Guidelines For Classification And Construction

Part 4 Special Equipment and Systems

Volume 3

GUIDELINES FOR LOADING GEAR ON SEAGOING SHIPS AND OFFSHORE INSTALLATIONS

2020

Biro Klasifikasi Indonesia

www.bki.co.id

Guidelines for Classification And Construction

Part 4 Special Equipment and Systems

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2020

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The following Guidelines come into force on 1st January 2021.

Foreword

These Guidelines for Loading Gear on Seagoing Ships and Offshore Installations (Pt.4, Vol.3) 2020 Edition are new guidelines which contains procedural and technical requirements for Loading Gear to obtain certification and where required, to obtain classification by BKI.

For existing loading gear where BKI has given approval to the technical documentation according to the Regulations for the Construction and Survey of Lifting Appliances (Pt.6, Vol.IV) or Guidelines for Certification of Lifting Appliances (Pt.7, Vol.1), apply only to new parts and repairs, as well as for tests and examinations.

These Guidelines are to be applied in conjunction with other applicable BKI Rules and Guidelines, codes and standards referenced therein. The general description about these guidelines in every section is described below:

Section 1 – Instruction for Use

Section 2 – Materials

Section 3 – Design and Calculation Principles

Section 4 – Cranes and Supporting Structures

Section 5 – Lifts and Lifting Platforms

Section 6 – Special Loading Gear and Means of Transport

Section 7 – Loose Gear and Interchangeable Components

Section 8 – Ropes and Rope Accessories

Section 9 – Mechanical Parts

Section 10 – Electrical Equipment

Section 11 – Construction of Steel Components

Section 12 – Technical and Operational Safety Requirements

Section 13 – Testing and Examination of Loading Gear

Annex A – Calculation of Dynamic Forces due to Motions of the Ship

Annex B – Hook Load of Subsea Operations

Annex C – Wind Loads, Form and Sheltering Coefficients

Annex D – Rigging Plan

These Guidelines are available to be downloaded at www.bki.co.id. Once downloaded, these Guidelines will be uncontrolled copy. Please check the latest version on the website.

Further queries or comments concerning these Guidelines are welcomed through communication to BKI Head Office.

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Section 1 Instruction to Use

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A General

1. Application of Guidelines

1.1 These "Guidelines for Loading Gear on Seagoing Ships and Offshore Installations", in short "Guidelines for Loading Gear", are applied by Biro Klasifikasi Indonesia (BKI) in all cases where the BKI is commissioned to assess loading gear in accordance with the scope of 2. They constitute the basis for certification and, where required, Classification of loading gear by BKI, see 3.

1.2 BKI's Head Office is exclusively entitled to interpret these Guidelines.

1.3 Any liability incurred under the "General Terms and Conditions" shall be limited to the scope of test and examination as defined in 3 and other Sections. The operational and functional capacity of the loading gear remain the sole responsibility of the manufacturer or operator respectively.

2. Scope

2.1 These Guidelines apply specifically to all loading gear as defined in C.3 on seagoing ships and offshore installations. Where national regulations permit, and an appropriate agreement is concluded, they may also be applied, as and where relevant, to loading gear and loose gear on board inland navigation vessels or onshore.

2.2 These Guidelines do not apply to:

– launching gear for lifesaving appliances with SWL of less than 100 kN and without powered slewing systems or powered luffing systems.
– launching gear for diving equipment
– structural parts of ramps and car decks, see Section 6, C.2.2.1
– dredging appliances which are not loading gear

2.3 For existing lifting appliances, where BKI has given approval to the technical documentation according to the "Guidelines for Certification of Lifting Appliances (Edition 2013)", these "Guidelines for Loading Gear" apply only to new parts and repairs, as well as for tests and examinations.

3. Certification and classification of loading gear

The certification and classification of loading gear includes the following examination steps which are harmonized with each other:

– examination of the technical documentation
– supervision of construction
– initial tests and examinations
– periodic tests and examinations
– extraordinary tests and examinations as required

3.1 Certification of loading gear

3.1.1 General notes

.1 The certification of loading gear on ships and offshore installations is not a part of ship classification or classification of an offshore installation. This applies also to the periodic confirmation and renewal of the loading gear certification.

.2 Certification is a precondition for operation and comprises loading gear as a complete unit. For that purpose, in the course of manufacture, BKI test certificates or manufacturers' certificates shall also be issued for assemblies, ropes, accessories, components and manufactured loading gear, if required.

.3 After the initial test and examination, certification is completed by issuing a test certificate for the load test and the examination documentation.

.4 Certification is a prerequisite for periodic tests and examinations and requires a Register book of loading gear or a special certificate confirming the tests and/or examinations performed.

.5 The purpose of certification of loading gear is to provide evidence of safety provisions for the handling staff, i.e. it aims to protect all persons who are inside loading gear or in its working area or danger area.

.6 The following requirements refer to new loading gear. For existing loading gear, BKI's Head Office determines the scope of tests and examinations for certification case by case. Existing certification can be accepted and continued.

3.1.2 Ship loading gear operating in the port and onboard seagoing ships

Prerequisites for BKI certification are:

- examination of technical documentation
- control of manufacture and examination prior to dispatch at the manufacturer's or in the subcontractors works.
- existence of test certificates for wire ropes, accessory and machinery components, insofar as required
- test and examination on the ship before it is put into operation

.1 For the attestation and documentation of all tests and examinations, BKI forms are used which are internationally recognized (ILO Certification).

Where differing national forms are required, these will be issued in addition to the BKI forms.

.2 In accordance with ILO regulations, the certification of loading gear shall be confirmed by annual examinations and shall be renewed by five-yearly examinations in conjunction with a load test.

3.1.3 Offshore loading gear

The prerequisites in 3.2.1 apply to certification, however with the following deviations:

.1 Tests, examinations and the scope of attestation are extended to selected electrical and additional machinery components, see Table 10.1 and Table 9.1.

.2 For confirmation and renewal of the certification, alternative periods and dates to those in 3.1.2.2 may be applicable as a result of national regulations.

3.1.4 Floating cranes

Depending on their allocation, floating cranes are treated as ship loading gear acc. to 3.1.2 or as offshore loading gear acc. to 3.1.3.

3.1.5 Ship loading gear not used for cargo handling

.1 The conditions for BKI Certification depend on the national regulations.

.2 For the attestation and documentation of all tests and examinations, BKI uses, depending on the circumstances or legal status, its own forms and additionally also national forms, if entitled to do so.

.3 For the confirmation and renewal of certification, the requirements in 3.1.2.2 apply. Deviations may arise due to the legal status nationally.

3.1.6 Special cases

.1 If commissioned correspondingly, BKI may also certify loading gear onboard ships which are not classified by BKI.

.2 Where loading gear on ships and offshore installations which are classified by BKI is not to be certified by BKI, nonetheless in any case the structural parts stated in 3.3 are to be tested and examined.

3.2 Classification of loading gear

3.2.1 General notes

By special application, any type of loading gear can be classified by BKI.

This classification is an expanded form of certification of loading gear. The requirements of 3.1 apply in their entirety.

.1 The classification of loading gear according to BKI exceeds the safety provisions for the handling staff and aims in addition to protect the operator from economic loss.

Tests, examinations and the scope of attestation will therefore be extended beyond certification on selected electrical and other machinery components, see Table 10.1 and Table 9.1.

.2 Classification is concluded by issuing the Class Certificate. For confirmation and renewal, the requirements for certified loading gear apply, see 3.1.2.2.

.3 The conditions acc. to 3.2.2 refer to new loading gear. For existing loading gear, BKI's Head Office determines the scope of tests and examinations for certification case by case.

3.2.2 Conditions for classification

Classification requires certification as well as additional measures, as described in 3.2.1.1.

3.2.3 Class certificate

After completion of all tests and examinations and loading gear certification by a BKI Surveyor, the operator receives a BKI Class Certificate for Loading Gear from BKI's Head Office, see also 3.2.4.

3.2.4 Obligation to classify

Classification of loading gear is optional in principle, but mandatory for ships type notation affixed with special notation "**CRANE**". See Guidance for Ship Notation (Pt.0, Vol.B) Sec.2 for these details of ship type notation.

Following the classification of loading gear in BKI, additional notation as described in Table 1.1 will be affixed.

Table 1.1 Additonal Notation

Notation	Description	Section to be referred
LA-A1 (SWL…ton)	For the operation of the ship or installation, such as e.g.: provision cranes, engine room cranes / workshop cranes, hatch cover cranes hose cranes	Section 4, B.2.3.1
LA-A2 (SWL…ton)	For offshore cranes not used for cargo-handling, such as e.g.: offshore working cranes	Section 4, B.2.3.2
LA-A3 (SWL…ton)	For floating cranes not used for cargo-handling, like e.g.: mounting cranes	Section 4, B.2.3.3
LA-B1 (SWL…ton)	For ship cranes for cargo-handling using spreaders or hooks, such as e.g.: container cranes, general cargo cranes	Section 4, B.3.2.1
LA-B2 (SWL…ton)	For cranes for cargo-handling at sea using hooks, such as e.g.: general cargo cranes, offshore cranes according to A.3.2	Section 4, B.3.2.2
LA-B3 (SWL…ton)	For floating cranes for cargo-handling using hooks, such as e.g.: floating cargo cranes	Section 4, B.3.2.3
LA-C1 (SWL…ton)	For ship cranes for cargo-handling using grabs, hooks or special loose gear, such as e.g.: grab cranes, pallet cranes	Section 4, B.4.2.1
LA-C2 (SWL…ton)	For ship cranes for cargo-handling offshore using grabs, such as e.g.: grab cranes, lighter cranes	Section 4, B.4.2.2
LA-C3 (SWL…ton)	For floating cranes for cargo-handling using grabs, such as e.g.: grab floating cranes, lighter floating cranes	Section 4, B.4.2.3

Example notation:

CONTAINER SHIP, LA-B1 (SWL…ton);

BARGE, CRANE, LA-B2 (SWL…ton), LA-B3 (SWL…ton).

3.3 Differentiation from the requirements in B.2.1

The structural elements stated in the following are part of the ship classification or the classification of offshore installations. However, they are to be dimensioned acc. to these Guidelines for Loading Gear:

- structure of the ship's hull or the offshore installation in the way of the loading gear.
- crane columns
- jib rests / sea lashing systems
- masts and posts of derrick boom systems
- foundations and fastenings
- rails of gantry cranes
- lift shafts
- guide rails for goods lifts and lift platforms

B. Basic Requirements for Loading Gear

For lifts and lift platforms, special loading gear and means of transport, loose gear as well as structural components and accessories, the provisions of the respective sections apply.

1. Provisions used

1.1 Design and calculation

1.1.1 The provisions of these Guidelines are essentially based on recognized standards and design fundamentals in a form interpreted by BKI.

1.1.2 In addition to 1.1.1, these Guidelines include provisions for special features on ships and offshore installations such as e.g. inclinations of the ship or platform, increased wind load and seaway effects, as well as other structural features for adapting to the maritime environment.

1.1.3 Calculations based on established design rules for loading gear will be recognized by BKI, if the stress level according to these Guidelines is complied with and ship specific particulars are considered.

1.2 Accident prevention

1.2.1 The provisions for accident prevention in these Guidelines are based on the Code of Practice "**Safety and Health in Dock Work**" issued by the International Labour Organization (ILO).

1.2.2 In addition to 1.2.1 these Guidelines embody further special accident prevention measures.

1.3 Checks and examinations

1.3.1 The provisions contained in these Guidelines relating to the initial and periodic testing and examination of loading gear on ships are based on ILO Convention 152 "**Convention Concerning Occupational Health and Safety in Dock Work**".

1.3.2 Loading gear for offshore installations are treated by BKI in a manner similar to that stated in 1.3.1 unless subject to special agreements or differing national regulations.

1.4 Systems of certification

The certification systems used by BKI for loading gear are described in Section 13, G.

2. Other applicable provisions

The following Rules, Guidelines and standards complement, where relevant or upon agreement, the provisions of these Guidelines:

2.1 Rules for Classification and construction and guidelines of BKI

2.1.1 BKI Rules – Part 1-Seagoing Ships and Part 5-Offshore Technology

- Rules for Hull (Pt.1, Vol.II)
- Rules for Machinery Installations (Pt.1, Vol.III)
- Rules for Electrical Installations (Pt.1, Vol.IV)
- Rules for Materials (Pt.1, Vol.V)
- Rules for Welding (Pt.1, Vol.VI)
- Rules for Structures (Pt.5, Vol.II)

2.1.2 BKI Additional Guidelines, Guidance and Regulation

- Regulations for Design, Construction and Testing of Pumps (Pt.1, Vol.v)
- Regulations for the Performance of Type Tests, Part 2 Test Requirements for Electrical/Electronic Equipment, Computers and Peripherals (Pt.1, Vol.F)
- Regulations for the Performance of Type Tests, Part 4 Test Requirements for Electrical Machinery, (Pt.1, Vol.F)
- Guidance for Approval and Type Approval of Material and Equipment for Marine Use (Pt.1, Vol.W)

2.2 Standards

ISO, EN and DIN standards or other basic calculation documents as mentioned in the text.

3. National regulations

3.1 National regulations for the certification of loading gear and the attestation of structural elements and components may deviate in various ways from international regulations, on which these Guidelines are based.

BKI applies national regulations if required or upon agreement. In addition these Guidelines can be taken as a reference.

3.2 For loading gear not used for cargo handling, only national regulations apply. The handling of this loading gear is described in A.3.1.5 and in Section 13, G.

4. International regulations

4.1 For loading gear which is used for cargo handling on ships, the regulations of ILO apply, which are part of these Guidelines in respect to accident prevention as well as tests and examinations, see 1.2.1 and 1.3.1.

C. General Definitions

Additional or special definitions can be found in the following Subsections.

1. Seagoing ships

All water craft regardless of their shape or purpose, if they are permitted to operate in international or coastal waters.

2. Offshore installations

Fixed structures supported by the seabed, or floating units supported by buoyancy forces, used for offshore exploration as well as the production and storage of hydrocarbons.

3. Loading gear

Generic term for all gear for lifting, handling, transporting or conveying goods and raw materials, with the exception of loose gear.

Apart from special loading gear and means of transport, in accordance with Section 6, this term essentially includes cranes, lifts, lifting platforms and derrick boom systems.

Various loading gear are defined below as follows:

3.1 Ship loading gear

General term for all rigidly mounted loading gear on ships which are designed for operation under harbour conditions. Loading gear also operating under seagoing conditions are to be dimensioned like offshore loading gear.

3.2 Offshore loading gear

General term for all rigidly mounted loading gear on offshore installations and floating cranes, where applicable.

3.3 Floating cranes

General term for cranes used for support and transportation, rigidly mounted on a floating structure designed for this purpose.

3.4 Derrick boom systems

Lifting and handling gear where the derrick booms are swung round by ropes.

3.5 Cargo handling gear

Ship loading gear used for cargo handling, normally operated by harbour personnel (stevedores).

3.6 Loading gear not used for cargo handling

Loading gear for ships or offshore installations used for internal ship operation and normally operated by the crew (e.g. engine-room cranes, trolleys, loading gear for hatch covers, for provisions and equipment and for supporting hoses).

3.7 Lifts

Power-driven devices with a guided lift car for the transport of persons and/or goods between specific points.

3.8 Lifting platforms

Power-driven devices without a cabin, with guided platform, for the transport of goods between variable positions.

Transportation of persons is permitted up to a maximum operating height of 1,8 m.

4 Loose gear

Means by which loads can be attached to loading gear but which do not form part either of the loading gear or of the load. They include devices and steel structures such as:

- grabs
- spreaders
- lifting magnets
- traverses
- heavers

5. Accessories

Load-bearing, not rigidly attached, interchangeable parts which may be integral components of loading gear and loose gear as well as employed individually, such as hooks, blocks, shackles, swivels, rings, chains, claws, clamps, pliers, load fastening ropes (slings/strops) and lifting straps.

6. Equipment for conveying persons

Equipment for conveying persons such as e.g. working baskets or landing booms (St. Lawrence Seaway booms).

7. Nominal load (L_{Ne})

7.1 Nominal load is the designation for the maximum permissible useful load of loading gear and loose gear.

7.2 Loading gear and loose gear can have different nominal loads depending on varying equipment condition or operational conditions, rope tackle systems or load radii.

8. Safe working load (SWL)

8.1 Safe working load is the international designation for the nominal load by ILO. The abbreviation SWL is used for marking the loading gear, loose gear and accessories.

8.2 The permissible load of accessories is also designated SWL.

8.3 The unit of SWL is specified in tons [t] or kilograms [kg].

9. Useful load (L_N)

9.1 Useful load is the load which may be directly lifted by the supporting component (e.g. cargo hook or grab) of the loading gear, by the lift car of a lift, by the platform of a lifting platform or by loose gear, see Fig. 1.1 to 1.3.

9.2 The useful load consists of the load to be transported and, where applicable, also of the dead load of the loose gear, see Fig. 1.1.

10 Hoist load (L_H)

10.1 The hoist load consists of the useful load and the dead load portion of the loading gear, which are used to carry the useful load.

10.2 The dead load portions (L_{EA}) of the hoist load of a crane are composed of the weights of a hook block or a grab and a rope weight portion, see Fig. 1.1.

10.3 The dead load portion of the hoist load of a lift consists of the car weight, the dead load portion of a lifting platform consists of the platform and a weight portion of the scissor lift mechanism, see Fig. 1.2 and 1.3.

11. Dead loads (L_E)

11.1 Dead loads are the weights of all the fixed and mobile components of loading gear and loose gear permanently present during operation.

11.2 For the purpose of marking, the dead loads of loose gear are designated as weight (WT) by the ILO, see Section 7, D.3.

11.3 The unit of WT is specified in tons [t] or kilograms [kg].

12 Test load (L_P)

12.1 The test load is a load increased by a specified amount relative to the nominal load, at which the load test has to be performed.

12.2 The test load (L_{Pdyn}) of loading gear is the test load which is to be raised, lowered and braked by motor during the test using the drives (dynamic test).

12.3 The test load (L_{Pstat}) of a component or loose gear is the load to be statically applied at the load test (static test).

13. Load radius

13.1 The load radius is the horizontal distance from the cargo runner to the heel of a derrick or of a sheer crane boom, or to the pivot axle of a single or double crane, with a horizontal loading gear as basis.

13.2 In the case of derrick booms, the load radius is defined by specifying the angle of inclination of the derrick boom relative to horizontal.

14. Strength

The ability of a material or component to withstand elastic failure or fracture.

15 Significant wave height ($H_{1/3}$)

The average of the 1/3 highest wave heights where sea conditions are constant for a short time, normally 3 hours.

16. Marking

General designation for information, permanently attached to structural parts, accessories, components, loading gear, loose gear and, when applicable, to ropes. They include e.g.:

- manufacturer's plate
- technical information (permanently attached e.g. by impact stamps or metal plates, or movable e.g. attached to ropes by small wire-fixed metal plates as well as by marking strips or marking fibres woven into ropes)
- stamping (marking by impact stamps, mandatory e.g. as a proof of tests and/or examinations as well as a correlation to the test certificates)
- lettering (information on loading gear and loose gear about nominal loads, load radius, sequential number on ships or offshore installations and where applicable on dead loads)

17. Certificate

General designation for the confirmation of tests and/or examinations of structural parts, ropes, accessories, loose gear, components and loading gear by (test) certificates.

18. Certification

Certification is the designation in each case of the whole system of all required certificates for loading gear and loose gear, based on international, national or BKI provisions, as a precondition for operation.

19. Classification

Classification is the certification of loading gear with an increased number of components, resulting in the issuance of a Class Certificate.

20. Surveys

The services of a BKI Surveyor, rendered for the evaluation and confirmation of the operational safety of loading gear and loose gear, are designated as Surveys in the BKI ship documentation.

21. Designation of components

In these Guidelines for Loading Gear, the designations applied to components are those shown in Fig. 1.4 to Fig. 1.7.

D. Submission and Examination of the Technical Documentation (Examination of Drawings)

The examination of the technical documentation is the first step of certification of loading gear (see A.3.1).

For lifts and lifting platforms, special loading gear and means of transport, loose gear as well as structural components and accessories, the technical documents are to be submitted which are described in the respective sections.

1. General notes

Examination of the technical documentation is mandatory for loading gear which is newly built.

1.1 Technical documentation is examined to verify the calculated safety provided against failure, to check the accident prevention measures, and to verify compliance with the design and contractual conditions where these have been specially agreed.

1.2 Technical documentation examined by BKI based on the "Guidelines for Loading Gear" allows exact replication, provided it does not conflict with new findings and/or experience. Examination of the technical documentation based on the superseded "Guidelines for Certification of Lifting Appliances (Edition 2013)" for further production is to be agreed with BKI case by case.

1.3 BKI may waive examination of the technical documentation for loading gear produced in series which is not used for cargo handling, if the loading gear is legally certified or recognized (e.g. as an approved type), and if the manufacturer provides evidence of static strength and, where required, of fatigue strength by recognized and documented tests.

2. Form of submission

To facilitate a smooth and efficient approval process drawings and other documents shall be submitted electronically.

3. Requirements for approval documents

3.1 Test documentation shall contain all the data and information needed for examination. This includes dimensions, details of materials, and welding and the tests applied.

Parts lists, material specifications, welding and test procedures, etc. shall accompany the documentation.

3.2 In the case of standardized parts, or parts which have been type-tested by BKI, it is normally sufficient to refer to the relevant standard or type-test number, indicating the proposed size and type of unit with details of the material and (heat) treatment, where applicable.

3.3 Calculations shall be set out in such a way that they can be easily interpreted and are traceable. In particular, design loads, system dimensions, input and output data, maximum values, bearing reactions and, if applicable, safety from overturning shall be clearly indicated.

The calculations to be submitted are required for control purposes. Examination of the calculations by BKI is carried out only upon special agreement.

3.4 From the approval documents, the functions of the loading gear or loading gear components shall be completely apparent. Otherwise function descriptions shall also be submitted.

3.5 The manufacturer shall ensure that the approval documents are ready for examination at the proper time, even if they are prepared by third party.

3.6 The client shall provide the manufacturer with all the necessary details concerning the proposed operating conditions for the loading gear, e.g. the type of ship or installation, operational area, environmental conditions, cargoes to be handled, etc.

4. Approval documents for newly manufactured loading gear

The following lists for newly manufactured loading gear do not have any claim to completeness. On the other hand, they are only applicable within the respective relevant scope.

4.1 Derrick boom system

For documents to be submitted for these systems, reference is made to the BKI "Guidelines for Certification of Lifting Appliances (Edition 2013)".

4.2 Loading gear in general

4.2.1 Documents for approval

.1 Structural parts

- crane booms, crane housings, crane columns, supporting structures
- crane boom supports, sea lashings
- foundations and rigidly attached fittings
- crane bridges, trolleys, gantries, bogies, runways, crane rails
- stopper, derailment guard, devices to prevent overturning
- material specifications
- welding and test plans
- accessory parts, if not standardized (hooks, blocks, shackles, etc.)
- rope-sheaves which are not manufactured in acc. with or generally in line with standards or type approved

.2 Mechanical engineering

- slew rings, with bolting system and limit load diagram
- rotary bearings such as king pins and rollers
- load-bearing hydraulic cylinders with their associated safeguard against pressure loss
- diagrams for hydraulic or pneumatic devices

– spindles, rack bars
– winch drums with rope fixings and winch bolting

.3 Further documents

– overview drawings of loading gear
– overview drawings of loading gear used for cargo handling including their arrangement and markings on the ship (rigging plan)
– information on the loading gear such as variable equipment conditions, nominal loads, load radii, hoist and luffing speeds, rope lengths and hook heights.

4.2.2 Documents for information

– details of manufacturer, client and shipyard
– details of proposed operational and environmental conditions
– details of ropes (make/strength), end connection of ropes, cable tackle system, rope-sheaves
– nominal data on electric main drive motor for the electric load analysis of the ship
– strength calculations
– details of type tests and type approvals
– details of nominal sizes (SWL) and standards on which standardized accessories are based

4.3 Offshore cranes

4.3.1 Documents for approval

.1 Steel structures

– see list given in 4.2.1.1
– platforms, accesses, ladders
– design and fixing of cabin

.2 Mechanical engineering

– see list given in 4.2.1.2
– complete winches
– complete slewing and swinging mechanisms and travelling gear
– swell compensator and/or swell absorbing systems

.3 Electrical engineering

– overview drawing of electrical installation (e.g. wiring diagram, single line diagram)
– circuit diagram including part list
– overview of devices with BKI type-approval
– overview of security-oriented devices and controls
– flow chart of control
– function description for all security installations such as emergency shut-down, limit switch, overload protection devices, etc.
– lighting plan including emergency power supply
– type of protection of motors and switch gear
– complete information on explosion protection

.4 Further documents

- useful load / load radius diagram(s)

4.3.2 Documents for information

- see list given in 4.2.2
- nominal data for prime mover
- details of protection devices to prevent over speed

4.4 Loading gear to be classified

4.4.1 Documents for approval

.1 Steel structures

- see list given in 4.3.1.1
- steering stands, if any

.2 Mechanical engineering

- see list given in 4.3.1.2
- hydraulic motors and pumps for nominal power over 50 kW
- ventilators and heat exchangers

.3 Electrical engineering

- see list given in 4.3.1.3
- control consoles and switch cabinets

4.4.2 Documents for information

- see list given in 4.3.2
- function descriptions and manuals, if required

5. Documents for approval for identical reproductions

The following documents are to be submitted for identical reproductions:

- overview drawings of the loading gear
- list of drawings of all structural elements subject to approval which are used for the production including following information:
  1. drawing number
  2. diary number of the initial BKI approval
- further documents, to be agreed with BKI

6 Documents for approval of existing loading gear

If existing Loading gear has been certified or classified by recognized organizations or societies, BKI can waive approval of the technical documentation, otherwise the following requirements apply.

6.1 If necessary, the drawings are to be procured from the manufacturer, or reproduced by taking measurements with the participation of a BKI Surveyor, where appropriate. Missing certificates concerning the required material properties (material test certificates) have to be completed upon agreement with BKI.

6.2 In each individual case the BKI Head Office decides if parts of the examination of technical documentation can be dispensed with. BKI Head Office will also, if required, again determine and fix the SWL and/or load radius.

7 Essential changes and repairs

7.1 Essential changes are, amongst others, an increase in nominal load, a change of load radius as well as changes to load-bearing structural components on existing loading gear.

7.2 Essential repairs are alterations or the exchange of load-bearing structural elements

7.3 In the case of essential changes and repairs, besides documentation for the components to be newly installed, drawings of the components which are affected by the changes shall also be submitted.

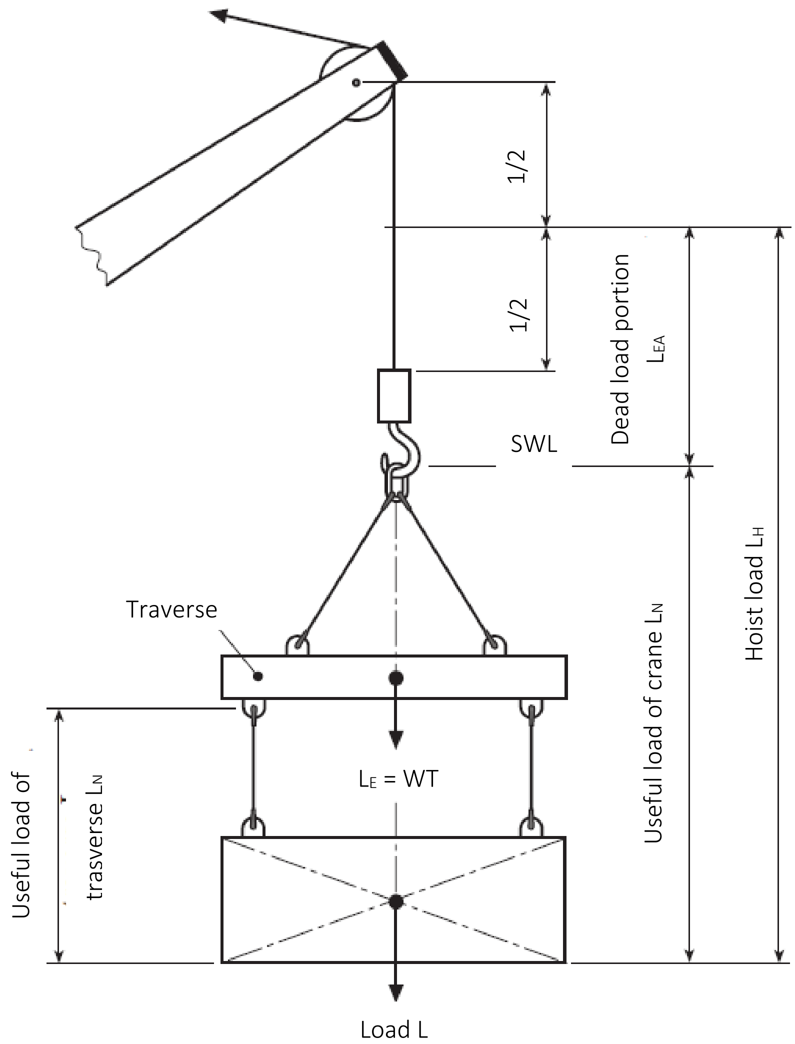
7.4 If necessary, changed rigging plans shall also be submitted.

8. Stamping and validity of the approved documents

8.1 Documents subject to examination receive an "**EXAMINED**" stamp. If the structural components to be examined are part of the ship's Classification, they receive an "**APPROVED**" stamp.

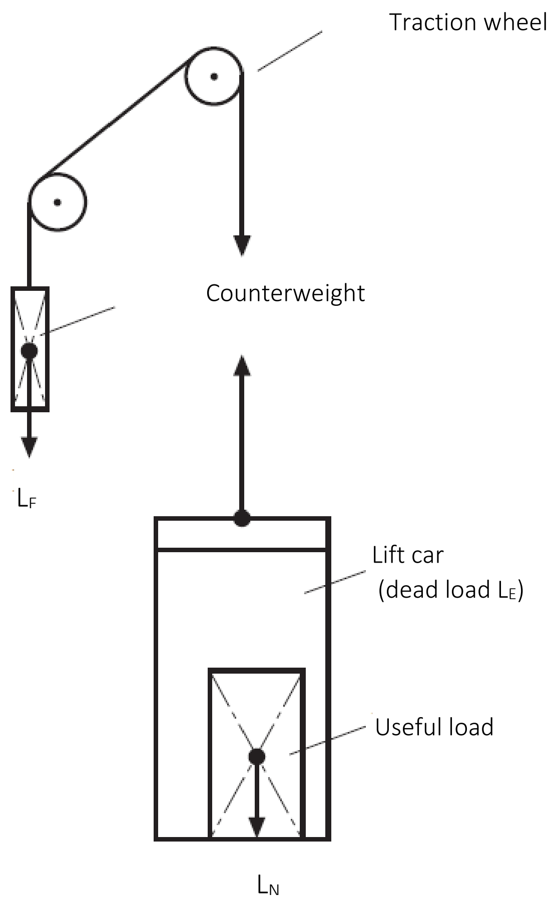
8.2 Documents for information receive a "**SEEN**" stamp or the inscription "**REFERENCE**".

8.3 Documents stamped "**EXAMINED**" or "**APPROVED**" are binding for the production. Later modifications require renewed examination by BKI.



(maximum $L_N = L_{Ne}$ = SWL, see C.7 to C.9)

Fig. 1.1 Crane with traverse (schematic)



Hoist load $L_H = L_N + L_E$

(The wight of cargo runners may be ingored)

Fig. 1.2 Passenger lift (schematic)

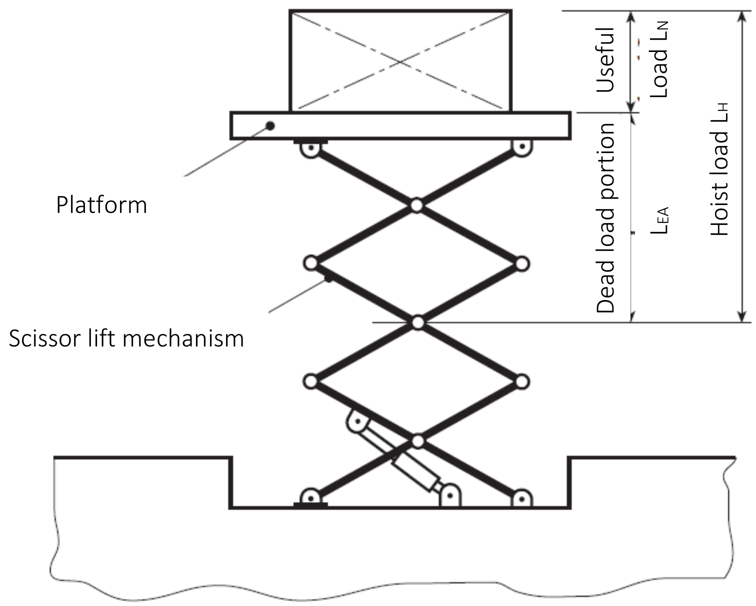
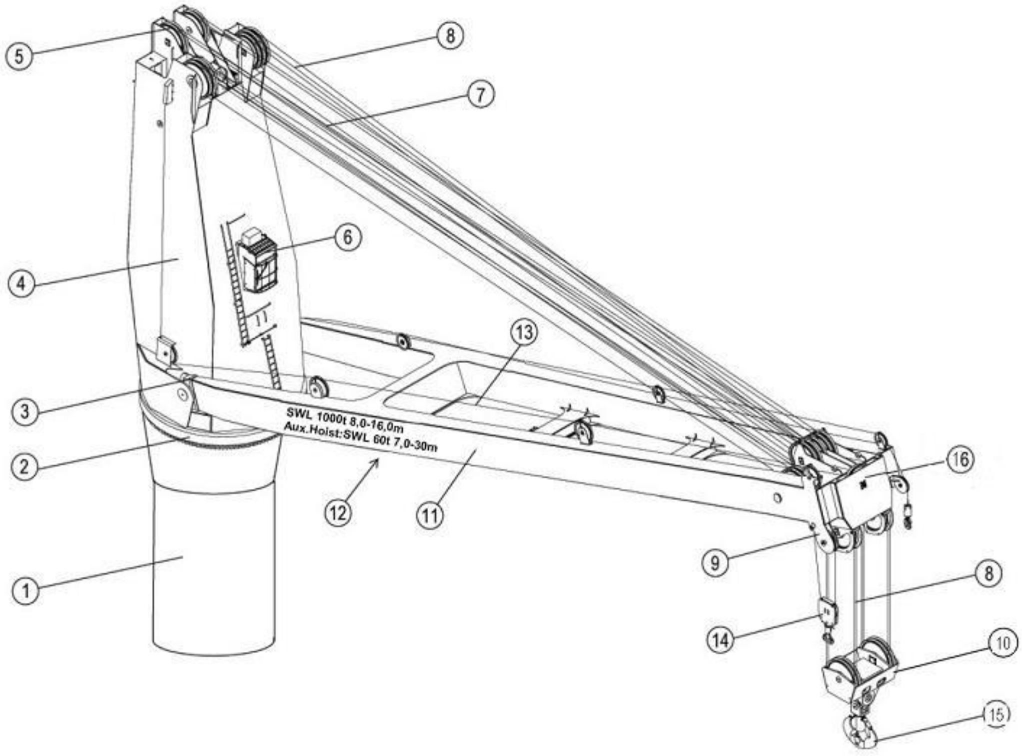
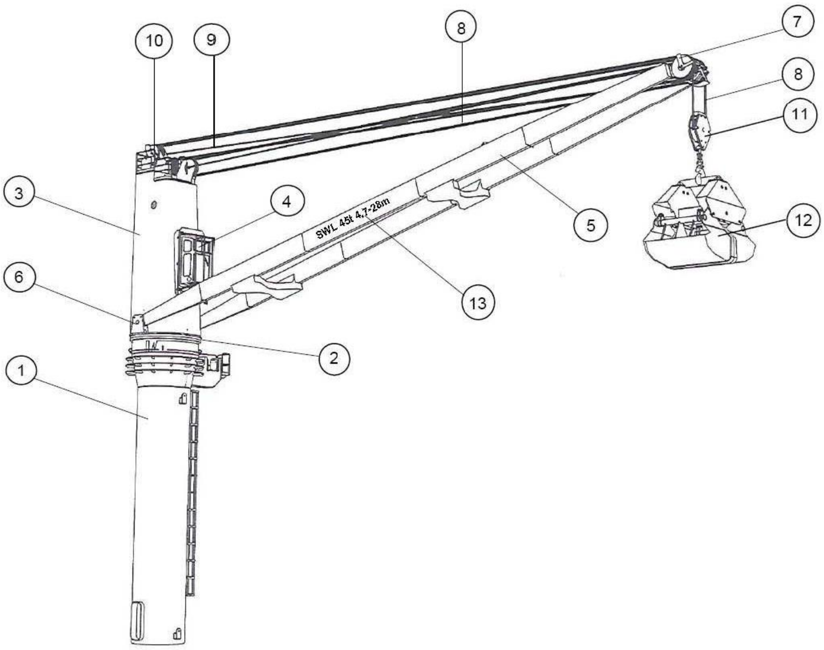


Fig. 1.3 Scissor lift (schematic)



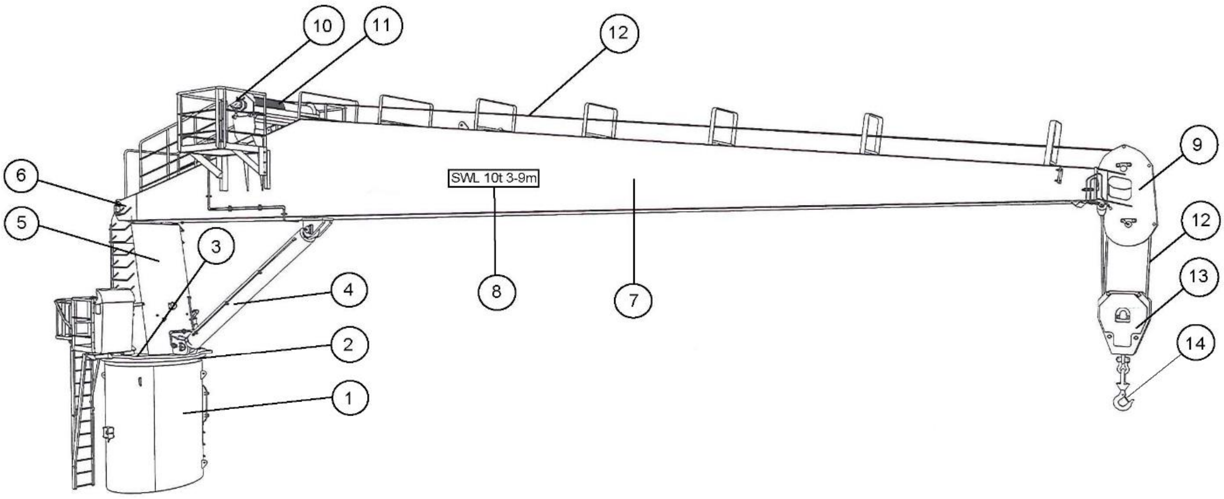
No.	Item
1	crane column
2	slewing ring
3	jib foot bearing
4	crane house
5	rope sheaves
6	crane cabin
7	luffing rope (main hoist)
8	hoist rope (main hoist)
9	side plate
10	hook block (main hoist)
11	jib
12	lettering
13	hoist rope (auxiliary hoist)
14	hook block (auxiliary hoist)
15	cargo hook (main hoist)
16	jib head

Fig.1.4 Heavy lift crane



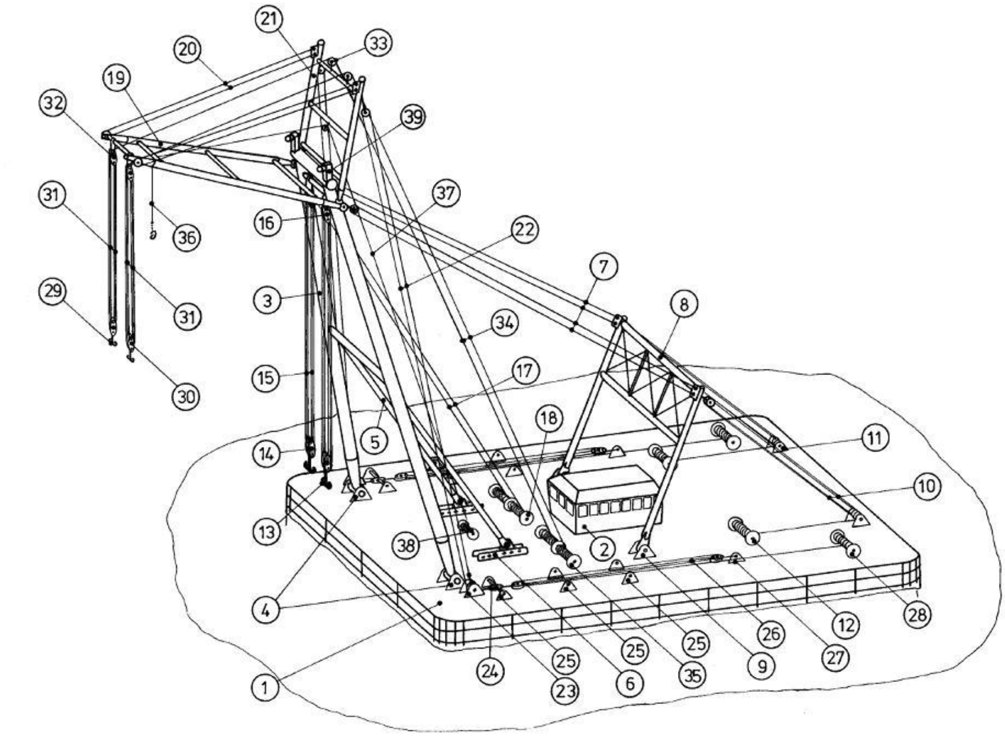
No.	Item
1	crane column
2	slewing ring
3	crane house
4	crane cabin
5	jib
6	jib foot bearing
7	rope lowering guard
8	hoist rope
9	luffing rope
10	rope sheaves
11	lower cargo block
12	grab
13	lettering

Fig. 1.5 Slewing crane (rope-luffing)



No.	Item
1	crane column
2	slewing ring
3	base plate
4	luffing cylinder
5	crane house
6	jib foot bearing
7	jib
8	lettering
9	jib head
10	hydraulic motor
11	hoist winch
12	hoist rope
13	lower cargo block
14	cargo hook

Fig.1.6 Slewing crane (cylinder-luffing)



No	Item	No	Item
1	Pontoon	21	flying jib bracing
2	wheel house	22	adjusting pendant for flying jib
3	main frame (A-frame)	23	standing block for adjusting pendant
4	main frame bearing	24	adjusting piece
5	main frame bracing	25	bearing for adjusting pin
6	guide for main frame bracing	26	adjusting tackle for flying jib
7	span pendant	27	pad eye
8	span bracing	28	winch for adjusting tackle
9	bearing for span bracing	29	ram horn hook
10	span tackle	30	lower purchase block
11	standing block for span tackle	31	hoisting tackle of flying jib
12	span winch	32	upper purchase block
13	ram horn hook	33	guide sheave for hoisting rope
14	lower purchase block	34	hoisting rope of flying jib tackles
15	hoisting tackle for main frame	35	winch for flying jib tackles
16	upper purchase block	36	auxiliary hoist
17	hoisting ropes of main frame tackles	37	hoisting rope of auxiliary hoist
18	hoisting winch for main frame tackles	38	winch for auxiliary hoist
19	flying jib	39	bouncing back prevention
20	span pendant for flying jib		

Fig. 1.7 Floating Crane (sheer crane)

Section 2 Materials

A. General 2–1
B. Selection of Materials 2–1
C. Manufacture and Testing 2–3
D. Materials for Welded Components 2–5
E. Materials for Hydraulic Cylinders 2–10
F. Forgings 2–12
G. Steel Castings 2–14
H. Bolts and Nuts 2–15

A. General

1. This Section contains provisions for the selection, manufacture and testing as well as the specification of steel materials for various loading gear (including their foundations) and loose gear components. They are based on Rules for Materials (Pt.1, Vol.V) and Rules for Welding (Pt.1, Vol.VI)

2. Materials not covered by this Section, see list in B.1.5, are, as far as possible, to be dealt with in accordance with the BKI Rules, acc. to recognized standards or by agreement.

3. Suitable standardized steels which are not covered in Tables 2.2 - 2.4 may also be used upon agreement with BKI.

B. Selection of Materials

1. Selection criteria

1.1 The selection of materials shall be carried out taking all material properties into consideration, and BKI's approval is normally effected by means of approved drawings.

1.2 When selecting materials of normal strength, higher strength and high strength steel for the various loading gear and loose gear components, the following criteria are to be applied:

– effect of the components on the mechanical strength of the assembly
– type and magnitude of the load (static or dynamic loading, internal stresses in the component, stress concentrations, direction of the stress relative to the structure of the material)
– design temperature (see Section 3, B.3.)
– chemical composition and weldability
– mechanical properties of the material (dimensioning of components)
– toughness of the material (resistance to brittle fracture at design temperature, as verified by the notched-bar impact test)
– properties of the material perpendicular to the surface of the product (resistance to lamellar fracture)

It may be appropriate to apply further criteria to the selection of materials.

1.3 For the application at temperatures below -10 °C and in consideration of Section 3, B.3, steels are to be used which have sufficient toughness at these temperatures, as verified by the notched-bar impact test at the prescribed temperature.

1.4 If a component is subject to multi-axial stresses, e.g. on greater material thicknesses and large volume welding connections, steels with improved properties in the direction of thickness shall be selected.

1.5 Other materials, such as stainless steels, cast steel, aluminium alloys, timber or plastics shall be chosen and used in accordance with the criteria stated in 1.2 and in consideration of their properties, as and when applicable.

1.6 For materials intended to be used as crane columns for offshore cranes, the particular requirements of Rules for Structure (Pt.5, Vol.II) are to be observed (see Section 1, B.2.1.1).

2. Categorization of components

2.1 Depending on their relevance to the overall safety of the structure, components are to be allocated to the following 3 categories, see Table 2.1.

2.2 The categorization of components according to the criteria of Table 2.1 shall take place at the design stage, and be submitted with the documents for approval.

2.3 Components not specifically mentioned in Table 2.1, shall be categorized in accordance with the loading conditions.

3 Strength categories

3.1 Materials for welded components are to be subdivided into the following strength categories on the basis of their minimum yield strength:

- normal strength materials with minimum yield strengths up to 285 N/mm^2
- higher strength materials with minimum yield strengths over 285 N/mm^2 up to 390 N/mm^2
- high strength materials with minimum yield strengths above 390 N/mm^2

Table 2.1 Categorization of components into categories of order

Category of order	Component description	Component [1] (Examples)
1st order	Components essential for the total safety of the structure as well as its safe operation and which, where applicable, are exposed to local or also multi-axial stresses in addition to global stresses.	– crane jibs – crane houses – crane columns – foundations – hydraulic cylinders for lifting gear and luffing gear as well as for telescopic crane booms – derrick heel bearing and rotary bearing – screws for slew rings – load-bearing components of loose gear and accessories – axles, hoisting eyes – winch drums – winch frames
2nd order	Components essential for safe operation and functional capability.	– hydraulic cylinders for slewing mechanisms – fittings – lateral wind bracings – rope – sheaves

Table 2.1 Categorization of components into categories of order *(continued)*

Category of order	Component description	Component [1] (Examples)
3rd order	Components subjected to low loads, or of minor importance respectively, and which cannot be allocated to the 1st or 2nd category of order.	– cabins – stairs – platforms – reinforcements – consoles
[1] For fasteners such as bolts and screws the category of order of the joined components is applicable. In case of differing categories of the joined components, the higher category is to be chosen.		

3.2 The strength category selected for the component concerned, or the material allocated to this category, is to be indicated in the documents for approval. The same applies where the material is required to meet special conditions.

When selecting materials, it shall be borne in mind that a decline in the mechanical characteristics is to be expected as the product thickness increases.

C. Manufacture and Testing

1. Manufacturer's approval

Rolling-mill products, forgings and castings as well as bolts and nuts for loading gear and loose gear components of 1st and 2nd order shall only be produced by those manufacturers approved by BKI or recognized organizations.

Application for approval is to be made in writing to BKI and is normally based on a factory test and a product test. The scope of testing for this purpose is determined case by case.

2. Requirements for materials and products

2.1 Manufacturing

All materials and products are to be manufactured in accordance with sufficiently tested procedures which guarantee that the required properties are achieved.

2.2 Chemical composition and required properties

All materials and items manufactured from them which are to be categorized as 1st or 2nd order components according to Table 2.1 are to comply with the requirements of this Section or other applicable provisions with respect to chemical composition and mechanical properties.

2.3 Supply condition and heat treatment

All products are to be supplied in the required heat-treated condition. Where the final heat treatment is only carried out at the final manufacturer, the supply condition of the pre-material shall be appropriately documented in the test certificates.

2.4 Absence of defects

Materials and products shall not show defects which may adversely affect the use or further processing of the material more than insignificantly.

2.5 Weldability

Materials intended for the manufacture of welded constructions shall be weldable in terms of applying customary workshop procedures. If welding is only possible under special conditions, the conditions shall be determined in consultation with BKI and verified by a weldability test.

3. Testing

3.1 Chemical composition

The chemical composition of the materials is normally to be verified by the manufacturer by means of heat analysis, and shall include all elements for which limit values are set in this section or in other applicable provisions, or which are added on as alloys in order to achieve the required mechanical properties.

In general, the manufacturer's certificate is accepted as proof of the chemical composition.

3.2 Mechanical and technological properties

3.2.1 When the mechanical and technological properties are tested, the general procedures and test samples shall be used in accordance with Rules for Materials (Pt.1, Vol.V) Sec.2. Test requirements and results are to be presented in international (SI) units.

3.2.2 Materials and products for 1st order components are to be covered by BKI Material Certificates or by inspection certificates 3.2 as per EN 10204.

For materials and products for 2nd and 3rd order components, testing by the manufacturer may be agreed.

3.3 Dimensions and absence of defects

3.3.1 All products shall be checked by the manufacturer for compliance with the prescribed dimensions, surveyed in respect of possible defects and, if required, presented to the BKI Surveyor.

Unless specially agreed in the following sections, the BKI Surveyor will carry out a random examination of the dimensions and the surface conditions as deemed necessary.

3.3.2 Where non-destructive tests are required for the various types of products, they shall be performed by the manufacturer in accordance with Rules for Materials (Pt.1, Vol.V) Sec.3.

The results as well as the particulars of the test procedure shall be evaluated in accordance with recognized acceptance criteria and attested by a certificate.

Products not complying with the requirements shall be set aside by the manufacturer.

3.4 Proof of mechanical properties

3.4.1 The results of the required tests on materials and products of 1st order components shall be certified by BKI in accordance with Rules for Materials (Pt.1, Vol.V) Sec.1.H.2.1 (A-type Certificate), if not specified otherwise in these Guidelines.

3.4.2 The results of the required tests on materials and products of 2nd order components may be attested by a certificate according to Rules for Materials (Pt.1, Vol.V) Sec.1.H.1.2 (B-type Certificate), e.g. inspection certificate 3.1 as per EN 10204.

3.4.3 The material certificates of products for components of 1st and 2nd order shall include specific details on manufacturing method, composition, heat treatment, mechanical properties and marking.

3.4.4 Materials and products for 3rd order components may be certified non-specifically by the manufacturer in accordance with Rules for Materials (Pt.1, Vol.V) Sec.1.H.1.1 (C-type Certificate), e.g. test report 2.2 in accordance with EN 10204. Corresponding equivalent certificates may be accepted.

3.5 Retesting

Where the certificates for materials or products are insufficient, or their identification or correlation with the test certificates is not properly possible, BKI may ask for retests on the delivery under BKI's supervision.

Type and scope of the tests will be determined case by case based on Rules for Materials (Pt.1, Vol.V).

3.6 Marking

3.6.1 Materials and products are to be marked by the manufacturer in such a way that a proper identification on the basis of the material certificates can be made.

Materials and products which have been tested under BKI's supervision also receive test stamps according to Rules for Materials (Pt.1, Vol.V) Sec.1.F.

3.6.2 Cast steel and forgings shall be marked with the manufacturer's stamp, an abbreviation for the cast type and a mark or code number for the melting charge (e.g. the last three digits of the melting charge number). Any additional markings are a matter of agreement between customer and manufacturer of the material.

D. Materials for Welded Components

1. General note

The following requirements apply to plates, profiles, bars and hollow sections, which are intended for the manufacture of welded 1st and 2nd order loading gear and loose gear components.

2. Selection of materials

2.1 The criteria and provisions set out in B. are applicable. Steel materials are to comply with the requirements in 3.

2.2 Products made of aluminium or aluminium alloys shall comply with Rules for Materials (Pt.1, Vol.V) Sec.10.A or the requirements set out in the relevant standards or approved material specifications, respectively.

2.3 For design temperatures TE down to and including -10 °C, the normal strength, higher strength and high strength materials set out in the Tables 2.2, 2.3 and 2.4 can be used, taking into consideration the thickness-related requirements for the material toughness

Table 2.2 Suitable materials for welded components in strength category "Normal strength"

Material group	BKI Rules, Material standard	Strength class or steel grade, respectively	Applicable product thickness for design temperatures down to -10 °C Components belonging to one of the order categories set out in Table 2.1		
			1st order	2nd order	3rd order
Normal strength hull structural steels	Rules for Materials (Pt.1, Vol.V) Sec.4.B	KI-A	≤ 12,5 mm	≤ 25 mm	No particular provisions
		KI -B	≤ 25 mm	≤ 50 mm	
		KI -D	≤ 50 mm	over 50 mm	
		KI -E	over 50 mm		

Table 2.3 Suitable materials of strength category "Higher strength" for welded components

Material group	BKI Rules, Material standard	Strength class or steel grade, respectively	Applicable product thickness for design temperatures down to -10 °C Components belonging to one of the order categories set out in Table 2.1		
			1st order	2nd order	3rd order
higher strength hull structural steels	Rules for Materials (Pt.1, Vol.V) Sec.4.B	KI-A32 KI-A36 KI-A40	≤ 25 mm	≤ 50 mm	No particular provisions
		KI-D32 KI-D36 KI-D40	≤ 50 mm	over 50 mm	
		KI-E32 KI-E36 KI-E40	over 50 mm		
		KI-F32 KI-F36 KI-F40	over 50 mm		

Table 2.4 Suitable materials of strength category "High strength" for welded components

Material group	BKI Rules, Material standard	Strength class or steel grade, respectively	Applicable product thickness for design temperatures down to -10 °C Components belonging to one of the order categories set out in Table 2.1		
			1st order	2nd order	3rd order
high strength steels for welded constructions, hull structural steels	Rules for Materials (Pt.1, Vol.V) Sec.1.B.2.1.1	KI-A420/A460 KI-A500/A550 KI-A620/A690	≤ 25 mm	≤ 50 mm	No particular provisions
		KI-D420/D460 KI-D500/D550 KI-D620/D690	≤ 50 mm	≤ 70 mm	
		KI-E420/E460 KI-E500/E550 KI-E620/E690	≤ 70 mm		
		KI-F420/F460 KI-F500/F550 KI-F620/F690	≤ 70 mm		

Table 2.5 Percentage limits for the chemical composition of normal strength and higher strength carbon and carbon manganese steels

C	Si	Mn	P	S	Cr	Mo	Cu	Ni	Al	Other
0,22	0,55	1,60	0,04	0,04	0,30	0,08	0,30	0,40	0,08	[1]

[1] Nb max. 0,05%, V max. 0,10 %, Ti max. 0,02 % , Nb + V + Ti max. 0,12 %

3. Requirements for steel materials for welded components

3.1. Production method

The steels are to be produced in accordance with a method approved by BKI. The melting process shall be made known to BKI. The steels shall be cast, fully killed.

3.2 Chemical composition

3.2.1 For normal strength and higher strength carbon and carbon-manganese steels, the chemical composition shall not exceed the maximum content given in Table 2.5 in the heat analysis.

3.2.2 For evaluation of the weldability or susceptibility to cold cracking, respectively, the carbon equivalent C_{eq} or the P_{cm} value shall be determined by the following equations:

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad [\%]$$

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B \quad [\%]^1$$

The values determined by the above equations are not to exceed the values given in Table 2.6.

3.2.3 For high strength or alloyed steels, above strength class 460, the provisions of BKI's approved material specifications apply.

3.3 Delivery condition and heat treatment

3.3.1 For normal strength and higher strength steels the provisions of Rules for Materials (Pt.1, Vol.V) Sec.4.B.5 or Section 1, B.2.1.1 apply, respectively.

3.3.2 High strength steels are to be delivered in principle in a heat-treated condition or treated by a BKI approved method, e.g. thermo-mechanically formed according to Rules for Materials (Pt.1, Vol.V) Sec.4.B.5 or Sec.4.D.3.3, respectively.

3.3.3 For austenitic, stainless steels, the provisions of Rules for Materials (Pt.1, Vol.V) or Sec.1.B.2.1.1 apply.

Table 2.6 Weldability requirements

Strength category	Strength class	Carbon equivalent [%]		P_{cm} [%]
		General	TM-rolled	
normal strength	235	0,45	By special agreement	by special agreement
	275		0,36	
higher strength	315	0,45	0,36	
	355		0,38	
	390		0,40	
high strength	420	0,48	0,45	
	460	0,53	0,46	
	Over 460	by special agreement		

3.4 Mechanical properties

3.4.1 The requirements of Rules for Materials (Pt.1, Vol.V) Sec.4.B.4.2, Sec.4.C.5.2 or Sec.4.D.3.4 apply, as well as the requirements of the relevant standards or approved material specifications.

3.4.2 The requirements relating to tensile strength, yield strength or 0,2 % proof stress, respectively, elongation and reduction in area at fracture are to be verified by tests.

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1 Value for determining the preheating temperature and cold crack sensitivity

3.5 Impact energy

3.5.1 The requirements relating to impact energy depend on the category of order of the component under consideration, see B.2, the product thickness, the yield strength and the design temperature. The requirements shall be determined in accordance with Table 2.7 and Table 2.8.

3.5.2 Material selection shall be made based on the material specification, such that the requirements can be met by it. For design temperatures down to –10 °C, the applicable product thicknesses for normal strength, higher strength and high strength materials are given in the Tables 2.2, 2.3 and 2.4.

3.5.3 The requirements relating to impact energy of steels apply similarly to components which are unwelded, tension-stressed, notched or otherwise subjected to a 3-axial stress state and are to be verified as prescribed by tests with an ISO-V-specimen.

3.6 Characteristics in direction of thickness

Where steel plates and wide flats are required to have enhanced properties in the direction of thickness, Rules for Materials (Pt.1, Vol.V) Sec.4.I shall be observed.

3.7 Test of surface finish and dimensions

3.7.1 The requirements of Rules for Materials (Pt.1, Vol.V) Sec.4.A.5 and A.6 or the requirements of the relevant standards or approved material specifications, respectively, apply.

Compliance with the requirements is to be confirmed by the manufacturer of the material.

3.7.2 The manufacturer shall check the products with respect to their external finish and dimensions. Surface defects may be removed mechanically, weld repairs are not permitted.

3.8 Non-destructive tests

3.8.1 Plates and wide flats with enhanced properties in the direction of thickness shall be subjected to an ultrasonic test. They shall meet the requirements of Test Class 2, laid down in the Test Class S2/E3 according to EN 10160.

The test width of the rim zone depends on the product thickness, but should have a minimum width of 50 mm.

3.8.2 Flats products with a product thickness of t ≥ 15 mm which are used for the manufacture of connection flanges and rings for 1st order components, shall undergo an ultrasonic surface test. They shall meet the requirements of Test Class 2, laid down in the Test Class S2 in accordance with EN 10160. The test grid used shall not exceed 100 mm.

3.8.3 Connection flanges and rings made of flat products with a product thickness t ≥ 40 mm shall undergo a non-destructive test according to F.3.6.

4. Proof of mechanical properties of pipes

The mechanical properties of pipes shall be certified in accordance with C.3.4.

Table 2.7 Requirements for impact energy

Strength category	Strength class	Impact energy KV[1] [J] min.	
		Longitudinal	Transverse
normal strength	235	27	20
	275	29	21
higher strength	315	31	22
	355	34	24
	390	41	27
high strength[2]	420	42	28
	460	46	31
	500	50	33
	550	55	37
	620	62	41
	Over 690	69	46

1 Mean value for 3 specimens. There may be one lower value but not less than 70 % of the mean value.
2 Up to 70 mm thickness, larger thicknesses upon special agreement.

Table 2.8 Test temperatures for the notched bar impact test (welded components)

Product thickness t [mm]	Test temperature T_p [°C]		
	Order categories of components		
	1st order	2nd order	3rd order
t ≤ 12,5	–[1]	–[1]	No special provisions[1]
12,5 < t ≤ 25	$T_p = T_E + 10$[2]	–[1]	
25 < t ≤ 50	$T_p = T_E – 10$	$T_p = T_E + 10$	
50 < t ≤ 70	$T_p = T_E - 20$	$T_p = T_E + 10$	
Over 70	$T_p = T_E – 30$[3]	$T_p = T_E - 10$	

1 The requirements stated in Rules for Materials (Pt.1, Vol.V) Sec.4 or in the relevant standards or approved material specifications apply.
2 T_E = design temperature.
3 Generally, test temperatures below -60 °C are not required.

Table 2.8a Test temperatures for the notched bar impact test (non-welded components, 1 or 2- axial stress state)

Product thickness t [mm]	Test temperature T_p [°C]		
	Order categories of components		
	1st order	2nd order	3rd order
t ≤ 12,5	–[1]	No special provisions[1]	No special provisions[1]
12,5 < t ≤ 25	$T_p = T_E + 20$[2]		
25 < t ≤ 50	$T_p = T_E + 10$[2]		
50 < t ≤ 70	$T_p = T_E + 10$		
Over 70	$T_p = T_E – 10$		

1 The requirements stated in Rules for Materials (Pt.1, Vol.V) Sec.4 or in the relevant standards or approved material specifications apply.
2 T_E = design temperature.

E. Materials for Hydraulic Cylinders

1 General notes

1.1 The following provisions apply to pipes intended for the manufacture of cylinder jackets of 1st and 2nd order hydraulic cylinders.

1.2 Where cylinder jackets are manufactured from flat products by rolling and fusion welding, the requirements of this Section apply as and where relevant to the basic material. In addition, Rules for Welding (Pt.1, Vol.VI) shall be observed.

2 Selection of materials

2.1 For the selection of material, the selection criteria and provisions laid down in B. apply. The selected materials shall comply with the requirements in 3.

2.2 Special steels or pipes manufactured by cold rolling shall comply with a material specification approved by BKI.

3. Requirements

3.1 Chemical composition

3.1.1 For the manufacture of welded hydraulic cylinders, carbon and carbon-manganese steels shall preferably be used, the chemical composition of which complies with the limit values set out in D.3.2. The carbon equivalent C_{eq} shall not exceed 0,45.

3.1.2 The requirements of Rules for Materials (Pt.1, Vol.V) Sec.5.B.4.1 or Sec.5.D.3.1 apply, respectively.

3.1.3 Compliance with the requirements is to be verified by the material manufacturer. Where the base material is not molten at the pipe manufacturer, the manufacturer's heat analysis of the base material can be accepted. For special steels, the properties stated in the approved specifications apply.

3.2 Delivery condition and heat treatment

3.2.1 For welded hydraulic cylinders, the provisions of Rules for Materials (Pt.1, Vol.V) Sec.5.B.3 or Sec.5.D.2 apply.

3.2.2 For hydraulic cylinders which are not produced by welding, cold-rolled pipes can be used up to a wall thickness of 15 mm and design temperatures down to and including –10 °C, if the requirements relating to impact energy set out in 3.5 are achieved and elongation A is 15 % as a minimum.

3.3 Mechanical properties

3.3.1 The requirements of Rules for Materials (Pt.1, Vol.V) Sec.4.B.3.2 or the requirements of the relevant standards or approved material specifications apply, respectively.

3.3.2 The requirements relating to tensile strength, yield strength or 0,2 % proof stress, respectively, elongation and reduction in area at fracture are to be verified by tests.

3.3.3 Testing of the mechanical properties of 1st order components is to be carried out in the presence of the BKI Surveyor.

3.4 Technological Test

3.4.1 Pipes with longitudinal weld seams and seamless pipes of grade KI-R 490 shall undergo one of the ring test examinations specified in Rules for Materials (Pt.1, Vol.V) Sec.5.A.8.5.

3.4.2 In the case of fusion-welded pipes with an outer diameter over 200 mm, a weld seam bend test in accordance with Rules for Welding (Pt.1, Vol.VI) Sec.11.D shall be carried out, applying a bending mandrel diameter of 3 times wall thickness t.

3.5 Impact energy

3.5.1 The requirements relating to impact energy depend on the order category of the component under consideration, see B.2, the product thickness and the design temperature and are to be verified by ISO-V specimen tests.

Testing of the mechanical properties of 1st order components is to be carried out in the presence of the BKI Surveyor.

3.5.2 For product thicknesses up to and including 25 mm, Rules for Materials (Pt.1, Vol.V) Sec.5.B.3.4 apply, or the requirements of the other applicable standards or approved material specifications.

3.5.3 Unless otherwise specified, the materials used shall have an impact energy of 41 J (longitudinal specimen) or 27 J (transverse specimen) at a test temperature as per Table 2.9.

3.5.4 For pipes manufactured by hot rolling up to a product thickness of 10 mm, the impact energy test may be dispensed with. Below 6 mm an impact energy test is not generally required.

3.6 Test of surface finish and dimensions

3.6.1 The requirements of Rules for Materials (Pt.1, Vol.V) Sec.5.A.4 and A.5 and the requirements of the relevant standards or approved material specifications, respectively, apply.

Table 2.9 Test temperature for the notched bar impact test (hydraulic cylinders)

Product thickness t [mm]	Test temperature T_p [°C]	
	Order categories of components	
	1st order	2nd order
$t \leq 25$	–[1]	–[1]
$25 < t \leq 50$	$T_p = T_E - 10$[2]	–[1]
$50 < t \leq 70$	$T_p = T_E - 20$[2]	$T_p = T_E - 10$
Over 70	$T_p = T_E - 30$[3]	$T_p = T_E - 10$

[1] The requirements stated in Rules for Materials (Pt.1, Vol.V) Sec.5 or the requirements of the other applicable standards or approved material specifications apply.
[2] T_E = design temperature.
[3] Generally, test temperatures below -60 °C are not required.

Compliance with the requirements shall be confirmed by the manufacturer of the material. Finally, pipes for 1st order cylinder jackets shall be submitted in their delivery condition to the Surveyor.

3.6.2 The manufacturer shall check the products with respect to their external finish and dimensional properties. Weld repairs are not allowed.

3.7 Non-destructive test

All pipes shall be subjected to non-destructive tests along their total length according to Rules for Materials (Pt.1, Vol.V) Sec.5.B.4.6. The success of the test shall be confirmed by the manufacturer.

3.8 Tightness test

All pipes shall be tested for leaks by the manufacturer. The success of the test shall be confirmed by the manufacturer.

4. Proof of mechanical properties

4.1. Mechanical properties of pipes shall be certified in accordance with C.3.4.

4.2 Based on a special approval, diverging from C.3.4.1, proof of mechanical properties of 1st order hydraulic cylinders may also be furnished by certifying in accordance with Rules for Materials (Pt.1, Vol.V) Sec.1.H.1.2 (B-type Certificate), e.g. inspection certificate 3.1 as per EN 10204.

F. Forgings

1. General notes

1.1 The provisions of this Section apply to steel forgings and rolled or forged slewing rings as well as for rolled or forged bars for piston rods of hydraulic cylinders. The slewing rings shall conform to a specification approved by BKI.

1.2 For rolled or forged bars for the manufacture of bolts and nuts with proof of mechanical properties the requirements specified in H. apply.

2. Selection of materials

For the selection of materials, the selection criteria and provisions stated in B apply. Accordingly, slewing rings are considered to be 1st order components.

The selected materials shall comply with the following requirements.

3. Requirements

3.1 Chemical composition

3.1.1 The requirements of Rules for Materials (Pt.1, Vol.V) Sec.6.B.4.1 apply.

For special steels and slewing rings the properties in the approved specifications apply.

3.1.2 Where forgings are to be used in welded structures, preference is to be given to carbon and carbon-manganese steels whose chemical composition meets the limit values stated in D.3.2. The carbon equivalent C_{eq} thereof shall not exceed 0,45.

3.1.3 Compliance with the requirements is to be verified by the manufacturer of the material. Where the base material is not molten at the forge shop, the manufacturer's heat analysis of the base material can be accepted.

3.2 Delivery condition and heat treatment

The provisions of Rules for Materials (Pt.1, Vol.V) Sec.6.B.3 apply.

3.3 Mechanical properties

3.3.1 The requirements of Rules for Materials (Pt.1, Vol.V) Sec.6.B.4.2 and the requirements of the other relevant standards or approved material specifications apply, respectively.

3.3.2 The requirements relating to tensile strength, yield strength or 0,2 % proof stress, respectively, elongation and reduction in area at fracture are to be verified by tests.

3.3.3 Testing of the mechanical properties of 1st order components shall be carried out in the presence of the BKI Surveyor.

3.4 Impact energy

3.4.1 For design temperatures down to and including -10 °C, the requirements of Rules for Materials (Pt.1, Vol.V) Sec.6.B.4.3 and the requirements of the other relevant standards or approved material specifications apply, respectively.

3.4.2 Unless otherwise specified, for design temperatures below -10 °C the requirements according to Table 2.10 apply.

3.4.3 The requirements related to impact energy are to be verified by tests with ISO-V specimens. Testing of the impact energy of 1st order components is to be carried out in the presence of the BKI Surveyor.

Table 2.10 Impact energy requirements for forgings with design temperatures below -10 °C

Components belonging to one of the order categories set out in Table 2.1	Minimum impact energy KV^1 [J]		Test temperature T_P [°C]
	Longitudinal	Transverse	
1st order	41 (29)	27 (19)	$T_E - 10^2$
2nd order	41 (29)	27 (19)	$T_E + 10$
3rd order	No special requirements [3]		

1 Mean value for 3 specimens. One individual value may be below the mean value, but not less than the individual values in brackets.
2 T_E = design temperature.
3 The requirements stated in Rules for Materials (Pt.1, Vol.V) Sec.6 or the requirements of the other applicable standards or approved material specifications apply.

