

TO ALL FLEET VESSELS

Ref: DMA-SAPID/AIFI01/00/C1144

Date: 2021.08.25

In The Name Of God

Dear Captain
Good Day,

Pl's find attached file "**Shipboard lifting appliances**" for your kind attention and necessary precaution measures.

Noted, that this manual is very useful for procedure of test, operation, maintenance and certification & documentation related to all lifting appliances on your board of ship.

Pl's take copy of this manual & keep on Master library.

You are requested to confirm receipt, discuss the contents in the next consolidated meeting on board & keep a copy in the file DA-11 .

BEST REGARDS

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STANDARD

DNVGL-ST-0377

Edition October 2018

Shipboard lifting appliances



FOREWORD

DNV GL standards contain requirements, principles and acceptance criteria for objects, personnel, organisations and/or operations.

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Any comments may be sent by e-mail to rules@dnvgl.com

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CHANGES - CURRENT

This document supersedes the May 2016 edition.

Changes in this document are highlighted in red colour. However, if the changes involve a whole chapter, section or subsection, normally only the title will be in red colour.

Changes October 2018, entering into force as from date of publication

• Sec.1

- Revision of definitions.
- Topic *Design temperature* ([1.1.7] and [1.1.8]) deleted (shifted to and merged with [4.2.3]).
- Clarification on certification process.

• Sec.2

- Table 2-1 *Documentation requirements* revised and column *Additional description* completed.

• Sec.3

- This section has been aligned with DNVGL-ST-0378.

• Sec.4

- [4.2.3] *Design temperature* revised. Previous [1.1.7] and [1.1.8] have been included.
- See DNVGL-CG-0194 included in [4.9.2] *Hydraulic cylinders*.

• Sec.7

- Second paragraph in [7.3.6.1.1] has been replaced completely.
- Revision of Table 7-4 *Static test loads for interchangeable components* concerning single-sheaved blocks.

• Sec.8

- Obsolete topic "natural fibre ropes" has been removed from this standard.
- [8.1.2] *Certification requirements* is a new paragraph. Previous [8.1.2] *Approval for manufacture* has been replaced completely.
- Requirements for metallic rope sheaves revised, see [8.2.4.2.2].
- Table 8-3 *Minimum diameter of rope sheaves and rope drums* revised (increased values in column *nominal tensile strength of wire ropes*).
- Clarification on tensile tests of wire ropes (additional paragraph [8.5.1.1.2] and additional Table 8-6).
- Specification of dimensional check of wire ropes (additional paragraph [8.5.1.1.3]).
- Specification of wire ropes' identification colours, see [8.5.1.1.4].
- Revision of discard criteria for wire ropes, see [8.5.3.3].

• Sec.9

- Previous Table 9-1 deleted.

- **Sec.11**

- Clarification on requirements concerning cold forming, see [11.2.3.3].
- Clarification on requirements concerning corrosion protection of bolts and nuts, see [11.2.3.5.5].
- Clarification on requirements concerning welding consumables, see [11.2.4.4.1].
- Revision of the requirements for welding in cold-formed areas, see [11.3.2.7].
- Revision of the requirements for non-destructive tests, see [11.5.8].

- **Sec.12**

- Clarification concerning emergency exits, see [12.2.1.3.2].

- **Sec.13**

- Clarification on certification and reporting of manufacturing surveys and tests, see [13.2.7].
- Clarification on initial load tests, see [13.3.3.1.2].

Editorial corrections

In addition to the above stated changes, editorial corrections may have been made.

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SECTION 1 GENERAL INFORMATION

1.1 Introduction

1.1.1 Objective

1.1.1.1 This standard provides requirements for certification and verification of lifting appliances intended for load handling within and outside ship while in the harbour or in sheltered waters and within the ship while at sea.

Guidance note:

For lifting appliances intended for load handling outside ship while at open sea, and load handling onboard offshore units/installations, see [DNVGL-ST-0378](#) *Standard for offshore and platform lifting appliances*.

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1.1.2 Scope

1.1.2.1 This standard covers the design, materials, fabrication, installation, testing and commissioning of shipboard lifting appliances and industrial lifting appliances.

The categorization of lifting appliances is based on installation and intended function for the lifting appliance:

- a) Shipboard lifting appliances:
 - lifting appliances on board ships intended for load handling within and outside ships while in the harbour and within ships while at sea.
- b) Industrial lifting appliances:
 - lifting appliances onshore and offshore, not covered by a) and [DNVGL-ST-0378](#).

Guidance note:

The main purpose of the lifting appliance will define the category of the lifting appliance and relevant applicable standard.

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1.1.2.2 Each lifting appliance has its separate intended functions. Examples of intended functions are, but not limited to:

- loading and discharging of ships
- handling of provision, store and spare parts, cargo hoses, gangways and ammunition
- handling of Suez canal boats and search lights
- conveyance of persons/personnel
- handling of ramps and moveable cargo decks etc.

1.1.2.3 Requirements presented herein are minimum requirements to be satisfied, although subject to acceptance by the Society, other minimum requirements may be agreed e.g. based on new technology available at the time of application for certification.

1.1.2.4 The requirements of this standard may be supplemented with additional requirements where installation of specific design or assessment shows that standards that provide equivalent or higher level of integrity and safety are more appropriate.

1.1.2.5 The standard consists of a three level hierarchy of documents:

- [Sec.1](#) and [Sec.2](#) provide principles and procedures of the Society's classification, certification, verification and consultancy services.

- [Sec.3](#) through [Sec.13](#) provide technical provisions and acceptance criteria as well as the technical basis for the services stated in the first two sections.
- Appendices provide proven technology and sound engineering practice as well as guidance for the higher level documents mentioned in this document.

1.1.2.6 This standard distinguishes between:

- information and description of services
- requirements.

Consequently, these two subjects are separated, and the standard is divided into three parts:

- [Sec.1](#) to [Sec.2](#): General information, application, definitions and references. Description of applicable services and relations to rules and regulation from institutions other than the Society.
- [Sec.3](#) to [Sec.13](#): Requirements and technical provisions.
- Appendices.

1.1.3 Application

1.1.3.1 This standard shall be applied for certification of shipboard lifting appliances for ships with class notation **Crane**. This standard may also be applied as voluntary basis for verification and certification of lifting appliances and load-handling devices that are not classed with the Society.

Guidance note:

The standard may also be applied to industrial cranes.

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1.1.3.2 The requirements presented herein should be applied consequently from concept design through the final construction, including major modifications. Alternatives to detailed requirements in this standard may be accepted when the overall safety and reliability level is found to be equivalent or better than that of this standard. Approval may be revoked if subsequent information indicates that the chosen alternative is not satisfactory.

1.1.3.3 Specifications of the services provided by this standard are given in [\[1.2\]](#) and [\[1.4\]](#).

1.1.3.4 The standard does not apply to launching appliances for LSA (except [Sec.3](#) and [Sec.11](#)), launching gear for diving equipment and ROVs, structural parts of ramps and car decks, dredging appliances, which are no loading gear, personnel lifts (elevators), jacks, overhead drilling equipment, portable hoisting gear, suspensions (if not integral component of a load-handling device), etc.

1.1.3.5 Personnel lifting with cranes otherwise designed for lifting of loads/cargo may be covered upon agreement.

1.1.3.6 Without prejudice to [\[1.1.2.4\]](#), deviations from the requirements given in this standard may only be substituted where shown to provide an equivalent or higher level of integrity or safer than under this standard.

1.1.3.7 At the Society's discretion equivalent solutions and exemptions from the requirements given in this standard may be accepted.

1.1.3.8 In case of conflict between requirements given in this standard and a reference document, the requirements given in this standard shall prevail.

1.1.3.9 Where reference is made to codes other than the Society's documents, the valid revision shall be taken as the revision which was current at the date of issue of this standard, unless otherwise noted.

1.1.4 Relation to the Society's other documents

1.1.4.1 For lifting appliances covered by the class notation, **Crane**, see [DNVGL-RU-SHIP Pt.6 Ch.5 Sec.3](#) *Permanently installed cranes – Crane*.

1.1.5 Definitions, abbreviations, symbols and references

1.1.5.1 Active cable tensioning system (ACT)

System keeping the tension of the hoisting wire to a given set point value.

Guidance note:

A supply of external energy is required.

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1.1.5.2 Active heave compensation system (AHC)

System that maintains the position of the load to a given set point value.

Guidance note:

A supply of external energy is required.

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1.1.5.3 Class notations

Reference is made to [DNVGL-RU-SHIP Pt.1 Ch.1 Sec.1](#)

1.1.5.4 Ship type notation

Code used by the classification societies to define a type of vessel related to its most typical service. (**Multi-purpose dry cargo**, **Bulk carrier**, **Container ship** and **Crane vessel** are typical examples). Reference is made to [DNVGL-RU-SHIP Pt.1 Ch.2 Sec.3](#).

1.1.5.5 Automatic overload protection system (AOPS)

A system that automatically safeguards and protects the crane against overload and "over-moment" during operation by allowing the hook to be pulled away from the crane in order to avoid significant damage.

