

1ST OFFICER

INTERNATIONAL STANDARDS

SAFETY IN DOCK WORK

INTERNATIONAL CARGO GEAR BUREAU, INC.

INTRODUCTION

The International Labor Organization was established in 1919 and is now a specialized agency of the United Nations. It is an association of Nations, financed by member Governments and democratically controlled by representatives of Government, of management and of labor organizations.

The International Labor Office of the International Labor Organization acts as a secretariat, and a world information center. It is staffed by experts drawn from many countries, whose knowledge, experience and advice are available to all the nations which are members of the Organization.

The Governing Body, is composed of Government representatives and an equal number of representatives from management and labor. This is the Executive Council of the Organization and exercises general supervision over the work of the Office.

The International Labor Conference is a world parliament. Each national delegation to the annual meetings comprises four delegates, two representing the Government, one representing management, and one representing labor; each of these three sections speaks and votes independently, so that all points of view find full expression.

To give effect to the standards adopted by the International Labor Organization for the Protection against Accidents (Dockers) Convention (Revised) 1932 and/or the National Regulations or standards in force for "Safety in Dock Work" in the following countries:

ARGENTINA	FRANCE	NORWAY
AUSTRALIA	GERMANY	PAKISTAN
BELGIUM	GREECE	REPUBLIC OF CHINA
BULGARIA	INDIA	REPUBLIC OF THE PHILIPPINES
BURMA	IRELAND	UNION OF SOUTH AFRICA
CANADA	ISRAEL	SPAIN
CHILE	ITALY	SWEDEN
CUBA	JAPAN	TURKEY
DENMARK	MEXICO	PORTUGAL
ENGLAND	NETHERLANDS	UNITED STATES
FINLAND	NEW ZEALAND	URUGUAY

it was decided to establish the International Cargo Gear Bureau, Inc., a non-profit organization of specialists interested only in the safety of Cargo Handling equipment. The purposes of the International Cargo Gear Bureau are to facilitate compliance with International Cargo Gear safety requirements and standards; to maintain a current library containing the International standards in effect throughout the world for the protection against accidents of workers employed in loading and unloading of ships; to provide experienced, competent inspectors to certify that the cargo gear carried aboard ocean going vessels complies with the International standards established.

Endeavoring to eliminate the many misunderstandings existing regarding the various regulations for certification of cargo gear, the International Cargo Gear Bureau makes equally available to all interested Governmental, Management and Labor Groups, complete information on the International Standards in effect to aid in the implementation of these standards in the interests of safety.

The purposes and the functions of the International Cargo Gear Bureau have no relation to the classification of vessels nor compliance with any International Standards, Rules or Conventions other than those noted herein. The International Cargo Gear Bureau, however, is prepared to aid and assist compliance with all Standards or Rules pertaining to Safety in Dock Work. In pursuit of its safety objectives the International Cargo Gear Bureau is distributing this Standard which is recognized throughout the world.

Additional copies of these standards are available. Requests should be addressed to the International Cargo Gear Bureau, Inc., 52 Broadway, N. Y.

Cable Address: Incargear New York

INTERNATIONAL

Convention (No. 32) concerning the Protection against Accidents of Workers Employed in Loading or Unloading Ships (Revised 1932)

The General Conference of the International Labour Organisation of the League of Nations,

Having been convened at Geneva by the Governing Body of the International Labour Office, and having met in its Sixteenth Session on 12 April 1932, and

Having decided upon the adoption of certain proposals with regard to the partial revision of the Convention concerning the protection against accidents of workers employed in loading or unloading ships adopted by the Conference at its Twelfth Session, which is the fourth item on the agenda of the Session, and

Considering that these proposals must take the form of a Draft International Convention,

adopts, this twenty-seventh day of April of the year one thousand nine hundred and thirty-two, the following Draft Convention for ratification by the Members of the International Labour Organisation, in accordance with the provisions of Part XIII of the Treaty of Versailles and of the corresponding Parts of the other Treaties of Peace:

For the purpose of this Convention:

(1) The term "processes" means and includes all or any part of the work performed on shore or on board ship of loading or unloading any ship whether engaged in maritime or inland navigation, excluding ships of war, in, on, or at any maritime or inland port, harbour, dock, wharf, quay or similar place at which such work is carried on; and

(2) The term "worker" means any person employed in the processes.

Any regular approach over a dock, wharf, quay or similar premises which workers have to use for going to or from a working place at which the processes are carried on and every such working place on shore shall be maintained with due regard to the safety of the workers using them.

In particular,

(1) Every said working place on shore and any dangerous parts of any said approach thereto from the nearest highway shall be safely and efficiently lighted;

(2) Wharves and quays shall be kept sufficiently clear of goods to maintain a clear passage to the means of access referred to in Article 3;

(3) Where any space is left along the edge of any wharf or quay, it shall be at least 3 feet (90 cm) wide and clear of all obstructions other than fixed structures, plant and appliances in use; and

(4) So far as is practicable having regard to the traffic and working,

(a) All dangerous parts of the said approaches and working places (e.g. dangerous breaks, corners and edges) shall be adequately fenced to a height of not less than 2 feet 6 inches (75 cm);

(b) Dangerous footways over bridges, caissons and dock gates shall be fenced to a height of not less than 2 feet 6 inches (75 cm) on each side and the said fencing shall be continued at both ends to a sufficient distance which shall not be required to exceed 5 yards (4.5 m).

(5) The measurement requirements of paragraph (4) of this Article shall be deemed to be complied with, in respect of appliances in use at the date of the ratification of this Convention, if the actual measurements are not more than 10 per cent. less than the measurements specified in the said paragraph (4).

(1) When a ship is lying alongside a quay or some other vessel for the purpose of the processes, there shall be safe means of access for the use of the workers at such times as they have to pass to or from the ship, unless the conditions are such that they would not be exposed to undue risk if no special appliance were provided.

(2) The said means of access shall be:

(a) Where reasonably practicable, the ship's accommodation ladder, a gangway or a similar construction;

(b) In other cases a ladder.

(3) The appliances specified in paragraph (2) (a) of this Article shall be at least 22 inches (55 cm) wide, properly secured to prevent their displacement, not inclined at too steep an angle, constructed of materials of good quality and in good condition, and securely fenced throughout to a clear height of not less than 2 feet 9 inches (82 cm) on both sides, or in the case of the ship's accommodation ladder securely fenced to the same height on one side, provided that the other side is properly protected by the ship's side.

Provided that any appliances as aforesaid in use at the date of the ratification of this Convention shall be allowed to remain in use:

- (a) Until the fencing is renewed if they are fenced on both sides to a clear height of at least 2 feet 8 inches (80 cm);
- (b) For two years from the date of ratification if they are fenced on both sides to a clear height of at least 2 feet 6 inches (75 cm).

(4) The ladders specified in paragraph (2) (b) of this Article shall be of adequate length and strength, and properly secured.

(5) (a) Exceptions to the provisions of this Article may be allowed by the competent authorities when they are satisfied that the appliances specified in the Article are not required for the safety of the workers.

(b) The provisions of this Article shall not apply to cargo stages or cargo gangways when exclusively used for the processes.

(6) Workers shall not use, or be required to use, any other means of access than the means specified or allowed by this Article.

When the workers have to proceed to or from a ship by water for the processes, appropriate measures shall be prescribed to ensure their safe transport, including the conditions to be complied with by the vessels used for this purpose.

(1) When the workers have to carry on the processes in a hold the depth of which from the level of the deck to the bottom of the hold exceeds 5 feet (1.5 m), there shall be safe means of access from the deck to the hold for their use.

(2) The said means of access shall ordinarily be by ladder, which shall not be deemed to be safe unless it complies with the following conditions:

(a) Provides foothold of a depth, including any space behind the ladder, of not less than 4½ inches (11.5 cm) for a width of not less than 10 inches (25 cm) and a firm handhold;

(b) Is not recessed under the deck more than is reasonably necessary to keep it clear of the hatchway;

(c) Is continued by and is in line with arrangements for secure handhold and foothold on the coamings (e.g. cleats or cups);

(d) The said arrangements on the coamings provide foothold of a depth, including any space behind the said arrangements, of not less than 4½ inches (11.5 cm) for a width of not less than 10 inches (25 cm);

(e) If separate ladders are provided between the lower decks, the said ladders are as far as practicable in line with the ladder from the top deck.

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Where, however, owing to the construction of the ship, the provision of a ladder would not be reasonably practicable, it shall be open to the competent authorities to allow other means of access, provided that they comply with the conditions laid down in this Article for ladders so far as they are applicable.

In the case of ships existing at the date of the ratification of this Convention the measurement requirements of subparagraphs (a) and (d) of this paragraph shall be deemed to be complied with, until the ladders and arrangements are replaced, if the actual measurements are not more than 10 per cent. less than the measurements specified in the said subparagraphs (a) and (d).

(3) Sufficient free passage to the means of access shall be left at the coamings.

(4) Shaft tunnels shall be equipped with adequate handhold and foothold on both sides.

(5) When a ladder is to be used in the hold of a vessel which is not decked it shall be the duty of the contractor undertaking the processes to provide such ladder. It shall be equipped at the top with hooks or with other means for firmly securing it.

(6) The workers shall not use, or be required to use, other means of access than the means specified or allowed by this Article.

(7) Ships existing at the date of ratification of this Convention shall be exempt from compliance with the measurements in paragraph (2) (a) and (d) and from the provisions of paragraph (4) of this Article for a period not exceeding four years from the date of ratification of this Convention.

(1) While the workers are on a ship for the purpose of the processes, every hatchway of a cargo hold accessible to the workers which exceeds 5 feet (1.5 m) in depth from the level of the deck to the bottom of the hold, and which is not protected to a clear height of 2 feet 6 inches (75 cm) by the coamings, shall, when not in use for the passage of goods, coal or other material, either be securely fenced to a height of 3 feet (90 cm) or be securely covered. National laws or regulations shall determine whether the requirements of this paragraph shall be enforced during meal times and other short interruptions of work.

(2) Similar measures shall be taken when necessary to protect all other openings in a deck which might be dangerous to the workers.

When the processes have to be carried on on a ship, the means of access thereto and all places on board at which the workers are employed or to which they may be required to proceed in the course of their employment shall be efficiently lighted.

The means of lighting shall be such as not to endanger the safety of the workers nor to interfere with the navigation of other vessels.

SAFETY IN DOCK WORK

In order to ensure the safety of the workers when engaged in removing or replacing hatch coverings and beams used for hatch coverings,

(1) Hatch coverings and beams used for hatch coverings shall be maintained in good condition;

(2) Hatch coverings shall be fitted with adequate hand grips, having regard to their size and weight, unless the construction of the hatch or the hatch coverings is of a character rendering the provision of hand grips unnecessary;

(3) Beams used for hatch coverings shall have suitable gear for removing and replacing them of such a character as to render it unnecessary for workers to go upon them for the purpose of adjusting such gear;

(4) All hatch coverings and fore-and-aft and thwart-ship beams shall, in so far as they are not interchangeable, be kept plainly marked to indicate the deck and hatch to which they belong and their position therein;

(5) Hatch coverings shall not be used in the construction of cargo stages or for any other purpose which may expose them to damage.

Appropriate measures shall be prescribed to ensure that no hoisting machine, or gear, whether fixed or loose, used in connection therewith, is employed in the processes on shore or on board ship unless it is in a safe working condition.

In particular:

(1) Before being taken into use, the said machines, fixed gear on board ship accessory thereto as defined by national laws or regulations, and chains and wire ropes used in connection therewith, shall be adequately examined and tested, and the safe working load thereof certified, in the manner prescribed and by a competent person acceptable to the national authorities;

(2) After being taken into use, every hoisting machine, whether used on shore or on board ship, and all fixed gear on board ship accessory thereto as defined by national laws or regulations shall be thoroughly examined or inspected as follows:

(a) To be thoroughly examined every four years and inspected every twelve months: derricks, goose necks, mast bands, derrick bands, eyebolts, spans and any other fixed gear the dismantling of which is specially difficult;

(b) To be thoroughly examined every twelve months: all hoisting machines (e.g. cranes, winches), blocks, shackles and all other accessory gear not included in (a).