3.5 Test of surface finish and dimensions

3.5.1 The manufacturer shall check the forgings at every stage of the process with respect to their external finish and dimensional properties. Forging defects shall be eliminated if they are not removed by the subsequent mechanical treatment. Weld repairs are not permitted.

3.5.2 Finally, forgings for 1st order components shall be submitted in the delivery condition to the BKI Surveyor.

3.6 Non-destructive test

3.6.1 Forged or rolled rings shall be subjected to an ultrasonic test by the manufacturer and, where applicable, also to a surface crack test. The tests shall be carried out in accordance with Rules for Materials (Pt.1, Vol.V) Sec.6.H.

3.6.2 The results of the non-destructive tests shall be documented by the manufacturer. The test reports shall be presented to the BKI Surveyor.

4. Proof of mechanical properties

The mechanical properties of forgings shall be certified in accordance with C.3.4. Diverging from this, proof of the mechanical properties of slewing rings of ships' cranes of groups A or B, and of bars for piston rods, may be attested by a certificate in accordance with Rules for Materials (Pt.1, Vol.V) Sec.1.H.1.2, e.g. inspection certificate 3.1 as per EN 10204.

G. Steel Castings

1. General notes

The provisions in this Section apply to steel castings for use in welded constructions.

2. Selection of materials

For the selection of materials, the selection criteria and provisions stated in B apply. The selected materials are to comply with the following requirements.

3. Requirements

3.1 Chemical composition

3.1.1 The requirements of Rules for Materials (Pt.1, Vol.V) Sec.7.B.4.1 apply.

Compliance with the requirements is to be verified by the manufacturer of the material by means of heat analyses.

3.1.2 Where steel castings are to be used in welded structures, preference is to be given to carbon and carbon-manganese steels whose chemical composition meets the limit values stated in D.3.2. The carbon equivalent C_{eq} thereof shall not exceed 0,45.

3.1.3 For alloyed steel castings, the properties stated in the approved specifications apply.

3.2 Delivery condition and heat treatment

The requirements of Rules for Materials (Pt.1, Vol.V) Sec.7.B.3 apply.

3.3 Mechanical properties

3.3.1 The requirements of Rules for Materials (Pt.1, Vol.V) Sec.7.B.4.2 and the requirements of the other relevant standards or approved material specifications apply, respectively.

3.3.2 The requirements relating to tensile strength, yield strength or 0,2 % proof stress, respectively, elongation and reduction in area at fracture are to be verified by tests.

3.3.3 Testing of the mechanical properties of 1st order components shall be carried out in the presence of the BKI Surveyor.

3.4 Impact energy

3.4.1 For design temperatures down to and including -10 °C the requirements of Rules for Materials (Pt.1, Vol.V) Sec.7.B.4.3 and the requirements of the other relevant standards or approved material specifications apply, respectively.

3.4.2 For design temperatures below –10 °C the requirements of Table 2.11 apply, unless otherwise specified.

3.4.3 The requirements related to impact energy are to be verified by tests with ISO-V specimens. Testing of the impact energy of 1st order components shall be carried out in the presence of the BKI Surveyor.

3.5 Test of surface finish and dimensions

3.5.1 The manufacturer shall check the steel castings with respect to their external finish and dimensional properties. Casting defects shall be eliminated, if they are not removed by the subsequent mechanical treatment. Rules for Materials (Pt.1, Vol.V) Sec.7.A.13 are to be observed.

Repair of defects by means of welding requires approval by BKI.

3.5.2 Finally, castings for 1st order components shall be submitted in the delivery condition to the BKI Surveyor

3.6 Non-destructive test

Steel castings for 1st order components shall be subjected to an ultrasonic test by the manufacturer and, where applicable, also to a surface crack test.

The tests are to be carried out in accordance with Rules for Materials (Pt.1, Vol.V) Sec.7.G. The test reports shall be presented to the BKI Surveyor during the inspection of the steel castings.

4. Proof of mechanical properties

The mechanical properties of the steel castings shall be certified in accordance with C.3.4.

Table 2.11 Impact energy requirements for steel castings for design temperatures below -10 °C

Components belonging to one of the order categories set out in Table 2.1	Minimum impact energy KV^1[J]	Test temperature T_p [°C]
1st order	27 (19)	T_E - 10[2]
2nd order	27 (19)	T_E + 10
3rd order	No special requirements [3]	

[1] Mean value for 3 specimens. One individual value may be below the mean value, but not less than the individual values in brackets.

[2] T_E = design temperature.

[3] The requirements stated in Rules for Materials (Pt.1, Vol.V) Sec.7 or the requirements of the other applicable standards or approved material specifications apply.

H. Bolts and Nuts

1. General note

The provisions of this Section apply to bolts and nuts, and to non-alloyed and alloyed steel bars used in their manufacture. The scope includes all bolts and nuts with nominal tensile strengths of > 600 N/mm², for which a quality certificate is required.

2. Manufacture

2.1 Bolts and nuts can be produced by hot or cold forming, or by machining. Hot-formed and cold-formed bolts and nuts shall undergo heat treatment.

2.2 Heat treatment can be dispensed with in the case of hot-formed bolts and nuts made of non-alloyed steels, if they are to be used at normal ambient temperatures in accordance with Table 2.12 and a uniform structure is brought about by the hot-forming process.

3. Requirements

3.1 Bolts and nuts shall comply with the requirements of Rules for Materials (Pt.1, Vol.V) Sec.9.C.2 or with the requirements of recognized standards.

3.2 Notwithstanding 3.1, machining steels with enhanced S-, P- or Pb contents may be used for bolts and nuts, provided that no requirements relating to heat resistance or impact strength at low temperatures exist.

3.3 Chemical composition

For the chemical composition, the requirements of Rules for Materials (Pt.1, Vol.V) Sec.9.C.4.1 apply. In addition, the carbon content of the steels shall not exceed 0,55 %, as established by product analysis.

3.4 Elongation at fracture

The elongation at fracture A shall conform to the characteristic values for the strength class or steel grade. It shall in any case not be less than 8 % for ferritic steels, or 30 % for austenitic steels.

3.5 Impact energy

The impact energy shall conform to the characteristic values of the steel grade, but shall, at a minimum, meet the requirements stated in Table 2.12.

3.6 Expansion (of nuts)

The expansion of ferritic steel nuts shall be at least 4 % with non-machining forming processes, and at least 5 % with machining methods. The expansion requirements for austenitic steel nuts are to be specially specified.

3.7 Non-destructive test

Bolts used for the assembly of 1st order components are to be subjected to a crack test by the manufacturer.

The results of the non-destructive tests shall be documented by the manufacturer.

4. Proof of mechanical properties

The mechanical properties of bolts and nuts are to be certified in accordance with C.3.4.

Table 2.12 Impact energy requirements for bolts and nuts

Service or design temperature[1]	Steel grade or nominal tensile strength		Minimum impact energy		Test temperature T_p [°C]
			KV [J]	KU [J]	
-10 °C	ferritic	< 800 N/mm²	32	30	+20 °C
		≥ 800 N/mm²	32	30	
		≥ 1000 N/mm²	25	25	
		≥ 1200 N/mm²	18	20	
	Austenitic		41	-	
	Alloyed and tempered		41	-	
	Non-alloyed		41	-	
Below -10 °C to -55 °C	All		41	-	10 °C below lowest design temperature

[1] at increased temp. > +50 °C
- alloyed and tempered: KV 52 J – T_p +20 °C

Section 3 Design and Calculation Principles

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A. General

1. This Section contains provisions of general validity governing the design and calculation of loading gear on seagoing ships and offshore installations.

The special provisions contained in the following Sections of these Guidelines for Loading Gear are to be observed additionally or with priority, respectively.

2. Calculations acc. to established calculation principles or standards, e.g. acc. to EN 13001 or EN 13852, may be accepted, if the particular properties of seagoing ships, as stated in these Guidelines, have been taken into consideration.

B Design Principles

1. General notes

1.1 Prerequisites for the design

1.1.1 Determination and specification of the operating and seagoing conditions on which the design is based are in principle the responsibility of the customer and the manufacturer. The shipyard is to be consulted as well. The specifications decided upon are of considerable importance for the reliable operation and expected service life.

1.1.2 The intended use of ships and loading gear, the shipping routes and the operational area, high ship speeds and the shape of the ship's hull are to be considered as required.

1.2 Design criteria for operating loading gear

Essential design criteria, in addition to the statements in 2. to 5., are in particular:

- the total service life, i.e. the number of loading cycles within the expected service life
- the loading condition, i.e. the relative or percentage frequency at which the various hoist loads are reached or exceeded in the total service life
- the type of service, e.g. handling containers, general or palletized cargo, grabs or provision under harbour or sea conditions

1.3 Design criteria for the status "out of operation"

1.3.1 Essential criteria for the design are, in relation to 1.2, increased inclinations of the supporting structure and increased wind loads, as well as ship accelerations.

1.3.2 In particular cases, loads caused by vibrations are to be considered which may be generated e.g. by ship machinery or seagoing influences.

2. Environmental conditions

2.1 Special attention is to be given to the operation site, weather conditions, humidity, dust, aggressive media, oil and salt-bearing air, exhaust gases and exhaust gas heat, vibrations, etc., if known or specified by contract.

2.2 Machinery and electrical installations are to be dimensioned with respect to temperature and humidity at least for the following limit values, if no stricter limit values are specified:

a) in enclosed spaces
   - air temperature: 0 °C to +45 °C
   - relative air humidity: 80 %

b) on the open deck
   - air temperature:
     lifting appliances in operation: 10 °C to +45 °C
     lifting appliances out of operation: 25 °C to +45 °C
   - relative air humidity: 80 % and influence of salt spray

2.3 Vibrations are in general not part of dimensioning of the loading gear. Where loading gear is prone to vibrations, vibration analyses are to be performed.

2.4 Where necessary, manufacturer, ship yard or operator have to specify the environmental conditions in particular.

3. Design temperature

3.1 Definitions

3.1.1 The design temperature is the mean value of the lowest daily average temperature in the operational area of a lifting appliance. The definitions of 3.1.2 to 3.1.4 apply.

3.1.2 The daily average temperature is the mean value of day and night temperature.

3.1.3 The lowest daily average temperature is the lowest value of daily average temperature measured during one year.

Where the duration of operation is limited with respect to seasons of the year, the lowest value of daily average temperature measured during the period of operation is to be used.

3.1.4 The mean value of the lowest daily average temperature is the statistical mean value measured during an observation period of at least 20 years.

3.2 Ship loading gear

3.2.1 The design temperature which is, amongst other things, decisive for the material selection, shall be at least –10 °C.

3.2.2 Where the design temperature is specified below –10 °C, this has to be explicitly stated by the shipyard or the manufacturer of the loading gear in the drawings or in other documents submitted to BKI for approval. It also has to be considered with respect to material selection and processing (welding) as well as with respect to dimensioning of systems sensitive to low temperatures.

3.2.3 In extreme cases loading gear may be operated at an environmental temperature which is lower than design temperature. In this case, the following conditions are to be complied with:

a) The environmental temperature shall not be less than 20 °C below design temperature.

b) The number n_{low} of the lifting operations at low temperatures is yearly to be limited as follows:

$$n_{low} \leq N / 1000$$

N : total number of all lifting operations in the expected life time for the loading gear (to be taken from load assumptions of the fatigue analysis)

If the fatigue analysis for a loading gear could be dispensed with, then the number of lifting operations at low temperatures is to be limited to $n_{low} \leq 20$ per year.

c) The manufacturer of the loading gear must agree on the low temperature. Where necessary the susceptibility of certain components to low temperatures is to be considered.

3.3 Offshore loading gear

3.3.1 The provisions of 3.2 also apply to offshore loading gear, with the statements in 3.3.2 being taken into consideration.

3.3.2 Loading gear on offshore installations are to be dimensioned for the same environmental conditions as the installation itself, i.e. for the same design temperature.

3.4 Floating cranes

The provisions of 3.2 also apply to floating cranes.

4. Load assumptions

4.1 General notes

4.1.1 Ship loading gear is subject to other and partly greater loads than loading gear onshore. This includes amongst others ship inclinations, seagoing accelerations as well as increased wind loads.

4.1.2 For the design, in principle all loads are to be considered which act upon the loading gear “in operation” and in the "out of operation" state.

4.1.3 The design as well as the calculation and dimensioning of all loading gear is to be based on the following load assumptions, if applicable.

4.1.4 The following Sections of these guidelines may contain further load assumptions which are then to be observed additionally or given preference where applicable, for the loading gear under consideration.

4.1.5 Where loading gear is exposed to special loads which are not stated in these Guidelines, then these are to be taken as a basis for design and dimensioning.

Special loads are to be indicated expressly by the shipyard or manufacturer of the loading gear in the drawings or in other documents submitted to BKI for approval. Regarding the proof acc. to C.8, the partial safety factor to be considered is to be agreed with BKI.

4.2 Dead loads

4.2.1 Dead loads acc. to Section 1, C.11 are to be calculated using recognized standards such as e.g. EN 1991-1-1, or are to be determined by weighing.

4.2.2 Dead loads are calculated by multiplying the mass by the acceleration of gravity g = 9,81 m/s^2.

4.3 Dynamic forces

4.3.1 Dynamic forces due to drives

.1 The acceleration of loading gear components and/or useful loads due to drives generates positive or negative dynamic forces, depending on definition, which are to be calculated as follows:

force [N] = mass [kg] · acceleration [m/s^2]

.2 Braking forces due to drives are to be assumed as negative dynamic forces.

.3 Dynamic forces due to drives may normally be assumed as quasi-static loads. They are specified in Section 4, C.2.4 as dimensioning loads.

4.3.2 Seagoing dynamic forces

.1 Horizontal dynamic forces due to motions of a floating body are to be considered for loading gear used in sea or offshore operations in accordance with the method described in Section 4, C.2.5.

.2 Vertical dynamic forces due to motions of a floating body are to be considered if the calculation is made in acc. with Section 4, C.2.5.1. If Annex A is applied, they are included in the method used therein; if Section 4, Table 4.2 is applied, they may be ignored.

.3 Seagoing dynamic forces may be assumed as quasi-static loads.

4.4 Inclinations of the supporting structure

4.4.1 Loading gear in operation

.1 Loading gear is to be dimensioned for operation at the static minimum inclinations acc. to Table 3.1.

Table 3.1 Static minimum inclinations

Type of floating body	Static minimum inclination	
	Heel angle α	Trim angle β
Ships and similar floating bodies	± 5°	± 2°
Pontoons	± 3°	± 2°
Floating docks	± 2°	± 2°
Semisubmersibles	± 3°	± 3°
Fixed platforms	± 1°	± 1°

Exceptions from this provision are defined in 4.4.1.6.

.2 Dynamic loads due to motions of the supporting structure are to be considered in acc. with Section 4, C.2.5.

.3 Static inclinations α (= heel) and β (= trim) are to be assumed to be acting simultaneously.

.4 Simplifying, it may be assumed that heel and trim are superimposed as follows:

$$\varepsilon = \sqrt{\alpha^2 + \beta^2}$$

The resulting angle ε is to be assumed to have the most unfavourable direction.

.5 The values of Table 3.1 assume sufficient stability of the floating body. Where larger inclinations are to be expected during operation of the lifting appliance, then these are to be taken as the basis.

.6 In special cases, to be proven by measurements or calculations, the values may be lower than those in Table 3.1.

For dimensioning, the inclinations which are determined are to be increased by 1° heel and 0,5° trim.

4.4.2 Loading gear out of operation.

.1 For the calculation of dynamic forces in the "out of operation" state, the dynamic inclinations as well as the respective accelerations of the floating body are to be observed.

For this purpose, the dynamic inclinations of the floating body acc. to Annex A, Table A.1 are to be assumed

.2 Simplifying, the calculation of dynamic forces may be performed acc. to Annex A.

4.5 Wind loads

4.5.1 General notes

.1 Ship and offshore loading gear shall in general only be operated up to a mean wind speed of approximately 80 % of the dimensioning wind speed.

At higher wind speeds, the loading gear is to be taken out of operation and to be stowed in the stowing position.

.2 Simplifying, the statements in 4.5.2 and 4.5.3 are based on a constant mean wind speed acting in any assumed direction and height.

.3 Static or dynamic calculations of wind loads in accordance with recognized rules or standards, or calculations with suitable wind load parameters, may be accepted by BKI.

4.5.2 Calculation of wind load

The wind load L_W acting on a structure is to be assumed to have the most unfavourable direction and is to be calculated using the following formula:

$$L_W = q \cdot c_f \cdot A_w \quad [N]$$

$$q = \frac{v^2}{1{,}6} \quad [N/m^2] \text{ (dynamic pressure)}$$

v = wind speed acc. to 4.5.3 [m/s]

c_f = form coefficient acc. to 4.5.4 [-]

A_w = wind area [m^2]

4.5.3 Wind speeds

.1 The determination of wind load is to be based on the wind speeds acc. to Table 3.2.

Table 3.2 Wind speeds

Mode of operation of the load gear	Wind speed	
	In operation	Out of operation
Ship loading gear harbour operation	20 m/s	50 m/s[1]
Ship loading gear sea operation	25 m/s	50 m/s[1]
Offshore loading gear	25 m/s	63 m/s

[1] Not to apply for topped craned.

.2 For topped shipboard cranes out of operation, the wind speed is to be calculated as a function of height acc. to the following formula:

$$v = 44 \cdot \left(\frac{h_L}{10}\right)^{0,15} \geq 50 \qquad [m/s]$$

h = height of the centre of area of the crane boom above waterline [m]

.3 The wind speed v is assumed to be constant along the height.

.4 Floating cranes are to be treated like ship's loading gear.

4.5.4 Form coefficients

The form coefficients may be determined acc. to Annex C or simplified as follows:

c_f = 1,6 for rolled profiles and box girders

= 1,3 for rectangular areas of closed super structures like e.g. engine houses

= 1,2 for cylindrical structural elements

4.5.5 Wind areas located behind one another

The wind loads of areas located behind one another may be determined acc. to Annex C or simplified as follows:

For wind loads of areas located behind one another, the wind load of the respective area lying behind may be assumed to be 75 % of the area lying in front. From the 9th area onwards, the wind load remains constant at 10 %.

4.5.6 Wind load on the useful load

.1 The wind load acting on the useful load is to be calculated acc. to 4.5.2, based on the largest wind area of the useful load and acting in the most unfavourable direction.

.2 Where a more precise information on the useful load is not available, the wind load may be calculated using the following values for $c_f \cdot A_w$:

$c_f \cdot A_w = 1,2 \cdot L_N \quad [m^2]$ for $L_N \leq 50$ t

$c_f \cdot A_w = 8{,}5 \cdot \sqrt{L_N} \cdot N \; [m^2]$ for $L_N > 50$ t

L_N = useful load [t]

4.6 Snow and ice loads

4.6.1 The manufacturer has to specify by agreement with the client. If, and to what extent, snow and ice loads are to be considered for individual operating conditions. Generally, lifting appliances with ice accretion shall not be operated.

4.6.2 Where ice accretion is to be considered, and no empiric or specified values are available, simplified, a general ice accretion of 3 cm thickness may be assumed for all parts of the construction which are exposed to the weather conditions.

4.6.3 The specific weight of the ice is assumed to be 700 kg/m^3. The specific weight of snow is assumed to be 200 kg/m^3.

4.6.4 In the case of ice load, the wind load is to be related to the area increased by ice accretion.

4.7 Loads due to temperature

Parts of the structure or other structural elements which cannot expand or contract freely shall be avoided, if possible. Otherwise, the lower and upper temperature is to be agreed with BKI and the temperature loads are to be considered in the calculated strength analyses.

5 Special provisions

5.1 Conveyance of persons in the harbour

The following provisions imply safety devices which are required in principle in Sections 9, 10 and 12 such as e.g.

- emergency shut-down switches or buttons
- control elements return automatically to the neutral position
- load and load moment reducing motions when safety devices apply

5.1.1 The nominal load (L_{Ne}) of loading gear for the conveyance of persons shall be at least twice the sum of the dead load and nominal load for the means of conveyance of persons used.

5.1.2 The maximum lowering and hoisting speed for the conveyance of persons shall not exceed 0,5 m/s. The control system shall be capable of observing this speed limitation.

5.1.3 At a lowering speed of more than 0,3 m/s, the control system shall be capable of setting-down gently the means of conveying persons.

5.1.4 The minimum lowering and hoisting speed for the conveyance of persons shall not be less than 0,05 m/s.

5.1.5 Means of conveying persons are to be attached to the loading gear by secured shackles or other approved fixed connections. Cargo hooks with seawater-resistant safety latch are permitted if compatible with the master link of the means.

Automatically release hooks for life-saving appliances are also not permissible.

5.1.6 Hoisting and luffing winches of loading gear for conveying persons are to be equipped with a mechanical second brake. The second brake shall be independent of the primary brake.

5.1.7 If hydraulic cylinders are used for luffing, knuckling or telescoping of a boom, they have to be equipped with hydraulic restriction systems. Alternatively two independent hydraulic cylinders can be used of which each single one shall be capable to hold the nominal load resulting from the conveyance of persons (SWL (M)), if the other hydraulic cylinder fails.

Safety against failure shall then be verified for loading condition III_5 as per Section 4, E.2.

5.1.8 Special devices shall be provided to rescue passengers from a means of conveying persons in case of the failure of the drive.

5.2 Conveyance of personnel at sea

For the conveyance of personnel at sea the provisions of 5.1 apply, with the exception of 5.1.2 and 5.1.3. In addition the following provisions are to be observed:

5.2.1 Aside from an emergency, the following environmental conditions are to be adhered to unless deviating conditions are agreed upon:

- average wind speed : ≤ 10 m/s
- significant wave height : ≤ 2 m
- visibility conditions : daylight or sufficient illumination

5.2.2 Offshore cranes and, if provided for the conveyance of personnel, also shipboard cranes for operations at sea, shall be equipped with a manual switch which allows switching between "normal operation" and "conveyance of personnel".

5.2.3 Cranes according to 5.2.2 shall comply with the following conditions in the "conveyance of personnel" mode, if applicable:

- automatic de-activation of safety systems for release of the cargo runner (emergency system for hooking on of cargo hooks)
- automatic de-activation of active or passive heave compensators. These are, however, permissible for the handling of work boats, if they are adjusted to these boats.
- in addition to the main power supply an emergency power supply shall be available to ensure main functions of the crane (lifting, luffing, slewing, telescoping and knuckling) at a minimum speed of 10 % of the nominal operational speed in the mode "conveyance of personnel". Exceptions (e.g. very large cranes) are individually to be agreed with BKI.

5.3 Sea lashing

5.3.1 All mobile parts of loading gear, such as derricks, crane booms, trolleys, gantries, etc., shall have a special park and stowage position, where they can be lashed to be seaworthy.

Exceptions like e.g. free hanging or topped crane booms require approval by BKI case by case.

5.3.2 Special stowage positions are to be provided for mobile loading gear. They are to be selected such that the prospective loads, like e.g. ship accelerations, wind and wash, are minimized.

5.3.3 The loading gear, as well as their support and lashing devices, shall be sufficiently dimensioned for the loads in the "out of operation" state.

C. Calculation Principles

1. Basic requirements

1.1 All strength analyses shall correspond to generally recognized rules of statics, dynamics and strength of materials.

1.2 Details on system measurements, sections, materials used etc. in the drawings shall agree with the corresponding calculations.

1.3 Mobile loads are to be assumed in the most unfavourable positions for the structural element considered.

1.4 Where, non-linear relations, inherent to the system, exist between loads and stresses, the stress determination is to be performed acc. to the 2nd order theory for γ_p-fold loads with consideration of deformations.

1.5 Calculations acc. to 2nd order theory are to be based on a reduced value for dimensioning the Young's modulus:

$$E_d = E_k / \gamma_m$$

E_d = dimensioning value of Young's modulus

E_k = significant value of the Young's modulus

γ_m = partial safety factor for resistance values acc. to 7.4.3

Explanations on this can be found in 7.1 and 7.2.

2. Proofs required

2.1 Normally, the following proofs are to be submitted for all loading gear:

- proof of structural safety acc. to D
- proof of stability acc. to E
- proof of fatigue strength acc. to F
- proof of suitability for use acc. to G

2.2 The following Sections of these guidelines may contain more detailed and/or additional information on proofs required for the loading gear considered there.

3. Materials

3.1 General notes

3.1.1 The materials intended for use are to be indicated in the calculation.

3.1.2 Tables 2.2 to 2.4 in Section 2 show a selection of steels generally approved by BKI for plates and profiles.

Other steels may be approved.

3.1.3 Regarding the materials for machinery elements, axes, shafts, bolts, etc. as well as for nonferrous metals, Rules for Materials (Pt.1 Vol.V) apply, see Section 1, B.2.1.1.

3.1.4 Regarding bolts and nuts, the provisions in Section 2, H apply.

3.2 Calculated yield strength

3.2.1 General notes

.1 The strength analyses acc. to these guidelines refer as a failure criterium to the yield strength of the material.

.2 For metallic materials without significant yield strength R_{eH}, the yield strength $R_{p0,2}$ is used instead.

.3 To avoid brittle fracture, the materials used shall be sufficiently ductile.

This means that the failure of a structural element due to overload may possibly be indicated sooner by large plastic deformations.

.4 For less ductile materials with a small ratio of tensile strength R_m over yield strength R_{eH}, additional safety against reaching or exceeding the tensile strength is stipulated.

This is achieved in strength analyses by taking into consideration a reduced value for the yield strength – the calculated yield strength f_{yr}.

3.2.2 Steels

.1 The calculated yield strength f_{yr} is determined as follows:

$$f_{yr} = 0{,}83 \cdot R_m \leq R_{eH} \text{ (or } \leq R_p \text{ 0,2)}$$

R_m = tensile strength [N/mm^2]

R_{eH} = yield strength [N/mm^2]

$R_{p\,0,2}$ = 0,2 % – yield strength [N/mm^2]

.2 Where austenitic steels are used with a ratio $R_{p\,0,2}/R_m \leq 0{,}5$, subject to special approval by BKI, for dimensioning, the 1 %-yield strength $R_{p\,1,0}$ may by applied instead of $R_{p\,0,2}$.

3.2.3 Aluminium alloys

.1 If aluminium alloys suitable for seawater, stated in the Rules for Materials (Pt.1, Vol.V) are used, the yield strength is calculated as follows:

$$f_{yr} = 0{,}37 \cdot (R_{p\,0.2} + R_m) \leq R_{p\,0.2}$$

R_m = tensile strength [N/mm^2]

$R_{p\,0,2}$ = 0,2 % – yield strength[N/mm^2]

.2 In the case of welded connections, the respective mechanical properties in the welded condition are to be assumed. If these values are not available, the corresponding values in the soft condition are to be assumed.

4. Section values

4.1 Hole weakening by bolts

4.1.1 The sections to be considered are the net sections (including hole deduction) for all structural elements stressed by tension.

4.1.2 A calculated deduction due to holes may be dispensed with for all sections stressed by pressure and shear, if:

– the maximum hole clearance is 1 mm and
– the deformations of the structure are not to be limited.

4.1.3 Where the conditions acc. to 4.1.2 are complied with, the section values of sections which are subject to bending, may be determined, simplified, as follows:

For the tension side, the net section and for the compression side, the gross section, is to be taken. For the centre of gravity, the centre of gravity of the gross section is to be assumed.

4.1.4 Elastic deformations are normally to be determined using the gross sections.

4.2 Effective breadth of plating

When determining section values, the effective breadth of plating is to be taken into consideration, if necessary. The calculation of the effective breadth of plating may e.g. be conducted in acc. with EN 1993-1-5.

5 Particularities

5.1 Local stresses

The local stresses in the area of force transmissions and discontinuities such as e.g. diversions of force, steps of a section, cut-outs, etc., see Fig. 3.1, are to be proven separately and superimposed on the global stresses.

Notes regarding local stresses due to wheel loads may be taken from I.5.

5.2 Tie rods

Tie rods which may be subject to compressive stresses due to small deviations from the regular load assumptions, are to be proven in the same way as compression members.

6. Verification procedures

6.1 General note

In these Guidelines, the methods of "partial safety factors" and "permissible stresses" are allowed to be used for verification.

6.2 Partial safety factor method

The partial safety factors method is generally applicable. It enables weighting of different loads and is the standard proof of these Guidelines.

6.3 Method of permissible stresses

The method of permissible stresses is not generally applicable and therefore shall not be used if one or more of the following structural characteristics exist:

a) non-linearity between loads and stresses (compression-stressed structural elements with major deformations requiring proof acc. to 2nd order theory)
b) dead loads with a favourable effect (counter-weights/overhanging engine houses)
c) pre-stresses due to:
   – weights besides b), in particular mobile weights
   – ropes/tension elements

– bolts (in general, only relevant in special cases)

d) loading gear is not fixed and stability against turn-over has not been proven by tests

7. Proof by the method of partial safety factors

7.1 General notes

The method of partial safety factors distinguishes between safety factors γ_m relating to resistance values and safety factors γ_P relating to loads.

7.2 Definitions

7.2.1 Loads

.1 Loads is the term for all external influences which impact on a structure.

.2 Loads can e.g. be dead loads, hoisting loads, dynamic loads, temperature changes or enforced deformations.

.3 The loads to be considered in each individual case are regulated in the following Sections for the respective loading gear.

7.2.2 Stresses

.1 Stresses is the term for the effects of loads on a structure.

.2 Stresses can e.g. be stresses and deformations.

.3 Stresses are marked by the index "S“.

7.2.3 Load bearing capacities

.1 Load bearing capacities is the term for the permissible limit values of a stress.

.2 Load bearing capacities are marked by the index "R“.

7.2.4 Resistance values

Resistance values are material properties like e.g. yield strength, tensile strength and Young's modulus, by which e.g. load bearing capacities and stiffness of cross-sections are calculated.

7.2.5 Characteristic values

.1 Characteristic values of loads or resistance values do not include safety factors.

.2 Characteristic values are marked by the index "k".

7.2.6 Dimensioning values

.1 Dimensioning values of loads L are the characteristic values, increased by the partial safety factor γ_P:

$$L_d = \gamma_P \cdot L_k$$

.2 Dimensioning values of resistance values WG are the characteristic values, reduced by the partial safety factor γ_m:

$$WG_d = WG_k / \gamma_m$$

.3 Dimensioning values are marked by the index "d“.

7.3 General proof format

In general, the degree of utilization (stress/utilization ratio) is to be calculated. The proof is demonstrated if the degree of utilization is not larger than 100 %.

As an alternative, stress and utilization can be compared directly. The proof is demonstrated if the stress is not larger than the utilization.

$$S_d / R_d \leq 1 \quad \text{or} \quad S_d \leq R_d$$

S_d = dimensioning value of load, determined from the impacts multiplied by varying partial safety factors γ_P

R_d = dimensioning value of load bearing capacity, determined from the resistance values, divided by the partial safety factor γ_m

7.4 Partial safety factors

7.4.1 For the calculation, the loads which loading gear is exposed to, are increased by partial safety factors of varying magnitude.

7.4.2 The partial safety factors for loads are given in Section 4, together with the load combinations to be verified.

7.4.3 The partial safety factor for resistance values γ_m is always:

$$\gamma_m = 1{,}10$$

unless stated otherwise in individual cases.

7.5 Load combinations

7.5.1 Loads acting simultaneously acc. to B.4, are to be increased by the partial safety factors acc. to 7.4 and to be superimposed in load combinations.

7.5.2 Notes and explanations regarding load combinations are given in the following Sections in connection with the required proofs.

8. Proof by the method of permissible stresses

8.1 General notes

8.1.1 The method of permissible stresses is only applicable under certain prerequisites. It is regarded to be a "special case" within the method of partial safety factors, see 6.2 and 6.3.

8.1.2 Depending on the type of design, differing results are possible with the two methods of proof. Therefore, BKI reserves the right, in individual cases, to apply a proof using the method of partial safety factors.

8.2 Proof formats

Without partial safety factors, the following proof formats exist:

$$\sigma_{perm} = \frac{f_{yr}}{\gamma_s}$$

$$\tau_{perm} = \frac{f_{yr}}{\gamma_s \cdot \sqrt{3}}$$

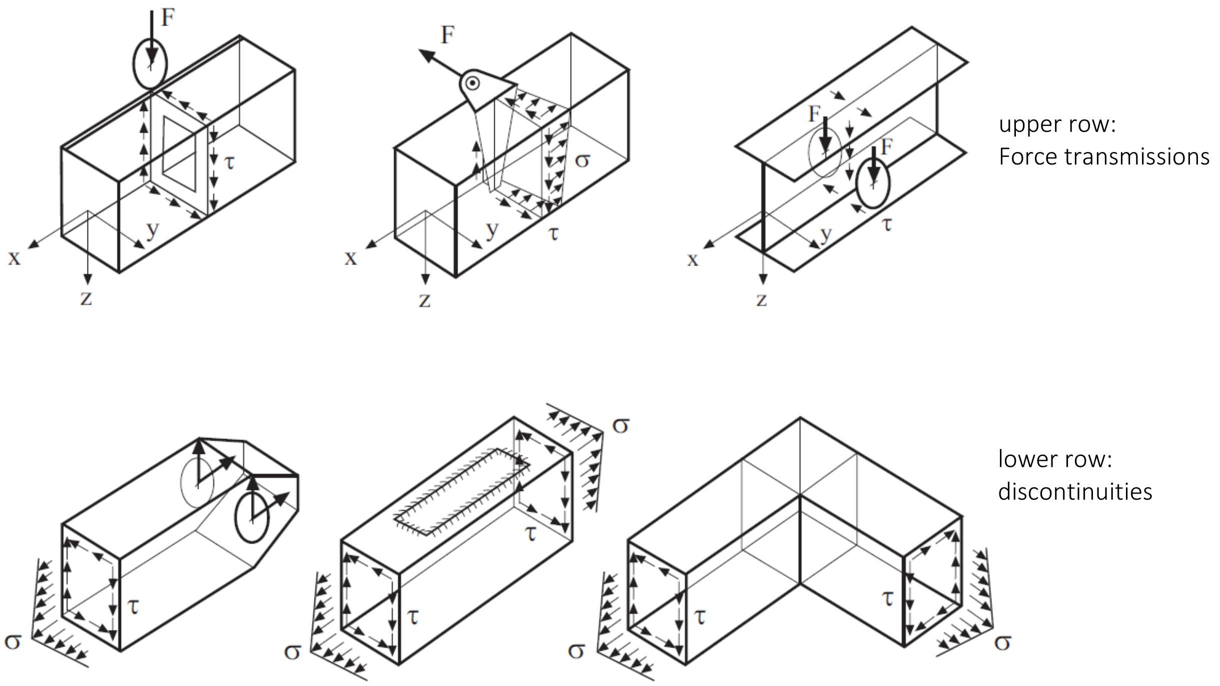

Fig. 3.1 Examples for local force transmissions and discontinuities

f_{yr} = calculated yield strength acc. to 3.2

γ_S = global safety factor, depending on the load combinations acc. to Table 4.4 and Table 4.5

load combination I : γ_S = 1,48

load combination II : γ_S = 1,34

load combination III: γ_S = 1,22

D. Proof of Structural Safety

1. General notes

1.1 The following statements shall be observed for proofs load bearing structural elements made of steel and aluminium, as well as for proofs of special machinery elements according to the method of partial safety factors.

1.2 Calculation and dimensioning of machinery elements which are not dealt with, may be performed using recognized standards or generally recognized technology rules.

2. Scope of proofs

2.1 General notes

2.1.1 The ultimate strength analysis consists of two partial proofs:

- the general stress analysis acc. to 2.2 and
- the proof of stability acc. to 2.3

2.1.2 The internal forces and moments on which the proof of the structural element being considered, cross-section or a weld/bolt are based, shall include all impacting static and dynamic load components.

2.1.3 The proofs of structural safety are to be shown in each case for the most unfavourable load combination acc. to C.7.5.

2.1.4 If load combinations are not taken into consideration or proofs not carried out, this is to be substantiated in writing, unless the reasons for doing so are obvious.

2.2 General stress analysis

The general stress analysis is the proof of safety against reaching the calculated yield strength acc. to C.3.2.

2.2.1 General notes

.1 The designations of axes of structural elements used in these Guidelines, as well as forces and moments which may have an impact on a structural element, are illustrated in Fig. 3.2.

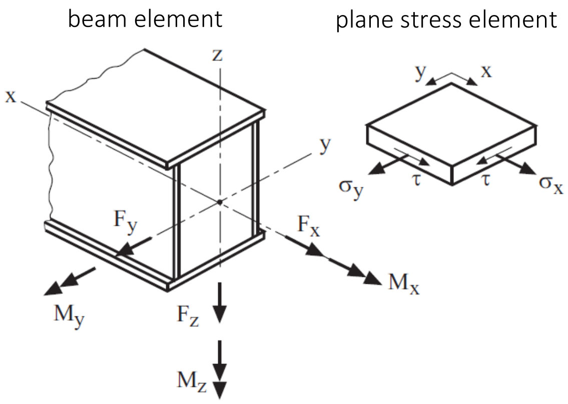

Fig. 3.2 Axes of structural elements and possible loads

$F_{x,y,z}$ = Force in direction of the respective axis [N]

$M_{x,y,z}$ = Moment around the respective axis [Nmm]

$\sigma_{x,y}$ = Normal stress in direction of the respective axis [N/mm^2]

τ = Shear stress [N/mm^2]

2.2.2 Equivalent stresses

.1 Where normal and shear stresses act simultaneously in a cross-section, the equivalent stress σ_v is to be calculated from the respective allocated stresses. Spatially oriented stresses are to be broken down to the co-ordinate system acc. to Fig. 3.2.

.2 Generally, the equivalent stress σ_v is to be calculated acc. to the distortion energy theory (Von Mises) as follows:

$$\sigma_v = \sqrt{\sigma_x^2 + \sigma_y^2 + \sigma_z^2 - \sigma_x \cdot \sigma_y - \sigma_x \cdot \sigma_z - \sigma_y \cdot \sigma_z + 3 \cdot \tau_{xy}^2 + 3 \cdot \tau_{xz}^2 + 3 \cdot \tau_{yz}^2}$$

.3 In the case of biaxial stresses, the calculation of σ_v is simplified as follows:

$$\sigma_v = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x \cdot \sigma_y + 3 \cdot \tau^2}$$

.4 In the case of uniaxial stresses, the calculation of σ_v is simplified as follows:

$$\sigma_v = \sqrt{\sigma^2 + 3 \cdot \tau^2}$$

2.2.3 Format of the strength analysis

.1 The strength analysis is to be performed for both the individual stress components as well as the equivalent stresses, analogous to C.7.3 as follows:

$$\sigma_{Sd} / \sigma_{Rd} \leq 1 \quad \text{or} \quad \sigma_{Sd} \leq \sigma_{Rd}$$

$$\tau_{Sd} / \tau_{Rd} \leq 1 \quad \text{or} \quad \tau_{Sd} \leq \tau_{Rd}$$

$$\sigma_{v.Sd} / \sigma_{Rd} \leq 1 \quad \text{or} \quad \sigma_{v,Sd} \leq \sigma_{Rd}$$

σ_{Sd}; τ_{Sd} and $\sigma_{v,Sd}$ are dimensioning values of the stresses based on the loads multiplied by partial safety factors γ_P.

$$\sigma_{Rd} = \frac{f_{yr}}{\gamma_m}$$

$$\tau_{Rd} = \frac{f_{yr}}{\gamma_m \cdot \sqrt{3}}$$

σ_{Rd} and τ_{Rd} are dimensioning values of the permissible stresses (load bearing capacity)

f_{yr} = calculated yield strength C.3.2

γ_m = partial safety factor acc. to C.7.4.3

.2 Where more accurate strength analyses acc. to recognized calculation methods, e.g. acc. to the method of finite elements are conducted or where test results exist, BKI may, depending on the facts, agree to an increase of the locally permissible stresses.

2.3 Proof of stability

2.3.1 Proof of calculated safety against lateral buckling, lateral torsional buckling or buckling is to be conducted acc. to a recognized calculation principle or standard for all essential combinations of loads.

2.3.2 Proofs of stability for steel constructions may be conducted acc. to EN 1993-1-1, EN 1993-1-3, EN 1993-1-5, EN 1993-1-7.

2.3.3 Proofs of stability for aluminium alloy constructions may be conducted acc. to EN 1999-1-1, EN 1999-1-4, EN 1999-1-5.

2.3.4 Proofs of stability for constructions made of austenitic steel may be conducted acc. to EN 1993-1-4.

2.3.5 When applying 2.3.2 to 2.3.4 for stability proofs, the following is to be taken into consideration:

– Instead of safety factor γ_{M1} according to the 2.3.2 to 2.3.4, the value γ_m acc. to C.7.4.3 is to be used.
– Instead of the yield strength, the calculated yield strength f_{yr} acc. to C.3.2 is to be used.

E. Proof of Safety against Overturning

1. General notes

1.1 Loading gear and parts of loading gear not connected integrally to the residual structure, are to be sufficiently safe against overturning at all times.

For mobile loading gear, also whereat operating on a circular track, safety against overturning is to be proven in all cases.

1.2 Safety against overturning of loading gear is a measure of its resistance to overturning and drifting e.g. by wind and/or inclinations of the supporting structure.

The many factors which influence safety against overturning in the longitudinal and transverse directions include dead load and dead load distribution, track gauge, wheel base, Safe Working Load and load radius, motor and braking power, and the deformations which occur under load.

1.3 Loading gear which travels on rails shall be equipped with devices to prevent overturning, and shall generally be stable even without such devices.

1.4 Proof of safety against overturning ensures safe working, if the equipment is normally and carefully operated.

It should be noted that the danger of overturning arising from inexpert or incorrect operation cannot be precluded, no matter how stringent the conditions for proof of safety against overturning.

2. Proof of safety against overturning

With regard to safety against overturning, a distinction is made between loading gear on rails and fork lift trucks.

Where the danger of overturning exists for parts of non-mobile loading gear, the proof is to be demonstrated analogously to 2.1.

2.1 Loading gear on rails

2.1.1 Mathematical proof is regarded as sufficient for the safety against overturning of loading gear on rails.

This proof is to be conducted using the method of partial safety factors acc. to C.7.

Thereby the partial safety factors for loads acc. to C.7 are generally to be considered.

2.1.2 Loading gear is deemed to be sufficiently safe against overturning if relative to the respective most unfavourable tilting edge in the most unfavourable proof and in consideration of the partial safety factors, the sum of restoring moments is larger than the sum of overturning moments.

The following condition is to be observed:

$$\frac{\sum M_{St}}{\sum M_{Ki}} \geq 1{,}0$$

$\sum M_{St}$ = sum of restoring moments

$\sum M_{Ki}$ = sum of overturning moments

2.1.3 Where desirable or necessary, e.g. in the case of existing lifting appliances, proof of safety against overturning may also be provided by a special loading test.

This test shall in each case be agreed with BKI, who will also determine the magnitude of the test load and the nature of the test (static and/or dynamic).

2.1.4 Devices to prevent overturning are to be dimensioned for the overturning moment which would result from twice the static hoist load, or where lifting appliances without prevention devices are not safe against overturning, in accordance with the forces occurring in operation.

2.2 Fork lift trucks

The safety against overturning of fork lift trucks shall be determined on an inclinable platform for each new type.

On the basis of the results obtained from these measurements, the manufacturer shall, on demand. Revise and certify the conditions ensuring stable operation on inclined planes (due to inclinations of the ship, or the camber and sheer of decks).

F. Proof of Fatigue Strength

1. General notes

1.1 The proof of sufficient fatigue strength, i.e. the strength against crack initiation under dynamic loads during operation, is useful for judging and reducing the probability of crack initiation of structural members during the design stage.

Due to the randomness of the load process, the spreading of material properties and fabrication factors and to the effects of ageing, crack initiation cannot be completely excluded during later operation. Therefore, among other things, periodical surveys are necessary.

1.2 The fatigue strength analysis is to be conducted acc. to Rules for Hull (Pt.1, Vol.II) Sec.20 taking into account 2. to 5. or, subject to agreement with BKI, acc. to another recognized basic calculation principle.

1.3 Low cycle fatigue problems in connection with fracturing of structural elements have to be specially considered.

2. Application

2.1 The fatigue strength analysis is in principle required for all structural elements, connections and supporting structures of loading gear which are exposed to dynamic loads for the states "in operation" and "out of operation" and may be demanded by BKI for any type of lifting appliance and operational condition.

2.2 The provisions stated here are applicable to constructions made of normal and higher-strength hull structural steels, austenitic steels as well as aluminium alloys. Other materials such as high-strength structural steel and cast steel can be treated, upon agreement with BKI, in an analogous manner by using appropriate design S-N curves.

3. Stress range spectrum

3.1 Definitions

3.1.1 The stress range spectrum of a design detail describes the frequency of the different stress ranges to be expected at that location during the lifetime of the loading gear.

3.1.2 The standard stress range spectrum of loading gear describes the frequency of the different useful loads to be handled during the lifetime of the loading gear.

3.1.3 Regarding the fatigue strength analysis, it shall be taken into consideration that the standard stress range spectrum of loading gear and the stress range spectrum of a design detail may be different in terms of form of spectrum and particularly in terms of number of load cycles or stress cycles, respectively.

3.2 Stress range spectrum for the condition "in operation"

3.2.1 Regarding the fatigue strength analysis for the condition "in operation", loading gear are normally to be categorized in groups corresponding to the standard stress range spectra S0 to S7 acc. to Fig. 3.3.

3.2.2 Where the operating conditions are precisely known, individual, clearly separated from each other, structural groups or elements may or must be categorized differently.

3.2.3 The number n_{max} of stress cycles during operation is to be provided by the manufacturer.

3.2.4 The stress spectra S0 to S6 are defined by the following equation (see Fig. 3.3):

$$\left(\frac{\Delta\sigma}{\Delta\sigma_{max}}\right)^{\kappa} = 1+\left(p^{\kappa}-1\right)\frac{\log n}{\log n_{max}}$$

$\Delta\sigma$ = stress range

$\Delta\sigma_{max}$ = maximum stress range of the spectrum acc. to 4.

n = number of stress cycles

n_{max} = total number of stress cycles

$$\kappa = \frac{1}{(2{,}5\cdot p-2{,}8)\cdot\log(p)}+1{,}5$$

p = coefficient acc. to Table 3.3

For p = 0; κ = 1,5 to be assumed

Table 3.3 Coefficients for the calculation of the κ-value

S	S0	S1	S2	S3	S4	S5	S6
p	0/7	1/7	2/7	3/7	4/7	5/7	6/7

3.2.5 Applicable for the stress range spectrum S7:

$$\frac{\Delta\sigma}{\Delta\sigma_{max}} = 1 = \text{constant}$$

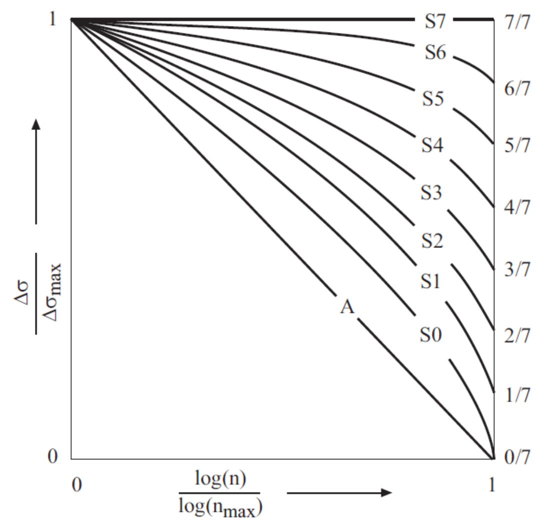

Fig. 3.3 Standards stress range spectra

3.2.6 Where the operating conditions of loading gear are exactly known, individually determined stress range spectra may be used for the fatigue strength analysis, based on calculated cumulative damage ratios. The individual stress range spectra are to be proven by the manufacturer.

3.3 Stress range spectra for the condition "out of operation"

The fatigue strength analysis for the condition "out of operation" is to be conducted for the straight-line spectrum A acc. to Fig. 3.3 and a total number of stress cycles $n_{max} = 5 \cdot 10^7$.

4. Calculation of the maximum stress range

4.1 The maximum stress range for a construction detail is to be calculated from the highest maximum stress σ_{max} and the lowest minimum stress σ_{min} in this detail:

$$\Delta\sigma_{max} = \sigma_{max} - \sigma_{min}$$

4.2 The maximum upper stress σ_{max} and the minimum lower stress σ_{min} are to be determined each from loads of the most unfavourable magnitude, location and direction acting on the loading gear in the most unfavourable position.

Thereby all partial safety factors are to be set $\gamma_p = 1$.

5. Proof

5.1 Calculation of the cumulative damage ratio

5.1.1 Where the fatigue strength analysis is based on the calculated cumulative damage ratio, the partial damages D_i caused by the operating conditions "in operation" and "out of operation" are to be determined as follows:

$$D_i = \sum_{k=1}^{K} \frac{n_k}{N_k}$$

K = total number of blocks of the stress range spectrum for summation (in general, $K \geq 20$)

n_k = number of stress cycles in block k

N_k = number of endured stress cycles determined from the corrected S-N curve (see Rules for Hull (Pt.1, Vol.II) Sec.20) taking $\Delta\sigma = \Delta\sigma_k$

$\Delta\sigma_k$ = stress range of block k

For this purpose, in the condition "in operation", standard stress range spectra acc. to 3.2.4 or 3.2.5 or individually determined stress range spectra acc. to 3.2.6 may be applied. For the condition "out of operation", the straight-line stress range spectrum acc. to 3.3 is to be applied.

5.1.2 The proof of fatigue strength is demonstrated if, for the total cumulative damage ratio D, the following condition is met:

$$D = \sum D_i \leq 1$$

5.2 Permissible stress range

5.2.1 The fatigue strength analysis may be performed based on the permissible maximum stress ranges. For this purpose, in the condition "in operation", standard stress range spectra acc. to 3.2.4 or 3.2.5 are to be applied, for the condition "out of operation", the straight-line stress range spectrum acc. to 3.3.

The requirements stated in the following are applicable for fatigue strength analyses conducted separately for the conditions "in operation" and "out of operation".

A superposition of the damages caused by the conditions "in operation" and "out of operation" is not required, provided that the maximum stress range caused by the condition "out of operation" does not exceed 10 % of the maximum stress range caused by the condition "in operation". Otherwise the fatigue strength analysis is to be conducted on the basis of the calculated cumulative damage ratios acc. to 5.1 or upon agreement with BKI.

Table 3.4 Factor f_n for the determination of the permissible stress range for welded joints ($m_0 = 3$)

Stress Spectrum	Number of stress cycles n_{max}										
	$2 \cdot 10^4$	$5 \cdot 10^4$	10^5	$3 \cdot 10^5$	$6 \cdot 10^5$	10^6	$3 \cdot 10^6$	$6 \cdot 10^6$	10^7	$5 \cdot 10^7$	10^8
S0	16,54	12,94	10,68	7,84	6,44	5,58	4,09	3,36	2,91	1,95	1,67
S1	12,63	9,70	7,87	5,68	4,61	3,97	2,84	2,32	2,01	1,37	1,19
S2	10,25	7,75	6,23	4,43	3,57	3,04	2,15	1,74	1,51	1,05	0,92
S3	8,36	6,23	5,00	3,52	2,82	2,40	1,68	1,34	1,16	0,82	0,72
S4	6,93	5,16	4,12	2,88	2,30	1,95	1,36	1,08	0,93	0,66	0,58
S5	5,92	4,38	3,48	2,44	1,94	1,64	1,14	0,91	0,77	0,56	0,48
S6	5,13	3,78	3,02	2,09	1,66	1,40	0,98	0,78	0,66	0,47	0,41
S7	4,70	3,45	2,75	1,91	1,51	1,27	0,89	0,70	0,59	0,43	0,37

Table 3.5 Factor f_n for the determination of the permissible stress range for free edges of plates with m_0 = 3.5

Stress Spectrum	Number of stress cycles n_{max}										
	$2\cdot10^4$	$5\cdot10^4$	10^5	$3\cdot10^5$	$6\cdot10^5$	10^6	$3\cdot10^6$	$6\cdot10^6$	10^7	$5\cdot10^7$	10^8
S0	9,34 12,51[1]	8,18 10,19[1]	7,39 8,73[1]	6,20 6,77[1]	5,48 5,74[1]	4,96	3,91	3,33	2,96	2,09	1,84
S1	7,75 9,83[1]	6,68 7,87[1]	5,95 6,65 [1]	4,85	4,20	3,72	2,82	2,38	2,11	1,51	1,34
S2	6,65 8,09[1]	5,68 6,38[1]	4,97 5,34[1]	3,94	3,33	2,90	2,17	1,82	1,61	1,17	1,05
S3	5,62 6,65[1]	4,75 5,20[1]	4,14	3,20	2,66	2,30	1,71	1,41	1,25	0,93	0,83
S4	4,75 5,55[1]	4,00 4,30[1]	3,50	2,62	2,17	1,88	1,38	1,14	1,00	0,76	0,68
S5	4,07 4,73[1]	3,40 3,66[1]	3,00	2,22	1,83	1,59	1,16	0,95	0,84	0,63	0,56
S6	3,54 4,12[1]	2,96 3,17[1]	2,60	1,91	1,57	1,36	1,00	0,82	0,71	0,54	0,48
S7	3,25 3,77[1]	2,70 2,90 [1]	2,35	1,74	1,43	1,23	0,90	0,74	0,64	0,49	0,43

[1] for $\Delta\sigma_R$ < 125 [N/mm²]
($\Delta\sigma_R$ FAT class acc. to Rules for Hull (Pt.1, Vol.II) Sec.20.Table 20.3)

Table 3.6 Factor f_n for the determination of the permissible stress range for free edges of plates with m_0 = 4

Stress Spectrum	Number of stress cycles n_{max}										
	$2\cdot10^4$	$5\cdot10^4$	10^5	$3\cdot10^5$	$6\cdot10^5$	10^6	$3\cdot10^6$	$6\cdot10^6$	10^7	$5\cdot10^7$	10^8
S0	7,78 8,83[1] 10,07[2]	6,85 7,32[1] 8,48[2]	6,20 6,62[1] 7,45[2]	5,28 5,60[1] 5,98[2]	4,73 5,00[1]	4,36 4,58[1]	3,65	3,22	2,93	2,19	1,95
S1	6,47 6,93[1] 8,09[2]	5,62 6,00[1] 6,68[2]	5,02 5,36[1] 5,80[2]	4,18 4,43[1]	3,72 3,88[1]	3,39	2,75	2,40	2,17	1,61	1,45
S2	5,54 5,94[1] 6,74[2]	4,75 5,07[1] 5,52[2]	4,21 4,49[1] 4,73[2]	3,56 3,63[1]	3,04	2,75	2,17	1,86	1,68	1,27	1,15
S3	4,67 5,00[1] 5,60[2]	3,97 4,24[1] 4,53[2]	3,49 3,72[1]	2,85	2,48	2,24	1,72	1,46	1,32	1,01	0,92
S4	3,95 4,24[1] 4,70[2]	3,33 3,56[1] 3,77[2]	2,91 3,11[1]	2,37	2,05	1,83	1,40	1,18	1,06	0,83	0,75
S5	3,39 3,63[1] 4,01[2]	2,84 3,04[1] 3,20[2]	2,48 2,66[1]	2,01	1,74	1,54	1,17	0,99	0,88	0,69	0,63
S6	2,96 3,17[1] 3,49[2]	2,47 2,65[1] 2,78[2]	2,15 2,30[1]	1,73	1,50	1,33	1,01	0,85	0,75	0,6	0,54
S7	2,70 2,90[1] 3,19[2]	2,25 2,41[1] 2,54[2]	1,96 2,11[1]	1,58	1,37	1,2	0,92	0,77	0,68	0,54	0,49

[1] for $\Delta\sigma_R$ < 150 [N/mm²]
[2] for $\Delta\sigma_R$ < 140 [N/mm²]
($\Delta\sigma_R$ FAT class acc. To Rules for Hull (Pt.1, Vol.II) Sec.20.Table 20.3)

Table 3.7 Factor f_n for the determination of the permissible stress range for free edges of plates with $m_0 = 5$

Stress Spectrum	Number of stress cycles n_{max}										
	$2 \cdot 10^4$	$5 \cdot 10^4$	10^5	$3 \cdot 10^5$	$6 \cdot 10^5$	10^6	$3 \cdot 10^6$	$6 \cdot 10^6$	10^7	$5 \cdot 10^7$	10^8
S0	7,29	6,42	5,83	4,96	4,47	4,14	3,49	3,14	2,91	2,30	2,09
S1	6,07	5,26	4,71	3,94	3,52	3,23	2,69	2,40	2,21	1,75	1,60
S2	5,19	4,46	3,95	3,27	2,88	2,63	2,17	1,92	1,77	1,42	1,30
S3	4,38	3,71	3,27	2,67	2,35	2,14	1,74	1,53	1,41	1,14	1,06
S4	3,71	3,11	2,73	2,21	1,94	1,76	1,42	1,24	1,14	0,94	0,87
S5	3,17	2,66	2,33	1,88	1,64	1,49	1,20	1,05	0,95	0,79	0,73
S6	2,77	2,31	2,01	1,63	1,42	1,28	1,03	0,90	0,81	0,68	0,63
S7	2,53	2,11	1,84	1,48	1,29	1,16	0,93	0,81	0,73	0,61	0,57

Table 3.8 Factor f_n for the straight-line stress spectrum with $n_{max} = 5 \cdot 10^7$

Welded joints	Free edges of plates		
$m_0 = 3$	$m_0 = 5$	$m_0 = 4$	$m_0 = 3{,}5$
3,53	3,63	3,66	3,65

5.2.2 The maximum stress range of the spectrum shall not exceed the permissible value $\Delta\sigma_p$:

$$\Delta\sigma_{max} \leq \Delta\sigma_p$$

$\Delta\sigma_{max}$ = maximum stress range acc. to 4.

$\Delta\sigma_p$ = permissible maximum stress range acc. to 5.2.1

5.2.3 The maximum permissible stress ranges are to be calculated by the following formula:

$$\Delta\sigma_p = f_n \cdot \Delta\sigma_{Rc}$$

$\Delta\sigma_{Rc}$ = corrected FAT class acc. to 5.2.4

f_n = factor for the shape and extent of the spectrum acc. to Table 3.4 to 3.8

5.2.4 The corrected FAT class is to be calculated as follows:

$$\Delta\sigma_{Rc} = f_m \cdot f_R \cdot f_w \cdot f_i \cdot f_t \cdot \Delta\sigma_R$$

$\Delta\sigma_R$ = FAT class acc. to Rules for Hull (Pt.1, Vol.II) Sec.20, Table 20.3, as well as EN 1993-1-9

f_m, f_R, f_w, f_t = correction coefficients for the influence of material, mean stress, shape of weld and plate thickness acc. to Rules for Hull (Pt.1,Vol.II) Sec.20

f_i = correction coefficient for the influence of the importance fi of the structural element acc. to Table 3.9

G. Proof of Suitability for Use

1. General notes

1.1 Loading gear as well as its structural elements and equipment is to be such designed and dimensioned, that its safety and proper functioning is not adversely affected or endangered by one or more of the influences stated hereafter:

- Deformations (e.g. formation of large amplitudes of vibration, bending loads on hydraulic cylinders of telescopic beams)
- Vibrations (e.g. generated by simultaneous operation of several loading gear drives, by ship machinery or influences of sea state)
- Heat (e.g. expansion, overheating of drives or brakes)
- highest position of boom (see Section 12, B.1.1)

1.2 Suitability for use is to be demonstrated in the course of the initial testing on board.

Table 3.9 Influence of the importance f_i of a structural element on the fatigue strength analysis

Accessibility	"Safe to operate" structural element	"Not safe to operate" structural element	
		No hazard to persons	Hazard to persons
Accessible structural elements	1,0	0,9	0,83
Badly accessible structural elements	0,95	0,87	0,8

"Safe to operate" structural elements are parts with restricted consequences of a failure, i.e. where the local breakage of a structural element does not result in the failure of the structure or fall-down of the load.

"Not safe to operate" structural elements are parts, where the local breakage of a structural element results in immediate failure of the structure of fall-down of the load.

2. Permissible deformations

2.1 Compression members

2.1.1 The uniform deflection of compression members under permissible load shall not be larger than the rod length divided by 250.

2.1.2 The uniform deflection of unloaded compression members or compression members loaded by the dead load, which are 1st order structural elements, shall not be larger than the rod length divided by 500.

2.1.3 The uniform deflection of unloaded compression members or compression members loaded by the dead load, which are 2nd order structural elements, such as e.g. wind installations or framework stiffeners shall not be larger than the rod length divided by 350.

2.2 Tension members

The uniform deflection of unloaded tension members shall not be larger than the rod length divided by 50.

H Joints

1. Proof of weld joints

1.1 Prerequisites

The strength of welding consumables is to be equal to or higher than that of the structural elements to be connected.

For further general prerequisites see Section 11.

1.2 General strength analysis

1.2.1 General notes

Weld thicknesses, which are the basis of the strength analysis, are given in Section 11, D for various shapes of welds.

1.2.2 Welds located in the plate plane

The permissible stress of welds located in the plate plane is the dimensioning value of the permissible stress of the adjoining plate acc. to D.2.2.3.1.

1.2.3 Fillet welds

For fillet welds, the strength analysis may be conducted acc. to the Rules for Hull (Pt.1, Vol.II), see Section 1, B.2.1.1, or acc. to a recognized basic principle of calculation or standard.

1.2.4 Plates loaded by tension transversely to the direction of rolling

.1 Where enhanced properties in thickness direction are required for plates and wide flat bar steel, the following minimum requirements apply for the reduction of area after fracture, Z, which is the mean value of 3 tensile test samples, to be taken with their longitudinal axis perpendicular to the surface of the product.

$$Z_{min} = 25\ \%$$

Of these, one single value may be less than 25 %, but not less than 20 %.

.2 Where structural elements are exposed to increased loads, a minimum value of 35 % (lowest single value 25%) may be required, see EN 1993-1-10.

1.3 Proof of fatigue strength

Regarding the proof of fatigue strength, the statements in F. apply.

2. Proofs for bolted connections

2.1 General notes

2.1.1 Bolted connections are to be dimensioned acc. to recognized guidelines, basic principles of calculation or standards, which possibly also allow for a fatigue strength analysis for the bolts.

2.1.2 The approaches acc. to 2.2 and 2.3 in principle imply that:

- connected areas are secured against distortion, e.g. by use of at least 2 bolts

- contacting areas are smooth and free from grease
- the use of bolts of **strength class 12.9** is agreed with BKI (see Table 3.11)

2.2 Gusset connections with fitting-bolts (Fitting-bolt shear connections)

2.2.1 Definition

In the case of fitting-bolt shear connections, the loads to be carried are transferred by form-fitting. These forces generate shear stresses in the bolts and bearing stresses at the gussets.

2.2.2 Construction notes

.1 Fig. 3.5 shows a typical gusset connection. If it is intended to be constructed as a fitting-bolt shear connection, the following notes shall be observed:

- The clearance between bolt and drilling hole shall correspond to the tolerance classes h13 and h11 (or less) acc. to ISO 286-2.
- Bolt shafts shall be as long as the thickness of the parts to be connected. Where, due to the cylindric shaft length, it is not possible to tighten the bolts, washers are to be used.
- Controlled pre-stressing of bolts is not required, however a suitable securing device against loosening.
- A special surface treatment of the contact areas is not required.
- Forces to be transferred may at the maximum be distributed over 5 (**strength classes 4.6** and **5.6**) or 3 (**strength classes 8.8**, **10.9** and possibly **12.9**) bolts per row, to be arranged one after another in the direction of force.

.2 Regarding the edge and hole distances acc. to Fig. 3.5, the limit values acc. to Table 3.10 apply.

Table 3.10 Limit values for edge and hole distances

	Min.	Max.[1]
Edge distances e_1 and e_2	$1{,}5 \cdot d_\ell$	$4 \cdot t + 40$ mm
Hole distances p_1 and p_2	$3{,}0 \cdot d_\ell$	The less value of $14 \cdot t$ or 200 mm
[1] t–thickness of the thinnest external plate.		

2.2.3 Permissible stresses for bearing stress and shearing-off

.1 For the bearing stress of structural elements made of steel as well as for the shearing-off of bolts, the following permissible stresses apply:

$$\sigma_{zul} = \alpha_\sigma \cdot \frac{R_{eH}}{\gamma_m \cdot 0{,}7} \quad \text{(bearing stress)}$$

$$\tau_{zul} = \alpha_\tau \cdot \frac{R_{eH,s}}{\sqrt{3} \cdot \gamma_m} \quad \text{(shearing-off)}$$

R_{eH} = yield strength of structural elements and/or gussets acc. to material standard (nominal value)

$R_{eH,s}$ = yield strength of bolts acc. to Table 3.1

.2 Correction coefficients α_σ, α_τ :

a) Multi-shear bolt connections

$\alpha_{\sigma m}$ = minimum of:

– $\frac{e_1}{3 \cdot d_\ell}$, or

– $\frac{p_1}{3 \cdot d_\ell} - 0{,}25$, or

– $\frac{R_{m,s}}{R_m}$, or

– 1,0

$\alpha_{\tau m}$ = 1,0

$R_{m,s}$ = tensile strength of bolts acc. to Table 3.11 [N/mm^2]

R_m = tensile strength of structural elements acc. to material standard (nominal value) [N/mm^2]

b) Single-shear bolt connections

$\alpha_{\sigma e}$ = $0{,}78 \cdot \alpha_{\sigma m}$

α_τ = 0,77

Table 3.11 Strength values of bolts

Strength class	4.6	5.6	8.8	10.9	12.9
$R_{eH,s}$ [N/mm^2]	240	300	640	900	1080
$R_{m,s}$ [N/mm^2]	400	500	800	1000	1200

2.2.4 Proofs for transmissible bolt forces

.1 To determine the largest bolt forces for the example in Fig. 3.5, the following forces are to be added geometrically:

$$\Delta F_{x,d} = \frac{F_{x,d}}{6}$$

$$\Delta F_{z,d} = \frac{F_{z,d}}{6}$$

$$\Delta F_{M,d} = \frac{M_{y,d} + F_{z,d} \cdot a}{4 \cdot \sqrt{0{,}25 \cdot p_1^2 + p_2^2}}$$

.2 For the most unfavourably stressed fitting-bolts on a connection or joint, the following proofs for shearing-off of bolts and bearing stresses of the connected parts are to be provided:

bearing stresses: $F_{r,d} \leq d_s \cdot t_{min} \cdot \sigma_{perm}$

shearing-off: $F_{r,d} \leq A_s \cdot n_f \cdot \tau_{perm}$

$F_{r,d}$ = largest resulting bolt force (rectangular to the bolt axis) acc. to 2.2.4.1

d_s = shaft diameter of the fitting-bolt (nominal diameter + 1,0 mm)

t_{min} = smallest effective plate thickness

A_s = cross-section area of shaft of fitting-bolt

n_f = number of effective shear areas (single-shear or multi-shear)

σ_{perm}, τ_{perm} = permissible stresses acc. to 2.2.3 [N/mm^2]

.3 In the case of a dynamic shear load, the fatigue strength analysis is to be conducted for the most unfavourably loaded fitting-bolt as follows:

Stress spectra are to be determined acc. to F.

The maximum stress range of the shear stress $\Delta\tau_{max}$ is to be determined acc. to F for the shaft cross section of the fitting-bolt.

The design S-N curve for shear stress of fitting-bolts is shown in Fig. 3.4.

The fatigue strength analysis may be conducted on the basis of calculated damage ratios acc. to F.

As an alternative, the fatigue strength analysis may be conducted on the basis of permissible stress ranges for the standard spectra S0 to S7 acc. to F as follows:

$$\Delta\tau_{max} \leq f_n \cdot f_i \cdot \Delta\tau_R$$

$\Delta\tau_{max}$ = maximum stress range of the shear stress for the shaft cross-section of the fitting-bolt

$\Delta\tau_R$ = reference value for the stress range of the shear stress at $2 \cdot 10^6$ stress cycles;

$\Delta\tau_R$ = 100 N/mm^2

f_n = factor for the shape and extent of the spectrum acc. to Table 3.12

f_i = influence of the importance of the structural element acc. to Table 3.9

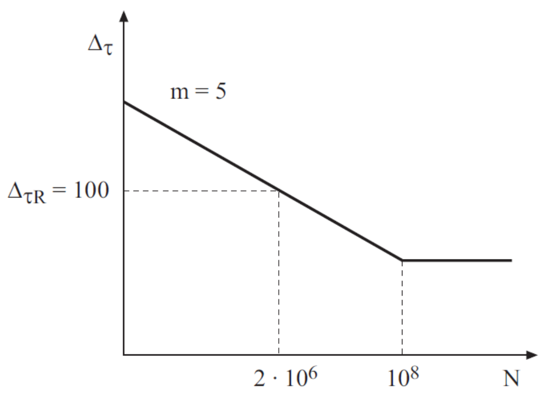

Fig. 3.4 Design S-N curve for shear load of fitting-bolts

2.2.5 Proofs for structural elements and gussets

The strength analyses for the structural elements and gussets connected with each other is to be based on the cross-sections designed for tension, compression, shear and bending acc. to C.4.

For the permissible stresses, see D.2.2.

2.3 Gasset connections with prestressed bolts (friction-grip connections)

2.3.1 Definition

With friction-grip connections, the forces to be sustained are submitted by friction between the contact areas (frictional locking).

Fitting-bolts with the normal clearance do not effect any increase in the transmissible forces.