1.1.5.6 Declaration of conformity

A document attesting that a product or service is in conformity with specific standards or technical specifications (ISO/IEC 17050 *Conformity assessment - Supplier's declaration of conformity*). Issued by manufacturer or vendor.

1.1.5.7 Competent person/body

Person or body possessing knowledge and experience required for performing thorough examination and test of lifting appliances and loose gear, and who is acceptable to the competent authority.

1.1.5.8 Crane stiffness

Coefficient defined as the force applied on the hook necessary to obtain a unit deflection at the hook level.

1.1.5.9 Customer

Agreement (contract) holder with the Society. Signifies the party who has requested the Society's service.

1.1.5.10 Dead loads

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

For the purpose of marking, the dead loads of loose gear are designated as weight by the ILO. The unit is specified in tonnes (t) or kilograms (kg).

1.1.5.11 Designer

Reference is made to [DNVGL-RU-SHIP Pt.1 Ch.1 Sec.1](#).

1.1.5.12 Design approval

Verifying that a design, represented by a drawing or set of drawings, is found to comply with all requirement given in a specified Society standard or Society regulation.

Guidance note:

In the Society's business procedures design approvals are valid for one order only. One order, however, may include a specified number of units for specified locations/vessels.

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1.1.5.13 Design approval letter

Written confirmation of a design approval.

1.1.5.14 Design assessment for type approval

Assessment and acceptance of a design for type approval. The type approval will be assigned first after a prototype test also has been successfully carried out.

1.1.5.15 Design verification report (DVR)

Formalized report confirming the result of a completed design verification assignment.

1.1.5.16 Hoist load coefficient

Also referred to as dynamic amplification factor (DAF).

A variable factor representing the vertical dynamic effects that the hoist load is exposed to.

1.1.5.17 Dynamic hoist load

The hoist load when subjected to (multiplied with) a *hoist load coefficient*.

1.1.5.18 Dynamic working load

The working load when subjected to (multiplied with) a *hoist load coefficient*.

1.1.5.19 Engineered lift

Safe lift planned by qualified engineers with basis in thorough information with respect to crane capacity, crane functions and performance, rigging, crane support as well as weather and sea conditions.

1.1.5.20 Fixed load-lifting attachments

Any equipment, from which the working load for lifting appliance can be suspended and which is permanently fastened to the lower end of the hoist medium, see [Figure 1-1](#).

Fixed load-lifting attachments are part of the lifting appliance.

1.1.5.21 Heavy lift crane

Crane with SWL above 250 t.

1.1.5.22 Hoist load

Sum of a lifting appliance's working load, the weight of its fixed load-lifting attachment(s) and half of the weight of that part of hoist medium, which is arranged between rope exit point and fixed load-lifting attachment(s), see [Figure 1-1](#).

The hoist load is subjected to inertia forces.

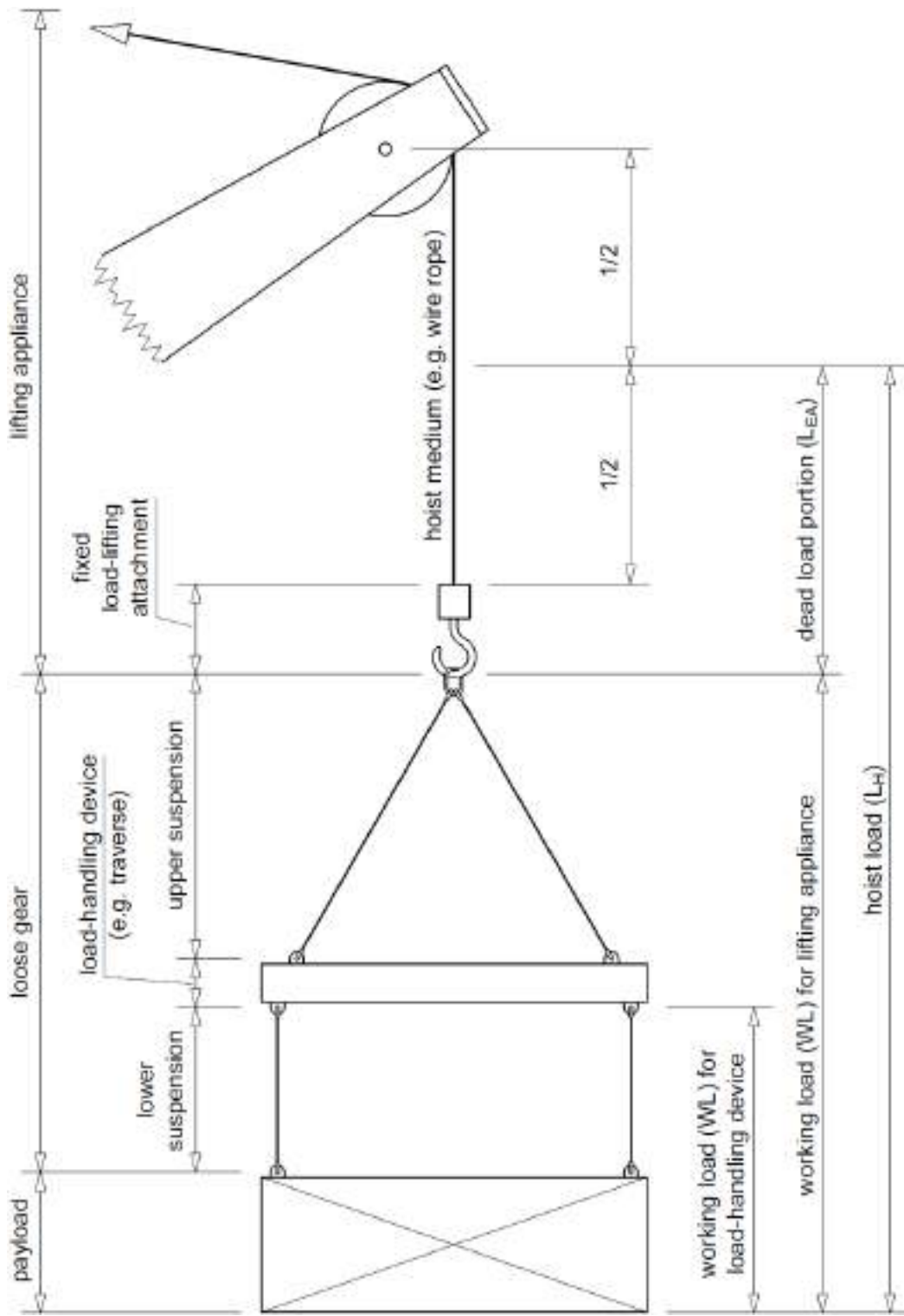


Figure 1-1 Definitions

1.1.5.23 Hoist medium

Wire rope(s), chain(s) or other equipment, hanging down from the lifting appliance, for example from the crab or the jib head, operated by a winch, etc., used to lift and lower loads suspended from the lower end(s) of the hoist medium(s), see [Figure 1-1](#).

Hoist mediums are part of the lifting appliance.

1.1.5.24 ILO

International labour organization.

1.1.5.25 Inertia forces

The forces induced by change of velocity.

1.1.5.26 Inspection certificate 3.1

A document issued by the manufacturer which contains the results of all the required tests. It shall certify that the tests have been carried out by the manufacturer on samples taken from the delivered products direct. See EN 10204 and ISO 10474.

1.1.5.27 Inspection certificate 3.2

A document prepared by both the manufacturer's authorized inspection representative, independent of the manufacturing department, and either the purchaser's authorized representative or the inspector designated by the official regulations, and in which they declare that the products supplied are in compliance with the requirements of the order and in which test results are supplied. See EN 10204 and ISO 10474.

1.1.5.28 Interchangeable components

Load-bearing, not rigidly attached, interchangeable parts which may be integral components of lifting appliances and loose gear, e.g. hooks, blocks, shackles, swivels, rings, chains, claws, clamps, pliers, load fastening ropes (slings/strops), lifting straps, etc.

1.1.5.29 Lifting appliance

Machine or appliance used for the purpose of lifting goods and materials, or in special modes, personnel.

1.1.5.30 Lifting equipment

General expression including lifting appliances, loose gear and other lifting attachments; used separately or in combination.

1.1.5.31 Load chart

Diagram or table showing safe working load of a lifting appliance depending on radius or boom angle for specified operational conditions.

1.1.5.32 Load-handling device

Device (hook, grab, electromagnet, fork, traverse, spreader or other) for grabbing, holding or handling the load, which is not part of the lifting appliance, see [Figure 1-1](#).

Load-handling devices are part of the loose gear.

1.1.5.33 Loose gear

Any equipment which connects the payload with the lifting appliance and which does not form an integral part either of the lifting appliance or of the payload.

Guidance note:

Loose gear is easily detachable from the lifting appliance and from the payload.

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1.1.5.34 Machinery components

Rotating components transferring torque for driving/braking purpose. Examples are gearboxes, wheels and shafts.

1.1.5.35 Man riding winch

Winch specially designed for hoisting/lowering of a person.

