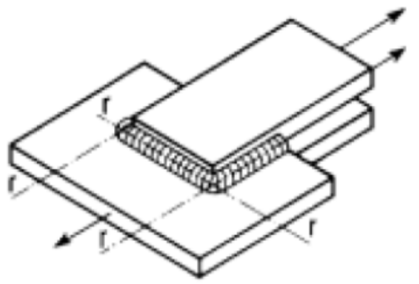
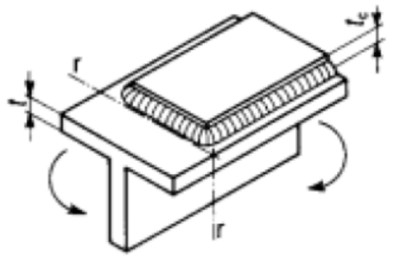
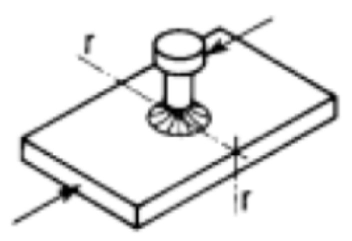
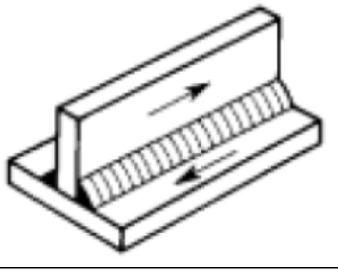
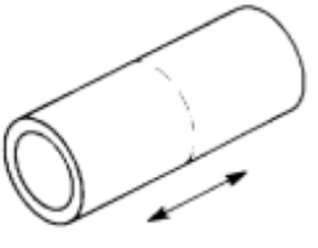
$\Delta\sigma_a$ (1) N/mm^2	Structural details (rr = breaking section)	Notes
Group I - Not-welded details		
160		Raw plates and bars with no defect and not subjected to further treatments
140	 	Bolted joints (with friction bolts) calculated in the gross section; when calibrated bolts are used, the section to be considered is the net one. Oxyfuel cut plates and bars subjected to be machined or grinded.
125		Automatic oxyfuel cut plates and bars with regular edges and free from defect cut.
Group II.1- welded details - longitudinal joints		

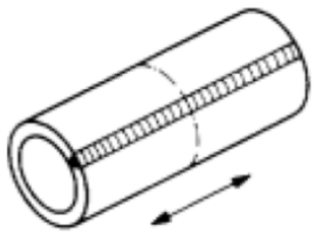
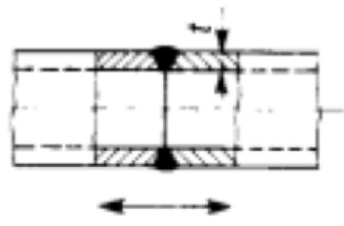
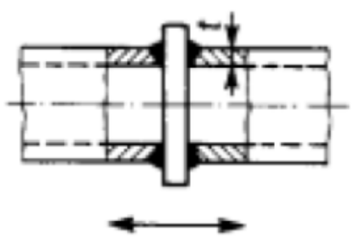
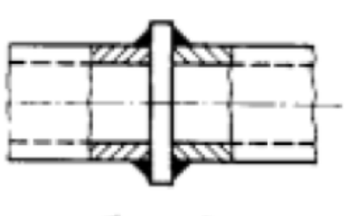
<table>
<tr><td>140</td><td rowspan="3"></td><td>Automatic full penetration or fillet weld without any longitudinal superficial discontinuities which may be caused by stops and restarts.</td></tr>
<tr><td>112</td><td>Normal execution automatic welding</td></tr>
<tr><td>100</td><td>Manual welding</td></tr>
<tr><td>100</td><td></td><td>Backing strip welding.</td></tr>
<tr><td>100</td><td></td><td>Partial one side penetration welding.
A very good adherence of the welded edge and a suitable root face (to prevent welding excess or penetration defects) is required</td></tr>
<tr><td>80</td><td></td><td>intermittent fillet welding</td></tr>
</table>

71		Scallop fillet welding
Group II.2- welded details - Transversal butt joints		
125		Excess weld metal carefully removed and 100% NDT checked.
90		Flat welding. Height of excess weld metal not greater than 10% of its width. Smooth transitation between excess weld metal and plate.
80		Flat or in position welding with excess weld metal having greater than 10% of its width.