Table 3.12 Factor f_n for standard stress range spectra S0 to S7 acc. to F and design S-N curve acc. to Fig. 3.4

Stress spectrum	Number of stress cycles n_{max}										
	$2 \cdot 10^4$	$5 \cdot 10^4$	10^5	$3 \cdot 10^5$	$6 \cdot 10^5$	10^6	$3 \cdot 10^6$	$6 \cdot 10^6$	10^7	$5 \cdot 10^7$	10^8
S0	7,29	6,42	5,83	4,96	4,47	4,14	3,49	3,13	2,88	2,24	2,01
S1	6,07	5,26	4,71	3,94	3,51	3,23	2,69	2,38	2,18	1,67	1,51
S2	5,19	4,46	3,95	3,27	2,88	2,63	2,16	1,91	1,73	1,32	1,19
S3	4,38	3,71	3,27	2,67	2,35	2,14	1,74	1,53	1,38	1,03	0,94
S4	3,71	3,11	2,73	2,21	1,94	1,76	1,42	1,24	1,13	0,82	0,76
S5	3,17	2,66	2,33	1,88	1,64	1,49	1,20	1,05	0,95	0,69	0,62
S6	2,77	2,31	2,01	1,63	1,42	1,28	1,03	0,90	0,81	0,59	0,53
S7	2,53	2,11	1,83	1,47	1,28	1,16	0,93	0,81	0,73	0,53	0,45

2.3.2 Construction notes

Fig. 3.5 shows a typical gusset connection. For construction purposes, the following notes shall be observed:

– Bolt holes shall not exceed the shaft diameter by more than 1,0 mm.

– The bolts are to be pre-stressed by controlled procedures and under consideration of the dispersion of the installation force to the maximum installation force $FM_{max} = \alpha_s \cdot R_{eH,s} \cdot A_\sigma$ where A_σ is the stress cross-section of the bolt. Preferably, the pre-stress coefficient is α_s = 0,7. Well-founded deviations in the range of $0{,}6 \le \alpha_s \le 0{,}8$ may be permitted.

– Up to a thread diameter of 30 mm, the pre-stress may be effected by the application of a torque. With larger diameters, hydraulic lengthening is to be applied.

– For the contact areas, a special surface treatment is required acc. to 2.3.3.

– Casting compound for compensation of unevennesses in the contact areas is not permissible.

– Only bolts of **strength class 8.8**, **10.9** and possibly **12.9** may be used (see Table 3.11).

– The forces to be submitted may be distributed over 3 rows of bolts at a maximum.

– The hole distances shall comply with the requirements acc. to 2.2.2.2.

– Only one plate of a gusset connection may have a plate thickness which is equal to, or higher than, the bolt diameter.

– Bolts of **strength class 12.9** require a highly accurate layout in the supporting areas under the head and nut (see Table 3.11).

2.3.3 Friction coefficient μ

The friction coefficient depends on the surface treatment and is to be selected as follows:

μ = 0,50 for surfaces:

- of shining metal layers, steel shot or sand blasted without unevennesses
- steel shot or sandblasted and covered with aluminium
- steel shot or sandblasted and metal covered by a metal cover made of a zinc material, which effects a friction coefficient of at least 0,5.

μ = 0,40 for surfaces: steel shot or sand blasted and coated with a 50 μm to 80 μm thick alkali-zinc-silicate layer

μ = 0,30 for surfaces: shiny metallic, cleaned with a steel brush or by flame deseaming

μ = 0,20 for surfaces: free of rust, oil and dirt.

2.3.4 Proof of transmissible forces

A sufficient slide resistance is to be proven for the most unfavorable bolt in a connection or joint, see example in 2.2.4.1, using the following condition:

$$F_{r,d} \leq F_{\mu,d} \cdot n_r$$

$$F_{\mu,d} = \left[\frac{1}{\alpha_A} \cdot \alpha_s \cdot R_{eH} \cdot A_\sigma - \Delta F_{Setz} - F_a\right] \frac{\mu}{\gamma_m \cdot 1{,}25}$$

$F_{\mu,d}$ = force transmissible by friction in 1 friction area

n_r = number of effective friction area

A_σ = stress section-area of the bolt acc. to Table 3.13.

F_a = external tension force in the direction of the bolt axis

μ = friction coefficient acc. to 2.3.3

ΔF_{Setz} = loss of pre-stress force by setting acc. to I.1.4.2

α_A = tightening factor of the tightening procedure used: $\alpha_A = F_{M,max}/F_{M,min}$

$F_{M,max}$ = maximum installation force in consideration of the dispersion of installation force for the tightening procedure used

$F_{M,min}$ = minimum installation force in consideration of the dispersion of installation force for the tightening procedure used

Additionally, sufficient resistance against shearing-off and bearing pressure acc. to 2.2 is to be proven, including the calculation of the shear capability of the stress cross-section A_σ.

2.3.5 Proof of surface pressure under head and nut of the bolt

For material S 235 and, where applicable, also for S 355, proof of the permissible surface pressure under the head or nut of the bolt respectively, is to be to carried out in the following way:

$$\frac{\alpha_s \cdot R_{eH} \cdot A_\sigma + F_{a,d} \cdot \Phi}{A_a} \leq \sigma_{p,\,perm}$$

If proof cannot be provided, tempered washers shall be used.

$\sigma_{p, perm}$ = permissible surface pressure in acc. with Table 3.14 [N/mm²]

A_a = smallest contact surface of the bolt head or nut, considering bore diameter and chamfers [mm²]

$F_{a,d}$ = dimensioning value of the external tensile force in the direction of the bolt axis

Φ = tensioning factor acc. to I.1.3.2

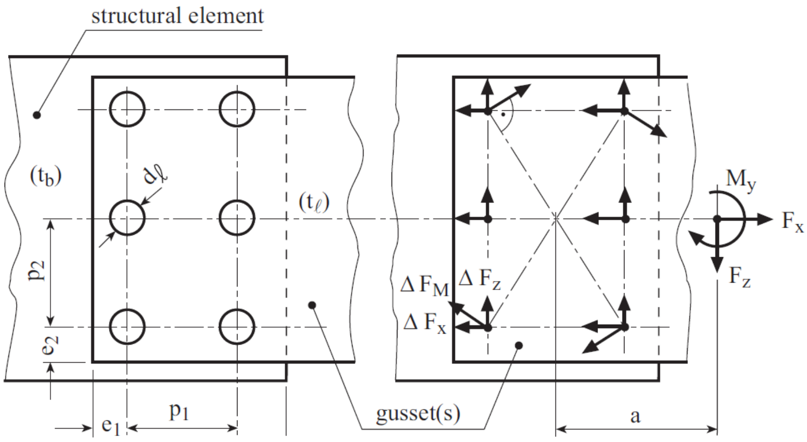

Fig. 3.5 Example of a gusset connection

2.3.6 Proofs for structural elements and gussets

For the strength analyses the statements acc. to 2.2.5 apply. It may be assumed, that ⅓ of the force $F_{\mu,d}$ transmissible by friction, has already been transmitted before the bolt hole, see 2.3.4.

Table 3.13 Stress and core sections of bolts

Diameter [mm]	Stress section A_σ [mm²]	Core section A_k [mm²]
Metric ISO thread, acc. to DIN 13		
12	84,3	76,25
14	115	104,7
16	157	144,1
18	193	175,1
20	245	225,2
22	303	281,5
24	353	324,3
27	459	427,1
30	561	519,0

Table 3.13 Stress and core sections of bolts *(continued)*

Diameter [mm]	Stress section A_σ [mm²]	Core section A_k [mm²]
Metric thread with large clearance, acc, to DIN 2510, Sheet 2		
33	668	617
36	786	723
39	943	873
42	1083	999
45	1265	1174
48	1426	1320
52	1707	1590
56	1971	1833
64	2599	2426
72	3372	3174
80	4245	4023
90	5479	5226
100	6858	6575

Table 3.14 Permissible surface pressure under heads and nuts of bolts

Material	$\sigma_{p,\, perm}$ [N/mm²]
S 235	260
S 355, C45N, 46G2N, 46Cr4N	420
C45V, 46Cr4V, 42CrMo4V	700
GG25	800

3. Proofs for rivet connections

For proof of rivet/shear connections, the statements in 2.2 apply analogously. Instead of shaft diameter, the hole diameter is to be used.

Only hydraulic riveting is permissible. The clamping length of the rivet is to be restricted to the value $6{,}5 \cdot d_{rivet}$, where d_{rivet} is the nominal diameter of the rivet.

I. Special Structural Elements

1. Flange connections with prestressed bolts

1.1 General

1.1.1 In the case of flange connections with prestressed bolts, the forces to be sustained are transmitted by tensional load of the bolts and possibly by friction fitting.

1.1.2 The provisions under 1.3 and 1.4 do not apply to flanges for the connection of large slewing bearings. In this respect Section 4, G.4.1 shall be observed.

1.2 Construction note

Fig. 3.6 shows a typical flange connection. For construction purposes, the following notes shall be observed:

- Bolt holes may be larger than the shaft diameter ds by the value Δd:

  $\Delta d \leq 0{,}1 \cdot d_s \leq 3{,}0$ mm

- In general, the bolt distance s (see Fig. 4.4) shall not be larger than $6 \cdot d_s$.
- In general, the span length of bolts shall be at least $3 \cdot d_s$.
- At least 3 threads shall remain free.
- The bolts are to be pretensioned by controlled procedures. The degree of utilization ν of the yield strength $R_{eH,s}$ of the bolt in the mounted condition is preferably in the range $0{,}7 \leq \nu \leq 0{,}9$. Well-founded deviations may be permitted.
- Up to a thread diameter of 30 mm, pretension may be conducted by application of a torque, in the case of larger diameters hydraulic lengthening is required.
- The contact surfaces require a special surface treatment acc. to 2.3.3.
- Casting compound for compensation of unevennesses of the contact areas is not permissible, unless otherwise stated by slewing bearing makers.
- Only bolts of **strength class 8.8**, **10.9** and possibly **12.9** may be used (see Table 3.11).
- Bolts of **strength class 12.9** require a highly accurate layout in the supporting areas under the head and nut (see Table 3.11).

1.3 Forces acting on a flange connection

1.3.1 Fig. 3.6 shows a typical flange connection with its essential dimensions and the proportional external axial force F_a per bolt sector.

The external axial force F_a acting on the individual bolt location of the flange connection may normally be determined by means of elastomechanics from the operational loads of the gusset connection.

In the case of an excentric load, the compensating line of action of the external axial force has the distance a_{ers} from the bolt axis. The distance a_{ers} is to be determined from the location of the zero point of the bending moment curve of the system, which is the nearest to the bolt.

1.3.2 The external force F_a in the connecting parts (tension force) acts as an additional load on the prestressed bolt and reduces the surface pressure in the parting line. The force ratio Φ governs the portion of the external axial force, which acts on the bolt additionally to the prestressing force, as well as the remaining portion, which discharges the tensioned structural elements.

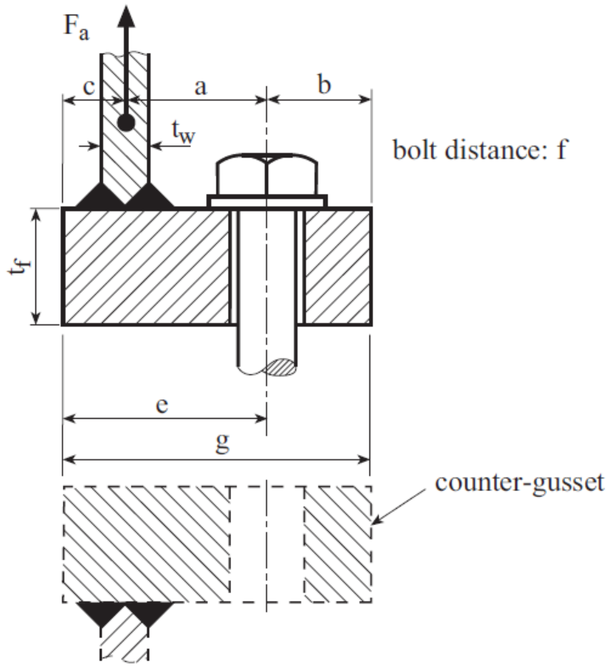

Fig. 3.6 Flange connection

The force ratio Φ depends on the resiliences of the bolt and the tensioned structural elements, the excentricity of the tensioning and/or the external operational force as well as the leading-in of the force. The reliable determination of Φ is therefore complex and shall in principle be conducted by way of measurement techniques or based on recognized calculation procedures.

Provided that the bending of the bolt due to the excentricity of the tensioning and the bending of the bolt due to the excentricity of the external axial force F_a do not superimpose each other in the same direction, Φ may be approximately calculated as follows:

$\Phi = \alpha$ for proofs in 1.4.1, 1.4.3, 1.5.1 and H.2.3.5

$= 0$ for proofs in 1.4.2 and 1.5

$$\alpha = \gamma_m \cdot \frac{\delta_p}{\delta_p + \delta_s}$$

$$\delta_s = \frac{4}{\pi \cdot E_s} \cdot \frac{l_k}{d_s^2}$$

$$\delta_p = \frac{4}{\pi \cdot E_s} \cdot \left[\frac{l_k - 2 \cdot (D_A - d_w)}{D_A^2 - d_s^2} + 2 \cdot \frac{D_A - d_w}{D_A \cdot d_w - d_s^2} \right]$$

$$D_A = \min \begin{bmatrix} g \\ f \\ l_k / 2 + d_w \end{bmatrix}$$

δ_s = axial resilience of the bolt [mm/N]

δ_p = axial resilience of the tensioned structural elements [mm/N]

l_k = clamping length [mm]

d_s = shaft diameter of the bolt [mm]

E_s = Young's modulus of the bolt [N/mm^2]

E_p = Young's modulus of the tensioned structural elements [N/mm^2]

d_w = head bearing diameter [mm]

g = flange dimension acc. to Fig. 3.6 [mm]

f = bolt distance [mm]

1.4 Proofs for the external tension force F_a of the bolt

The proofs described in the following apply to bolt connections with an external axial force F_a acc. to 1.3.1 provided that:

- Tensioned structural elements form simple prismatic bodies.
- The load on the bolt is proportional to the external axial force.
- Where external loads are absent, the surface pressure in the parting line of the prestressed bolt connection is to a large extent evenly distributed.

A surface pressure in the parting line of the prestressed bolt connection, to a large extent evenly distributed,

may normally be assumed if the dimensions of the parting line are as follows:

$$g < d_w + t_f$$

t_f = thickness of the thinner flange plate

Bolt connections which are in addition to an external axial force or solely loaded by an external bending moment, are to be proven separately.

1.4.1 Proof of yield strength of the bolt

In the mounted condition, the following condition is to be observed:

$$F_{M,max} \leq F_{M,perm}$$

$$F_{M,perm} = \frac{\nu \cdot A_\sigma \cdot R_{eH,s}}{\sqrt{1+3\cdot\left[\frac{3}{2}\cdot\frac{d_2}{d_\sigma}\cdot\left(\frac{P}{\pi\cdot d_2}+1{,}155\cdot\mu_G\right)\right]^2}}$$

Where torsion-free tightening procedures are applied, the permissible installation force $F_{M,perm}$ is as follows:

$$F_{M,perm} = \nu \cdot A_\sigma \cdot R_{eH,s}$$

$F_{M,max}$ = maximum installation force

$F_{M,perm}$ = permissible installation force

$R_{eH,s}$ = yielding strength of the bolt

ν = predefined degree of utility of the yield strength in the mounted condition

A_σ = stress cross-section of the bolt acc. to Table 3.13

d_σ = stress diameter of the bolt

d_2 = effective diameter of the bolt

P = pitch of thread

μ_G = friction coefficient in the thread

If there is no information about the friction coefficient μ_G in the thread, the friction coefficient is to be estimated conservatively, e.g. acc. to VDI Guidelines 2230 Part 2; "Systematic calculation of highly stressed bolted joints - Multi bolted joints" with consideration of surface properties and lubricants used.

In service, the equivalent stress of the bolt shall not exceed the permissible value

$$\sigma_{v,d} \leq \frac{R_{eH,s}}{\gamma_m}$$

$$\sigma_{v,d} = \sqrt{\sigma_{z,d}^2 + 3 \cdot \tau_{red,d}^2}$$

$$\sigma_{z,d} = \frac{F_{S,d}}{A_\sigma}$$

$$\tau_{red,d} = F_{M,max} \cdot \frac{4 \cdot d_2}{\pi \cdot d_\sigma^3} \cdot \left(\frac{P}{\pi \cdot d_2} + 1{,}155 \cdot \mu_G \right)$$

$$F_{S,d} = F_{M,max} + \Phi \cdot F_{a,d}$$

In the case of torsion-free tightening procedures or in the case of complete reduction of torsion stresses in the thread in service, proof of operational stress of the bolt may be conducted as follows:

$$F_{a,d} \leq \frac{1}{\Phi} \cdot \left(\frac{R_{eH,s} \cdot A_\sigma}{\gamma_m} - F_{M,max} \right)$$

$\sigma_{v,d}$ = design value of the maximum equivalent stress of the bolt in operation

$\sigma_{z,d}$ = design value of the maximum tensile stress of the bolt in operation.

$\tau_{red,d}$ = design value of the reduced maximum torsion stress of the bolt in operation

$F_{S,d}$ = design value of the maximum bolt force in operation

1.4.2 Proof against open gap

The following condition is to be met for the proof against open gap (see Fig. 3.6):

$$F_{a,d} \leq \frac{F_{V,min}}{\frac{f_{eff} \cdot g_{eff} + 9{,}4 \cdot (e+z) \cdot (a_{ers} + z)}{f_{eff} \cdot g_{eff} + 9{,}4 \cdot (e+z) \cdot z} - \Phi}$$

$F_{V,min}$ = $F_{M,min} - \Delta F_{Setz}$

$F_{M,min}$ = $F_{M,max} / \alpha_A$

$$\Delta F_{Setz} = 3{,}29 \cdot 10^{-3} \cdot \left(\frac{l_k}{d} \right)^{0{,}34} \cdot \frac{1}{\delta_s + \delta_p}$$

$F_{V,min}$ = lowest pre-stressing force of the bolt

$F_{M,min}$ = smallest installation force

α_A = tightening factor of the tightening procedure used (see H.2.3.4)

ΔF_{Setz} = loss of pre-stressing force due to setting [N]

A 2-fold pre-stressing with time-lag reduces the setting to a residual value, which may possibly be disregarded.

δ_s, δ_p = resilience of the bolt and the tensioned structural elements acc. to 1.3.2 [mm/N]

a_{ers} = distance between the compensating line of action from F_a and the bolt axis acc. to 1.3.1

f_{eff} = the smaller value of f or $(d_w + t_f)$

g_{eff} = the smaller value of g or $(d_w + t_f)$

z = the smaller value of 0 or $\left(\frac{g_{eff}}{2} - e\right)$ for $g \le d_w + t_f$;

= the smaller value of 0 or $\left(g - \frac{g_{eff}}{2} - e\right)$ for $g > d_w + t_f$

In the case of through-bolt connections, for t_f the thickness of the thinner gusset plate is to be assumed, in the case of screw-in connections, the thickness of the gusset plate with the through-bore.

Minor one-sided gapping of the parting line is accepted in the above condition. Large-area gapping of the parting line may be accepted if the bolt connection, by means of measurement techniques, or based on recognized calculation procedures, while considering the progressive increase of the bolt stress due to removal of tensioned structural elements, is proven separately.

1.4.3 Proofs of fatigue strength

In the case of dynamic loads, proof of fatigue strength of the bolts is to be conducted as stated in the following.

Stress range spectra are to be determined acc. to F.

The maximum stress range of the normal stress $\Delta\sigma_{max}$ is to be determined acc. to F. for the stress cross-section of the thread of the bolt.

For a proof of fatigue strength of gaping bolt connections, e.g. by numeric calculation methods, $\Delta\sigma_{max}$ is to be determined for the lowest prestress force of the bolt $F_{V,min}$.

When the stress range of the normal stress $\Delta\sigma_{max}$ is calculated, tensile and bending stresses in the stress cross-section of the thread of the bolt are to be taken into consideration. For the bending stress in the cross-section of the thread's stress cross-section the following applies:

$$\sigma_b = \frac{1}{\kappa} \cdot \frac{E_s}{E_p} \cdot \frac{32 \cdot F_a \cdot (a_{ers} + z)}{\pi \cdot d_\sigma^3}$$

$$\kappa = 1{,}7 \cdot \frac{f_{eff} \cdot g_{eff}^3}{d_s^4} - 1$$

σ_b = bending stress in the stress cross-section of the thread of the bolt

d_s = shaft diameter of the bolt

The design S-N curves for proofs of fatigue strength of prestressed bolts are shown in Fig. 3.7.

The proof of fatigue strength may be conducted on the basis of calculated cumulative damage ratios acc. to F.

Alternatively, the proof of fatigue strength may be conducted based on permissible stress ranges for the standard spectra S0 to S7 acc. to F as follows:

$$\Delta\sigma_{max} \leq f_n \cdot k_s \cdot f_i \cdot \Delta\sigma_R$$

k_s = 1 for d ≤ 30 mm

= $(30/d)^{0,25}$ for d > 30 mm

$\Delta\sigma_{max}$ = maximum stress range of the normal stress in the stress cross-section of the bolt

$\Delta\sigma_R$ = reference value of the stress range of the normal stress at $2 \cdot 10^6$ stress cycles

= 71 N/mm² for bolts either tempered or rolled as final treatment

= 50 N/mm² for all other bolts

f_n = factor for shape and extent of the spectrum acc. to Table 3.15

f_i = influence of importance of structural element acc. to Table 3.9

k_s = influence factor for size

d = nominal thread diameter

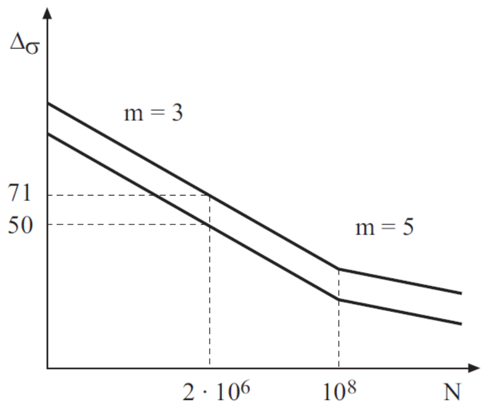

Fig. 3.7 Design S-N curves for prestressed bolts

Table 3.15 Factor f_n for standard stress range spectra S0 - S7 acc. to F and design S-N curve acc. to Fig. 3.7

Stress spectrum	Number of stress cycles n_{max}										
	$2 \cdot 10^4$	$5 \cdot 10^4$	10^5	$3 \cdot 10^5$	$6 \cdot 10^5$	10^6	$3 \cdot 10^6$	$6 \cdot 10^6$	10^7	$5 \cdot 10^7$	10^8
S0	16,54	12,94	10,68	7,84	6,44	5,55	4,06	3,33	2,87	1,82	1,51
S1	12,63	9,70	7,87	5,68	4,61	3,97	2,84	2,29	1,95	1,23	1,03
S2	10,25	7,75	6,23	4,43	3,57	3,04	2,15	1,72	1,46	0,89	0,76
S3	8,36	6,23	5,00	3,52	2,82	2,40	1,68	1,34	1,14	0,68	0,58
S4	6,93	5,16	4,12	2,88	2,30	1,95	1,36	1,08	0,92	0,54	0,46
S5	5,92	4,38	3,48	2,44	1,94	1,64	1,14	0,91	0,77	0,45	0,37
S6	5,13	3,78	3,02	2,09	1,66	1,40	0,98	0,78	0,66	0,39	0,31
S7	4,67	3,45	2,73	1,89	1,51	1,27	0,88	0,70	0,59	0,35	0,28

1.5 Proof of transmissible forces in the clamping gap

The statements in H.2.3.4 apply, where $n_r = 1$.

Normally, this proof is not to be conducted for the connection of large diameter slewing rings.

1.5.1 Proof of surface pressure below head and nut of bolt

The statements in H.2.3.5 apply.

1.5.2 Construction and calculation of flanges

.1 Construction

The dimensions a, b and c in Fig. 3.6 shall comply with the following requirements:

1) not larger than necessary for clamping tools
2) sufficiently large for generating the supporting force
3) sufficiently large for the weld, including the excess length required for the welding process $b/a \geq 0{,}75$

The workmanship of the weld next to the connecting bolts requires special diligence.

.2 Calculation of flange thickness

The gusset thickness t_f may, simplified, be calculated as follows:

$$t_f \geq \sqrt{\alpha_e \cdot \frac{\sigma_w \cdot t_w \cdot a}{\sigma_{F,perm}}}$$

α_e	=	coefficient for the construction of the wall	
	=	5,0	for cylindric walls
	=	6,0	for flat walls
σ_w	=	existing stress in the wall	
$\sigma_{F,perm}$	=	permissible stress in the flange acc. to D.2.2	

2. Hydraulic cylinders

2.1 General notes

For compression and tension loaded hydraulic cylinders, the following proofs are to be conducted for the operating conditions "loading gear in operation" and "loading gear out of operation":

– proof of structural safety acc. to D
– proof of fatigue strength acc. to F
– proof of suitability for use acc. to G

2.2 Simplified dimensioning of cylinder pipes

2.2.1 For thin-walled cylinder pipes, the required wall thickness $t_{w,req}$ may be calculated as follows, if the requirement acc. to 2.2.2 is complied with:

$$t_{w,req} = \frac{1{,}7 \cdot D_a \cdot p_c}{20 \cdot f_{yr} + 1{,}7 \cdot p_c}$$

D_a = outer diameter [mm]

p_c = setting pressure of the relief valves acc. to Section 9, F.2.2 [bar]

f_{yr} = calculated yield strength acc. to C.3.2 [N/mm^2]

2.2.2 The formula in 2.2.1 for the required wall thickness is based on the shear stress hypothesis. Therefore the following condition shall be complied with, if the cylinder pipe is dimensioned using this formula:

$$-p_c \le \sigma_\ell \le p_c \cdot \left(\frac{D_a}{2 \cdot t_w} - 1\right)$$

σ_ℓ = longitudinal stress in the cylinder pipe (characteristic value without partial safety factor γ_p)

2.2.3 The wall thickness t_w of the cylinder pipe is to comply with the following requirement:

$$t_w \ge t_{w,req} + c$$

t_w = wall thickness of the cylinder pipe

$t_{w,req}$ = required wall thickness acc. to 2.2.1

c = addition acc. to 2.2.3

2.2.4 Cylinder pipes, not complying with the condition acc. to 2.2.2, are to be proven acc. to D. In this case, the partial safety factor for the internal pressure (= setting pressure p_c of the safety valves) is:

$$\gamma_p = 1{,}34$$

2.2.5 A calculated strength analysis is to be conducted for the connecting welds of the pipes.

2.2.6 In order to avoid local bending stresses, the head and bottom plate of the cylinder pipes shall not fall below the following minimum thickness:

$$t_p \ge 3 \cdot t_w$$

t_p = thickness of head or bottom plate, respectively

t_w = wall thickness of the cylinder pipe

2.3 Notes regarding the proof of stability

2.3.1 The proof of stability is acc. to D.2.3 to be conducted for the most unfavourable combination of buckling length ℓ_{ki} and respective pressure (depending on the kinematics of the loading gear).

2.3.2 The dimensioning force shall include the partial safety factors γ_p as well as any dynamic coefficients (ψ) and is to be calculated for the most unfavourable load combination.

2.3.3 As an imperfection for the proof of stability, a distortion of the hydraulic cylinder of $\ell_{ki}/300$ is to be taken into consideration.

2.3.4 At the ends of the cylinder, the following moment shall be assumed due to friction of the carrier bolts:

$$M = N_d \cdot \mu \cdot d_B/2$$

N_d = dimensioning force (pressure) in the hydraulic cylinder including the partial safety factors γ_p

μ = 0,08 (= friction coefficient)

d_B = bolt diameter

2.4 Notes regarding the tensile stresses

In the case of tensile-stressed hydraulic cylinders, particular attention is to be paid to the thread of the piston rod during strength analysis.

3. Large cylindric pipes

3.1 Dimensions and loads

3.1.1 Fig. 3.8 shows the dimensions and loads of circular cylinder shells.

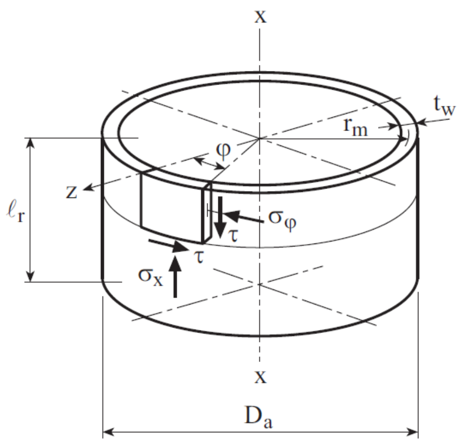

Fig. 3.8 Dimensions and loads of circular cylinders

r_m	=	radius, related to the middle of wall thickness	[mm]
t_w	=	Wall thickness	[mm]
ℓ_r	=	pipe length	[mm]
D_a	=	outer diameter (nominal diameter)	[mm]
σ_x	=	longitudinal stress	[N/mm^2]
τ	=	shear stress	[N/mm^2]
σ_φ	=	circumferential stress	[N/mm^2]

3.1.2 The longitudinal and shear stresses are calculated as follows:

$$\sigma_x = \frac{1}{r_m \cdot t_w \cdot \pi} \cdot \left(\frac{F_x}{2} + \frac{M_z}{r_m} \right)$$

$$\tau = \frac{1}{r_m \cdot t_w \cdot \pi} \cdot \left(F_z + \frac{M_x}{2 \cdot r_m} \right)$$

σ_x = longitudinal stress [N/mm²]

τ = shear stress [N/mm²]

F_x = force in x-direction [N]

F_z = force in z-direction [N]

M_z = bending moment [Nmm]

M_x = torsional moment [Nmm]

3.2 Proofs of stability

3.2.1 Proofs against buckling are to be performed acc. to D.2.3. Proofs against shell buckling may be conducted acc. to EN 1993-1-6.

3.2.2 Regarding the application of the proofs of stability acc. to EN 1993-1-6, the following is to be observed:

– Instead of safety factor γ_{M1}, the value γ_M acc. to C.7.4.3 is to be used.

– Instead of the yield strength, the calculated yield strength f_{yr} acc. to C.3.2 is to be used.

3.2.3 Proofs against shell buckling need not be conducted, if the following requirements are complied with:

a) pipes loaded by stress in circumferential direction[1]

$$\frac{r_m}{t_w} \leq 0{,}21 \cdot \sqrt{\frac{E}{R_{eH}}}$$

E = Young's modulus [N/mm²]

= $2{,}06 \cdot 10^5$ N/mm² for steel

R_{eH} = yield strength acc. to material standards [N/mm²]

b) pipes loaded by compression in longitudinal direction[1]

$$\frac{r_m}{t_w} \leq 0{,}03 \cdot \frac{E}{R_{eH}}$$

c) pipes loaded by shear[1]

$$\frac{r_m}{t_w} \leq \left(\frac{E}{15 \cdot R_{eH}} \right)^{2/3}$$

d) very long pipes, loaded by compression[1]

$$\frac{\ell_{ki}}{r_m} \geq 10 \cdot \sqrt{\frac{r_m}{t_w}}$$

ℓ_{ki} = buckling length of the pipe [mm]

[1] These proofs apply provided that the edges are radially undisplacable

3.2.4 The requirements acc. to 3.2.3 apply, provided that the imperfections acc. to 3.3 are not exceeded during manufacture.

3.3 Imperfections due to manufacture

3.3.1 Curvatures

In the case of outward or inward curvatures caused by manufacture, the depth gauge f acc. to Fig. 3.9 shall not exceed 1 % of the smallest gauge length. The following gauge lengths apply:

gauge length in longitudinal direction of the pipe [mm]

$$\ell_{mx} = 4 \cdot \sqrt{r_m \cdot t_w} \quad \text{(in the unwelded area)}$$

$$= 25 \cdot t_{min} \leq 500\text{mm} \quad \text{(in the area of welds)}$$

gauge length in circumferential direction [mm]

$$\ell_{m\varphi} = \frac{2{,}3 \cdot r_m}{\left(r_m / \ell_r\right)^{1/2} \cdot \left(r_m / t_w\right)^{1/4}} \leq r_m \quad \text{(in the unwelded area)}$$

$$= 25 \cdot t_{min} \leq 500 \text{ mm} \quad \text{(in the area of welds)}$$

t_{min} = thickness of the thinner plate adjacent to the weld

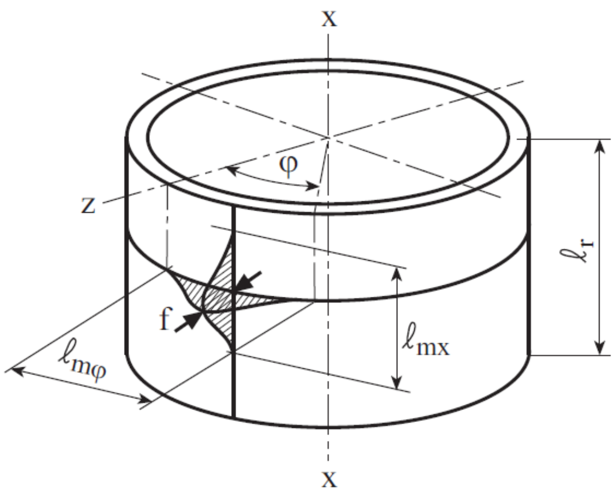

Fig. 3.9 Curvature including designations

3.3.2 Out-of-roundness

.1 The out-of-roundness is defined as follows:

$$U = \frac{d_{max} - d_{min}}{d_{nom}} \cdot 100 \quad [\%]$$

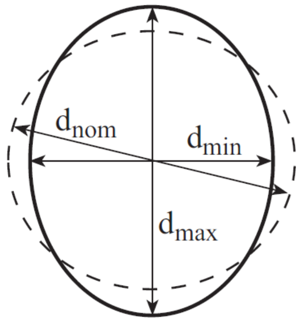

Fig. 3.10 Measurement of the diameters for determination of out-of-roundness

.2 The permissible out-of-roundness U_{adm} may be calculated as follows:

$U_{adm} \leq 2{,}0\ \%$ for $d_{nom} \leq 500$ mm

$\leq 2{,}0 - \dfrac{d_{nom} - 500}{750}$ [%] for $500 < d_{nom} < 1250$ mm

$\leq 1{,}0\ \%$ for $d_{nom} \geq 1250$ mm

Proof format = $U \leq U_{adm}$

3.3.3 Excentricities in x-direction

Planned eccentricities or eccentricities due to manufacture, located at the centerline of joints of plates with equal or differing wall thickness t_w shall not exceed the following values e_x:

$e_x \leq 0{,}2 \cdot t_{min} \leq 3$ mm

t_{min} = the smaller of the two plate thicknesses

4. Shear connection of circular structural elements

Regarding the connection of circular masts, posts and crane columns with e.g. deck plates, the required plate thickness of the deck plating t_p and the required weld thickness a may be determined acc. to the following formula:

$$t_p \text{ or } a \geq \frac{\gamma_m \cdot \sqrt{12}}{D \cdot f_{yr} \cdot \pi} \cdot \left(F_z + \frac{M_x}{D}\right) \quad [mm]$$

t_p = required minimum thickness of deck plates

a = required minimum thickness of weld

D = connection diameter [mm] (D_a or possibly D_i)

f_{yr} = calculated yield strength acc. to C.3.2 [N/mm²]

γ_m = partial safety factor for resistance values acc. to C.7.4.3 [-]

F_z = maximum horizontal force to be transmitted [N]

M_x = torsional moment of the connection [Nmm]

The internal forces F_z and M_x are dimensioning values and include the partial safety factors γ_p for loads acc. to C.7.4.

Regarding the designation of axes see Fig. 3.8.

5. Local loads due to wheel loads

5.1 General notes

5.1.1 Local loads due to wheel loads occur mainly with rails, girders of crane rails and girders of trolleys.

Structural elements which are e.g. loaded by wheels of fork lift trucks are to be treated analogously.

5.1.2 Local loads shall be taken into consideration, when the proof of structural safety acc. to D. as well as the proof of fatigue strength acc. to F. are conducted.

5.2 Girders of crane rails

5.2.1 For the calculation of the local compression stresses, the relationships as shown in Fig. 3.11 apply.

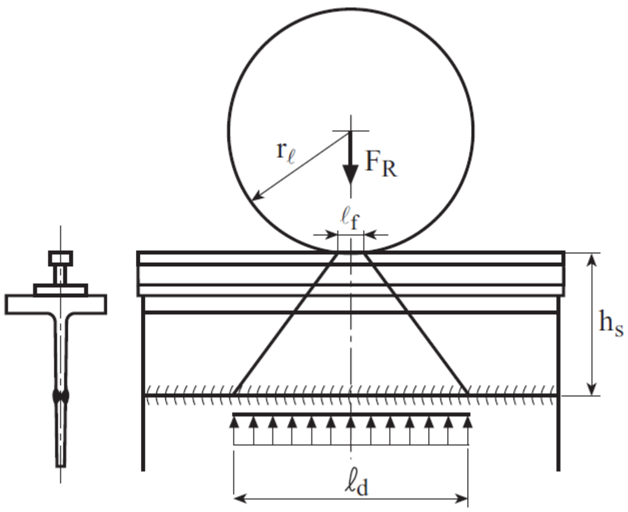

Fig. 3.11 Pressure distribution of wheel loads

ℓ_d = length of pressure distribution [mm]

= $2 \cdot h_s + \ell_f$

h_s = distance between contact area of the wheel and intersection line considered [mm]

ℓ_f = length of contact area of the wheel [mm]

= $0{,}2 \cdot r_\ell \le 50$ mm

r_ℓ = running radius [mm]

F_R = wheel load [N]

5.2.2 Regarding the connecting welds of crane rails made of square steel bars and welds joining web and flange, it shall be assumed that the transmitted pressure takes place solely through the welds.

5.3 Girders of trolleys

5.3.1 In Fig. 3.12, typical local deformations are shown highly magnified.

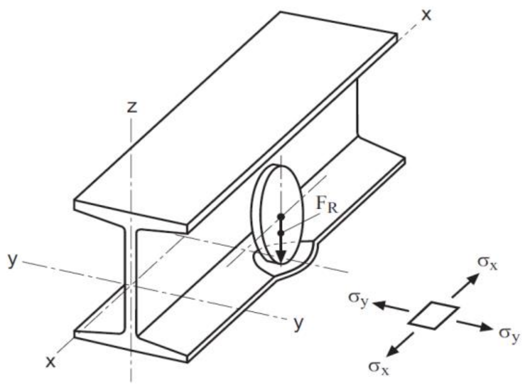

Fig. 3.12 Local deformation of girders of trolleys (highly magnified) F_R = wheel load

F_R = wheel load

σ_x, σ_y = local and global stresses

5.3.2 Calculation of local stresses in the lower flanges of girders for trolleys may be conducted in accordance with a recognized calculation method or standard.

5.3.3 For general strength analysis, local and global stresses are to be superimposed, with the local stresses reduced to 75 %.

5.3.4 In the case of lower flanges welded to the web, for the connecting weld a proof of fatigue strength may possibly be required.

6. Bolt connections

6.1 Bolts are to be secured against falling out. Outer bearing plates and gussets are to be secured against gapping.

6.2 Bolt connections are to be proven acc. to Section 7, C.4.4.

7. Eye plates and eye rods

7.1 Proof of eye plates may be conducted acc. to Section 7, C.4.3.

7.2 Eye rods acc. to Fig. 3.13. may be dimensioned as follows:

$$a \geq \frac{F}{2 \cdot t} \cdot \frac{\gamma_m}{f_{yr}} + \frac{2}{3} \cdot d_\ell$$

$$b \geq \frac{F}{2 \cdot t} \cdot \frac{\gamma_m}{f_{yr}} + \frac{1}{3} \cdot d_\ell$$

$$d_\ell \geq d_b + \Delta d$$

F = dimensioning value of the tensile force (including partial security factor γ_p acc. to C. 7.4)

f_{yr} = calculated yield strength acc. to C.3.2

γ_m = partial safety factor for resistance values acc. to C.7.4.3

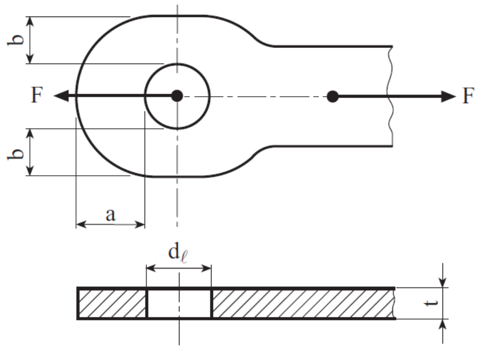

Fig. 3.13 Example of an eye rod

8. Joints of hollow profile girders

Dimensioning of hollow profile girder joints may be performed acc. to EN 1993-1-8.

Alternatively, a shape strength analysis for the joints of hollow profiles to other hollow profiles or open profiles may be conducted based on another recognized calculation method.

9. Stairs, ladders, platforms and railings

9.1 Load assumptions

9.1.1 Accesses, platforms, etc. are to be dimensioned for a distributed load of at least 3000 N/m^2 or for a movable single load of 1500 N.

9.1.2 Guard-rails and toe boards shall be dimensioned for a lateral load in the form of a movable single load of 300 N.

9.1.3 The loads acc. to 9.1.1 and 9.1.2 need not be considered for the global calculation of lifting appliances.

9.2 Proof of structural safety

9.2.1 Proof of structural safety is to be conducted acc. to D.

9.2.2 The partial safety factor for the loads is γ_p = 1,34.

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Section 4 Cranes and Supporting Structures

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A. General

1. Description of contents

1.1 This Section contains requirements for design and dimensioning of cranes and their supporting structures onboard ships and offshore installations which are also correspondingly applicable to other loading gear and their supporting structures according to Section 1, A.3.1.

1.2 The type of design is not subject to restrictions. However, the requirements of G. shall be taken into account.

1.3 The dimensioning is based on Section 3 and distinguishes between the conditions "in service" and "out of service" for all proofs.

2. Influences caused by the ship and the ship's operation

2.1 Apart from special tasks, such as e.g. handling of hatch covers or offshore activities, the ship's influence shall also be considered for the design and dimensioning of cranes on board ships predetermined e.g. by the form of the hull, its bending and torsional stiffness or the ship's operation.

Possible influences to be considered may be:

- arrangement of the cranes on the ship
- stability of the ship
- area of operation of the ship
- high ship speed
- sea lashing of the cranes
- special operating conditions

2.2 The increase of load radius of cranes due to the existing heel of the ship and/or the heel generated by the lifting of load may be taken advantage of upon approval by BKI. The values of Table 3.1 shall be complied with.

3. Dimensioning of cranes

The cranes listed in the following are to be dimensioned according to different criteria.

3.1 Shipboard cranes

3.1.1 Cranes for harbour operation

3.1.2 Cranes for sea operation

3.2 Offshore cranes

Slewing cranes on offshore installations used for loading and unloading of supply ships as well as for hoisting tasks on the installation.

3.3 Floating cranes

Depending on their use, floating cranes are to be dealt with like ship cranes for harbour or sea operation, respectively.

3.4 Loading gear not handling cargo

Loading gear used onboard of ships or installations are to be dealt with like ship cranes for harbour operation, taking into consideration their service or environmental conditions.

4. Dimensioning of supporting structures

4.1 The principal supporting structures are:

- crane columns
- crane foundations
- runways for mobile cranes
- crane boom supports
- structural transits into the ship's hull or the offshore installation

4.2 Crane columns and crane foundations are to be dimensioned similarly like the allocated cranes, where applicable also according to D.1.2.

4.3 When dimensioning runways, the requirements according to Section 3, I.5 as well as according to G.4.4 are to be observed.

4.4 Crane boom supports are to be dimensioned according to F.6.

B. Crane Groups

1. General notes

1.1 The allocation to crane groups may be of influence on the determination of hoist load coefficients, the main aspect, however, is the fatigue strength.

1.2 Non-distinct allocations have to be agreed with BKI. This applies in particular to side and auxiliary hoists.

1.3 The following allocations to crane groups in each case refer to the main hoist of a crane.

2. Crane group A

2.1 Crane group A includes mainly cranes which do not handle cargo and which, with the exception of hatch cover cranes and hose cranes, are not always exposed to the full nominal load. Such cranes are characterized by irregular use and longer rest periods.

2.2 Cranes of group A1, which also launch and recover lifesaving appliances, are to be dimensioned in addition according to the LSA Code - International Life-Saving Appliance Code – Resolution MSC.48(66).

2.3 Crane group A is further subdivided as follows:

2.3.1 Crane group A1 includes cranes for the operation of the ship or installation, such as e.g.:

– provision cranes
– engine room cranes / workshop cranes
– hatch cover cranes
– hose cranes

2.3.2 Crane group A2 includes offshore cranes not used for cargo-handling, such as offshore working cranes

2.3.3 Crane group A3 includes floating cranes not used for cargo-handling, like mounting cranes

3. Crane group B

3.1 Crane group B primarily includes cranes used for cargo-handling, and which are not always exposed to the full nominal load. These cranes are characterized by regular use and longer rest periods.

3.2 Crane group B is further subdivided as follows:

3.2.1 Crane group B1 includes ship cranes for cargo-handling using spreaders or hooks, such as e.g.:

– container cranes
– general cargo cranes

3.2.2 Crane group B2 includes cranes for cargo-handling at sea using hooks, such as e.g.:

– general cargo cranes
– offshore cranes according to A.3.2

3.2.3 Crane group B3 includes floating cranes for cargo-handling using hooks, such as floating cargo cranes

4. Crane group C

4.1 Crane group C primarily includes cranes for cargo-handling and which are regularly exposed to the full or nearly full nominal load.

4.2 Crane group C is further subdivided as follows:

4.2.1 Crane group C1 includes ship cranes for cargo-handling using grabs, hooks or special loose gear, such as e.g.:

– grab cranes
– pallet cranes

4.2.2 Crane group C2 includes ship cranes for cargo-handling offshore using grabs, such as e.g.:

– grab cranes
– lighter cranes

4.2.3 Crane group C3 includes floating cranes for cargo-handling using grabs, such as e.g.:

– grab floating cranes
– lighter floating cranes

5. Change of crane group

In the cases of a change of crane group, change to the nominal load or change to the load radius, in addition to an examination of drawings, the manufacturer shall calculate the estimated residual lifetime, where applicable.

C. Design Loads

1. General notes

1.1 The loads acting on the structural components of cranes and their supporting structures are subdivided as follows:

- regular loads
- irregular loads
- special loads

1.2 Cranes for the conveyance of persons are to comply with the requirements according to Section 3, B.5.1 and 5.2.

1.3 If necessary, loads not addressed in the following shall be properly taken into account. The rating of such loads and considering them in the corresponding load combinations is to be agreed with BKI.

2. Regular loads

2.1 Dead loads L_E

Dead loads are to be determined in accordance with Section 3, B.4.2. A distinction should be made between loading and unloading dead loads acting on each structural element.

2.2 Hoist load L_H

The definition of hoist load is given in Section 1, C.10. Regarding the crane dimensioning, the nominal load is to be regarded as part of the hoist load.

Depending on the type of operation, the following hoist loads exist:

- harbour operation: $L_H = (L_{EA} + L_{Ne})$
- sea operation: $L_{Hsee} = (L_{EA} + L_{Nsee})$
- underwater operation: $L_{Hu} = (L_{EA} + L_{Nu})$

L_{Nsee} is to be calculated according to D.3.2.1, L_{Nu} according to Annex B.

2.3 Loads from driving over an uneven runway

Where the design conditions according to G.4.4 are met, the application of vertical dynamic forces caused by driving over an uneven runway may be omitted. Or else the application of the load is to be agreed with BKI.

2.4 Dynamic forces due to drive systems

2.4.1 General notes

.1 The dynamic forces to hoist loads and to components of lifting appliances caused by drive systems may be determined in a simplified manner using the method described in the following. The set down of a load corresponds arithmetically to the lifting of a resting load and is not mentioned explicitly in the following.

.2 The designations "vertical" and "horizontal" refer to the coordinate system of the cranes.

2.4.2 Vertical dynamic forces due to lifting of a load

.1 The acceleration forces generated by the lifting of a resting load during harbour operation are allowed for by using the hoist load coefficient ψ to be determined according to D.3.1.

.2 The acceleration forces generated by the rising of a resting or moving load during sea operation are allowed for by using the hoist load coefficients ψ_{see} or ψ_u, to be determined according to D.3.2 or according to Annex B.

2.4.3 Vertical dynamic loads due to suspended load

Generally, for a suspended load no lifting or braking forces need to be considered. This also applies for braking a crane boom with suspended load.

2.4.4 Horizontal dynamic forces due to lifting of a load

.1 In the case of lifting a resting load during harbour operation, the horizontal components of the load $L_H \cdot \psi$, resulting from the ship's heeling angle according to Table 3.1, are to be assumed as horizontal dynamic forces, see also 2.6.2.

.2 In the case of lifting a resting or moving load during sea operation, the horizontal components of the loads $L_{Hsee} \cdot \psi_{see}$ or $L_{Hu} \cdot \psi_u$, resulting from the ship's heeling angle according to Table 3.1 and the cargo runner deflection angle according to 2.6.3, are to be assumed as horizontal dynamic forces.

2.4.5 Horizontal dynamic forces due to suspended load

.1 The accelerations at the crane boom peak due to rotating, slewing, pivoting and telescoping motions are to be indicated by the manufacturer.

.2 If no other proof is given, the radial acceleration b_r for rotating and slewing cranes may be calculated as follows:

$$b_r = \omega^2 \cdot r = \frac{v^2}{r} \approx \frac{r \cdot n^2}{91} \quad [m/s^2]$$

ω = angular speed [1/s]

= $(\pi \cdot n)/30$ [1/s]

r = rotating/slewing radius [m]

v = circumferential speed [m/s]

= $\omega \cdot r$ [m/s]

n = revolution per minute (r.p.m.) [1/min]

In the case of rotating cranes, for hoists on the ship or on the installation half of the circumferential speed may be assumed.

.3 In the case of rotating or slewing cranes, the tangential acceleration b_t may be assumed to be equal to the radial acceleration b_r according to 2.4.5.2, if no other proof is given.

.4 The horizontal forces of the useful load and the dead load of the crane boom due to the ship´s heeling ε and the rotating or slewing acceleration may be added vectorially. For ε see Section 3, B.4.4.1.4.

2.4.6 Horizontal dynamic forces with mobile cranes

Horizontal dynamic forces, caused by starting and braking in the direction of travelling, are to be indicated by the manufacturer. If such manufacturer's information is not available, at least 1/6 of the loads of powered or braked wheels is to be assumed.

The wheel loads are calculated from the dead loads of the crane and the hoist load. Oscillatingly suspended hoist loads may be disregarded.

In the case of an off-center location of the center of gravity, the horizontal side forces, which occur simultaneously, are to be considered as well.

2.5 Dynamic forces generated by ship motions

2.5.1 General note

The following requirements apply exclusively for the dead loads L_E of cranes. For a more accurate determination of the dynamic forces, the requirements in D.7 apply.

2.5.2 Cranes in service

.1 Vertical dynamic forces

Generally, vertical dynamic forces during operation of cranes at sea, need not be allocated any load combination according to E.2 and they also need not be explicitly proven.

.2 Horizontal dynamic forces due to the inclination of the crane base

For the sea operation of cranes, the horizontal forces resulting from the ship inclinations according to Table 3.1 may be assumed, unless not deviant indicated by the operator.

The inclination of the crane base may be considered to be an obliquely positioned system or by distribution of the forces into components.

.3 Horizontal dynamic forces due to the acceleration of the crane basis

For the sea operation of cranes, in addition to the horizontal forces according to 2.5.2.2, the following horizontal accelerations b_h are to be assumed, if cranes are operated at significant wave heights of $H_{1/3} > 2$ m:

- pontoons/barges $b_h = 0{,}75 \cdot (H_{1/3} - 2) \geq 0$ [m/s²]
- ships and similar floating bodies $b_h = 0{,}5 \cdot (H_{1/3} - 2) \geq 0$ [m/s²]
- semi-submersibles $b_h = 0{,}25 \cdot (H_{1/3} - 2) \geq 0$ [m/s²]

$H_{1/3}$ = significant wave height [m]

2.5.3 Cranes out of service

In the condition "out of service at sea", the vertical and horizontal dynamic forces may be calculated according to Annex A.

2.6 Diagonal pull forces due to cargo runner deflection angles

2.6.1 General notes

.1 Diagonal pull forces may be generated when a load is hoisted, due to a relative shift between load and crane boom peak. They are to be superimposed to the ship inclinations of Table 3.1.

.2 Cargo runner deflection angles in the longitudinal and transverse direction of a crane boom are to be considered as occurring simultaneously in the dimensioning process.

2.6.2 Harbour operation

In general, diagonal pull forces due to cargo runner deflection angles need not be taken into consideration during harbour operation.

2.6.3 Sea operation

.1 Ship cranes

When not determined more precisely, the cargo runner deflection angle is to be assumed as:

$$\varphi_l = \varphi_q = H_{1/3} \quad [°]$$

φ_l = deflection angle in longitudinal direction of the crane boom

φ_q = deflection angle in transverse direction of the crane boom

$H_{1/3}$ = significant wave height [m]

For cranes with a slewing mechanism, the deflection angle in transverse direction may be halved, if the requirement of G.3.2.1.2 is met.

.2 Offshore slewing cranes on fixed installations

When not determined more precisely, the cargo runner deflection angle is to be assumed as:

$$\varphi_l = (4 + H_{1/3}) \quad [°]$$

$$\varphi_q = \tfrac{1}{2} \cdot \varphi_l \quad [°]$$

The above deflection angles apply provided that the requirements of G.3.2.1 are met.

.3 Floating cranes

For floating cranes with a nominal load L_{Ne} < 60 t the requirements according to 2.6.3.1 apply. In the case of higher nominal loads the requirements according to G.3.2.2 are to be met additionally.

2.7 Partial dropping of the useful load during normal operation

2.7.1 When a part of the useful load L_N is dropped during normal operation, as e.g. by cranes with grabs or load magnets, this may be accounted for by application of a dropping factor f_a.

2.7.2 The load F_{Sa} which is to be used for dimensioning, see Fig. 4.1, is to be calculated as follows:

$$F_{Sa} = f_a \cdot L_N$$

$$f_a = 1 - (1 + \varphi) \cdot \frac{\Delta L_N}{L_N}$$

φ = 0,5 for grabs or slow load dropping

= 1,0 for load magnets or fast load dropping

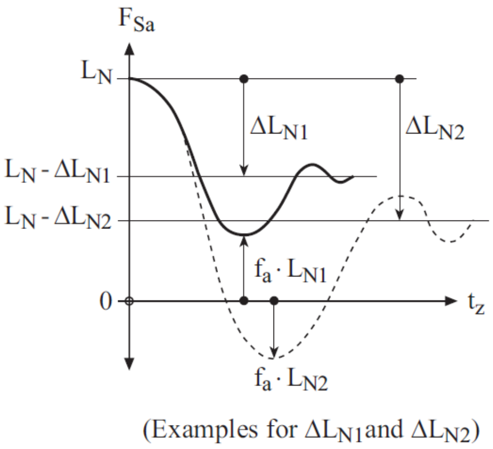

Fig. 4.1 Dropping of a part of the useful load

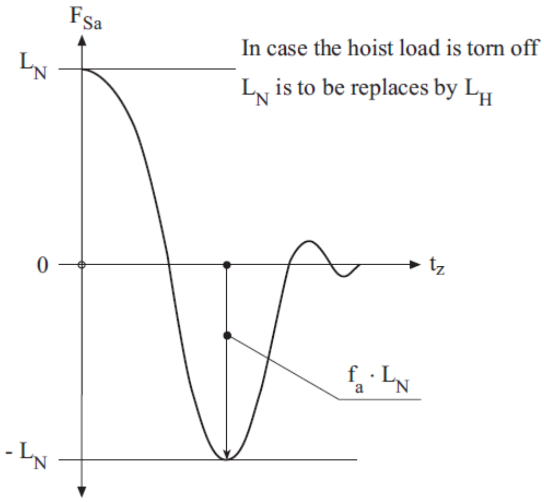

Fig. 4.2 Hoist load torn off (see 4.5)

2.7.3 When the dropping factor is $f_a < 0$, the load F_{Sa} may become negative as well. This corresponds to a load directed upwards.

2.8 Tie-down force of the cargo hooks

When cargo hooks are tied-down for the load condition "crane out of service", this load is to be considered as the tie-down force. This load is to be indicated by the manufacturer. If no information is available, this load may be assumed to be 10 % of the nominal load L_{Ne}.

3. Irregular loads

3.1 Wind loads

Wind loads are to be assumed according to Section 3, B.4.5.

The total wind load acting on a crane structure is the sum of the single wind loads acting on its various structural components.

3.2 Snow and ice loads

For snow and ice loads, the requirements of Section 3, B.4.6 apply.

3.3 Temperature loads

For temperature loads, the requirements of Section 3, B.4.7 apply.

3.4 Side forces when driving (diagonal drive)

3.4.1 The side forces occurring when the crane or trolley is being driven are to be taken into consideration.

3.4.2 When 2 wheels or wings are mounted for 1 rail, the two forces generated by one-sided guidance may be calculated by multiplying the wheel or wing load with the side force coefficient γ_{Sk} according to Fig. 4.3. The side force coefficient γ_{Sk} depends on the ratio between span b_s and wheel spacing ℓ_r.

3.4.3 Two-sided guidances or more than 2 wheels or wings on 1 rail are to be considered separately.

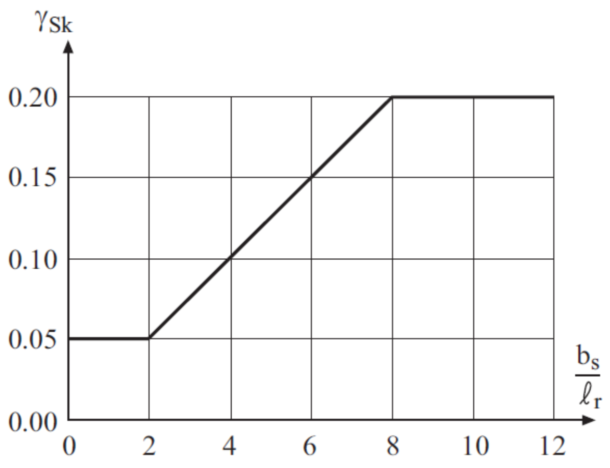

Fig. 4.3 Side force coefficient γ_{Sk}

4. Special loads

4.1 Dynamic test loads

The dynamic test loads L_{Pdyn} for cranes are to be taken from Table 13.2. The hoist load coefficient ψ may be reduced using the following formula:

$$\psi_P = (1 + \psi) / 2$$

4.2 Buffering forces

4.2.1 At the ends of carriage ways of cranes and trolleys, arrestors are to be mounted with buffers attached either to them or to the cranes.

Buffers are to be dimensioned such that they are capable to absorb 70 % of the kinetic energy of the loading gear driving at maximum speed. The mass of oscillatingly suspended hoist loads are not considered.

4.2.2 The impact force on the buffer is to be determined from the buffer characteristic and - in order to take into consideration the dynamic effect of the buffering force - to be multiplied with the following factor f_p:

f_p = 1,25 for buffer with linear characteristic

= 1,60 for buffer with rectangular characteristic

4.2.3 Lower speeds than according to 4.2.1 may be assumed, if reliable (redundant) appliances reduce the speed in way of the runway ends.

4.3 Loads on stairs, ladders, platforms and railings

For access loads, see the requirements of Section 3, I.9.

4.4 Loads due to safety systems

The loads L_S due to safety systems, such as e.g.

- AOPS (Automatic Overload Protection System)
- MOPS (Manual Overload Protection System)
- ELRS (Emergency Load Release System)

are to be indicated by the crane manufacturer.

4.5 Tear-off of the hoist load

In the catastrophic case of the hoist load torn off, this results in $f_a = -1$, according to 2.7.2 and Fig. 4.2, f_a and with this, the calculated load, directed upwards, becomes $-L_H$.

D. Hoist Load Coefficients

1. General notes

1.1 The hoist load or the loads resulting from it are to be multiplied with an allocated hoist load coefficient for the lifting of the resting load. If the crane has several hoisting appliances or differing hoisting speeds, individual hoist load coefficients are to be allocated to each of them.

1.2 For the strength analysis of load-bearing structural elements as far as its fastening to the ship hull, reduced hoist load coefficients may be applied, if the corresponding dampening in the load-bearing system is proven by calculation or measurement.

2. Hoist load coefficient ψ as a function of crane group and hoisting speed

2.1 For harbour operations, the hoist load coefficient may be simplified taken from Table 4.1.

2.2 An individual calculation of the hoist load coefficient according to 3. may be necessary or advisable.

Table 4.1 Hoist load coefficient for different crane groups

Crane group	Hoist load coefficient ψ	ψ_{min}
A1	$1{,}05 + 0{,}34 \cdot v_h$	1,17
B1	$\alpha + \beta \cdot v_h$	$1{,}2 - \frac{3 \cdot L_{Ne}}{10000\ t} \geq 1{,}05$
C1	$1{,}15 + 0{,}51 \cdot v_h$	1,35

For descriptions of crane groups, see B.2 to B.4.

V_h acc. to Table 4.2, $\alpha = 1{,}15 - \frac{L_{Ne}}{5000\ t}$ and $\beta = 0{,}5 - \frac{L_{Ne}}{1500\ t}$

Table 4.2 Hoisting speed in the course of lifting the load

Load Combination (LC)	Lifting Gear type and hoisting speed v_h			
	HD 1	HD 2	HD 3	HD 4
LC I + LC II	v_{hmax}	v_{hF}	v_{Hf}	$0{,}5 \cdot v_{hmax}$
LC III[1]	–	v_{hmax}	–	v_{hmax}

[1] For lifting gear types HD 2 and HD 4, the hoist load coefficient ψ calculated from v_{hmax} is to be proven as load combination III_1

HD 1 = creep hoist not possible

HD 2 = creep hoist selectable by the crane driver

HD 3 = creep hoist switched on automatically until the load is lifted from the ground

HD 4 = hoisting speed is infinitely variable by the crane driver

v_{hmax} = maximum constant hoisting speed of the allocated load [m/s]

v_{hF} = constant creep hoisting speed [m/s]

3. Calculation of the hoist load coefficient ψ as a function of the crane stiffness

3.1 Harbour operation

3.1.1 Calculation of the hoist load coefficient ψ

The hoist load coefficient is to be calculated as follows:

$$\psi = \left[1 + \frac{v_h}{9{,}81} \cdot \sqrt{\frac{c_s}{L_{Ne}}}\right] \geq \psi_{min}$$

ψ_{min} = minimum value according to Table 4.1

v_h = hoisting speed in the course of lifting of the nominal load according to Table 4.2 [m/s]

c_s = crane stiffness according to 3.3 [kN/m]

L_{Ne} = nominal load [t]

3.1.2 Simplified calculation for jib cranes with hoisting and luffing ropes

In the case of jib cranes with hoisting and luffing ropes, only the hoisting and luffing ropes as well as the crane boom need to be included in the simplified calculation. The hoist load coefficient ψ is then calculated as follows:

$$\psi = \left[1 + 0{,}9 \cdot \frac{v_h}{9{,}81} \cdot \sqrt{\frac{c_s}{L_{Ne}}}\right] \geq \psi_{min}$$

3.2 Sea operation

3.2.1 Calculation of the hoist load coefficient ψ_{see}

$$\psi_{see} = \left[1 + \frac{v_r}{9{,}81} \cdot \sqrt{\frac{c_s}{L_{Nsee}}}\right] \geq \psi$$

v_r = relative speed between load and hook in the course of lifting the load [m/s] according to 3.2.2

c_s = crane stiffness [kN/m] according to 3.3

L_{Nsee} = nominal load at sea [t]

ψ = hoist load coefficient for harbour operation

With the exception of cranes dimensioned only for sea operation, the following condition is to be observed:

$$L_{Ne} \cdot \psi \geq L_{Nsee} \cdot \psi_{see}$$

3.2.2 Relative speed between load and hook

$v_r = 0{,}5 \cdot v_h + v_{see}$ [m/s] for LCI (E.2.1.1)

$v_r = v_h + v_{see}$ [m/s] for LCIII (E.2.3.1)

v_h = hoisting speed in the course of lifting the respective nominal load L_{Nsee} according to Table 4.2 [m/s]

= The minimum hoisting speed according to G.3.1.1 is to be taken, if larger than v_h.

v_{see} = speed induced by sea state according to Table 4.3

= $v_a^2 + v_d^2$

Table 4.3 Speed induced by sea state v_{see}

From the location of the crane (v_a)	To the cargo deck or to the sea surface (v_d)						
	Fixed installation	semi-submersible	FSO / FPSO	Large barge	Small barge	Supply ship	Sea surface
Fixed installation	0	$0{,}25\cdot(H_{1/3})^{0,75}$	$0{,}32\cdot(H_{1/3})^{0,75}$	$0{,}38\cdot(H_{1/3})^{0,75}$	$0{,}50\cdot(H_{1/3})^{0,75}$	$0{,}70\cdot(H_{1/3})^{0,75}$	$0{,}85\cdot(H_{1/3})^{0,75}$
semi-submersible	$0{,}25\cdot H_{1/3}$	$0{,}35\cdot(H_{1/3})^{0,90}$	$0{,}40\cdot(H_{1/3})^{0,88}$	$0{,}47\cdot(H_{1/3})^{0,87}$	$0{,}60\cdot(H_{1/3})^{0,83}$	$0{,}73\cdot(H_{1/3})^{0,80}$	$0{,}90\cdot(H_{1/3})^{0,70}$
FSO / FPSO	$0{,}40\cdot H_{1/3}$	$0{,}45\cdot H_{1/3}$	$0{,}53\cdot(H_{1/3})^{0,88}$	$0{,}62\cdot(H_{1/3})^{0,90}$	$0{,}70\cdot(H_{1/3})^{0,90}$	$0{,}80\cdot(H_{1/3})^{0,87}$	$(H_{1/3})^{0,78}$
Large barge	$0{,}60\cdot H_{1/3}$	$0{,}65\cdot H_{1/3}$	$0{,}70\cdot(H_{1/3})^{0,94}$	$0{,}75\cdot(H_{1/3})^{0,94}$	$0{,}85\cdot(H_{1/3})^{0,94}$	$0{,}90\cdot(H_{1/3})^{0,94}$	$1{,}20\cdot(H_{1/3})^{0,94}$
Small barge	$1{,}10\cdot H_{1/3}$	$1{,}11\cdot H_{1/3}$	$1{,}16\cdot(H_{1/3})^{0,94}$	$1{,}18\cdot(H_{1/3})^{0,97}$	$1{,}20\cdot(H_{1/3})^{0,97}$	$1{,}30\cdot(H_{1/3})^{0,94}$	$1{,}40\cdot(H_{1/3})^{0,91}$

v_a = vertical speed of the crane boom peak [m/s]
v_d = vertical speed of the cargo deck or sea surface [m/s]
$H_{1/3}$ = significant wave height [m]

3.3 Calculation of the crane stiffness c_s

3.3.1 Principals of calculation

.1 The stiffness of a crane depends on the load radius and the height of the load hook.

.2 For calculation of the crane stiffness, besides the ropes all load-bearing structures as far as the fastening of the crane column or the crane base are to be taken into consideration, with the exception of 3.1.2.

.3 Regarding the approach of the rope stiffness, the Young´s modulus indicated by the rope manufacturer is to be taken.

3.3.2 Permissible simplification for the calculation

.1 For round strand ropes, without a more precise proof a Young's modulus of $1{,}0 \cdot 10^5$ N/mm^2, based on the gross cross-section, may be taken.

.2 **Curve-shaped load grading**

In the case of a uniform, curve-shaped useful load vs. load radius diagram, the crane stiffness is to be calculated at least for the end points and the one-third points of the regarded range of load radius. Based on these values, a continuous curve may be determined.

.3 **Step-shaped load grading**

In the case of a step-shaped grading of the useful load vs. load radius diagram, the stiffness is to be calculated for each load level according to 3.3.2.2. As an alternative, the stiffness may be calculated for the minimum load radius of each load level. These values apply then for the whole range of one level.

.4 **Height of the cargo hook**

For operations in harbour conditions it may be assumed, that the cargo hook is at the altitude of the crane boom pivot point. For operations in sea state/offshore conditions it may be assumed that the cargo hook is 6 m above the water surface, except for underwater operations.

4. Calculation of the hoist load coefficient Ψ_u for underwater operations

For underwater operations, calculation of the hoist load coefficient ψ_u may be simplified in accordance with Annex B. Using this method, special appliances such as e.g. rope-spindling devices or heave compensators cannot be considered.

The following condition is to be observed:

$$L_{Ne} \cdot \psi \geq L_{Nu} \cdot \psi_u$$

5. Calculation of the hoist load coefficient for hoists onboard the ship or on the installation

For hoists onboard the ship or on the installation, the simplified hoist load coefficient for sea operations may be assumed to be:

$$\psi_{see} = 1{,}15 + 0{,}51 \cdot v_h \geq \psi$$

v_h = hoisting speed in the course of lifting the nominal load according to Table 4.2 [m/s]

ψ = hoist load coefficient for harbour operation

6. Calculation of the hoist load coefficient for auxiliary hoists

The hoist load coefficient for auxiliary hoists is calculated (simplified) to be:

$$\psi = 1{,}20 + 0{,}68 \cdot v_h \geq \psi_{min} = 1{,}45$$

7. Calculation of the hoist load coefficient by means of hydrodynamic analysis

7.1 Using model tests or stochastic and hydrodynamic calculation methods, the hoist load coefficient can be determined more accurate. These methods generally apply for all service conditions of the crane.

7.2 The calculation is to be performed under consideration of the motion behavior of the floating bodies involved and the stiffness of the crane. Influences of special appliances such as rope-spindling devices or heave compensators may be taken into account in the process.

7.3 The calculation is to include at least the following influences, if applicable:

– vertical and horizontal motions of the cargo deck
– motion behavior of the offshore installation / the floating body, on which the crane is mounted
– load-bearing structure of the crane
– hydrodynamic properties of a floating or submerged load
– influence of anchoring systems
– environmental conditions agreed

7.4 The calculation is to be submitted to BKI for the examination of the crane as a document for information. In particular, the influences listed in 7.3 are to be represented clearly in the document.

E. Load Combinations and Partial Safety Factors

1. General notes

1.1 The load combinations regarded as essential for cranes and their supporting structures are listed in the Tables 4.4 (Cranes in service) and 4.5 (Cranes out of service).

Further load combinations may be relevant, if necessary.