1.1.5.36 Manual overload protection system (MOPS)

System, activated by the crane operator, protecting the crane against overload and “over-moment” by reducing the load-carrying capacity and allowing the hook to be pulled away from the crane.

1.1.5.37 Mean time to failure (MTTF)

The mean value of service time until failure occurs.

1.1.5.38 Mechanism

Devices needed to cause or to stop a relative motion between two rigid parts of a crane, between the crane and its foundation, or between the crane and the lifted load. Thus motors, brakes, transmission systems and similar components are defined as mechanisms.

1.1.5.39 Mobile deck crane

A mobile deck crane is a cable-controlled crane mounted on crawlers or rubber-tired carriers or a hydraulic-powered crane with a boom mounted on truck-type carriers or as self-propelled types.

1.1.5.40 Overload

Load which exceeds the safe working load (SWL).

1.1.5.41 Over-moment

Load moment which exceeds the maximum load moment (safe working load (SWL) multiplied by radius).

1.1.5.42 Passive cable tensioning system (PCT)

System keeping the tension of the hoisting wire between predefined limits, using stored energy.

1.1.5.43 Passive heave compensation system (PHC)

System that maintains the position of the load between predefined limits, using stored energy.

1.1.5.44 Payload

Load, which is lifted by the lifting appliance and suspended from the loose gear or, if such loose gear is not used, directly from the fixed load-lifting attachment(s), see [Figure 1-1](#).

Guidance note:

If lifting appliances are used for lifting the load from water, the payload may also include forces due to water flow suction or water adhering by suction.

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1.1.5.45 Product certificate (general)

Reference is made to [DNVGL-RU-SHIP Pt.1 Ch.3 Sec.5 \[2.2\]](#)

1.1.5.46 Product certificate (the Society's)

Reference is made to [DNVGL-RU-SHIP Pt.1 Ch.3 Sec.5 \[2.4\]](#).

1.1.5.47 Purchaser

Company or person who orders the lifting equipment from a manufacturer. This standard does not necessarily require that the purchaser will need to have any direct relationship to or communication with the Society.

1.1.5.48 Remark

Defect in terms of the ILO model form 1 found in a shipboard lifting appliance or in an item of loose gear which are not part of class.

Remarks do not influence the validity of class.

1.1.5.49 REP

Rope exit point. Location on the lifting appliance where the rope is suspended - typically found at the outer sheave in the crane boom tip.

1.1.5.50 Risk

Combination of the probability of occurrence (frequency) of harm and the severity (consequence) of the harm.

1.1.5.51 Risk control measure (RCM)

A means of controlling a single element of risk; typically, risk control is achieved by reducing either the consequence or the frequencies.

1.1.5.52 ROV

Remote operated vehicle.

1.1.5.53 Running rigging

Wire ropes passing over rope sheaves of guide rollers, or wound on winches, irrespective of whether or not the ropes are moved under load.

1.1.5.54 Safe working load (SWL)

Also referred to as working load limit, rated capacity or nominal load.

Safe working load is the designation for the maximum permissible working load of lifting appliances, loose gear or interchangeable components. The abbreviation SWL is used for marking the lifting appliance, loose gear and interchangeable components.

The unit of SWL is specified in tonnes (t) or kilograms (kg).

Guidance note:

Lifting appliances and loose gear can have different safe working loads depending on varying equipment conditions or operational conditions, cable tackle systems or load radii.

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

Average height of the highest one third of the individual wave heights in a short-term constant sea state, typically three (3) hours.

1.1.5.56 The Society

The Society signifies DNV GL.

1.1.5.57 Standing rigging

Ropes that are not turned round or wound on to winches (e.g. guided wires, pendants, stays).

1.1.5.58 Subsea cranes

Cranes intended for handling of unmanned submersibles, for lowering to and retrieval from below sea level.

1.1.5.59 Suspension

Gear, which connects the payload with the load-handling device, the load-handling device with the fixed load-lifting attachment or which connects the payload directly with the fixed load-lifting attachment, if no load-handling device is used, e.g. load fastening ropes (slings/strops) or lifting straps (see [Figure 1-1](#)).

Suspensions are part of the loose gear.

Guidance note:

Suspensions are no subject of this standard unless they are integral part of a load-handling device.

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1.1.5.60 Test report

A document signed by the manufacturer stating:

- conformity with requirements given by a relevant standard
- that tests are carried out on samples from the current production.

Reference is made to [DNVGL-RU-SHIP Pt.1 Ch.3 Sec.5 \[2.8\]](#).

1.1.5.61 Type approval

A type approval of the Society confirms compliance with DNV GL rules for standard designs and/or routinely manufactured, identical components. See [DNVGL-CP-0338 Type approval scheme](#).

Type approval may be used as an alternative to a case by case design approval.

1.1.5.62 Type approval certificate

A document issued by the Society confirming a type approval.

1.1.5.63 Verification

Reference is made to [DNVGL-RU-SHIP Pt.1 Ch.1 Sec.1](#).

1.1.5.64 Vessel

Reference is made to [DNVGL-RU-SHIP Pt.1 Ch.1 Sec.1](#).

1.1.5.65 Working load of lifting appliance

Also referred to as actual hook load, useful load or suspended load.

Load, which is lifted by the lifting appliance and suspended from the fixed load-lifting attachment(s), see [Figure 1-1](#).

Guidance note:

Working load of lifting appliance is the sum of the payload and the loose gear.

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1.1.5.66 Working load of load-handling device

Load, which is lifted by the load-handling device and suspended from it, see [Figure 1-1](#).

Guidance note:

Working load of load-handling device is the sum of the payload and the lower suspensions.

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1.1.5.67 Works certificate

Reference is made to [DNVGL-RU-SHIP Pt.1 Ch.3 Sec.5 \[2.5\]](#).

1.1.6 Crane design types

1.1.6.1 Winch luffing crane

A crane where the boom is controlled by wire ropes through a winch.

1.1.6.2 Cylinder luffing crane

A crane where the boom is controlled by hydraulic cylinder(s).

1.1.6.3 Knuckle boom crane

A crane where the boom is hinged and the boom and knuckle angles are controlled by a set of hydraulic cylinders.

1.1.6.4 Derrick crane

A simple crane consisting of a vertical mast and a hinged jib. The derrick crane is provided with devices for raising and lowering a load, luffing the jib and slewing the jib about the mast.

1.1.6.5 Overhead travelling crane

A crane which lifts the object by a trolley which normally moves horizontally along the crane beam. The crane beam ends have wheels running on rails at high level.

1.1.6.6 Gantry crane

A crane which lifts the object by a trolley which normally moves horizontally along the crane beam. The crane beam is supported by vertical legs having wheels running on rails at ground level.

1.1.6.7 A-frame crane

A hinged frame intended for lifting. Hydraulic cylinders control the movement of the A-frame while a winch is fitted for hoisting and lowering the load.

1.2 Services

1.2.1 Introduction

1.2.1.1 This subsection describes possible combinations of the different services offered. Furthermore, various alternatives are described for confirmation of the various services by the Society.

1.2.1.2 [Figure 1-2](#) describes the services offered and the associated documents issued by the Society to proof compliance.