All loose gear (e.g. chains, wire ropes, rings, hooks) shall be inspected on each occasion before use unless they have been inspected within the previous three months.

Chains shall not be shortened by tying knots in them and precautions shall be taken to prevent injury to them from sharp edges.

A thimble or loop splice made in any wire rope shall have at least three tucks with a whole strand of rope and two tucks with one half of the wires cut out of each strand; provided that this requirement shall not operate to prevent the use of another form of splice which can be shown to be as efficient as the form hereby prescribed.

(3) Chains and such similar gear as is specified by national laws or regulations (e.g. hooks, rings, shackles, swivels) shall, unless they have been subjected to such other sufficient treatment as may be prescribed by national laws or regulations, be annealed as follows under the supervision of a competent person acceptable to the national authorities:

(a) In the case of chains and the said gear carried on board ship:

- (i) Half inch (12.5 mm) and smaller chains or gear in general use once at least in every six months;
- (ii) All other chains or gear (including span chains but excluding bridle chains attached to derricks or masts) in general use once at least in every twelve months;

Provided that in the case of such gear used solely on cranes and other hoisting appliances worked by hand, twelve months shall be substituted for six months in subparagraph (i) and two years for twelve months in subparagraph (ii);

Provided also that, if the competent authority is of opinion that owing to the size, design, material or infrequency of use of any of the said gear the requirements of this paragraph as to annealing are not necessary for the protection of the workers, it may, by certificate in writing (which it may at its discretion revoke), exempt such gear from the said requirements subject to such conditions as may be specified in the said certificate.

(b) In the case of chains and the said gear not carried on board ship:

Measures shall be prescribed to secure the annealing of the said chains and gear.

(c) In the case of the said chains and gear whether carried on board ship or not, which have been lengthened, altered or repaired by welding, they shall thereupon be tested and re-examined.

(4) Such duly authenticated records as will provide sufficient *prima facie* evidence of the safe condition of the machines and gear concerned shall be kept, on shore or on the ship as the case may be, specifying the safe working load and the dates and results of the tests and examinations referred to in paragraphs (1) and (2) of this Article and of the annealings or other treatment referred to in paragraph (3).

Such records shall, on the application of any person authorised for the purpose, be produced by the person in charge thereof.

(5) The safe working load shall be kept plainly marked on all cranes, derricks and chain slings and on any similar hoisting gear used on board ship as specified by national laws or regulations. The safe working load marked on chain slings shall either be in plain figures or letters upon the chains or upon a tablet or ring of durable material attached securely thereto.

(6) All motors, cogwheels, chain and friction gearing, shafting, live electric conductors and steam pipes shall (unless it can be shown that by their position and construction they are equally safe to every worker employed as they would be if securely fenced) be securely fenced so far as is practicable without impeding the safe working of the ship.

(7) Cranes and winches shall be provided with such means as will reduce to a minimum the risk of the accidental descent of a load while in process of being lifted or lowered.

(8) Appropriate measures shall be taken to prevent exhaust steam from and, so far as practicable, live steam to any crane or winch obscuring any part of the working place at which a worker is employed.

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

Only sufficiently competent and reliable persons shall be employed to operate lifting or transporting machinery whether driven by mechanical power or otherwise, or to give signals to a driver of such machinery, or to attend to cargo falls on winch ends or winch drums.

(1) No load shall be left suspended from any hoisting machine unless there is a competent person actually in charge of the machine while the load is so left.

(2) Appropriate measures shall be prescribed to provide for the employment of a signaller where this is necessary for the safety of the workers.

(3) Appropriate measures shall be prescribed with the object of preventing dangerous methods of working in the stacking, unstacking, stowing and unstowing of cargo, or handling in connection therewith.

(4) Before work is begun at a hatch the beams thereof shall either be removed or be securely fastened to prevent their displacement.

(5) Precautions shall be taken to facilitate the escape of the workers when employed in a hold or on 'tween decks in dealing with coal or other bulk cargo.

(6) No stage shall be used in the processes unless it is substantially and firmly constructed, adequately supported and where necessary securely fastened.

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No truck shall be used for carrying cargo between ship and shore on a stage so steep as to be unsafe.

Stages shall where necessary be treated with suitable material to prevent the workers slipping.

(7) When the working space in a hold is confined to the square of the hatch, and except for the purpose of breaking out or making up slings:

- (a) Hooks shall not be made fast in the bands or fastenings of bales of cotton, wool, cork, gunny-bags, or other similar goods;
- (b) Can hooks shall not be used for raising or lowering a barrel when, owing to the construction or condition of the barrel or of the hooks, their use is likely to be unsafe.

(8) No gear of any description shall be loaded beyond the safe working load save in exceptional cases and then only in so far as may be allowed by national laws or regulations.

(9) In the case of shore cranes with varying capacity (e.g. raising and lowering jib with load capacity varying according to the angle) an automatic indicator or a table showing the safe working loads at the corresponding inclinations of the jib shall be provided on the crane.

At docks, wharves, quays and similar places which are in frequent use for the processes, such facilities as having regard to local circumstances shall be prescribed by national laws or regulations shall be available for rapidly securing the rendering of first aid and in serious cases of accident removal to the nearest place of treatment. Sufficient supplies of first-aid equipment shall be kept permanently on the premises in such a condition and in such positions as to be fit and readily accessible for immediate use during working hours. The said supplies shall be in charge of a responsible person or persons, who shall include one or more persons competent to render first aid, and whose services shall also be readily available during working hours.

At such docks, wharves, quays and similar places as aforesaid appropriate provision shall also be made for the rescue of immersed workers from drowning.

Any fencing, gangway, gear, ladder, life-saving means or appliance, light, mark, stage or other thing whatsoever required to be provided under this Convention shall not be removed or interfered with by any person except when duly authorised or in case of necessity, and if removed shall be restored at the end of the period for which its removal was necessary.

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It shall be open to each Member to grant exemptions from or exceptions to the provisions of this Convention in respect of any dock, wharf, quay or similar place at which the processes are only occasionally carried on or the traffic is small and confined to small ships, or in respect of certain special ships or special classes of ships or ships below a certain small tonnage, or in cases where as a result of climatic conditions it would be impracticable to require the provisions of this Convention to be carried out.

The International Labour Office shall be kept informed of the provisions in virtue of which any exemptions and exceptions as aforesaid are allowed.

Except as herein otherwise provided, the provisions of this Convention which affect the construction or permanent equipment of the ship shall apply to ships the building of which is commenced after the date of ratification of the Convention, and to all other ships within four years after that date, provided that in the meantime the said provisions shall be applied so far as reasonable and practicable to such other ships.

GENERAL MEASURES OF PROTECTION FOR HOISTING AND TRANSPORT MACHINERY USED IN LOADING AND UNLOADING SHIPS

§ 1—Fencing of Dangerous Parts

Although most of the machinery and equipment used in the loading and unloading of ships is of a special type, different from that used in industry generally, there are certain general rules of protection which are applicable in both cases.

Thus, as with industrial machinery in general, hoisting and transporting appliances used on board ship and in docks, *e.g.* winches, derricks, cranes, conveyors and transporters, must be provided with proper fencing or other adequate protection at all points where there is a risk of injury to the men in charge of machinery or to other persons employed in loading or unloading. All dangerous machine parts, such as cog-wheels, chain or friction drives, gears, shafting, etc., should either be completely enclosed or otherwise adequately protected to prevent any person from coming into accidental contact with them. The guards must not be removed while the machine or apparatus is in use; if they have to be removed they must be replaced as soon as possible, and in any case before the machines or apparatus are again taken into normal service.

As a general rule, it can be said that the types of enclosures or guards ordinarily used in industry for similar purposes afford sufficient protection for the installations that we are dealing with here.

On steam-driven winches and other machinery the steam pipes and all other steam-carrying or steam-heated parts must be adequately insulated or otherwise enclosed, so as to prevent burns.

Where electrically driven winches or other appliances are used, care must be taken that all live electric conductors and other current-carrying parts are protected in conformity with the special regulations concerning electrical installations.

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§ 2—Safe Means of Access

Safe means of access should be provided for all drivers' platforms on cranes and other hoisting or transporting appliances, and all such platforms and all other places on which crane operators, winch drivers or other persons have to work, or over which they have to pass in the course of their work, should be provided with adequate railings so as to prevent persons from falling.

§ 3—Protection against Accidental Descent of Loads

All cranes, winches and other lifting machines should be provided with efficient brakes and with any other safety devices required to prevent accidental descent of suspended loads. This general rule is of even greater importance in loading and unloading operations in docks than at many other workplaces where hoisting operations are being carried out.

Brakes and other devices installed for this purpose should be of sound construction and of sufficient strength to hold safely the heaviest load permissible for the crane or winch to which they belong. All such devices should be kept in good working order and properly examined and tested at regular intervals.

§ 4—Safety Factors

Since in many of the following chapters strength of materials will be discussed, it may be useful to include here an enumeration of safety factors for hoisting equipment.

In connection with the adoption of the (revised) Convention (No. 32) concerning the protection against accidents of workers employed in loading or unloading ships (see Part II), the International Labour Conference, at its 1932 Session, also adopted a Recommendation requesting the Governments of the principal countries concerned to make arrangements with a view to securing reasonable uniformity in the application of the Convention.

In pursuance of this provision, meetings of representatives of a number of maritime countries were held in London in 1932 and 1935.

The matter of safety factors was among those dealt with by these meetings. The meeting in 1935 unanimously adopted a recommendation on this subject, as follows¹:

Safety Factors.

In view of the importance of the provision by manufacturers of adequate safety factors in their designs of hoisting machines and gear, manufacturers

GENERAL MEASURES OF PROTECTION

should be given some guidance in this matter. For this purpose the adoption of the following minimum safety factors is proposed without prejudice to account being taken of the provisions and measures recommended by National Standards Associations:

For all metal structural parts used in hoisting machinery:

- (a) when the safe working load is 10 tons or less..... 5
- (b) when the safe working load is over 10 tons..... 4

For wooden structural details.....	8
For chains.....	4½
For wire ropes as a general rule.....	5
For fibre ropes.....	7

It must be borne in mind that these figures are given as minima, each country wishing to fix higher factors being authorised to do so.

TESTING AND EXAMINATION OF LIFTING MACHINES AND GEAR BEFORE BEING TAKEN INTO USE

Article 9 of the Convention (No. 32) concerning the protection against accidents of workers employed in loading or unloading ships (revised 1932)¹ provides for the issue of appropriate regulations to ensure that no hoisting machine, or gear, whether fixed or loose, used in connection therewith, is employed in stevedoring operations ashore or on board ship unless it is in a safe working condition.

This provision of the Convention has been supplemented by the recommendations of the Conference, London, 1935, as follows:

(1) Tests and examinations of hoisting machines and gear on board.

Before being taken into use:

(a) Every *winch* with the whole of the gear accessory thereto (including derricks, goose-necks, eye-plates, eye-bolts or other attachments) should be tested with a proof load which should exceed the safe working load as follows:

<i>Safe working load</i>	<i>Proof load</i>
Up to 20 tons	25 per cent. in excess
20 — 50 tons	5 tons in excess
Over 50 tons	10 per cent. in excess

The proof load should be hoisted with the ship's normal tackle with the derrick at an angle which should not be more than 15° to the horizontal, or when this is impracticable, at the lowest practicable angle. The angle at which the test was made should be stated in the certificate of the test. After the proof load has been hoisted, it should then be swung as far as possible in both directions.

As a general rule all tests should be carried out in this way by dead load, and no exception should be allowed in the case of gear on new ships. In the case of replacements or renewals, however, spring or hydraulic balances may be used where dead loads are not available. Where a spring or hydraulic balance is used it should be reliable and accurate and the test should not be regarded as satisfactory unless the indicator remains constant for a period of at least several minutes.

Thorough examination for the purposes of Article 9 (2) of the Convention should be understood to mean a visual examination, supplemented if necessary by other means such as a hammer test, carried out as carefully as the conditions

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permit in order to arrive at a reliable conclusion as to the safety of the parts examined; and if necessary for this purpose, parts of the machines or gear must be dismantled.