1.2 Only those load combinations from Tables 4.4, 4.5 and further load combinations, if necessary, which are essential or necessary for the actual structural element under consideration, are to be verified

1.3 Regarding load combinations for operation at sea and for offshore-cranes, instead of ψ the hoist load coefficient ψ_{see}, for underwater operations the hoist load coefficient ψ_u, is to be taken.

1.4 The load combinations for the proof of stability against overturning are listed in Table 4.6.

1.5 The partial safety factors ψ_{pi} are to be taken from Tables 4.4 to 4.6.

2. Explanations regarding load combinations for cranes in service according to Table 4.4

2.1 Load combinations I

The load combinations I include regular loads in normal service.

2.1.1 I_1 – Lifting and setting-down of the nominal load

All regular loads, which occur during lifting and setting-down of a load, are to be superposed, as required, for the load combination I_1,

For vertical and horizontal dynamic forces, the requirements in C.2.4 and 2.5 apply.

2.1.2 I_2 – Suspended load

All regular loads, which are generated by acceleration and deceleration forces of lifting gear, luffing gear and travelling gear, when a load is positioned, are to be superposed, as required, for the load combination I_2 taking into consideration static ship inclinations and possible diagonal pull.

2.2 Load combinations II

The load combinations II include regular loads during normal service combined with non-regular loads.

2.2.1 II_1 – Load combination I_1 with wind loads

Load combination II_1 results from load combination I_1 plus appropriate wind loads. Snow, ice ore temperature loads are only to be assumed upon agreement.

2.2.2 II_2 – Load combination I_2 with wind loads

Load combination II_2 results from load combination I_2 plus appropriate wind loads. Snow, ice ore temperature loads are only to be assumed upon agreement.

2.2.3 II_3 – Constant drive including diagonal pull

For load combination II_3 all loads are to be superimposed, as required, which occur at constant drive including diagonal pull. Snow, ice or temperature loads are only to be assumed upon agreement.

2.3 Load combinations III

Load combinations III include special load combinations.

2.3.1 III_1 – Hoisting of the nominal load at maximum hoisting speed

Complementing load combination I_1, load combination III_1 includes operating errors during hoisting of the load. The hoist load coefficient is to be determined for the maximum possible hoisting speed / relative speed between load and hook and the respective load level.

2.3.2 III_2 – Test loads

Load combination III_2 includes hoisting of the dynamic test load at 20 % wind load.

2.3.3 III_3 – Buffer forces

Load combination III_3 comprises the impact of a crane with hoist load against the end buffers.

2.3.4 III_4 – Safety systems

Load combination III_4 comprises loads which may result from activated safety systems.

2.3.5 III_5 – Failure of hydraulic cylinder

Load combination III_5 contains special load combinations covering a cylinder failure of a lifting appliance conveying persons.

3. Explanations regarding load combinations for cranes out of service according to Table 4.5

3.1 Load combination I_A

Load combination IA includes regular loads for cranes out of service.

3.1.1 I_{A1} – Combination of regular loads

For load combination I_{A1}, all regular loads are to be superimposed, as required.

3.2 Load combination III_A

Load combination III_A includes special load combinations for cranes out of service.

3.2.1 III_{A1} – Special load combination

For load combination III_{A1}, the wind loads out of operation are to be superimposed with the regular loads, as required. Snow, ice or temperature loads are only to be assumed as non-regular loads upon agreement.

Table 4.4 Load combinations and partial safety factors for cranes in service

Load categories	Loads	i	Reference		Load Combinations												
					I			II				III					
					γ_{pi}	I_1	I_2	γ_{pi}	II_1	II_2	II_3	γ_{pi}	III_1	III_2	III_3	III_4	III_5
Regular loads	Dead loads L_E (including inclination of crane base)	1	4	C.2.1	1,22[1]	1,0	1,0	1,16[1]	1,0	1,0	1,0	1,10[1]	1,0[2]	1,0	1,0	1,0	1,0
	Hoist load L_H[6] (including inclination of crane base)	2	4	C.2.2	1,34	ψ	1,0	1,22	ψ	1,0	1,0	1,10	-	-	1,0	-	1,0
	Dynamic forces due to drives[3]	3	4	C.2.4	1,34	-	1,0	1,22	-	1,0	-	-	-	-	-	-	-
	Diagonal pull	4	4	C.2.6	1,34	ψ	1,0	1,22	ψ	1,0	-	-	-	-	-	-	-
Non-regular load	Wind loads in operation	5	4	C.3.1				1,22	1,0	1,0	1,0	1,10	-	0,2	-	-	1,0
	Snow and ice loads	6	4	C.3.2				1,22	1,0	1,0	1,0	-	-	-	-	-	-
	Temperature loads	7	4	C.3.3				1,16	1,0	1,0	1,0	-	-	-	-	-	-
	Side forces during drive	8	4	C.3.4				1,16	-	-	1,0	-	-	-	-	-	-
Special loads	Hoisting of hoist load at v_{hmax}	9	4	Tab. 4.2								1,10	ψ_{max}	-	-	-	-
	Dynamic test load $L_{p,dyn}$ (including inclination of crane base)	10	4	C.4.1								1,10	-	ψ_p	-	-	-
	Buffing forces	11	4	C.4.2								1,10	-	-	1,0	-	-
	Loads caused by safety systems[4, 5]	12	4	C.4.4								1,10	-	-	-	1,0	-
Drag coefficient γ_m					1,10			1,10				1,10					
Global safety coefficient γ_s					1,48			1,34				1,22					

1 When load components have a favourable effect, γ_{pi} = 0,95. If masses and centres of gravity are determined by weighing, 0, 95 · γ_{pi} may be assumed.
2 Components caused by inclination of crane base may be neglected.
3 applicable for load components from dead load and hoistload
4 Emergency stop is to be verified by a practical test with a test load of L_{Pdyn}, see Section 13, B.4.2.2.3.
5 Loads which may be generated by activated safety systems, are to be indicated by the manufacturer
6 for load combination III_5 L_H = SWL (M)

4. Explanations regarding load combinations for the proof of stability against overturning according to Table 4.6

4.1 Load combination I

Load combination I includes regular loads under normal operation.

4.1.1 I_1 - Combination of regular loads

For load combination I_1, all regular loads are to be superimposed, as necessary.

4.2 Load combination II

Load combination II includes regular loads in normal operation together with non-regular load.

4.2.1 II_1 - Load combination I with wind loads

Load combination II results from load combination I plus allocated wind loads.

4.3 Load combination III

Load combinations III comprise special load combinations.

4.3.1 III_1 - Test loads

Load combination III_1 considers the hoisting of the dynamic test load at a 20 % wind load.

4.3.2 III_2 - Buffer forces

Load combination III_3 comprises the impact of a crane with hoist load against the end buffers.

Table 4.5 Load combinations and partial safety factors for cranes out of service

Load categories	Loads	I	Reference		Load combinations			
					I_A		II_{IA1}	
					γ_{pi}	I_{A1}	γ_{pi}	III_{A1}
Regular loads	Dead loads L_E	1	4	C.2.1	1,22[1]	1,0	1,10[1]	1,0
	Dynamic forces due to ship motions	2	4	C.2.5.3	1,34	1,0	1,10	1,0
	Tie-down force of the cargo hook	3	4	C.2.8	1,22	1,0	1,10	1,0
Non-regular loads	Snow and ice loads	4	4	C.3.2			1,10	1,0
	Temperature loads	5	4	C.3.3			1,05	1,0
Special loads	Wind loads out of operation	6	3	C.3.1			1,10	1,0
Drag coefficient γ_m					1,10		1,10	
Special loads					1,48		1,22	

[1] Where load components have a favourable effect, γ_{pi} = 0,95

Table 4.6 Load combinations and partial safety factors for proof of stability against overturning

Load categories	Loads	I	Reference		Load combinations						
					I		II		III		
					γ_{pi}	I_1	γ_{pi}	II_1	γ_{pi}	III_1	III_2
Regular loads	Dead loads L_E (including inclination of the crane base)	1	4	C.2.1	1,10[1]	1,0	1,10[1]	1,0	1,10[1]	1,0	1,0
	Hoist load L_H (including inclination of the crane base)	2	4	C.2.2	1,34	1,0	1,22	1,0	1,10	-	1,0
	Dynamic forces due to drives[2]	3	4	C.2.4	1,34	1,0	1,22	1,0	1,10	-	1,0
	Diagonal pull	4	4	C.2.6	1,34	1,0	1,22	1,0	-	-	-
Non-regular loads	Wind loads in operation	5	4	C.3.1			1,22	1,0	1,10	0,2	1,0
Special loads	Dynamic test load $L_{p,dyn}$ (including inclination of the crane base)	6	4	C.4.1					1,16	1,0	-
	Buffer forces	7	4	C.4.2					1,10	-	1,0

[1] Where load components have a favourable effect, γ_{pi} = 0,95

[2] Applicable for load components from dead load and hoist load

F. Proofs

1. General

1.1 The following proofs are to be conducted for all structural elements, connections and supporting structures of cranes for the conditions "in service" and "out of service":

- strength analysis according to Section 3, D and Section 3, H
- proof of stability according to Section 3, D
- fatigue strength analysis according to Section 3, F

1.2 The following proofs are to be conducted for a complete crane, as required:

- proof of stability against overturning according to Section 3, E
- proof of suitability for use according to Section 3, G

1.3 For the proof of crane boom supports and rectangular crane columns, the requirements in 6. and 7. apply.

2. Strength analyses and proofs of stability

2.1 Strength analyses and proofs of stability are to be conducted using the partial safety factors of Table 4.4 or Table 4.5, respectively, for the load combinations of E.

3. Fatigue strength analyses

3.1 In general, fatigue strength analyses are to be conducted for the load combination I of Table 4.4 and Table 4.5 with the partial safety factors γ_{pi} = 1,0.

As a basis for dimensioning regarding fatigue strength analyses the crane manufacturer shall provide load cycles and the respective load spectrum (see also Table 4.7).

Table 4.7 Load spectra and load cycles (examples for a service life of 20 years) for ships and floating cranes in harbour operation

Crane group acc. to Section 4, B	Crane type	Load spectrum acc. to Section 3, F.3.1	No. of load cycles
A1 Cranes operating on ships or installations	Hatch cover crane	S6	$20 \cdot 10^3$
	Engine room/workshop crane	S2	$10 \cdot 10^3$
	Provision crane	S2	$20 \cdot 10^3$
	Hose crane	S6	$50 \cdot 10^3$
A3 Floating cranes	Mounting crane, SWL ≤ 60 t	S2	$80 \cdot 10^3$
	Mounting crane, 60 t < SWL ≤ 500 t	S3	$50 \cdot 10^3$
	Mounting crane, SWL > 500 t	S4	$20 \cdot 10^3$
B1 Ship cranes	Container crane SWL ≤ 60 t	S3	$350 \cdot 10^3$
	General cargo crane, SWL ≤ 60 t	S2	$250 \cdot 10^3$
	General cargo crane , 60 t < SWL ≤ 250 t	S3	$100 \cdot 10^3$
	General cargo crane , 250 t < SWL ≤ 500 t	S4	$70 \cdot 10^3$
	General cargo crane , SWL > 500 t	S4	$50 \cdot 10^3$
B3 Floating cranes	Cargo-handling crane, SWL ≤ 60 t	S2	$300 \cdot 10^3$
	Cargo-handling crane, 60 t < SWL ≤ 250 t	S3	$125 \cdot 10^3$
	Cargo-handling crane, 250 t < SWL ≤ 500 t	S4	$80 \cdot 10^3$
	Cargo-handling crane, SWL > 500 t	S4	$60 \cdot 10^3$
C1 Ship cranes	Grab crane, SWL ≤ 60 t	S5	$600 \cdot 10^3$
	Gab crane, SWL > 60 t	S5	$450 \cdot 10^3$
	Pallet crane	S6	$600 \cdot 10^3$
C3 Floating cranes	Grab crane, SWL ≤ 60 t	S5	$700 \cdot 10^3$
	Grab crane, SWL > 60 t	S5	$500 \cdot 10^3$
	Lighter crane	S5	$2 \cdot 10^6$

3.2 For cranes with load cycle numbers $\leq 2 \cdot 10^4$, a fatigue strength analysis may be dispensed with.

3.3 The fatigue strength analysis for the condition "out of service" is to be conducted for a load cycle number of $5 \cdot 10^7$. This assumes a straight-line spectrum A according to Fig. 3.3.

3.4 Superposition of "in service" and "out of service"

A superposition of the fatigue damage due to the conditions "in service" and "out of service" is not necessary, as long as the maximum stress in the condition "out of service" does not exceed 10 % of the maximum stress in the condition "in service". Or else the load spectrum applicable for the analysis and the allocated load cycle numbers are to be agreed with BKI.

4. Proof of stability against overturning

4.1 The proof of stability against overturning is to be conducted with the partial safety factors and load combinations according to Table 4.6, unless not shown in practice, see Section 3, E.2.1.3.

5. Proof of suitability for use

5.1 Proof procedures

5.1.1 Proofs of suitability for use may be performed in the course of the initial testing onboard, mathematically or as a combination of both procedures.

5.1.2 In general, the mathematical proof of suitability for use is to be conducted for the load combination I according to Tables 4.4 and 4.5 using partial safety factors γ_{pi} = 1,0.

5.2 Proof of permissible deflection of crane booms

The maximum deflection of pressure-loaded crane booms shall correspond to the crane boom length divided by 350, if the dead weight alone is considered, and to the crane boom length divided by 250, if dead weight plus hoist load are considered.

The peak of crane booms under bending stress which are held by luffing cylinders, shall in general not exceed a vertical lowering of the maximum crane boom length divided by 100.

5.3 Proof against remaining in the highest crane boom position

5.3.1 Where no restoring or warning devices according to Section 12, B.1.1.2.2 are provided, a proof of suitability for use is to be shown for crane booms handled by luffing ropes under the following boundary conditions:

- dead load coefficient φ_e = 0,95 for all load components of the crane boom, unless they are confirmed by weighing. Else φ_e = 1,0
- static ship inclinations according to Table 3.1
- hoist load coefficient ψ = 1,0
- wind load acting unfavourably, calculated from 80 % of the mean dimensioning wind speed in service according to Section 3, B.4.5
- consideration of all friction and guide losses

5.3.2 For crane booms handled by cylinders, the requirements in Section 12, B.1.1.3 apply.

6. Proof of crane boom supports

Crane boom supports are to be proven for the load combinations in Table 4.5 and the allocated partial safety factors. In addition, the following is to be observed:

- The dead load also includes the dead load component of the crane boom.
- Where a relative movement is possible between the crane boom and the crane boom support, additionally an alternating friction force is to be considered, with a friction coefficient of at least μ = 0,15.
- tie-down force of a cargo hook (see G.5)

7. Proof for rectangular crane columns

A general strength analysis is to be conducted regarding the maximum corner stress. This is done by allocating the maximum crane moment M_{Kmax} to the main axes of the crane column in the most unfavourable distribution.

G. Requirements for Design and Equipment

1. General note

The following statements complement the requirements in this Section and other Sections of this Guidelines.

Structural elements, details of equipment and design, which are not covered, are to be dealt with according to the "Generally recognized rules of good practice".

2. Supporting structures

2.1 Design requirements for crane columns

2.1.1 Access to cranes

Regarding the accesses to cranes inside or outside of crane columns, the statements in Section 10, F.2.2 and Section 12, B.1.4 apply.

2.1.2 Notes on design and calculation

.1 In the case of tapered transition components, which transit from a cylindrical crane connection to a rectangular column, special attention is to be paid to the knuckle line between the cambered parts and the plane gussets. If necessary, thicker plates are to be provided.

.2 In way of connections of tapered or trapezoid transitions of crane columns, knuckle lines, especially of even plates are to be stiffened, if necessary by bulkheads, in order to absorb the deviation forces.

.3 The transition parts and their connection areas described above, require special care regarding fabrication and suitable mathematical proofs.

.4 The connection of container supports to crane columns requires special care regarding design and calculation.

2.1.3 Execution of cylindrical crane columns welds

In the case of cylindrical crane columns, all transverse and longitudinal welds are to be the full penetration type.

2.1.4 Execution of rectangular crane columns welds

All transverse welds of rectangular crane columns are to be the full penetration type. Regarding longitudinal welds, the following applies:

1) Longitudinal welds in the plates are to be the full penetration type.
2) The connecting welds at the corners may be dimensioned for the maximum shear force and may be executed as fillet welds.

2.1.5 Connection to the ship hull/offshore installation

.1 Wherever possible, crane columns should be linked to the hull over a full deck height, if necessary, e.g. in the case of crane columns located at the ship's side, even to a greater depth into the structure of the ship.

.2 Supporting structures interrupted by decks, shall have well aligned connections. If necessary, control bores are to be provided, which are to be welded up after the control.

.3 For the shear connection of inserted cylindrical crane columns, the required plate thickness of the connecting deck or of the connecting weld may be calculated according to Section 3, I.4.

.4 Crane columns which due to their location act as stiffness-discontinuities in the longitudinal and transverse structures of ships, such as e.g. laterally arranged crane columns with outer longitudinal walls, which are attached to the shell plating of the ship, are to have suitable taper brackets, as required.

.5 Crane columns shall not be connected to hatch coamings, if possible. Where the connection to hatch coamings cannot be avoided, suitable measures are required, like e.g. tapered brackets and strength analyses for the additional loads.

2.2 Requirements for the design of the stowage trough of crane boom supports

2.2.1 If possible, the stowage trough shall embrace the stowage spur or a stowage holm without major clearance (10 to 20 mm at maximum) and be lined with wood or other suitable material.

2.2.2 The gripping effect in the stowage trough, caused by torsion of the ship's hull, in particular with crane booms which are not stowed lengthwise, is to be counteracted by a suitable design.

2.2.3 Where a luffing rope operated crane boom is not fixed downwards by tying-down of the cargo hook, locking devices are to be provided in way of the stowing trough in order to prevent of the crane boom coming off.

These devices shall not restrain the relative motions between stowing trough and crane boom.

2.2.4 Each stowing trough shall be accessible by means of ladders or climbing irons and locally provide a suitable area for operating, control and/or maintenance purposes.

3. Hook speeds when operating under sea/offshore conditions

3.1 Minimum hoisting speed

3.1.1 Cranes with a nominal load ≤ 60 t

.1 When operating under sea/offshore conditions, the hoisting speed shall be high enough to avoid repeated contact between load and cargo deck after hoisting.

.2 The uniform minimum hoisting speed v_{hmin} shall not fall below the following value:

– multiple- reeved cargo runner:

$$v_{hmin} \geq 0,3 \cdot v_{see} \quad [m/s]$$

– single-reeved cargo runner:

$$v_{hmin} \geq 0,5 \cdot v_{see} \quad [m/s]$$

v_{see} = seastate-induced speed according to Table 4.3 [m/s]

3.1.2 Cranes with a nominal load > 60 t

When operating under sea/offshore conditions, the hook speed resulting from superimposing the hoisting and the luffing speed as well as the ballast speed of the floating body shall be high enough to avoid damage to the crane or the load from repeated contact between load and cargo deck

3.2 Horizontal hook speed

3.2.1 Revolving cranes with a nominal load ≤ 60 t

.1 During loading and unloading of floating bodies, it is important that the crane hook is capable of following the horizontal movement of the cargo deck.

.2 The uniform slewing speed v_ω at the crane boom peak at about ¾ of the maximum load radius shall not fall below the following value:

$$v_\omega \geq 0{,}60 \cdot v_{see} \quad [m/s]$$

v_{see} = seastate-induced speed according to Table 4.3 [m/s]

3.2.2 Revolving cranes with a nominal load > 60 t

.1 The luffing speed and luffing acceleration shall be sufficient to ensure control of transverse load oscillation.

.2 Load arresting ropes which limit the swinging of the load may be taken into consideration according to their effectiveness.

3.3 Luffing speed

The uniform vertical luffing speed v_W at the crane boom peak at about ¾ of the maximum load radius shall not fall below the following value:

$$v_W \geq 0{,}10 \cdot v_{see} \quad [m/s]$$

4. Design details

4.1 Connection of slewing bearings

4.1.1 Proof of bolts

.1 The bolt connection is to be dimensioned according to recognized guidelines, calculation principles or standards according to which, if need be, also a fatigue strength proof for the bolts can be conducted, e.g. VDI Guidelines 2230.

The global safety factors according to Section 3, C.8.2 are to be proven.

.2 Special care is to be taken over the determination of the maximum bolt force, as e.g. an opening of the gap increases the bolt force non-linear.

.3 The stiffness of the slewing bearing can have a significant influence on the stress distribution in the connecting structure. The sector force F_a for the maximum loaded bolt according to Fig. 4.4 is to be determined according to a recognized calculation procedure (e.g. FEM calculation under consideration of the connecting structure's stiffness) or by measurement.

.4 A simplified bolt proof according to 4.1.2 can be conducted on condition the restrictions for application according to 4.1.2.1 are complied with.

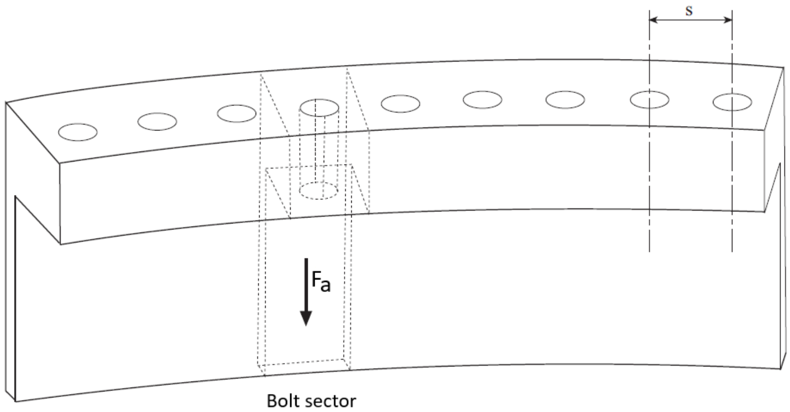

Fig 4.4 Bolt sector and sector force

4.1.2 Simplified bolt proof

.1 Restrictions for application

The simplified bolt proof can be applied if:

- the outer bolt circle diameter does not exceed 3,5 m,
- stiffness of connecting structures (e.g. crane house, crane pedestal) is approximately equal over the circumference,
- foot bearings of jibs and, if applicable, bearings of hydraulic cylinders on the crane house sufficiently distant from the base plate of the crane house,
- the bolts of the standing and of the rotating ring are even distributed over the circumference and their quantity per ring is not less than 12,
- the following relations are kept:

$$a \leq 2 \cdot d_\ell$$

$$b \geq 1{,}5 \cdot d_\ell$$

$$b/a \geq 0{,}75$$

a, b, d_ℓ according to Fig. 4.6

d = thread diameter of bolt

.2 Format of proof

The following relations are to be kept:

$$Z_{max} / Z_{limit} \leq 1 \quad \text{or} \quad Z_{max} \leq Z_{limit}$$

Z_{max} = maximum tensile force in bolt according to 4.1.2.3 [kN]

Z_{limit} = limit value of tensile force in bolt according to 4.1.2.8 [kN]

.3 Maximum tensile force in bolt

The maximum tensile force in the bolt is calculated as follows:

$$Z_{max} = f \cdot Z_{nom} \quad [kN]$$

Z_{nom} = nominal tensile force of the highest loaded bolt of a multiple bolt connection according to 4.1.2.7 [kN]

f = form factor according to Table 4.8 [-]

.4 Forces on a large slewing bearing

For the terms and forces in Fig. 4.5 the following abbreviations are valid, which apply to the outer ring analogously:

D_r = roller circle diameter [mm]

D_t = pitch circle diameter [mm]

D_m = middle diameter of pedestal [mm]

a = distance between pitch circle and middle of pedestal wall [mm]

b_r = vertical force lever [mm]

e = distance between bolt centre and start of chamfer (constraint lever) [mm]

h_r = horizontal force lever [mm]

t_f = flange thickness [mm]

t_w = wall thickness of pedestal [mm]

.5 Load from the crane

The following loads are to be determined including the global safety factor γ_s according to Section 3, C.8.2 for the most unfavourable load combination according to Tables 4.4 and 4.5:

M_S = tilting moment [Nmm]

V_{Sd} = vertical force [N]

H_{Sd} = horizontal force [N]

.6 Forces acting on the ring per bolt sector

According to Fig. 4.5 the following forces are valid in case V_{Sd} is pointing in that direction shown in Fig. 4.5 (compressive force):

$$F_{vd} = \left(\frac{4 \cdot M_{Sd}}{D} + V_{Sd}\right) \cdot \frac{1}{n_s} \quad [N]$$

$$F_{vz} = \left(\frac{4 \cdot M_{Sd}}{D} - V_{Sd}\right) \cdot \frac{1}{n_s} \quad [N]$$

$$F_h = \frac{4 \cdot H_{Sd}}{n_s} \quad [N]$$

Table 4.8 Form factors

Kind of flange connection		Tensile class of bolts		
		8.8	10.9	12.9
Ball bearing	Tensioning procedure with torsion	1 ,3876	1 ,3592	1 ,3451
	Tensioning procedure without torsion	1 ,1563	1 ,1327	
Roller bearing	Tensioning procedure with torsion	1 ,2923	1 ,2659	1 ,2528
	Tensioning procedure without torsion	1 ,0769	1 ,0550	

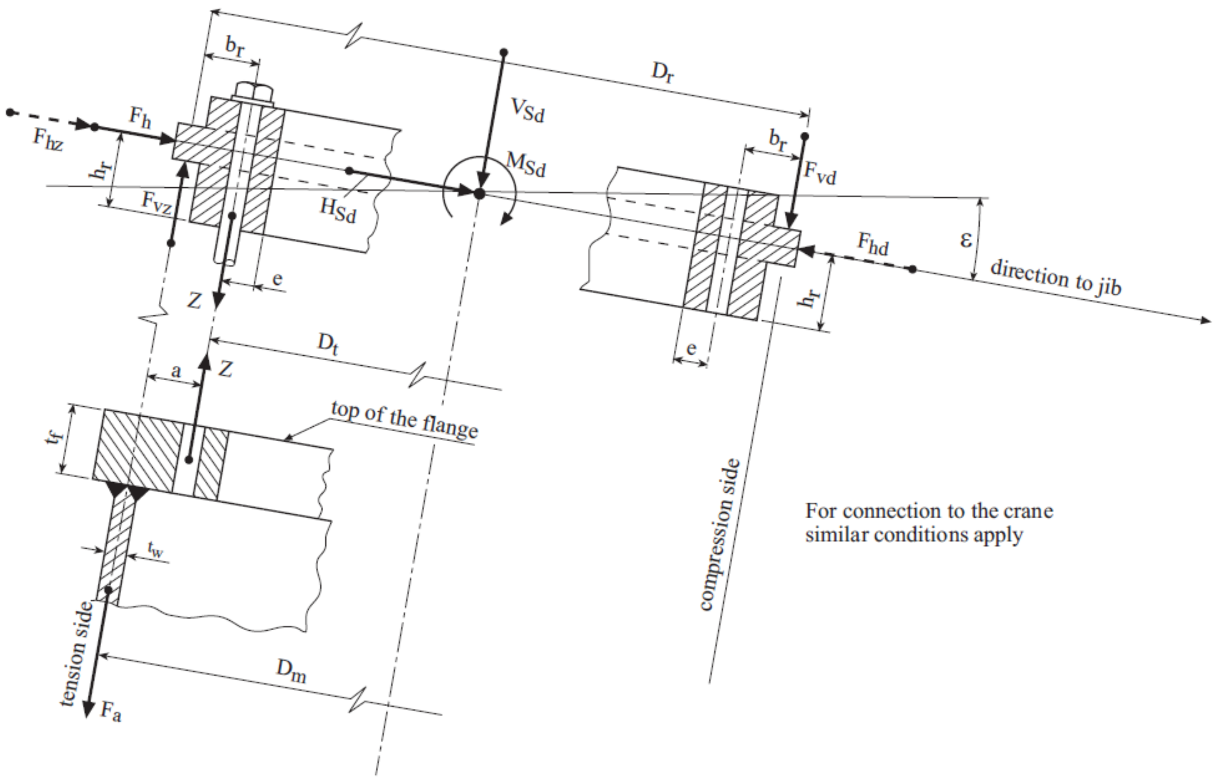

Fig. 4.5 Forces on a large slewing bearing

D = lowest value of D_m, D_t and D_r

n_s = number of bolts

F_{hd} = $F_{vd} \cdot \gamma_h$ [N]

F_{hz} = $F_{vz} \cdot \gamma_h$ [N]

F_{hd}, F_{hz} = forces between the rings with influence to the bolt forces

γ_h = horizontal force coefficient:

= 0 for multi row bearing

= 0,577 for single row ball bearing

= 1 for single row cross roller bearing

.7 Calculation of maximum nominal tensile force

Based on the dimensions acc. to Fig. 4.5 and on the forces acting on the bearing ring acc. to 4.1.2.6 the maximum nominal tensile force is calculated as follows:

$$Z_{nom} = F_{vz} + (F_h + F_{hz}) \cdot \frac{h_r}{a+e}$$

.8 Limit value of tensile force of bolt

The limit value of tensile force of the bolt is to be calculated as follows:

$$Z_{limit} = \sigma_{limit} \cdot A_k / 1000 \quad [kN]$$

σ_{limit} = limit stress acc. to Table 4.9 [N/mm^2]

A_k = core section of bolt acc. to Table 3.13 [mm^2]

Table 4.9 Limit stresses of bolts

Tensile class	8.8	10.9	12.9
Limit stess σ_{limit} [N/mm^2]	560	768	912

4.1.3 Requirements for the flange

.1 Flange connection

In general, the upper part of crane columns which are provided with a flange for connection to a slewing bearing shall be designed according to Fig. 4.6 In the case of an inner bore circle, the same conditions apply.

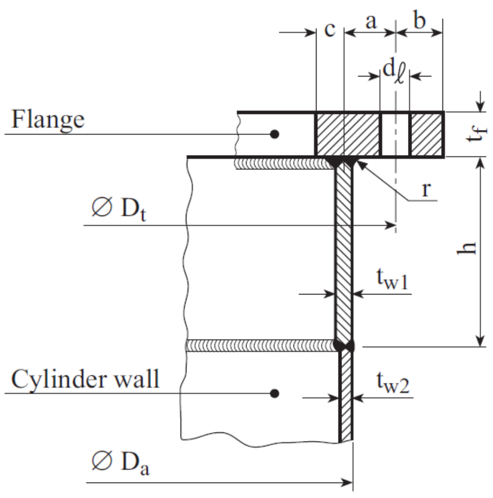

Fig. 4.6 Upper part of crane column

D_t = partial circle diameter

D_a = outer cylinder diameter

t_f = flange thickness

d_ℓ = bore diameter

r = corner radius

$a = \frac{D_t - D_a + t_{w1}}{2}$ external partial circle

$a = \frac{D_t - D_a - t_{w1}}{2}$ internal partial circle

h = height of connection area

t_{w1} = cylinder wall thickness in the connection area

t_{w2} = cylinder wall thickness below the connection area

.2 Dimensioning of the flange

The flanges are to be designed and dimensioned according to Section 3, I.1.5.2. As far as no proof by FE-computation has been conducted in addition the following conditions are to be met:

$$t_f \geq 3 \cdot t_{w1}$$

$$t_{w1} \geq 1{,}5 \cdot t_{w2}$$

.3 Facing

The flange thickness according to 4.1.3.2 shall still be warranted after the facing.

.4 Flange evenness

The evenness of the connecting areas on a slewing bearing shall meet the requirements of the manufacturer of this bearing.

.5 Use of compounds

The use of compounds in order to achieve the evenness required by the manufacturer of the slewing bearing, is only accepted in exceptional cases for repair purposes upon agreement by BKI and slewing bearing manufacturer.

4.1.4 Requirements for the cylinder wall in the connection area

.1 Dimensioning

The wall thickness t_1 and the connection weld are to be dimensioned with regard to fatigue strength.

.2 Height of connection

As far as no proof by FE-computation has been conducted the height of the uppermost cylinder section according to Fig. 4.6 shall at least be $0{,}2 \cdot D_a$, where the upper limiting point is formed either by the lower edge of the flange or by the lower edge of brackets.

4.1.5 Revolving circle diameter of the slewing bearings

.1 The diameter of the revolving circle shall correspond to the mean diameter of the upper and lower connection cylinder, if possible, in order to avoid additional measures, such as e.g. welding of brackets.

.2 Where brackets are to be attached, they shall not be spaced further than two bore distances.

4.1.6 Requirements for bolts and bores

.1 In general, the span length of bolts shall be at least $5 \cdot d_s$.

.2 At least 6 thread turns shall remain free.

.3 The connecting bolts of slewing bearings of cranes of the groups B2, B3 and C must have rolled threads.

.4 The size of bolt bores is to be indicated by the bearing manufacturer (in general according to Section 3, I.1.2).

4.2 Doubling plates

Doubling plates for the transmission of tension forces and bending moments are not permissible.

4.3 Cruciform joints

Regarding cruciform joints for the transmission of forces perpendicular to the roll direction, the requirements in Section 3, H.1.2.4 apply.

4.4 Joints of runways

Runways are to be welded continuously and the welds are to be executed such, that no vertical dynamic forces can be induced when travelling.

5. Securing of the hook in the condition "crane out of service"

The swinging of cargo hooks in the condition "crane out of service" shall be prevented by design, unless they are tied-down. The tie-down force may exceed 10 % of the nominal load L_{Ne} only in cases where this was a basis for the dimensioning.

Section 5 Lifts and Lifting Platforms

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A. General

1. General notes

1.1 This Section contains provisions for the selection and dimensioning as well as the manufacture and operation of lifts and lifting platforms on board seagoing ships. For employment on offshore installations, these devices can be treated in a similar manner.

1.2 The requirements of Section 1 are to be observed if applicable.

1.3 Lifts and lifting platforms will be certified by BKI following the procedure described in F In the event of a classification being required for goods lifts and lifting platforms, this will be conducted specially, where required, according to the individual case.

Certification and classification of loading gear are described in Section 1, A.

1.4 As regards the requirements for the materials to be used, as well as manufacture and welding, the provisions of Sections 2 and 11 apply.

1.5 As regards the requirements for machinery components or electrical installations, the provisions of Sections 9 and 10 apply, as applicable.

1.6 In this Section a distinction is made between "passenger and small goods lifts" and "goods lifts and lifting platforms", because they are dealt with differently in principle.

2. National regulations

2.1 For passenger and small goods lifts as well as goods lifts and lifting platforms for operation on board ship, only national regulations apply.

2.2 As regards application of national regulations, the requirements in Section 1, B.3 apply.

3. International regulations

3.1 Goods lifts and lifting platforms used for handling cargo are subject to the provisions of the ILO, which have been incorporated into these Guidelines with regard to accident prevention as well as tests and investigations.

4. Special lifts and installations

4.1 Lifts for disabled persons are treated according to the requirements of the following standard:

ISO 9386, Power operated lifting platforms for persons with impaired mobility - Rules for safety, dimensions and functional operation.

- Part 1, Vertical lifting platforms
- Part 2, Powered stair lifts for seated, standing and wheelchair users moving in an inclined plane

4.2 The following installations are not regarded as lifts or lifting platforms and are not dealt with in these Guidelines:

- retractable wheelhouses
- equipment and units for serving shelves
- escalators

B. Design Principles

1. Special features associated with ships

1.1 Static and dynamic ship inclinations

1.1.1 Operation in harbour

Lifts and lifting platforms operated in harbour or other calm waters shall be designed for static ship inclinations according to Table 3.1.

1.1.2 Operation at sea

Passenger lifts operated at sea shall at least be designed for the following dynamic ship inclinations and natural periods and shall remain safely operable under these conditions:

a)	roll angle of ship	α_{see}	=	$\pm 10°$
	associated roll period	T_R	=	10 s
b)	pitch angle of ship	α_{see}	=	$\pm 5°$
	associated pitch period	T_S	=	7 s

1.1.3 "Out of operation" condition at sea

Lifts and lifting platforms shall be designed for the dynamic forces stated in 2.3.2.2.

1.2 Electrical installations

1.2.1 Electrical installations shall operate reliably up to a heel of 15° and up to a trim of 7,5°. For electrical components which shall not fail even in an emergency situation, these values are 22,5° and 10° respectively.

1.2.2 Up to a 45° inclination of the ship, there shall be no inadvertent switching processes or changes of function.

1.3 Taking out of operation

If the seaway conditions according to 1.1.2 or the deviating design conditions are exceeded, passenger lifts shall be switched off and if appropriate, brought to special stowage positions.

1.4 Environmental conditions

Lifts and lifting platforms are to be designed for the expected environmental conditions, see Section 3, B.2.

2. Design loads

2.1 Main loads

2.1.1 The main loads of lifts and lifting platforms consist of dead loads and the useful load. Both load components form the hoist load, see Section 1, C.

2.2 Dynamic forces due to drives

For the hoist load and for counterweights, a hoist load coefficient of ψ = 1,15 is to be incorporated.

2.3 Dynamic forces generated by the ship

2.3.1 Horizontal forces due to ship inclinations

For in harbour operation, the forces due to static ship inclinations given in Table 3.1 are to be taken into consideration.

2.3.2 Dynamic forces due to motions of the ship

.1 Lifts and lifting platforms operating in a seaway

For operation in a seaway, dynamic forces due to the dynamic ship inclinations and the natural periods are to be calculated according to Annex A.

.2 Lifts and lifting platforms out of operation

For lifts and lifting platforms in their stowage positions, dynamic forces due to ship motion are to be calculated according to Annex A.

2.4 Wind and ice loads

The wind and ice loads defined in Section 3, B.4.5 and B.4.6 are to be taken into consideration where required for goods lifts whose operating area exceeds the main deck level as may be the case with e.g. transverse loading gear.

2.5 Special loads

Gripping device forces and buffering forces are to be estimated based on the respective EN 81-Standard, see B.3.3.4 and B.3.3.5.

3. Passenger and small goods lifts

3.1 Design and dimensioning

Passenger and small goods lifts are to comply with the following standards. Any required deviations and the resulting compensatory measures required are to be clearly indicated in the documentation submitted.

3.1.1 Passenger Lifts

– EN 81-20: Electric lifts

– EN 81-50: Hydraulic lifts
– ISO 8383, Lifts on ships – Specific requirements

The standards EN 81-20 and 81-50 are also applicable to goods lifts.

3.1.2 Small goods lifts

EN 81-3: Electric and hydraulic small good lifts

3.2 Definitions

In addition to Section 1, C the following definitions apply:

3.2.1 Passenger lifts

Electrically or hydraulically driven appliances with a guided lift car for the transport of persons, or persons and goods, between defined stopping positions.

3.2.2 Small goods lifts

Electrically or hydraulically driven appliances defined as loading gear with a guided, not accessible, lift car, for the transport of goods between defined stopping positions up to a nominal load of 300 kg and the following lift car dimensions:

– car floor area $\leq$ 1,0 m^2
– depth $\leq$ 1,0 m
– height $\leq$ 1,2 m

Where the lift car consists of multiple compartments, each of which does not exceed the above dimensions, the height is not restricted to 1,2 m.

3.3 Load conditions

For the following load conditions, only those which are applicable or relevant to the component under consideration need to be verified.

3.3.1 Load condition I_1, operation in harbour

$$LF\ I_1 = (L_H + L_{HH}) \cdot \psi$$

L_H = hoist load

L_{HH} = horizontal hoist load components due to the ship's inclinations, as per Table 3.1.

3.3.2 Load conditions I_2, I_3, operation at sea

$$LF\ I_2 = L_{HVR} + L_{HHR} \quad \text{(roll)}$$

$$LF\ I_3 = L_{HVS} + L_{HHS} \quad \text{(pitch)}$$

Vertical and horizontal hoist load components due to roll, index R, and due to pitch, index S. For the calculation see 2.3.2.1.

3.3.3 Load conditions III_1, III_2, lifts out of operation

$$LF\ III_1 = L_{EVR} + L_{EHR} \quad \text{(roll)}$$

$$LF\ III_2 = L_{EVS} + L_{EHS} \quad \text{(pitch)}$$

Vertical and horizontal dead load components due to roll, index R, and due to pitch, index S. For the calculation see 2.3.2.2.

3.3.4 Load condition III_3, gripping device forces

$$LF\ III_3 = (L_E + L_{Ne}) \cdot k$$

L_E = dead loads

L_{Ne} = nominal load

k = 5 in case of a wedge type safety catch

= 3 in case of a roller type safety catch

= 2 in case of a brake type safety catch

3.3.5 Load condition III_4, impact due to buffers

$$LF\ III_4 = (L_E + L_{Ne}) \cdot \left(2 + \frac{0{,}07 \cdot v^2}{s}\right)$$

$$\geq (L_E + L_{Ne}) \cdot 2{,}5$$

v = rated speed [m/s]

s = proven buffer stroke [m]

3.3.6 Load conditions for the counterweight

In load conditions I_1 to I_3, L_H is to be replaced by L_E, if the calculation refers to the counterweight. In load conditions III_3 and III_4 the component of nominal load L_{Ne} is to be omitted.

3.4 Strength analysis and dimensioning of various components

3.4.1 The strength analysis of passenger and small goods lifts is to be conducted in accordance with the requirements of EN 81-20, EN 81-50 and EN 81-3. Additionally the requirements of this Section are to be considered.

3.4.2 For analysis of load conditions I_1 to I_3, an off-centre location of the nominal load centre of gravity according to the respective EN standard is assumed. For small goods lifts a value of 10 % longitudinally and transversely is to be used for the lift car.

3.4.3 Guide rails are to be dimensioned for the applicable load conditions. In the case of passenger lifts, no continuity effect along several fixed points shall be assumed.

3.4.4 The safety of means of suspension and drive ropes of speed limiters is to be observed according to the respective EN standard.

3.4.5 Hydraulic cylinders and pressure lines for passenger lifts are to be dimensioned in accordance with EN 81-50. For small goods lifts in this regard, EN 81-3 is applicable.

4. Goods lifts and lifting platforms

4.1 Design and dimensioning

4.1.1 General notes

.1 Goods lifts and lifting platforms are to be dimensioned according to 4.4.1. As regards design, Sections 9 to 12 are to be observed additionally.

.2 Deviating from 4.1.1.1, goods lifts may also be designed and dimensioned in accordance with the standards EN 81-20 or 81-50.

4.1.2 Carrying persons

.1 Goods lifts and lifting platforms without permission to also carry persons shall not be equipped with operating buttons in the lift car or on the lifting platform, nor shall such buttons be within reach of anyone there.

.2 Where goods lifts and lifting platforms may also be used for carrying persons, they are to comply with the safety requirements of EN 81-20 or 81-50.

An essential safety criterion in this case is the installation of a safety catch. If there is a direct hydraulic drive, a safety device against pressure loss, directly attached to the cylinder, is sufficient.

.3 The above requirements do not apply for an operating range or lifting height up to 1,8 m.

4.2 Definitions

In addition to Section 1, C the following definitions apply:

4.2.1 Goods lifts

Normally devices with guided lift car without counterweight for the transport of goods between defined stopping positions.

4.2.2 Lifting platforms

Lifting platforms without guide rails which spatially follow a completely fixed course, as is the case e.g. with a scissor lift, are regarded as lifting platforms with guided loose gear.

4.3 Load conditions

Amongst the following load conditions only those which are applicable or relevant for the component under consideration need to be verified.

4.3.1 Load condition I_1, operation in harbour

For this load condition the requirements in 3.3.1 apply.

4.3.2 Load conditions I_2, I_3, operation at sea (only for devices for internal ship service)

For these load conditions the requirements in 3.3.2 apply.

4.3.3 Load condition II

$$LF\ II = (L_H + L_{HH}) \cdot \psi + L_{Wind} + L_{Eis}$$

This load condition applies only in special cases, see 2.4.

4.3.4 Load conditions III_1, III_2, goods lifts and lifting platforms out of operation

For these load conditions the requirements in 3.3.3 apply.

4.3.5 Load condition III_3, dynamic load test

$$LF\ III_3 = (L_E + L_{Pdyn}) \cdot \psi$$

L_E = dead loads

L_{Pdyn} = dynamic test load according to Table 13.2

4.4 Strength analysis and dimensioning of various components

For goods lifts which are designed and dimensioned in accordance with EN 81-20 or 81-50, only these requirements apply. Apart from that, the following applies:

4.4.1 For goods lifts and lifting platforms the strength analyses are to be conducted in accordance with Section 3 and 8.

4.4.2 For the analysis of load conditions I_1 to I_3 an off-centre location of the nominal load centre of gravity of 10 % longitudinally and transversely respectively is to be used for the platform.

4.4.3 Guide rails are to be dimensioned for the applicable load conditions.

4.4.4 For wire ropes the following safety factors according to Table 8.1 apply:

1) Operation with useful load = γ_{D1}
2) Operation with persons = $\gamma_{D1} \cdot 2$

4.4.5 The ultimate load of chains shall be at least γ_K - times the highest static chain tension:

1) Operation with useful load = $\gamma_K \geq 4{,}0$
2) Operation with persons = $\gamma_K \geq 8{,}0$

4.4.6 Hydraulic cylinders for goods lifts and lifting platforms are to be dimensioned according to Section 3, I.2.

4.4.7 Pressure lines for goods lifts and lifting platforms are to be dimensioned in accordance with generally recognized state-of-the-art technology or in accordance with the Rules for Machinery Installations (Pt.1, Vol.III) stated in Section 1, B.2.1.1.

4.4.8 Scratch boards for motor vehicles are to be designed to meet the line loads according to Table 5.1.

Table 5.1 Loading of scratch boards

Vehicle type	Line load	Height of load application
Passenger vehicles	2 kN/m	0,3 m
Trucks	5 kN/m	0,5 m

C. Design Requirements

1. Passenger and small goods lifts

The requirements of EN 81-20, EN 81-50 and 81-3 for the design of lifts are to be complied with in principle. In addition the following applies:

1.1 Lift shaft

1.1.1 Single or multiple lifts in one shaft, plus the associated counterweights, are to be separated by suitable metal partitions.

1.1.2 Components inside lift shafts shall be located or secured in such a way that persons in the shaft for test, maintenance or repair purposes are not endangered.

1.1.3 Ropes hanging in the shaft shall be protected against seaway damage.

1.1.4 Lift shafts shall be sealed so that water cannot enter.

1.1.5 Lift shafts shall comply with the SOLAS fire protection regulations.

1.1.6 In the lift shafts of passenger lifts, emergency lighting is to be provided which shall be connected to the ship's emergency power supply (SOLAS).

1.2 Doors and hatches

1.2.1 The mechanism controlling doors and hatches shall prevent self-activated opening, closing or slamming shut even in a seaway.

1.2.2 The clear height of doors may be restricted by a sill of max. 0,6 m height, if this is required by the freeboard convention.

1.2.3 Hatches intended for passing through shall have a clear opening of at least 600 x 600 mm in lift shafts. For escape hatches see 1.7.

1.2.4 Deck areas giving access to lift shaft doors shall have a non-slip covering.

1.2.5 Lift shaft doors shall comply with the SOLAS fire protection regulations.

1.3 Lift car and counterweight

1.3.1 Lift cars in which persons may travel shall have a non-slip floor covering and a handrail along at least one side.

1.3.2 Lift cars for transporting persons shall have ventilation openings of adequate size and be adequately lit.

1.3.3 Only counterweights of steel or similar solid materials are permitted; counterweights of concrete are not permitted. Fill or balance weights shall be inside a steel frame or fixed permanently in some other way.

1.3.4 The guide shoes sliding or rolling along the guide rails of passenger lifts shall be fitted with emergency guide plates or other means of emergency guidance. Parts of safety catch gear shall not be used for emergency guidance.

1.3.5 In the lift cars of passenger lifts, emergency lighting is to be provided which shall be connected to the ship's emergency power supply (SOLAS).

1.4 Safety catch and buffer

1.4.1 Counterweights shall also have safety gears which in the event of excessive downward speed are engaged by independent speed governors.

1.4.2 In the case of small goods lifts, 1.4.1 applies only if the runway of the counterweight extends down to the double bottom, or if there are accessible compartments underneath.

1.4.3 Buffers shall be capable of absorbing the kinetic energy of bringing to a stop lift cars loaded with the nominal load or counterweights, moving at the trigger speed of the speed governor.

1.4.4 In the case of passenger lifts, the average deceleration of the lift car shall not exceed 1 x g.

1.5 Drives

1.5.1 The electrical equipment shall be unaffected by current fluctuations in the ship's mains and shall comply with the regulations in IEC publication 92.

1.5.2 The drives of lifts for passengers on board passenger vessels shall be connected to the ship's emergency power supply (**SOLAS**).

1.5.3 Rope sheaves made of plastic may only be used with BKI approval.

1.6 Passenger lift equipment

1.6.1 Besides the emergency lighting, the emergency alarm and intercom in the lift car shall all be connected to the ship's emergency power supply.

1.6.2 Emergency alarm and intercom shall be in contact with a permanently manned area in the ship.

1.6.3 The emergency lighting in the lift car and lift shaft shall switch on automatically in the event of a power failure.

1.7 Escape from passenger lifts

1.7.1 General notes

.1 Passenger lifts shall be constructed in such a way that trapped passengers can be rescued and crew members can escape.

.2 Passenger lifts on board cargo vessels carrying up to 12 passengers count as lifts for crew members.

1.7.2 General requirements for lift cars

.1 The lift car ceiling is to incorporate an escape hatch with a minimum area of 0,24 m^2, the length of no of the sides being less than 350 mm. Lift car escape hatches may only open outwards and may not project beyond the edge of the lift car when open.

.2 The escape hatch shall be controlled electrically, i.e. opening of the hatch shall cause the lift to stop. Mere closing of the hatch shall not allow travel to continue; operability shall only be restored by intentional re-locking combined with the activation of a switch in the power unit area.

1.7.3 Requirements for passenger lift cars

.1 The escape hatch in cars for the transport of passengers is to be provided with a mechanical spring catch. The hatch shall only have a handle on the outside.

.2 For passenger lift cars, a ladder is to be provided which permits exit from or access to the lift car through the escape hatch in the ceiling. The ladder is to be kept in a supervised place accessible only to persons authorised to operate the lift.

1.7.4 Requirements for lift cars for crew members

.1 Lift cars for the transport of crew members shall be equipped with a permanently installed ladder or comparable equipment in the lift car.

.2 The escape hatch in the ceiling of lift cars for the transport of crew members shall be able to be opened from outside the car without a key; from inside, with a key e.g. a triangular emergency release key.

This emergency key shall be placed visibly in the lift car, in a small box with a glass front. The escape hatch is to have a handle on both the outside and the inside.

1.7.5 Escape ladders/steps for crew members

.1 Inside the lift shaft over its entire length there shall preferably be a fixed ladder, or else step irons. These shall lead to the shaft doors and to the escape hatch in the upper part of the shaft. Ladders or step irons shall be installed on the transverse ship walls.

.2 In the upper part of the shaft of lifts for crew members, an escape hatch is to be provided. This is to have a minimum area of 0,24 m^2, the length of one of the sides being not less than 350 mm. The hatch shall open outwards.

.3 The escape hatch shall be electrically monitored like the lift car's escape hatch (see 1.7.2.2).

.4 Opening the escape hatch from inside the lift shaft shall be possible without a key. From outside, the escape hatch shall be able to be opened only with an emergency release key.

The emergency release key is to be placed in the immediate vicinity of the escape hatch, in a small box behind a glass front. A second key is to be kept in the power unit area.

.5 Proper locking of the escape hatch is to be monitored electrically. Resumption of operation of the lift shall only be possible after intentional relocking of the escape hatch.

1.7.6 Description of the escape routine

.1 In all lifts descriptions of the escape routine shall be fitted in English and another language as well as pictograms at the following locations:

– in the lift car (only in lifts for crew members)
– on the ceiling of the lift car
– inside the lift shaft, beside each exit

.2 Descriptions of the escape routines are to be fitted in the machinery room of all lifts.

2. Goods lifts and lifting platforms

The following design requirements apply only to goods lifts and lifting platforms not carrying persons. Otherwise the requirements of 1. are applicable, where relevant.

2.1 Guide rails

Goods lifts and lifting platforms may be guided either by guide rails or by the operating equipment itself, as for instance in the case of a scissor lift.

2.2 Locks

2.2.1 No goods lift or lifting platform may be supported purely by ropes or chains, except when moving up or down. Mechanical locks or setting-down arrangements shall be provided at all stopping positions.

2.2.2 In special cases, such as side-loading equipment with an automatic follow-up device, mechanical locking may be dispensed with.

2.3 Overload protection

In an overload situation the goods lift or lifting platform shall remain at a standstill following activation. As regards the settings on overload protection devices, the requirements of Section 12, D.1.1.1 apply.

2.4 Emergency lowering devices

Every goods lift and every lifting platform shall be equipped with emergency lowering devices which permit safe, controlled lowering.

2.5 Safety devices against pressure loss

Load-bearing hydraulic cylinders shall be fitted with suitable safety devices against pressure loss which shall be connected directly to the cylinders.

2.6 Counterweights

Counterweights shall move in enclosed shafts and be provided with guide rails.

2.7 Tilting

Tilting of goods lifts and lifting platforms under load is to be prevented by suitable means.

2.8 Safeguards against persons falling into openings.

2.8.1 Openings/apertures in the deck shall be safeguarded as necessary by fixed or movable railings.

Movable railings shall have automatic locks controlled by the movement of the lift car or lifting platform.

2.8.2 If the decks with shaft openings can also be used by vehicles, a 30 cm high guard rail for passenger vehicles or a 50 cm high one for trucks is to be provided in addition to the railings.

2.9 Requirements for equipment

2.9.1 Marking

Regarding the manufacturer´s identification plate and stamping in conjunction with the issue of test certificates, the requirements of Section 13, B apply.

With respect to marking and other measures the following applies:

.1 Every goods lift or lifting platform respectively, and stopping position, is to be fitted permanently with a clearly visible designation of the nominal load and, if required, its configuration (e.g. the distribution of axle loads).

.2 On every goods lift and every lifting platform, and at every stopping position, notices shall be put up prohibiting the transport of persons.

.3 Safeguards against persons falling into openings, such as railings and guard rails, shall be painted in a warning colour and well illuminated.

2.9.2 Control stands and controls

.1 Control stands shall be located in such a way as to allow the best possible supervision of all movements to be controlled.

.2 All control stands are to be safeguarded against unauthorised operation.

.3 All controls shall be made in such a way that the way they are moved makes sense.

.4 If a goods lift or lifting platform has several control stands, the operating personnel shall be able to communicate via intercom.

.5 Each control stand shall be equipped with an emergency switch or key. Resumption of operation of a unit brought to a stop with this shall only be possible from the machinery room.

.6 Inscriptions on each control stand shall be in the language of the country and also in English.

2.9.3 Warning devices

When operating goods lifts or lifting platforms, dangerous areas shall be safeguarded by suitable means, e.g. warning signals, warning lamps and warning colours.

D. Examination of Drawings and Supervision of Construction

1. Examination of drawings

1.1 General notes

1.1.1 Examination of drawings and, where required, supervision of construction of passenger lifts and small goods lifts, as well as lifting platforms, is conducted by BKI only if mandatory as per national regulations and BKI is entitled to do so, or by request of the operator.

1.1.2 Deviating from 1.1.1, BKI requires the examination of drawings of planned new passenger lifts on board passenger vessels if this is not required by national regulations, see E.2.1.2.

1.1.3 In the case of lifts and lifting platforms which are under the control of BKI, an examination of drawings is required in principle for all safety or load-bearing components.

In such cases the scope of examination is determined in each individual case by BKI.

1.1.4 For existing lifts and lifting platforms which are to be under the control of BKI, the requirements in Section 1, D.6 apply as and where relevant.

1.2 Passenger lifts and small goods lifts

1.2.1 Documents to be submitted for examination according to EN 81

.1 The scope of information, drawings, calculations, wiring plans and component test certificates to be submitted by recognized test bodies for safety-related components shall correspond to EN 81-20, 81-50 and 81-3 as applicable.

.2 Consideration shall be given in regard to the configuration drawings, that lifts cannot be regarded as escape routes. This is to be considered in particular when accommodating persons with impaired mobility.

1.2.2 Additional documents to be examined

.1 In addition to the calculations required according to EN 81-20, further proofs of investigation may be required due to the specific conditions on board ship according to B.1.

.2 Test reports are to be submitted for the following Components:

- suspension ropes
- drive ropes of speed governors
- chains
- cylinders with pistons
- pressure hoses

.3 Specific salvaging and maintenance instructions shall be submitted for every passenger lift. These instructions are later to be put up in the lift machinery room in the form of information boards.

.4 For fire protection doors, BKI certificates or certificates of recognized organizations are to be submitted.

.5 The configuration drawings and/or overview drawings shall include information on all components in passenger lifts which are supplied with emergency power (drives, lighting, alarms and intercoms).

1.2.3 Handling of the documents for examination

.1 All documents to be examined by BKI are to be submitted in electronic format.

.2 After examination of all documents, BKI compiles two Register books, one of which is destined for the ship whilst the second remains as a parallel copy in BKI's Head Office.

.3 The submitting party receives a test report as confirmation, and where required examined documents are also returned, see 1.2.3.1.

1.3 Goods lifts and lifting platforms

For goods lifts designed in accordance with the provision of EN 81-20 or 81-50 the requirements in D.1.2 apply, otherwise the following applies, if applicable:

1.3.1 General requirements

With respect to the general requirements for the examination of drawings, the statements in Section 1, D.1 apply.

1.3.2 Documents to be submitted for examination

The following drawings and information are to be submitted in the scope required by 1.2.3.1 and, as necessary, to be discarded or completed:

.1 Steel structures

- lift cars, platforms and all kinds of load-bearing structures
- foundations and fixed fittings
- guide rails plus mounting
- guide blocks
- locking and setting-down devices
- material specifications
- welding procedure sheets and test plans

.2 Mechanical engineering

- load-bearing hydraulic cylinders with allocated safety device against pressure loss
- spindles and rack bars
- winch drums with rope attachment and screw joint of the winches
- Accessories, if not standard units (blocks, shackles, etc.)
- details of ropes, rope end attachments, rope-sheaves

.3 Electrical engineering

- illumination of access ways
- emergency power supply for the illumination of access ways, if necessary
- details of all safety devices, such as emergency stop, limit switches, overload protection devices
- protection category of motors and switch gear

.4 Documents for information

- details on manufacturer, customer and yard
- nominal data of electrical main propulsion plant for the electrical power balance of the ship
- overview drawings with arrangement of equipment on board, all access ways and arrangement of control stands
- strength analyses:
  - global strength analysis
  - elastic stability
  - fatigue strength analysis, if not dispensable
- functional descriptions, if necessary
- details of permissible "SWL" loads and basis of standards for standardized components of accessories
- details of nominal load, in the case of loads due to vehicles also the arrangement of axles and wheels

.5 Documents to be examined for Classification

Where goods lifts and lifting platforms are to be classified, BKI specifies the increased scope of examinations case by case in agreement with the manufacturer.

1.3.3 Handling of documents for examination

For the handling of documents for examination, the requirements in Section 1, D apply.

2. Supervision of construction

2.1 Passenger lifts and small goods lifts

For passenger lifts and small goods lifts, no supervision of construction is required by BKI.

2.2 Goods lifts and lifting platforms

2.2.1 For goods lifts and lifting platforms which are used for ship operation, no supervision of construction is required by BKI if these devices are not to be examined and/or certified by BKI.

2.2.2 Goods lifts and lifting platforms for the handling of goods are subject to the requirements of ILO. For these devices, supervision of construction by BKI, is required in accordance with the statements in Section 1, B.4 and Section 13, B.

E. Tests and Examinations on Board

1. General notes

1.1 The term "tests and examinations" includes functional tests and load tests, visual inspections, checks as well as other practical measures and is denoted as "tests" in the following.

1.2 Tests before newly built lifts and lifting platforms are put into operation, as well as after changing safety-related or load-bearing components, require examination of the drawings.

1.3 Depending on the flag state regulations, lift tests are conducted by BKI, by national administrative bodies or by organizations authorised by the authorities.

2. Tests on passenger lifts and small goods lifts

2.1 Test principles

For the testing of passenger lifts and small goods lifts, the requirements of the applicable EN 81-20, EN 81-50 and 81-3 apply as well as, in addition, the following requirements.

2.1.1 BKI conducts tests on passenger lifts and small goods lifts if national regulations require and permit it, or on request by the operator.

2.1.2 Passenger lifts on board passenger vessels classified by BKI are required to be tested as a prerequisite to the issue and renewal of the safety certificate for passenger vessels by BKI, see also D.1.1.2.

2.1.3 The operation and catch tests on lifts and lifting platforms shall be conducted by competent persons in compliance with the instructions of the BKI Surveyor.

2.2 Initial test

A successful initial test is the prerequisite for putting a lift into operation and requires the following actions:

2.2.1 Check it agrees with the examined drawings and with the other documents for examination.

2.2.2 Check there is agreement between the components' test certificates and the corresponding safety-related components.

2.2.3 Operation and catch tests with test load to the extent required by one of the applicable EN 81-20, 81-50 and EN 81-3.

2.2.4 Issue of a Certificate of Testing of Lifts by BKI.

2.2.5 Handover of a Register book prepared by BKI, see 1.2.3.2, together with the Certificate of Testing of Lifts, to the yard or the operator.

2.2.6 Stamping of the lifts after issue of test certificate is not provided for.

2.3 Principal tests

2.3.1 Principal tests on passenger lifts are to be performed 2,5 years after the initial test and every 2,5 years after the last principal test.

2.3.2 Principal tests on small goods lifts are to be performed 5 years after the initial test and every 5 years after the last principal test.

2.3.3 Principal tests require operation and catch tests in accordance with the requirements of one of the applicable standards EN 81-20, EN 81-50 and 81-3 as well as a check on the current condition.

2.3.4 After the tests, BKI issues a Certificate of Testing of Lifts and attaches it to the Register book.

2.4 Intermediate tests

2.4.1 Within the time period between the initial test and the following principal test, as well as between the principal tests, an intermediate test is required. The intermediate tests are due one day after expiry of half the period of time.

2.4.2 Intermediate tests are of a lesser scope than principal tests and consist substantially of a functional test and a condition check, which normally does not require the assistance of specialists.

2.4.3 After the tests, BKI issues a Certificate of Testing of Lifts and attaches it to the Register book.

2.5 Time frame

2.5.1 For both the principal and intermediate tests on passenger lifts, a time frame of ± 3 months applies.

2.5.2 For both the principal and intermediate tests on small goods lifts, a time frame of ± 6 months applies.

2.5.3 The utilization of a time frame does not change the due date of principal and intermediate tests.

2.6 Special tests

2.6.1 Special tests are required following damage and repair as well as after changes to safety-related or load-bearing components.

2.6.2 The scope of testing is determined case by case by BKI.

2.6.3 After the tests, the BKI Surveyor issues a Certificate of Testing of Lifts and attaches it to the Register book.

3. Testing of goods lifts and lifting platforms

3.1 Goods lifts and lifting platforms for the handling of goods are subject to the requirements of ILO. For all tests and certificates therefore the requirements in Section 13, C to E apply.

3.2 Goods lifts and lifting platforms for ships' operation are solely subject to national regulations, which BKI adheres to, if authorized to do so:

3.2.1 Where national regulations do not exist, nor deviations therefrom, BKI tests, investigates and certifies according to the requirements of ILO.

3.2.2 Instead of the ILO's certification systems, a BKI "Lifting Appliances not handling cargo test/Examination Certificate" can also be issued for each device. These certificates are kept together in a BKI file. The differences between the certification systems of ILO and BKI are described in Section 13, G.

F. Lift Documentation

1. General notes

The following requirements refer to passenger lifts and small goods lifts.

For goods lifts and lifting platforms the requirements of Section 13, G apply, see also 3.2.2.

2. Marking

2.1 In the lift cars of passenger lifts a permanently installed sign with the nominal load and the permissible number of persons is to be displayed.

2.2 At each stopping position of small goods lifts, a permanently installed sign with the nominal load is to be displayed.

3. Test certificates

3.1 Manufacturer's Test certificates

The lift manufacturer shall submit to BKI the component test certificates and the suppliers' test reports which are required by EN 81-20, 81-50 and EN 81-3 and by BKI according to D.1.2.2, and shall also supply a test report for each lift.

3.2 BKI test certificate

3.2.1 The purpose of Certificate of Testing of Lifts issued after each test, is to confirm the tests performed and to document their results.

4. Register book

All Information and certificates are to be compiled in a Register book and stored. The following applies:

4.1 Every lift shall have a separate Register book which has always to remain on board the ship and shall be submitted to the BKI Surveyor or other authorised person on demand.

4.2 The Register book serves as the storage place for examined documents as well as for the documentation of tests and maintenance procedures.

4.3 The BKI “Register book” consists of a file containing the following:

- BKI “Test Confirmation”
- BKI test certificates and/or test reports
- component test certificates
- examined drawings
- description of the lift installation
- operating and maintenance instructions
- salvage instructions
- calculations
- new Certificate of Testing of Lifts issued after every test

4.4 It is the task of the ship's management to store the Register books safely during the entire lifetime of the passenger lifts and small goods lifts.

Section 6 Special Loading Gear and Means of Transport

A. General 6–1
B. Rope and Chain Hoists 6–1
C. Ramps and Car Decks 6–5
D. Loading Gear for Research Work 6–9
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A. General

1. This Section deals with the requirements for the design and dimensioning as well as for the manufacture and operation of special loading gear and means of transport.

2. The requirements in Section 1 are to be observed where relevant.

3. As regards requirements for the materials to be used as well as for manufacture and welding, the requirements of Sections 2 and 11 apply.

4. Calculation and dimensioning is to be based on Sections 3 and 8 as well as further Sections as required. Deviating requirements in this Section are to be observed.

5. For machinery components and the electrical fittings on special loading gear and means of transport, the requirements of Sections 9 and 10 are to be complied with, if applicable.

6. Accessories shall be selected using recognized standards. The dimensioning of non-standard accessories can be carried out in accordance with Section 7.

B. Rope and Chain Hoists

1. General notes

1.1 The requirements that follow apply to rope and chain hoists, regardless of drive mode, which are not used for handling cargo. They only apply to manually operated devices however, where relevant.

1.2 Handling of goods for ship operation is not regarded as cargo handling.

2. Manufacture

2.1 Materials

In addition to the steels and materials generally used for machinery components, special steels, aluminium, plastics and other materials can be used if they are appropriate for the intended use.

2.2 Dimensioning

The requirements of A.4 also apply to foundations or runway girders of rope and chain hoists produced in series.

3. Equipment and safety regulations

For all types of drive, the requirements of Section 12 are also to be observed, if applicable. In addition, the following applies:

3.1 Overload protection

3.1.1 Series production

.1 For hydraulic, pneumatic and electrical hoist drives, effective overload protection devices are to be provided.

.2 In the case of hydraulic hoist drives, pressure relief valves are permissible up to a nominal load of 1000 kg.

.3 As regards response limits and response tolerances of overload protection devices, the settings or parameters given by the manufacturer apply.

3.1.2 Individual production

For rope and chain hoists manufactured by individual or special production, the requirements in Section 12, D.1.1 apply.

3.2 Hook travel limits

3.2.1 General requirements

.1 Rope and chain hoists shall have limit switches for the upper and lower hook position.

.2 In the case of power-operated rope and chain hoists, the limit switches are to act mechanically and/or electrically on the hoist drives.

3.2.2 Series production

.1 For hydraulic, pneumatic and electrical hoist drives, effective limit switches for the hook travel are to be provided.

3.2.3 Individual production

For rope and chain hoists manufactured by individual or special production, limit switches for the upper and lower hook position are to be provided which function electrically.

3.3 Runway limit

As regards runway limit, the requirements in Section 4, C.4.2 and Section 12, D.2 apply, if applicable.

3.4 Slack rope limit

In special cases, slack rope monitoring and limitation may be required, e.g. at high hoist speeds, with multiple coils or if required by the mode of operation.

3.5 Eye plates for load tests

It is recommended suitable eye plates be fitted to the ship's hull for load tests on hoisting ropes and hoisting chains located below deck. For this kind of load test the application of the test load shall be conducted with a separate manual hoist only, but not with the power drive of the rope or chain hoist itself.

4. Means of suspension

4.1 Hoisting ropes

4.1.1 General notes

.1 Hoisting ropes and their end attachments are covered by the requirements in Section 8.

.2 Wire-ropes made of stainless materials, as well as fibre ropes, may be allowed for special purposes if suitable, and if the design of the hoist rope is verified accordingly.

4.1.2 Safety against fracture

.1 Safety against fracture is defined by the coefficient of utilization γ_{D1} or γ_F according to Table 8.2 and Table 8.4 and this is to be applied to the maximum static hoisting rope force.

.2 When using rope hoists below deck γ_{D1} may be $\leq 4,0$.

.3 For the use of rope hoists above deck the following applies:

a) In the case of rope hoists manufactured by series production γ_{D1} may be $\leq 4,0$ unless national regulations dictate otherwise.

b) For rope hoists manufactured by individual or special production, the values in Table 8.2 and Table 8.4 are to be used without limitation of γ_{D1} or γ_F.

4.2 Hoisting chains

4.2.1 General notes

.1 Hoisting chains shall comply with recognized standards.

.2 Chain wheels of hoisting chains as well as their end links or fasteners for leading-in the tow chain are to conform to standards.

4.2.2 Safety against fracture

The breaking load of hoisting chains shall be at least the γ_K-fold of the chain's maximum static towing force. The following coefficients of utilization γ_K are to be applied:

$\gamma_K \geq 5,0$ (power-driven)

$\gamma_K \geq 4,0$ (operated manually)

4.3 Accessories

4.3.1 Accessories such as e.g. cargo hooks, shackles and rope sockets, shall comply with recognized standards, and shall be dimensioned for test loads according to Table 7.4.

4.3.2 The dimensions of the eye plates on normal strength and higher strength shackles are to comply with the Tables in Section 7.

4.3.3 Regarding the use of detachable rope end attachments (rope sockets or rope clamps), the requirements in Section 8, D.2.3 apply.

5. Examination of drawings and supervision of construction

5.1 Series production

5.1.1 Manufacturers of rope and chain hoists made by series production, are permitted to produce under their own responsibility and to certify their products themselves, if the manufacturing processes and products are certified in a legally-binding and recognized manner, e.g. by type approval.