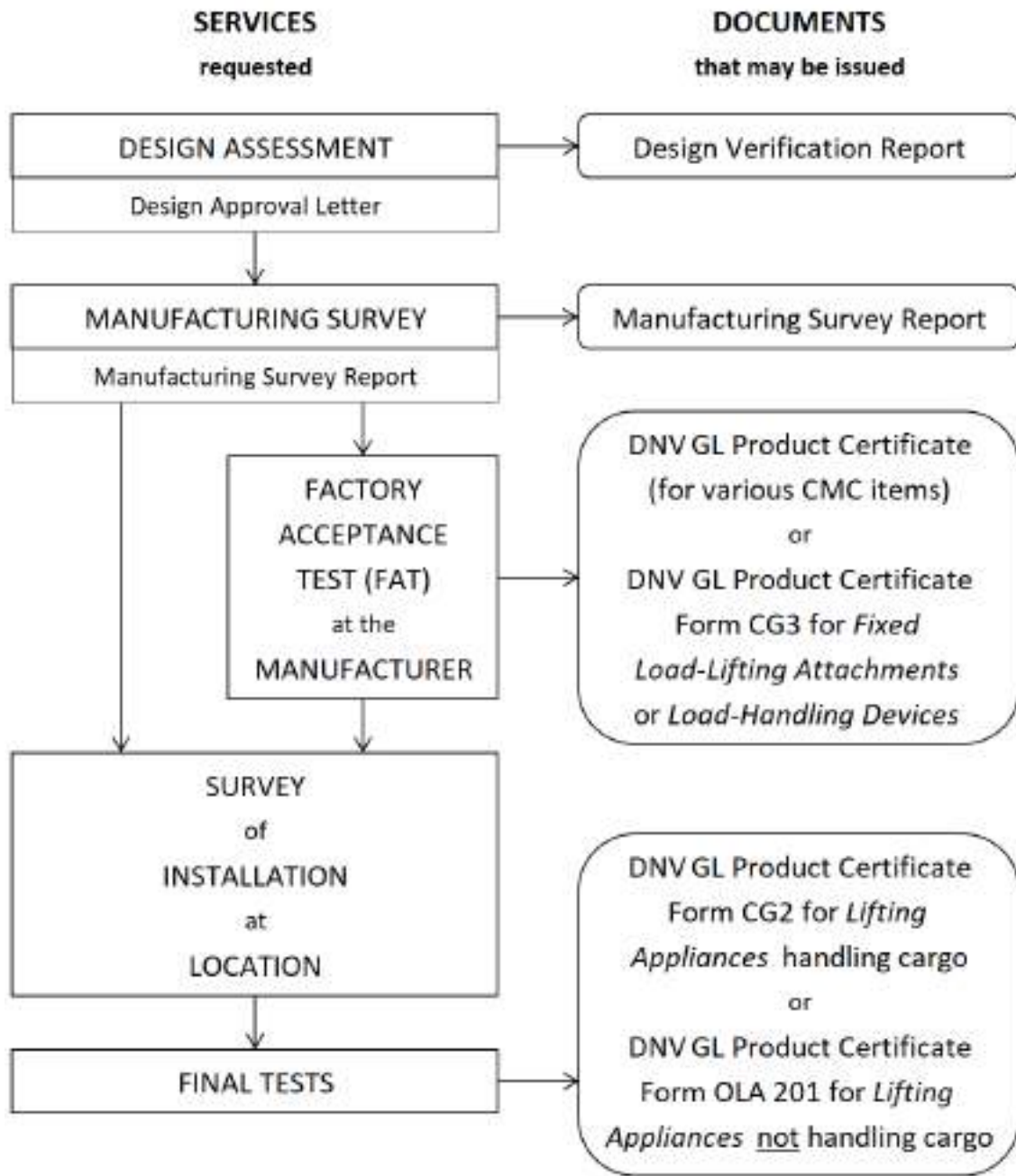


Figure 1-2 Alternatives for documentation that may be issued to customers depending on type and combination of services requested

1.2.2 Regulatory basis

1.2.2.1 This standard is based on the Society's understanding and interpretation of the ILO Convention No.152 and Recommendation No.160 of 1979.

1.2.3 Acceptance by national authorities

1.2.3.1 Regulatory bodies, such as port authorities, flag administrations, shelf authorities and municipal or governmental health and safety authorities require that lifting appliances and loose gear shall be certified. Normally, the Society's certification in accordance with this standard will satisfy the authorities' requirements.

1.2.3.2 In cases where requirements laid down by the pertinent body exceed the Society's requirements described in [Sec.3](#) through [Sec.13](#). The Society may, as a voluntary service, include the additional requirements in the design assessment/examination and confirm whether or not they are found to be fulfilled.

1.3 Certification procedure

1.3.1 General

1.3.1.1 The following parts, components and systems are covered by this standard:

- all load-carrying structural members and components of the lifting appliance
- cargo hooks, chains, rings, blocks, sheaves, shackles, lifting beams, swivels and ropes
- structural integrity of grabs, hydraulic dampers or other load transferring components
- rope drums
- slewing bearing including fasteners
- power systems (for hoisting, derricking, slewing and travelling)
- brakes and braking systems
- safety equipment
- protection against fire
- seating and fasteners for prime movers, winches and for bearings of power transmitting components
- control and monitoring systems
- electrical installation.

1.3.1.2 The following activities are covered by this standard:

- design assessment
- survey during fabrication and installation
- witness testing and marking.

1.3.2 Design assessment

1.3.2.1 Load-carrying and other important components of a lifting appliance are subject to design assessment with respect to strength and suitability for its purpose. A design approval is granted when the design assessment has been concluded without detection of non-compliances.

The design assessment may be substituted, partly or completely, by enhanced manufacturing survey and/or testing. In cases where the substitutions are applied for by the customer, agreements shall be made between the customer and the Society regarding possible reductions of documentation to be submitted for approval/information.

Upon special agreement, the design assessment may be substituted by a strength evaluation based upon testing until failure.

Strength examination of components related to power supply and safety equipment is normally not carried out by the Society.

Guidance note:

The certification process includes the sequential steps design approval, manufacturing survey (including installation survey) and testing. The Society's reports covering the separate phases are considered intermediate documents only and are documenting the progress of the certification process.

The Society's formal documentation of the certification to the customer will be:

- Product certificate issued after completion of manufacturing process and full testing at the manufacturer
- CG2 issued after installation and full testing onboard in accordance with ILO152 requirements.

For lifting appliances not subject to ILO 152, Form OLA201 may be issued after installation and full testing onboard.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.3.2.2 Each lifting appliance is normally given a separate design approval.

1.3.2.3 The design approval may be obtained either on a case-by-case basis or as a type approval.

The type approval means that the design as approved can be applied for identical units to be fabricated, i.e. requested documents need not be submitted for each unit.

The type approval will be based on certain conditions and its period of validity will be limited.

See [DNVGL-CP-0338](#) *Type approval scheme*.

1.3.3 Survey during fabrication and installation

1.3.3.1 Normally, a survey during manufacture of each separate lifting appliance shall be carried out by the Society's surveyor in order to ascertain compliance with the approved drawings, other requirements given in this standard as well as general good workmanship.

1.3.3.2 As an alternative to survey during manufacture of each separate lifting appliance, modified survey procedures and survey arrangements may be accepted provided the manufacturer operates a quality-assurance system approved and certified by the Society. Acceptance shall be clearly formalized.

1.3.3.3 After a lifting appliance has been installed on its permanent foundation, and before testing can take place, it shall be subjected to a survey by a surveyor of the Society.

1.3.4 Testing

1.3.4.1 Components and each completed lifting appliance shall be subjected to functional testing and load-testing as specified in [Sec.13](#).

1.3.5 Extension of scope of work

1.3.5.1 Upon request from the customer, the scope of work may be extended beyond the subjects and aspects covered in this standard.

1.3.5.2 Extensions shall be agreed in writing. The Society may, if found necessary, require that the customer presents reference documents for the extended scope of work, such as authority regulations, norms and standards.

1.3.5.3 In case of disputes regarding interpretations of requirements on which extended work is based, the customer shall contact the publisher/owner of the requirements and obtain their written interpretation. If the publisher/owner is not willing to interpret the disputed requirement, or an interpretation for other reasons cannot be acquired, the respective extension of the scope of work shall be omitted.

1.3.6 Reduced scope of work

1.3.6.1 For lifting appliances not to be installed on vessels classed by the Society upon request from and agreement with the customer, parts of the scope of work, components, systems or specific aspects or requirements may be excluded from the scope of work specified in the standard. This will be annotated in the documentary evidence of the completed assignment (certificate).

1.3.6.2 The Society will not agree to limit the scope of work or parts of the suggested services if this may lead to hazards or unacceptable lowering of the safety standard.

1.4 Type of services

1.4.1 Basic certification

1.4.1.1 The basic requirements presented in [Sec.3](#) through [Sec.13](#) are considered to cover the requirements given in the ILO Convention No.152 of 1979 specified in [\[1.2.2.1\]](#). Lifting appliances and load-handling devices found to comply with these basic requirements are qualified for the Society's product certification, whereupon the Society's product certificate may be issued based on FAT (factory acceptance test) and survey. Following successful testing and survey after installation onboard, a DNV GL CG2 certificate will be issued for cranes covered by the ILO regime (cargo cranes). For cranes not covered by the ILO regime, a product certificate Form OLA 201 will be issued by the Society following successful onboard testing. The cargo gear register (CG1 if published by the Society) may be endorsed accordingly, either as ILO crane or as "other lifting appliances".

1.4.1.2 The basic requirement covers the two categories of lifting appliances a) and b) defined in [\[1.1.2.1\]](#) as well as fixed load-lifting attachments and load-handling devices, as well as personnel lifting as denoted in [\[1.1.2.2\]](#).

1.4.1.3 Some details of the basic requirements given in [Sec.3](#) through [Sec.13](#) are different for the different category of lifting appliance a) and b). Furthermore, some specific requirements are stated for cranes also used for personnel lifting.


1.4.2 Cranes included in class scope

1.4.2.1 On a voluntary basis, cranes installed on board vessels and offshore units classed by the Society may be included in the scope of work covered by classification. In such cases the vessel/offshore unit will be assigned the additional class notation **Crane**, see [DNVGL-RU-SHIP Pt.6 Ch.5 Sec.3](#).

1.4.2.2 Some of the requirements given in this standard have been extended with additional detailed requirements for cranes to be covered by classification.

1.4.3 Assignments completed before installation

1.4.3.1 Assignments completed at the manufacturers' premises can be agreed. Such services shall normally be completed with monitoring of tests at the manufacturer, (FAT-tests). Applicable reports or certificates may be issued. See also [\[1.4.3.2\]](#).



1.4.3.2 The reason for, or purpose of, such assignments may e.g. be:

- completed certification of fixed load-lifting attachments, load-handling devices or components. The Society will normally issue the product certificate CG3 after completion of the tests
- provisional certification after FAT-test. For instance, if final destination is not decided, or if the manufacturer is producing for stock. Or the customer has requested FAT-tests and a documentary confirmation of the Society's service rendered until a certain point. A *Manufacturing survey report* should be issued.