(b) *Every crane and other hoisting machine* with its accessory gear should be tested with a proof load, which should exceed the safe working load as follows:

<i>Safe working load</i>	<i>Proof load</i>
Up to 20 tons	25 per cent. in excess
20 — 50 tons	5 tons in excess
Over 50 tons	10 per cent. in excess

The said proof load should be hoisted and swung as far as possible in both directions. If the jib of the crane has a variable radius, it should be tested with a proof load as defined above at the maximum and minimum radii of the jib. In hydraulic cranes where, owing to the limitation of pressure, it is impossible to hoist a load 25 per cent. in excess of the safe working load, it will be sufficient to hoist the greatest possible load.

(c) *Wire ropes* should be tested by sample, a piece being tested to destruction.

Owing to the risk of breakage of a part of the gear during the test, the load should not be hoisted higher than is absolutely necessary and a preventer wire should be attached. Hatches must be kept closed, so that if anything breaks the load will fall only a short distance and will not damage the bottom of the ship.

BLOCKS

In stevedoring, blocks facilitate the hoisting, lowering and trailing of goods and are also employed for moving the derricks. They enable a comparatively small power to act as a much greater power. Consequently they are greatly used in stevedoring and as much ignorance exists concerning them, they will be considered separately.

The number of sheaves determines the mechanical advantage obtained in hoisting a certain load, as is shown in figs. 34 to 39.

Many practical men know that when hoisting a weight of p tons with a rope led over one sheave it is necessary to exert a pull of p tons at the other end, but they do not know that the stress in the block and the fastening point amounts to $2p$ tons (see fig. 34).

It is very useful to demonstrate this, and it can be done in a very simple way by means of a spring balance as is shown in figs. 40-40c.

Men also know that when using double purchase (see fig. 35) they only need a power of $\frac{p}{2}$ tons to hoist a weight of p tons. They are, however, often unconscious of the fact that the stress in the block and the fastening point then amounts to $\frac{3p}{2}$ tons.

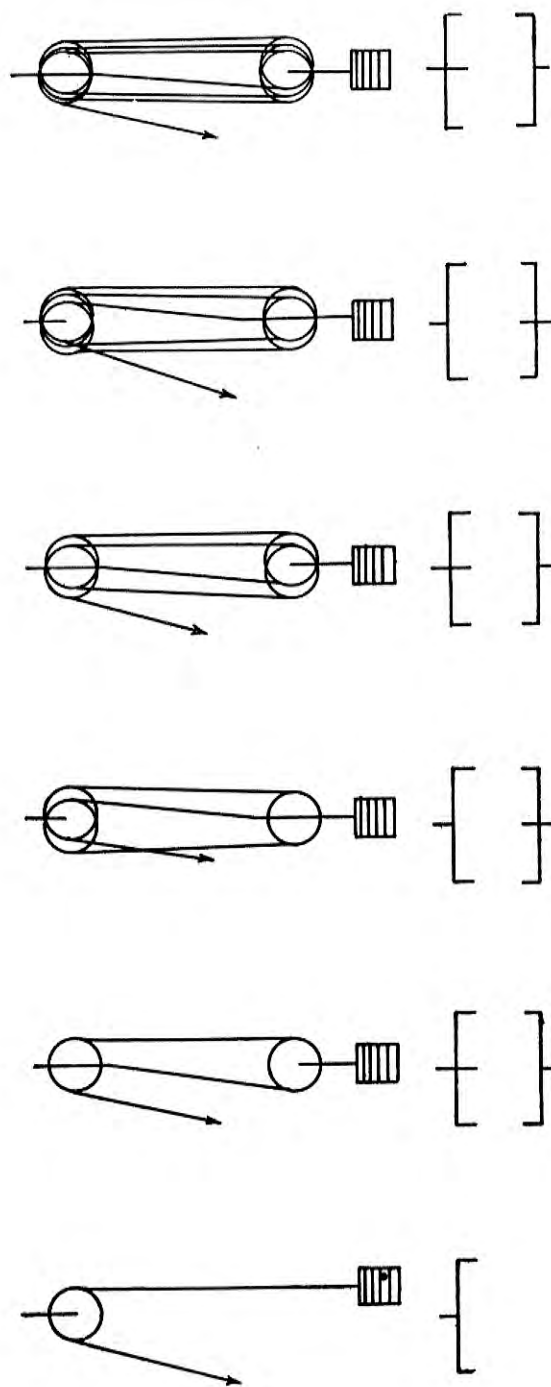
Figs. 36 to 39 inclusive speak for themselves.

Officers and petty officers on board and inspectors and foremen of the stevedoring company, as well as seamen and dockers, should be aware of these facts, because several severe accidents have been due to the misuse of blocks.

When a load is hoisted, friction has to be overcome and this is generally estimated at 5 per cent. of the load per sheave. When the safety factor is taken into account the increase in the stress is not very large if one sheave is used. If more sheaves are used this increase becomes larger and larger; in fig. 39 for instance, the increase is no less than 30 per cent.

Moreover, it is evident that greasing the blocks is a very important matter that should not be neglected, otherwise the stresses may further increase.

SAFETY IN DOCK WORK



Figs. 34-39

BLOCKS

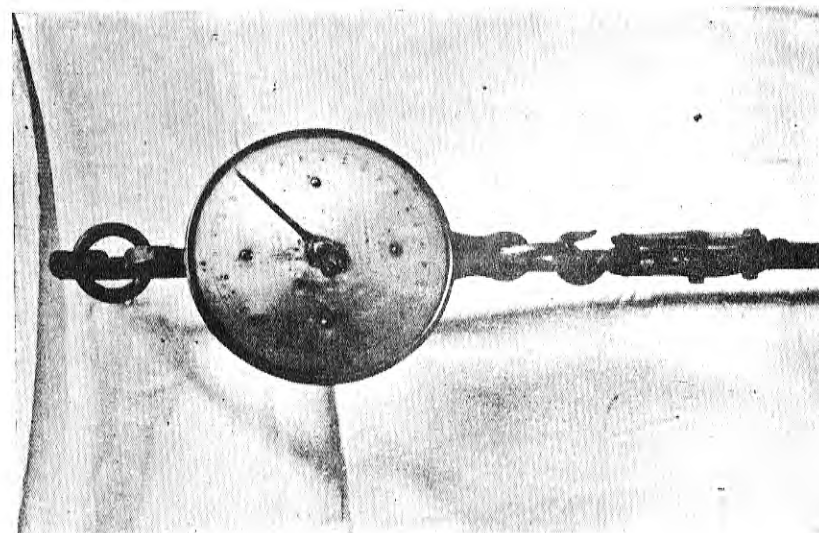


Fig. 40a

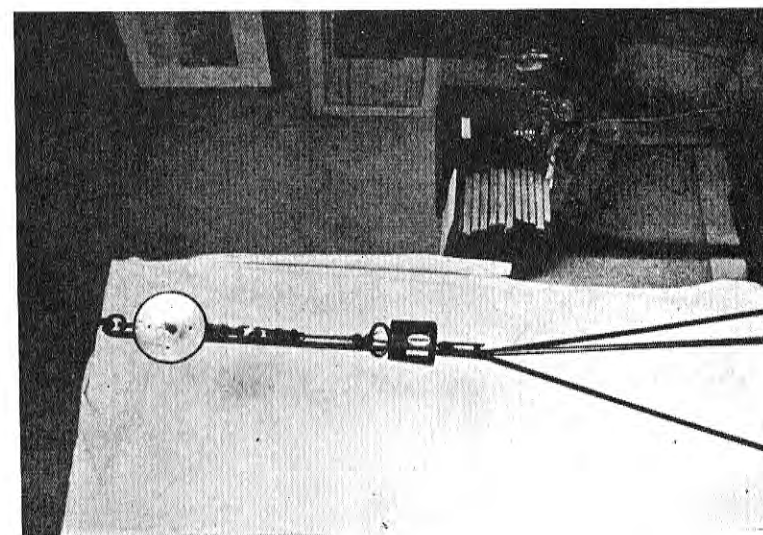


Fig. 40

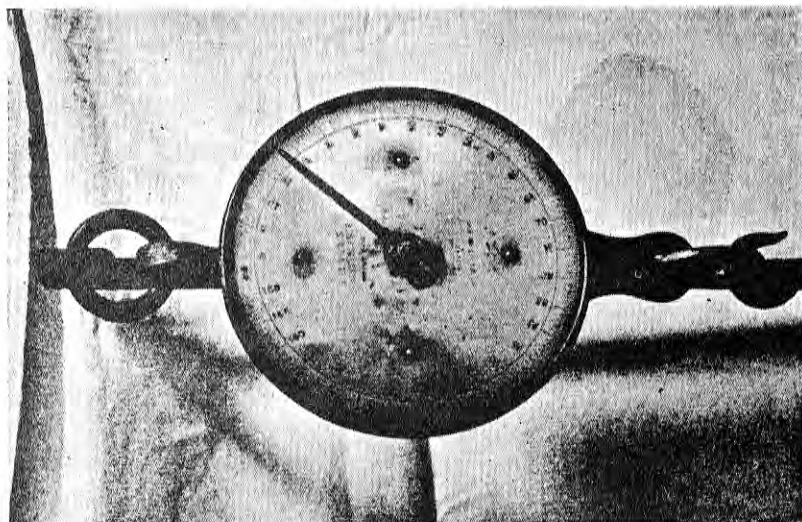


Fig. 40c

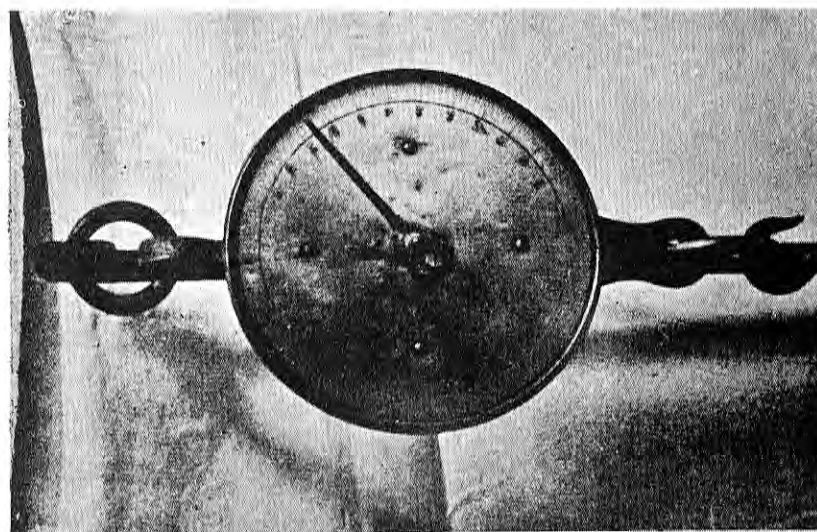


Fig. 40b

The stresses have been calculated in the preceding pages with the different parts of the runner in a vertical or nearly vertical position, or with both parts parallel and thus having the same effect.

When these parts form angles, the stresses will change more or less, as has been demonstrated in Chapter V, but it is always reasonable and safe to calculate the stresses in cargo blocks for a vertical position of the different parts of the runner, because:

- (a) the derrick is sometimes used in an almost vertical position, in which case both parts of the runner are almost vertical also (fig. 41);
- (b) the place where the load has to be hooked on is not determined (trailing from under deck, etc.) and the different parts of the runner may be almost parallel (fig. 42).

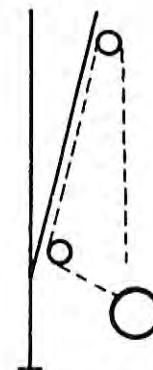


Fig. 41

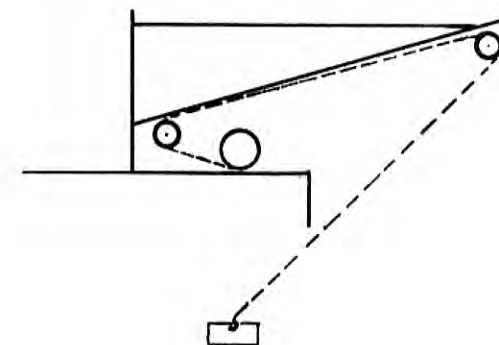


Fig. 42

For leading and span blocks there would be more reason to take account of the angle, but these blocks are often interchangeable with the cargo blocks; and even if these three types of blocks have a somewhat different form it is often possible to put one in the place of another. From a practical point of view, owners often prefer the same sizes for span, cargo and leading blocks, which seems the safest.