For those, in addition to drawings of foundations or runway girders including fastenings, the following information at a minimum is to be submitted, if applicable:

- designation of manufacturer and type
- nominal load(s) and dead weight(s)
- hoist speed and operating speed, if applicable
- type of drive
- type(s) of electrical protection, see Section 10, F.1.7
- further information as required

5.1.2 For a BKI type approval the Guidance for Approval and Type Approval of Material and Equipment for Marine Use (Pt.1,Vol.W) stated in Section 1, B.2.1.2 apply.

5.2 Individual production

5.2.1 Rope and chain hoists manufactured by individual or special production are subject to examination of drawings and supervision of construction by BKI.

5.2.2 For the examination of drawings, the list of documents to be submitted for examination in Section 1, D.2.2 is to be applied as and where relevant. In addition the following drawings and information are to be submitted, if applicable:

- housing
- rollers including fastening to housing
- form-locking drive devices such as e.g. rack bars and pinions
- runway limits
- details of hoisting ropes and hoisting chains including end attachments
- rope-sheaves/chain wheels
- foundations or runway girders including fastenings
- stowage position including fastening devices
- further documents as required

5.2.3 For supervision of construction, the requirements in Section 13, B apply.

6. Tests and examinations on board

6.1 For the initial test and examination, the requirements in Section 13, C apply.

6.2 For the periodic testing and examinations, the requirements in Section 13, D apply.

7. Documentation

7.1 Identification

For the identification of rope and chain hoists, the requirements in Section 13, B.4.2.1, B.5 and B.6 and C.5 apply.

7.2 Certificates

7.2.1 Certificates for production

.1 Series production

Rope and chain hoists manufactured by series production shall be delivered with a test report as well as with test reports for all means of suspension, such as ropes, chains and accessories.

.2 Individual production

For rope and chain hoists manufactured by individual or special production, a Test Certificate based on an examination before delivery is required.

BKI test certificates are to be submitted for all means of suspension such as ropes, chains and accessories.

7.2.2 Certificate for load tests

.1 Certificates to be issued after every load test, due to national regulations, are described in Section 13, G.

.2 For rope and chain hoists which are not to be subjected to ongoing control by BKI, BKI may recognize deviating forms or certificates not issued by BKI.

7.3 Register book

7.3.1 All certificates for means of suspension and load tests, investigation reports as well as information for operation (manuals, maintenance protocols, etc.), where applicable, shall be compiled in a Register book and stored. For details see Section 13, G.

C. Ramps and Car Decks

1. General notes

1.1 Testing, investigation and certification of ramps and car decks fixed to the ship is part of the Classification of the ship.

1.2 As regards naval-architectural concerns such as ship's strength, water-tightness, impact stress by the sea, etc. the requirements in the BKI Rules for Hull (Pt.1, Vol. II) Sec. 21 apply, see Section 1, B.2.1.1.

1.3 The following requirements relate to mobile shipborne ramps and car decks.

2. Production

2.1 Materials

In addition to ship structural steels, other steels and aluminium may also be used for load-bearing constructions, if they are suitable for the intended purpose.

For machinery components, materials are to be selected in acc. with Rules for Materials (Pt.1, Vol.V).

2.2 Dimensioning

2.2.1 The dimensioning of steel or aluminium ramp or car deck construction shall comply with the requirements stated in 1.2.

2.2.2 For the dimensioning of structural or machinery components of rope or chain drives, a hoist load coefficient of ψ = 1,15 is to be applied to moved masses.

3. Equipment and safety regulations

3.1 Scratch boards, railings and barriers

3.1.1 Ramps and car decks are to be fitted with scratch boards, railings and barriers, as necessary. For the dimensioning of scratch boards Section 5, B.4.4.8 applies, for railings Section 3, I.9.2.

3.1.2 The construction of scratch boards, railings and barriers including their associated safety devices such as e.g. colour markings, photoelectric barriers and warning signals are subject to drawing examination by BKI.

3.2 Anti-slip safeguards

Ramps shall be fitted with welded-on or bolted-on anti-slip safeguards.

In special cases, anti-slip paint may be permitted in lieu.

3.3 Ramp inclination

Ramp inclination shall not in general exceed the ratio 1:10.

3.4 Permissible deflection

3.4.1 The permissible deflection of ramps and car decks under nominal load in the stowed position shall not exceed:

$$f = \frac{b_s}{200}$$

where

f = deflection (depth gauge)

b_s = spacing of supports (span)

3.4.2 In the stowed position, the deflection may not endanger either the water-tightness of the ship or any cargo (e.g. vehicles) underneath.

3.5 Stowage positions

3.5.1 In the stowage positions provided, ramps and car decks shall not be hung on ropes or chains but shall have mechanical supports and locks.

3.5.2 Supports and locks shall be dimensioned according to the requirements in 1.2 and safeguard the water-tightness of the ship, where ramps are part of the shell.

4. Means of suspension

4.1 Hoisting rope and suspension rope

4.1.1 General notes

.1 For hoisting ropes and suspension ropes and their end attachments, the requirements in Section 8 apply.

.2 Wire ropes of stainless materials as well as fibre ropes may be permitted for special purposes in individual cases, if they are suitable and if the design of the rope drive is adjusted accordingly.

.3 Fibre ropes for the transport of persons are only permitted under special conditions.

4.1.2 Safety against fracture

.1 Safety against fracture is defined by the coefficient of utilization γ_{D1} or γ_{D2} according to Table 8.2 and is to be applied to the maximum static towing rope force.

.2 For hoisting ropes, the following safety factors are to be applied, depending on the mode of operation, in accordance with Table 8.2:

a) operation without useful load : $\gamma_{D1} \geq 3,6$

b) operation with useful load : γ_{D1}

c) operation involving persons : $\gamma_{D1} \cdot 2,0$

.3 Ramps which are not supported at their free end when used by vehicles, may, apart from chains, also be fixed by hoisting ropes or special suspension wires. In this case, the following safety factors are to be used:

a) hoisting ropes or guided suspension ropes : $\gamma_{D1} \cdot 2,0$

b) suspension ropes, not guided : $\gamma_{D2} \cdot 2,0$

4.2 Hoisting chains and suspension chains

4.2.1 General notes

.1 Hoisting chains and suspension chains are to comply with recognized standards.

.2 Chain wheels as well as their end links or fasteners for leading in the tow chain are to be selected in conformance with standards.

4.2.2 Safety against fracture

The breaking load of hoisting chains and suspension chains shall be at least the γ_K-fold of the chain's maximum static towing force. Depending on the mode of operation, the following coefficients of utilization γ_K are to be applied:

a) operation without useful load : $\gamma_K \geq 2,8$

b) operation with useful load : $\gamma_K \geq 4,0$

c) operation involving persons : $\gamma_K \geq 8,0$

4.3 Accessories

4.3.1 The requirements in B.4.3.1 and 4.3.2 are to be observed.

4.3.2 Detachable rope end attachments (rope sockets or rope clamps) are not permitted for rope drives of ramps and car decks.

4.4 Hydraulic cylinders

Hydraulic cylinders are to be dimensioned in accordance with Section 3, I.2.

5. Examination of drawings and supervision of manufacture

Ramps and car decks are subject to examination of drawings and supervision of manufacture.

5.1 Examination of drawings

For the examination of drawings, the list of documents to be submitted in Section 1, D.4.2 is to be applied as and where relevant. In addition, the following drawings and information are to be submitted, if applicable:

- overview drawing with layout and numbering of ramps and car decks, where applicable
- complete rope drives and chain drives
- guide blocks including fastenings
- scratch boards, barriers and railings
- rigging plans
- additional documents as required

5.2 Supervision of manufacture

For the supervision of manufacture the requirements in Section 13, B apply.

6. Tests and investigations on board

6.1 Initial test and investigation

6.1.1 For the initial test and investigation, the requirements in Section 13, C apply.

6.1.2 The load tests with test loads according to Table 13.2 are to be performed statically in the stowage positions and dynamically for the movable installations.

6.2 Periodic testing and investigations

6.2.1 As part of the ship's Classification, ramps and car decks are subject to annual Class surveys and 5-year Class Renewal surveys. Instead, provision is made for annual performance tests, but not for 5-year load tests.

6.2.2 Where required by national regulations, ramps and car decks are to be treated like loading gear for the handling of cargo. The requirements in Section 13, D apply in this case. During the 5 years load tests, 6.1.2 is to be observed.

7. Documentation

7.1 Identification

For the identification of ramps and car decks, the requirements in Section 13, B.5, B.6 and C.5 apply.

7.2 Certificates

7.2.1 Manufacturing Certificates

.1 The manufacturer of ramps and car decks shall supply BKI test certificates for all means of suspension such as ropes, chains, accessories and hydraulic cylinders as well as for winches.

.2 As confirmation of investigation before delivery, a Test Certificate is required for every ramp and every car deck or for every series of such ship components.

7.2.2 Certificates for load tests

.1 As a confirmation of the load tests, a Test Certificate is required for every ramp and every car deck or for every series of such ship components.

.2 Where, due to national regulations, ramps and car decks are to be treated like loading gear for the handling of cargo, the requirements in Section 13, C.6 and D.6 apply.

7.3 Register book

7.3.1 All certificates for means of suspension and load tests, investigation reports as well as information about operation (manuals, maintenance protocols, etc.), where applicable, shall be compiled in a Register book and stored. For details, see Section 13, G.

7.3.2 Where ramps and car decks are not to be treated like loading gear for the handling of cargo, the following applies:

.1 After the initial test and investigation the BKI Surveyor compiles a documentation file including, if applicable:

- Test Certificate; for the initial test and investigation
- Form LA4 for wire ropes, where required also as Certificate of test and examination of fibre ropes
- Form LA3 for accessories
- Test Certificate(s) for chain, hydraulic cylinders and winches

.2 Confirmation of the Class surveys according to 6.2.1 is effected within the scope of ship Classification. Relevant excerpts of the survey report for the ship may be added to the documentation file.

D. Loading Gear for Research Work

1. General notes

1.1 Loading gear for research work is employed for the extraction of seabed samples and water samples, for towing and for general handling of research equipment. In the process, ropes, cables or a combination of both are utilized.

1.2 Exceptional loads may result from large rope or cable lengths, from ship movements, or from extraction devices getting caught, as well as being pulled out of the sediment.

1.3 Loading gear for research work is e.g.:

- stern gantry crane
- slewing gallows
- lateral outrigger

– hatch beam
– loading gear with special functions
– A-frames

2. Treatment of loading gear for research work

Loading gear for research work is treated like loading gear not intended for the handling of cargo. The following specific features, however, shall be considered.

3. Special features

3.1 Dimensioning

3.1.1 Loading gear for research work is to be dimensioned for the breaking loads of ropes or cables. For the dimensioning, the following load combination is to be assumed, following Table 4.4, load combination III:

– dead loads γ_{pi} = 1,10
– rope/cable breaking load γ_{pi} = 1,10
– diagonal pull γ_{pi} = 1,10
– resistance coefficient γ_m = 1,10

In general, for this purpose the diagonal pull is to be assumed for the most unfavourable direction as follows:

– lifting 15°
– towing longitudinally to the ship 30°
– towing transversely to the ship 45°

3.1.2 Where loading gear for research work is also intended for handling goods for ship operation, it is also to be dimensioned accordingly.

3.1.3 Accessories are to be selected in such a way that the breaking load of ropes or cables corresponds to the test loads of the accessories stated in Table 7.4.

3.2 Marking

3.2.1 When marking loading gear for research work, the requirements in Section 13, B.5 apply. Instead of SWL and a quantity in kg or t, the minimum breaking load of the rope as MBL_{Rope} and a quantity [kN] is to be used.

3.2.2 Where several ropes or cables are attached to one item of loading gear, marking is required on every single rope or cable.

3.2.3 Where loading gear for research work is also intended for handling goods for ship operation, it is also to be marked with SWL.

When determining the quantity to be indicated, the breaking load of the rope is to be divided by the coefficient of utilization γ_{D1} in accordance with Table 8.2, and then to be converted into kg or t.

3.3 Operating manual

3.3.1 An individual operating instruction is to be prepared for every item of loading gear for research work, in which the special features of operation and control are described.

3.3.2 Operating manuals are subject to examination and shall remain permanently on board as part of the loading gear documentation.

E. Industrial Cargo Handling-Vehicles

1. General notes

1.1 The following requirements apply to industrial cargo-handling vehicles in series production which are certified in a legally-binding or recognized manner, unless otherwise provided by national regulations.

1.2 Prerequisites for use on board are proofs of stability against overturning, see Section 3, E.2.2, and, at a minimum, the existence of test reports.

1.3 The requirements in 3. and 4. apply only to industrial cargo-handling vehicles which remain in permanent employment on board.

2. Safety regulations

2.1 The employment of industrial cargo-handling vehicles on board presupposes that decks and hatch covers are adequately dimensioned to be run over.

2.2 Where industrial cargo-handling vehicles remain permanently on board, fastening arrangements (e.g. eye plates) for securing for use at sea are to be fitted both to the vehicle and to the hull.

2.3 The use of industrial cargo-handling vehicles powered by IC engines or by non-explosion proof electric motors is not permitted in hazardous locations and areas.

2.4 Industrial cargo-handling vehicles run on fuel may only be used in cargo spaces if there is adequate ventilation. Otherwise, only battery-powered vehicles are to be employed.

2.5 The use of fuels with a flash point below 60 °C is not permitted.

2.6 In general fork-lift trucks to be used on board are to have a tiltable lifting frame.

3. Control measures

3.1 Initial control

Before start of operation, the following measures are required at a minimum:

- check the information documents included with delivery
- function check with nominal load
- test run over the operational areas with nominal load as proof the deck or hatch covers are sufficiently strong.

3.2 Regular controls

Industrial cargo-handling vehicles are subject to supervision and regular control by the ship's management at intervals not exceeding 6 months.

These controls shall be confirmed in a suitable manner and added to the documentation.

4. Documentation

4.1 Certification

For the control as per 3.1, BKI issues a Test Certificate.

4.2 Identification

For stamping, correlating to the test certificate, the requirements in Section 13, C.5 apply.

4.3 Register book

4.3.1 All certificates for load tests, investigation reports as well as information about operation (manuals, maintenance protocols, etc.), where applicable, shall be compiled in a Register book and stored. For details, see Section 13, G.

4.3.2 In addition to the certificate as per 4.1, the manufacturer's documentation is to be included in the Register book. This also applies to all confirmations of control measures by the ship's management, see 3.2.

F. Means of Conveying Persons

1. Shipborne working baskets

1.1 Newly-manufactured working baskets are to meet the requirements in EN 14502-1.

1.2 Shipborne working baskets are to be treated in all respects similarly to loading gear not handling cargo. Their dimensioning and testing shall however be subject to the static test loads according to Table 7.2.

2. Requirements for loading gear for conveying persons

Loading gear for conveying persons shall comply with the requirements in Section 3, B.5 with respect to dimensioning, operation and control.

3. Landing booms

3.1 General notes

3.1.1 The provision and the arrangement of landing booms (swinging booms for conveying persons) are required by the St Lawrence Seaway Authority.

3.1.2 Landing booms shall only be used for conveying one single person at a time.

3.1.3 Landing booms shall be treated as loading gear, not handling cargo, except where otherwise determined in what follows.

3.2 Dimensioning

3.2.1 Landing booms together with the associated posts shall be designed for a static test load L_{Pstat} of 300 kg (Table 7.1, load condition III_2, without wind and hoist load coefficient).

3.2.2 Ropes and interchangeable components shall be designed, in addition to the dead loads, for a static boom load of 150 kg at a minimum.

3.2.3 The slenderness ratio λ of a landing boom may not exceed a value of 200.

The following equations apply:

$$\lambda = \frac{\ell_k}{i}$$

$$i = \sqrt{\frac{I_L}{A_L}}$$

I_L = moment of inertia of boom

A_L = cross-section area of boom

3.3 Construction and layout

3.3.1 The load radius of landing booms shall be about 9,0 m.

3.3.2 If landing booms are equipped with several span ropes (e.g. a second span rope about halfway along the boom), the length of these intermediate span ropes shall be adjustable.

The length adjustment of the intermediate span rope shall be effected in such a way that no unfavourable stress may arise under load (cantilever effect).

3.3.3 Landing booms are to be operated exclusively by hand. The lowering system shall allow gentle set-down.

3.3.4 Landing booms shall be located in the forward portion of the ship, roughly at the point where the bow has widened to the full beam, and shall swing forward from aft.

3.4 Examination of drawings and supervision of construction

3.4.1 Landing booms together with the associated posts shall be constructed according to the drawings approved by BKI.

3.4.2 Because all components are normally easily accessible for subsequent controls, supervision of construction is not required in general. Test reports are to be included in the delivery.

3.5 Tests and investigations on board

3.5.1 For the tests and investigations on board, the requirements in Section 13, C and D apply with the following deviations:

3.5.2 Landing booms are to be tested before start of operation and periodically every 5 years, either statically by swinging a test load of 300 kg, or by swinging, lowering and braking a test load of 200 kg.

3.6 Documentation

With respect to identification, certification and documentation, the requirements for loading gear not handling cargo apply, see Section 13.

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Section 7 Loose Gear and Interchangeable Components

A General 7–1
B. Loose Gear 7–1
C Interchangeable Components 7–11
D Marking of Loose Gear and Interchangeable Components 7–18
E Wear, Damage, Repair 7–22

A General

1. This Section deals with the requirements for design and calculation as well as production and employment of loose gear and interchangeable components.

2. With respect to requirements for the materials to be used as well as for production and welding, the provisions in Sections 2 and 11 apply.

3. For machinery components and electrical loose gear equipment, the requirements in Sections 9 and 10 are to be complied with, where relevant.

B. Loose Gear

1. General notes

The following requirements apply to loose gear according to Section 1, C.4 and C.5.

2. Design principles

2.1 General notes

The requirements in Section 3 are to be observed as appropriate. In addition the following applies:

2.1.1 Suspension ropes, rope slings and their rope attachments are to comply with the requirements in Section 8.

If a Form LA4 for the rope is submitted and proof is provided that the rope connections have been produced by manufacturers with BKI approval, then further requirements for interchangeable components may be dispensed with.

Regarding the rope deflection, the reduction of the minimum breaking load which depends on the ratio D/d is to be taken into account.

2.1.2 Suspension chains and their end attachments are to comply with recognized standards.

2.1.3 Regarding the suspension height of loose gear, it shall be pointed out that the opening angle of suspension ropes or chains is not to exceed 120° and of ramshorn hooks is not to exceed 90°.

2.1.4 In order to warrant balance (safety against turn-over) of the total system or parts of it, consisting of loose gear and/or load, it is assumed in the requirements of this Section that both the loose gear and the loads have a positive stability height, see illustration in Fig. 7.1.

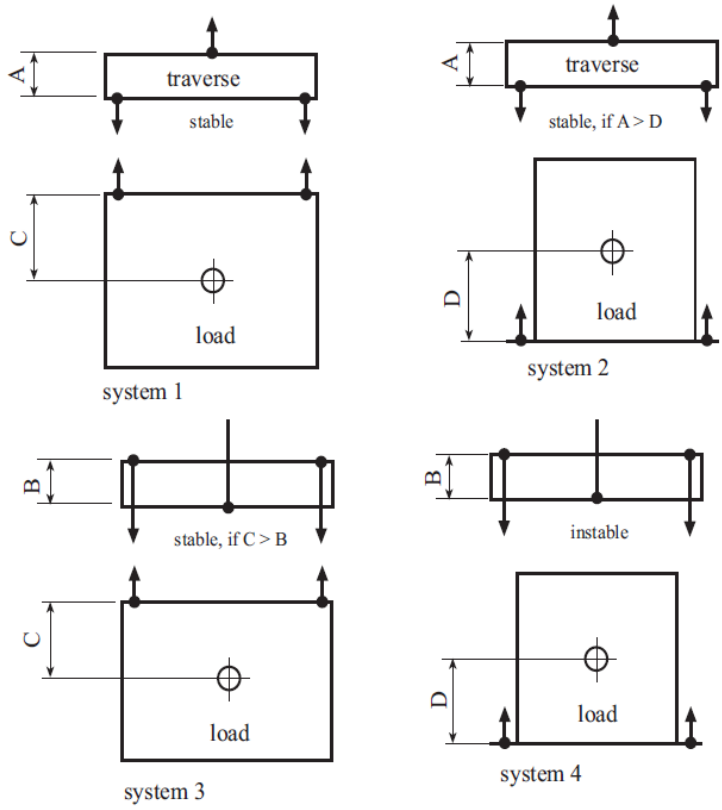


Fig. 7.1 Balance conditions

2.1.5 Suspensions

Suspensions are loose gear consisting of tension elements which are directly connected to the lifting appliance hook or to other loose gear (e.g. a traverse or frame-type traverse / spreader). For examples of typical suspensions see Fig. 7.2.

Regarding 4-leg suspensions without load equalisation it is to be taken into consideration that these systems are statically indeterminate. The individual legs of the suspension are stressed depending on the rigidity of the load or the loose gear to be handled. Where the load or the loose gear has high rigidity the load distribution on each leg of the suspension is to be verified by static calculation. Without verification of the actual load distribution in the complete system (suspension and load or loose gear) only 2 legs shall be assumed as load-bearing.

2.2 Traverses

2.2.1 Traverses may only be loaded symmetrically to the centre of gravity of the load, unless they are dimensioned for asymmetric loading and marked accordingly.

When there are more than 2 attachment points between the loose gear and the load, the strength test corresponding to the rigidity of the load (statically indeterminate system) is to be conducted.

Alternatively, devices may be fitted which indicate the load.

2.2.2 Where longitudinal lifting beams have underslung transverse lifting beams using tension elements, this system is to be designed for safe operation in accordance with the static degrees of freedom. Sufficient strength is to be proven by a strength analysis.

2.2.3 Telescopic traverse parts shall be lockable in their working positions.

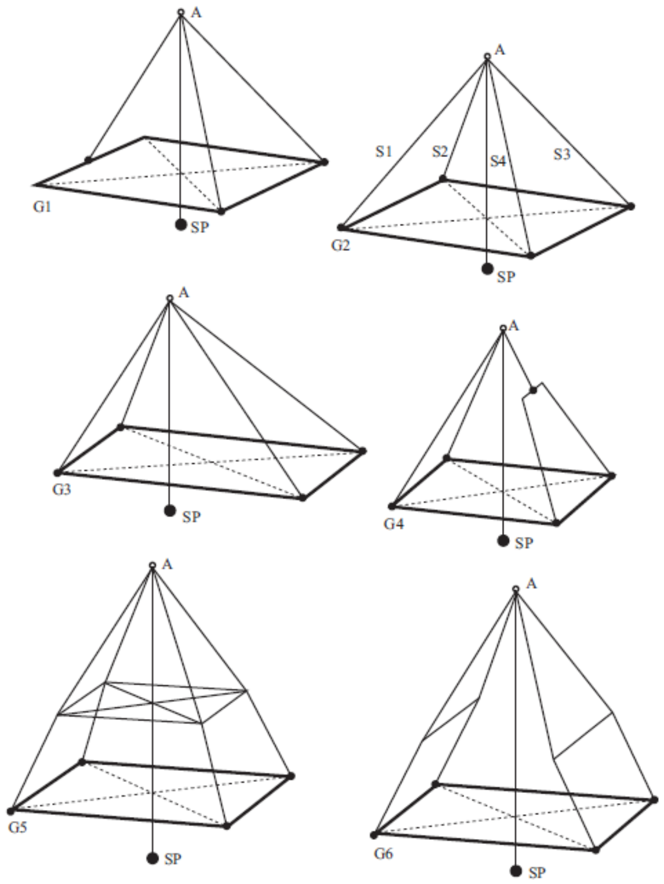


Fig. 7.2 Suspending systems for typical suspensions

G1 : 3-leg suspension (statically determinate, load connecting points are not in one vertical plane)

G2 : 4-leg suspension, symmetrical (statically indeterminate with rigid load). The total load is carried either by leg S1 and S3 or by S2 and S4. The center of gravity of the load (SP) is located in both of the planes spanned by S1/S3 and S2/S4

G3 : 4-leg suspension, asymmetrical (statically indeterminate with rigid load), see also notes under G2

G4 : 4-leg suspension with load compensation on one side (statically determinate with sufficient geometry of load compensation)

G5 : 4-leg suspension with frame spreader (statically indeterminate, see also notes under G2)

G6 : 4-leg suspension with two spreaders (statically determinate)

2.3 Frame traverses / spreader

2.3.1 In the case of adjustable container spreaders, the movable beams shall either lock into the desired working positions, or constructional measures shall be taken to ensure that the beams are accurately placed and held in these positions.

2.3.2 Container spreaders shall be equipped with indicators showing in a suitable manner whether the twist locks are locked or unlocked.

2.3.3 Locking pins which automatically unlock when unloaded are not acceptable.

2.4 Grabs and lifting magnets

2.4.1 The structural design and operating mode of grabs and lifting magnets shall be suited to the intended type of cargo.

2.4.2 The mechanical strength and electrical equipment of grabs and lifting magnets shall company with the requirements of these Guidelines.

2.4.3 Closing ropes of grabs are to be protected in a suitable way against excessive wear.

2.4.4 Lifting magnets shall comply with the requirements in EN 13155.

3 Calculation principles

3.1 General notes

3.1.1 Calculations and dimensioning of loose gear are subject to the requirements in Sections 3 and 4.

3.1.2 Regarding the loads to be considered and the proofs to be provided, the following requirements are to be observed.

3.2 Dimensioning loads

3.2.1 General

.1 The loads acting on loose gear are subdivided as follows:

- regular loads
- irregular loads
- special loads

.2 If necessary, loads not addressed in the following are to be considered additionally in a suitable way. The grading of such loads and the consideration of them in the corresponding load combinations is to be agreed with BKI.

3.2.2 Regular loads

.1 Dead load L_E

Deadloads are to be determined in accordance with Section 3, B.4.2.

.2 Useful load L_N

The useful load is defined in Section 1, C.9. When dimensioning the loose gear, this is assumed to be the nominal load.

.3 Dynamic forces caused by drives

Regarding the dynamic forces caused by drives, the provisions of Section 4, C.2.4 apply, including the following additions:

- For dimensioning, in general only those vertical dynamic forces are to be considered, which are covered by the hoist load coefficient ψ. Therefor the useful loads acc. to 3.2.1.2 are to be multiplied by the maximum hoist load coefficient ψ for this application, of the allocated loading gears.
- L_{Ne} is to be always relevant for dimensioning. This is to be ensured by the conditions in Section 4, D.3.2.

– If loose gear or interchangeable components cannot be allocated to loading gear, the following hoist load coefficient is to be used:

For	$SWL \leq 10$ t;	$\psi = 1{,}6$
	$10 \text{ t} < SWL \leq 160$ t;	$\psi = 1{,}4$
	$160 \text{ t} < SWL \leq 500$ t;	$\psi = 1{,}3$
	$500 \text{ t} < SWL \leq 1000$ t;	$\psi = 1{,}2$
	$SWL > 1000$ t;	$\psi = 1{,}15$

This is only permissible if the loading gear is used in harbour operations. When used under seaway conditions, the increased requirements of the loading gear used thereby are to be considered.

3.2.3 Irregular loads

.1 Wind loads

Wind loads are to be assumed acc. to Section 3, B.4.5.

.2 Snow and ice loads

If snow loads are to be considered, these are to be provided by the manufacturer.

If ice loads are to be considered, these are to be determined acc. to Section 3, B.4.6.

3.2.4 Special loads

.1 Test loads

Loose gear is to be dimensioned for a static test load L_{Pstat} acc. to Table 7.2 or, if more unfavourable, for the dynamic test load of the loading gear acc. to Section 4, C.4.1 including the reduced hoist load coefficient (ψ_{Pred})

$$\psi_{Pred} = \max (L_{Pstat}; L_{Pdyn} \cdot \psi_P)$$

.2 Lateral impact

For frame-type traverses/spreader, a lateral impact of 1/10 of the maximum vertical load in the frame level is to be assumed:

$$HS = (L_{Ne} + L_e)/10$$

3.3 Load combinations and partial safety factors

3.3.1 General notes

.1 The load combinations deemed to be essential for loose gear in operation are compiled in Table 7.1.

.2 For the condition "cranes out of operation" the load combinations and partial safety factors according to Section 4, E.3 (Table 4.5) shall be assumed regarding strength analysis.

.3 According to circumstances further load combinations may arise.

.4 From the load combinations in Table 7.1 and, where required, further load combinations, only those combinations which are prevailing or necessary for the structural element being considered, are to be proved.

3.3.2 Comments on the load combinations for loose gear under operating conditions, Table 7.1.

.1 The load combinations I_1, II_1, III_1 and III_2 correspond to those given in Section 4, E.2.

Table 7.1 Load combinations for loose gear under operating conditions

Load categories	Loads	i	Reference		Load combinations I		II		III			
					γ_{pi}	I_1	γ_{pi}	II_1	γ_{pi}	III_1	III_2	III_3
Regular loads	Dead loads L_E	1	7	B.3.2.2.1	1,22[1]	1,0	1,16[1]	1,0	1,10[1]	1,0	1,0	1,0
	Useful load L_N	2	7	B.3.2.2.2	1,34	ψ	1,22	ψ	1,10	-	-	ψ
Irregular loads	Wind loads under operating conditions	3	7	B.3.2.3.1			1,22	1,0	1,10	-	0,2	-
	Snow and ice loads	4	7	B.3.2.3.2			1,22	1,0	-	-	-	-
Special loads	Hoisting the hoist load at v_{hmax}	5	7	Table 4.2					1,10	ψ_{max}	-	-
	Test load	6	7	B.3.2.4.1					1,10	-	ψ_p	-
	Lateral impact	7	7	B.3.2.4.2					1,10	-	-	1,0
Resistance coefficient γ_m					1,10		1,10		1,10			
Global safety coefficient γ_s					1,48		1,34		1,22			

[1] Where load combinations have a favourable effect, γ_{pi} = 0,95 may be assumed. If the component's masses and centre of gravity is determined by weighing, 0,95 · γ_{pi} may be assumed.

.2 Consideration of the deviation of the load's centre of gravity

Due to an unexpected and not precisely determinable deviation in the centre of gravity, stresses on the loose gear are to be considered, assuming an inclined position deviating 6° from the ideal location in relation to both main axes. This load condition has to be examined additionally.

.3 III_3 - Lateral impact

The load combination comprises the loads due to hoisting of the hoist load including a lateral impact.

3.4 Proofs

3.4.1 General

The loose gear is to be dimensioned taking into consideration the following points:

.1 The centre of gravity is located in the axis of symmetry of the suspension.

.2 Regarding frame-type traverses or spreaders, the bending rigidity of the load is also to be evaluated with respect to load transfer and possibly to be included in the static strength analysis. Without proof of the static strength of the frame-type traverse or spreader as an overall system complete with the load, only two load attachment points may be assumed to be load-bearing.

3.4.2 Strength analyses

Regarding the strength analyses. In general the statements in Section 3, D and Section 3, H apply. The load combinations are to be formed using the values for the partial safety factors according to Table 7.1.

.1 Telescopic parts of traverses or spreaders

In the case of the telescopic parts of traverses or spreaders, careful attention is to be paid to the transverse force in the overlapping area and to the force transferred at the outlet, as well as at the inner end of the movable part.

3.4.3 Proof of stability (buckling, lateral torsional buckling, warping)

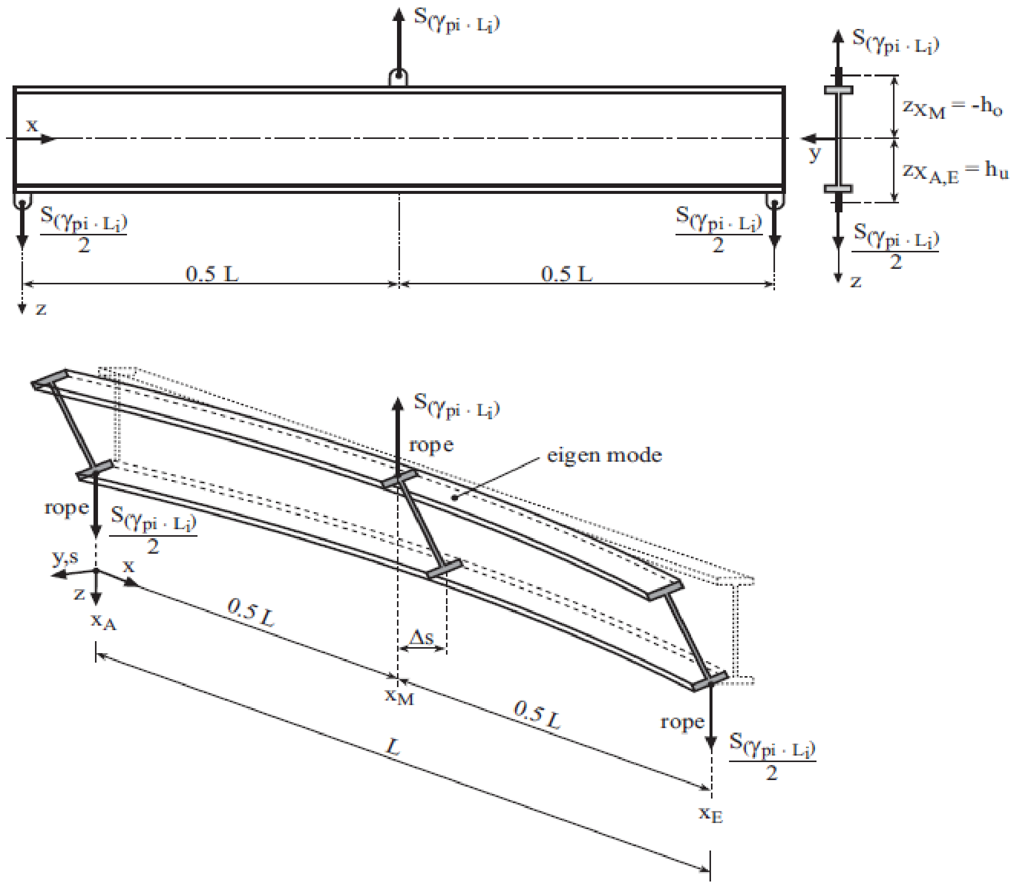
For proof of stability, the statements in Section 3, D apply in general. The load combinations are to be formed using the partial safety factors according to Table 7.1.

.1 Special boundary conditions for traverses

Regarding the proof of stability of traverses, special boundary conditions are to be assumed for the determination of the critical buckling load. It is to be considered that there is no fork bearing i.e. the proofs of stability used in the general steel engineering to determine the critical buckling load are not applicable.

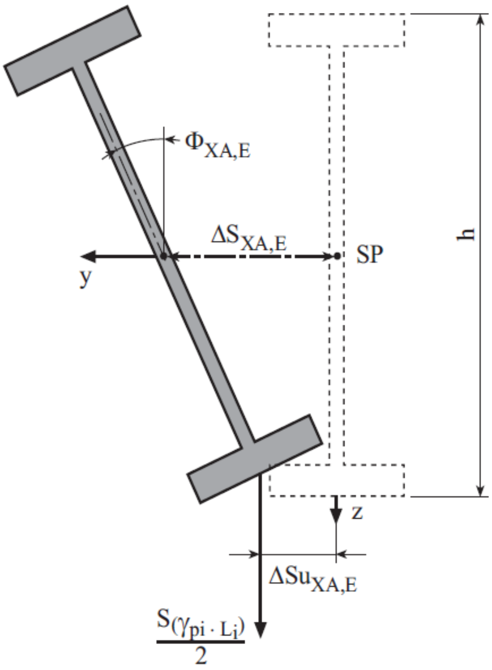
For the determination of the minimum potential energy due to outer and inner forces, only the restoring moments between the traverse's suspension and the load's suspension can be applied, which are activated by the eigen mode of the traverse. In determining the ideal lateral torsional buckling moment (M_{ki}) these boundary conditions are to be applied.

.2 System assumptions for the determination of M_{ki} for traverses (ideal lateral torsional buckling moment)



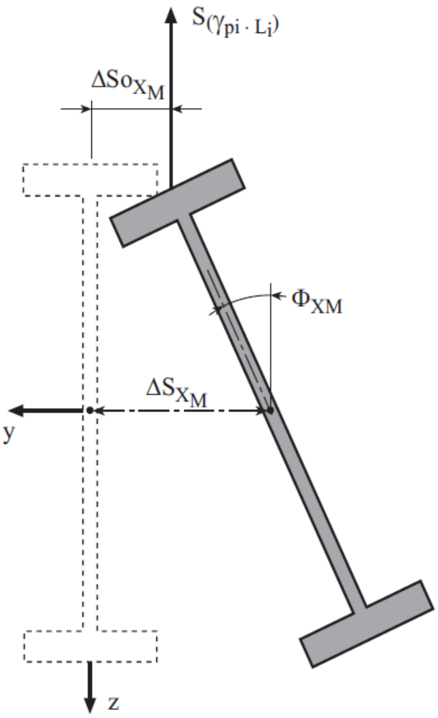
Assumption: Three points are always located in a vertical plane $S_{XA(hu)} = S_{XM(-ho)} = S_{XE(hu)} = 0$

Fig. 7.3 Eigen mode of the traverse



Assumption: $\Delta Su_{XA,E} = \Delta S_{XA,E} - \Phi_{XA,E} \cdot 0{,}5 \cdot h = 0$

Fig. 7.4 Eigen mode of the traverse



Assumption: $\Delta Su_{XA,E} = \Delta So_{X_M} = \Delta S_{X_M} + \Phi x_M \cdot 0{,}5 \cdot h = 0$

Fig. 7.5 Eigen mode of the traverse

.3 Boundary conditions for the proof of traverses

- determination of the section forces and deformations in accordance with 2nd order theory
- application of the geometrical replacement imperfections using $\Delta S = L/150$ (maximum ΔS of the eigen mode), see Fig. 7.3
- limitation of the torsional angle $\Phi \leq 0{,}3$ rad, see Fig. 7.4 and Fig. 7.5.

3.4.4 Fatigue strength analyses for loose gear

.1 For fatigue strength analyses, in general the statements in Section 3, F apply. Generally, they are to be conducted for the load combination I of Table 7.1 using a partial safety factor of $\gamma_{pi} = 1{,}0$.

.2 For loose gear with stress cycles ≤ 20000, a fatigue strength analysis may be dispensed with.

3.4.5 Proofs of suitability for use

For proofs of suitability for use, in general the statements in Section 3, G apply. Generally, they are to be conducted for the load combination I of Table 7.1 using a partial safety factor of $\gamma_{pi} = 1{,}0$.

.1 Traverse

The maximum deformation is to be limited to ≤ L/500, related to the traverse's length.

.2 Frame-type traverse/spreader

The maximum bending deformation due to the deadweight is to be limited to ≤ L/1000, related to the spreader´s length, the maximum bending deformation is to be limited to ≤ L/500, related to the spreader's length.

.3 Container spreader

The maximum bending deformation (bending stiffness) of the spreader is to be limited such that the lift-locks cannot unlock under operational conditions.

4 Examination of drawings and supervision of construction

4.1 Examination of drawings

4.1.1 The general requirements in Section 1, C.1 are to be observed.

4.1.2 Regarding the documents to be submitted for examination, the lists in Section 1, D.4.2 are to be applied as and where relevant. In addition, the following documents are to be submitted for examination:

- overview drawings showing all variations of functions, loads and load fastenings
- workshop drawings of all steel components
- strength analyses for all load-bearing components (static, dynamic, fatigue strength, as required)
- stowage and fastening devices for shipborne loose gear
- additional documents as required

4.2 Supervision of construction

4.2.1 The general requirements of Section 1, A are to be observed.

4.2.2 The supervision of construction and acceptance testing before delivery is required in principle.

4.2.3 For loose gear which is still accessible for comprehensive examination after completion, supervision of construction may be dispensed with, subject to the consent of the BKI Surveyor. Acceptance testing is required in every case, where appropriate together with the first load test.

4.2.4 The requirements to be met by the manufacturer are set out in Section 11, B.

5 Tests and examinations

5.1 Tests

5.1.1 Before being put into use, and after every major modification or repair to load-bearing parts, loose gear shall be subjected to a functional and load test in the presence of the BKI Surveyor.

5.1.2 Regularly repeated load testing of loose gear is not prescribed internationally by ILO. It shall be noted, however, that various flag states do have regulations on this.

5.1.3 The static test loads given in Table 7.2 are applicable to loose gear according to the definition in Section 1, C.4.

Table 7.2 Static test loads for loose gear

Nominal loads "L_{Ne}" of loose gear	Static test loads [1] "L_{Pstat}"
up to 10 t	2 x SWL
above 10 t up to 160 t	(1,04 x SWL) + 9,6 t
above 160 t	1,1 x SWL

[1] If applicable to be multiplied with f_d according to C.3.4

5.2 Examinations

5.2.1 Before being put into use, after each load test, and after each modification or repair to loadbearing parts, all loose gear is to be subjected to a thorough examination by the BKI Surveyor and, where necessary, a functional test under his supervision.

5.2.2 In addition to the regulations according to 5.2.1, all loose gear shall be subjected to a visual examination by the BKI Surveyor at least every 12 months, as well as a thorough examination every 5 years and, where necessary, a functional test.

For due dates of examinations the provisions in Section 13, D.2 are applicable.

6 Documentation

For marking, see D.

6.1 Certification

6.1.1 After each load test using the prescribed test load according to Table 7.2, the supervising BKI Surveyor issues one of the two following certificates. Functional tests are not specially certified.

6.1.2 For ship's loose gear, a Form LA3 will be issued. For use on board more than one ship, additional copies may be issued.

6.1.3 For loose gear which cannot be allocated to a particular ship, a Test Certificate will be issued.

For use on board, a Test Certificate requires to be transcribed by the BKI Surveyor into Form LA3, in order to warrant international acceptance. In addition, the loose gear shall be stamped with the new certificate number.

6.2 Register Book

6.2.1 As described in Section 13, G, Form LA3 are added to the Register book of loading gear carried on board.

Upon request by the operator, an individual Register book for each piece of loose gear can be issued for use on board more than one ship.

6.2.2 For all examinations according to 5.2, a BKI examination report will be compiled. In addition, the examinations are confirmed in the Register book of loose gear.

6.2.3 Test Certificate will be handed out to the operator without a Register book. The operator shall add these certificates and examination reports according to 6.2.4 to his own documentation.

6.2.4 The confirmation of examinations of loose gear, for which a Test Certificate has been issued, is effected by the examination report.

C Interchangeable Components

1. General notes

1.1 Accessories according to Section 1, C.5 are regarded as interchangeable components.

1.2 Although not stated in Section 1, C.5, eye plates and bolt connections are to be treated as interchangeable components.

2 Design and construction

2.1 Block frames shall be designed in such a way that ropes cannot get caught between the sheave and the block cheeks.

2.2 Cargo hooks, shackles, swivels and rings shall be forged. Exceptions to this rule require the consent of BKI.

2.3 Grades of cast steel are to be selected according to recognised standards. The consent of BKI is required in every instance for other grades of cast steel.

2.4 Galvanization is permitted only with forged components of fully killed steels. Galvanization of forged interchangeable components may take place only after the load testing of the components.

Where delivery is carried out by a recognised manufacturer, it is to be documented that a stress test has been conducted at the manufacturer under application of the minimum test loads, in accordance with BKI Rules, including crack test.

2.5 The galvanizing of cold-formed components is permitted only if the suitability of the material for this purpose has been proved.

3 Interchangeable components conforming to recognized standards

3.1 Verification by calculation is not required in respect of interchangeable components which conform to recognized standards.

Deviating from Table 2.1 and 3.4 the materials of their load bearing components can be attested by inspection certificates 3.1 as per EN 10204.

3.2 Determination of the nominal load

The nominal load is determined depending on the location of service, without partial safety factors and hoist load coefficients

- in the loading gear acc. to Section 4, Load combination I
- in the loose gear acc. to B.3.3, load combination I

Where applicable, the nominal load determined as above is to be multiplied additionally by a dynamic factor f_d acc. to 3.4.

3.3 For interchangeable components conforming to standards, a choice has to be made according to the indicated nominal sizes. The nominal sizes correspond to the nominal load acc. to 3.2.

3.4 In all cases where the hoist load coefficient ψ is greater than the value of ψ_{perm}, the permissible load, on which the choice of the nominal size is based, is to be increased by the following dynamic factor f_d:

$$f_d = \frac{\psi}{\psi_{perm}} \geq 1,0$$

ψ : hoist load coefficient acc. to Section 4, D

ψ_{perm} : permissible hoist load coefficient acc. to Table 7.3

Table 7.3 Permissible hoist load coefficient ψ_{perm}

L_{Ne}	ψ_{perm}
up to 60 t	1,6
above 60 t to 160 t	$1{,}6 - \frac{L_{Ne} - 60\,t}{200\,t}$
above 160 t	1,1

4 Basic principles for proofs for interchangeable components not corresponding to a recognized standard.

4.1 General notes

4.1.1 For the calculation and the dimensioning of interchangeable components the requirements in Section 3 and 4 apply.

4.1.2 The load for dimensioning is determined depending on the location of service, taking into consideration partial safety factors and hoist load coefficients

- using load combinations for the loading gear acc. to Section 4, E
- using load combinations for the loose gear acc. to B.3.3

Additionally, the static test load L_{Pstat} acc. to Table 7.4 with a partial safety factor of γ_{pi} = 1,10 is to be observed for the determination of the load for dimensioning.

4.2 Proofs

4.2.1 General

.1 Basis for the dimensioning is the applicable design load for dimensioning which is to be determined acc. to 4.1.2.

.2 The calculation of non-standardized interchangeable components may be carried out using suitable calculation methods acc. to the provisions in Section 3.

.3 A method to determine the strength of non-standardized eye plates is given in 4.3.

.4 Proof of bolt connections may be provided acc. to 4.4.

4.2.2 Strength analyses and proofs of stability

For strength analyses generally the statements in Section 3, D and Section 3, H apply. They are to be conducted using the design load for dimensioning.

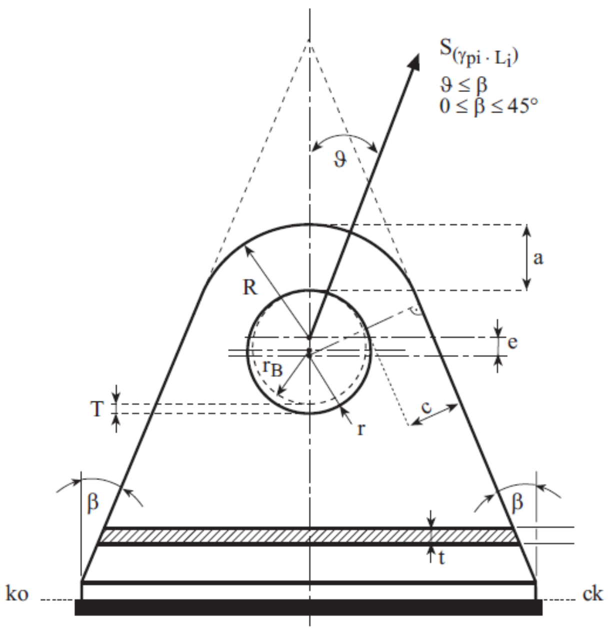
4.2.3 Proofs of fatigue strength

.1 For the proofs of fatigue strength the statements in Section 3, F apply. In general, they are to be conducted using the load combination I of Table 4.4 or Table 7.1 with the partial safety factor γ_{pi} = 1,0.

.2 For interchangeable components with load cycles ≤ 20000 the proof of fatigue strength may be dispensed with.

4.3 Non-standardized eye plates

4.3.1 The determination of the dimensioning stress for eye plates which correspond to Fig. 7.6 and to the boundary conditions acc. to 4.3.2 may be performed using the following method, unless a more precise proof is provided.



Remark:

R	:	outer radius of head [mm]
r	:	bore radius [mm]
c	:	cheek width [mm]
e	:	change of head height [mm]
t	:	plate thickness [mm]
β	:	inclination angle of flanks [°]
ϑ	:	angle of force attack [°]
r_B	:	bolt radius [mm]
T	:	clearance between bolt and bore [mm]
a	:	head height [mm]
$S_{(\gamma_{pi} \cdot L_i)}$	:	design load for dimensioning [kN]

Fig. 7.6 Eye plate

4.3.2 Boundary conditions

For the dimensioning, the following boundary conditions are to be adhered to:

I) Radii ratio ρ of the eye: $2 \le \frac{R}{r} \le 3$

II) Clearance T bolt/bore:

$T = 2(r - r_B) \leq 0{,}2 \cdot r \leq 3\text{ mm}$

For bolt diameters of 50 to 300 mm a clearance between bolt and bore of 3 to 6 mm can be permitted. However, in this case the design load has to be increased by 5 %.

III) For moving bolt connections a wear of Δ_T = 2 mm is to be taken into consideration in the strength analysis.

IV) Inclination angle of flanks: $0° \leq \beta \leq 45°$

V) Angle of attack: $0° \leq \vartheta \leq \beta$

4.3.3 Determination of the stress for dimensioning and stress proof

The stress for dimensioning is calculated as follows:

$$\sigma_{d,max} \leq \alpha \cdot \sigma_N$$

α = form factor as per 4.3.5

σ_N = nominal stress as per 4.3.4

It is to be proven that:

$$\sigma_{d,max} \leq R_d$$

where

$$R_d = \frac{f_{y \cdot k}}{1{,}0}$$

4.3.4 Nominal stress due to design load

The nominal stress due to design load without friction component is calculated as follows:

$$\sigma_{n,S} = \frac{S_{(\gamma_{pi} \cdot L_i)}}{2ct}$$

where :

$S_{(\gamma_{pi} \cdot L_i)} = \gamma_{pi} \cdot \psi \cdot F_N$ (see also Table 7.1)

F_N = nominal load on eye plate

$c = R + e \sin\beta - r$ (see also Fig. 7.6)

The nominal stress component due to friction (friction coefficient μ) between bolt and bore is calculated as follows:

$$\sigma_{n,\mu} = \frac{8\mu}{\pi\left(1 + \frac{R}{r}\right)} \sigma_{nS}$$

Consequently, the nominal stress due to the design load including friction component is calculated as follows:

$$\sigma_N = \sigma_{n,S} + \sigma_{n,\mu}$$

4.3.5 Determination of form factor

In general the form factor is calculated as follows:

$$\alpha = \sum_i \alpha_i = \alpha_p + \alpha_\beta + \alpha_\varepsilon + \alpha_\vartheta$$

where:

$\alpha_p = \frac{3}{4}\rho + \frac{5}{2}$ (base value)

$\alpha_\beta = -\left(\frac{1}{2} - \varepsilon\right)(4-\rho)\sin\beta$ (components due to inclination of flanks)

$\alpha_\varepsilon = -(3-\rho)\varepsilon$ (components due to change of heat height)

$\alpha_\vartheta = \rho^{-1}\cos\beta\sin\vartheta$ (components due to angle of attack)

and:

$\rho = \frac{R}{r}$ (radii ratio)

$\varepsilon = \frac{2e}{R}$ (change of head height ratio)

4.3.6 Connection to supporting structure

The connection to the supporting structure (see Fig. 7.6 cross section ko-ck) is to be proven separately in accordance with Section 3.

4.3.7 Load fastening ropes and lifting straps are to comply with the following standards:

– ISO 7531 for wire ropes
– EN 1492-4 for natural and chemical fibre ropes
– EN 1492-1 and -2 for lifting straps

5 Examination of drawings and supervision of construction

5.1 Examination of drawings

5.1.1 Examination of drawings is not required in respect of interchangeable components and eye plates which conform to recognized standards.

5.1.2 Details or drawings are to be submitted for examination in respect of interchangeable components or eye plates which are made of materials and/or to designs which do not conform to a standard.

5.1.3 Where such interchangeable components or eye plates are to be repeatedly manufactured, the relevant drawings may also be approved as works standards. Where reference is made to such works standards in the documents submitted, the date and journal number of the BKI approval shall also be indicated.

5.2 Supervision of construction

The supervision of construction is not required for interchangeable components and eye plates.

6 Tests and examinations

6.1 Tests

6.1.1 Interchangeable components

.1 Before being assembled or put into use, interchangeable components in the unpainted and, as far as possible, ungalvanized condition shall be subjected to a static load test in the presence of the BKI Surveyor, performed on a calibrated and approved testing machine using the test loads given in Table 7.4.

.2 Where the origin of interchangeable components is unknown, or certificates for the materials are unavailable, the BKI Surveyor is entitled to demand that one specimen of the interchangeable component undergo a tensile test at 4 times the permissible load.

The specimen shall withstand this load without breaking. A further increase to the load until the specimen breaks is not generally required. However, the BKI Surveyor is entitled to demand a test to establish the actual breaking load.

Specimens which have undergone tensile testing at 4 times the permissible load are overstressed, and are to be destroyed or recycled after the test.

.3 After changes or repairs to interchangeable components, a load test according to 6.1.1.1 is to be repeated.

.4 Regularly repeated load testing of individual parts of interchangeable components is not prescribed internationally by ILO. They are load tested together with the lifting appliance or loose gear to which they are fastened.

6.1.2 Eye plates

.1 Eye plates which are integral parts of loading gear and loose gear are included in the load tests of them.

.2 Eye plates for assembly and maintenance work as well as for transportation purposes require a strength analysis with respect to their welding joints and the supporting structures. These analyses will be checked within the scope of examination of drawings.

Load tests with agreed static test loads may be conducted on request of the ship's owner.

6.2 Examinations

6.2.1 Interchangeable components

.1 The manufacturer and dealer has to present all interchangeable components to the BKI Surveyor, in an unpainted and, if possible, ungalvanized condition, for examination of the dimensions and workmanship, together with the certificates covering the materials used.

.2 After the static load test, each component is thoroughly examined by the BKI Surveyor, and shall, if the Surveyor considers it necessary, be taken apart for closer scrutiny.

.3 After start of operation, every interchangeable component shall be subjected to an examination by the BKI Surveyor at least every 12 months, as well as to a thorough examination every 5 years. For highly stressed components, non-destructive tests may be carried out.

Components shall, if the Surveyor considers it necessary, be taken apart for closer scrutiny.

6.2.2 Eye plates

.1 Eye plates, which are integral parts of loading gear and loose gear, are examined together with them.

.2 Eye plates according to 6.1.2.2, including their joints, are examined before their first employment, after every load test and at agreed intervals.

.3 Examinations of eye plates may be complemented by crack and ultrasonic tests upon agreement.

These examinations are mandatory, if the visual inspection during the examination gives reason to do so.

7 Documentation

7.1 Interchangeable components

For marking, see D.

7.1.1 Certificates

.1 The BKI Surveyor issues a certificate for each interchangeable component which has successfully undergone a load test and a thorough examination.

This certificate gives details of the manufacturer or supplier, the date of the test, special materials (high strength / low temperature), the size of the test load and the permissible load.

2 Form LA3 is used for shipborne loading gear or interchangeable components and test certificate for all others.

For the transcription of test certificate into Form LA3 for use on board, the requirements in B.6.1.3 apply as and where relevant.

.3 For closer definition of tested and examined components, the following details are entered on the certificates:

– shackles:

  bolt diameter; where the inside width is non-standard, the following dimensions are to be indicated in the order shown: diameter of the shackle in the middle of the bow, bolt diameter, and inside width

– cargo hooks and swivels:

  nominal size

– blocks:

  groove diameter of the sheave, and the sheave pin diameter, together with the type of head fitting and an indication of whether or not a becket is fitted

– double yoke pieces:

  bolt diameter, and length of the double yoke piece between the bolt centres

– rope sockets:

  nominal size, and details of the material test

– cable joints:

  nominal size

– rigging screws:

  nominal size, or thread diameter, and the type of bolt head (oval eye, round eye or fork eye)

– chains:

diameter of the round steel bar, external width of the chain link, and length of the chain

.4 Where interchangeable components are manufactured to approved drawings, the certificates also indicate the relevant drawing, together with the date and BKI reference number of the approval.

7.1.2 Register book

.1 In accordance with the requirements in Section 13, G, Form LA3 are added to the Register book of loading gear on board.

.2 Interchangeable components which are integral parts of loading gear or loose gear are examined together with them.

For the devices examination reports are compiled and the examinations are confirmed in the Register book of loading gear.

.3 For interchangeable components which are certified by Test Certificate, the requirements in B.6.2.3 and B.6.2.4 apply as and where relevant.

7.2 Eye plates

7.2.1 Eye plates in accordance with 6.1.2.1 are included in the documentation of the devices stated there.

7.2.2 The tests and examinations of eye plates in accordance with 6.1.2.2 are confirmed by examination reports.

Table 7.5 Static test loads for interchangeable components

Line	Interchangeable components	Permissible loads "SWL" [1]	Static test loads "L_{Pstat}" [2]
1	chains, rings, hooks, shackles, swivels, etc.	up to 25 t over 25 t	2 x SWL (1,22 x SWL) + 20 t
2	single-sheaved blocks with and without becket	up to 25 t over 25 t	2 x SWL (1,22 x SWL) + 20 t
3	multi-sheaved blocks	up to 25 t over 25 t up to 160 t over 160 t	2 x SWL (0,933 x SWL) + 27 t 1,1 x SWL

[1] The permissible load "SWL" of single and multi-sheaved blocks is equal to the permissible load on the suspension.
[2] If need be, to be multiplied with f_d according to C.3.4.

D Marking of Loose Gear and Interchangeable Components

1. Manufacturer's plate

Loose gear according to Section 1, C.4 is to be fitted with a manufacturer's plate, which shall include at least the following information, if applicable:

– manufacturer's name
– type of loose gear
– serial number
– year of construction
– characteristics, where applicable, such as e.g. nominal pressure, nominal voltage, filling volume, etc.

- nominal load(s)
- dead load
- with lifting beams, traverses and spreaders: a symbol for the inclination angle of the allocated suspension ropes or chains

2. Stamping

2.1 General notes

2.1.1 Stamping is regarded to be the proof of a test and/or examination. Loose gear and interchangeable components shall therefore undergo (renewed) load testing, if a certificate is required in this regard.

2.1.2 The stamp height shall be at least 6 mm.

2.2 Loose gear

2.2.1 Scope of stamping

All loose gear which has successfully undergone testing and thorough examination is stamped as follows:

- certificate number, together with the code letters of the examining inspection office
- BKI stamp with the month and year of testing
- Safe Working Load in tonnes or kg preceded by the letters "SWL"
- dead load in t or kg preceded by the letters "WT"

2.2.2 Stamp location

The stamp is to be applied on one side, in a prominent position, if possible in the centre, but not concealed by the marking.

2.2.3 Multiple stamping

.1 Loose gear subjected to supervision of construction at the manufacturer's premises is double stamped (see Table 7.5).

.2 After periodic load tests and re-issuing of test certificates, stamping is not repeated.

2.3 Interchangeable components

2.3.1 Scope of stamping

.1 Each interchangeable component which has successfully undergone testing and thorough examination is stamped as follows:

- certificate number, together with the code letters of the examining inspection office
- BKI stamp with the month and year of testing

Table 7.6 Examples of stamping and marking

<table>
<tr><th colspan="3">Documentation</th><th>Loose gear</th><th>Interchangeable components</th></tr>
<tr><td rowspan="2">Stamping</td><td>Certificate Form:
Test Certificate</td><td>Acceptance testing</td><td>12345TP
BKI stamp – mm – yy</td><td rowspan="2">12345TP
BKI stamp – mm – yy
SWL 15 t
rope 5 t
(single-sheaved block with becket)</td></tr>
<tr><td>Certificate Form:
Form LA3 or
Test Certificate</td><td>Load test</td><td>12345TP
BKI stamp – mm – yy
SWL 30 t
WT 5 t</td></tr>
<tr><td>Marking</td><td colspan="2">Rigging plans</td><td>SWL 30 t
WT 5 t</td><td>-</td></tr>
<tr><td colspan="3">Abbreviations:</td><td>Nominal load: SWL
Weight: WT</td><td>Permissible load:
SWL</td></tr>
</table>

– permissible load in tonnes or kg preceded by the letters "SWL"

– permissible rope hoist in tonnes or kg with blocks, e.g.:

  – single-sheaved block without becket SWL 6 t
    rope 3 t

  – single-sheaved block with becket SWL 15 t
    rope 5 t

  – multiple-sheaved blocks with 4 sheaves SWL 64 t
    rope 8 t

.2 With interchangeable components made of special materials, the stamp is extended with the following letters, if applicable:

– H for high strength material

– T for low-temperature materials

Where interchangeable components are composed of several single parts which may be disassembled, such as e.g. shackle hook and shackle round nut, each part will get this special stamp.

2.3.2 Stamp location

The stamp is to be applied to the following locations for the parts given below:

– shackles:
  to one of the limbs close to the eye

– cargo hooks:
  to the side of the hook, close to the suspension

– swivels:
  to the traverse; the oval eye only gets the anchor stamp

– blocks:
  to the side bar, if any; otherwise to the side plate close to the point of suspension of the block

– double yoke pieces:
  to the middle of one side

– rope sockets:
  to the conical section, opposite the existing stamp for material testing

– cable joints:
  to the middle of one side

– rigging screws:

  on the body: to every eye head fitting or double lug head fitting, plus the BKI stamp

– suspension ropes and slings:

  to a permanently fastened small metal plate

– chains:

  to the last link at each end

2.3.3 Special features

.1 With a permissible load up to 15 t, the figure on the stamp shall be rounded to one decimal place. With values of 15 t and over, the figure shall be rounded to a whole number.

.2 For the galvanization of forged interchangeable components, the requirements in C.2.4 apply.

The stamp shall still be recognizable after galvanization, or where required, it shall be re-stamped.

.3 The stamp height shall be at least 6 mm, or 4 mm for small parts.

.4 On small parts to which it is difficult or impossible to apply the whole stamp, the month and year of testing may be omitted, followed, if necessary, by the certificate number and the permissible load, where required.

The following is applicable for stamping of small parts:

– components with a SWL of 1,6 t and over:

  These are stamped in full, as described in 2.3.1.

– components with a SWL between 0,25 t and 1,0 t:

  These only receive the BKI stamp, and where required, also the permissible load.

– components with a SWL of less than 0,25 t SWL:

  These only receive the BKI stamp, and where required, the stamp shall be waived.

3 Marking of loose gear

3.1 Loose gear shall be permanently marked in a prominent position on both sides in the manner described in 3.2 and 3.3.

The inscription shall comprise characters at least 80 mm in height, the permanence of which shall be assured by punching, by applying weld seams or small metal plates adequately fastened. The fatigue strength of the marked components shall not be unduly impaired by these measures.

Glued-on lettering foils are not permitted.

3.2 Lifting beams, traverses and spreaders shall be marked as follows:

- nominal load "SWL" in t or kg
- dead load "WT" in t or kg (mandatory, if over 100 kg)
- special types of fastening or loading

3.3 Grabs and lifting magnets shall be marked as follows:

- nominal load "SWL" in t or kg
- dead load "WT" in t or kg
- capacity in m^3 for grabs

E Wear, Damage, Repair

1. Loose gear

1.1 With respect to tolerable reduction in the plate thickness due to rusting or wear, the requirements in Section 13, F.2 apply.

1.2 With respect to a reduction in the nominal load of loose gear covered by Section 1, C.4, as an alternative to removal from service in the event of damage, inadmissible wear or other causes, the requirements in Section 13, F.9 apply.

2 Interchangeable components

2.1 Interchangeable components such as bolts, chains, rings, etc., as well as eye plates, shall be replaced if the parts are visibly deformed, if the diameter is reduced by 10 % at some points, or if the area of the load-bearing cross-section is reduced by 20 %.

2.2 The use of welding to repair cracks in, or worn portions of, interchangeable components is generally not permitted. The same applies to bolts and other removable elements of loose gear.

BKI reserves the right to approve such repairs in special cases. Then the following is to be observed:

2.2.1 After repair of forged interchangeable components, evidence is to be provided that heat treatment has been carried out.

2.2.2 After repair of interchangeable components, a load test in accordance with C.6.1.1.1 is required.

2.2.3 Renewal of axes, bolts and rope-sheaves in general does not require rerunning of the load tests.

Section 8 Ropes and Rope Accessories

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B. Wire Ropes 8–1
C. Fibre Ropes 8–7
D. Rope-end Attachments 8–9
E. Tests and Examinations 8–10
F. Documentation 8–13

A. General

1. Scope

1.1 The following requirements apply to wire and fibre ropes used as running and standing rigging for loading gear and loose gear as well as for rope slings.

1.2 The following requirements apply to passenger lifts and small goods lifts only in so far as they do not conflict with EN 81-20, 81-50 and 81-3.

(Differences with respect to EN 81 are e.g.: rope safety, end attachments, sheave and drum diameters, etc.)

2. Approval for manufacture

2.1 With regard to manufacture and quality assurance, rope manufacturers shall have been approved by BKI.

BKI approval is given provided that the requirements for the manufacture, testing and marking of wire ropes set out in Rules for Materials (Pt.1, Vol.V) is complied with, see Section 1, B.2.1.1 (Rules for Materials (Pt.1, Vol.V) Sec.14 and 15).

2.2 For approval, the manufacturer shall amongst other things prove, during a tour of the works, that the necessary equipment is available for the proper manufacture and testing of ropes. BKI reserves the right to demand that a qualification test be performed on specimen lengths of rope.

2.3 Approved rope manufacturers can also be approved for testing and certificating ropes on their own authority. Upon receiving this extended approval, BKI assigns the manufacturer an approval number.

B. Wire Ropes

1. General requirements

1.1 Wire ropes shall conform to recognized standards, such as e.g. EN 12385.

1.2 For employment on deck, wire ropes for running rigging shall be drawn galvanized, and wire ropes for standing rigging shall be fully galvanized.

After being galvanized, the ropes shall be impregnated and conserved with non-thermosetting and acid-free grease in order to avoid penetration of water and subsequent corrosion.

1.3 Galvanized wire ropes with diameters of less than 8 mm are not permitted for shipboard lifting appliances and loose gear exposed to the weather.

1.4 Free rope ends shall be sized, tapered or socketed to prevent fraying of the rope ends or to prevent changes in the lay lengths of the rope and strands.

1.5 Special rope designs, Lang lay ropes, ropes with a nominal tensile grade of more than 1960 N/mm^2, and ropes of austenitic or stainless materials may, on application, be approved, provided that they are suitable for the proposed use.

1.6 Wire ropes of stainless materials shall be suitable for use in marine atmospheres.

To avoid crevice corrosion, the materials used for the wires shall have a sufficiently high chromium and molybdenum content.

Steels are regarded as resistant to crevice corrosion in a marine atmosphere if the sum "W" is 29 or over, where:

$$W = C_r\,[\%] + 3{,}3 \cdot Mo\,[\%] \geq 29$$

1.7 Ropes with a nominal diameter exceeding 5 mm shall at least consist of 100 single wires, running rigging shall at least have 6 strands.

2. Definitions

2.1 "Running rigging" refers to all ropes passing over rope sheaves or guide rolls, or wound on winches, irrespective of whether or not the ropes are moved under load.

2.2 "Standing rigging" refers to all wire ropes which are not turned round or wound on to winches, such as shrouds, stays, pendants, etc. Standing rigging shall be fitted with thimbles or rope sockets.

2.3 "Rope slings" refer to ropes not forming an integral part of loading gear or loose gear, which are used to attach loads, and can be employed without special adaptation or fitting operations.

2.4 The Calculated Breaking Load F_r of a rope is the product of the theoretical metal cross-section and the nominal tensile strength of the wires.

2.5 The Minimum Breaking Load F_{min} of a rope is the product of the calculated breaking load F_r and the Spinning Factor k_s.

2.6 The Actual Breaking Load F_{wi} of a rope is the load determined by a tensile test to destruction of the complete rope.

2.7 The Proven Breaking Load F_n of a rope is the product of the "measured aggregate breaking load" F_e and the Spinning Factor k_s.

2.8 The Measured Aggregate Breaking Load F_e of a rope is the sum of the individually determined breaking loads of all the wires in the rope, ascertained by tensile tests.

2.9 The Spinning Factor k_s is an empirical factor which takes account of the strength reduction due to stranding.

The spinning factors of established types of wire rope are given in relevant standards or manufacturers' information.

3. Dimensioning

3.1 The Breaking Load F_{Br} of wire ropes for loading gear and loose gear shall not be less than the product of the Rope Tension F_S and one of the safety factors γ_{Di} shown in Table 8.2:

$$F_{Br} \geq F_S \cdot \gamma_{Di}$$

F_{Br} = actual breaking load F_{wi} or proven breaking load F_n

3.2 The Rope Tension F_S is the maximum force calculated for load condition I_1 disregarding the hoist load coefficient ψ, but taking into consideration the losses due to friction and bending in the rope sheaves. In addition, the following shall be observed:

3.2.1 For the partial safety factors, γ_{pi} = 1,0 may be applied.

3.2.2 The determination of rope tensions, taking into consideration the sheave friction and bending resistance of the ropes, is based on a frictional coefficient of 5 % per turn for friction bearings, and 2 % per turn for anti-friction bearings.

Where calculations are to be performed with smaller frictional coefficients, special proof of these is to be provided.

3.2.3 Rope deflection angles due to static ship inclinations do not increase the hoisting rope force.

Enforced rope deflection angles, due to acceleration forces or e.g. the drift of an offshore supply vessel, result in an increase in the hoisting rope force. They can, however, within the scope of these Guidelines, be ignored when dimensioning hoisting ropes or rope slings.

3.2.4 When dimensioning luffing ropes and standing rigging, the deflecting angles of hoisting ropes shall be considered in principle, if they effect an increase in rope forces.

3.2.5 For shipboard lifting appliances and loose gear, where an increased hoist load coefficient (> $\psi_{perm,S}$) has to be applied, the rope tension F_S is to be multiplied by the dynamic factor $f_{d,s}$. For $\psi_{perm,S}$ and $f_{d,S}$ see 3.2.6 and Table 8.1. This applies in particular to lifting appliances which will be dimensioned only for sea operation (see Section 4, D.3.2) or for lifting appliances in grab operation.