See also [Figure 1-2](#).

SECTION 2 DOCUMENTATION AND CERTIFICATION

2.1 Documentation to be submitted

2.1.1 General

2.1.1.1 The documentation necessary for verification assignments will depend on the scope of work agreed. The documentation and information requirements stated below are necessary for design approval and ensuing certification.

2.1.2 Documentation requirements

2.1.2.1 Documentation shall be submitted as required by [Table 2-1](#), as applicable for the lifting appliance. Completeness of submitted documentation is in the responsibility of the manufacturer of a lifting appliance. It may be partly or completely delegated to a sub-contractor (e.g. external designer or supplier of components). Where a sub-supplier provides components including DNVGL product certificate according to [Tables 2-2](#) to [Table 2-4](#), no detail drawings of that component need to be resubmitted by the manufacturer of the lifting appliance.

Table 2-1 Documentation requirements

<i>Object</i>	<i>Document type</i>	<i>Additional description</i>	<i>Shipboard cranes</i>	<i>Shipboard cranes (if Crane notation)</i>
General	C010 - Design criteria	<ul style="list-style-type: none"> – load charts and/or load tables – dynamic factors – fatigue load assumptions – hoisting, luffing and slewing speeds – operational and environmental conditions – variable rigging conditions – rope lengths and hook heights – category of crane, see definitions [1.1.2] – particulars of brake spring performance 	FI	FI
	C020 - Assembly or arrangement drawing	<ul style="list-style-type: none"> – overview drawings – additional <i>rigging plans</i> required for cargo crane certification complying with ILO152 	FI	FI

Object	Document type	Additional description	Shipboard cranes	Shipboard cranes (if Crane notation)
General (continuation)	C030 - Detailed drawing	Steel structures (general): <ul style="list-style-type: none"> – crane booms, crane housings, crane columns, supporting structures – crane boom supports, sea lashing – foundations and rigidly attached fittings – crane bridges, trolleys, gantries, bogies, runways, crane rails – stopper, derailment guard, devices to prevent overturning – interchangeable components, if not standardized (hooks, blocks, shackles, etc.) See Sec.7 for requirements about documentation for CG3 certification. <ul style="list-style-type: none"> – rope sheaves which are not manufactured in accordance with or generally in line with standards or type approved 	AP	AP
		Steel structures (additional): <ul style="list-style-type: none"> – platforms, accesses, ladders – design and fixing of cabin – steering stands, if any 	---	AP
		Mechanical engineering (general): <ul style="list-style-type: none"> – slew rings with bolting system and load limit diagram – rotary bearings such as king pins and rollers – load-bearing hydraulic cylinders with their associated safeguard against pressure loss – spindles, rack bars – winch drum with rope fixings and winch bolting 	AP	AP
		Mechanical engineering (additional): <ul style="list-style-type: none"> – complete winches – complete slewing and swinging mechanisms and travelling gear – swell compensator and/or swell absorbing systems – hydraulic motors and pumps for nominal power over 50 kW – ventilators and heat exchangers 	---	AP

<i>Object</i>	<i>Document type</i>	<i>Additional description</i>	<i>Shipboard cranes</i>	<i>Shipboard cranes (if Crane notation)</i>
General (continuation)	C030 - Detailed drawing (continuation)	Documents for information: <ul style="list-style-type: none"> – details of ropes (make, strength), end connections of ropes, cable tackle system, rope sheaves (Alternatively, this information may be provided on the assembly drawing.) – details of type tests and type approvals – details of nominal sizes (SWL) and standards on which standardized interchangeable components are based (Alternatively, this information may be provided on the assembly drawing.) 	FI	FI
	C040 - Design analysis	– including fatigue analysis	FI	FI
	M150 - Non-destructive testing (NDT) plan		FI	FI
	Z060 - Functional description	upon request	FI	FI
	Z161 - Operation manual	upon request	FI	FI
Power supply	Z030 - System arrangement plan	– nominal data on electric main drive motor for the electric load analysis of the ship	FI	FI
		– type and maker of prime mover or specification of other main and emergency power supply – including mechanical components	---	FI
Electric power system	E170 - Electrical schematic drawing	– overview drawing of electrical installation (e.g. wiring diagram, single line diagram) – circuit diagram including part list – lighting plan including emergency power supply – type of protection of motors and switch gear – complete information on explosion protection – control consoles and switch cabinets	---	AP
		Z090 - Equipment list	---	FI
Hydraulic power system	S011 - System diagram (P&ID)		---	FI
	S042 - Hydraulic control diagram		AP	AP
	Z060 - Functional description		FI	FI
	Z090 - Equipment list		FI	FI

<i>Object</i>	<i>Document type</i>	<i>Additional description</i>	<i>Shipboard cranes</i>	<i>Shipboard cranes (if Crane notation)</i>
Control and monitoring	I200 - Control and monitoring system documentation	Functional description of safety system and the safety equipment to be included: <ul style="list-style-type: none"> – overview of security oriented devices and controls – flow chart of control – functional description of safety system and the safety equipment to be included (emergency shut-down, limit switch, overload protection devices, etc.) 	---	AP
		– details of protection devices to prevent overspeed	---	FI

2.1.2.2 For general requirements for documentation, including definition of the Info codes, see [DNVGL-RU-SHIP Pt.1 Ch.3 Sec.2](#).

2.1.2.3 For a full definition of the documentation types, see [DNVGL-RU-SHIP Pt.1 Ch.3 Sec.3](#).

2.1.3 Design analysis

2.1.3.1 For structural parts and components specified in [\[2.1.2\]](#), the drawings shall be supplemented with calculations demonstrating that the structural strength complies with the requirements.

2.1.3.2 A complete listing of structural components and parts subjected to strength calculations shall be submitted. The list shall include information of:

- types of failures considered (excessive yielding, buckling, fatigue fracture)
- method of analysis performed
- permissible stress or limit state method used.

See also [\[4.3\]](#).

2.1.3.3 The design calculations for hydraulic cylinders shall be based on the maximum obtainable pressure (safety valve setting). Alternatively, if the maximum dynamic force applied on the crane is known, this may be used as basis for the design calculations. In both cases different outreach positions shall be evaluated.

2.2 Certification

2.2.1 Certificate requirements

2.2.1.1 Certificates for components of shipboard lifting appliances shall be issued as required by [Table 2-2](#) to [Table 2-4](#).

Material certificates shall be issued as required in [Sec.3](#).

Certificates for entire lifting appliances shall be issued as required by [\[13.7\]](#).

Table 2-2 Certificate requirements for shipboard lifting appliances

<i>Object</i>	<i>Certificate type</i>	<i>Issued by</i>	<i>Certification standard*</i>	<i>Additional description</i>
Slewing bearings	PC	The Society		3.1 for crane group A. 3.1 for other crane groups if maker holds valid DNV GL approval of manufacturer (AoM). See Sec.9 for requirements about certification.
Hydraulic cylinders	PC	The Society		Applicable also for accumulators. See Sec.9 for requirements about certification.
Sheaves	PC	Manufacturer		Plastic sheaves to be delivered with the Society's TA. Plastic sheaves not having valid type approval certificate may be accepted on basis of a DNVGL product certificate.
Hoisting blocks	PC	The Society		CG3, alternatively ILO form No. 3, issued by IACS class or flag state administration. See Sec.7 for requirements about certification.
Hooks	PC	The Society		CG3, alternatively ILO form No. 3, issued by IACS class or flag state administration. See Sec.7 for requirements about certification.
Chains	PC	The Society		CG3, alternatively ILO form No. 3, issued by IACS class or flag state administration. See Sec.7 for requirements about certification.
Swivels	PC	The Society		CG3, alternatively ILO form No. 3, issued by IACS class or flag state administration. See Sec.7 for requirements about certification.
Shackles	PC	The Society		CG3, alternatively ILO form No. 3, issued by IACS class or flag state administration. See Sec.7 for requirements about certification.
Wire ropes	PC	The Society		CG4/LA4, alternatively ILO form No. 4, issued by IACS class or flag state administration. See Sec.8 for requirements about certification.
Winches	PC	Manufacturer		See Sec.9 for requirements about certification.
Slewing gear	PC	Manufacturer		Works certificate. See Sec.9 for requirements about certification.
Transmission gears and brakes	PC	Manufacturer		Works certificate. Applicable when transmitting braking forces for hoisting and luffing. For personnel handling the Society's PC required. See Sec.9 for requirements about certification.
Hydraulic components	TR	Manufacturer		Except mountings. See Sec.9 for requirements about certification.
<p>*Unless otherwise specified the certification standard is this standard. PC = Product Certificate, TR = Test Report</p>				