The principles to be followed when using snatch blocks, blocks for guys and the like are evident from the foregoing.

It will now be useful to describe briefly the conditions that a block has to satisfy.

- (1) All parts should be constructed according to the working stresses that they may have to support, assuming a safety factor of at least 5 for ordinary gear with which:

SAFETY IN DOCK WORK

- (a) the diameter of the swivel must be suited to the anticipated tension;
- (b) the centre pin may be considered as a part mainly in shear.

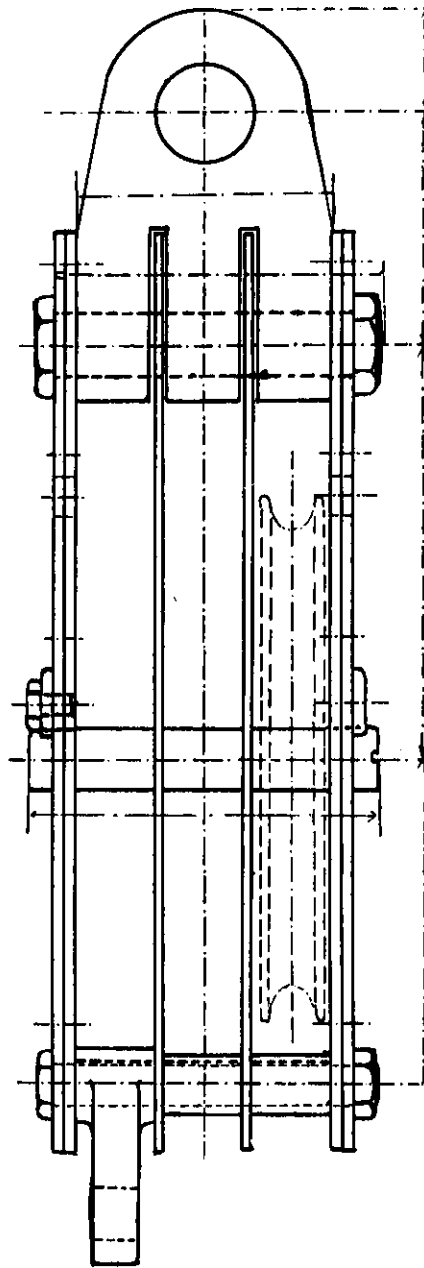


Fig. 43

BLOCKS

- (2) The runner must be prevented from coming between the sheave and the housing.
- (3) The lubricating system must work perfectly.

As it is sometimes the practice to use another material for the swivel and pin than for the housing and sheave, specification of the material is necessary.

Multiple-sheave blocks are often designed with a shackle and bolt or similar construction instead of a swivel. In this case the bolt may be calculated in the same way as for the centre pin. Figs. 43 and 44 may explain this.

In this chapter only swivel blocks will be considered.

A standardised design for a single-sheave cargo block is reproduced in figs. 45-48 in which the swivel and pin are clearly shown.

A most important question is the safe working load of a block. As always, the weakest part determines the strength of the whole, and as the centre pin is practically a part in shear, the swivel, which is a part in tension, forms the weakest part of the construction, provided that the other structural parts such as the shell and sheave have been calculated correctly.

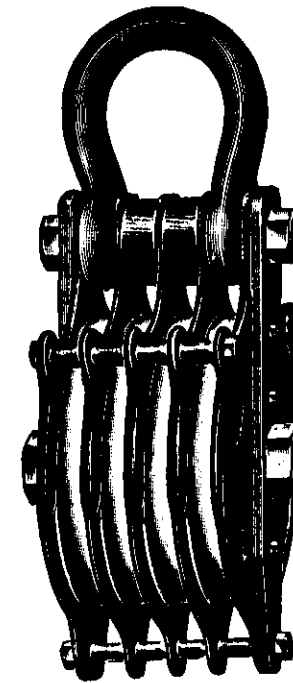


Fig. 44

The diameter of the sheave, the size of which usually designates the block, has nothing to do with the safe working load of the block, as can be seen in the following table compiled by a world-renowned manufacturer:

10 in. diameter single—tested to 10 tons on private machine for 8 tons working load	
12 in. diameter single—	<i>idem</i>
14 in. diameter single—	"
16 in. diameter single—	"

Swivel bolt and centre pin are generally of the same or almost the same diameter, and the rupturing tensile stress may be calculated at half the breaking stress when shearing is taken into account.

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Moreover, the swivel is generally forged, and hence the breaking strength of the material cannot be much more than 34-42 kg/mm², while the centre pin is sometimes made of material with a higher breaking strength.

Considering what has been said above, the swivel bolt may as a rule be taken as the weakest part of a block. Persons desirous of ascertaining the approximate strength of a block will do well to measure the diameter of this bolt, and then the tensile strength can be very easily calculated by multiplying the cross-sectional area by $\frac{34-42}{2}$ kg/mm², which may be taken for this purpose as the

breaking strength of material used for such bolts. If the specification of the material is known, the actual breaking strength has naturally to be taken. If an inspector takes one fifth of the tensile strength, he will have a sufficient idea of the strength of the block.

Moreover, it is quite clearly of the utmost importance to enter the dimensions of the swivel bolt (if not the centre pin as well) on the certificate.

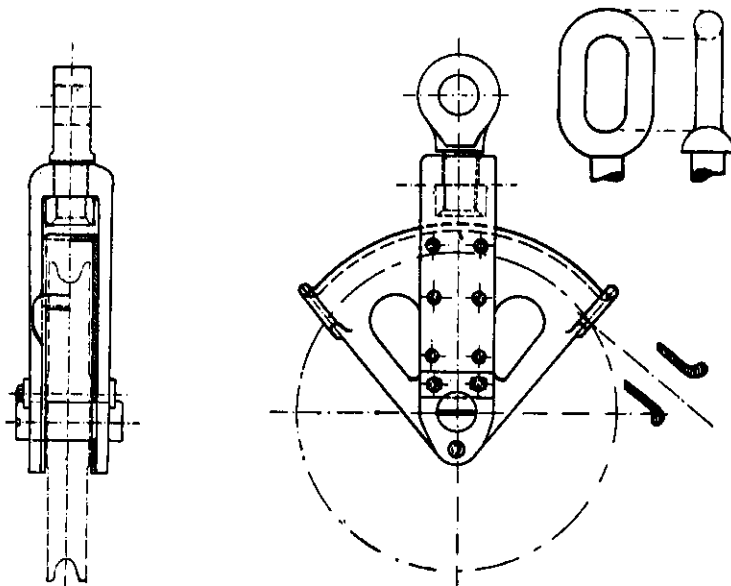


Fig. 45

Figs. 46, 47 and 48

As to the *marking* of blocks much misunderstanding exists. Practical users must know what load may be hoisted with a certain block, and this should be indicated on the block.

BLOCKS

For single-sheave blocks used with a single runner this could be done in a simple way by putting on the shell:

Load (to be hoisted) tons.

With a double purchase, with one end of the runner fastened to the upper or the lower block, and with multiple-sheave blocks the question is not so simple.

The Netherlands Committee for Loading and Unloading Gear etc. on Board Seagoing Ships advised in its Report of 1932 the marking of blocks as indicated in figs. 34 to 39. This method has the advantage of mentioning not merely the load that may be hoisted but also the maximum allowable stresses in the principal parts of the block.¹ Some manufacturers make a habit of marking their blocks with the test load, but this should be discouraged.

The diameter of the sheave has to be determined in connection with the wear of the wire. Most manufacturers designate their blocks according to the diameter measured at the outer circumference of the sheave (e.g. 16 in. block). In practice, however, the diameter of the sheave measured at the bottom of the groove is of more importance, since the bending of the wire depends on the inner diameter. (A 16 in. block measured by the first method would become a 15 in. block by the second method.) To avoid misunderstanding, uniformity should be established.

Several countries have rules concerning the relationship between sheave and wire and between wire and groove.

GERMANY: *Vorschriften der See-Berufsgenossenschaft*, No. 13, 1935, page 34 (*Sonderabdruck*):

The sheaves must have a diameter of about 15 times the diameter of the wire.

GREAT BRITAIN: *British Standard Specification for Ships' Cargo Lifting Blocks*, No. 408, 1931:

To increase the working life of wire ropes, it is recommended that where the angle of embrace is 90° or more [see figs. 49-51] the minimum diameter of each sheave should be as follows for the various sizes of ropes:

¹ In some countries, e.g. Great Britain, the competent authorities do not agree with this method, as they consider that it may give rise to confusion in the minds of users. See British Docks Regulations 1934 (secs. 23 and 33), and British Standard Specification for Ships' Cargo Lifting Block, No. 408, 1931.

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Size of wire rope circumference		Diameter of sheave	
in.	mm	in.	mm
Under 2	Under 50.8	10	254
2 - 2½	50.8 - 63.5	12	305
2½ - 3	63.5 - 76.2	14	356
3 - 4	76.2 - 101.6	16	406
4 and over	101.6 and over	18	457

The minimum diameter of sheaves for any other conditions should be not less than four times the circumference of the rope.

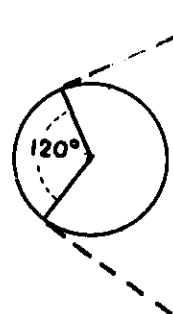


Fig. 49

Angle of embrace
more than 90°

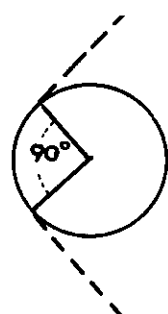


Fig. 50

Angle of embrace
90°

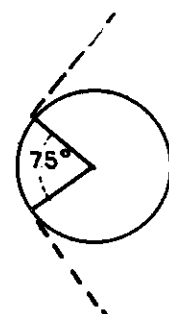


Fig. 51

Angle of embrace
less than 90°

NETHERLANDS: Report of the Committee for Loading and Unloading Gear on Board Seagoing Ships, 1932:

The diameter of the sheave, measured at the bottom of the groove, must be at least:

For single-sheave topping blocks, 4 to 4.5 times the circumference of the wire rope to be used, if it is composed of 6 × 12 wires with 7 cores of hemp or 6 × 19 wires with 1 core of hemp; and 3.5 to 4 times that circumference if it is composed of 6 × 24 wires with 7 cores of hemp;

For load and derrick lowering blocks, 5.5 to 6 times the circumference of the wire to be used in a construction of 6 × 12 wires with 7 cores of hemp, or 5 to 5.5 times that circumference if composed of 6 × 24 wires with 7 cores of hemp.

If the wire rope is composed of a larger number of wires than 6 × 24, the diameter should be that for wire rope consisting of 6 × 24 wires with 7 cores of hemp.

It is recommended not to have the width of the groove of the sheaves more than 1 to 2 mm larger than the diameter of the thickest rope for which the block is made.

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Finally, the test loads as stipulated by the Conference in London 1935 are as follows:

Pulley blocks:

Single-sheave block { 300 per cent. in excess
of the safe working load

Multiple-sheave block with safe load up to and including 20 tons { 100 per cent. in excess
of the safe working load

Multiple-sheave block with safe load over 20 tons up to and including 40 tons { 20 tons in excess of the
safe working load

Multiple-sheave block with safe load over 40 tons { 50 per cent. in excess
of the safe working load.

CHAINS, RINGS, HOOKS, SHACKLES, SWIVELS, ETC.

It may be useful, to reproduce here the conclusions reached at the Conference, held in London, July 1935, as regards testing and annealing with a view to amending and completing regulations under the Dockers Convention. They read as follows:

In substance the Conference recommended that chains, shackles, rings, hooks and swivels should be tested with a proof load 100 per cent. in excess of the safe working load, but pitched chains, used with hand-operated pulley blocks and shackles, rings, hooks or swivels permanently attached thereto should be tested with a proof load 50 per cent. in excess.