3.2.6 The factor for consideration of an increased dynamic to be used for calculation of the rope tension is to be determined as follows:

$$f_{d,s} = \frac{\psi}{\psi_{perm,S}}$$

ψ = hoist load coefficient according to Section 4, D

$\psi_{perm,S}$ = permissible hoist load coefficient according to Table 8.1

Table 8.1 Permissible hoist load coefficient

L_{Ne}	$\psi_{perm,S}$
up to 10 t	1,6
over 10 t up to 160 t	$1,6 - \frac{L_{Ne}}{1600}$
over 160 t	1,5

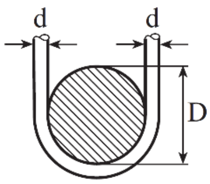
3.2.7 Where the efficiency of rope end joints is below 80 %, the loss of breaking force is to be compensated up to 80 %.

3.2.8 Wire ropes for multi-rope grabs are to be dimensioned, in addition to the dead weight of the grab, for the following nominal loads L_{Ne}:

– closing rope, double lever control L_{Ne}
– closing rope, single lever control 2/3 L_{Ne}
– holding cable 2/3 L_{Ne}

3.3 Reduction in breaking load of the rope

Where ropes are wound around design elements with a small diameter (e.g. shackle bolts, crane hooks, load connecting elements, etc.), the permissible breaking load is to be reduced.



D = diameter of the slung part

d = rope diameter

The breaking load of the rope is to be reduced for the following range of diameters:

$1 \leq D/d \leq 7$ (D/d < 1 is not permissible)

The reduced breaking load is to be determined according to the following formula:

$$F_{Br\,redu} = \left[1 - \frac{\left(\frac{D}{d} - 9\right)^2}{128}\right] \cdot F_{Br}$$

$F_{Br\,redu}$ = reduced breaking load

F_{Br} = breaking load of the non-deformed rope (no rope bending)

Within spliced sections, the rope is not to be slung with small radii.

3.4 Alternative provisions for the dimensioning of wire ropes for ramps and car decks can be found in Section 6, C.4.1.

4. Requirements for rope drives

4.1 Interaction between ropes and rope drums

4.1.1 In determining the necessary length of wire ropes, and the length of drum, it is to be borne in mind that at least 3 safety turns have to remain on the drum at all times.

The requirement for 3 safety turns also applies to luffing ropes with respect to the stowing position of the crane boom.

4.1.2 It shall be ensured that ropes are wound up properly on the rope drums. The length of rope drums shall in general be designed such that no more than 3 layers of rope may be wound on top of each other.

Where the number of layers exceeds 3, a special coiling device, or other system or equipment, shall be provided.

Table 8.2 Safety factors for wire ropes

Safety factors γ_{D1}[1]	
Nominal load (L_{Ne}) of loading gear and loose gear [2]	running rigging
up to 10 t	5
over 10 t up to 160 t	$\frac{10^4}{(8{,}85 \cdot SWL)+1910}$
over 160 t	3
Safety factors γ_{D2}[1]	
Nominal load (L_{Ne}) of loading gear and loose gear [2]	Standing rigging
up to 10 t	4
over 10 t up to 160 t	$\frac{10^4}{(5{,}56 \cdot SWL)+2444}$
over 160 t	3
Safety factors γ_{D3}[1]	
weight of load	Rope slings[3]
up to 10 t	6
over 10 t up to 160 t	$\frac{1{,}2 \cdot 10^4}{(8{,}85 \cdot SWL)+1910}$
over 160 t	3,6

1 if applicable, to be multiplied with $f_{d,s}$ (see B.3.2.5)

2 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

3 Rope slings which are not turned round may be treated as wire ropes for standing rigging, provided that both ends are fitted with thimbles or rope sockets.

4.1.3 Uncut rope drums may only be used with the consent of BKI.

4.1.4 Offshore supply cranes and grab cranes shall have a rope-spindling guide in principle, if the hoist rope drum cannot be clearly viewed by the operator at all times. Rope-spindling guides are grooved drums and rope-spindling devices and similar devices.

4.1.5 Design requirements for rope drums are described in Section 9, E.2.

4.1.6 Wire ropes which are wound on to drums in several layers shall have a steel core. For heavy loads, ropes with compressed strands are recommended.

4.1.7 The first rope layer is to be tension loaded.

4.1.8 The direction of rope runout shall be coordinated with the direction of rotation of the drums to avoid twisting of the ropes.

The winding direction of ropes on rope drums shall be clearly recognizable at the drums, and where required the winding direction shall be indicated.

4.2 Rope-sheaves

4.2.1 Design features shall prevent ropes from being jammed between rope-sheaves and side plates, or leaving the rope groove.

The distance between the upper edge of rope-sheaves and e.g. side plates shall not exceed 1/3, with plastic rope-sheaves 1/4, of the rope diameter or 8 mm at most.

4.2.2 With respect to steel materials for assembled rope-sheaves, all normal strength steels with proven notch toughness are suitable.

For cast rope-sheaves, the steel casting type GE200 acc. to EN 10293 (previously GS-38 acc. to DIN 1681) or cast iron type EN-GJS-400-18-RT with proven notch toughness or EN-GJS-400-18-LT acc. to EN 1563 (previously GGG-40.3 acc. to DIN 1693) or corresponding types with cast test pieces.

4.2.3 Where plastic rope-sheaves are used, they are to be type-tested. In the case of single layer spooling on the rope drum at least the sheave which generates most of the alternating bends in the rope is to be produced from steel. Alternatively, defined criteria for scrapping or usage periods may be approved.

4.2.4 The following requirements apply to the design of rope grooves:

- depth of groove : $\geq \sqrt{2}$ times nominal rope diameter
- diameter of groove : 1,06 to 1,08 times nominal rope diameter
- opening angle : 45° to 60°

Table 8.3 Minimum diameter of rope-sheaves and rope drums[1]

Application/ crane group[2]	Rope-sheave diameter[3] minimum	Rope drum diameter[3]		Nominal tensile strength of wire ropes[4]
		ungrooved minimum	grooved minimum	
Wire ropes not operated under load	9 d_s	10 d_s	9 d_s	1570 N/mm^2
A	18 d_s	20 d_s	16 d_s	1770 N/mm^2
B	20 d_s	not permitted	18 d_s	1770 N/mm^2
C1	22 d_s	not permitted	20 d_s	1770 N/mm^2
C2 + C3	25 d_s	not permitted	22 d_s	1770 N/mm^2

1 In case of rope-sheaves and machined drums measured in the bottom of the groove.
2 for crane group definition, see Section 4, B
3 Where non-rotating or poorly-rotating ropes are used, it is recommended that the diameters indicated be increased by 10 %.
4 Where ropes with a higher nominal tensile strength are used, the prescribed diameters are to be increased proportionally.

4.3 Diameter of sheaves and rope drums

The required rope-sheave and rope drum diameters relative to rope diameter "d_s" shall be as shown in Table 8.3.

For all other types of wire ropes the ratio is to be agreed with BKI in each individual case.

4.4 Lateral deflection angle of the rope

4.4.1 The lateral deflection of wire ropes relative to the plane of the groove in the rope-sheave or rope drum, shall not be greater than 1:14 (4°).

4.4.2 In the case of poorly-rotating ropes, the lateral deflection angle shall not be greater than 1:28 (2°).

4.4.3 Exceptions to the above requirements are made for unwinding hoist ropes. Special wear reducing design measures are to be taken for offshore supply cranes.

4.5 Employment of swivels

Swivels shall only be employed with poorly-rotating ropes.

C. Fibre Ropes

1. General requirements

1.1 Fibre ropes are to comply with recognized standards. On application, special rope designs may be approved.

1.2 Fibre ropes (of natural or synthetic fibre) except carbon fibre ropes may be used for "Standing Rigging" and for "Running Rigging" of special loading gear which is stressed moderately subject to agreement with BKI.

Fibre ropes may also be used for the cargo tackles of landing booms according to Section 6, F.3 and for rope slings, with the exception of carbon-fibre ropes. The agreement of BKI is required for other applications.

1.3 Synthetic fibre ropes shall be stabilized with respect to light and heat.

1.4 Free rope ends shall be yarn-wound to prevent disintegration of the rope structure. Synthetic fibre ropes may be partially melted.

2. Definitions

2.1 The terms "running rigging", "standing rigging" and "rope sling" as well as the term "actual breaking load" F_{wi}, are defined in B.2.

2.2 The "proven breaking load" F_n of a fibre rope is the load calculated from the breaking load of the yarns contained in the rope multiplied by a reduction factor.

2.3 The "reduction factor" is an empirical value which takes account of the loss of strength due to stranding.

The reduction factors of the best-established fibre ropes are given in the BKI Rules listed in A.2.1.

3. Dimensioning

In the case of fibre ropes used for loading gear and loose gear, the breaking load F_{Br} shall not be less than the product of the static rope tension "F_S" and one of the safety factors "γ_F" given in Table 8.4:

$$F_{Br} \geq F_S \cdot \gamma_F$$

F_{Br} = required breaking load of the rope analogous to B.3.1

F_S = rope tension acc. to B.3.2

Table 8.4 Safety factors for standardized fibre ropes

Nominal diameter of rope [mm]	Coefficient of utilization γ_F
10 – 13	12
14 – 17	10
18 – 23	8
24 – 39	7
40 and over	6

For non-standardized fibre ropes γ_F is to be agreed with BKI.

4. Requirements for rope drives

4.1 Synthetic fibre ropes are not to be used on capstan heads or other devices, where a major slippage may occur.

4.2 Fibre ropes shall only be wound up in one layer. Winding shall be performed under tension.

4.3 The required rope-sheave diameters relative to the nominal rope diameter "d_s" shall be as shown in Table 8.5.

For non-standardized fibre ropes the rope sheave diameter is to be agreed with BKI.

Table 8.5 Minimum diameter of rope-sheaves for standardized fibre ropes

Rope material	Rope-sheave diameter minimum
manila, hemp	5,5 d_s
polypropylene	4 d_s
polyamide	6 d_s
Polyester	6 d_s
Carbon-fibre	14 d_s

4.4 The required diameters of rope drums are to be agreed with BKI in each case. For carbon fibre ropes, 12d_s is to be taken.

4.5 The lateral deflection of fibre ropes relative to the plane of the groove of rope-sheaves or rope drums shall not be greater than 1:14 (4°).

4.6 The number of safety turns remaining on rope drums shall not be less than 5. In case of synthetic fibre ropes a higher number of safety turns may be required.

D. Rope-end Attachments

Rope-end attachments shall be designed in accordance with recognized standards, e.g. the following.

1. Splices for wire ropes and fibre ropes

1.1 Wire ropes and fibre ropes are not to be made up of parts spliced together.

1.2 Loop splices (eye splices) and thimble splices shall conform to standard EN 13411-2, or be of equivalent design.

The dimensions of thimbles shall comply with standard EN 13411-1 (Shaped steel thimbles for wire ropes), or standard VG 85275 (Steel thimbles for fibre ropes), as appropriate.

1.3 Provided that B.4.1.1 and C.4.6 are met, rope ends connected to winches may be spliced without thimbles, see Section 9, E.2.6.

1.4 Splices of any kind are not permitted for cranes of types B and C, because of their inadequate fatigue strength.

1.5 Splices shall not be sheathed.

2. End attachments for wire ropes

2.1 Rope sockets

2.1.1 Rope sockets (open and closed sockets), into which wire rope ends are to be socketed, shall conform to standard EN 13411. On application, other designs may be approved.

2.1.2 The socketing process using metal or plastic resin shall be performed as prescribed in standard EN 13411-4, and may only be carried out by companies which have been approved.

Only approved cast materials may be used. Rope sockets shall be marked with the code letter of the manufacturing company.

2.2 Wrought ferrules

2.2.1 Wrought aluminium alloy ferrules shall conform to EN 13411-3.

Flemish eyes as per EN 13411-3 are to be used wherever possible for the end attachments of the hoisting and luffing ropes of cranes, if the cranes are working with grabs.

2.2.2 On application, swaged or rolled end fittings (terminals) may be approved.

2.2.3 Application of ferrules in accordance with 2.2.1 and 2.2.2 may only be carried out by approved companies. Ferrules shall be marked with the code letter of the manufacturing company.

2.3 Detachable end joints

2.3.1 Cable joints (wedge clamps) may only be used if the ropes are permanently under tension. They shall be clearly visible and readily accessible, to facilitate inspection.

The free end of the rope shall be secured from being pulled through, e.g. by rope sockets. The safeguard connection of the rope end to the load-bearing part of the rope shall not be force-transmitting. However, it shall be capable of bearing 10 % of the rope tension F_S.

Cable joints shall correspond to EN 13411-6. Up to a rope diameter of 8 mm, EN 13411-7 may also be applied.

2.3.2 Rope sockets as per EN 13411-5 are not permitted. This does not apply to the securing of free rope ends to cable joints.

Rope sockets as per standards EN 81-20, 81-50 and 81-3 are permissible for fixing the rope ends of passenger lifts and small goods lifts.

2.3.3 With regard to the attachment of rope ends to winch drums, the requirements in Section 9, E.2.6 and E.2.7 apply.

E. Tests and Examinations

1. Supervision of manufacture

1.1 Wire rope and fibre ropes

1.1.1 General notes

.1 With regard to testing and examination of ropes, the requirements in the BKI Rules stated in A.2.1 apply.

.2 Instructions for the testing and use of ropes, and an excerpt from the BKI Rules for wire ropes and fibre ropes, are to be found on the reverse sides of the BKI certificates for ropes.

1.1.2 Tensile tests

After manufacturing, ropes shall be subjected to a tensile test, which is mandatory for the issue of a BKI certificate. The following applies:

.1 Ropes shall be loaded to destruction in their entirety. Where the tensile force of the testing machine is not sufficient to perform a tensile test for the whole rope, individual wires or yarns shall be loaded to destruction in a prescribed procedure and the breaking load of the rope determined by calculation.

.2 The results of the tensile tests of the ropes shall achieve the values prescribed in the relevant rope standards.

.3 Tensile tests of ropes shall be performed in the presence of the BKI Surveyor, if:

- the manufacturer is not approved by BKI to test and issue certificates on his own authority
- special rope designs are not covered by the BKI approval
- the customer requests it

.4 Before each tensile test, the protocols on the checks performed by the manufacturer are to be presented to the BKI Surveyor.

.5 Following every tensile test, checking the diameter tolerances, method of manufacture and manufacturers' protocols, the BKI will issue a certificate of test and thorough examination of wire rope or fibre rope using one of the forms stated in F.2.1.

1.1.3 Marking

Ropes are to be marked by woven-in identification bands and coloured identification threads. The following shall be taken into account:

.1 The identification band shall carry the name or mark of the manufacturer, and in the case of a BKI approval, in addition the manufacturer’s identification number, assigned by BKI.

.2 The colour of the identification thread gives information about the nominal tensile strength of wires or the type of yarn used (identification colour).

.3 The coloured identification thread may be dispensed with, if the identification band itself carries the identification colour.

1.2 End attachments

1.2.1 End attachments which are not standardized, or do not correspond to standards, are subject to an examination of drawings.

1.2.2 With regard to tests and examinations of rope sockets, cable joints and terminals, the requirements in Section 7, C.5 apply. For terminals, it may be required to produce specimens connected to a small length of rope.

1.2.3 In the case of short, ready-made units, the rope sockets and terminals can be load-tested together with the rope.

2. Initial testing

Ropes and their end attachments are subject to a visual examination and a check of the relevant certificates within the scope of the initial testing of loading gear.

3. Periodic testing

3.1 Wire ropes and fibre ropes

3.1.1 In the scope of the periodic testing of loading gear and loose gear, the ropes are to be examined by the BKI Surveyor with regard to condition and fitness for use.

3.1.2 When ropes are examined, attention shall be paid to deformation, crushing, corrosion/ rottenness and broken wires. If necessary the ropes have to be twisted open for an internal examination.

3.1.3 Special attention is to be paid to the end attachments. There, broken wires or yarns are to be expected, with wire ropes also corrosion, especially with downward hanging end attachments. Sheathings shall be removed for examination.

3.1.4 Sheaves used for length compensation within tackle where a rope only seems to be resting, are particularly prone to wire ruptures caused by regular compensation motions.

3.1.5 Where splices have become loose, the ropes shall be shortened and spliced again or, where required, replaced.

3.2 End attachments

With regard to end attachments, the requirements in 3.1.1 apply. Attention shall be paid to wear, cracks and corrosion.

3.3 Ropes to be discarded

3.3.1 Wire ropes

.1 Wire ropes shall be discarded when, over a length equal to 8 times the rope diameter d_s, the number of detected broken wires is greater than 10 %, with Lang lay ropes 5 %, of the total number of wires in the rope.

.2 Wire ropes shall also be discarded when:

- the rope diameter ds being reduced, owing to friction or wear, by more than 10 % of the nominal diameter, or in case of wear to the core
- corrosion (external or internal)
- deformations of the rope, such as "bird caging", formation of loops, buckling, kinking, crushing, loosening of individual wires or strands, etc.

.3 Wire ropes which are regularly employed under water shall be shortened in the vicinity of the loose gear (e.g. the hook) at least once per year, in order to enable the cut-off end, which should have a minimum length of 1 m, to be thoroughly examined and subjected to a tensile test.

If the remaining breaking load is below 80 % of the original breaking load, the rope shall be discarded. If the remaining breaking load is 80 % or above the original load, an estimate shall be made, based on the condition and the period of employment, whether the rope may be employed for another year.

.4 Wire ropes employed above deck shall be discarded at the latest after the following periods of employment, even when no external damage is visible:

- running rigging: 10 years
- standing rigging: 15 years

Wire ropes may be employed for a longer period of time, if a "Certificate of Fitness" has been issued by a recognized rope company or by the rope manufacturer after a thorough examination.

3.3.2 Fibre ropes

.1 Fibre ropes shall be discarded when, over a length equal to 8 times the rope diameter d_s, more than 10 % of the total number of yarns in the rope are broken.

.2 Fibre ropes shall also be discarded in the event of:

- breakage of a strand
- mechanical damage or wear
- release of fibre particles
- rotting
- larger fused patches on synthetic fibre ropes

F. Documentation

1. Marking

1.1 Wire ropes and fibre ropes

1.1.1 Ropes are marked by the method described in E.1.1.3.

1.1.2 With regard to ropes, the rope tension "F_s", calculated according to B.3.2, shall not be less than the permissible load SWL, stamped on the end attachments.

1.1.3 With regard to ropes with splices, a small metal plate, stamped in accordance with Section 7, D.2.3 shall be fastened near an end attachment.

1.2 End attachments

End attachments for wire ropes are stamped like interchangeable components, see Section 7, D.2.3. Where applicable, this is also possible on ferrules or terminals, taking account of D.2.3.3.

2. Certificates

2.1 Wire ropes and fibre ropes

After the tension test, approved manufacturers, or in cases described in E.1.1.2.3, BKI will issue one of the following test certificates:

- wire ropes: Form LA4
- fibre ropes: Certificate of test and examination of fibre ropes

2.2 End attachments

With regard to certification of end attachments, the requirements in Section 7, C.6.1.1 apply.

3. Storage of rope certificates

As described in Section 13, G, test certificates for ropes and test certificates for end attachments will be added initially and after each re-issue to an allocated Register book on board.

4. Confirmation of examinations

4.1 Ropes and end attachments which are integral parts of loading gear or loose gear, will be included in the examination of them.

For these devices examination reports will be prepared and the examinations will be confirmed in the Register book.

4.2 The confirmation of examinations of ropes and end attachments which cannot be allocated to particular loading gear or loose gear, will be effected by an examination report for these parts.

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Section 9 Mechanical Parts

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A. General

1. General Notes

1.1 This Section contains requirements for the mechanical parts of loading gear and, where required, also loose gear.

1.2 Complementary or more comprehensive requirements, in particular for mechanical parts not covered hereafter are to be taken from the following rules:

– BKI Rules for Part 1 Seagoing Ship and Part 5 Offshore Technology as well as BKI Guidelines.

– recognized standards and requirements, where applicable to loading gear, unless contrary to the provisions in this Section.

1.3 The requirements in Section 1 are to be observed, if applicable.

1.4 As regards the materials to be used, the manufacture and the safety requirements, the provisions in Sections 2, 11 and 12 apply.

2. Scope of application

2.1 Table 9.1 is a list of the essential mechanical parts which are subject to examination of drawings as deemed necessary by BKI, and which are to be delivered in the designated manner, together with test reports or inspection certificates.

2.2 The requirement for an examination of drawings, and the type of certificate, depends on the safety relevance of the components, with respect to their strength and reliability, and on the operational mode and the type of certification of the loading gear.

2.3 Table 9.1 reflects the general requirements of BKI. BKI reserves the right to impose additional requirements or to permit deviations.

2.4 BKI reserves the right to impose additional requirements for all kinds of mechanical parts, should this be necessary on account of new findings or operational experience.

3. Differing designs

3.1 Designs differing from the requirements of this Section may be approved if examined by BKI for their suitability and approved as being equivalent.

3.2 Mechanical parts developed on the basis of novel technical concepts but not yet sufficiently proven, require special approval by BKI. Such systems may be subjected to more stringent supervision, if the prerequisites as per 3.1 are not applicable.

3.3 In the cases mentioned in 3.1 and 3.2, BKI is entitled to demand presentation of additional documentation and performance of special trials.

B. Design Criteria and Operational Requirements

1. General notes

1.1 Mechanical parts of loading gear and loose gear shall be designed for the environmental conditions agreed on or prescribed, and be capable of being operated without problem under these conditions.

1.2 The effects of deformation of the supporting structure on machinery and equipment are to be observed.

1.3 Mechanical parts are to be designed in such a way that repairs and regular maintenance are easy to perform using on-board tools.

2. Dimensioning

2.1 Mechanical parts shall be dimensioned in such a way as to provide adequate strength in respect of dynamic stress peaks, plus adequate fatigue strength in relation to the load and service life.

With respect to dimensioning, attention is to be paid particularly to the stress peaks arising during acceleration and retardation, and if applicable, the dynamic influences resulting from lifting and lowering of loads.

2.2 All mechanical parts shall measure up to the special circumstances of operation on board ships, such as ship movements and acceleration, increased corrosion, temperature changes, etc.

2.3 With regard to structural design and fastening, in general, acceleration of 0,7 g in the frequency range from 13 to 100 Hz shall additionally be considered, see also 3.1.

3. Effects of vibration

3.1 Machinery and equipment shall not cause any vibrations and shocks which may unduly stress other components, or the structure of the loading gear and loose gear. The permissible amplitudes and accelerations are stated in Rules for Machinery Installations (Pt.1, Vol.III).

3.2 If compliance with the permissible values of amplitude and acceleration cannot be ensured by structural measures, damping measures are required.

3.3 Within the frequency ranges which occur, there shall be no resonance phenomena in components, support- and suspension arrangements - nor within equipment.

4. Lubrication

4.1 Lubrication of the moving parts of loading gear and loose gear shall be guaranteed under all operating conditions.

4.2 Each grease-lubricated bearing shall be provided with its own proven type of grease nipple.

4.3 Accessibility to manual greasing points shall be ensured.

5. Corrosion protection

Components at risk of corrosion are to be given suitable corrosion protection.

C. Power Drives

The requirements in B. are to be observed. In addition, the following applies:

1. Drives in general

1.1 Power drives shall be adequately dimensioned for the working conditions laid down, to allow trouble-free and low-vibration operation.

1.2 For electrical drives and electrical controls in general, the requirements in Section 10 are applicable.

2. Main drives

2.1 Main drives of loading gear shall be dimensioned in such a way that the installed power meets the requirements in 1.1 for all combinations of motion and speed.

Where the installed power is not sufficient to execute all motions simultaneously at nominal load and at full speed, the speed shall be reduced automatically.

2.2 Diesel engines shall not be capable of running at excessive speeds or being stalled.

D. Slewing Gears and Slew Rings

1. Slewing gears

1.1 Slewing gears are to be designed for maximum operating torque and, where the gears are of a self-locking type, they are to be equipped with a slewing gear brake.

1.2 Slewing gears on board ships are to be designed in such a way that, in the event of the vessel's permissible inclination being exceeded by 5°, none of the materials employed shall be stressed beyond 90 % of its yield point.

1.3 In the case of slewing gears on board ships, it is to be taken into account that it might be necessary in the "out of operation" condition to reduce the load on the slewing gear brakes by means of locking devices.

1.4 Slewing gears of offshore cranes are to be dimensioned for at least 1,3 times the design torque, based on wind, transverse tension and inclination of the crane's base and shall have at least 2 independent drives.

2. Slew rings

2.1 Large roller bearings

2.1.1 The design of large roller bearings shall, together with the connecting structures and the bolting, be suitable for the intended operation and the intended environmental conditions.

2.1.2 The connecting flanges on the loading gear and foundations shall be adequately distortion resistant, their surfaces machined.

Accuracy of plane and distortion shall be within the tolerances stated by the manufacturer.

The mating surfaces shall be steel to steel. Casting of synthetic material is permitted only in exceptional cases and requires BKI approval in each individual case, see Section 4, G.4.1.2.4.

2.1.3 Large roller bearings are to be designed in such a way that a failure of important runway elements does not result in a total loss of the loading gear.

With regard to offshore cranes, retaining devices are to be provided where required.

2.1.4 If large roller bearings have to be dismantled during employment for an internal examination, special dismantling equipment shall be available which can hold the loading gear and raise it after the connecting bolts have been unscrewed.

As an alternative, the loading gear shall have special eyebolts for lifting by another appliance, and a safe place for setting-down.

2.1.5 Where an interchange of seals is intended, large roller bearings are to be designed such that this is enabled without dismantling of the bearings or loosening of the connecting bolts.

2.1.6 With respect to the materials to be used, as well as their heat treatment and proof of mechanical properties, the requirements in Section 2, D apply.

2.2 Bolting of large roller bearings

In addition to Section 4, G.4.1 the following applies:

2.2.1 The fixed ring at the foundation or at the crane column is to be bolted at even intervals around its circumference.

2.2.2 For bolting of the rotating ring to the loading gear, uneven bolt intervals may be applied if the safety of such bolting is verified by calculation or measurement.

2.2.3 The distance between the bolts shall in general not exceed 6 times the bolt diameter.

2.2.4 The requirements for the bolts are as follows:

.1 Up to a diameter of ≤ 30 mm, bolts may be preloaded according to the instructions of the slew ring's manufacturer by applying a torque.

For larger diameters, preloading shall be by hydraulic elongation. This calls for increased thread tolerances.

.2 With respect to the materials to be used for the bolts as well as the proof of their mechanical properties, the requirements in Section 2, H apply.

2.3 King pins and support rolls

2.3.1 If not safe by design, loading gear is to be secured against overturning by king pins and support rolls, also with rolls which engage from below where required.

2.3.2 The rotating system shall meet the following requirements:

- support rolls shall be installed in a stationary position.
- support rolls and king pins shall be easily accessible for maintenance and inspection, support rolls also for exchange purposes.

– after failure of one support roll, even under load, the loading gear shall still be capable of being turned into a secure position.

E. Winches

1. Design notes

1.1 Winches shall be of a reversible type, i.e. the lowering process shall also be motor-controlled.

1.2 Design features incorporated in each winch shall ensure that the load cannot run back inadvertently (e.g. by a ratchet wheel, self-locking gears, non-return valves, automatic brakes, etc.).

1.3 The use of belts or friction discs to transmit power between the winch drum and the reverse travel prevention device referred to in 1.2 is not allowed.

2. Rope drums

2.1 The drum diameter shall be determined in accordance with the intended purpose of the winch, in accordance with Section 8, B.4.3 or a recognized standard.

2.2 Rope drums shall be provided with flanges whose outer edges extend above the top layer of rope by at least 2,5 times the rope diameter unless the rope is prevented from overriding the flange by a spooling device or other means.

It is to be ensured that ropes can wind onto drums properly and without excessive deviation.

2.3 The number of safety-turns left on the rope drum shall not be less than 3.

2.4 Rope grooves shall comply with the following requirements:

– groove diameter : $\geq$ 1,05 · rope diameter d_s

– groove depth : $\geq$ 0,33 · rope diameter d_s

2.5 In the case of multiple winding, wedges at the flanges shall facilitate the ropes onto the second layer, unless special measures are provided, such as:

– small lateral deflection $\leq$ 1,5°

– cable guides

– lebus grooving

2.6 Rope-end attachments at the winch drum are to be designed in such a way that:

– the ropes are not pulled over edges

– the end fastening cannot be released unintentionally

– the end fastening is easy to inspect

If the end attachment of wire ropes is based on clamping at least 3 clamping plates are to be used.

The construction of end attachments for fibre ropes is to be agreed with BKI.

For nominal loads up to 12 t and loading gear which is only occasionally loaded, spliced rope loops can also be used.

2.7 The following conditions are to be met for the minimum required rope tension force "F_a" at the drum:

2.7.1 Loading gear in general:

$$F_a \geq F_S \cdot \frac{\gamma_{D1}}{2 \cdot e^{\mu\alpha}}$$

F_S = rope tension as per Section 8, B.3.2

γ_{D1} = safety factor for wire ropes as per Table 8.2 (where applicable, Section 8, B.3.3 is to be observed)

μ = coefficient of friction between rope and drum. Applicable values are:

- smooth drum : $\mu \leq 0{,}08$
- grooved drum : $\mu \leq 0{,}10$

α = wrap angle. For 3 turns is

$$\alpha = 6 \cdot \pi$$

2.7.2 Offshore cranes:

$$F_a \geq \frac{F_{Br}}{e^{\mu\alpha}}$$

F_{Br} = rope breaking load according to Section 8, B.3.1.

BKI may also demand this rope tension for other loading gear, if this is employed under similar operational conditions, e.g. for floating cranes operating offshore.

3. Brakes

3.1 Each winch shall be fitted with a braking device capable of braking and holding the maximum permitted load safely under all operating conditions and this action shall not generate inadmissible dynamic influences.

The minimum friction coefficient of the brake is not to exceed 0,3 in the design calculation.

The winch and its substructure shall be able to safely withstand the forces set up during braking.

3.2 Having regard to the dynamics of the braking action, the braking torque must exceed the maximum load torque by an adequate safety margin. As a guide, the maximum braking torque may be set at about 80 % above the maximum load torque.

If need be, $f_{d,s}$ according to B.3.2.6 is to be considered.

3.3 The required braking device may take the form of

– self-locking gear
– mechanical brake with brake pads or brake discs
– a hydraulic or pneumatic device which prevents lowering of the load, or
– electromotive brake

and shall be actuated when

– the control returns to the neutral position
– a safety device comes into action
– the power supply fails, or

– on hydraulic installations, a non-scheduled pressure loss occurs

3.4 Hydraulic retention brakes shall comply with the following requirements:

– The shut-off valve of hydraulic motors shall activate at the low-pressure connection in the case of pressure loss.
– Hydraulic motors shall have a shut-off valve, hydraulic cylinders a valve according to F.2.4, which is to be fitted directly at the high-pressure connection.
– A hydraulic motor and cylinder shall always be fed with a sufficient quantity of working fluid, also the fluid supply in the event of power failure , e.g. by gravity.
– Shut-off valves and valves according to F.2.4 shall be capable of absorbing the pressure impacts caused by braking.

3.5 Electromotive brakes additionally require a mechanical holding brake (drum brake or spring loaded motor brake).

3.6 Braking devices shall be designed in such a way that on the one hand they may be adjustable, on the other the designed braking effect cannot easily be interfered with. Due to humidity, oils or impurities, braking power shall not decrease below the design value.

Where a gear box is arranged between brake and drum, the load-bearing components shall be dimensioned like the corresponding components of a brake.

Spring-loaded braking pads or discs shall be loaded by pressure springs.

Checking wear to braking pads or discs shall be possible without dismantling the braking unit.

Self-blocking brakes are only admissible for stowage or idle positions.

3.7 The following requirements apply for offshore cranes and floating cranes which transport persons, operating offshore.

3.7.1 In addition to the normal working brake, hoisting and luffing winches are to be fitted with a secondary brake which is independent in terms of mechanical and operational layout.

3.7.2 Secondary brakes shall have their own, independent control circuit and at least be dimensioned to withstand loads as per Section 3, B.5.

4. Winch drives

4.1 Power drives

For power drives, the requirements in C. and F.1.4 apply.

4.2 Manual drives

4.2.1 Manual drives shall incorporate the following features:

– The crank handle turns in the same direction for all gear ratios.
– Crank handles have a crank radius of approximately 350 mm and a rotatable grip sleeve.
– Detachable crank handles are safeguarded against being detached unintentionally.
– The load is hauled in manually with a force of max. 160 N.
– A speed of about 30 rev/min^{-1} is not exceeded.

4.2.2 Where winches are constructed for both powered and manual operation, the power- and manual systems shall be mutually interlocked.

5. Couplings

5.1 Clutch couplings between the drive and the rope drum are only permitted where one of the means to prevent runback stipulated in 1.2 has been provided.

5.2 Where winches have more than one disengageable drum, only one drum shall be in operation at any time.

5.3 Control levers shall be safeguarded against unintentional operation.

6. Gearing

6.1 The design of gearing shall conform to established engineering practice; location, positioning and mode of operation are to be taken into account.

6.2 Gearing shall, amongst others, include the following characteristics:

- easy access for maintenance
- facilities for checking the oil level
- ventilation- and oil filler pipes appropriate to the location
- inspection openings

7. Controls and monitoring instruments

7.1 The controls and monitoring instruments shall be clearly arranged on the control platform.

7.2 Controls and monitoring instruments shall be permanently, clearly and intelligibly marked with the direction or the function of the movements they control, see Section 12, D.2.

7.3 The arrangement and direction of movement of controls and monitoring instruments shall match the direction of the movement which they control.

7.4 The operating movement range of control levers shall be less than 300 mm, and when released, they shall return automatically to the neutral position.

7.5 In the case of push-button controls there shall be a separate button for each direction of movement.

F. Hydraulic Systems

1. General requirements

1.1 The dimensioning and design of hydraulic systems shall conform to the established rules of engineering practice. Safe operation under all envisaged service conditions shall be ensured by suitable equipment (e.g. filters, coolers, control devices and primary pressure control) and by selecting an appropriate hydraulic fluid.

1.2 Hydraulic systems shall be protected against overpressure and against over speed of the load by a corresponding limitation of flow rate and pressure.

1.3 Instead of pipes, high pressure hoses may be used. These shall comply with the requirements of EN 13135 or an equivalent standard.

The hoses shall be suitable for the proposed operating fluids, pressures, temperatures, operating and environmental conditions and be appropriately laid, and of an approved design.

1.4 For hydraulically-powered winches, a standstill brake to prevent slip is required if necessitated by the construction of the winch.

Any slip occurring shall generally not exceed the equivalent of one revolution of the drum or 1 m hook lowering per minute, whichever is the lesser.

2. Hydraulic cylinders

2.1 Hydraulic cylinders are to be dimensioned for 1,1 x relief pressure p_c and dynamic forces which may occur in and out of service.

2.2 The relief pressure pc of the safety relief valves is to be set at a sufficiently high level that dynamic forces which may occur can be absorbed and hoist load coefficients are considered.

2.3 Piston rods shall be sufficiently rigidly connected to the piston or telescopic rod, in order to meet the requirements for calculation given in Section 3, I.2.3.

The stroke of the piston rods shall be limited by end stops which shall be capable of preventing the pushing-out of the piston rods, even at the utmost pressure and dynamic load. If necessary, devices for terminal damping or end limitation are to be provided.

2.4 With telescopic cylinders, extending and run-in of the telescopic rods shall be conducted in a specified order. For lifts, synchronous cylinders may be applied, provided they meet the requirements in EN 81-50 or 81-3.

2.5 Load-bearing hydraulic cylinders, e.g. for lifting, luffing, folding and telescoping of crane booms as well as for slewing of loading gear, shall be provided with a device which maintains the position of the load, the crane boom or the loading gear in the event of pressure loss and failure of a pipe or hose line.

Such a device may be an automatic shut-off brake valve, a pilot-operated check valve, or a load holding valve and shall be installed inside or outside directly at the cylinder.

2.6 The type of fastening and the design of the bearings shall safeguard that no unacceptable external bending moments can be transmitted to the hydraulic cylinders.

3. Hydraulic tanks

3.1 Regarding dimensioning of hydraulic tanks, tasks like e.g. cooling (radiation of heat), eliminating air and depositing contaminants shall be taken into consideration. At the same time the container shall be able to accommodate the total amount of oil in the system.

3.2 Hydraulic tanks shall be fitted with:

- fluid level indicator (including minimum and maximum values)
- access opening
- outlet valve
- ventilation

Design, operational and environmental conditions may in addition require cooling and/or heating of the tanks.

3.3 Pressure tanks shall be capable of withstanding a 2-fold maximum working pressure and shall have a safety valve against overpressure.

G. Protective Measures and Safety Devices

1. Protective measures

1.1 Moving parts, flywheels, rope and chain drives, rods and other components which might come to constitute an accident hazard for the handling staff shall be provided with protection against accidental contact. The same applies to hot mechanical parts, pipes and walls not provided with insulation.

1.2 Measures shall be taken to provide power supply lines with effective protection against mechanical damage.

1.3 Cranks for starting internal combustion engines shall disengage automatically once the engine starts running.

1.4 Machinery employed in potentially explosive areas shall comply with the requirements in ISO 80079-36.

2. Safety devices

2.1 Winches and drive systems shall be equipped with adjustable protection devices (e.g. pressure relief valves, winding and slip clutch thermal overload relays). Following a power failure, drives shall not restart automatically.

2.2 Devices provided to unlock slewing or hoisting gear are only permissible for special operational purposes or as emergency measures, e.g. on offshore cranes.

2.3 Safety devices shall not be rendered unserviceable by environmental conditions at the point of installation, because of dirt or springs breaking. There shall be a means of checking the devices.

H. Examination of Drawings and Supervision of Construction

1. Examination of drawings

1.1 The general requirements in Section 1, D.1 are to be observed.

1.2 In addition to the requirements in Section 1, D.4, the mechanical parts listed in Table 9.1 are subject to examination of drawings within the scope indicated there.

2. Supervision of construction

2.1 General notes

2.1.1 Mechanical parts shall be manufactured by staff qualified in handling the installations and devices necessary. During manufacture and before delivery the parts have to undergo the quality tests required in accordance with state-of-the-art technology and experience.

2.1.2 All materials shall be suited to the intended purpose. Proof of the mechanical properties of the materials used is to be furnished. Identification of the materials shall be possible on the basis of test certificates or reports.

2.1.3 Mechanical parts which require an inspection certificate 3.2 according to Table 9.1, are subject to supervision of construction by BKI, with the restrictions described in the explanations to Table 9.1 where required.

.1 The BKI inspection in charge decides in coordination with the manufacturer on type and scope of supervision of production and certification, taking the in-house quality control and/or approval for production into consideration.

.2 With respect to assistance by the manufacturer during supervision of production by BKI, the requirements in Section 13, B.2 are to be observed.

2.2 Tests and examinations

The following requirements contain general test requirements, and in addition, provisions for the supervision of production by BKI.

2.2.1 General notes

.1 For the acceptance tests before delivery and, if applicable, also for the supervision of production, BKI shall be given material test and internal control certificates, test reports and manufacturing documents, in particular approved drawings, including the relevant examination reports, as a prerequisite for the tests and examinations described below.

.2 Test reports shall include the following information, if applicable:

– designation of type and nominal dimensions
– purchase and order number
– drawing number
– results of internal controls
– certificate numbers of material tests and non-destructive tests
– additional details, as necessary

.3 For series-production components, other test procedures may be agreed with BKI instead of the prescribed ones, if they are accepted to be equivalent.

.4 BKI reserves the right to extend the scope of testing, if necessary, and also to subject such components to a test, for which testing is not expressly required in these Guidelines.

.5 Where mechanical parts are to be used for the intended purpose for the first time, BKI may ask for a type approval.

2.2.2 Winches

.1 After completion, winches are to be subjected to an examination and functional test at nominal rope tension by repeated hoisting and lowering of the nominal load. During the functional test, in particular the brake and safety devices are to be tested and adjusted.

.2 Where winches are designed for a holding force greater than the nominal rope tension, the nominal rope tension is to be tested dynamically and the holding force statically.

.3 Where winches are designed with a constant tension device, the maintenance of constant tension is to be proven for all levels of tension set by the design.

.4 The above tests, including the setting of the overload protection, can also be performed on board, together with the functional testing of the loading gear. In this case, a functional test at available load is to be performed at the manufacturer's.

Testing of winches at test load will be performed within the scope of initial tests of the loading gear, see Section 13, C3.

2.2.3 Load-bearing hydraulic cylinders

.1 Load-bearing or 1st order components are hydraulic cylinders designed for hoisting, luffing, telescoping and slewing.

.2 Load-bearing hydraulic cylinders shall undergo a functional test at relief pressure and a pressure test at test pressure. The test pressure shall be 1,5 times relief pressure p_c, however with relief pressures over 200 bar, it need not be higher than p_c + 100 bar.

.3 With reference to F.2.5, in the case of series-production of loading gear of the same type and with multiple cylinders, e.g. with slewing cranes with luffing, folding and/or telescopic crane booms, a regular check on the cylinders at a minimum of 1,25 times the relief pressure may be accepted.

The BKI Surveyor is entitled to ask for cylinders to be tested which are selected at random, in accordance with 2.2.3.2.

2.2.4 Large roller bearings

.1 The material properties of forged rings shall be tested according to Rules for Materials (Pt.1, Vol.V) by tensile tests and by notched-bar impact tests and shall comply with the requirements in the agreed specification.

The manufacturer shall, in addition, ultrasonically test the rings for internal defects and certify that the materials are free from defects which may impair the performance characteristics.

.2 Rings shall be heat-treated as appropriate to the material, and the running surfaces are to be hardened additionally. After hardening, the runway surfaces of the rings shall be crack-tested along their entire length.

Cracks may be removed by grinding, if by this measure the functional capability of the slewing ring is not impaired. Residual cracks are not permitted. The BKI Surveyor may demand the crack test be performed in his presence.

.3 The hardened runways are to undergo a hardness test at least 8 points equally distributed along the circumference. The hardness values shall be within the specified range.

Where there are reasonable doubts about the hardened depth, proof shall be furnished using specimens which have been hardened under the same conditions as the ring under consideration.

.4 For the acceptance test before delivery, the large roller bearing shall be assembled and presented to the BKI Surveyor. The functional capability (slewing without load), the bearing clearance and the accuracy in plane and round travelling are thereby to be tested. In addition, the dimensions shall be checked randomly, as deemed necessary by the Surveyor.

2.2.5 Bolts and nuts for large roller bearings

With respect to tests and examinations of bolts and nuts, Rules for Materials (Pt.1, Vol.V) apply.

2.2.6 Mechanical and hydro mechanical parts

.1 With respect to tests and examinations of mechanical and hydro mechanical parts, the Guidelines stated in Section 1, B.2.1.2 apply, where relevant.

Parts not covered by Guidelines shall be tested and examined using appropriate procedures agreed with BKI.

.2 Instead of testing at the manufacturer's, tests can also be performed on board within the scope of initial tests of the loading gear, if practicable.

I. Documentation

1. Marking

1.1 Each mechanical part shall be marked by the manufacturer in a suitable way. The marking shall at least include the following, if applicable:

– manufacturer's name
– year of construction
– designation of type
– purchase order number or serial number
– characteristics such as nominal load, nominal pressure, nominal voltage, etc.
– additional details, as necessary

1.2 If, after the acceptance test before delivery, the requirements for issuing Test Certificates for hydraulic cylinders, diesel engines, etc. are complied with, the tested mechanical part will be stamped in a prominent position.

The stamp shall include the following information:

– certificate number, together with the code letters of the examining inspecting office
– BKI stamp with the month and year of testing

for hydraulic cylinders additionally:

– working pressure
– testing pressure

for winches additionally:

– rope tension [kN]
– holding force [kN]

for slewing gear rings additionally:

– abbreviation for the material type
– melting charge number
– specimen number

1.3 The winding direction of ropes on rope drums shall be clearly recognizable on the drums.

Where required, the winding direction shall be indicated appropriately on the drum or winch.

2. Certificates

2.1 Table 9.1 shows the required types of certificates for essential mechanical parts.

The loading gear manufacturer shall order the stated parts together with the required certificates, the parts manufacturer shall include them in the delivery.

2.2 The inspection certificate 3.2 shall be issued by BKI.

2.3 The certificates listed in Table 9.1 are not part of the loading gear documentation on board.

Table 9.1 Examination of drawings and certification of mechanical parts

Components		Loading gear in general[5]		Offshore Cranes		Classified loading gear	
		Examination of drawings	Certificate	Examination of drawings	Certificate	Examination of drawings	Certificate
Winch drum		Z	–	Z	–	Z	–
Winch mounting		Z	–	Z	–	Z	–
Winch, complete unit		I	2.2	Z	3.2[1]	Z	3.2[1]
Hydraulic cylinder, load-bearing Z		Z	3.2	Z	3.2	Z	3.2
Large roller bearings		Z	3.2[2]	Z	3.2[2]	Z	3.2
Bolts and nuts for large roller bearings	≤ M52	I	2.2	I	3.1	I	3.1
	> M52	I	3.1	I	3.1	I	3.2
King pin/support rolls		Z	2.2	Z	3.1	Z	3.2
Slewing gear, complete unit		I	2.2	Z	3.1	Z	3.2
Slewing gear	Cylinder	Z	2.2	Z	3.1	Z	3.2
	Rack bar	Z	2.2	Z	3.1	Z	3.2
Luffing gear (Cylinder/ spindle) Z		Z	3.2	Z	3.2	Z	3.2
Travelling gear, complete unit		Z	2.2	–	–	Z	3.1
Main drive (diesel)		–	2.2	I	3.1	I	3.1
Hydromotors and pumps	≤ 50 kW	–	2.2	I	2.2	Z	3.1
	> 50 kW	–	2.2	Z	3.1	Z	3.2
Pressure lines	≤ 40 bar ≤ 32 DN	–	–	I	2.2	I	2.2
	> 40 bar > 32 DN	–	–	I	2.2	I	3.1 3
Safety valves against pressure loss		I	2.2	I	2.2	I	2.2
Hydraulic hose lines		–	2.2	I	3.2 4	I	3.24
Hydraulic fittings		–	2.2	I	2.2	I	2.2
Ventilators/heat exchangers		–	2.2	I	3.1	Z	3.2
Sheaves		I	2.2	I	3.1	Z	3.2
Swell compensators		–	–	Z	3.2	Z	3.2
Damping devices		–	–	Z	3.2	Z	3.2

Explanations:

– The column "Loading gear in general" may also be applied to loose gear as and where relevant
– "Z" means drawings and calculations
– "I" means documents for information
– The designation of the certificate types corresponds to EN 10204. The numbers mean the following certificates:
  – 2.2 : test report (BKI designation: C-type Certificate)
  – 3.1 and 3.2 : inspection certificates (BKI designation: B- and A-type Certificate)

[1] At the manufacturer's at least 1 functional test is required, see H.2.2.2.4
[2] Certificate of type 3.1, if the manufacturer is approved by BKI
[3] The certificate shall confirm the performance of a pressure test at 1,5 times the nominal pressure
[4] Certificate of type 3.1, if the manufacturers of both, the hose as well as the hose line are approved by BKI and proof is furnished of a pressure test at 2 times the nominal pressure
[5] Includes offshore working cranes on wind energy plants

Section 10 Electrical Equipment

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A General

1. General notes

1.1 This Section contains the requirements of electrical equipment of loading gear and, where applicable, also of loose gear.

1.2 Additional or more comprehensive requirements, e.g. for switch cabinets and for electrical equipment not covered hereafter can be taken from the following:

– BKI Rules for Part 1 Seagoing Ship and Part 5 Offshore Technology as well as BKI Guidelines.

– recognized standards and regulations where applicable to loading gear, unless contrary to the requirements in this Section.

1.3 The requirements in Section 1 are to be observed where relevant.

2. Scope of application

2.1 Table 10.1 is a list of the essential electrical equipment which is subject to examination of drawings as deemed necessary by BKI, and which is to be delivered together with test reports or inspection certificates.

2.2 The requirement for an examination of drawings and the type of certificate depend on the safety relevance of the equipment, with respect to its suitability and reliability, and on the operational mode and/or the type of certification of the loading gear.

2.3 In case of founded exceptions also the approval and certification of electrical equipment not listed in Table 10.1 can be required if they are exceedingly relevant for the safety and/or reliable function of the loading gear.

3. Deviating designs

3.1 Designs differing from the requirements which follow may be approved if examined by BKI for their suitability and deemed equivalent.

3.2 Electrical equipment developed on the basis of novel technical concepts but not yet sufficiently proven, requires particular approval by BKI. Such equipment may be subjected to more stringent supervision, if the prerequisites as per 3.1 are not fulfilled.

3.3 In the cases mentioned in 3.1 and 3.2, BKI is entitled to demand presentation of additional documentation and performance of special trials.

3.4 BKI reserves the right to impose additional requirements for all kinds of electrical equipment, should this be necessary on account of new findings or operational experience.

B. Design Criteria and Operational Requirements

1. The electrical control and switch gear, as well as the motors, shall be designed or arranged in such a way that necessary maintenance of contacts, contactors, collectors, slip rings, brakes, etc. can be carried out with means available on board.

2. Switch and control cabinets as well as motors arranged on deck are to be provided with adequate heating for the standstill condition, if sufficient internal space is available.

3. When choosing electrical equipment, the expected environmental conditions such as humidity, heat, cold and vibrations shall receive special consideration. In addition, the following applies:

3.1 In general, acceleration of 0,7 · g in the frequency range from 13 to 100 Hz shall also be taken into account as regards design and mounting.

3.2 Plug-in cards with electronic controls may have to have extra fastenings.

4. Where special circuits for lighting, standstill heating, etc. are fed through separate power supply switches so that they can also be operated when the main supply to the loading gear is switched off, special measures shall be taken in the switchgear to prevent direct contact with live parts. A double feed is to be indicated by labels.

5. For supply lines fixed laid to shipborne loading gear, including the external fixed cabling, marine cable is to be used, as per Rules for Electrical Installations (Pt.1, Vol.IV).

6. An adequate power supply shall be provided on board or, if applicable, onshore. Onshore power supply is to be adapted to the supply system onboard.

C. Drives and Brakes

1. Driving power

1.1 All motors are to be dimensioned in accordance with their envisaged purpose and expected use.

1.2 In the case of shipborne loading gear, the working speeds laid down for the nominal load shall be maintained, also at the vessel's prescribed minimum inclinations.

1.3 The required power for winches is calculated from the rated pull, and the rated rope speed, of the first layer of rope on the drum, taking gearing efficiency into account.

2. Winch drives

For winch drives, the following operating modes S_i are defined:

2.1 For drives up to about 5 t L_{Ne} started very frequently (about 160-400 starts per hour) with short load travel and lifting periods: duty type S5, i.e. intermittent periodic duty with electric braking, with the starting process and electrical braking influencing the heating-up of the motor.

2.2 For drives with long load travel and lifting periods and less frequent starts (up to about 160 starts per hour): duty type S3, i.e. intermittent periodic duty without the starting and braking processes having any noticeable effect on the heating-up of the motor.

2.3 For heavy loads with prolonged load handling and lengthy intervals: duty type S2, i.e. short time duty with an ensuing interval long enough for the driving motor to cool down approximately to the ambient temperature. Preferred duration of duty is 30 min.

2.4 In the case of hydraulic drives, the electric motors driving the pumps are to be matched to the given conditions. Possible operating modes are S1 (continuous running) or S6 (continuous operation periodic duty). In the case of mode S6, particular regard has to be paid to the mode of operation of the hydraulic unit, e.g. the power required during idling.

2.5 The driving motors are to be capable of running-up at least 1,3 times against the rated torque. When designing the motors, the moment of inertia of the gearing is to be taken into account. The moment of inertia of the driven masses shall be based on an inertia factor FJ of at least 1,2.

2.6 The duty types S1 to S3, S5 and S6 are defined in IEC 60034-1. In addition the following applies:

2.6.1 When operating in type S5, at least 160 starts per hour shall be possible. This is based on the assumption that 50 % of the starts will be without load.

2.6.2 Where the requirements are more stringent than 2.6.1, the drives shall be designed for 240, 320 or 400 starts per hour.

2.7 For operating modes S5 and S3, differing duty times shall be assumed, depending on the service conditions. For the operating steps, a total operating period of 25 % of the overall total is to be considered. In addition the following applies:

2.7.1 In the case of more stringent requirements than in 2.7 (shorter intervals between the separate hoisting operations), duty times of 40 %, 60 % or 75 % shall be chosen.

2.7.2 In the case of pole changing motors, where all the speed steps are designed for the rated load and where generally the top speed step is reached by switching through the individual lower steps, the overall operating period is to be shared out between the individual switching steps.

2.7.3 If one of the speed steps is intended for light-hook operation only, the overall operating period applies only to the operating steps. However, the light hook step shall be designed for at least 15 % of the overall operating period.

3. Brakes

3.1 The frequency of operation of the brakes shall correspond to that of the associated motor. It is assumed that when operating, braking will only ever be effected from a low-speed step. The braking equipment shall function automatically and arrest the load with the minimum possible impact.

3.2 Winches shall, as a matter of principle, be equipped with safety brakes which brake the load safely at any speed if the power supply fails.

D. Cables and Lines

1. Supply line

1.1 As a matter of principle, power is to be supplied via suitable cables, possibly using cable trolleys or cable drums with integral slip rings. All cables and lines shall be flame-resistant and self-extinguishing. Furthermore, all cables shall be approved by BKI, possibly UV-radiation resistant and, where hydraulic systems are concerned, oil resistant.

1.2 Devices, e.g. cable drums, introduced to prevent the lines dragging on the floor during operation, shall be designed in such a way that the inner bend radius of the cables does not remain under the following values unless otherwise stated by the cable maker:

– in the case of cables with an external diameter up to 21,5 mm: 5 times the cable diameter
– in the case of cables with an external diameter exceeding 21,5 mm: 6,25 times the cable diameter

2. Wire cross-sections

2.1 Dimensioning shall take the load into account, possibly giving consideration to an utilisation factor and the expected ambient temperature.

2.2 For loading gear with only one driving motor, particularly with electro-hydraulic drive systems, the power supply is to be dimensioned as appropriate to the rated current at the maximum operating stage, for continuous operation.

2.3 For loading gear with several motors, for calculation of the amperage, 100 % of the power of the hoisting unit motor, plus 50 % of the power of all remaining drives, may be used as a basis. The amperage resulting is to be applied as the continuous operation value.

These values also apply to the dimensioning of slip ring bodies and brushes.

3. Laying of cables

3.1 General notes

3.1.1 Fastening for cables shall measure up to the vibrations expected during loading gear operation.

3.1.2 Cables suspended from cable trays or running vertically shall, if secured by means of plastic straps, as a matter of principle also be fastened in this area with corrosion-resistant metal clips or metal straps at intervals of at least 1 m where they pass from one tray to another.

3.1.3 Openings for passing through cables shall be deburred and lined so that the cable sheathing cannot be damaged by sharp edges.

3.1.4 Leakage of hydraulic oil into control cabinets, switchgear and cable boxes is to be avoided; therefore wherever practicable, cables are to be introduced into the boxes or cabinets from below. Where they are introduced from above, they may have to be additionally sealed in areas exposed to the risk of oil leakage in an appropriate way.

3.2 Cable trays

3.2.1 Cables shall be laid on adequately strong, corrosion-resistant cable trays. Exceptions to this are possible when laying single cables, e.g. to light fittings.

3.2.2 Cable trays are to be arranged so that hydraulic oil from hydraulic systems cannot drip onto the cables. Where this is not possible, oil guards shall be provided.

3.3 Cable bundles

3.3.1 In revolving cranes or in swing cranes with a limited slewing range, all circuits/supply lines may be led in via flexible cable bundles, suitably arranged in the rotational centre of the crane column.

3.3.2 Suspended cable bundles shall be appropriately led at both ends over curved cable trays with a radius of curvature not less than 10 times that of the thickest cable, and fastened there in such a way that the weight of the bundle is distributed as evenly as possible over all the cables, depending on their size.

3.3.3 Cable bundles shall not strike or rub against anything during slewing and in the event of movement of the loading gear, loading gear parts, or the ship.

4. Cable drums and cable trolley trays

4.1 Drum-wound cables are to be dimensioned in such a way that, even with the cable fully wound on and under normal operating power load, the cable does not heat up beyond its permitted limit.

4.2 For cable trolleys, minimum bend radii are as follows:

- cable up to 8 mm outside diameter: 3 times the conductor diameter
- cable up to 12,5 mm outside diameter: 4 times the conductor diameter
- cable over 12,5 mm outside radii: 5 times the conductor diameter

4.3 In the case of flat cables, the thickness of the cable corresponds to the outside diameter of round cables.

E. Switches

1. Crane main switches /crane circuit breakers

1.1 Loading gear shall be fitted with a manually operated circuit breaking device, with which all movement can be stopped. It shall be possible to isolate all the electric equipment from the mains using the circuit breaking device. The circuit breaking capacity shall be sufficient to switch off simultaneously both the power of the largest motor when stalled and the total power of all other consumers in normal operation.

The "OFF"-position shall be capable of being locked. The OFF position shall only be indicated after having reached the prescribed air and creepage distances. The circuit breaking device shall only have one "on" and "off" position with dedicated arresters.

1.2 A circuit breaking device may also be used as a load switch if it permits the maximum shortcircuit power to be switched off safely. Dimensioning is to be carried out in accordance with IEC Publication 60947-4-1 "Type 2".

1.3 In the case of electro-hydraulic loading gear, the load switch shall also switch off power to the hydraulic pump motor(s).

2. Limit switches

2.1 The control circuits of the safety limit switches shall be designed on the closed-circuit current principle, or shall be self-regulating.

2.2 In the case of automated, or programme-controlled motion processes (including use of microprocessor systems), the continued safe functioning of movement limitation systems is to be ensured, even in the event of a fault or malfunction in the computer.

This may be achieved by using separate control elements or additional, main frame independent, electronic units, insofar as these have been approved by BKI, and the switching has been qualified as "safe" by BKI as regards its safety aspect (fault elimination assessment).

2.3 In programme-controlled movement processes, limit switches may not be used for operational speed or movement measurement.

2.4 Where the hazard analysis has shown that a second movement limiter is to be provided, failure of the first limiter is to be indicated to the crane driver.

F. Protective Measures and Safety Devices

1. Protective measures

1.1 In general, the operating voltage for motor drives should not exceed 690 volts and for controls, heating and lighting systems, 250 volts. Insulation shall be all-pole.

1.2 All equipment with a working voltage exceeding 50 volts, connected via movable cable, shall be earthed via a protective conductor inside the cable. The following shall be observed:

1.2.1 For cable cross-sections up to 16 mm^2, its cross-section shall match that of the main conductors; for those exceeding 16 mm^2, it shall be at least half that of the main conductors.

1.2.2 If power is supplied via slip rings, the protective conductor shall be provided with a separate slip ring.

1.3 Any non-earthed conductor is to be provided with overload and short-circuit protection in accordance with Rules for Electrical Installations (Pt.1, Vol.IV).

1.4 For motors, monitoring of the winding temperatures is recommended as protection against inadmissible heating. If the admissible temperature or load is exceeded, power shall be switched off.

Switch-off due to thermal overload should be indicated. Lowering of the load shall be still possible after the electric drive has been switched off due to overheating.

1.5 Switches, switchgear and control cabinets shall be located in such a way that work on them, and operational tests, can be performed safely. For arrangements inside the crane column, gratings or platforms are to be provided.

1.6 The service passage in front of switchgear and control cabinets shall not be less than 0,5 m wide with 1,80 m headroom. If this headroom cannot be maintained, it may be reduced to 1,40 m if the passage is at least 0,7 m wide.

1.7 As a minimum, the following protective systems (contact-, foreign body- and water protection) shall be provided:

1.7.1 For electrical installations below deck or in the enclosed spaces of loading gear, the protective system shall be at least IP 44, in dry spaces at least IP 20.

1.7.2 For electrical installations on deck, the protective system shall be at least IP 56; under certain circumstances, e.g. where there is a heightened risk of dust, even IP 66.

1.8 Where required, electrostatic discharges shall be prevented by earthing and/or connection of metallic components.

1.9 Control stands, crane driver's cabins and hand-operated equipment are to be fitted with mechanically locked emergency shut-down switches or push-buttons. See also the requirements in Section 12, D.3.

1.10 Motors, in particular for lifting and luffing gear, shall be selected and protected in such a way that, in the event of power failure, they do not overspeed in the time before the brakes respond.

Even after the response of the overspeed protection device, the speed limits shall not be exceeded.

1.11 Electrical appliances which are employed in areas with a potentially explosive atmosphere shall comply with the requirements in respective international or national regulations regarding explosion protection, e.g. the directive 94/9/EG.

2. Safety devices

2.1 Controls

2.1.1 Control handles are to be constructed in such a way that, at the least, the stop position engages without fail. In systems with pole-changing motors, a separate notch shall be allocated to each speed step.

When the control handles are released, they shall automatically move to the stop position.

2.1.2 Following failure of the electric power supply and when this is restored, or following operation of the emergency switch-off button or push-button, restarting the drives shall only be possible via the stop position.

2.1.3 Where winch motors are provided with a speed step designed for light-hook operation only, the control mechanism shall automatically prevent this step operating when there is a load on the hook. This also applies to other part-load operating steps.

2.1.4 Radio controls, programmed control mechanisms or microprocessor systems shall have been type tested by BKI. Alternatively their operational safety may be proved in a different way recognized by BKI.

2.2 Lighting

2.2.1 In addition to an adequate main lighting system for the loading gear working area, an emergency lighting system is to be provided for the cabin and the area of descent, where crane columns are higher than 10 m, in the cabin, at the crane column and at the switch gear and machinery.

2.2.2 Emergency lighting systems should be guaranteed to last about 30 min. and shall preferably be connected to the emergency power supply. As an alternative, BKI may approve a battery-operated emergency power supply.

2.2.3 Where emergency lighting is powered by batteries, the emergency power supply chargers for these lamps shall be connected to a separate circuit not switched off by the load-circuit switch.

G. Examination of Drawings and Supervision of Construction

1. Examination of drawings

1.1 The general requirements in Section 1, D.1 are to be observed.

1.2 In addition to the requirements in Section 1, D, the electrical equipment listed in Table 10.1 are subject to examination of drawings in the scope indicated there.

2. Supervision of construction

2.1 General notes

2.1.1 Electrical equipment shall be manufactured by qualified staff handling the necessary installations and devices. During manufacture and before delivery, the parts have to undergo the quality tests required in accordance with state-of-the-art technology and experience.

2.1.2 Electrical equipment which requires an inspection certificate 3.2 according to Table 10.1, is subject to supervision of construction by BKI, where required, with the restrictions described in the explanations to Table 9.1.

.1 The BKI inspection in charge decides, in conjunction with the manufacturer, on type and scope of supervision of production and certification, taking into consideration the in-house quality control and/or approval for production.

.2 With respect to assistance by the manufacturer during supervision of production by BKI, the requirements in Section 13, B.2 are to be observed.

2.2 Tests and examinations

The following requirements contain general test requirements and, in addition, provisions for the supervision of production by BKI.

2.2.1 General notes

.1 For the acceptance tests before delivery and, if applicable, also for the supervision of production, the BKI Surveyor shall receive certificates for material tests and internal controls, test reports and manufacturing documents, in particular approved drawings, including the allocated examination reports, if required acc. to Table 10.1, as a prerequisite for the tests and examinations described below.

.2 Test reports shall include the following information, if applicable:

- designation of type and nominal dimensions
- purchase and order number
- drawing number
- results of internal controls
- certificate numbers of material tests and non-destructive tests
- additional details, as necessary

.3 For series-production electrical equipment, other test procedures may be agreed with BKI instead of the prescribed ones, if they are accepted as equivalent.

.4 Where electrical equipment is to be used for the intended purpose for the first time, BKI may ask for a type approval.

2.2.2 Electrical equipment

Electrical equipment is to be tested according to Rules for Electrical Installations (Pt.1, Vol.IV) Sec.20 and to undergo a functional test, if possible.

H. Documentation

1. Marking

1.1 Any electrical equipment shall be marked by the manufacturer in a suitable way. The marking shall at least include the following information, if applicable:

- manufacturer's name
- year of construction
- designation of type

- purchase order number or serial number
- characteristics such as nominal speed, nominal voltage, etc.
- additional details, as necessary

1.2 If after the acceptance test, and before delivery, the requirements for issuing a Test Certificate are complied with, the electrical equipment will be stamped in a prominent position.

The stamp shall include the following information:

- certificate number, together with the code letters of the examining inspecting office
- BKI stamp with the month and year of testing

2. Certificates

2.1 Table 10.1 shows the required types of certificate for essential electrical equipment.

The loading gear manufacturer shall order the stated equipment, together with the required certificates, and the equipment manufacturer shall include them in the delivery.

2.2 The inspection certificate 3.2 shall be issued by BKI.

2.3 The certificates listed in Table 10.1 are not part of the loading gear documentation on board.

Table 10.1 Examination of drawings and certification of electrical equipment

Equipment		Loading gear in general [3]		Offshore cranes		Classified loading gear	
		Examination of drawings	Certificate	Examination of drawings	Certificate	Examination of drawings	Certificate
Motors	≤ 50 kW	-	-	-	2.2	-	2.2
	> 50 kW	-	-	Z	3.1	Z	3.2
Frequency converters	≤ 50 kW	-	-	-	2.2	-	2.2
	> 50 kW	-	-	Z	2.2	Z	3, 3.22
Brake ventilators		-	-	-	3.1	-	2.2
Brake ventilators		-	-	I	3.1	I	3.23,2
PLC - controls		BKI type approval	3.1	BKI type approval	3.1	BKI type approval	3.1
Safety devices	Emergency shut-down, limit switch, load measuring devices, overspeed, etc.	-	-	I	2.2	I	3.1
	AOPS/MOPS ELRS AHC/PHC ART/PRT [1]	-	-	BKI type approval	3.1	BKI type approval	3.1
Radio controls [2]		BKI type approval	3.1	BKI type approval	3.1	BKI type approval	3.1
Switch cabinets		-	-	Z	3.1	Z	3.2
Control consoles		-	-	Z	3.1	Z	3.2
Cables and lines		-	-	-	2.1	-	-

Explanations:

- "Z" means drawings
- "I" means documents for information
- The designation of the certificate types corresponds to EN 10204. The numbers mean the following certificates:
  - 2.1 and 2.2 : test reports (BKI designation for 2.2: C-type Certificate)
  - 3.1 and 3.2 : inspection certificates (BKI designation: B- and A-type Certificate)

[1] AOPS / MOPS = automatic/manual overload protection system
ELRS = emergency load release system
AHC /PHC = active/passive heave compensator
ART / PRT = active/passive rope tension

[2] Requires a manual emergency control

[3] Includes offshore working cranes on wind energy plants

Section 11 Construction of Steel Components

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C. Design Details 11–5
D. Types of Welds 11–9
E. Workmanship and Testing of Weld Joints 11–13
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A General

1. This Section contains requirements for the construction of steel components for loading gear and loose gear with a special focus on welding.

2. Complementary or more comprehensive requirements and special details are to be taken from the following:

- Rules for Hull (Pt.1, Vol.II)
- Rules for Welding (Pt.1, Vol.VI)
- BKI recognized standards or regulations

3. The requirements in Section 1 are to be observed where relevant.

4. With respect to materials to be used, the requirements in Section 2 apply.

B. Requirements Applied to Manufacturers

1. General requirements

1.1 Manufacturers shall be equipped with installations and devices suitable for professional and proper handling of the individual materials, manufacturing methods, components, etc. BKI reserves the right to check the production shop in this respect and to impose requirements concerning this matter, or to reduce the scale of operations according to the capabilities of the production shop.

1.2 The manufacturer shall have a sufficiently qualified staff of experts. The supervising and controlling personnel is to be indicated to BKI, including their areas of responsibility. BKI reserves the right to ask for certified proof of qualifications.

2. Quality control

2.1 By means of an effective internal quality control, the manufacturing works shall ensure that construction and assembly comply with these Guidelines, the approved documents (drawings, specifications, etc.) or with the conditions stated in the approvals.

2.2 It is the responsibility of the manufacturing works to observe these Guidelines and to meet the special requirements associated with the examination of documents or the conditions imposed with the approval.

Examinations carried out by BKI do not release the manufacturing works from this responsibility.

2.3 It is the responsibility of the manufacturing works to make sure that production conditions and quality correspond to those of the approval test. BKI cannot take any responsibility that products comply with these Guidelines which have been tested in an approval test or at random during production, in all parts or during the entire production process.

2.4 BKI may reject further use of products, processes, etc. which have proved unsatisfactory during application, in spite of an earlier satisfactory approval test, and may demand they be improved, including proper verification.

3. Workmanship

3.1 Details in the production documents

3.1.1 The production documents (workshop drawings, etc.) shall include all those details which are essential for quality and functional capability of the component under consideration. This includes besides dimensions e.g. details on tolerances, surface finish quality (reworking), special production processes, as well as tests and requirements as appropriate.

3.1.2 All the important details of the welding, e.g. the types of base material, configuration and dimensions of the welds, welding method, welding consumables, heat treatment, tests to be performed and any special requirements imposed, shall be indicated in the production documents (drawings, parts lists, etc.). In special cases, BKI may require submission of a welding schedule.

3.1.3 Where quality or functional capability of a component is not assured or dubious, BKI may ask for suitable improvements. This also applies, as and where relevant, to complementary or additional (e.g. strengthening) components, even if these were not required for the examination of drawings, or were not required due to poorly detailed presentation.

3.2 Cut-outs, edges of plates

3.2.1 Openings, boreholes and other cut-outs shall be rounded with a sufficiently large radius.

3.2.2 The face areas (cut areas) of cut-outs shall be finished cleanly and without notches. Notches and the like due to flame-cutting shall not in general be repaired by welding, but shall be ground into a flat trough. Edges shall be broken or, in cases of very high loads, rounded.

3.2.3 Exposed edges of plates or flanges cut by flame-cutting or a shearing machine shall not be sharp-edged and are to be reworked where required as stated in 3.2.2, just as notches and the like due to flame-cutting. This applies as and where relevant to welded joints, transitional sections or similar discontinuities.

3.3 Cold forming

3.3.1 Where plates are formed at low temperatures, (bending, flanging, beading) the mean bending radius should not fall below $3 \cdot t$ (t = plate thickness), it shall however be at least $2 \cdot t$. These values refer only to ship hull structural steels and comparable structural steels.