Table 2-3 Additional certificate requirements for Crane notations

<i>Object</i>	<i>Certificate type</i>	<i>Issued by</i>	<i>Certification standard*</i>	<i>Additional description</i>
Winches	PC	The Society		See Sec.9 for requirements about certification.
Control and monitoring system	PC	The Society		See Sec.10 for requirements about certification.
Electric motors with rating 100 kW and above	PC	The Society		Rating 300 kW and above. See Sec.10 for requirements about certification.
	TA	The Society		Rating 100 kW and above, but less than 300 kW. See Sec.10 for requirements about certification. Equipment not having valid type approval certificate may be accepted on basis of a DNVGL product certificate, reference is made to RU-SHIP Pt.4 Ch.8 Sec.1 [2.3.2].
Motor starters and frequency converters with rating 100 kW and above	TA	The Society		See Sec.10 for requirements about certification. Equipment not having valid type approval certificate may be accepted on basis of a DNVGL product certificate, reference is made to RU-SHIP Pt.4 Ch.8 Sec.1 [2.3.2].
Slip rings, 100 kW and above	PC	The Society		See Sec.10 for requirements about certification.
*Unless otherwise specified the certification standard is this standard. PC = Product certificate, TA = Type approval certificate, TR = Test report				

Table 2-4 Additional certificate requirements for ESV(Crane) notations

<i>Object</i>	<i>Certificate type</i>	<i>Issued by</i>	<i>Certification standard*</i>	<i>Additional description</i>
Control and monitoring systems	PC	The Society		See Sec.10 for requirements about certification.
*Unless otherwise specified the certification standard is this standard. PC = Product certificate				

2.2.1.2 For general certification requirements, see [DNVGL-RU-SHIP Pt.1 Ch.3 Sec.4.](#)

2.2.1.3 For a definition of the certification types, see [DNVGL-RU-SHIP Pt.1 Ch.1. Sec.4](#) and [DNVGL-RU-SHIP Pt.1 Ch.3 Sec.5.](#)

SECTION 3 MATERIALS

3.1 General

3.1.1 Scope

3.1.1.1 This section gives requirements for materials for structural members and equipment for lifting appliances with design temperature T_D down to -30°C .

Materials for lifting appliances with design temperature below -30°C will be especially considered. Design temperature is defined in [4.2.3].

3.1.1.2 Materials with properties deviating from the requirements in this section may be accepted upon special consideration by the Society. See also DNVGL-RU-SHIP Pt.2 Ch.1 Sec.1 [3.4].

3.1.1.3 For materials where no specific requirements are given, generally recognised standards and engineering principles may be applied.

3.1.1.4 A traceability system that ensures correct installation and documentation of the material grades or strength classes shall be established by the customer throughout the prefabrication and installation process. Proper care shall be exercised during handling and storage to preserve identification of such material.

3.1.2 Structural category

3.1.2.1 The following categorisation will be used for structural members:

- *Special*: highly stressed areas where no redundancy for total collapse exists
- *Primary*: structures carrying main load as well as components with highly stressed areas
- *Secondary*: structures other than primary and special members.

Slowing bearings with flanges will normally be categorised as special, other structure transmitting principle loads are normally categorised as primary.

The categories shall be agreed with the Society in each case.

See also detailed categorisation for bolt connections in [3.4.4.1].

Guidance note:

Highly stressed areas are considered to be areas utilised more than 85% of the allowable yield capacity.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.1.3 Steel manufacturing process

3.1.3.1 Steel shall be made by the basic oxygen process, electric furnace process, or by other process especially approved by the Society.

3.1.4 Material manufacture survey, certification and testing procedures

3.1.4.1 Certificates covering specification of the chemical composition and mechanical properties shall be presented for all materials for all load-carrying structures and mechanical components. The test values shall show conformity with the approved specification. Test specimens shall be taken from the products delivered.

Requirements as per [DNVGL-RU-SHIP Pt.2 Ch.1 General requirements for materials and fabrication](#) to be fulfilled.

Approved steel manufacturer will not be required.

Material certificates type 3.1 will suffice for special and primary structures, except for slewing rings and slewing ring fasteners for shipboard cranes (class notation) in which case certificate type 3.2 is required. The material certificates for the shipboard crane (class notation) slewing rings shall be signed by the Society's representative.

Guidance note:

The document designation inspection certificate type 3.1, 3.2 and 2.2 are in accordance with ISO 10474 .

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.1.4.2 The materials shall be adequately marked for identification. The marking shall at least comprise name or trade mark of the manufacturer, material grade, heat number, and when referred to 3.2 certificates, the stamp of the purchaser's authorized representative.

3.1.4.3 Marking and identification of smaller items, e.g. bolts and nuts, shall be especially agreed upon between manufacturer and the Society, but shall at least comply with fastener product standard.

3.1.4.4 Materials without proper identification will be rejected unless renewed testing verifies compliance with approved specifications. The number and type of tests will be decided in each case.

3.1.5 Retesting

3.1.5.1 Materials that prove unsatisfactory during delivery testing may be retested. If the standard, with which the materials shall comply, gives no directive for retesting, the retesting shall be carried out as given in [DNVGL-RU-SHIP Pt.2 Ch.1](#). Provided the new test results are found to satisfy the prescribed specification, the material may be accepted.

3.2 Rolled structural steel for welding

3.2.1 General

3.2.1.1 In addition to the requirements for structural steels set out in the following, further requirements may be stipulated in special cases depending on the material application. Thus, testing for fracture mechanics analysis and through thickness ductility properties may be required. Fracture mechanics testing in accordance with an approved procedure will be required for materials and welded joints when the crane manufacturer cannot document satisfactory experience from previous similar material application.

3.2.1.2 Rolled structural steel for welded constructions may be carbon steel or carbon-manganese steel. The steels are divided into three groups dependent on the specified yield strength(R_{eH}) as follows:

- *normal strength steels:* $235 \text{ N/mm}^2 \leq R_{eH} < 265 \text{ N/mm}^2$
- *high strength steels:* $265 \text{ N/mm}^2 \leq R_{eH} < 420 \text{ N/mm}^2$
- *extra high strength steels:* $420 \text{ N/mm}^2 \leq R_{eH} \leq 750 \text{ N/mm}^2$.

3.2.1.3 Application of steel with specified minimum yield strength above 750 N/mm^2 shall be especially agreed.

3.2.1.4 Steels having through thickness ductility ("Z-steel") may be required for members which will be significantly strained in the thickness direction.

For evaluation of required Z-grades, reference is made to Eurocode 3 (EN 1993-1-10).

Guidance note:

Reduction of area after fracture (Z) is the mean value of three (3) tensile test samples, to be taken with their longitudinal axis perpendicular to the surface of the product.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.2.1.5 The requirements for chemical composition, mechanical properties etc., are given in [DNVGL-RU-SHIP Pt.2 Ch.2 Sec.2 \[3\]](#) for normal strength steels, [DNVGL-RU-SHIP Pt.2 Ch.2 Sec.2 \[4\]](#) for high-strength steels, and [DNVGL-RU-SHIP Pt.2 Ch.2 Sec.2 \[5\]](#) for extra high strength steels.

Requirements for impact energy are given in [Table 3-1](#) for structural steel for special, primary and secondary applications.

Table 3-1 Required impact energy values for welded structural steel

Strength category	Strength class	Minimum impact energy KV ¹⁾ [J]	
		Longitudinal	Transverse
Normal strength	235	27	20
High strength	265	27	20
	315	31	22
	355	34	24
	390	41	27
Extra high strength ²⁾	420	42	28
	460	46	31
	500	50	33
	550	55	37
	620	62	41
	690	69	46
	750	69	46

1) Mean value for three (3) specimens. There may be one lower value but not less than 70% of the mean value.
 2) Up to 150 mm thickness, larger thicknesses upon special agreement.

3.2.1.6 As an alternative to [\[3.2.1.5\]](#), materials that comply with national or proprietary specifications may be accepted provided such specifications give reasonable equivalence to the requirements given in this section or are approved for a specific application. See also [DNVGL-RU-SHIP Pt.2 Ch.1 Sec.1 \[3.4\]](#).

3.2.2 Impact test temperatures

3.2.2.1 Required impact test temperatures are dependent on design temperature T_D and the material thickness. Impact test temperatures are given in [Table 3-2](#) for structural steel for special, primary and secondary applications. For definition of design temperature see [\[4.2.3\]](#).

For structural members subjected to compressive and/or low tensile stresses, modified requirements may be considered, i.e. greater material thicknesses for the test temperatures specified.

3.2.2.2 Impact test temperature for flanges for slewing bearings shall be as for *special and primary members* given in [Table 3-2](#) based on actual thickness.

3.2.2.3 When welding a thinner plate to a thicker plate, e.g. connecting a flange to the supporting structure for the flange, inserted reinforcement rings etc., the following apply provided the thicker plate does not contain butt welds:

The impact test temperature shall be the lower of the temperatures according to [Table 3-2](#), based on $t = t_1$ or $t = 0.25 \cdot t_2$ where:

t_1 = thickness of the thinner supporting plate

t_2 = thickness of the flange.

However, the impact test temperature for the flange (thicker plate) shall not be higher than the required test temperature, based on t_2 according to [Table 3-2](#), plus 30° C.