Every chain, shackle, ring, hook or swivel after it has been lengthened, altered or repaired by welding should be tested and examined.

The recommendations then continue as follows:

Chains, shackles, rings, hooks and swivels made of wrought (*i.e.* puddled) iron should as a general rule be annealed.

The following classes of special gear may be exempted:

- (1) Chains made of malleable cast iron;
- (2) Plate-link chains;
- (3) Pitched chains;
- (4) Rings, hooks, shackles and swivels permanently attached to pitched chains, pulley blocks or weighing machines;
- (5) Hooks and swivels having screw-threaded parts or ball bearings or other case-hardened parts;
- (6) "Bordeaux" connections.

In the present state of knowledge steel gear may also be exempted.

In all cases annealing should be carried out in a suitably constructed closed furnace and not in an open fire.

For wrought iron gear the temperature should be between 600° and 700°C and the exposure should last for between 30 and 60 minutes. Should new steel gear be annealed the temperature should be that generally employed for normalising, *i.e.* not less than 900°C.

After being annealed the article should be allowed to cool slowly and should be carefully inspected.

The Conference evidently was not in a position to give a definite opinion on annealing steel gear, and left the matter to be dealt with in national regulations. In fact, several countries have regulated the annealing of steel gear with good results.

It now remains to deal with shackles. Careful attention should be given to the bolts of shackles used at places where it is not possible to keep them constantly under notice, and further they should be securely fastened. For cargo and span block shackles, for instance, fig. 52 shows an adequate fastening.

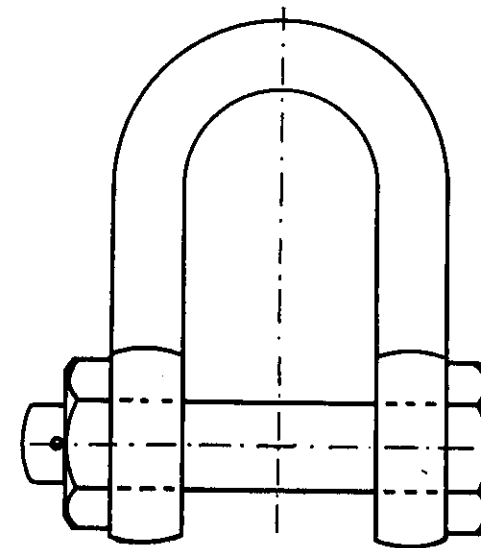


Fig. 52

This type of shackle, however, is not practical for fastening the runner hook, as it is too easy for the nut to catch under the coamings or elsewhere, and so cause an accident. Such shackles should be of a type without protruding parts as shown in fig. 53. With this type the bolt is screwed into the shackle, the rounded head of the bolt being provided, for this purpose, with a square recess into which a key can be inserted.

Mention must be made of a type of shackle, which is still to be found on several merchant ships, and in which the fastening of the

SAFETY IN DOCK WORK

bolt is inadequate for rigging purposes, as has been proved by at least one fatal accident. The bolt of this shackle had been fastened by a cotter pin only, which had come out during the work; the shackle bent open and consequently the derrick fell down, hitting a dock worker, who died a few minutes afterwards.

The construction was as indicated in fig. 54. Shackles of this type should never be used.

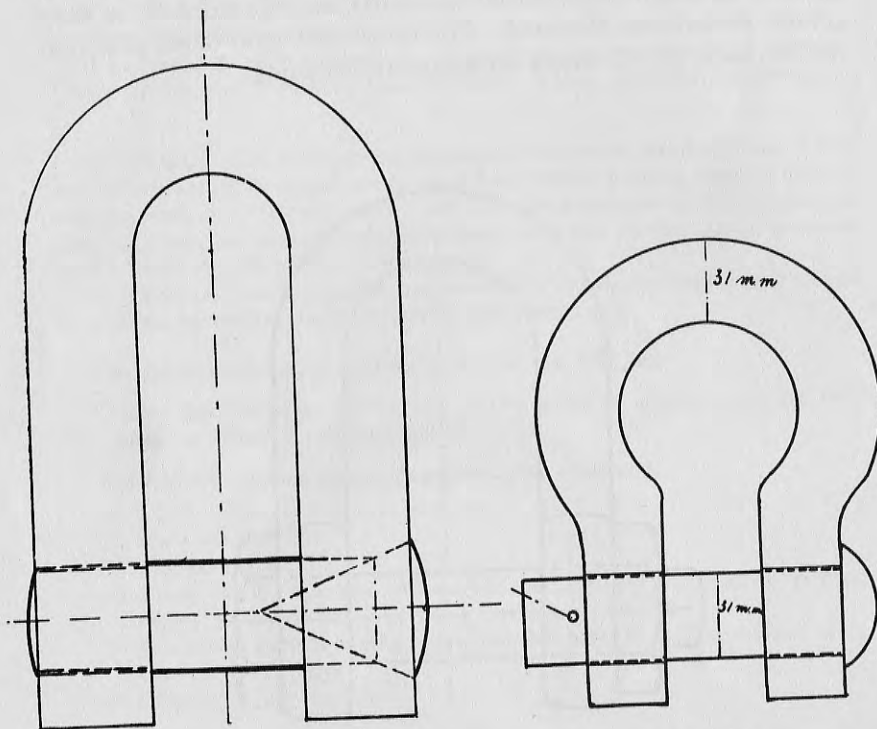


Fig. 53

Fig. 54

The standardisation committees in several countries have done splendid work in designing good chains, shackles, hooks, etc., and the attention of all concerned is drawn to their publications.

The permissible wear of chains, etc., is also a matter for consideration. In some countries regulations on this subject have been issued.

The *Germanischer Lloyd* for instance laid down in 1929 that chains, etc., should be renewed when the section at certain places has so diminished that it must be considered dangerous to use them. As a rule they should be renewed if the wear at certain places has reached 10 per cent. of the original diameter.

CHAINS, RINGS, HOOKS, ETC.

The German *See-Berufsgenossenschaft* laid down in 1935 that parts (of the gear) that are worn down should be renewed when the wear has reached 10 per cent. of the original diameter or of the original dimensions.

In the Netherlands, the Report of the Committee for Loading and Unloading Gear on Board Sea-going Ships expresses the opinion that chains, shackles, hooks, rings, swivels, rigging screws, fastenings on deck, eyes, bolts and other forged material should be renewed when one of the dimensions has diminished by more than 15 per cent.

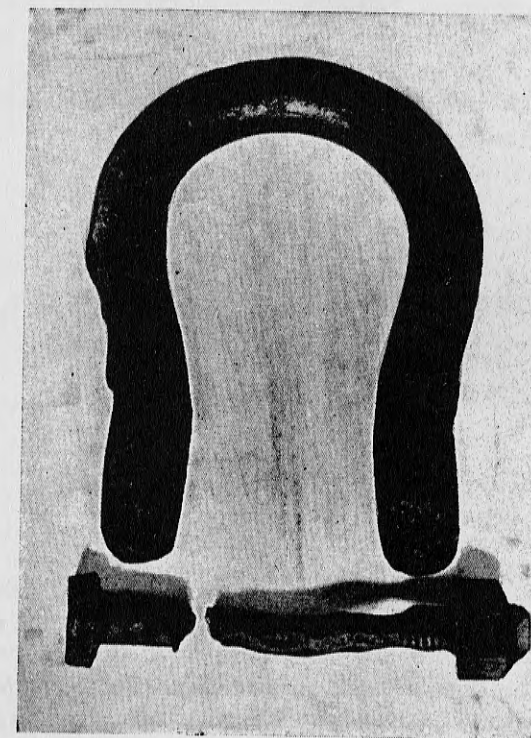


Fig. 55

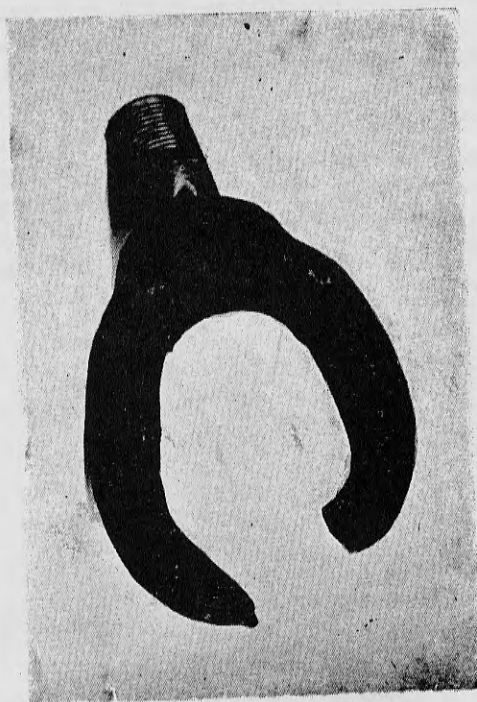


Fig. 56

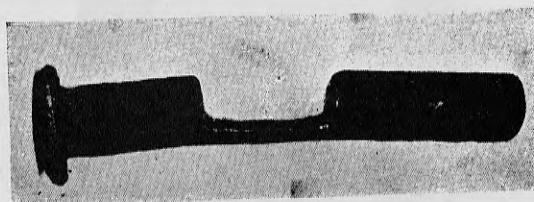


Fig. 57

It is not sufficient, however, to have regulations about the permissible wear; every link, shackle, hook, etc., should be submitted to frequent inspections and examinations. A great advantage of periodical annealing is that it offers an opportunity for careful examination of the chain, etc., since after all grease and dirt has been removed by fire, the bare metal is exposed.¹

STRENGTH OF SLINGS. INFLUENCE OF THE ANGLE BETWEEN THE LEGS OF A SLING ON THE ACTUAL TENSION IN THE LEGS

It is the merit of G. STEVENSON TAYLOR to have drawn the attention of practical users to the relation between angle and tension in sling legs in 1915 in his *Memorandum on Chains and Other Lifting Appliances* (reprinted 1930); and in several other countries publicity has since been given to the dangers latent in sling angles. Notwithstanding all educational efforts, however, much ignorance still exists on the subject.

Stevenson Taylor's *Memorandum* contains several tables and diagrams. The table reproduced below clearly shows the effects of angular changes.

TABLE V. SAFE WORKING LOADS FOR TWO-LEGGED SLINGS
MADE OF WROUGHT IRON SHORT LINK CHAINS
OF DEFINITE STANDARD OF QUALITY

Chain diameter (inches) (1)	Safe working loads in tons (2,240 lbs.) for given angles between legs				
	0° (2)	30° (3)	60° (4)	90° (5)	120° (6)
3/16	0.42	0.40	0.36	0.29	0.21
1/4	0.75	0.72	0.65	0.53	0.37
5/16	1.16	1.12	1.00	0.82	0.58
3/8	1.68	1.62	1.45	1.18	0.84
1/2	3.00	2.89	2.60	2.12	1.50
5/8	4.66	4.50	4.04	3.30	2.33
3/4	6.75	6.52	5.85	4.77	3.37
7/8	9.16	8.85	7.94	6.48	4.58
1	12.00	11.58	10.39	8.48	6.00
1 1/8	15.18	14.64	13.14	10.71	7.59
1 1/4	18.75	18.10	16.25	13.25	9.37
1 3/8	22.68	21.85	19.60	16.00	11.32
1 1/2	27.00	26.05	23.40	19.08	13.50
1 5/8	31.60	30.06	27.43	22.40	15.84
1 3/4	36.75	35.45	31.80	25.95	18.37
1 7/8	42.18	40.70	36.50	29.80	21.09
2	48.00	46.40	41.56	33.93	24.00
2 1/8	54.10	52.30	46.90	38.25	27.05
2 1/4	60.75	58.60	52.60	42.95	30.37
2 3/8	67.60	65.30	58.60	47.80	33.80
2 1/2	75.00	72.47	65.00	53.00	37.50

Although the sizes of chains given in this table range from $\frac{3}{16}$ in. (5 mm) to $2\frac{1}{2}$ in. (65 mm), it is strongly recommended that chains made from iron less than $\frac{5}{16}$ in. (8 mm) should not be used for lifting purposes, because they are more liable to overloading and to damage than chains above this size.