3.3.2 Before cold formation, flame or shear cut burrs shall be removed in order to avoid cracks. Following cold formation, the components, in particular the lateral ends of bent plates (plate edges) are to be checked with respect to cracks. Cracked components minor cracks excepted shall be set aside.

Repair by welding is not permitted.

3.4 Assembly, straightening work

3.4.1 During assembly of single components, excessive force shall be avoided. If possible, major deformations of single components shall be straightened prior to further assembly.

3.4.2 Girders, stiffeners and the like which are interrupted by transverse components, shall be assembled in a well aligned manner. If necessary, on essential components, control bores shall be made for this purpose which shall be welded closed again afterwards.

3.4.3 Straightening works after completion of welding works shall be conducted in such a way that no noticeable deterioration of material properties takes place. In case of doubt, BKI may require a type approval or production test samples.

3.5 Corrosion protection

3.5.1 All steel components shall be provided with suitable corrosion protection. For shop primer see E.1.4 and E.1.5.

3.5.2 Hollow spaces, e.g. box girders, tubular pillars and the like, which are demonstrably or by general experience permanently air-tight, need not be preserved internally. During assembly, the hollow spaces shall be clean and dry.

3.5.3 The wall thickness of load-bearing parts shall be at least 4 mm. Lower wall thicknesses are subject to the consent of BKI in each individual case.

3.5.4 Welded-on reinforcing rings shall be protected against rusting underneath.

3.5.5 Spring washers of corrodible materials shall not be used if exposed to the marine atmosphere.

4. Conditions for welding

4.1 Approval to weld

4.1.1 All works, including subcontracting firms, wishing to carry out welding operations on parts of loading gear and loose gear shall have at their disposal the necessary equipment and qualified personnel, and be approved by BKI for this work, see Rules for Welding (Pt.1 Vol.VI).

4.1.2 Approval for fabrication is to be applied for from BKI Head Office, with the appropriate documentation.

Existing approval by other independent testing institutions may be taken into account if the relevant documents are submitted.

4.1.3 The works shall have at their disposal the necessary workshops, equipment, machinery and devices to carry out the welding work properly. This includes also e.g. stores and drying equipment for the welding consumables and auxiliary material, equipment for preheating and for heat treatment, test means and equipment, as well as weather-protected areas for the outdoor execution of welding works.

4.1.4 The works shall have at their disposal qualified welders or staff sufficiently trained for handling fully mechanical or automatic welding installations. In addition they shall have at their disposal qualified welding supervisors responsible for the professional execution of the welding tasks.

4.1.5 The suitability of the welding method used in conjunction with the materials in question is to be proved to BKI in an appropriate way. BKI may to this end require BKI supervised method checks (test welds, non-destructive and mechanical-technological tests).

4.1.6 For the (non-destructive) testing of the weld connections, suitable test procedures shall be used, and appropriately qualified testers. BKI may demand a check, under its supervision, of ultrasonic testers. The scope of tests is to be indicated in the test documentation. The test reports are to be submitted to BKI.

4.2 Welders

4.2.1 Welders for manual or semiautomatic welding shall be examined according to recognized standards (e.g. ISO 9606 or ASME Section IX). Regarding the welding method, base material, welding consumable and welding position, and the test shall cover the conditions of the type of production envisaged.

4.2.2 A welder's qualification test remains valid for two years with effect from the test date, provided that during this period welding work is constantly performed in the range of approval of the test and the work of the welder is monitored by the welding supervisors at all times.

4.2.3 The required number of qualified welders depends on the size of the works and the scope of welding tasks to be executed under BKI supervision. At least two qualified welders are required per welding method.

4.3 Supervision of welding

4.3.1 Every work carrying out welding shall employ its own welding supervisor. This supervisor shall have a suitable deputy in the welding shop. The welding supervisor shall be responsible for supervising the preparation and execution of the welds, and if applicable, their testing.

4.3.2 Supervisors shall have training and the experience appropriate to the production requirements, and furnish the necessary proofs to BKI.

According to the nature and scope of the welding work performed, the supervisory function may be exercised by a welding engineer (welding engineering specialist or comparably-trained engineer), a welding expert, or some other person with adequate specialist qualifications.

4.3.3 The names of the responsible welding supervisors and their deputy shall be made known to BKI.

4.3.4 Changes in the personnel responsible for supervising welding shall automatically be reported to BKI.

4.4 Welding consumables, auxiliary materials

4.4.1 Only welding consumables and auxiliary materials which have been tested and approved by BKI shall be used, with a quality grade corresponding to the base material to be welded.

4.4.2 For highly stressed components and parts stressed at low temperatures, for higher-strength steels, steel castings and forgings and for low-temperature welding work, hydrogen-controlled welding consumables and auxiliary materials are preferable.

4.4.3 Welding consumables and auxiliary materials for special materials may also be tested and approved, together with the welding method. Such approvals are, however, restricted to the user’s works and remain valid for at most one year unless repeat tests are performed.

Welding consumables and auxiliary materials jointly tested in this way may be replaced by other equivalent materials approved for the application in question.

4.5 Welding methods, procedure tests

4.5.1 Only those welding methods may be employed whose suitability for the application in question has either been established by general practice or proved by a procedure test.

4.5.2 Procedure tests for the purpose of proving the satisfactory application of the procedure in the welding shop and adequate quality of the results obtained, shall be performed under production conditions on the premises of the company using the method, in all cases where materials other than normal strength ship building steels A to D, or comparable structural steels, forging steels and types of casting steel are to be welded, or welding methods other than manual arc welding (E) or partly-mechanised inert gas shielded welding (MAG) are to be employed.

Procedure tests shall also be performed where these processes are applied in a special manner, e.g. in single side welding, using a (ceramic) weld pool support, see Rules for Welding (Pt.1, Vol.VI).

4.5.3 The scope of the test, the samples, the test specimens and the requirements shall be determined from case to case depending on the proposed application, in general accordance with Rules for Welding (Pt.1, Vol.VI). In this connection, account may be taken of procedure tests carried out elsewhere (on submission of the reports).

4.5.4 Welders employed for procedure tests are, on successful completion of the test, deemed qualified for the procedure employed, or the materials concerned.

C. Design Details

1. General notes

1.1 The materials selected for the design shall in every respect be appropriate to the design requirements, the production and the intended use.

If necessary, special measures are to be adopted.

1.2 The design of the structure shall achieve a power flow as undisturbed as possible, without local discontinuities and steps in rigidity, and to be suitable for construction and meet the requirements for long-lasting and reliable operation.

1.3 The following requirements refer only to welded joints. For the design of screw joints, the requirements of Section 3, H.2 apply.

2. Configuration of welded joints

2.1 Welded joints in general

2.1.1 Welded joints shall be planned in such a way as to ensure that they are readily accessible during fabrication and can be executed in the optimum welding position and welding sequence.

2.1.2 Welded joints and welding sequences shall be designed to minimize residual weld stresses and avoid excessive deformation. Welded joints shall therefore not be over-dimensioned.

2.1.3 All welded connections are to be configured to achieve a power flow as undisturbed as possible without major internal or external notches or rapid changes of rigidity, and without impeding expansion.

2.1.4 The requirements in 2.1.3 apply as and where relevant to the welding of secondary components on primary structures too, the highly stressed areas of which and the exposed plate or flange edges of which shall be kept free from notches caused by welded joints, if possible.

2.1.5 Welded joints shall be designed to ensure that the proposed weld type and quality (e.g. complete root fusion in the case of single- and double-bevel butt welds) can be satisfactorily achieved under the given fabricating conditions. Failing this, provision shall be made for welds which are easy to execute, and their (possibly inferior) load-bearing capacity shall be allowed for when dimensioning the welds.

2.1.6 Welded joints in girders and profiles (especially field joints) shall not, if possible, be located in an area of high stresses. Welded joints on flanges with cold formed bending positions shall be avoided.

2.1.7 Highly stressed welded joints, which are therefore normally subject to compulsory inspection, shall be designed to facilitate application of the most appropriate inspection technique (radiography, ultrasonic or surface crack inspection, possibly in combination) so that tests offering reliable results can be carried out.

2.2 Welded nodes in tubular structures

2.2.1 Depending on tube wall thickness and angle of intersection, nodes linking relatively small tubes, e.g. in tubular-frame crane jibs, may be designed either in the form of fillet welds or of single-bevel welds as in D.2.4.

2.2.2 The nodes of relatively large tubes, where the wall thickness of the branches exceeds about 8mm, shall be designed in the form of full-penetration single bevel welds as shown in Fig. 11.1. Where the stress is lower, single-bevel welds with a backing strip as in D.2.4 may also be used.

2.2.3 The weld configuration chosen and the effective weld thickness shall be taken into account in the dimensioning (especially in the proof of fatigue strength) and shown in detail on the drawings. Where proof of fatigue strength is required, the quality of surface finish required shall also be specified on the drawings.

2.3 Transitions between differing dimensions

2.3.1 Differing dimensions are to be made to match gradually by means of gentle transitions. Where girders or sections have web plates of different heights, the chords or bulbs shall be brought to the same height by tapering, or by slitting and splaying or reducing the height of the web plate. The transition length shall be three times the difference in height.

2.3.2 Where the joint is between plates of differing thicknesses, thickness differences of more than 3 mm (see Fig. 11.2) shall be evened out by bevelling the extending edge with a 1:3 slope, or in accordance with the notch. Thickness differences of less than 3 mm may be evened out within the weld.

2.3.3 For connection to plates or other relatively thin-walled elements, steel castings and forgings, as shown in Fig. 11.3, shall be provided with matching tapered elements or cast, or forged-on welding flanges respectively.

2.4 Localised closely grouped welds, minimum spacing

2.4.1 Local close grouping of welds and short distances between welds are to be avoided. Adjacent butt welds shall be separated by at least

50 mm + 4 x plate thickness

Fillet welds shall be separated from each other and from butt welds by at least

30 mm + 2 x plate thickness

2.4.2 The width of plate areas (strips) subject to replacement shall however be at least 300 mm or 10 x plate thickness, whichever is the greater.

2.4.3 Reinforcing plates, welding flanges, hubs or similar components welded into plating shall have the following minimum dimensions:

$$D_{min} = 170 + 3\,(t - 10) \geq 170 \text{ mm}$$

D_{min} = minimum diameter of round, or length of side of polygonal, weld-on parts [mm]

t = plate thickness [mm]

The corner radii of polygonal weld-on parts shall be at least 50 mm.

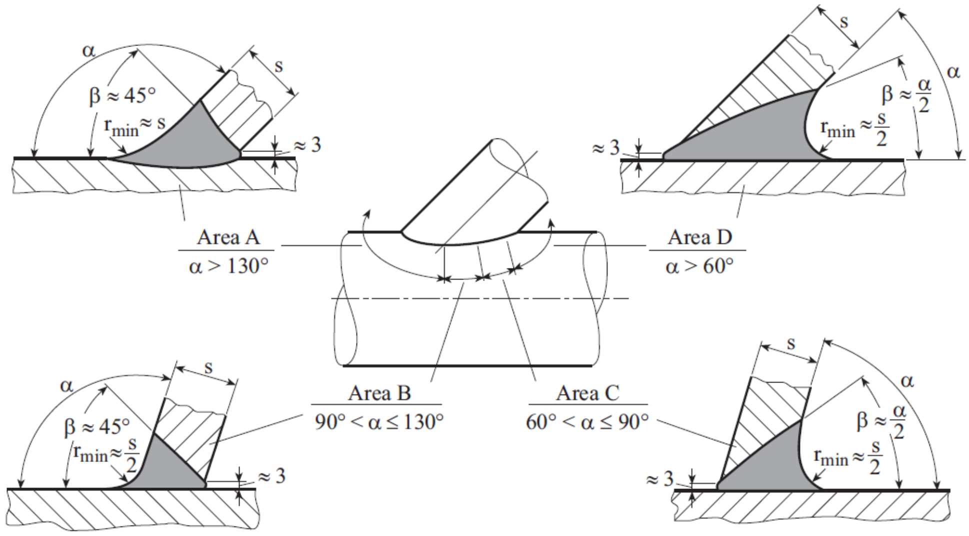

Fig. 11.1 Single-sided weld connections (tube connections not accessible from inside)

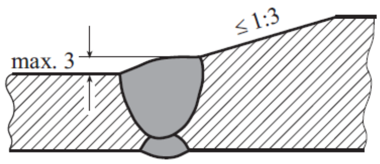

Fig. 11.2 Accommodation of different thickness

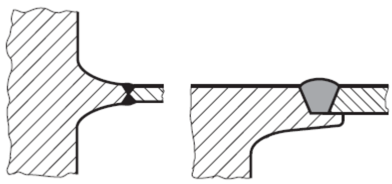

Fig. 11.3 Welding flange on steel castings or forgings

2.5 Welding cut-outs

2.5.1 Welding holes for (subsequent) butt or fillet welding following the fitting of transverse parts shall be rounded (minimum radius 25 mm or twice the plate thickness, whichever is the greater) and (especially where the loading is mainly dynamic) shall be provided with “gentle” run-outs and appropriately notch-free circumferential welds, see Fig. 11.4.

2.5.2 Where joints are fully welded prior to the fitting of transverse parts, no welding holes are needed, provided any weld reinforcement is machined away before fitting.

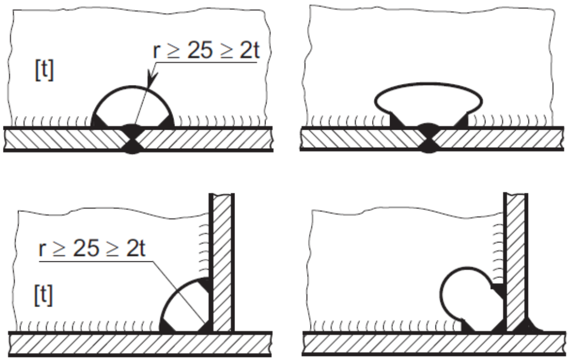

Fig. 11.4 Welding cut-outs

2.6 Local reinforcements, doubling-plates

2.6.1 Where plating is subject to locally increased loading (e.g. girder or pipe walls), thicker plates shall wherever possible be used rather than doubling-plates. As a matter of principle, bearing bushes, hubs, etc. shall take the form of thicker, welded-in plating; regarding this see also 2.4.3.

2.6.2 Where doubling-plates cannot be avoided, they shall not be thicker than twice the plate thickness.

Doubling-plates wider than about 30 times the doubling-thickness shall be welded to the underlying plating by welding with cut-outs, at intervals not exceeding 30 times the thickness of the doubling-plate.

When welding with cut-outs, these shall preferably be designed in form of elongated holes lying in the direction of the principal stress.

2.6.3 Doubling-plates are to be welded along their (longitudinal) edges by continuous fillet welds with a thickness

a = 0,3 x thickness t of the doubling-plate

At the ends of doubling plates, as shown in Fig. 11.5, thickness "a" along the terminal edges shall be

a = 0,5 x thickness t of the doubling plate

though it shall not exceed the plate thickness.

The weld transition angles between the terminal edge and the plating shall be 45° or less.

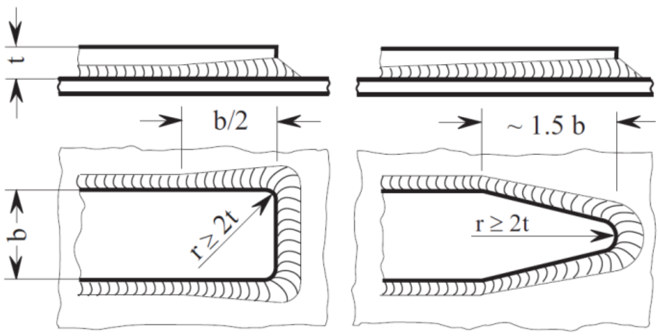

Fig. 11.5 Weldings at the ends of doubling plates

Where proof of fatigue strength is required, the configuration of the end of the doubling plate shall correspond with the detail category selected.

2.7 Welding in cold-formed areas

2.7.1 Welding is permitted at and close to structural areas cold-formed from ship structural and comparable structural steels, provided that the minimum bending radii specified in Table 11.1 are adhered-to.

Table 11.1 Minimum bending radii

Plate thickness	Minimum inner [1] bending radius
up to 4 mm	1 x plate thickness
up to 8 mm	1,5 x plate thickness
up to 12 mm	2 x plate thickness
up to 24 mm	3 x plate thickness
over 24 mm up to 70 mm	10 x plate thickness

1 Edge bending operations may necessitate a larger bending radius.

2.7.2 For steels other than stated in 2.7.1, or other materials if applicable, the necessary minimum bending radius shall, in case of doubt, be determined by tests.

2.7.3 In the case of steels with a minimum nominal upper yield point exceeding 355 N/mm^2 and plate thicknesses of 30 mm and over, where cold-forming with 3 % or more permanent elongation has been performed, proof of adequate toughness after welding is required in the procedure test and by means of in-production tests.

2.8 Bend reinforcements

2.8.1 Bent structural elements, e.g. the chords of girders, where the change of direction means that forces are generated or have to be transmitted perpendicular to the bend, shall be adequately supported at the bending location. The conditions set out in 2.7.1 shall be complied with.

2.8.2 Where welded joints at bending locations cannot be avoided, three-plate welds generally as in D.2.6 may be used. Such connections are to be depicted in detail on the drawings.

D. Types of Welds

The chosen type of weld shall be suitable and sufficiently dimensioned or favourably designed to transfer the type (static, dynamic) and magnitude of forces.

1. Butt joints

1.1 Depending on plate thickness, welding procedure and -position, butt welds shall take the form of square, single- or double-V welds (X welds) in conformity with the standards (e.g. EN 12345, EN 22553 / ISO 2553, EN ISO 9692-1, -2, -3 or -4).

1.2 Where other forms of weld are envisaged, these are to be depicted specially in the drawings.

Weld geometries for special welding processes (e.g. submerged-arc, single-side and electro-gas or electro- slag welding) shall have been tested and approved as part of a procedure test.

1.3 Butt welds shall, as a matter of principle, be grooved out on the root side and given at least one capping pass. Exceptions to this guidelines, e.g. in the case of submerged-arc welding or the aforementioned processes also require to be tested and approved as part of a procedure test.

The theoretical throat shall be the thickness of the plate or, where the plates are of differing thickness, the lesser thickness. Where proof of fatigue strength is required, the detail category depends on the configuration (quality) of the weld.

1.4 If the above conditions cannot be fulfilled, e.g. where welds are accessible from one side only, open square-edge joints with back-up bars or permanent machined or integrally cast backing, as in Fig. 11.6, shall be used.

The calculated weld thickness may be taken as 90 % of the (lesser) plate thickness t, maximum (t-1) mm.

Where proof of fatigue strength is required, these welds shall be placed in the corresponding detail category.

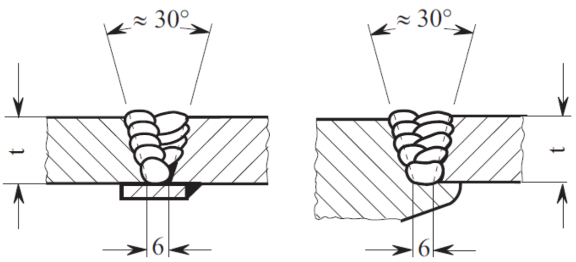

Fig. 11.6 Single-side welds with permanent weld pool supports (backings)

2. Corner-, T- and double-T- (cross) welds

2.1 Full-penetration corner-, T- and double-T- (cross) welds for the full connection to the abutting plates shall take the form of single- or double-bevel joints with the minimum possible shoulder and an adequate gap, as shown in Fig. 11.7. The root shall be grooved out and welded from the reverse side.

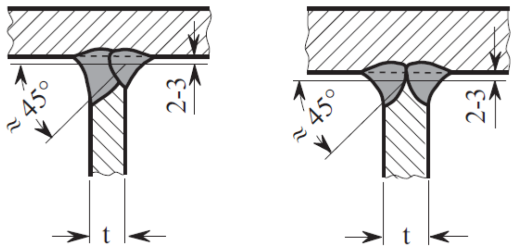

Fig. 11.7 Single- and double-bevel welds with full root penetration

The theoretical weld thickness shall be the thickness of the abutting plate. Where proof of fatigue strength is required, the detail category depends on the configuration (quality) of the weld.

2.2 Corner-, T- and double-T- (cross) welds with a defined root defect f as shown in Fig. 11.8 shall take the form of single- or double-bevel welds as described in D.2.1, with reverse-side welding but without grooving-out of the root.

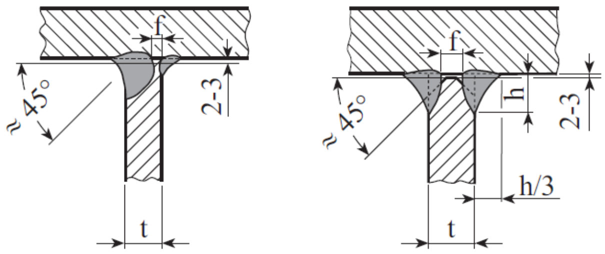

Fig. 11.8 Single- and double-bevel welds with defined incomplete root penetration

The theoretical weld thickness may be taken as the thickness t of the abutting plate minus f, being equal to 0,2 · t up to a maximum of 3 mm. Where proof of fatigue strength is required, these welds shall be placed in the corresponding detail category.

2.3 Corner-, T- and double-T- (cross) welds with an unwelded root face c and a defined incomplete root penetration f to be taken into consideration shall take the general form shown in Fig. 11.9.

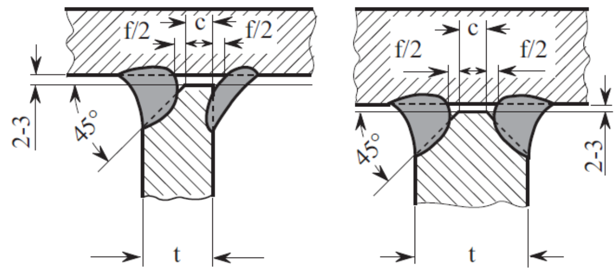

Fig. 11.9 Single- and double bevel welds with an unwelded root face and a defined incomplete root penetration

The theoretical weld thickness shall be the thickness t of the abutting plate minus (c + f), f being equal to 0,2 · t up to a maximum of 3 mm. Where proof of fatigue strength is required, these welds shall be placed in the corresponding detail category.

2.4 Corner-, T- and double-T- (cross) welds accessible from one side only may, as shown in Fig. 11.10, be made either as butt joints with a weld pool support analogous to those described in 1.4, or as one-sided single-bevel welds analogous to those in 2.2.

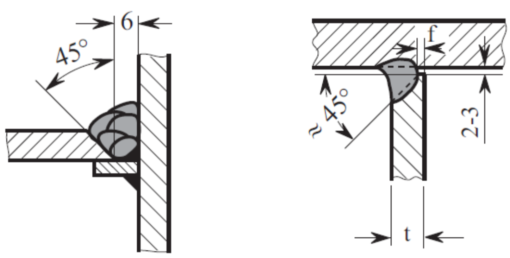

Fig. 11.10 Single-side welded T joints

The theoretical weld thickness shall similarly be determined in accordance with 1.4 or 2.2. Where proof of fatigue strength is required, use of these welds shall be avoided if possible.

2.5 In the case of flush corner joints, i.e. where neither of the plates projects, joint configurations as shown in Fig. 11.11 shall be used with bevelling of the plates shown as upright, to avoid the danger of lamellar rupture (stepwise cracking).

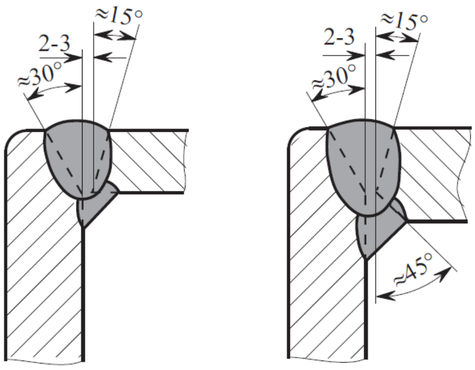

Fig. 11.11 Flush fitted corner joints

2.6 Where in T-joints the main stress acts in the plane of the plates shown in the horizontal position in Fig. 11.12 (e.g. in plating) and the connection of the vertical (edge-on) plates is of secondary importance, then (except in the case of mainly dynamic stresses) three-plate welds as shown in Fig. 11.12 may be used.

The theoretical weld thickness of the joint connecting the horizontal plates shall be determined in accordance with 1.3. The required "a" dimension is determined by the joint connecting the vertical (edge-on) plate and shall where necessary be ascertained by calculation, as for fillet welds.

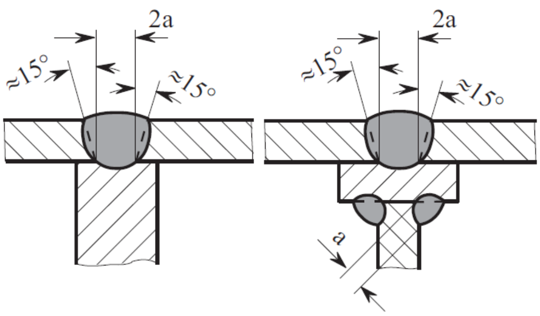

Fig. 11.12 Three-plate welds

3. Fillet welds

3.1 Fillet welds shall, as a matter of principle, be made on both sides. Exceptions to this guidelines (e.g. in the case of closed box girders and in the case of primary shear stress parallel to the weld) require approval in every instance. The thickness a (the height of the inscribed equilateral triangle) shall be determined by calculation.

The leg length "z" of a fillet weld, see Fig. 11.13, shall not be less than 1,4 times the fillet weld thickness "a".

3.2 The thickness of fillet welds shall not exceed 0,7 times the lesser thickness of the parts to be welded (generally the web thickness). The minimum thickness is defined by:

$$a_{min} = \sqrt{\frac{t_1 + t_2}{3}} \quad [mm] \quad \text{(but not less than 3 mm)}$$

t_1 = the lesser plate thickness [mm] (e.g. the web thickness)

t_2 = the greater plate thickness [mm] (e.g. the chord thickness)

3.3 The aim with fillet welds shall be to have a flat, symmetrical cross-section with good transition to the base metal. Where proof of fatigue strength is required, it may be necessary to carry out machining (grinding-out the notch) depending on the detail category. The weld shall extend at least to the immediate proximity of the theoretical root point.

3.4 Where mechanical welding processes are used which produce a deeper penetration going well beyond the theoretical root point, and capable of being reliably and uniformly maintained under production conditions, it is permissible to take account of the deeper penetration when determining the fillet weld throat. The mathematical dimension:

$$a_{tief} = a + \frac{2 \min e}{3} \quad [mm]$$

is to be determined by reference to the configuration shown in Fig. 11.13 and shall take into account the value of "min e" which is to be established for each welding procedure by a procedure test. The weld thickness shall, in relation to the theoretical root point, not be less than the minimum thickness for fillet welds specified in 3.2.

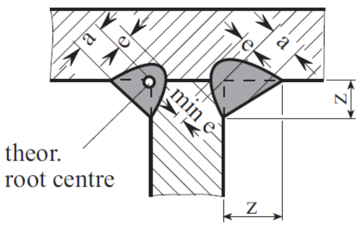

Fig. 11.13 Fillet welds with increased penetration

3.5 Depending on the welding technique used, an increase of the "a" dimension of up to 1 mm may be stipulated when laying down welds over production coatings particularly liable to cause porosity. This particularly applies when using fillet welds of minimum thickness size.

The extent of the increase shall be determined on a case to case basis according to the nature and magnitude of the stress, based on the results of the production-coating tests according to the BKI Rules for Welding. The same applies in turn to welding processes too, in which there is a likelihood of insufficient root penetration.

E. Workmanship and Testing of Weld Joints

Welding workmanship shall comply with Rules for Welding (Pt.1, Vol.VI).

1. Weld preparation and assembly

1.1 When preparing and assembling structural parts, care is to be taken to ensure compliance with the prescribed joint geometry and root face (air) gaps. Where the permissible root face gap is slightly exceeded, it may be reduced by build-up welding at the weld edges. Inserts or wires are not allowed to be welded into the gap.

1.2 Plates and profiles shall be aligned accurately, especially where joints are interrupted by transverse parts. The magnitude of the permissible misalignment of plate edges depends on the particular structural part, the plate thickness and the stress, see Rules for Welding (Pt.1, Vol.VI).

1.3 In the welding zone, structural parts shall be clean and dry. Scale, rust, slag, grease, paint (except for production coatings) and dirt shall be removed carefully prior to welding.

1.4 If plates, profiles or structural parts are given a corrosion-inhibiting coating (shop primer) before welding, this shall not impair the quality of the welds.

1.5 Only those weldable production coatings shall be applied for which a BKI report of no objection exists, based on a pore formation tendency test.

2. Protection against the weather, preheating

2.1 The working area of the welder shall be protected, in particular for outside work, against wind, dampness and cold. In the case of submerged-arc welding, special care shall be taken to protect against draughts. When working outdoors, it is recommended in any case to dry heat the weld edges in unfavourable weather conditions.

2.2 In low temperatures (component temperatures below 5 °C) suitable measures are to be taken (e.g. covering, large-area heating, preheating in particular when welding at relatively low heat input, e.g. with thin fillet welds or with thick-walled components) to ensure that the welding work can proceed satisfactorily.

If the temperature drops below -10 °C, no further welding should be performed if possible.

3. Welding positions and sequence

3.1 Welding work shall be performed in the most favourable welding position. Welding in restricted positions, e.g. positions PE or PD (overhead), shall be restricted to unavoidable cases.

3.2 Vertical downward welding of fillet welds shall not be applied to loading gear components and loading gear, including supporting structure (e.g. crane columns), even after a successful welding procedure test.

3.3 Obstruction of weld shrinkage is to be minimized by the choice of a suitable construction and welding sequence.

4. Workmanship

4.1 The welds shall have sufficient penetration and clean, regular weld surfaces with "soft" transitions to the base material. Excessive over thickness and grooves as well as notches at the edges of plates or cut-outs are to be avoided.

4.2 Cracked tacks may not be welded over but shall be removed by machining. In multi-pass welding, the slag from preceding passes is to be removed completely. Pores, visible slag inclusions and cracks may not be welded over, but shall be removed by machining and repaired.

5. Repair of defects

Repair of major defects of workmanship may only be undertaken after agreement with BKI. This applies similarly to the repair by welding of worn, broken or otherwise damaged parts. Prior to repair work on load-bearing structural parts (1st order), a sketch of the repair is to be submitted.

6. Preheating

Regarding the requirement for and amount of preheating, several decisive criteria exist, e.g. chemical composition, plate thickness, two or three dimensional heat dissipation, environmental or component temperature, heat input due to welding (energy per unit length), see Rules for Welding (Pt.1, Vol.VI).

7. Heat treatment

7.1 The nature and scope of any heat treatment which may have to be applied to welded structural parts depends on their residual stress state (weld geometry and thickness, rigidity of part) and the characteristics of the material concerned, i.e. its behaviour or any change in characteristics to be expected when subjected to heat treatment. Generally, it is a matter of stress-relieving or annealing treatment.

The steelmaker's directions and recommendations are to be followed.

7.2 Depending on the type of material concerned, flash butt welds are to be subjected to normalising or quenching and tempering treatment.

7.3 The way in which the mechanical properties of the weld are affected by subsequent heat treatment is one of the factors to be investigated in the weld-procedure test. In addition to this, BKI may call for production tests.

7.4 Any non-destructive tests required shall be carried out after heat treatment.

8. Non-destructive tests

8.1 The nature and scope of non-destructive tests depends on the importance and loading of the part concerned (its component class) and on the possible weld defects or effects on the base metal which may arise from the welding technique, position, etc.

8.2 By way of example, in Table 11.2, the tests required for the important parts of loading gear and loose gear have been compiled. Additionally, as a guide, requirements imposed on welded connections in the form of assessment categories according to ISO 5817 have been added.

Where proof of fatigue strength is required, the test requirements in the detail category table used apply.

The manufacturing documents (drawings, welding diagram, test schedule) shall contain, for each structural component, comprehensive information concerning the nature and scope of the tests required.

8.3 Non-destructive tests shall be carried out by suitably qualified personnel.

8.4 The tests shall be carried out in accordance with accepted practice. The results shall be presented to the BKI Surveyor at the latest at the acceptance testing of the components.

9. Production tests

9.1 If the manufacturing process, or any subsequent (heat) treatment which may be required, leads to the expectation of a substantial change in, or indeed deterioration of, the properties of the material or the welded connection, BKI may stipulate production tests to prove that the mechanical qualities remain adequate.

9.2 Production tests during the course of manufacture shall, as a matter of principle, be performed when welding is carried out on cold-formed portions made from materials with a minimum nominal upper yield point of more than 355 N/mm^2, with a wall thickness of 30 mm or more and with degrees of deformation of 3 % permanent elongation ε and over.

Elongation in the external tensile zone

$$\varepsilon = \frac{100}{1+2\ /t} \quad [\%]$$

r = internal bending radius

t = plate thickness

Table 11.2 Test specifications for welded connections

Test specifications for welded connections		
Components [1]	1st Order	2nd Order
Notes	See Table 2.1	See Table 2.1
Nature and scope of tests to be applied	Butt welds perpendicular to direction of main stress including weld intersections: Radiographic and/or ultra-sonic inspection of 10 % of weld length; in special cases of 100 % of weld length. Where necessary, magnetic particle testing.	Butt welds perpendicular to direction of main stress including weld intersections: Radiographic and/or ultra-sonic inspection randomly. Where necessary, magnetic particle testing.
	Butt welds parallel to direction of main stress: Radiographic and/or ultra-sonic inspection randomly. In special cases as above. Where necessary, magnetic particle testing.	Other welded connections and components, as above in cases of doubt. Recommended: Magnetic particle testing of single (HV) or double bevel (DHV-(K) seams on thickwalled components.
	Single (HV) or double bevel (DHV-(K)) seams - especially in thicker plates – perpendicular and parallel to the direction of the main stress: Ultrasonic and magnetic particle testing of at least 10 %; in the case of thicker plates and rigid structural components as a rule of 100 % of the weld length	
Requirements	Assessment category B as per ISO 5817	Assessment category C as per ISO 5817

Remarks:
- With BKI consent, dye penetrant testing may be used instead of magnetic particle testing.
- Deviations from the recommended assessment categories – even in respect of individual criteria – may be agreed.
- As regards ultrasonic tests, the assessment criterion will be specified by BKI as part of the process of approving and authorising testing locations and inspectors.
- The BKI Surveyor retains the right to determine or alter the position of random tests and to increase the scope of tests, particularly if there is an accumulation of defects.

[1] For 3rd order components (see Table 2.1) no tests are prescribed.

F. Examination of Drawings and Supervision of Construction

1. Examination of Drawings

For the examination of drawings of steel components the requirements in Section 1, D are to be observed.

In addition to the welding diagrams and test plans stated there, the following applies:

1.1 Details on welded joints in the documents to be examined

1.1.1 In the documents to be examined and to be submitted for approval, production details shall be included which are relevant to the quality of the welded joint and the examination by BKI. Besides the materials and the weld geometry, this requires the following information:

– weld preparation procedure (mechanical, thermal, etc.)
– welding method, welding positions
– welding consumables and auxiliary material
– preheating and heat conduction during welding where required
– weld composition and number of layers
– welding sequence (in special cases)
– root side grooving (method)

- possibly finishing (heat) treatment
- number and location of production specimens to be welded simultaneously, if required

1.1.2 As long as weld preparation and workmanship of the welds (in combination with approved welding methods, welding consumables and auxiliary materials) comply with the accepted practice of welding technology, these Guidelines and recognized standards, BKI may waive a special description or details in the test documentation.

1.2 Description of welded joints

1.2.1 The description of welded joints including the gap and weld geometry shall e.g. comply with the standards EN 12345, ISO 2553, ISO 9692-1, -2, -3 or -4. The designations in the documents to be examined (drawings, etc.) shall be well-defined e.g. by standard symbols.

1.2.2 Deviating weld geometries or symbols in the documents to be examined (drawings, welding diagrams or specifications) shall be presented or commented on in detail and require approval by BKI (e.g. in connection with the examination of drawings or with a procedure test).

2. Supervision of construction

Regarding supervision of construction by BKI, the requirements in Section 1, A and the following requirements apply.

2.1 Surveillance of production

2.1.1 Steel components shall be surveyed during production with respect to workmanship and compliance with the approved drawings. The start of production is to be indicated in good time to the BKI inspection in charge, in order to enable the BKI Surveyor to supervise the complete production process.

2.1.2 Professional, proper and complete execution of the joining processes shall be ensured by means of thorough controls by the factory.

2.1.3 If the manufacturing process, or any subsequent (heat) treatment which may be required, may lead to a substantial change in, or deterioration of, the properties of the material or the welded connection, BKI may stipulate in-production tests to prove that the mechanical qualities remain adequate.

3. Acceptance test

3.1 Before delivery of steel components, a suitable date for the acceptance test shall be agreed with the BKI inspection in charge.

For the acceptance test before delivery, the manufacturer shall have ready the following documents:

- purchase and order documents
- workshop drawings
- BKI approved drawings including examination reports
- results of internal checks
- material test certificates
- certificates or protocols of welding tests
- further documents as required

G. Documentation

1. Marking

1.1 Where the BKI acceptance test before delivery has not given reason for complaint, the steel component shall be stamped as follows:

– BKI stamp with the month and year of testing

– BKI certificate number as per 2.1, together with the code letter(s) of the examining inspection office

1.2 Where the steel components are produced in the manufacturer's works for loading gear, a special stamp and certification of these parts after manufacturing will be dispensed with. This will be included in the acceptance test before delivery of the assembled loading gear.

2. Certification

2.1 BKI will issue a Test Certificate for each finished and tested steel component.

This certificate includes the following information:

– manufacturer's name

– date and reference number of the approved drawing

– replica of stamp

2.2 The certificate issued according to 2.1 is not part of the loading gear documentation on board.

Section 12 Technical and Operational Safety Requirements

A. General 12–1
B. Design Requirements 12–1
C. Equipment 12–5
D. Safety Devices 12–6
E. Passive Protective Measures 12–8
F. Stowage and Lashing Devices 12–9
G. Operational Requirements 12–10

A. General

1. This Section contains selected provisions in addition to the previous Sections as regards safety of loading gear and the protection of persons, based on the following requirements for design, fitting and operation of these devices.

Further requirements or measures are to be taken from the relevant standards and regulations, if applicable.

2. A general precondition for the safe operation of loading gear is first of all its dimensioning and its design and equipment in accordance with Sections 2 to 6 of these Guidelines.

Complementary details regarding rope drives, mechanical parts and electrical equipment are given in Sections 8 to 10.

3. For loose gear, the requirements of this Section apply similarly, where relevant.

B. Design Requirements

1. Loading gear in general

1.1 Highest boom position

1.1.1 General notes

Each boom shall be capable of being lowered in the highest position, with or without useful load. Combinations of different influences are to be taken into account.

1.1.2 Rope-operated booms

.1 With rope-operated booms, the boom weight and the influence of all systems which prevent it remaining in the highest position shall be sufficient to overcome all losses due to friction and turning.

.2 To prevent remaining in the highest boom position a restoring device may be provided, which is to be controlled from the crane drivers cabin.

Alternatively, a warning device for the crane driver may be installed, which warns of further luffing in due time. This device is only permissible if it is reasonable from a technical and operational point of view.

1.1.3 Cylinder-operated booms

With cylinder-operated booms, the cylinder force shall be great enough to comply with the requirements of 1.1.2.1.

1.2 Secondary components

Secondary components and auxiliary structures such as inter alia ladders, consoles, cable trays shall not, if possible, be welded to highly stressed components. Where appropriate, a proof of fatigue strength is to be furnished.

1.3 Access to crane drivers´ cabins

1.3.1 Crane drivers' cabins shall be designed and arranged in such a way, and be of such a size, that they are easily accessible no matter what the position of the crane. An accident-proof standing position for a second person shall be provided within the area of the crane driver’s cabin.

1.3.2 If there is a danger that the regular access to the driver’s cab can be obstructed (e.g. in case of an accident, fire, etc.) an independent emergency exit shall be provided.

1.3.3 If normal access is impossible when the cabin is occupied, a second entrance of sufficient size, which may also be the emergency exit, shall be provided.

1.3.4 Where the floor of the crane cabin is not more than 5 m above the deck, it is sufficient if the cabin can be reached without particular danger when the crane is in one position but can be left via an emergency exit no matter what the position of the crane.

1.4 Accesses in general

1.4.1 Unobstructed access to all essential components of the loading gear shall be ensured for maintenance and repair purposes, by means of suitable accesses, platforms, ladders and standing spaces.

1.4.2 The headroom of entrances shall be at least 2 m, the clear width at least 0,6 m. The clear height of the opening may be reduced by a sill up to 0,6 m high.

1.4.3 Ladder rungs and climbing irons shall be of 20/20 square steel bar set edgewise, with a footstep width of at least approx. 30 cm. From a climbing height of 2,5 m and above a safety cage or track for safety harness is to be provided.

1.4.4 Ladders

.1 The inclination of ladders, measured from the horizontal, shall be at least 65°.

.2 Ladder rungs and climbing irons shall be of 20/20 (L = 300) or 22/22 (300 < L ≤ 350) square steel bar set edgewise, with a footstep width of at least 30 cm. The horizontal distance from fixed structures shall be at least 15 cm.

.3 The distance of the lowest ladder rung from the deck or platform shall be between 100 mm and 400 mm.

.4 Climbing irons shall have a uniform distance of 300 mm from each other.

.5 The minimum distances and spaces to be kept clear for movement within the reach of a ladder (see also Figs. 12.1 and 12.2) are:

- 750 x 750 mm in front of the climbing irons, excluding obstacles extending into this space (in exceptional cases a limit down to 550 x 550 is permissible, however in this case obstacles such as brackets shall be covered, in order to prevent injuries)
- 150 mm behind the ladder, measured from the axis of the climbing iron
- 75 mm as an access clearance for the hands on each side of the ladder and around vertical hand grips

.6 A fall arresting device (safety cage or guide rail for a safety harness) is to be provided if:

a) the mounting height exceeds 2,5 m or

b) a falling height of more than 3,0 m is possible.

.7 For ladders with a height of more than 3 m or of any length (if a falling height of more than 3 m is possible) the following requirements also apply:

- The lowest safety cage retainer shall not be positioned lower than 2,2 m above the deck or platform.
- The retainers shall have uniform spacing of not more than 900 mm.
- The safety cage shall at a minimum consist of 5 longitudinal struts.
- The clearance between climbing iron and rear cage shall be between 550 mm and 750 mm.

.8 The maximum vertical length of a ladder between two platforms is 6 m.

.9 The ladder shall stop at intermediate platforms. The ladder which arrives, ends at the platform and the follow-on ladder is offset (not above the opening in the platform).

.10 The rails of the ladder shall extend past the upper platform by at least 1 m or hand grips are to be fixed up to this height.

1.4.5 Landings/platforms

.1 Outer edges of platforms or floors are to be provided with a coaming, unless people and/or items slipping is prevented by other means.

.2 Floors and their coverings respectively are to be skid-proof.

.3 Platform openings require a cover, if a ladder located above the platform may be adjusted on the opening (e.g. if the upper ladder is fastened to rotating crane parts).

The cover shall be capable of being held in the "open" position.

1.4.6 Guard rails

.1 The height of guard rails of accesses, platforms, etc. shall be at least 0,90 m and be provided with an upper handrail and a rail at mid-height. A foot-bar with a minimum height of 0,10 m is to be provided.

.2 Where guard-rails are used to separate working areas from traffic areas, their clearance from moveable parts shall be at least 0,10 m.

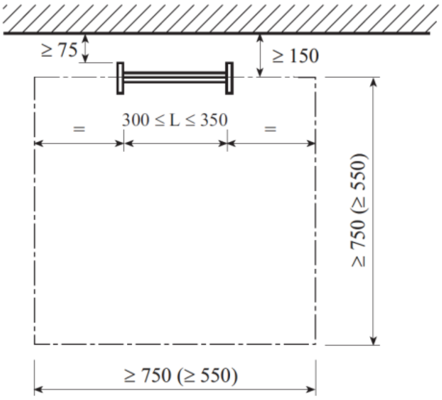

Fig. 12.1 Minimum clearances and movement space

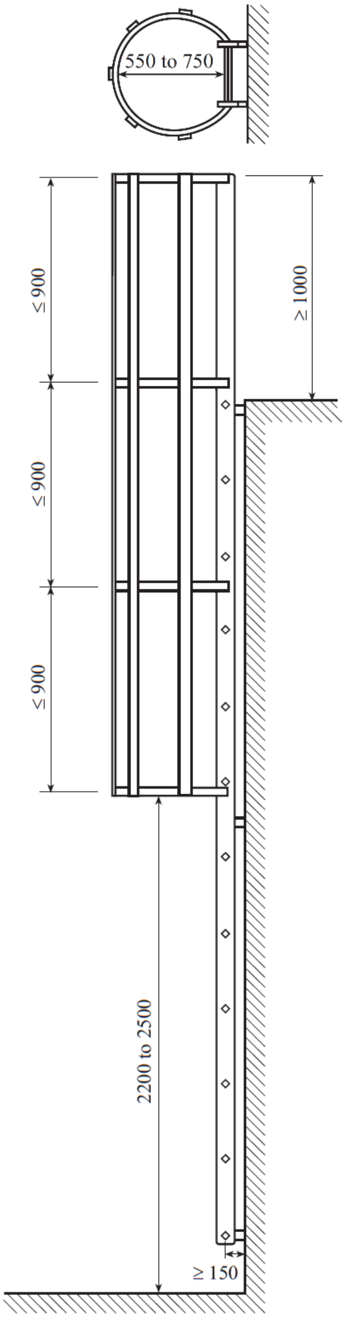

Fig. 12.2 Safety cage

2. Mobile loading gear

2.1 General requirements

2.1.1 Rail-mounted cranes and trolleys shall be protected from derailment, overturning and dislodging and against unintentional movement in a seaway and in operation. Rail stops as well as warning devices and rail clearers for loading gear on deck shall be provided.

2.1.2 Cranes and trolleys which can be moved athwartships shall be fitted with a form-locking drive (rack and pinion drive or equivalent). The drive shall be self-locking or fitted with brakes.

2.1.3 For cranes and trolleys in engine and pump rooms up to a nominal load of 1,0 t which can be moved athwartships, the requirement of 2.1.2 is considered to be complied with if the load can be safely held, also in a seaway, by suitable fastening devices (tackles, pulleys and the like).

2.1.4 Cranes and trolleys which can be moved fore and aft are to be fitted with a self-locking drive or with brakes. For such cranes, calculations are to be submitted proving that the cranes are able to move against a 2° inclination and against a wind load 50 % higher than specified in Section 4, C.3.1 for offshore operation and with or without load, by friction contact.

2.1.5 Cranes and trolleys with a nominal load over 1,0 t which can be moved fore and aft are to be fitted with a direct drive as per 2.1.2, if they shall be employed for working at sea state. This predominantly includes cranes and trolleys above the main engine.

2.1.6 Each crane rail shall be arranged parallel to the design waterline of the ship.

2.1.7 Where the operator has to move with the crane or trolley control unit, the speed of travel may not exceed 0,5 m/s.

2.2 Industrial cargo-handling vehicles

For industrial cargo-handling vehicles the requirements of Section 6, E apply.

C. Equipment

1. Highest boom position

1.1 Cranes whose booms are held by luffing ropes shall be equipped with buffers for the uppermost position.

1.2 The requirements in D.7.2 shall be observed when designing buffers.

2. Control stands and controls

2.1 Control stands and controls shall be designed and located in such a way that the crane driver has an unobstructed view of the area of operation, or at least of the person guiding him.

2.2 The control stands of cranes for cargo handling and offshore cranes shall be closed driver cabins constructed of fire-resistant material with adequate lighting, heating and ventilation. They shall be fitted with accident-proof window panes, sun shields, window wipers, protective grids and with one suitable fire extinguisher.

2.3 The controls shall be marked to indicate their function. Movement of the controls shall be appropriately related to the corresponding crane movements, e.g.:

- When a vertical lever is pulled towards the operator, a horizontal lever is raised or a swivel lever or hand-wheel turned clockwise, the load shall rise or the crane move backwards.
- When a vertical lever is pushed away from the operator, a horizontal lever is pushed down or a swivel lever or hand-wheel turned anticlockwise, the load shall descend or the crane move forwards.
- As regards the slewing or rotation of cranes, the direction of slewing or rotation of the crane shall agree with the direction or layout of the controls.

2.4 Additional requirements for the controls and the control mechanism are given in Section 10, F.2.1.

3. Cranes with load radius-dependent nominal loads shall have a load radius diagram in the driver's cabin.

The actual load radius shall be continually visible to the driver.

4. Working hours counter

Cranes for cargo handling and offshore cranes are to be provided with working hours counting mechanisms.

5. Lighting

For the main and emergency power lighting of loading gear, the requirements of Section 10, F.2.2 apply.

6. Fresh air supply

For closed control stands sufficient supply of fresh air is to be provided. Air inlets shall be arranged in the open-air and such that no contamination with exhaust gas, dust or fuel/oil mist may occur.

7. Protection and precautions against fire and explosion

Necessary protection and precautions against fires and explosions shall be considered. The number, capacity and location of fire extinguishers shall be adequate for the type of crane and its intended service.

D. Safety Devices

1. Overload protection

1.1 Load limit

1.1.1 Loading gear shall have overload protection devices. These shall become effective when the nominal load is exceeded by 10 % at most (in exceptional cases with certain types of hydraulic drive, by 15 % at most).

1.1.2 Where loading gear has variable nominal loads, the overload protection device shall adjust automatically to the actual load radius.

1.1.3 For rope and chain hoists manufactured by series production, the manufacturer's settings and tolerances apply, see Section 6, B.3.1.1.

1.2 Load moment limitation

1.2.1 Where loading gear has variable nominal loads, a load moment limitation device is also required in addition to the overload protection device.

1.2.2 Devices for limitation of the load moments shall act directly on the luffing and/or telescope drives.

On hydraulic systems, suitable pressure limitation devices are permissible.

1.3 Overload protection system for offshore cranes

1.3.1 Offshore cranes are to be equipped with an automatic protection system against transverse overload.

1.3.2 Offshore supply cranes are to be equipped with an automatic overload protection system (AOPS) and with a manual overload protection system (MOPS) acc. to EN 13852-1.

1.3.3 Offshore floating cranes are to be equipped with an emergency load release system (ELRS) acc. to EN 13852-2.

1.4 Load reduction after an overload

After the overload protection devices are activated, the load or load moment reducing motions of the loading gear and its mobile components shall still be possible.

2. Motion limiter

2.1 General requirements

2.1.1 The end positions of all motions which can be performed by loading gear or its mobile components shall be limited in an appropriate and safe way. For rotary motions, this is only applicable if they are restricted by local circumstances.

2.1.2 For conventional derrick boom systems, exceptions from the requirements of 2.1.1 can be permitted.

2.1.3 It shall not be possible for end positions to be overridden. Exceptions, e.g. for maintenance and boom stowage, require written approval by BKI.

2.1.4 If required, motion limiters shall also have an influence on other motions in order to avoid damage. This may e.g. be required for the highest hook position of booms with luffing ropes, see also 7.2.

2.2 Motion limitation by limit switches

2.2.1 Limit switches shall be designed and positioned in such a way that their efficiency is not affected by the weather or by dirt accumulation. Movement in the opposite direction shall be possible after they are activated. Proximity switches shall preferably be used.

2.2.2 Limit switches are to be located and adjusted in such a way that no damage can occur, even if they are approached at maximum speed and with full nominal load. If necessary, pre-limit switches are to be used.

2.2.3 Regarding additional requirements for limit switches see Section 10, E.2.

2.3 Motion limitation by design measures

2.3.1 Limit switches

.1 For hydraulically operated loading gear with low operating speeds and nominal loads up to 1000 kg, limit stops, with damping if required, may be permitted as a motion limitation.

.2 For rope and chain hoists from series-production, the requirements of Section 6, B.3.2.2 apply.

2.3.2 Runway limit

For limit stops of movable cranes the provisions in Section 4, C.4.2 are applicable.

3. Emergency switches/keys

3.1 On control stands, inside cabins or at manual controls, an emergency switch or emergency cut-out with mechanical locking device is to be provided.

3.2 The emergency shut-down shall cut off the power supply and all motions. In the case of hydraulic drives, the emergency shut-down shall also act on the drive of the hydraulic pump.

Return to service shall be solely from the zero position of the respective controls or operating instruments.

3.3 Emergency switches/keys shall meet the requirements of ISO 13850 and continue to function in the event of any failure of the control system.

4. Slack rope limiter

4.1 In particular cases, a slack rope limiter may be required, e.g. with fast hoisting speeds without automatic creep hoist, multiple coils, or if required for a special mode of operation.

4.2 For offshore cranes and floating cranes which are employed offshore, slack rope limiters in the lifting and luffing system, as well as a slack rope indication for the crane driver are required.

The slack rope limitation system of offshore cranes shall stop the winch(es) automatically.

5. Secondary brake for lifting appliances

Lifting appliances used for the conveyance of persons or personnel shall be equipped with a secondary brake at the hoist and luffing winch. The requirements of Section 3, B.5 and Section 9, E.3.7 apply.

6. Alarm devices

6.1 Outside the driver's cabin on cranes used for the handling of cargo and offshore supply cranes, a signal horn is to be provided by which the crane driver can raise an acoustic signal which can definitely be heard in the working area of the crane.

6.2 Mobile deck cranes shall give an optical and acoustic alarm while moving.

7. Strain of loading gear due to safety devices

7.1 The movements and dynamic loads occurring following the response of safety devices shall be kept to a minimum if possible.

7.2 Motion limiters for the highest boom position shall be designed in such a way that, after depositing the load, no damage may occur from the unloaded luffing ropes.

E. Passive Protective Measures

1. Safety distances

1.1 In accessible areas, the distance between fixed parts of the ship and moving parts of the loading gear shall be at least 0,50 m in all directions and, where passageways adjoin, at least 0,60 m.

If at certain points a distance of 0,50 m cannot be provided, the area concerned shall be identified with prominent black and yellow paintwork. Warning notices are to be fitted.

1.2 A distance of at least 0,50 m shall be provided between the lower edge of the boom in its lowest working position and fixed parts of the ship.

2. Safety of access and transport

2.1 Working passages, operating platforms, stairs and other areas accessible during operation shall be secured by railings.

2.2 All loading gear shall be fitted with a signboard forbidding access or ascent by unauthorized persons.

2.3 In utility spaces (on board ships and in cranes), adequately-dimensioned securing facilities for pull-lift hoists or holding devices shall be fitted at suitable points.

2.4 To permit load tests on loading gear inside utility spaces, eye plates shall be provided at suitable points, see Section 6, B.3.5.

3. Corrosion protection

3.1 For general requirements regarding corrosion protection, the provisions of Section 11, B.3.5 apply for steel components and Section 8, B.1.2 for wire ropes.

3.2 Components which are employed for hoisting services under water, e.g. loose gear, shall be designed in such a way that, as far as possible, no seawater can ingress.

F. Stowage and Lashing Devices

1. General requirements

1.1 It shall be possible for all wheeled loading gear and mobile components of loading gear to be positioned, or where required, supported, for sea use, as well as to be fastened securely by suitable devices or guys, see Section 3, C.5.3.

1.2 Supporting or fastening devices shall be designed in such a way that inadmissible forces or loads may not be transmitted to the loading gear or the components thereof, caused by deformations of the ship's hull in a seaway.

2. Wheeled loading gear

2.1 Wheeled loading gear shall be located in stowage positions which, as far as possible, are expected to suffer the least loads in a seaway.

2.2 For free-travelling loading gear , such as e.g. industrial cargo-handling vehicles, suitable stowage spaces and lashing eyes or other suitable devices are to be provided.

3. Revolving cranes

3.1 Revolving cranes with booms or projecting machinery rooms require supporting structures for these components and a special blocking device to relieve the slewing gear.

3.2 Where booms or projecting machinery rooms with an "out of operation" status shall not be stowed or supported, written BKI approval is required.

3.3 Booms with luffing ropes shall be guyed downwards, either hanging free or supported. Where the brakes of the loading gear are designed for it, this requirement can be complied with by proper fastening of the cargo hook and prestressing of the hoisting ropes. Prestressing is to be specified by the manufacturer.

Supported booms may also be fastened properly to the boom support, see Section 4, G.2.2.

For booms with luffing cylinders, the guy or fastening may be dispensed with, provided that a corresponding approval is at hand.

3.4 Where not serving to guy the boom cargo hooks are to be stowed in special devices at the boom or on deck. Grabs or other large and/or heavy loose gear shall be stowed on deck.

4. Design and dimensioning

4.1 Boom supports, supporting, stowage and lashing devices shall be designed and dimensioned with the same diligence and to the same criteria which apply to loading gear.

4.2 Stowage and lashing devices shall be dimensioned like cranes out of operation acc. to Section 4, F.

G. Operational Requirements

1. Loading gear in general

1.1 Marking of hoisting capacity

1.1.1 All loading gear shall be marked permanently and prominently with the nominal load "SWL" and the corresponding load radius.

In the case of load-radius dependent nominal loads, loading gear shall be marked in several places.

Detailed information regarding marking of loading gear is given in Section 13, B.5.

1.1.2 All loose gear shall be marked permanently and prominently with the nominal load "SWL" and the dead load "WT", the latter if WT ≥ 100 kg.

Detailed information regarding marking of loose gear is given in Section 7, D.3.

1.2 Ship stability

1.2.1 In the absence of any special measures, the ship's stability alone shall suffice to ensure simultaneous operation of all loading gear for transhipment, handling or transport of cargo under all operational conditions of the ship.

In doing so, the inclinations and/or motions of the ship which are the basis for dimensioning the loading gear, shall not be exceeded.

1.2.2 Special measures as per 1.2.1 can be e.g.:

- operational restrictions
- ballasting by water or weights
- supporting the ship ashore
- utilization of stabilizing pontoons

Special measures always require instructions recorded in writing, and supervisory personnel, and where required also additional supervising devices. These requirements also apply to fully automated operation.

1.2.3 The influence of loading gear on the ship's stability shall be verified by calculation. These calculations shall be included in the stability documentation of the ship.

1.3 Failure of the drive power

1.3.1 A design is to be employed, auxiliary means shall be available, and measures are to be taken to set down suspended loads as safely as possible, in the event of a failure of the drive power.

Mobile loading gear and/or mobile loading gear components may for this purpose possibly be transferred into a more favourable load position.

1.3.2 If no other loading gear is available, the following auxiliary means/measures may e.g. be employed:

- plug-on auxiliary drives/manual pumps
- eye plates attached to the loading gear for use by pull-lift hoists for small loads
- mechanical ventilation of brakes or opening of valves

Mechanical ventilation of brakes or opening of valves is only permissible if the design conditions regarding intake of the released energy allow for it. Required waiting periods for cooling-down shall be observed.

1.3.3 Loading gear used for the conveyance of persons shall be equipped with suitable rescue equipment. Descender devices may be employed for the descent from work-baskets.

1.4 Conveyance of persons

Loading gear used for the conveyance of persons shall comply with the requirements according to Section 3, B.5 with regard to dimensioning, control and operation.

Persons may only be transported at daylight and under environmental conditions (wind/seaway), which are considered to be acceptable by the supervisor in charge.

1.5 Communication

1.5.1 Crane drivers shall have an unobstructed view of the load and the working area under all working conditions, or else personnel guiding them, see also C.2.1.

1.5.2 If necessary, equipment shall be provided or measures taken which allow safe transmittance of instructions from the guiding person(s) to the crane driver or the person handling the crane.

2. Wheeled loading gear

For wheeled cranes, the operational requirements of B.2, D.6.2 and E.1 apply.

3. Floating cranes

3.1 Where pontoons carrying floating cranes under load are operated in calm water, a safety distance of at least 0,50 m shall be maintained between the deck edge at the lowest corner and the surface of the water. When working in unprotected waters, a safety distance of at least 1,00 m shall be maintained.

3.2 The transport of loads suspended from the crane hook across unprotected waters is subject in each case to approval by BKI, who may for this purpose issue a "Conveyance Certificate" if necessary.

3.3 In the event of the floating structure being grounded, the cranes located on it may only be operated if the structure is designed for that situation.

4. Responsibility of the ship's management

4.1 Special working conditions, operational restrictions, release and safety measures shall be recorded in writing and included with the corresponding loading gear documentation.

4.2 Maintenance and control measures performed by the ship's management and/or external personnel are to be confirmed properly in the loading gear documentation or added to it.

In the BKI Register book of loading gear, Register of Lifting Appliances (LA1), part 4 is provided for entries of this kind, see Section 13, G.

4.3 If the limit values for wind, ship inclination, ship motion or temperature, specified in Section 3, B.4 and Section 5, B, are reached, loading gear shall be put out of operation and, where required, be stowed in a special way and/or be lashed for sea, see F.

Deviating limit values may be specified for loading gear operating in a seaway or at low temperatures.

Section 13 Testing and Examination of Loading Gear

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A. General

1. Description of content

1.1 Subsections B. to E. contain requirements for testing, examination, marking and certification of loading gear used for cargo handling.

These provisions apply analogously to loading gear on offshore installations, which are only expressly mentioned if required.

1.2 The requirements in F. apply for the evaluation and treatment of worn-out or damaged loading gear components.

1.3 The loading gear documentation described in G. includes the following items:

- types and systems of certification
- compilation of test certificates in Register books (certification of loading gear)
- confirmation of investigations, inspections by the ship's management, replacement of components, as well as repair and maintenance activities
- rigging plans
- operating and maintenance instructions

2. Supplementary requirements

Supplementary/deviating requirements apply to the following loading gear, equipment and means of transport:

2.1 Loading gear

- goods lifts and lifting platforms (see Section 5)
- rope and chain hoists (see Section 6)
- ramps and car decks (see Section 6)
- loading gear for research work (see Section 6)
- industrial cargo-handling vehicles (see Section 6)

2.2 Equipment

- interchangeable components (see Section 7)
- wire and fibre ropes (see Section 8)
- mechanical parts (see Section 9)

– electrical equipment (see Section 10)

2.3 Means of transport

– loose gear (see Section 7)
– shipborne working baskets (see Section 6)
– landing booms (see Section 6)

3. Independent requirements

Independent requirements exist for testing, examination and certification of the following loading gear:

– passenger lifts and small goods lifts (see Section 5)

4. Definitions

In addition to Section 1, C, the following definitions apply:

4.1 Tests

4.1.1 Function test

The designation "function test" is applied to testing of all possible movements or functions, as well as to control, limiting and safety equipment.

This test shall generally be carried out with available weights.

To test and, if applicable, to adjust load monitoring equipment, calibrated weights or, if permitted, calibrated force measuring devices shall be made available.

4.1.2 Load test

The designation 'load test' is given to the test with the prescribed test load L_{Pdyn} or L_{Pstat}.

The purpose of the load test is to prove adequate strength, safety against hidden defects and if applicable adequate safety against overturning.

4.2 Examination

4.2.1 Thorough examination

A thorough examination means a detailed visual examination, supplemented if necessary by other suitable means or measures in order to arrive at a reliable conclusion as to safety.

If deemed necessary by the BKI Surveyor, parts of the interchangeable components, of the loose gear or of the loading gear are to be dismounted and, where required, dismantled.

4.2.2 Inspection

The term "inspection" means a visual inspection, whereby as far as is possible by this means it shall be determined whether continued use can safely be permitted.

B. Supervision of Construction

In addition to the following provisions, the general requirements in Section 1, A and, for steel construction, the requirements in Section 11, F.2 shall be observed.

1. General

1.1 Supervision of construction is required in principle. BKI may however dispense with it for loading gear manufactured in series, which is not used for cargo handling and which fulfils the requirements for omitting examination of drawings, see Section 1, D.1.3. In this case, manufacturer's test reports may be accepted, deviating from the certificates stated in 7.1.

1.2 Commencement of construction of a loading gear is to be advised to the BKI Branch Office in sufficient time for the BKI Surveyor to attend the construction process from the beginning.

1.3 The basis for the supervision of construction at the manufacturer of the loading gear is the approved documentation according to Section 1, D, plus, if applicable, further documentation, certificates, reports and information from the manufacturer which the BKI Surveyor needs for assessment of the parts to be examined.

1.4 Regarding supervision of construction and loading gear documentation, third party shall provide certificates and test reports in the scope specified in this Section 5 to 10.

2. Participation by manufacturers

2.1 As far as necessary and advisable, the works will have to check all components during and after manufacture for completeness, dimensional accuracy and proper workmanship.

2.2 Following checking and, if required, repair by the works, the components are to be presented to the BKI Surveyor for inspection during appropriate phases of construction, normally in easily accessible and unpainted condition.

Certificates for components and equipment delivered by third parties shall be submitted.

2.3 The BKI Surveyor may reject components not following test plan requirement, and stipulate that they be presented again following checking by the works and, if required, repair.

2.4 Components to be tested are to be indicated to the BKI Surveyor in good time for examination.

2.5 In order to enable the BKI Surveyor to perform his duties, he is to be given access to the workshops in which components for testing are manufactured and assembled. Manufacturers are to make available to the Surveyor the personnel and material support required to carry out the prescribed tests.

3. Supervision of construction

3.1 The BKI Surveyor examines the components constructed at the manufacturer's, or supplied, with regard to condition, marking and certification. He supervises the assembly of the loading gear and examines workmanship and agreement with approved documents, and witnesses the test runs and functional tests as appropriate or agreed.

3.2 Testing of materials for the manufacture shall be proven to the BKI Surveyor in accordance with Rules for Materials (Pt.1, Vol.V).

The certificates/reports for the materials used, as well as proofs on welding and non-destructive material tests, shall be submitted.

3.3 Components which are not type-tested but subject to tests and examination shall, as far as possible, be tested at the manufacturer's test plant in the presence of the BKI Surveyor as approved test plan in an agreed scope or as prescribed by these Guidelines.

Regarding series production, instead of the prescribed tests, other testing methods can be agreed with BKI, provided that they are accepted to be equivalent.

3.4 Where machines, devices or electrical equipment are provided for the intended purpose for the first time, BKI may demand a type-test.

4. Acceptance testing

4.1 General notes

4.1.1 Loading gear assembled ready for operation, or completely equipped assembly groups, shall be presented to the BKI Surveyor before they leave the manufacturer's works.

4.1.2 After completion of agreed test runs or tests, loading gear or loading gear assembly groups shall be subjected to a thorough examination. The testing methods applied are at the discretion of the BKI Surveyor. Following tests on the test plant, lubricating and hydraulic oil filters shall be checked for impurity.

4.2 Tests and examinations to be carried out

4.2.1 General test and examination

- checking of documentation
- examination in respect of workmanship, compliance with the approved documents and for completeness
- checking of safety clearances and passive protection measures
- examination of accesses, ladders, rails and platforms
- examination of the cabin or the control stand and the control equipment
- examination of the manufacturer's plate, on which at a minimum shall be permanently indicated:
  - manufacturer's name
  - year of construction
  - serial number
  - where applicable, type designation
  - nominal load(s) and load radius (radii)
- examination of marking, see 5.
- additional tests and/or examinations as required

4.2.2 Test run

.1 Newly designed loading gear shall be test-run in the presence of the BKI Surveyor according to a programme approved by BKI. If possible, this shall take place at the manufacturer's, but with BKI’s consent, it may also take place elsewhere, or at the place of operation.

.2 Loading gear subject to special operating conditions shall undergo test runs under these conditions. At least one of every different type of gear shall be tested in this way.

For shipborne loading gear, this for instance means that the test run shall be performed with the ship also at the stipulated inclination.

.3 A test run may cover the following, insofar as applicable:

- checking the interaction of all movable parts and functions
- function test under available load
- brake test with dynamic test load according to Table 13.2 by releasing the operator's control [1]
- emergency brake test with dynamic test load according to Table 13.2 (see also C.3.2.4)[1]
- checking the emergency load release device
- endurance tests on all power units under nominal load, with heating measurement
- noise measurement (also in the cabin)
- measurement of power consumption and contractually agreed speeds under nominal load
- additional measurements, including electrical ones, if necessary
- checking and adjustment of all valves and control equipment
- pressure tests
- testing and adjustment of all safety devices and limit stops
- testing of lighting, ventilation, intercom, etc.
- testing of fire protection system
- further tests as required

.4 Easing of testing requirements is to be agreed with BKI.

4.2.3 Proof of stability against overturning

For the proof of stability against overturning for wheeled loading gear, the requirements in Section 3, E.2.2 and Section 6, E.1.2 apply.

5. Marking of the loading gear

5.1 Loading gear number

5.1.1 The sequential numbering of shipborne lifting appliances shall agree with the details in the certificates and rigging plans.

5.1.2 The following rule for numbering shall be applied:

- first all loading gear for cargo handling, starting from the fore and arranged in pairs, progressing from port to starboard, starting on deck, then below deck
- next all loading gear needed for operating the ship, but none of the gear exclusively for launching life-saving equipment. Here also: starting on deck, then below deck.

5.1.3 The number of the loading gear shall be preceded by "No.".

5.2 Nominal load(s)

5.2.1 The nominal load(s) of loading gear for cargo handling shall be indicated in metric tonnes "t", on other loading gear, especially with lower nominal loads, the indication may also be in kilograms "kg".

The nominal load(s) of loading gear shall be preceded by the letters "SWL", where applicable with the following additions:

[1] Brake tests with test load shall be restricted to the required number. Emergency tests shall as far as possible be performed only once.