<table>
<tr><td>71</td><td>
</td><td>Backing strip welding. In case of welding on the external edge of the backing strip, the welding is to be stopped 10mm before the end of the joint. 2nd Class welding.</td></tr>
<tr><td colspan="3">Group II.3- welded details - Various type of attachments</td></tr>
<tr><td>80</td><td>
</td><td>Stud welding welded on stressed elements (breaking in plate).</td></tr>
<tr><td>80</td><td rowspan="3">
</td><td>End of longitudinal stiffeners
where l ≤ 50 mm</td></tr>
<tr><td>71</td><td>End of longitudinal stiffeners
where 50 < l ≤ 100 mm</td></tr>
<tr><td>56</td><td>End of longitudinal stiffeners
where l > 100 mm</td></tr>
<tr><td>80</td><td rowspan="2">
</td><td>Transversal stiffeners
where t ≤ 12 mm</td></tr>
<tr><td>71</td><td>Transversal stiffeners
where t > 12 mm</td></tr>
<tr><td>90</td><td rowspan="3">
</td><td>Welded lateral expansions
where R/W ≤ 1/3</td></tr>
<tr><td>71</td><td>Welded lateral expansions
where 1/3 < R/W ≤ 1/6</td></tr>
<tr><td>50</td><td>Welded lateral expansions
where R/W > 1/6</td></tr>
<tr><td colspan="3">Group II.4- welded details - Cruciform joints</td></tr>
</table>

71		Full penetration joint Intermediate plate free from lamellar tearing. Misalignment ≤ 15 % of the intermediate plate's thickness. 2nd Class welding.
63		Fillet welding cruciform joint whose throat dimension makes the breaking occur outside the welding (throat sufficiently big for the purpose). See previous structural detail for intermediate plate requirements and maximum cruciform misalignment.
40		Fillet welding cruciform joint whose throat dimension makes the breaking occur in the welding seam. See previous structural detail for intermediate plate requirements and maximum cruciform misalignment.
Group II.5- welded details - Overlapped joints		
50		Elements whose ends are overlap welded. Welding scantlings so as that the failure occurs on the overlapped elements.
63		Elements whose ends are overlap welded. Elements and welding properly designed for the failure occurs in the intermediate plate.

45		Elements whose ends are overlap welded. Relatively weak welding so that the failure occurs in it.
56		End of joint cover on flange of beams. t or $t_c \leq 20$ mm
40		End of joint cover on flange of beams. t or $t_c > 20$ mm
Group III- Shear stressed structural details		
80		Stud welding. Breaking section at the base of the stud.
80		Welded T joints. Failure section: throat's longitudinal section of the welding seams or web's longitudinal section.
Group IV- Tubular structural details		
160		Raw rolled pipe free from defects.

140		Longitudinally welded pipe free from longitudinal discontinuities both internal and external due to stops and restart. Welded 100% NDT checked and found free from defects.
71(80)		Circular pipe section. Butt pipes transversal welding. Root welding 100% NDT checked. When t > 8 mm, figures in brackets for $\Delta\sigma_a$ are to be used.
56(63)		Rectangular pipe section. Butt pipes transversal welding. Root welding 100% NDT checked. When t > 8 mm, figures in brackets for $\Delta\sigma_a$ are to be used.
50(56)		Circular pipe section. Butt pipe full penetration welding on intermediate plate.. Penetration to be 100% NDT verified. Intermediate plate free from lamellar tearing. When t > 8 mm, figures in brackets for $\Delta\sigma_a$ are to be used.
45(50)		Rectangular pipe section. Butt pipe full penetration welding on intermediate plate. Penetration to be 100% NDT verified. Intermediate plate free from lamellar tearing. When t > 8 mm, figures in brackets for $\Delta\sigma_a$ are to be used.
40		Circular pipe section Butt pipe fillet welding on intermediate plate. Penetration to be 100% NDT verified. Intermediate plate free from lamellar tearing.
36		Rectangulat pipe section Butt pipe fillet welding on intermediate plate. Penetration to be 100% NDT verified. Intermediate plate free from lamellar tearing.
(1) $\Delta\sigma_a$ is the admissible Δ for 2 x 10^6 cycles and represent the detail's category		