Table 3-2 Impact test temperatures for welded structural steel

Material thickness t in mm	Impact test temperature in °C ¹⁾	
	Structural steel for special and primary members ²⁾	Structural steel for secondary members ²⁾
$t < 6$	No special provisions ³⁾	No special provisions ³⁾
$6 \leq t \leq 12.5$	$T_D + 30$	No special provisions ³⁾
$12.5 < t \leq 25$	$T_D + 10$	$T_D + 30$
$25 < t \leq 50$	$T_D - 10$	$T_D + 10$
$50 < t \leq 70$	$T_D - 20$	$T_D + 10$
$t > 70$	$T_D - 30$	$T_D - 10$

1) For steel with yield strength below 500 MPa, the test temperature need not be taken lower than -40°C. For steel with yield strength above 500 MPa, the test temperature shall not be taken higher than 0°C and not lower than -60°C.

2) See [\[3.1.2.1\]](#) for definitions.

3) The requirements given in [DNVGL-RU-SHIP Pt.2 Ch.2](#) or in the relevant material standard or approved material specification apply.

3.2.3 Testing

3.2.3.1 Test samples

Unless otherwise required the test samples shall be taken for positions as specified in [DNVGL-RU-SHIP Pt.2 Ch.2](#) or other recognised standards. The sample of material from which test specimens are cut shall be treated together with and in the same way as the material presented. The samples shall be suitably marked for identification.

3.2.3.2 Test specimens

Test specimens shall be as specified in the approved standards. The following additional requirements shall apply:

- for impact testing of thin materials where the thickness makes it impossible to use an impact test specimen of 10 × 10 mm the largest practicable of the following specimens shall be used:
10 × 7.5 mm or 10 × 5 mm.

By this procedure the required impact values are reduced to 5/6 and 2/3, respectively, of the value of the standard 10 × 10 mm test specimen.

3.3 Rolled steel not for welding

3.3.1 General

3.3.1.1 Rolled steel for special and primary components other than those mentioned in [3.3.2] and [3.3.3] (e.g. mechanisms) shall be specified with reference to a recognised standard, see [3.2.1.5] and [3.2.1.6]. The material shall be delivered in the following conditions:

- *carbon and carbon/manganese steel*: normalized condition
- *alloy steel*: quenched and tempered condition
- as rolled (AR) condition, when subjected to special consideration.

For all materials, impact toughness shall be documented by Charpy V-notch impact tests. Test temperatures shall be as required by Table 3-4 but, in the case of low calculated stresses, e.g. not exceeding 50 N/mm² (characteristic value without partial safety factors), a test temperature of 20°C will be accepted. Required minimum impact energy shall be as required for welded parts, see [3.2.1.5].

3.3.2 Bolts and nuts

Materials for bolts and nuts considered as important for the structural and operational safety of the assembly in question, shall comply with the requirements given in [3.4.4] for bolts and nuts. This includes requirements for chemical composition and mechanical properties.

3.3.3 Rolled rings

3.3.3.1 Rolled rings for important components such as slewing rings, toothed wheel rims etc. shall comply with the requirements for steel forgings, see [3.4.5].

3.4 Steel forgings

3.4.1 General

3.4.1.1 Forgings shall generally be manufactured in accordance with the requirements given in DNVGL-RU-SHIP Pt.2 Ch.2 Sec.6 *Steel forgings*.

3.4.1.2 As an alternative to [3.4.1.1], materials that comply with national or proprietary specifications may be accepted provided such specifications show reasonable equivalence to the requirements given in [3.4.1.1] or are especially approved. As a minimum the following particulars shall be specified: manufacturing process,

chemical composition, heat treatment, mechanical properties and non-destructive testing. See also [DNVGL-RU-SHIP Pt. 2 Ch.1 Sec.1 \[3.4\]](#). For machinery components, see [DNVGL-RU-SHIP Pt.4 Ch.2 Sec.1 \[3\]](#).

3.4.2 Forgings for general application

3.4.2.1 Forgings shall be specified with reference to [DNVGL-RU-SHIP Pt.2 Ch.2 Sec.6 Steel forgings](#) or other national or proprietary specification, see [\[3.4.1.2\]](#). As a minimum the standard shall require impact testing according to [Table 3-3](#). Other mechanical properties shall minimum be according [DNVGL-RU-SHIP Pt.2 Ch.2 Sec.6 Table 8](#) for unwelded forgings and according to [DNVGL-RU-SHIP Pt.2 Ch.2 Sec.6 Table 6](#) for welded forgings. For thicknesses over 100 mm, smaller deviations from the specified mechanical properties may be accepted based on specific approval by the Society. For forged shackles, cargo hooks, swivels, sockets, chains, bolts/nuts and slewing bearings, the special requirements given in [\[3.4.3\]](#) to [\[3.4.5\]](#) apply.

Table 3-3 Impact testing for steel forgings and steel castings

<i>Design temperature T_D</i>	<i>Test temperature</i>	<i>Minimum Charpy Value</i>
$T_D \geq -20^\circ\text{C}$	0°C	27 J
$-20^\circ\text{C} > T_D > -30^\circ\text{C}$	-20°C or (0°C)	27 J (48 J)

3.4.3 Forged shackles, cargo hooks, swivels, sockets and chains

3.4.3.1 Carbon and carbon-manganese steel forgings shall be made from killed and fine-grain treated non-ageing steel. It may be required that the non-ageing properties are verified by tests. The chemical composition and mechanical properties of the material, with the exception of the impact test temperature, shall be as given in [\[3.4.2.1\]](#). It may be required that the non-ageing properties are verified by tests, see [DNVGL-RU-SHIP Pt.2 Ch.1 Sec.3 \[3.8\]](#).

Chemical composition and mechanical properties for alloy steels shall be specified with reference to recognised standard and are subject to individual consideration and approval by the Society. The chemical composition shall be suitable for the thickness in question. Alloy steels shall be delivered in quenched and tempered condition.

Requirements for impact test temperatures are specified in [Table 3-4](#).

Table 3-4 Impact test temperature for shackles, cargo hooks, chains, sockets and swivels

<i>Material thickness t (mm)</i>	<i>Impact test temperature</i>
$t \leq 10$	Impact test not required
$10 < t \leq 50$	$T_D + 20^\circ\text{C}$ ⁽¹⁾
$50 < t \leq 100$	$T_D + 10^\circ\text{C}$ ⁽¹⁾
$t > 100$	T_D ⁽¹⁾
1) T_D = design temperature	

3.4.4 Bolts and nuts

3.4.4.1 Bolt connections are normally considered to be in the following groups:

- *Special*: where it is part of a slewing ring connection.
- *Primary*: where the bolts or nuts are transferring principle loads.
- *Secondary*: where the bolts or nuts are transferring load, not belonging in the category special or primary. Examples are bolt connections in driver's cabin, platforms, stairs and ladders.

3.4.4.2 Bolts and nuts for use in connections categorised as special or primary shall conform with and be tested in accordance with a recognised standard, e.g. pertinent parts of ISO 898 or other recognised standard. Charpy testing will generally not be required for nuts.

Additional requirements for testing and inspection of slewing ring bolts are given in [Table 3-5](#).

Bolt connections considered as secondary shall be made from suitable materials.

3.4.4.3 Nuts may be accepted to be in one strength class lower than the bolts of bolt/nut assemblies.

3.4.4.4 Bolts and nuts shall be delivered with the following certificates as per ISO 10474, verifying compliance with the material requirements and other test requirements:

- inspection certificate type 3.2 for slewing ring bolts and nuts for shipboard cranes (**Crane** notation)
- inspection certificate type 3.1 for slewing ring bolts and nuts for cranes
- 2.2 test report for bolts and nuts in *primary* and *secondary* connections.

3.4.4.5 Fasteners (bolts, nuts and washers) in marine environment shall normally be hot-dipped galvanized or sherardized with coating thickness min. 50 micrometer. If special thread profiles or narrow tolerances prohibit such coating thickness, bolts/-nuts may be supplied electro-plated or black provided properly coated/painted after installation. Pickling and electro-plating operations shall be followed by immediate hydrogen-relief (degassing) treatment to eliminate embrittling effects.

3.4.4.6 Galvanizing of bolts and nuts are acceptable provided additional loss of bolt load (pretension) of at least 4% is compensated for.

Unless specific measures are taken against absorption of hydrogen, galvanizing is not accepted for 12.9 bolts.