The safe working loads given in the table are based on the formula:

$$\text{S.W.L. (tons)} = 6 d^2$$

where d is the diameter in inches of the iron in the chain link. Where there is any special risk to life or limb a safe working load of not more than $5 d^2$ should be adopted; where chains are subject to shock or heavy wear, or work over pulleys, or where links are liable to be bent or indented by severe local pressure, as where a single sling is reeved round a load having a hard irregular surface, the safe working load should not exceed $3.5 d^2$.

The German Standards Association (D.N.A.) has issued a pamphlet (DIN 685, 2nd edition, October 1935) on tested chains; the following is an extract from one of the tables (p. 4):

Angle between the legs	Safe working load per leg as percentage of the maximum
perpendicular position	100
45°	90
90°	70
120°	50

A note indicates that with an angle between the legs larger than 120°, the highest safe working load allowed is only 25 per cent. of that for an angle of 120° and that consequently the angle should not exceed 120°.

As a rule all warnings are limited to chains, although the same danger exists when steel wire or fibre rope is used; it should be noted, however, that some regulations (e.g. the British Docks Regulations, 1934) require the same precautions to be taken for wire rope slings as for chain slings, whether used singly or with multiple legs.

The *strength* of a sling depends on factors that may operate together or separately. For fibre ropes these factors include:

- (a) the circumference of the rope;
- (b) the quality of the material used;
- (c) the lay of the rope;
- (d) splices and knots;
- (e) the number of strands; and
- (f) the cross section of the hook (or shackle bolt) where the sling is suspended.

For steel wire ropes the influence of (a), (b) and (d) is, of course, **very** important, (c) and (e) exercising comparatively little influence, while the influence of (f) is not as important for steel wire rope as for fibre rope.

The flexibility of the rope, however, is an important factor, while for chain slings the diameter and quality of the material and the form of the links are important. The flexibility of a wire rope is determined by the number of wires per strand. Flexible rope for shipping purposes is usually 6×12 and special flexible 6×24 .

As a very large proportion of the slings used are made of manilla rope¹, the very variable factor introduced by the cross section of the hook will be dealt with first. It is obvious that a hook with a sharp edge (a small diameter) acts more or less as a knife and tends to cut the rope in two and accordingly a broad contact surface is to be recommended.

Further, a double sling, used with both parts vertical, is not double the strength of two single parts of the same material, as will be proved below.

A distinct difference exists between the stresses in the two following cases:

(1) A double sling taken round the load, with one end taken through the other and fixed in the hook (fig. 22); and

(2) A sling with the load in the middle, both ends being fixed in the hook (figs. 23 and 24).

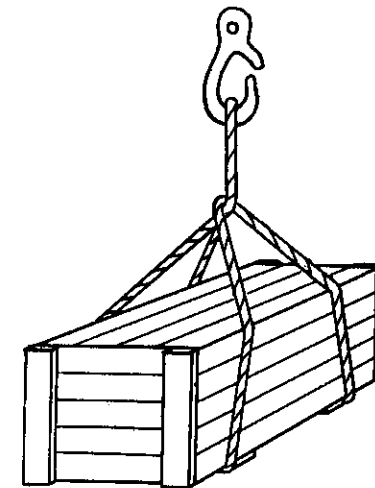


Fig. 22

Method 1 is usual for cargo of small and moderate weight; the sling is made of manilla rope or sometimes of steel wire, both of which slip sufficiently to fasten the load in the sling. With this method it is very important that the rope passing over the hook be kept as straight as possible. If the loads are composed of corrosive goods liable to destroy fibre, chain slings are sometimes used, but then method 2a (fig. 23) or 2b (fig. 24) is followed.

Methods 2a and 2b are further applied with heavy loads, for which manilla ropes are usually not strong enough, so that steel

wire ropes or sometimes chains are used. Chains are not suitable for method 1, as they do not slip sufficiently.

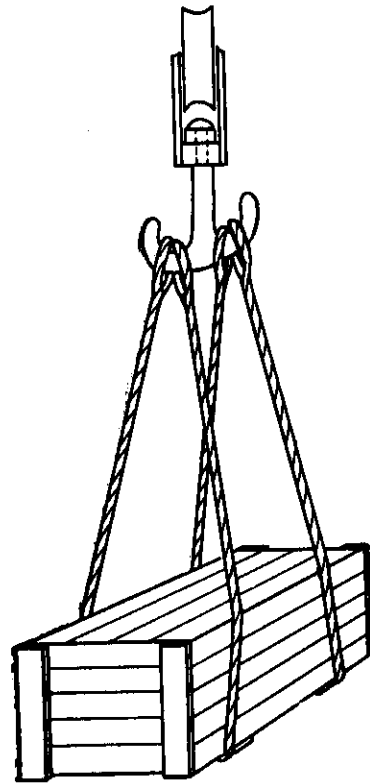


Fig. 23

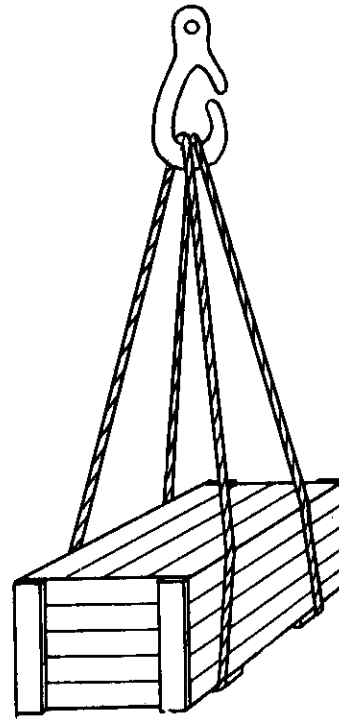


Fig. 24

It is evident that, when working with method 1, the stresses in the material are other and heavier than with the second method. Hence method 1 is commoner for loads hoisted with manilla slings.

Very many tests have been carried out in this connection at Rotterdam. The following table gives the results of 27 tests with a single rope and 27 with a double sling each of the same coil of manilla rope, the coils being of various qualities and circumferences and the legs being taken as parallel. The ropes were stretched between two bolts of a testing machine; the influence of differences in the diameter of the bolts was eliminated by seeing that in all tests one bolt had a diameter of 38 mm, the other being thicker.

Table VI, which could be completed from other tests, reveals important differences in the results of the tests.

In No. 5, for instance, the strength of the single rope is almost

TABLE VI

No.	Breaking strength of single part in kg	Breaking strength of double sling in kg	Ratio of breaking strengths, double to single
(a)	(b)	(c)	(d)
1	7,600	7,900	1.04
2	6,950	9,050	1.30
3	5,700	7,500	1.31
4	7,480	9,800	1.31
5	7,400	7,500	1.013
6	7,400	9,900	1.33
7	6,980	9,200	1.31
8	9,300	10,100	1.08
9	7,950	8,900	1.12
10	8,500	9,350	1.10
11	9,050	9,600	1.06
12	8,200	9,700	1.18
13	5,500	5,900	1.07
14	7,300	10,400	1.42
15	6,300	8,100	1.28
16	6,250	9,000	1.44
17	6,150	7,550	1.22
18	6,200	7,700	1.24
19	5,100	7,400	1.45
20	4,300	7,100	1.65
21	4,550	7,200	1.58
22	6,700	7,500	1.12
23	6,400	8,400	1.31
24	6,700	7,950	1.18
25	4,200	5,200	1.24
26	4,050	5,000	1.23
27	4,300	5,100	1.18
	176,510	218,000	1.24

the same as that of the double sling, and in No. 20 the double sling is 1.65 times as strong as the single rope.

When loading and unloading, the circumstances discussed above—and others as well—have to be considered. The inference seems justified that 1.235 or roughly $1\frac{1}{4}$ is the factor by which the breaking stress of the single manilla rope has to be multiplied to give the safe working load of the double sling.

For double steel wire slings the results of the tests led to the same conclusion. For double chain slings, which, however, are seldom used, the position is somewhat different. The weak point of these appliances is to be found in the unfavourable combination of stresses to which some links may be exposed. For the sake of uniformity it seems desirable to fix the strength of double slings with parallel legs for all kinds of material at $1\frac{1}{4}$ times the strength of the single rope or chain.

It is the safety factor that must ensure safety if the strength of the double sling is less than $1\frac{1}{4}$ times that of the single fall.

THE INFLUENCE OF QUALITY, LAY, SPLICES AND NUMBER OF STRANDS ON THE STRENGTH OF MANILLA AND STEEL WIRE ROPES

An enormous quantity of fibre and steel wire rope is used in dock work, both for standing and running rigging and for loading and unloading appliances, and above all for slings.

§2.—Manilla Ropes

When judging manilla ropes the following points have to be considered:

- (a) material: outward appearance, weight per unit, length, quality and breaking strength of the fibre and of the rope, addition of oil and chemical composition of the oil used;
- (b) nominal dimensions and method of measuring;
- (c) method of measuring the breaking strength of the rope;
- (d) breaking length.

(a) *Material*

Ropes display great differences in quality, and it is of the utmost importance that the certificates should mention the breaking strength, and here a clear distinction must be drawn between the real and the calculated breaking strength. For practical purposes

it is necessary to know the former, which is as a rule the lower of the two.

The weight of the rope per unit length is in proportion to the quantity of fibre utilised in its manufacture.

A soft laid manilla rope of some six strands may have a high breaking strength when used as a single fall, since the fibres, yarns and strands are not much bent. The same rope may, however, have a low breaking strength when used as a sling, as the loose lay causes the rope to be flattened on the bolt or hook of the testing machine.

If on the contrary a four-strand rope is hard laid the breaking strength of the single fall may be lower, as the fibres, etc., are bent more, and the breaking strength of the sling may be greater, as the rope remains more or less round when stretched between the hooks or shackles of the testing machine.

Of course on the whole, soft laid rope is weaker than rope with relatively more fibre (hard laid), the difference varying with the size and firmness of the yarns and strands and with the lay.

The addition of oil, which is made to preserve the rope and to lubricate the fibres, may have a great influence on the weight, and this point should be considered carefully. No corrosive substance may be added, nor any substance for weighting purposes.

The quantity of lubricant used should form 8 to 12 per cent. of the weight of the rope.

For good rope the fibre used in manufacture should consist solely of new genuine long fibre manilla, when this is obtainable. The fibre shall be well backled and free from shorts. Though the longest fibres are 3 to 4 m in length, fibre used in the manufacture is seldom longer than 2 m. Indeed, shorter fibres and even very short fibres are often used, a fact that influences the breaking strength considerably. The strands of the rope shall be well formed and shall be free from grooves and sunken yarns. As it is not always possible to judge the rope from its appearance, a heavy responsibility rests on the shoulders of the dealers who sell inferior manilla to customers who, considering price, outward appearance and sometimes certificates, may think they have bought good rope and use it as such. On the other hand, shipowners, captains and stevedores bear great responsibility, if out of misplaced thrift they buy cheap rope and thus endanger the lives of their workers, who have to use it without being aware of its inferior quality.

Sometimes the charter party requires the stevedore to use the ship's manilla slings. This is to be deprecated as it is the stevedore who has the responsibility. The interests of the two parties are opposite in such cases, the captain wanting to keep his expenses as low as possible, and the stevedore wanting to work as quickly

as possible. The latter, then, must make his sling loads as large as the circumstances permit.

If no certificates are available and there is no occasion to test the ropes, the following table, based on a medium quality of manilla, may give some guidance.

TABLE VIII

Circumference		Number of strands	Safe working load of single rope with a safety factor of 8
mm	in.		kg
50	2	3	200
56	2 1/4	3	250
63	2 1/2	3	325
69	2 3/4	3	375
75	3	3	425
82	3 1/4	3	525
88	3 1/2	3	625
94	3 3/4	3	725
100	4	3	850

(b) *Nominal Dimensions and Method of Measuring*

Manilla rope is generally designated according to the circumference; in some countries the diameter is given too.