– SWL (P) for pairs of loading gear
– SWL (G) for loading gear with grabs
– SWL (M) for conveyance of persons

Table 13.1 Examples of markings

Loading gear with boom				
Item No. on board the ship	Nominal load	Load radius	Loading gear type	Meaning of the marking
No.3	SWL 40 t	2,4 -32 m	revolving cranes	In the indicated area of load radius, loads up to 40 t may be transported
No.2	SWL 250 t SWL 120 t SWL 60 t	3,5 – 12 m 3,5 – 25,5 m 3,5 – 34 m		Crane with 3 load steps. The load radius limits of the allocated nominal loads shall not be exceeded[1]
No.4	SWL (G) 26,4 t SWL 30 t	2,8 – 28 m 2,8 – 28 m		In the indicated area of load radius, loads up to 26,4 t can be transported during grab operation, up to 30 t in general cargo operation[2]
Nos. 2 + 3	SWL (P) 60 t	2,6 – 31 m		In the indicated area of load radius, loads up to 60 t may be transported by 2 cranes slewing jointly
No.1	SWL 50 t	–	gantry crane with foldable trolley girders	In the whole operating range of the gantry crane and the trolley, loads up to 50 t may be transported
No.2	SWL 50 t SWL 18,6 t	3,6 - 14 m 3,6 - 40 m	Offshore revolving crane	Marking indicates nominal loads when the platform is hoisted[3]
	SWL 5 t	4,4 – 42 m		Marking for the auxiliary hoist
Loading gear without boom				
No. 10	SWL 16 t	–	Bridge crane, lifting platform	Nominal load of the loading gear
Nos. 3 + 4	SWL (P) 28 t	–	Good lift	A nominal load of 28 t may be transported by 2 goods lifts arranged side-by-side
No. 18	SWL 3 – 6 t	–	Rope hoist	Where the hoisting rope as a single reeve, loads up to 3 t may be lifted, up to 6 t in the case of double reeve[4]

1 In the crane driver's cabin, a load radius diagram shall be visibly displayed.
2 The difference between SWL (G) and SWL results from the different hoist load coefficients, see Table 4.2.
The nominal load SWL (G) includes the dead load of the grab. As an example a grab may be marked as follows: SWL 24 t, underneath WT 2,4 t.
3 Information about the curve-type variation of the nominal loads of platform or ship hoists can be taken from the load radius diagram displayed in the crane driver´s cabin, see Fig. 4.4.
4 The types of reeve shall be marked properly on the loading gear. In the case of more than double reeve, an operating instruction is required.

5.3 Load radius (radii)

5.3.1 The load radius (radii) of loading gear is (are) to be indicated in metres "m". When variable, the minimum and the maximum value each.

5.3.2 Gantry and bridge cranes with trolleys are not given a load radius indication.

5.4 Details of execution

5.4.1 The marking giving details of the nominal load shall be in writing at least 80 mm high, and that regarding loading gear number or boom inclination at least 50 mm high.

5.4.2 This marking is to be permanently applied, e.g. by means of metal plates or by tracing the contour with a centre-punch or by means of welding spots.

Glued-on foils are permitted only for lifting appliances under deck.

5.4.3 The marking for the nominal load and, if applicable, the load radius shall be located clearly apart from the loading gear number.

5.5 Location

5.5.1 The marking shall be applied at a clearly visible location, with jib cranes at both sides, with gantry cranes at the fore and aft side of the gantry, relative to the longitudinal direction of the ship.

5.5.2 In the case of loading gear which can be combined in pairs, e.g. goods lifts or slewing cranes with crane booms arranged on a common crane column, additional marking shall be applied at a suitable location for the combined load.

5.5.3 On slewing cranes with crane booms arranged on a common crane column, this marking shall be applied at the fore and aft parts of the column, relative to the longitudinal direction of the ship.

5.6 Examples of marking

5.6.1 Marking is part of the safety measures for the operation of loading gear and therefore subject to examination, see Section 1, D.4.2.1.3.

Where variable equipment and reeve options exist, operating instructions are required.

5.6.2 In Table 13.1, some typical marking examples are listed, including explanations.

Special marking requires agreement with BKI.

6. Stamping of loading gear

6.1 Prior to BKI issuing the test certificate as per 7.1, the loading gear shall be stamped as follows:

- the certificate number with the distinguishing letters of the BKI Branch Office in charge
- BKI stamp with month and year of test

6.2 An additional stamp covering the nominal load is not applied until after the load test has been carried out.

6.3 Cranes are to be stamped at the bottom end of the left-hand jib spar, next to the point where it joins the crane house.

Loading gear assembly groups and loading gear other than cranes are to be stamped in a prominent position.

7. Certification of supervision of construction

7.1 For all loading gear completed and tested, a Test Certificate is issued by BKI.

Where loading gear assembly groups are manufactured by subcontractors, each assembly group receives its own test certificate.

Where interchangeable components and loose gear are already a part of the loading gear during the supervision of construction, test and examination certificates of form LA3 are to be provided.

For wire and fibre ropes which are already part of the loading gear at the supervision of construction, test certificates and examination certificates of form LA4/Certificate of test and examination of fibre ropes are to be provided.

Where winches are already a part of the loading gear during the supervision of construction, test and examination certificates are to be provided.

Where luffing and slewing cylinders are already a part of the loading gear during the supervision of construction, test and examination certificates are to be provided.

This paragraph does not apply to hoists manufactured in series production.

7.2 Apart from explanatory notes concerning the acceptance procedures, the test certificate as per 7.1 may contain notes regarding other certificates (e.g. LA3, LA4, test certificate), protocols, etc. such as e.g. the following details:

– manufacturer's name
– type designation and production number
– nominal load(s) and, if applicable, load radius (radii)
– date and BKI reference number of the plan approval
– associated ship (yard no. or BKI Register No.)
– stamp

C. Initial Test and Examination

1. General notes

1.1 Prior to commissioning, an initial test and examination within the scope described in 2. to 4. at the place of operation is required.

The sequence of steps for the test and examination is as deemed necessary by the BKI Surveyor, who also decides the scope of his examination.

1.2 During practical testing of loading gear dependent on an external power supply, care is to be taken to ensure that the test is carried out using the type of power supply envisaged from the ship's main.

Where ships are fitted for shore side power supply, shore and ship power shall be compatible.

1.3 The certificates and rigging plans stated in 4.1.2 shall be presented as proof of supervision of construction, and as an integral part of the loading gear documentation.

1.4 For cranes fitted with slew ring bearings, the results of a “Rocking Test”, taken in accordance with the bearing manufacturer’s instructions, are to be included in the Register Book.

2. Function test

2.1 This test serves to provide proof of the good working order of all components, installed systems and safety devices. The test procedure is at the BKI Surveyor's discretion.

2.2 In the case of permanently installed loading gear, the function test amongst other things serves to verify whether parts of the ship's structure or the ship's equipment restrict the working range or impede the working process.

2.3 The function test to be carried out for the BKI Surveyor does not normally serve to check whether all possible operations wanted by the operator can be effected. Proving this is the responsibility of the manufacturer or supplier.

2.4 With the exception of the test on the overload protection devices, the function test may be carried out with any given load, see also A.4.1.1.

2.5 A function test using a test load requires the manufacturer's consent.

3. Load test

3.1 General requirements

3.1.1 All loading gear shall undergo a load test with weights prior to being put into service. The test shall be carried out at the place of operation, in order that their respective foundations or driveways be included in the test.

3.1.2 In the case of loading gear below deck which is difficult to access, load tests may alternatively be conducted using approved load measuring devices with a tolerance limit of ≤ 2,5 %.

3.1.3 Loading gear is to be subjected to a dynamic load test.

The size of the test load shall be taken from Table 13.2.

Table 13.2 Dynamic test loads for loading gear

Nominal loads (L_{Ne})	Test loads (L_{Pdyn})[1]
Up to 20 t	SWL + 25%
20 t to 50 t	SWL + 5 t
Over 50 t	SWL + 10%

[1] if applicable to be multiplied with f_d according to Section 7, C.3.4

3.2 Load test performance

For the dynamic load test to be performed for the BKI Surveyor, the test load is to be lifted slowly, and if possible also slewed and luffed. In detail, the following applies:

3.2.1 For loading gear generally, the test load is to be lowered rapidly and braked in various positions and/or settings. Braking is to be effected by releasing the control levers.

3.2.2 Cranes under test load shall run the full travelling distance, or at maximum load radius, slowly cover the full swinging or slewing range. Additionally, the minimum load radius is to be tested, and in the case of cranes with radius dependent nominal loads, also an intermediate value.

3.2.3 Regarding crane columns and their integration into the ship's hull, as well as loading gear foundations in general, tests according to 3.2.1 are required in longitudinal and transverse directions of the ship, i.e. to fore and aft and to port and starboard each.

3.2.4 For loading gear used for cargo handling, one emergency brake test with the test load, by operating the emergency switch or button, is to be carried out either at the manufacturer's or at the place of operation.

3.2.5 When carrying out the load test, care shall be taken to ensure that all movable parts are able to operate freely in all the loading gear and/or derrick boom's positions, all ropes are unobstructed by any other parts, and the ropes can wind satisfactorily onto the winch drums.

3.2.6 In the case of goods lifts, lifting platforms and ramps, the test load arrangement shall conform to the intended operating mode.

3.3 Requirements for hoisting winches

3.3.1 If the pull of the hoisting-winch is insufficient to lift the test load, a second winch or other loading gear may be brought in to assist with the hoist. Braking and holding the test load, however, has to be accomplished using solely the winch belonging to the loading gear.

3.3.2 Where hoisting-winches have not lifted the test load by themselves, proof is to be obtained by testing that with the maximum number of layers of rope on the winch drum, the nominal load is hoisted satisfactorily by the winches.

3.3.3 The ability of the winch to hold the test load with the drive to the winch switched off shall be proved. In doing so, no slip shall occur, with the exception of hydraulic winches without standstill brakes, see F.8.2.4.

3.3.4 Hydraulic cranes

If hydraulic cranes are unable to lift a test load 25 % greater than the nominal load because of the pressure limit, lifting the maximum possible load is sufficient. This shall however exceed the nominal load by at least 10 %.

4. Examination

4.1 Documentation check

4.1.1 Priority shall be given to checking if the examination of drawings for loading gear, crane columns, crane boom supports and lashing equipment, foundations, runways and all supporting structures has been concluded successfully and if all structural modifications or changes, possibly resulting therefrom, have been carried out.

4.1.2 Supervision of construction shall be documented by test certificates. The loading gear documentation remaining onboard shall include:

- rigging plans
- test certificates for interchangeable components and loose gear
- test certificates for ropes

4.1.3 Regarding the certificates stated in 4.1.2, their correct correlation to the certified structural parts or components shall be checked by comparing the stamping and/or properties of these parts.

The certificates shall be checked with respect to correctness in form and content.

4.2 General visual inspection

The general visual inspection may e.g. refer to the following checks:

- general condition, completeness and correct rigging
- assembly interfaces between components constructed on site and components supplied

- undisturbed power transmission through transversely arranged plates such as deck plates. (Where required, this shall be checked by means of drilling holes, which have to be welded up after the check)
- inscription of number, SWL and, where required, load radius
- warning and indication signboards as well as warning paintwork where required
- accesses to loading gear and to control stands
- accesses to driver cabins and working and control platforms inside and outside the loading gear and to boom supports
- emergency descents
- condition and equipping of control stands and driver cabins
- working area of the loading gear
- range(s) of sight for the operator from inside the driver cabin

4.3 Examination after the load test

After the load test, the load-bearing components of loading gear are to undergo a visual examination.

This examination shall, if possible, exclude the formation of possibly permanent deformations or cracks at force application points or at special design details.

5. Stamping

5.1 If the initial tests and examinations have not given rise to any objections, the loading gear is to be stamped before the relevant certificates are issued.

5.2 Cranes with boom are to be stamped at the bottom end of the right-hand jib member and next to the point where that member is connected to the crane house, and in a prominent position on all other loading gear.

5.3 The stamp shall contain the following information:

- shipboard number of the loading gear
- BKI stamp with the month and year of test
- nominal load of the loading gear in [t] or where required in [kg] and the permissible minimum and maximum crane load radius in [m]. Where the nominal load varies with the load radius, the nominal load and the corresponding load radius is to be stated for the maximum and minimum values
- certificate number and distinguishing letters of the BKI Branch Office in charge

6. Certification of the initial tests and examinations

6.1 Following performance of the tests and examinations and stamping, BKI issues the certificate form LA2 for the load-tested loading gear and "Lifting Appliances Not Handling Cargo, Test/ Examination Certificate" for other lifting appliances.

This certificate may include several sets of loading gear whilst "Lifting Appliances Not Handling Cargo, Test/ Examination Certificate" shall be issued for one lifting appliance each only.

6.2 The tests and examinations of the loading gear are confirmed by the BKI Surveyor in a Register book of Form LA1, to which the certificate and the survey report are added.

6.3 The certification and documentation system for loading gear is described in G.

D. Periodic Tests and Examinations

1. General notes

1.1 Loading gear subject to periodic supervision by BKI shall be examined at regular intervals by the BKI Surveyor and subjected to load tests in his presence.

1.2 The intervals between examinations, and between the load tests, described below are customary internationally. Deviating national requirements are to be taken into account if applicable.

1.3 In cases where loading gear dependent on an external power supply is tested, the requirements in C.1.2 apply.

2. Due dates

2.1 Examinations

2.1.1 Loading gear and loose gear shall be examined annually by the BKI Surveyor, unless other intervals are required by national regulations.

The operator obliged to apply survey request as a matter of principle, obliged to give BKI due notice of the examination.

2.1.2 The following examinations vary, depending on type and scope:

- annual examinations, see 3.
- five-yearly examinations, see 4.

2.1.3 For offshore cranes during the construction phase of the offshore installation, half-yearly examinations may be required. These correspond fully to the annual examinations.

2.2 Load tests

2.2.1 No later than five years after the load test, a further load test is required for loading gear, to be performed in the BKI Surveyor's presence.

The operator is, as a matter of principle, obliged to give BKI due notice of the load test.

A regular recurrent load test of loose gear is not required internationally by ILO.

2.2.2 For practical reasons, load tests shall coincide with the five-yearly examination, any discretion are given by BKI Head Office.

2.3 Exceeding the due date

2.3.1 In the case of loading gear subject to the regulations of ILO, the intervals of one and five years regarding examinations and load tests shall not be exceeded.

This applies on the analogy to recurrent thorough examinations of loose gear.

No exceptions are permitted for offshore cranes.

2.3.2 In the case of loading gear not subject to the ILO regulations and which are no offshore cranes, the interval stated in 2.3.1 may be exceeded by up to three months when admitted by the Flag State Administration. This applies also to related loose gear.

This does not, however, postpone the due date of the next examination. The same applies inversely to tests performed before the due date.

2.3.3 Where the intervals stated in 2.3.1 and 2.3.2 are exceeded, the validity of entries on examinations performed and the validity of test certificates expires in the Register book.

In the case of classified loading gear, the respective class notation is suspended once the five year interval has been exceeded by more than three months.

3. Annual examinations

The purpose of annual examinations is to confirm technical safety of operation within the periods of five yearly examinations.

3.1 Scope of examinations

3.1.1 The scope of examinations depends on age, condition and frequency of use of loading gear.

Normally, loading gear need not be unrigged and dismantled for the performance of yearly examinations.

3.1.2 Essentially, the scope of examination comprises:

- checking documentation and certificates for completeness and validity and with reference to maintenance and inspection measures, arranged or performed by the ship's management
- checking for completeness and correct rigging or reeving respectively, using the rigging plans
- checking for damage, wear, deformation, corrosion, soiling, oil leakage, etc.
- checking for proper marking
- function test using available load
- random examination of the interchangeable components and correlation to the relevant certificates based on the stamps applied
- verification of newly-fitted parts
- recording the examination carried out in the Register book or, where required, in a corresponding certificate
- preparation of a survey report

3.1.3 The list in 3.1.2 by way of an example, the actual scope of tests and examinations at the discretion of the BKI Surveyor, whereby negative findings may require further examinations or measures, see 4.2.

3.1.4 The slewing ring assembly, where applicable, is to be examined for slack bolts, damaged bearings and deformation or fractured weldments. Rocking Tests, in accordance with the bearing manufacturer's instructions, are to be taken every six months. The results of these tests are to be recorded in the Register of Lifting Appliances for review by the attending surveyor at each annual survey.

3.2 Dealing with components

3.2.1 Use of steels liable to age is not permitted as a matter of principle, so that heat treatment of components at regular intervals is not required.

3.2.2 Components which do not comply with these guidelines, or which are worn to the permitted limits, shall be replaced by new ones with the prescribed dimensions.

3.2.3 Any parts renewed since the last examination are to be submitted to the BKI Surveyor, together with the certificates required.

4. Five-yearly examinations

4.1 General notes

4.1.1 The purpose of five-yearly tests and examinations is to confirm or generate a solid technical basis for the upcoming annual examinations.

4.1.2 Five-yearly examinations and load tests shall be performed if possible at the time of Class Renewal, i.e. during the period in shipyard refit, to have available sufficient technical equipment, test weights and interchangeable components, if necessary.

4.2 Scope of examinations

In accordance with these guidelines, five-yearly examinations shall extend and complement the examinations described in 3.1 and, where required, the measures described thereafter, which may, if necessary, be extended:

4.2.1 Examination of structural and interchangeable components

.1 If deemed necessary by the BKI Surveyor, individual parts shall be dismantled and, if necessary, unrigged for the examination. All parts found to be unsafe to operate shall be repaired or replaced.

.2 The BKI Surveyor is entitled to demand a load test or a load test repeat for loading gear, interchangeable components or loose gear, if deemed necessary.

4.2.2 Examination of slew rings

.1 Slew rings shall be examined with respect to bearing clearance, noise, lubrication and corrosion.

The tight fit of the pins is to be checked by at least one random hammer test.

Where increased internal wear is suspected, extruded grease is to be checked by an appropriate method for abraded particles.

.2 Slew rings of offshore cranes which are not equipped with special control and measuring devices shall be checked regularly by special control measures, agreed with the manufacturer.

Where increased internal wear becomes apparent, it may be required to remove the slew ring and to dismantle it for examination.

.3 The associated drives and brakes shall be checked with respect to wear, function and general condition.

.4 Prior to proof load testing, cranes fitted with slewing ring bearings are to undergo the following tests and examinations:

1) Cranes 1 to 5 years old – Surveyor is to witness Rocking Test and a grease sample is to be analyzed.
2) Cranes 5 to 10 years old – Surveyor is to witness the requirements of 1) above plus 10 percent of the slew ring bearing bolts are to be removed and nondestructively tested.
3) Cranes 10 to 15 years old – Surveyor is to witness the requirements of 1) above plus 15 percent of the slew ring bearing bolts are to be removed and nondestructively tested.
4) Cranes 15 to 20 years old – Surveyor is to witness the requirements of 1) above plus 20 percent of the slewing ring bearing bolts are to be removed and nondestructively tested.
5) Cranes 20 years and older – Surveyor is to witness the requirements of 1) above plus 25 percent of all slewing ring bearing bolts are to be removed and nondestructively tested.

Notes:

i. *If the results of the Rocking Test and grease samples indicate bearing wear in excess of the manufacturer's recommendation the bearing is to be opened for internal examination.*

ii. *chosen for examination are to be taken from the most highly loaded area of the slew ring bearing. If any bolts are found with defects additional bolts are to be removed to confirm suitability for continued use.*

4.2.3 Examination of hydraulic cylinders

Apart from a thorough visual examination with respect to straightness, oil leakage, bearing clearance and absence of cracks in the connecting structures, a function test of pipe burst safety valves or similar safety components with available load is required.

4.2.4 Examination of winches

Winches shall be examined with respect to:

- condition, fastening and function
- wear to brakes, rope grooves and flanged discs
- sufficient lubrication
- function of safety equipment
- correct rope winding
- observance of the required three safety turns
- tight fit and absence of corrosion of the rope-end attachment(s)

4.2.5 Crack tests

Where a visual inspection gives reason for this, the BKI Surveyor may request crack tests, using the procedure appropriate to each case.

The following areas of design need particular attention:

- flange connection of the slew ring at the crane column or the foundation
- connections between longitudinal and transverse structural members of crane booms
- bend areas of all kinds, especially on crane columns
- connections between crane columns and hatch coamings
- corner connections of crane gantries
- power transmission in the direction of thickness of plates
- special (noticeable) details of construction

4.2.6 Examination for corrosion

The following areas of design need particular attention:

- supporting areas of crane booms at stowage devices
- loose ropes with downward hanging end attachments, see Section 8, E.3.1.3
- contact areas without watertight sealing, e.g. in case of welded eye plates
- special areas of design where water my accumulate

5. Load tests

5.1 For the performance of load tests, the requirements in C.3 apply, however no emergency shut-down test is required, nor tests with several different nominal loads, load radii and ship directions.

5.2 At the five-yearly load tests of loading gear, normal testing of the maximum nominal load at the associated maximum load radius will suffice.

5.3 At the five-yearly load tests, the tests are, if possible, to be performed using weights. The weights shall be calibrated and certified or verifiable.

5.4 The magnitude of test load shall correspond to Table 13.2. In exceptional cases, a lower test load may be used, with hydraulically driven loading gear, where the working pressure cannot be correspondingly increased, see C.3.3.4.

5.5 Five-yearly load tests of lifting appliances under deck may also be effected using a calibrated load measuring instrument, whose indication of measured values shall remain constant for five minutes.

The instrument is to have an accuracy of ± 2,5 %.

If the nominal load L_{Ne} of any loading gear exceeds 15 t, use of a load measuring instrument as far as possible is to be avoided.

6. Confirmation of periodic tests and examinations

6.1 Following performance of the tests and examinations, the BKI Surveyor will issue the certificate, Form LA2/"Lifting Appliances Not Handling Cargo Test/ Examination Certificate" for load-tested loading gear.

6.2 The tests and examinations of the loading gear used for cargo handling will be certified by the BKI Surveyor in the Register book of Form LA1, and the certificate plus survey report added to the Register book.

6.3 The tests and examinations of the loading gear not used for cargo handling will be certified by the BKI Surveyor in the "Lifting Appliances Not Handling Cargo Test/ Examination Certificate".

6.4 The stamping required according to C.5 in advance of the issuing of certificates is in general not required for periodic load tests.

6.5 The system of certification and documentation for loading gear is described in G.

E. Extraordinary Tests and Examinations

Modifications, damage, renewals and special occasions may require extraordinary load tests and/or examinations, as described in the following.

1. General notes

1.1 The operator has to inform BKI if essential modifications are intended to be made to loading gear or loose gear, when damage affecting safety has occurred, or renewal of load-bearing structural elements is to be carried out.

1.2 In the cases described above, BKI decides on the respective measures, examinations and load tests.

1.3 Any essential modification and any repair or renewal of load-bearing components, with the exception of ropes and interchangeable components, is to be carried out under the supervision of BKI. Where this is not possible in individual cases because of the circumstances, a re-examination is to be carried out on a suitable date.

1.4 Extraordinary load tests and examinations may be credited towards the periodic tests and examinations, if they comply with the prescribed conditions with respect to type and scope.

1.5 All load tests shall be performed using weights, in the manner described in D.5.

Regarding certification of tests and examinations, the requirements in D.6 apply.

2. Essential modifications

2.1 Essential modifications are subject to the same tests and examinations as the initial manufacture.

2.2 Essential modifications include, besides renewal of load-bearing components, modifications of:

- nominal load
- load radius
- hoisting and/or luffing systems
- cable tackle system, unless different types of reeve are provided in the design
- load-bearing components

2.3 Non-essential modifications include modifications which will in no way affect safety and/or function of loading gear or loose gear. Such modifications shall be presented to the BKI Surveyor on his first visit to the ship after the modification has been carried out.

3. Damage

3.1 The requirements in F. are to be observed when an evaluation is made whether damage unduly affects the safety of loading gear or loose gear.

3.2 Damage affecting safety requires an examination of the damage and a repair plan with specific details, which is subject to approval by BKI Head Office.

Following repair, an examination within the necessary scope and a load test are required.

3.3 Depending on the evaluation of the damage, loading gear or loose gear shall be put out of operation or, where required, be operated at reduced nominal load and/or load radius.

Regarding repairs and operation at reduced nominal load, the requirements in F.9 apply.

3.4 Damage which does not affect safety shall be presented to the BKI Surveyor at the first visit to the ship after the occurrence of the damage.

4. Renewals

4.1 Following each renewal of load-bearing components of loading gear and loose gear, a load test and an associated examination of this gear is required.

4.2 The requirements of 4.1 do not apply to ropes and interchangeable components, because these are tested, examined and certified independently.

Renewal of axes, pins, rope-sheaves, etc. do not, in general, require a new load test.

The renewal of all parts mentioned shall be pointed out to the BKI Surveyor on the occasion of the following examination.

4.3 Following replacement or repair of winches, a load test is required, unless the winch has been load-tested on a test plant and certified accordingly.

4.4 Special occasions

BKI reserves the right to ask for extraordinary load tests and/or examinations in specially justified cases.

F. Wear, Damage, Repair

1. General notes

1.1 The details which follow regarding deformation, wear, tolerances, etc. are to be considered as reference values to assess the remaining margin of safety of damaged, corroded or worn components.

In the case of major damage, or in cases of doubt, BKI Head Office shall be consulted.

1.2 Any damaged, worn or corroded part which is not replaced shall, once the tolerances have been exceeded, be restored to the original dimensions using equivalent materials.

Regarding an alternative reduction of the nominal load, see 9.1.

1.3 For worn or corroded parts which are close to reaching the tolerance limits, the BKI Surveyor may determine a time period for repair or replacement.

1.4 Regarding loose gear, interchangeable components and ropes, reference is also made to Section 7, E and Section 8, E.3.3.

2. Acceptable reduction of plate thickness

2.1 For plates, profiles and pipes, the acceptable reduction of plate thickness is 10 %.

2.2 In cases of limited local corrosion or wear, a reduction of plate thickness of up to 20 % is acceptable provided this does not result in a reduction of the load-bearing capacity of the cross-section.

2.3 In cases of isolated pitting, a reduction of plate thickness of up to 30 % is acceptable.

2.4 Due to the above reductions of plate thickness, the characteristic values of a cross-section under consideration may be weakened at the most by 5 %.

3. Acceptable cracks

3.1 In Category 1 components (see Table 2.1), no cracks can be tolerated.

3.2 In lateral wind bracing, latticework crosspieces and similar stiffeners, or knee plates whose purpose is to reduce the slenderness ratio or stiffen load-bearing structures, cracks up to the following lengths are acceptable, if there is evidence that they do not extend into the load-bearing structure:

– 10 % of the connection length
– 3 x plate thickness,

the lower of the two values applying.

In the case of pipes, the connection length is the circumference.

In the case of box girders or beams, each chord, web and flange width is to be considered separately as a connection length.

4. Acceptable deformations

4.1 Deflections

4.1.1 Compression bars

.1 Under the maximum permissible loading, compression bars may not display uniform deflection greater than the equivalent of the bar length divided by 250.

.2 Unstressed compression bars, or those stressed only by their own weight, which are Category 1 components, may not display uniform deflection greater than the equivalent of the bar length divided by 500.

.3 Unstressed compression bars, or those stressed only by their own weight, which are Category 2 components, such as lateral wind bracing or latticework crosspieces, may not display uniform deflection greater than the equivalent of the bar length divided by 350.

4.1.2 Tension bars

Tension bars shall not, when unstressed, display uniform deflection greater than the equivalent of the bar length divided by 50.

4.1.3 Booms / jibs

.1 For booms subject to compressive stress under permissible load, the requirements in 4.1.1.1 apply. The uniform deflection due to the dead weight alone shall not be greater than the equivalent of the crane boom length divided by 350.

.2 The lowering of the top of the boom under load and/or dead weight is not limited when the permissible load is observed.

4.2 Deformation of chords and flanges

4.2.1 I-Beams

Each half-flange may individually or together be deformed by up to 15 % of its breadth, measured from web to outer edge.

4.2.2 Angle profiles

Flanges of angle profiles may individually or together be deformed by up to 15 % of their breadth, measured from flange to outer edge.

5. Acceptable indentations

The following requirements presuppose smooth transition pieces and apply provided that no bends, folds, cracks or thinning have developed.

5.1 Compression bars

5.1.1 Cylindrical pipes

.1 Pipes forming Category 1 components

The following conditions are to be observed:

$\ell \leq d$
$b \leq 0{,}25\ d$
$f \leq 0{,}5\ t$

where

ℓ = length of indentation measured in the longitudinal direction of the pipe
b = breadth of indentation
f = depth of indentation (depth gauge)
d = outer diameter
t = wall thickness

.2 Pipes forming Category 2 components

The following conditions are to be observed:

a) central range ($1/3\ell$)
$\ell \leq d$
$b \leq 0{,}5 \cdot d$
$f \leq t$

b) outer range
$\ell \leq 1{,}5 \cdot d$
$b \leq 0{,}7 \cdot d$
$f \leq 2 \cdot t$

5.1.2 Rectangular tubes and box girders

.1 In the case of rectangular tubes and box girders, indentations at the corners may have a depth corresponding to 8 % of the smallest side dimension.

.2 For acceptable indentations of plates, the requirements for cylindrical pipes similarly apply. Instead of the diameter, the side dimension of the plate under consideration is to be taken.

5.1.3 I-Beams

The webs of I-beams may not have any indentations.

5.1.4 Angle profiles

Angle profiles may not have any indentations at the corners.

5.2 Tension bars

In the case of tension bars, the indentation depth may be up to one third of the indentation length. The outer dimensions of hollow profiles, however, shall not be reduced by more than 25 % in the indentation area.

If necessary, the requirements of Section 3, C.5.2 shall be observed.

5.3 Girders subject to bending

5.3.1 Indentations at bearing or load introduction points are not acceptable.

5.3.2 In areas other than mentioned in 5.3.1, the rule is that indentations up to the dimensions in 5.1.1 and 5.1.2 are acceptable on the tension side; on the compression side, only dimensions of half that size.

6. Acceptable wear on rope-sheaves

6.1 The side wall thickness of rope sheaves made from normal-strength materials shall meet the following condition at the bottom of the groove:

$$t = \sqrt{0{,}85 \cdot F_S}$$

t = side wall thickness [mm]

F_S = static rope pull according to Section 8, B.3.2 [kN]

6.2 The details at 6.1 apply to disc, or spoked, DIN rope-sheaves meeting the D/d ratio stipulated in Table 8.3.

Rope-sheaves of grey cast iron are not permitted.

6.3 The wall thickness according to 6.1 may reduce in an upward direction to 1/3 at the outermost edge.

6.4 Rope imprints located at the bottom of the rope groove require a change to the pairing of rope and rope-sheave.

7. Acceptable wear on pins / Increase of bearing clearances

7.1 Pins

From the point of view of load-bearing capacity a reduction in diameter of 10 % is acceptable.

7.2 Bearing clearance

7.2.1 Foot bearings

The tolerable increase of bearing clearance is two times the initial clearance.

7.2.2 Bearings in general

Greater clearances than stated in 7.2.1 are acceptable if the pin's load-carrying capacity and ability to function are not adversely affected, and if no alternating load exists.

7.2.3 Rope-sheave bearings

The following bearing clearances are acceptable:

– 1 mm in antifriction bearings
– 2 mm in sliding bearings

8. Acceptable wear of mechanical parts

8.1 Gearings

8.1.1 In the case of toothed racks and other "open" drives, the width of the teeth on the pitch circle (rolling circle) may not be less than 55 % of that at the root of the teeth.

8.1.2 In the case of "enclosed" gears, parts or the entire set of gearing shall be renewed if the material on the pressure lines/working faces starts to break away (pitting).

8.1.3 Wedges or fitting keys shall be renewed if there are visible signs of wear.

8.2 Brakes

8.2.1 Wear on all types of brakes, in so far as visible, may only have reached the point where, in all probability, they can be used for one more year.

In the case of band brakes with riveted-on linings, the rivets may not make contact with the braking surface.

8.2.2 Electric or hydraulic winches with automatic standstill brakes may not have any slip, not even under test load.

8.2.3 Winches with manually-applied standstill brakes may not have any slip when the brake has been applied, not even under test load.

8.2.4 Hydraulic winches without standstill brakes may not, under nominal load, show more slip per minute than one meter travelling distance of the hook, or one full rotation of the drum. The lower of the two values applies.

9. Reduction of nominal load(s) / load radius (radii)

9.1 If a repair or replacement is not performed immediately, a reduction of nominal load(s)/load radius (radii) because of damage, unacceptable wear, corrosion or for other reasons is principally permissible as an alternative to putting out of service.

This measure may be temporary or, if permissible according to an appropriate evaluation, also unlimited.

9.2 A reduction according to 9.1 requires a load test and certificate for the modified working conditions, plus a corresponding entry in the Register book and a note in the survey statement.

9.3 The marking on the loading gear or loose gear shall be correspondingly changed for the time of reduction of the nominal load(s)/load radius (radii).

Where the reduction is intended to last an unlimited period of time, the rigging plans of the affected loading gear shall also be modified accordingly.

10. Repairs

10.1 If the acceptable limiting values described above have been achieved, or are expected to be achieved soon, the components are to be properly repaired or replaced.

10.2 In the case of repairs, care shall be taken to restore the initial condition as far as possible and to avoid any adverse microstructure changes in the materials involved as a result of heating.

10.3 Any repairs shall be entered into the Register book and the survey report.

G. Loading Gear Documentation

1. General notes

1.1 The central element of all loading gear documentation is a Register book, in which all appropriate certificates and information are collected and/or noted.

1.2 The different Register books and certificates to be issued by BKI are based on international or national regulations, in a form as interpreted by BKI.

1.3 Secure storage of the loading gear documentation throughout the entire working life of the loading gear, and the presentation of Register books, certificates, rigging plans and survey reports to the BKI Surveyor or authorized persons before the start of any test and/or examination, is the responsibility of the ship's management.

1.4 When the Register book, Form LA1 is full, another Register book shall be issued and supplied by the surveyor with the certificates and information still effective from the expired Register book.

The ship's management shall store the expired Register book for at least 5 years.

1.5 When ships in operation receive BKI Class, Register books and certificates of recognized societies or organizations are accepted and continued until the next 5-yearly thorough examination and load test.

2. Register books

2.1 Explanatory notes

2.1.1 The purpose of Register books for loading gear is to provide information at any time about the actual situation as regards general data, plus the test, examination and maintenance status.

2.1.2 On completion of successful initial tests and examinations, the Register books described below are handed over by the BKI Surveyor to the shipyard or the ship's management after the stipulated certificates have been added and the examinations made have been confirmed in it.

2.1.3 In the Register books, certificates, results of examinations and, where required, survey reports and other information are collected. They are to be stored at the place of operation and submitted to the BKI Surveyor or to authorized persons on demand.

2.1.4 If a Register book is lost, a new one can be produced on the basis of a test and examination and with the help of BKI Head Office (supply of Certified True Copies, etc.).

2.1.5 A Register book normally includes several sets of loading gear. If it is reasonable, Register books may also be issued individually for loading gear, interchangeable crane boom systems on board floating cranes, loose gear, etc.

2.1.6 Special versions differing from the Register books described below may be issued by BKI or the operator (e.g. authority), if this is required or desired.

2.2 Register book for loading gear used for cargo handling (Form LA1)

2.2.1 For loading gear used for cargo handling, the BKI Surveyor issues a Register Book of Form LA1, which is based on a model ILO Register book.

2.2.2 Together with the relevant certificates, the Register book is handed over in a protective cover which also contains the rigging plans described In 4. and further serves to accommodate the survey reports.

2.2.3 Parts 1 and 2 of the Register book are reserved for entries by the BKI Surveyor, whereas the inspection of loose gear in part 3 and maintenance measures in part 4 are to be confirmed by the ship's management.

Entries by the BKI Surveyor refer to the recording of newly added certificates, the confirmation of examinations carried out and to special notes.

2.3 Register books for loading gear not used for cargo handling

2.3.1 BKI documentation folder

If no special Register book is required, certificates, survey reports and confirmations of inspection and/or maintenance measures by the ship's management are compiled in a BKI documentation folder and stored on board.

2.3.2 Register

As an alternative to 2.3.1 or 2.3.2 a "Register of Ship's Lifting Appliances not serving cargo handling" may be issued. This Register book shall be issued if required by national regulations.

3. Certificates

3.1 Recognition of certificates

Certificates for loading gear, interchangeable components and ropes, as well as for loose gear, shall be issued using the forms described in the following.

In special cases or by agreement, BKI may recognize deviating forms or certificates not issued by the BKI Surveyors.

3.2 Certificates for loading gear used for cargo handling

3.2.1 The following forms of certificates are based on ILO model certificates:

- Form LA2;
  Certificate of test and thorough examination of Lifting Appliances
- Form LA2(U);
  Certificate of test and thorough examination of Derricks used in union purchase
- Form LA3.
  Certificate of test and thorough examination of Interchangeable Components and Loose Gear
- Form LA4.
  Certificate of test and examination of wire rope

3.2.2 Load tests are confirmed by Forms LA2 to LA3, tensile tests by Form LA4.

In addition, Forms LA3 and LA4 confirm an examination after the test.

3.2.3 Forms LA2 to LA3 are issued new after each load test of loading gear or loose gear made for this equipment. Interchangeable components used in the tests receive no new certificate.

3.2.4 The certificates, Forms LA2 to LA4, may include several sets of loading gear, interchangeable components or loose gear.

3.2.5 The certificate, Form LA4, is issued after the stipulated tensile breaking test and examination by the BKI Surveyors or by BKI-approved firms.

3.2.6 Newly procured interchangeable components, loose gear and ropes shall be taken on board together with their certificates.

3.2.7 The numbers of all certificates issued on Forms LA2 to LA3 are to be entered by the BKI Surveyor in the appropriate parts of the Register book of Form LA1. This provides the connection between Register book and certificates.

3.3 Certificates for loading gear not used for cargo handling

3.3.1 BKI certification system

.1 When no special requirements are to be observed, the following form of certificate will be issued:

– ”Lifting Appliances Not Handling Cargo Test/ Examination Certificate”

.2 The purpose of certificate “Lifting Appliances Not Handling Cargo Test/ Examination Certificate” is to confirm a load test and associated examination.

Subsequently, the following annual examinations will also be confirmed by this certificate.

.3 “Lifting Appliances Not Handling Cargo Test/ Examination Certificate” applies to a single piece of loading gear and will be issued anew after each periodic load test.

.4 The certificates required in addition for interchangeable components, loose gear and ropes are listed in 6.2.2.

3.3.2 ILO certification system

The application of the certification system described in 3.2 may be prescribed or agreed.

3.4 Special certificate forms

3.4.1 Certificate of Class for Loading gear

.1 If the Classification of a set of loading gear, as described in Section 1, A.4.2, is agreed or prescribed, BKI issues the following certificate forms, in addition to the certificates described above:

– “Certificate of Class for Loading Gear”

.2 On completion of all tests and examinations, and following receipt of copies of the certificates and the survey report, the class certificate is issued by the Head Office and sent to the ship’s owner.

The owner shall have the Certificate of Class added to the Register book on board the ship.

3.4.2 Certificates for fibre ropes

.1 For fibre ropes, the following certificate form is provided:

– Certificate of test and examination of fibre ropes

.2 Certificate of test and examination of fibre ropes is issued by the BKI Surveyor or by BKI approved manufacturers, following the stipulated tensile breaking test and examination.

3.4.3 BKI test certificate (general form)

.1 The following BKI certificate form is issued to confirm tests and/or examinations of all kinds:

– Test Certificate

.2 Test Certificate is also issued in conjunction with load tests of loose gear and interchangeable components, insofar as these are not put into use on ships, or if the ship is not known.

.3 In special cases, e.g. for particular Register books issued by authorities, Test Certificate may replace all certificates described in 3.2 and 3.3.1.

4. Rigging plans

4.1 Rigging plans are required by the ILO for loading gear used for cargo handling. Loading gear not used for cargo handling, is not covered there.

They contain information useful for operation and maintenance, and for the procurement of spare parts and repair.

4.2 Rigging plans, for instance, have information on nominal loads and load radii, ropes, reeving of ropes, marking, arrangement of the loading gear on board the ship, working ranges, etc.

4.3 In the rigging plan examples given in Annex D:

- arrangement of loading gear, and
- reeving of ropes for loading gear,

the necessary nominal sizes of the individual parts, the minimum breaking load of the ropes and the special conditions for operation of the lifting appliances where required are to be indicated clearly.

4.4 For construction of the ship, the plans for the arrangement of loading gear shall be prepared by the yard, the plans for the reeving of ropes for the loading gear by the loading gear manufacturer.

5. Survey reports

5.1 For each test and/or examination of loading gear and loose gear, a survey report is prepared by the BKI Surveyor.

This report may be part of the overall report for the ship.

5.2 Each survey report number which refers to loading gear and loose gear is entered into a list in the Register book of Form LA1.

5.3 A copy of the survey report is added to the Register books in the form described in 2.3.1 and 2.3.2 if specific findings have resulted from the examination or if special measures have been or shall become necessary.

6. Documentation for the operator

6.1 General notes

6.1.1 For shipborne loading gear and loading gear on offshore installations, the documentation handed over by BKI consists of the Register books including certificates, rigging plans, lists and survey reports in the scope described below.

6.1.2 Flag state requirements may prescribe deviating national Register books, and authorities may keep their own Register books

6.2 Scope of documentation

6.2.1 BKI Register book of Form LA1

In accordance with its intended purpose, this Register book contains:

- BKI certificate(s), Form LA2, where required additionally Form LA2 (U).

- BKI certificate(s), Form LA3
- BKI certificate(s), Form LA4
- rigging plans
- where required, additionally “Certificate of Class for Loading Gear“
- survey reports

6.2.2 BKI documentation folder (Lifting appliances not handling cargo)

In accordance with its intended purpose, this folder contains:

- BKI certificate(s) “Lifting Appliances not handling cargo test/Examination Certificate“
- Form LA3 for interchangeable components
- Form LA4 for wire ropes
- where required, Form LA3 for loose gear
- where required, rigging plans
- survey statements, if issued

6.2.3 BKI Register (Lifting appliances not handling cargo)

In accordance with its intended purpose, this Register contains:

- cover sheet “Register of Ship’s Lifting Appliances not serving cargo handling”
- “List of continuous inspection and maintenance”
- BKI Certificate(s) “Lifting Appliances not handling cargo test/Examination Certificate”
- Form LA3 for interchangeable components
- Form LA4 for wire ropes
- Certificate of heat treatment of Interchangeable Components and Loose Gear
- where required, Form LA3 for loose gear
- where required, rigging plans
- survey statements, if issued

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Annex A Calculation of Dynamic Forces due to Motions of the Ship

A. General ...A–1
B. Dynamic Forces generated by Ships and Similar Floating Bodies ...A–1
C. Dynamic Forces due to Pontoons or Barges ...A–3

A. General

1. Dynamic forces due to motions in the seaway may be calculated by hydrodynamic methods from the movements of the floating bodies under consideration, alternatively also simplified as per 2 or 3.

2. For the sake of simplification the calculation of the dynamic forces can be conducted according to B.1.2 and B.2.2 with the ship's inclinations in Table A.1 or with agreed ship's inclinations.

3. Where calculated or agreed values for the ship's inclinations and natural periods exist, the dynamic forces may be calculated using the values according to B.1.3 and B.2.3, see also Annex B, E.

4. The dynamic forces for rolling and pitching each including also a force component of 20 % for heaving are to be considered separately, i.e. as not acting simultaneously.

5. The following approaches apply to monohull ships. With regard to other ship forms such as semisubmersibles, it is recommended that BKI be consulted.

B. Dynamic Forces generated by Ships and Similar Floating Bodies

1. Dynamic forces due to rolling

1.1 Designations of the dimensions and forces are shown in Fig. A.1.

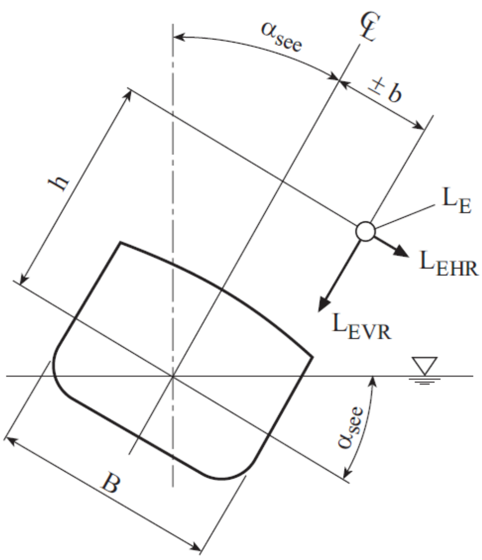

Fig. A.1 Vertical and horizontal forces due to rolling

L_E = dead load [kN]

α_{see} = roll angle acc. to Table A.1 [°]

b = distance from centre line of ship [m]

h = height above waterline [m]

1.2 Calculation of dynamic forces acc. to A.2

$$L_{EVR} \approx L_E \cdot \left(1{,}2 \cdot \cos\alpha_{see} + \frac{\alpha_{see} \cdot b \cdot L}{10^3 \cdot B^2}\right) \quad [kN]$$

$$L_{EHR} \approx L_E \cdot \left(1{,}2 \cdot \sin\alpha_{see} + \frac{\alpha_{see} \cdot h \cdot L}{10^3 \cdot B^2}\right) [kN]$$

B = breadth of ship [m]

L = length of ship between perpendiculars [m]

1.3 Calculation of dynamic forces acc. to A.3

$$L_{EVR} \approx L_E \cdot \left[\left(1 + \frac{L}{20 \cdot T_T^2}\right) \cdot \cos\alpha_{see} + \frac{\alpha_{see} \cdot b}{14{,}3 \cdot T_R^2}\right] \quad [kN]$$

$$L_{EHR} \approx L_E \cdot \left[\left(1 + \frac{L}{20 \cdot T_T^2}\right) \cdot \sin\alpha_{see} + \frac{\alpha_{see} \cdot h}{14{,}3 \cdot T_R^2}\right] \quad [kN]$$

T_T = natural period of heaving [s]

T_R = natural period of rolling [s]

2. Dynamic forces due to pitching

2.1 Designations of the dimensions and forces are shown in Fig. A.2.

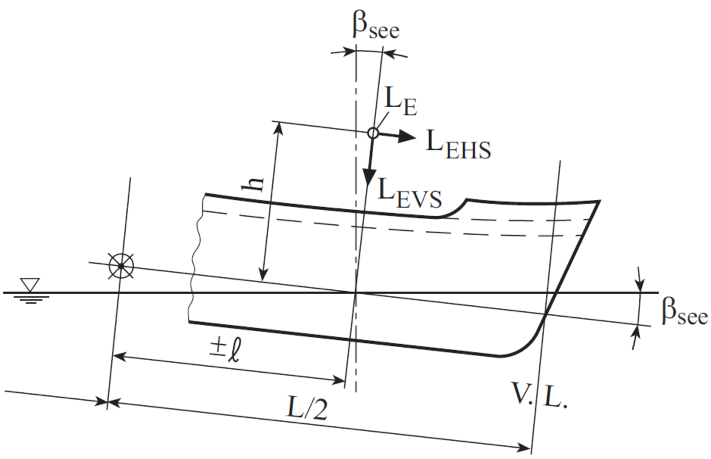

Fig. A.2 Vertical and horizontal forces due to pitching

β_{see} = pitch angle acc. to Table A.1 [°]

ℓ = distance from midship section, ahead or astern [m]

V.L. = fore perpendicular

2.2 Calculation of dynamic forces acc. to A.2

$$L_{EVS} \approx L_E \cdot \left(1{,}2 \cdot \cos\beta_{see} + \frac{\beta_{see} \cdot \ell}{3{,}6 \cdot \mathbf{L}}\right) \quad [kN]$$

$$L_{EHS} \approx L_E \cdot \left(1{,}2 \cdot \sin\beta_{see} + \frac{\beta_{see} \cdot h}{3{,}6 \cdot \mathbf{L}}\right) \quad [kN]$$

2.3 Calculation of dynamic forces acc. to A.3

$$L_{EVS} \approx L_E \cdot \left[\left(1 + \frac{L}{20 \cdot T_T^2}\right) \cdot \cos\beta_{see} + \frac{\beta_{see} \cdot \ell}{14{,}3 \cdot T_S^2}\right] \quad [kN]$$

$$L_{EHS} \approx L_E \cdot \left[\left(1 + \frac{L}{20 \cdot T_T^2}\right) \cdot \sin\beta_{see} + \frac{\beta_{see} \cdot h}{14{,}3 \cdot T_S^2}\right] \quad [kN]$$

T_S = natural period of pitching [s]

C. Dynamic Forces due to Pontoons or Barges

The following requirements are based on the calculations in B.1 and B.2.

1. Dynamic forces due to rolling

Regarding pontoon-type ship forms, calculation of dynamic forces shall be based on specified values for the natural periods and dynamic inclination of heeling (calculation according to B.1.3).

2. Dynamic forces due to pitching

For the calculation of dynamic forces due to pitching, the approaches in B.2.3 apply with laid down values for natural periods and for the dynamic inclination of pitching.

Table A.1 Dynamic inclinations

Type of floating body	Heel angle α_{see}	Trim angle β_{see}
Ships and similar floating bodies	$\pm 30°$	$\pm 1{,}2 \cdot e^{(-L/250)}$
Pontoons/barges	$\pm (3° + \Delta\alpha_{see})$ [1]	$\pm (1{,}5° + \Delta\beta_{see})$ [2]
Semi-submersibles[3]	$\pm 6°$	$\pm 6°$

[1] $\Delta\alpha_{see}$ is the smaller value of heel, either causing immersion of the deck or emerging of the bilge in calm water

[2] $\Delta\beta_{see}$ is the smaller value of trim either causing immersion of bow or stern, or emerging of stem or stern frame in calm water

[3] Basic values for calculation by BKI, see A.5

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Annex B Hook Load of Subsea Operations

A. General B–1
B. Design Loads B–1
C. Forces on Load when Lowered Through Water Surface B–2
D. Forces on Submerged Load B–4
E. Crane Tip Dynamics of Offshore Cranes B–5

A. General

1. Preferably, forces on submerged loads caused by ship motions and crane lifts during underwater operations are to be assessed by performing suitable hydrodynamic analyses. Alternatively, these forces may be estimated by following the procedure described in C. to E.

2. The procedure in C. to E. is applicable to single hull ships. For other hull shapes, such as semisubmersible platforms, BKI should be consulted.

3. To explicitly distinguish between harbour and open sea operations, loads, forces and coefficients are identified by index “u” plus an additional numeral 1 or 2. Numeral 1 identifies these loads, forces and coefficients when the load is being lowered through the sea surface; numeral 2, when the load is fully submerged.

4. The following relation applies:

$L = F/g$ where L in [t]; F in [kN]

B. Design Loads

1. Hoist load L_{Hu}

L_{Hu} = $L_{EA} + L_{Nu}$ [t]

L_{EA} = effective share of crane’s dead load [t]

L_{Nu} = safe working load for underwater operations [t]

= $(F_{stat} + F_{hyd})/g$

F_{stat} = hydrostatic force component according to C.1 or D.1 [kN]

F_{hyd} = hydrodynamic force component according to C.1 or D.1 [kN]

2. Hoist load coefficient ψ_u

$$\psi_u = \frac{F_{stat} + F_{hyd}}{F_{stat}} = \frac{F_g}{F_{stat}}$$

F_g = total force acting on load according to C.1 or D.1 [kN]

3. Condition to be complied with

$$L_{Ne} \cdot \psi \geq L_{Nsee} \cdot \psi_{see} \geq L_{Nu} \cdot \psi_u$$

C. Forces on Load when Lowered Through Water Surface

1. Total force on load L_{Nu1}

The total force acting on the load when lowered through the water surface may be estimated as follows:

$$F_{g1} = F_{stat1} \pm F_{hyd1}$$

F_{g1} = total force on load [kN]

F_{stat1} = hydrostatic submerged weight of load [kN]

F_{hyd1} = hydrodynamic force on submerged part of load [kN]

2. Hydrostatic force F_{stat1}

The hydrostatic force acting on the load when lowered through the water surface may be estimated as follows:

$$F_{stat1} = m \cdot g - \rho \cdot V_d \cdot g$$

m = mass of load [t]

g = acceleration of gravity [m/s^2]

ρ = density of water [t/m^3]

V_d = displaced volume of submerged part of load [m^3]

3. Hydrodynamic force F_{hyd1}

The hydrodynamic force acting on the load when lowered through the water surface may be estimated as follows:

$$F_{hyd1} = F_{slam} + F_{mk} + F_D + F_I$$

F_{slam} = slamming impact force [kN]

F_{mk} = impulsive mass force [kN]

F_D = hydrodynamic drag force [kN]

F_I = hydrodynamic inertia force [kN]

3.1 Slamming impact force F_{slam}

The slamming impact force acting on the bottom of the load when lowered through the water surface may be estimated as follows:

$$F_{slam} = 0{,}5 \cdot \rho \cdot k_s \cdot A_p \cdot v_s^2$$

k_s = slamming coefficient

= 3,0 for smooth circular cylinders

= 5,0 for other shapes

Alternatively, the slamming coefficient k_s may be determined experimentally.

A_p = projected area of load elements penetrating the water surface [m^2]

v_s = vertical slamming impact velocity [m/s]

The vertical slamming impact velocity may be estimated as follows:

$$v_s = v_h + 0{,}44\ v_{r0}\left(\frac{v_h}{v_{r0}}\right)^{-0{,}2}$$

v_h = crane tip velocity (typical = 0,5 m/s)

v_{r0} = vertical relative velocity between load and water particles at the water surface [m/s]

The vertical relative velocity between load and water particles at the water surface may be estimated as follows:

$$V_{r0} = \sqrt{v_A^2 + g \cdot H_{1/3} / \pi}$$

v_A = highest value of vertical crane tip velocity [m/s]

$H_{1/3}$ = significant wave height [m]

3.2 Impulsive mass force Fmk

The impulsive mass force acting on the load may be estimated as follows:

$$F_{mk} = m\left(g + v_r\sqrt{\frac{c}{m}}\right)$$

m = mass of load in air [t]

v_r = vertical relative velocity between load and water particles [m/s]

c = stiffness constant of lifting appliance and its foundation [kN/m]

The vertical relative velocity between load and water particles may be estimated as follows:

$$v_r = \sqrt{v_A^2 + v_d^2}$$

v_A = crane tip vertical velocity according to E.2 [m/s]

v_d = vertical velocity of water at center of gravity of submerged part of load [m/s]

$$= \sqrt{\frac{g \cdot H_{1/3}}{\pi}}\left(e^{-0{,}34d/H_{1/3}}\right)$$

d = distance from water surface to center of gravity of submerged part of load [m]

3.3 Hydrodynamic drag force F_D

The hydrodynamic drag force depends on the relative vertical velocity between load and water particles and may be estimated as follows:

$$F_D = 0{,}5 \cdot \rho \cdot C_d \cdot A_p \cdot v_r^2$$

C_d = drag coefficient, see Rules for Structures (Pt. 5, Vol. II) Sec.2

A_p = horizontal projected area of load [m²]

3.4 Hydrodynamic inertia force F_I

The hydrodynamic inertia force depends on the vertical acceleration of the load and may be estimated as follows:

$$F_I = (m + m_{hyd}) \cdot a_A$$

m_{hyd} = hydrodynamic added mass of load [t]

= $\rho \cdot V_d \cdot C_m$

V_d = volume of displaced water [m³]

C_m = hydrodynamic added mass coefficient, see Rules for Structures (Pt. 5, Vol. II) Sec.2

For a_A, see E.3.

D. Forces on Submerged Load

1. Total force on submerged load L_{Nu2}

The total force acting on the submerged load may be estimated as follows:

$$F_{g2} = F_{stat2} \pm F_{hyd2}$$

F_{g2} = total force acting on submerged load [kN]

F_{stat2} = hydrostatic submerged weight of load [kN]

= $m \cdot g - \rho \cdot V \cdot g$

V = volume of water displaced by submerged load [m³]

F_{hyd2} = hydrodynamic force acting on submerged load [kN]

2. Hydrodynamic force on submerged load F_{hyd2}

The hydrodynamic force acting on the submerged load may be estimated as follows:

$$F_{hyd2} = \sqrt{F_m^2 + F_D^2}$$

F_m = hydrodynamic mass force [kN]

F_D = hydrodynamic drag force [kN]

2.1 Hydrodynamic inertia force F_m

The hydrodynamic mass force, caused by the acceleration of the submerged load and the acceleration of the surrounding water, may be estimated as follows:

$$F_m = (m + m_{hyd})\, a_A + \rho \cdot V \cdot a_w + m_{hyd} \cdot a_w$$

For m, see C.3.2.

For m_{hyd}, see C.3.4.

a_w = vertical water particle acceleration at center of gravity of the submerged load [m/s²]

The vertical water particle acceleration may be estimated as follows:

$$a_w = \frac{g \cdot H_{1/3}^2 / \pi}{H_{1/3} + d}$$

$H_{1/3}$ = significant wave height [m]

d = distance from water surface to center of gravity of submerged load [m]

2.2 Hydrodynamic drag force F_D

To estimate the hydrodynamic drag force, see C.3.3.

E. Crane Tip Dynamics of Offshore Cranes

The following procedure applies to cranes having a lifting capacity $L_{Ne} \leq 60$ t.

1. Crane tip vertical motion

The crane tip's vertical motion may be estimated as follows:

$$s_A = \sqrt{s_3^2 + (b \cdot \sin\alpha_{see})^2 + (l \cdot \sin\beta_{see})^2}$$

s_A = highest value of vertical motion amplitude of crane tip [m]

s_3 = highest value of heave amplitude [m]

= (for an estimate: $s_3 \approx \frac{H_{1/3}}{4}$)

b = horizontal distance from ship centerline to crane tip [m]

l = horizontal distance from amidships to crane tip [m]

α_{see} = roll angle [°]

α_{see} = pitch angle [°]

For roll and pitch angles, see Table 3.1 unless obtained from a motion analysis or agreed upon otherwise.

2. Crane tip vertical velocity

The crane tip's vertical velocity may be estimated as follows:

$$v_A = 2\pi\sqrt{\left(\frac{s_3}{T_T}\right)^2 + \left(\frac{b \cdot \sin\alpha_{see}}{T_R}\right)^2 + \left(\frac{l \cdot \sin\beta_{see}}{T_S}\right)^2}$$

v_A = highest value of vertical crane tip velocity [m/s]

T_T = heave natural period [s]

T_R = roll natural period [s]

T_S = pitch natural period [s]

Natural periods of heave, roll, and pitch may be estimated as follows:

$$T_T = T_S$$

$$T_R = \frac{\pi \cdot B}{\sqrt{1{,}9 \cdot g \cdot M_T}} \quad [s] \qquad \text{for an estimate: } M_T \approx 0{,}0075 \cdot L$$

$$T_S = \frac{\pi \cdot L}{\sqrt{3{,}7 \cdot g \cdot M_L}} \quad [s] \qquad \text{for an estimate: } M_L \approx L$$

L = ship length between perpendiculars [m]

B = ship breadth [m]

g = acceleration of gravity [m/s^2]

M_T = transverse metacentric height [m]

M_L = longitudinal metacentric height [m]

Alternatively, these natural periods may be obtained from a separate sea-keeping analysis of the ship in waves.

3. Crane tip vertical acceleration

The crane tip's vertical acceleration may be estimated as follows:

$$a_A = 4\pi^2\sqrt{\left(\frac{s_3}{T_T^{\,2}}\right)^2 + \left(\frac{b \cdot \sin\alpha_{see}}{T_R^{\,2}}\right)^2 + \left(\frac{l \cdot \sin\beta_{see}}{T_S^{\,2}}\right)^2}$$

a_A = highest value of vertical crane tip acceleration [m/s^2]

Annex C Wind Loads, Form and Sheltering Coefficients

A. General C–1
B. Form Coefficients c_f C–1
C. Sheltering Coefficients η C–1

A. General

1. For the determination of wind loads acting on loading gear onboard ships, it is normally sufficient to use simplified form coefficients and to consider wind load reductions of areas arranged behind one another according to Section 3, B.4.5.4 and B.4.5.5.

2. Using form and sheltering coefficients from this Annex, which depend on various parameters, may lead to a reduction of wind loads, if compared to the statements in Section 4.

B. Form Coefficients c_f

1. The form coefficients for individual structural components and lattice frames, as well as for enclosed superstructures such as e.g. machine houses on a solid bottom plate, are given in Table C.1.

2. The form coefficients in Table C.1 depend on the aerodynamic slenderness ratio, see Fig. C.1.

3. Where, in the case of lattice constructions, the distance between nodes is defined as the length of the individual structural elements, see Fig. C.2, normally dimensioned gusset plates need not be considered.

4. The wind load on lattice beams can be calculated using the form coefficients in Table C.1. In this case, the aerodynamic slenderness ratio of each individual lattice bar shall be considered.

5. As an alternative to 4., the global form coefficients in Table C.1 may be used for lattice beams, if the lattice bars consist of round profiles or of profiles with flat sides.

C. Sheltering Coefficients η

1. Where components are arranged in such a way that they shelter one another, the wind loads on the sheltered components may be calculated by multiplication with the applicable sheltering coefficient η acc. to Table C.2.

2. Where several components are arranged at the same distance in a row so that they shelter one another, the sheltering effect increases up to the 9th component and then remains constant.

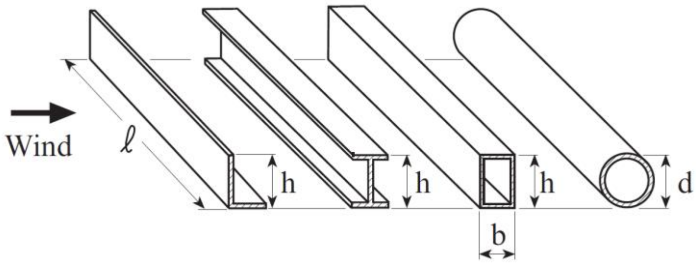
3. The wind load on areas arranged one after another is calculated as follows:

– first area: $L_{W1} = q \cdot c_f \cdot A_w$ (Section 3, B.4.5.2)

– second area: $L_{W2} = L_{W1} \cdot \eta$

– n^{th} area: $L_{Wn} = L_{W1} \cdot \eta^{(n-1)} \geq L_{W1} \cdot 0{,}1$

– 9th and following areas: $L_{W9} = L_{W1} \cdot \eta^8 \geq L_{W1} \cdot 0{,}1$

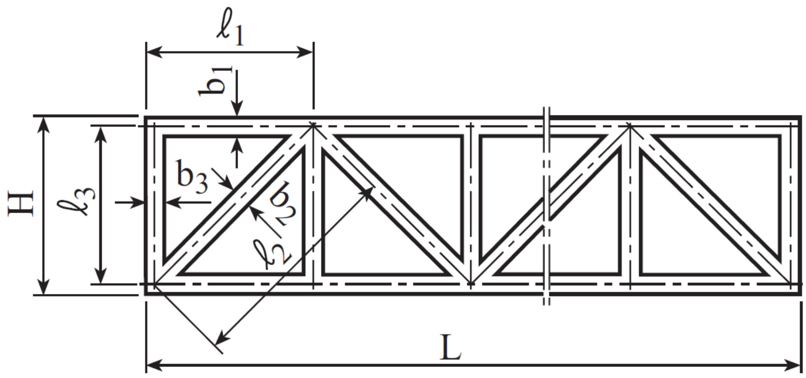


Slenderness ration on rolled section: ℓ/h

Slenderness ratio on round profiles: ℓ/d

Cross-section ratio of box profiles: h/b

Fig. C.1 Aerodynamic slenderness ratio and section ratio



$$\text{Area ratio} = \frac{A_B}{A_U} = \sum_1^n \frac{\ell_i \cdot b_i}{L \cdot H}$$

A_B = Area of components [m²]

A_U = Contour area [m²]

Fig. C.2 Area Ratio

Table C.1 Form coefficients c

Component groups	Description		Aerodynamic slenderness ratio ℓ/h or ℓ/d [1]					
			≤ 5	10	20	30	40	≥ 50
Components	Rolled profile such as I L C T I Box profiles square h < 0,4 m rectangular h < 0,5 m		1,3	1,35	1,6	1,65	1,7	1,8
	Round profiles[2] $d \cdot v < 6\ m^2/s$		0,7	0,75	0,8	0,85	0,9	1,0
	$d \cdot v \geq 6\ m^2/s$		0,6	0,65	0,7	0,7	0,75	0,8
	Box profiles	h/b[1]						
	Square	≥ 2	1,55	1,75	1,95	2,10	2,2	
	h ≥ 0,4 m	1	1,5	1,55	1,75	1,85	1,9	
	rectangular	0,5	1,0	1,2	1,3	1,35	1,4	
	h ≥ 0,5 m	0,25	0,8	0,9	0,9	1,0	1,0	
Global form coefficients for lattice beams	profiles with flat sides		1,7					
	Round profiles[2] $d \cdot v < 6\ m^2/s$		1,1					
	$d \cdot v \geq 6\ m^2/s$		0,8					
Machine houses, etc.	Rectangular, enclosed constructions on a solid bottom plate		1,1					

[1] see Fig. C.1

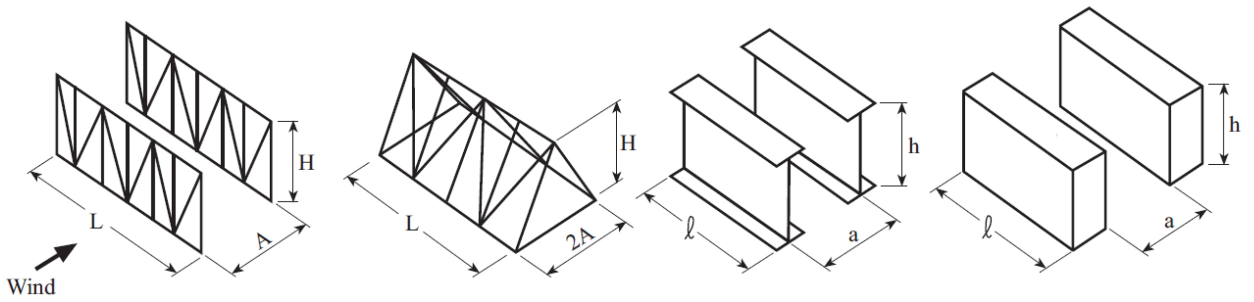
[2] v = wind speed according to Section 3, B.4.5.3

Table C.2 Sheltering coefficients η

Distance ratio A/H or a/h[2]	Area ratio A_B/A_U[1]					
	0,1	**0,2**	**0,3**	**0,4**	**0,5**	**≥ 0,6**
0,5	0,75	0,4	0,32	0,21	0,15	0,1
1,0	0,92	0,75	0,59	0,43	0,25	0,1
2,0	0,95	0,8	0,63	0,5	0,33	0,2
4,0	1,0	0,88	0,76	0,66	0,55	0,45
5,0	1,0	0,95	0,88	0,81	0,75	0,68
6,0	1,0	1,0	1,0	1,0	1,0	1,0

[1] see Fig. C.2

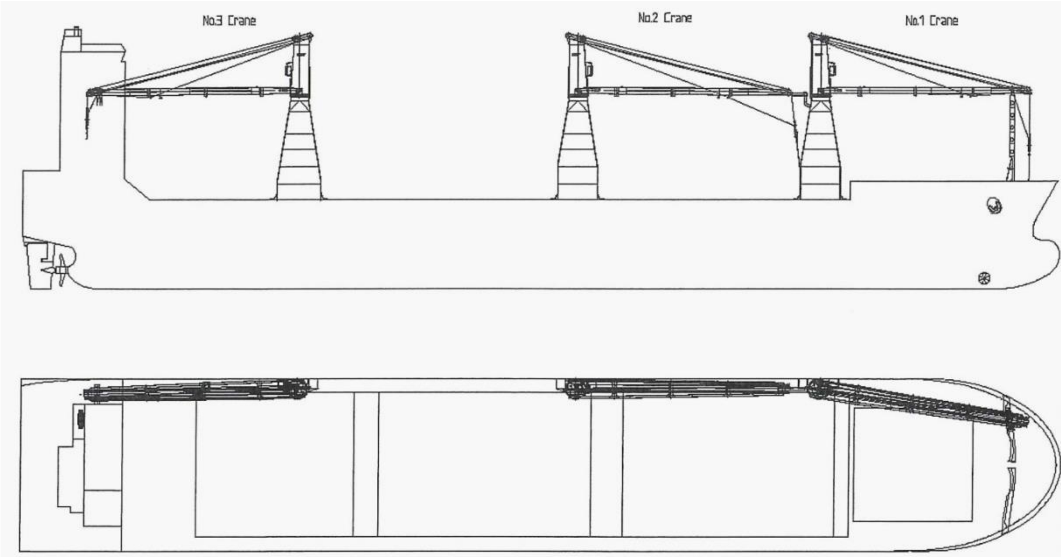
[2] see Fig. C.3



Distance ratio of girders $= \frac{A}{H}$ Distance ratio of profiles $= \frac{a}{h}$

Fig. C.3 Distance ratio

Annex D Rigging Plan



PLAN OF CARGO LIFTING GEARE

Derrick (Crane) NO.	SWL	Angle of Derrick	Length of derrick	l-a / l	Outreach	Tension in: Cargo runner	Tension in: Span rope	Tension in: aux. cargo runner	Number of sheaves: Cargo Purchase	Number of sheaves: Span tackle	Overhead sheave	Span lead block	Cargo runner		Span Rope		Aux cargo runner		Mark	Load limitation: Derrick	Load limitation: Load moment	Union Purchase: Derricks	Union Purchase: SWL	Preventers	
	t		m		m	kN	kN	kN					∅ mm	Br kN	∅ mm	Br kN	∅ mm	Br kN	SWL		mt		t	∅ mm	Br t
No.1	80		34,206		5,0-20,0														80t 5,0-20,0						
No.1	60		34,206		4,0-26,5														60t 4,0-26,5						
No.1	45		34,206		4,0-33,0														45t 4,0-33,0						
No.2	80		36,517		5,0-20,0														80t 5,0-20,0						
No.2	60		36,517		4,0-26,5														60t 4,0-26,5						
No.2	45		36,517		4,0-33,0														45t 4,0-33,0						
No.3	80		34,206		5,0-20,0														80t 5,0-20,0						
No.3	60		34,206		4,0-26,5														60t 4,0-26,5						
No.3	45		34,206		4,0-33,0														45t 4,0-33,0						

Slewing guy units for heavy lift

Derricks	Pendent ∅ mm	Pendent Br t	Tackle	Tackle ∅ mm	Tackle Br t

Special condition admissible heel 5°

	No	Manufactures	Certificate No	Normal size	Type of drive	Notes	Journal no.	Date	Item	Previously approved for yards no.
	Certification						Checking of drawings			
Span winches										
Cargo winches										
Mas a. post										
Derricks										
Crane	No 1 No 2 No 3			80 t	hydrl.					

Name of owner	Name of ship:	Yard:
Class Register No. / Code of letters:	Port of registry / Class:	Yard No: / Page 1/2

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