The circumference should be measured when the rope is slack and taken as the mean of at least five separate measurements made with a steel or paper strip, so that the strip follows a bent line (fig. 58). It is not usual to take as the circumference a circle which

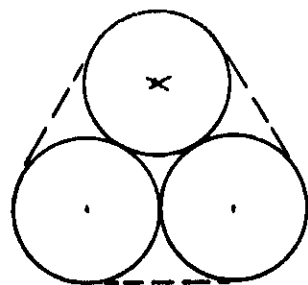


Fig. 58

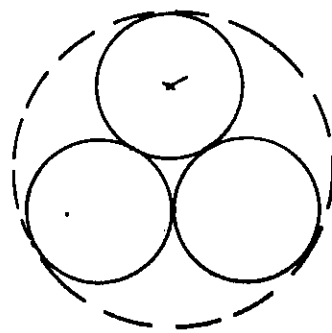


Fig. 59

touches the outer edges of the rope (fig. 59). For a three-strand rope the measurements obtained by these two methods would differ by about 10 per cent.

Instruments exist on which the circumference can be read immediately, but not as accurately as with the strip.

The circumference of a used rope may differ very considerably from that of the rope when new.

(c) *Method of Measuring the Breaking Strength of the Rope*

The best method is to stretch the rope between two holdfasts (vices) of the testing machine, which enables the more or less incalculable influence of the splices to be left out of account. The results will be different according as a long or a short length of rope is gripped by the vice.

Factors influencing the strength of a rope, include the strength of the yarns in combination with the length of the piece which is tested, and the lay of the rope.

As the average length of the fibres may be estimated at 1,000 to 1,500 mm it seems reasonable to make the test piece the same length.

(d) *Breaking Length*

A good idea of the strength of a rope is given by the "breaking length", meaning the number of km of rope, the weight of which is the same as the breaking strength.

The breaking length of ropes of the same material and of the same lay is constant and independent of the diameter. Consequently it is very easy to compare the quality of ropes of different sizes and qualities when the breaking length is known.

So far the breaking length has not often been used but the advantages that it offers for the future justify some mention of it.

§ 3.—Steel and Iron Wire Ropes

In some countries the term "iron" has been dropped and only the term "steel wire rope" is in use, but as in several important countries "iron" still remains and many manufacturers make use of it, iron wire may appropriately be discussed here.

By reason of their *lower* breaking strength so-called iron wire ropes have to be thicker than steel wire ropes. Some shipowners, especially of small ships, prefer them for their standing rigging, because they look steadier than the comparatively thin steel wire ropes of the same breaking strength. Moreover, they deem it an advantage that the same degree of wear causes a smaller decrease in the total breaking strength. These considerations make them forget the advantages of steel wire.

As the safe load of the gear of new ships, both large and small, is gradually increasing, iron wire ropes are becoming too clumsy

and are steadily disappearing, but in their turn, steel wire ropes, especially for heavy gear, have found a serious competitor in steel rods.

As a rule, material of a breaking strength of 130-180 kg/mm² is in use for steel wires, 130-140 kg/mm² being most common; material of a lower breaking strength is generally called iron. Iron wire is generally made of material with a breaking strength of 40-45 and 60-70 kg/mm².

The ropes should be of a composition suited to the operations for which they are intended.

For the standing rigging, steel wire ropes of 7 strands with 7, 12 or 19 wires to the strand are recommended, the choice of the number of wires depending on the circumference of the rope, and the diameter of the wires, as it bears on the suitability of the rope for splicing.

For runners, the ropes should be more flexible and the 6 × 12 quality with 7 hemp cores is considered more suitable when the circumference is 51 mm (2 in.) or less, and the 6 × 24 quality with 7 hemp cores for greater circumferences.

For spans and guy pennants with a circumference of 51 mm (2 in.) or less, the 6 × 12 construction with 7 hemp cores or the 6 × 19 with one hemp core is recommended, and for a greater circumference, the 6 × 24 construction with 7 hemp cores, or the 6 × 19 with 1 hemp core.

The choice of the strength and composition of the rope depends on the anticipated strain in conjunction with the safety factor, the diameter of the drum or sheave for which the rope is intended, and any special circumstances in the operations. The completed rope shall be securely and evenly laid.

Ropes should be adequately greased at regular intervals, care being taken that the grease is entirely free from acid.

The question of when a wire rope has become unfit for use has been dealt with by various countries.

The British Dock Regulations, 1934, contain the following regulation:

Section 20-(c). No wire rope shall be used in hoisting or lowering if in any length of eight diameters the total number of visible broken wires exceeds 10 per cent. of the total number of wires, or the rope shows signs of excessive wear, corrosion or other defect which, in the opinion of the person who inspects it, renders it unfit for use.

In the Netherlands, iron and steel wire ropes have to be renewed when extensive corrosion has occurred or when more than 10 per cent. of the total number of wires have been broken over a length of 10 times the diameter of the rope.

Naturally, very many other problems have to be solved, e.g., the resistance of masts and derricks to crushing stresses, and the safe working load of wires, rigging screws and fastening points. Generally speaking, standardisation committees, classification bureaux and manufacturers are now giving very useful indications on these points.

Lloyds Register Rules, for instance, require the scantlings of the masts to be in accordance with table 47 of these Rules and these scantlings are considered suitable for the support of average equipment of derricks of normal outreach, provided that the staying of the masts is efficient. Shrouds and stays are required to conform, in number and size, to the specifications in tables 48 to 57 of the Rules.

It is not very easy to devise a method for the calculation of the stresses in the guys, which are generally determined by practical means. The stresses may become very high, especially when working with fixed derricks and coupled runners (with inner and outer tackle).¹

For this method special regulations have been issued in some countries.

The *Vorschriften über Lade- und Lösch-Einrichtungen auf deutschen Seeschiffen* issued by the *See-Berufsgenossenschaft* in 1935 contain the following regulation:

§65.

3. The use of two fixed derricks with runners shackled together for loading and unloading is only allowed when the eyes on the outer guys of the derricks, and the outer guys themselves are strong enough.

and the Netherlands Committee for Loading and Unloading Gear on Board Sea-going Ships stated in their report of 1932 (Part I), section 20:

When cargo gear not especially constructed for this purpose is used for loading or unloading with inner and outer tackle, the load shall not exceed $\frac{1}{2}$ of the load on which are based calculations of the relevant part of the gear assuming normal use with slewing derricks.

The guys shall have at least the actual breaking strength mentioned below.

Care shall be taken that, for cargo gear, constructed for loading or unloading with inner and outer tackle, and for which sufficient directions for the fitting up and the fixing of the guys are carried on board, the stresses in the derricks and spans do not exceed the maximum values for the most unfavourable working position of the derricks.

No guy shall be subjected to a heavier load than two sevenths of the actual breaking strength.

¹ In Great Britain, this arrangement is generally known as the "Union Purchase" rig.

HOISTING GEAR ON BOARD

This mode of working is only allowed for single rope and for loads of 2 tons or less.

Moreover, when determining the length of the derricks consideration must be given to the capacity of the winches, the height of the bulwarks, and any other factors that may influence the stresses in the gear, and the dimensions and the weight of the loads to be worked.

TABLE IV. GUYS FOR SLEWING DERRICKS

Maximum load to be hoisted with the derrick (in tons of 1,000 kg)	Actual breaking strength of the guy (in tons of 1,000 kg)
1	4
2	6
3	8
4	10
5	12
6	13
10	17
15	22
20	27
30	33
40	37
50	40

As may be inferred from various publications it is generally accepted that when working with heavy loads the safety factor may be lower than when working with light loads. This is quite reasonable because, when a heavy load is to be hoisted, everything is especially examined beforehand, the work is executed very carefully and all shocks are avoided; the higher officers of the ship and of the stevedoring company are present. All these measures are not taken and cannot be taken during ordinary work. In addition, the loose gear for heavy derricks is generally stowed away and mounted when necessary. It is used only on a few occasions during its lifetime, so that practically no wear and tear is caused.

Moreover, it is almost impossible from a practical point of view to supply a ship that is fitted out with gear for heavy loads, with stays, etc., calculated for the highest safety factor, since these parts of the gear would become too clumsy, and in the light of the above considerations it does not seem necessary to give this gear the same relative strength as the ordinary gear, which is used under quite different circumstances.

HOISTING GEAR ON BOARD

It must also be remembered that, on vessels, the platform on which the hoisting machinery is built is not stable. This is not of much importance when general cargo is loaded or unloaded on large ships, unless the ship already has a list. Smaller ships may easily list over if the load is off the centre line, and with heavy loads the inclination may become very considerable, varying to a large extent with the stability of the ship. Constructors as well as users of gear must not overlook the possibility of inclination.

Another cause of accidents, which may usefully be discussed at this point, is that due to the closing up of a derrick on which the cargo runner is rigged parallel, or nearly so, to the span wire. The derrick, with its load, suddenly swings vertically towards the mast supporting it.

Simply, this matter may be considered as follows:

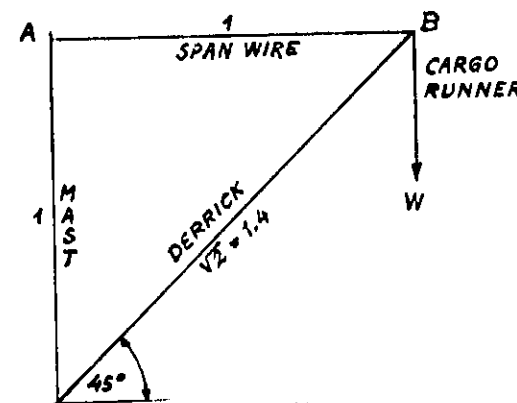


Fig. 16

If a weight W be suspended from the framework $A B C$ (fig. 16) the load on the span wire is $W \cdot \frac{AB}{AC}$. When, therefore, $AB = AC$, the load on the span rope, or, if multi-sheave blocks are used, the total pull in the part of the rope in the span,

equals the weight lifted. Now, if in such a case the cargo runner is parallel to the span wire, it is clear that the derrick would be on the point of closing up if there is only one part of rope in the runner. It will be seen, therefore, that in the case of a derrick in which the derrick ratio $\frac{CB}{AC}$ is approximately 1.4 (fig. 16) the derrick is on the point of closing up when at an angle of 45° to the horizontal, if the cargo runner (one part of rope) is taken parallel to the span rope and would close up at all angles over 45°.

The following example illustrates a handy method of readily ascertaining the critical angle at which a derrick is on the point of closing up.

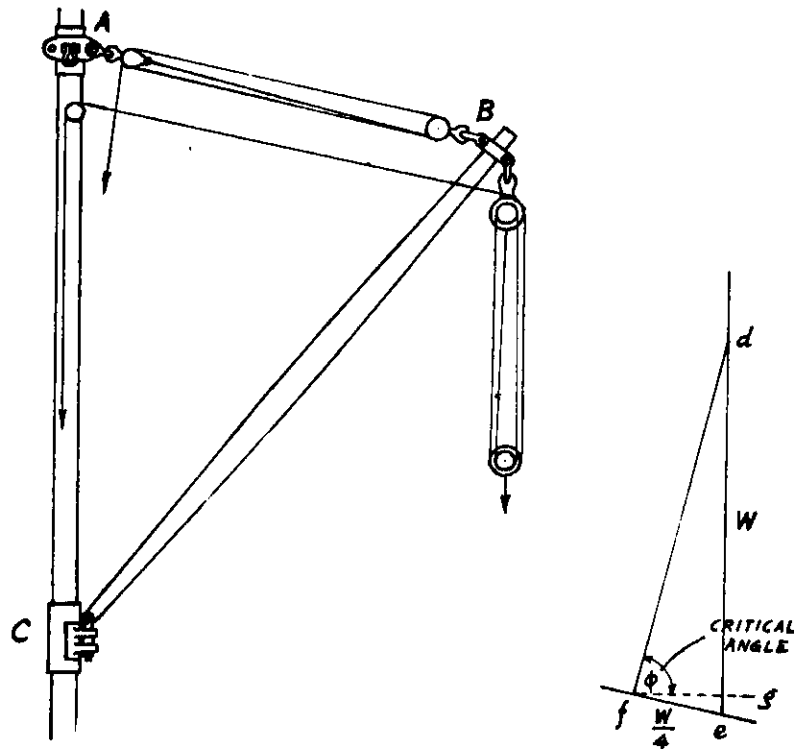


Fig. 17

ABC (fig. 17) represents a derrick having a derrick ratio of 1.1. The cargo runner, rigged parallel to the span, consists of four parts of rope. To find the critical angle to the horizontal at which the derrick will be on the point of closing up, draw de vertically to represent the load W . Set off ef parallel to BA and since there are four parts of rope in the runner, make ef equal to one quarter of de . Join fd and draw fg at right angles to de . Then, the angle ϕ , which measures approximately 77° , is the critical angle and it follows that at any greater angle to the horizontal than this the derrick will close up.

Using the same method it may be shown that for a derrick having a ratio of 1.4 and two parts in the runner, the critical angle is about 76° and that in the case of a derrick with a ratio of 0.8 the critical angle with one part of rope in the runner is approximately 24° , and with two parts, 60° .

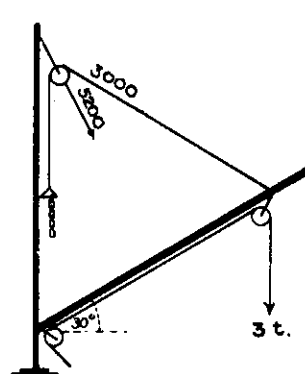
In short, it may be demonstrated that the smaller the derrick ratio and the smaller the number of ropes, the greater is the risk

of the derrick collapsing when the runner is rigged parallel to the span.

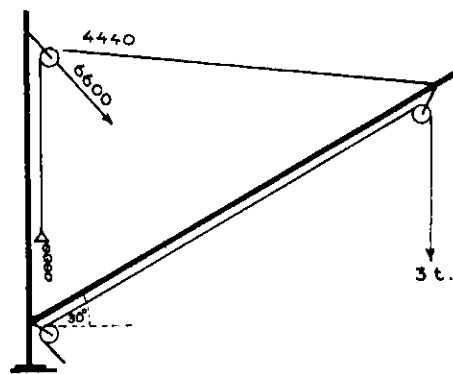
To prevent such an occurrence, the rig should be such as to give an ample margin of safety, especially as the effect of friction in the blocks is to increase the pull in the runner and therefore lessen the angle to the horizontal at which the derrick will close up when in use.

In addition to the precautions against closing up, measures must also be taken to prevent derricks from being accidentally lifted out of their sockets or supports. Occurrences of this kind may lead to very serious accidents and every derrick should therefore have its foot adequately secured, so that it can only be lifted out of the supports when this is necessary for the examination, repair or replacement of the derrick.

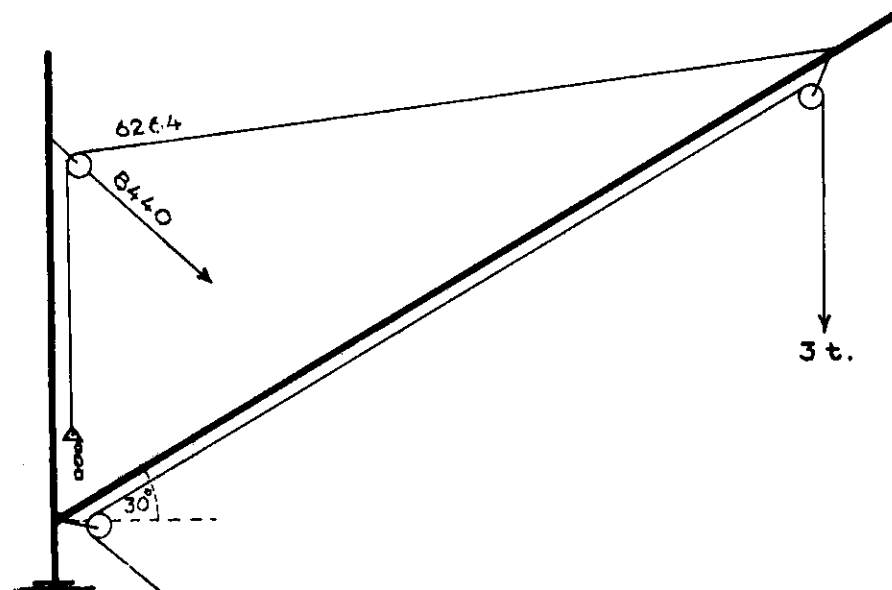
This is not the place for a detailed discussion of stresses, but a few general remarks may be useful. Given the safety factors, the dimensions of the different parts of the gear can be fixed when the stresses are known. However, the examples given below show how greatly the stresses vary according to the construction of the gear and the angle of the derrick to the horizontal.



$l:h=1$
Fig. 3

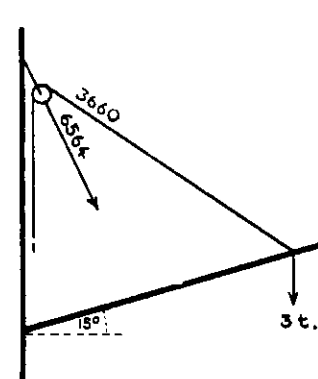


$l:h=1$
Fig. 4

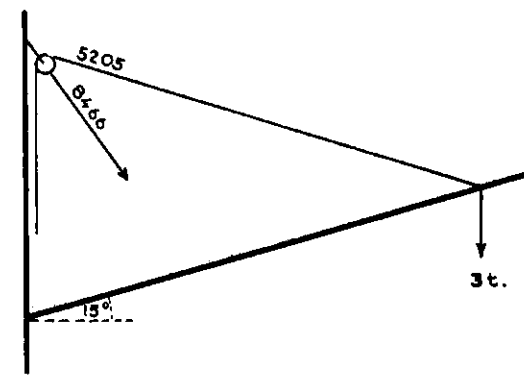


$h=2.4$
Fig. 5

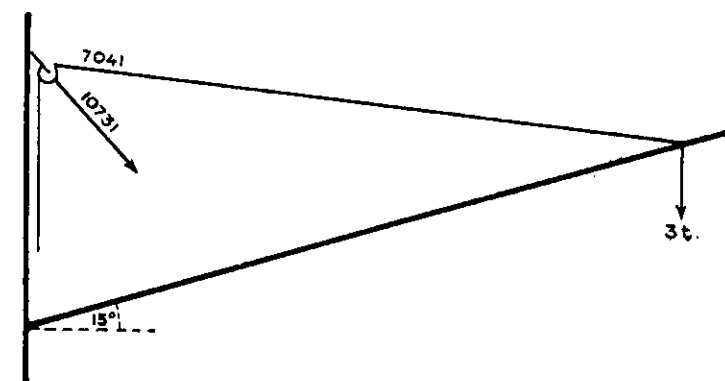
In the first series (figs. 3, 4, 5) three derricks of different lengths are fastened to the same mast at an angle of 30° and the same load is applied. The stresses in the single span wire rise from 3,000 to 6,264 kg, and the stress on the span block and on the fastening point of this block to the mast, from 5,200 to 8,440 kg.



$l:h=1$
Fig. 6



$l:h=1.7$
Fig. 7



$h=2.4$
Fig. 8

In the second series (figs. 6, 7, 8) the angle is 15° . With a 3-ton load, the stress in the single span wire rises from 3,904 to 7,500 kg and on the span block, from 7,000 to 11,146 kg.

Here the weight of the derrick with cargo block etc. (estimated at 400 kg) is taken into account; this should also have been done in the first series, but was omitted in order to bring out the theoretical stresses induced by the load.

HOISTING GEAR ON BOARD

In the third series (figs. 9, 10, 11) the stresses are given for 3 methods of hoisting with the same derrick at the same angle.

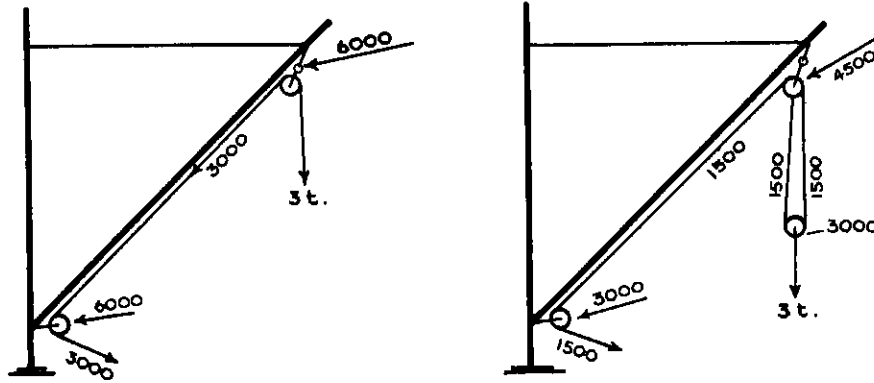


Fig. 9

Fig. 10

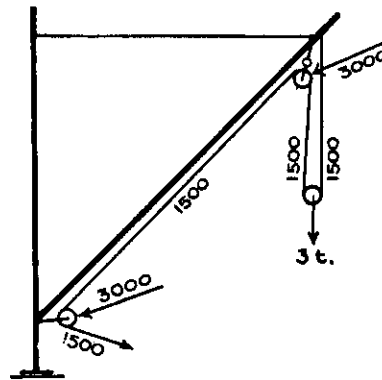


Fig. 11

It is worth mentioning that in most cases the stresses in the span wire, span blocks and fastening points are influenced only by the weight of the load; the rig or method of hoisting, *e.g.* by single or double gear or by fastening the upper end of the runner to the cargo block or to the derrick, etc., will have an influence on these stresses only when the cargo runner is taken parallel to the span wire.

However, the stresses in cargo runner, derrick-head cargo block; derrick-heel lead block and fastenings depend to a large extent on the manner of hoisting.

In principle, the influence of the weight of the derrick, cargo block, etc., should not be neglected and usually half this weight is taken into account. It can be considerable for heavy gear (*e.g.* the weight of a derrick pole with cargo and guy blocks and steel wire for a 50 ton derrick may amount to 6,000 kg). Moreover the fric-

tion of the sheaves in the blocks has to be considered, and this is generally estimated at 5 per cent. of the load per sheave.

With multiple-sheave blocks especially, the friction can be very considerable, and safety may be seriously endangered if no special attention is paid to it.

In this connection it may be useful to draw attention to the fact that in the case of a derrick rigged with the cargo runner parallel to the span, the greatest pull developed in the span wire during hoisting or lowering occurs, due to frictional forces developed in the runner blocks, during lowering. This may be illustrated by the following example:

A load of 50 t is being steadily raised and lowered by a set of blocks, having twelve parts of rope, connected to a boom having the derrick ratio of 1. The cargo runner is taken parallel to the span. When the derrick is at 45° to the horizontal; the tension in the span rope due to the static weight of 50 t is 38.5 t. In this case, the pull in the span rope can be calculated as follows: (1) assuming no friction, and (2) assuming a friction of 5 per cent. per sheave.

(1) *Assuming no friction.*

$$\text{Pull in cargo runner (hoisting or lowering)} = \frac{50 \text{ t}}{12} = 4.2 \text{ t.}$$

Hence, since the cargo runner is parallel to the span wire and therefore relieves the pull in the latter, the pull in the span rope (hoisting or lowering) = $38.5 \text{ t} - 4.2 \text{ t} = 34.3 \text{ t}$.

(2) *Assuming 5 per cent. friction per sheave.*

$$\text{Pull in cargo runner during hoisting} = 6.5 \text{ t}$$

$$\text{Pull on span wire} = 38.5 \text{ t} - 6.5 \text{ t} = 32 \text{ t}$$

$$\text{Pull in cargo runner during lowering} = 3 \text{ t}$$

$$\text{Pull on span wire} = 38.5 \text{ t} - 3 \text{ t} = 35.5 \text{ t}$$

Hence the pull in the span wire is approximately 10 per cent. greater when lowering the load than when raising it.

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