Table 3-5 Testing and inspection of slewing ring bolts

<i>Strength class, ISO 898, or equivalent</i>	<i>Diameter d in mm</i>	<i>Ultimate tensile strength N/mm²</i>	<i>Yield strength. Minimum. N/mm²</i>	<i>Elongation A5</i>	<i>Required Charpy V energy¹⁾ at test temperature</i>	<i>Fracture mechanics testing (CTOD)</i>	<i>Surface inspection</i>
8.8	d < 25	800 - 1000	640	14	—	—	Visual
	d ≥ 25				42 J	—	Visual and magnetic particle (MPI) ⁴⁾
10.9	d < 25	1000 - 1200	940	12	—	—	Visual
	d ≥ 25				42 J	—	Visual and magnetic particle (MPI) ⁴⁾
12.9	d < 25	1200 - 1400	1080	12 (10) ²⁾	25 J	To be documented ³⁾	Visual and magnetic particle (MPI) ⁴⁾
	d ≥ 25				25 J	To be tested ³⁾	

- 1) Average value of three specimens. One single value may be max 30% lower.
- 2) May be accepted on case-by-case basis.
- 3) Alternatively, a Charpy-V notch energy of minimum 55 J at T_D may be accepted.
- 4) For all bolts (100 %) connecting special or primary members and a random number of bolts connecting secondary members, magnetic particle testing shall be carried out at least 48 hours after completion of quenching and tempering for bolts with yield strength above 355 N/mm². Inspection shall be in accordance with ASTM E 709. Depth of longitudinal discontinuities shall not exceed 0.03 of the nominal diameter. Transverse cracks will not be acceptable irrespective of crack depth and location. Other surface irregularities will be considered in each case.

3.4.5 Forged rings for slewing bearings

3.4.5.1 Specifications of slewing rings essential for the structural and operational safety of the crane are subject to individual approval by the Society. All relevant details shall be specified such as chemical composition, mechanical properties, heat treatment, depth and hardness of surface hardened layer and surface finish of fillets. Position of test specimens shall be indicated. Method and extent of non-destructive testing shall be specified and the testing procedures shall be stated. Detailed information about method of manufacture shall be submitted.

3.4.5.2 For each new material of which the manufacturer has no previous experience and for any change in heat treatment of a material previously used, a principal material examination shall be carried out. This means that the Society may impose additional requirements not specified in this standard. The results shall be submitted to the Society for consideration. The programme for such examination shall be agreed with the Society.

3.4.5.3 All test results shall comply with the approved specifications.

3.4.5.4 Steel for slewing rings shall satisfy the requirements given in [Table 3-6](#).

Table 3-6 Slewing ring materials

<i>Heat treatment</i>		<i>According to approved Spec.</i>
<i>Charpy V-notch test temperature</i>		T_D
<i>Charpy V-notch value</i>	<i>Average</i>	42 J
	<i>Single min. value</i>	27 J
<i>Elongation A5</i>		14%
<i>Fatigue properties</i>		Documentation may be required by type tests on specimen of ring section
<i>Fracture toughness</i>		Documentation may be required by type tests on specimen of ring section in question

3.5 Steel castings

3.5.1 General

3.5.1.1 Steel castings shall generally be manufactured in accordance with [DNVGL-RU-SHIP Pt.2 Ch.2 Sec.8 Steel castings](#).

3.5.1.2 As an alternative to [\[3.5.1.1\]](#), materials which comply with national or proprietary specifications may be accepted provided such specifications give reasonable equivalence to the requirements given in [\[3.5.1.1\]](#) or are approved for each specific application. As a minimum the following particulars shall be specified: manufacturing process, chemical composition, heat treatment, mechanical properties and non-destructive testing. See also [DNVGL-RU-SHIP Pt.2 Ch.1 Sec.1 \[3.4\]](#). For machinery components, see [DNVGL-RU-SHIP Pt.4 Ch.2 Sec.1 \[2\]](#).

3.5.2 Castings for general application

3.5.2.1 Steel castings shall generally be manufactured in accordance with [DNVGL-RU-SHIP Pt.2 Ch.2 Sec.8 Steel castings](#) or other national or proprietary specification. As a minimum the standard shall require impact testing and mechanical properties according to [Table 3-3](#). Other mechanical properties shall minimum be according [DNVGL-RU-SHIP Pt.2 Ch.2 Sec.8 Table 5](#) for welded castings and according to [DNVGL-RU-SHIP Pt.2 Ch.2 Sec.8 Table 7](#) for unwelded castings.

3.6 Iron castings

3.6.1 General

3.6.1.1 Iron castings shall generally be manufactured in accordance with the [DNVGL-RU-SHIP Pt.2 Ch.2 Sec.9 Iron castings](#).

3.6.1.2 As an alternative to [\[3.6.1.1\]](#), materials that comply with national or proprietary specifications may be accepted provided such specifications give reasonable equivalence to the requirements given in [\[3.6.1.1\]](#) or are approved for each specific application. See also [DNVGL-RU-SHIP Pt.2 Ch.1 Sec.1 \[3.4\]](#).

3.7 Steel tubes, pipes and fittings

3.7.1 General

3.7.1.1 See [DNVGL-RU-SHIP Pt.2 Ch.2 Sec.5 Steel pipes and fittings](#), or other recognised standard/code. Recognition of other standards shall be evaluated by the Society.

3.8 Aluminium alloy structures

3.8.1 General

3.8.1.1 See [DNVGL-RU-SHIP Pt.2 Ch.2 Sec.10 Aluminium alloys](#).

3.9 Composite materials

3.9.1 General

3.9.1.1

Requirements to be specially developed for the intended use applying the technology qualification process required by [DNVGL-RP-A203 Technology qualification](#).

3.10 Wires for ropes

3.10.1 General

3.10.1.1 Wires for ropes shall be made by LD (Linz-Donawitz) process (applies to steel wires), or by other processes especially approved by the Society or an other classification society.

3.10.2 Materials

3.10.2.1 The nominal tensile strength of steel wires shall be 1570 N/mm², 1770 N/mm² or 1960 N/mm². Steel wires with higher nominal tensile strength (e.g. 2160 N/mm²) or austenitic and copper wires may be approved on application, provided they are suitable for the proposed lifting application.

3.10.2.2 The nominal tensile strength of steel wires shall not be exceeded by more than the values shown in [Table 3-7](#).

Table 3-7 Positive tolerances for nominal tensile strengths

<i>Nominal wire diameter d [mm]</i>	<i>Limiting deviations [N/mm²]</i>
0.20 up to < 0.50	+ 390
0.50 up to < 1.00	+ 350
1.00 up to < 1.50	+ 320
1.50 up to < 2.00	+ 290
2.00 up to ≤ 6.00	+ 260

3.10.2.3 Individual wires shall possess sufficient ductility, measured by their ability to withstand a fixed number of reverse bends and/or twists without crack initiation.

These requirements are regarded as fulfilled, if the values specified in EN 10264 or in an equivalent standard recognized by the Society are achieved.

3.10.3 Tolerances

3.10.3.1 The tolerance on the wire diameter shall lie within the limits specified in EN 10264 or in an equivalent standard recognized by the Society.

3.10.4 Coating

Wires used for standing rigging shall be fully galvanized.

Wires used for running rigging shall be normally galvanized.

The zinc coating shall conform to the data shown in [Table 3-8](#).

Wires made from austenitic steel need not to be coated.

Table 3-8 Zinc coatings

<i>Nominal wire diameter d [mm]</i>	<i>Minimum mass per unit area of zinc coating [g/m²] for type</i>	
	<i>Normally galvanized</i>	<i>Fully galvanized</i>
0.2 up to < 0.25	15	--
0.25 up to < 0.4	20	--
0.4 up to < 0.5	30	75
0.5 up to < 0.6	40	90
0.6 up to < 0.7	50	110
0.7 up to < 0.8	60	120
0.8 up to < 1.0	70	130
1.0 up to < 1.2	80	150
1.2 up to < 1.5	90	165
1.5 up to < 1.9	100	180
1.9 up to < 2.5	110	205
2.5 up to < 3.2	125	230

Nominal wire diameter d [mm]	Minimum mass per unit area of zinc coating [g/m^2] for type	
	Normally galvanized	Fully galvanized
3.2 up to < 3.7	135	250
3.7 up to < 4.0	135	260
4.0 up to < 4.5	150	270
4.5 up to < 5.5	165	280
5.5 up to \leq 6.0	180	280

3.10.5 Testing

3.10.5.1 Individual wire tests shall be performed for every wire dimension represented in the strands.

The number of tests for each wire dimension shall be the same as the number of strands in the rope.

The tests may be performed before or after rope manufacture. In the case of compacted ropes, wire tests shall be carried out before rope manufacture.

3.10.5.2 At the option of the manufacturer, the ductility test of wires shall be either tested by the reverse bend test or by the twisting test specified in a recognized standard (e.g. ISO 7801 or ISO 7800).

The test is considered successful, if at least 95% of the wires withstand the bend or twisting test as specified in the applied standard without breaking.

3.10.5.3 The specified weight of zinc coating shall be determined and certified by the manufacturer by chemically stripping the coating and measuring the weight loss of the stripped wires.

The adhesion of zinc coating shall be verified by a winding test. For the test the wires shall be wound on a test mandrel of the diameter specified in Table 3-9 as to form at least 10 adjacent turns. The zinc coating shall continue to adhere firmly to the substrate after winding. At least five (5) wires of each size shall be tested.

Table 3-9 Winding test

Method of galvanizing	Diameter of test mandrel expressed as a multiple of the wire diameter of:	
	< 1.5 mm	\geq 1.5 mm
fully galvanized	4	6
normally galvanized	2	3

3.10.5.4 Where the tensile loading capacity of a wire rope testing machine is insufficient to test a wire rope in its entirety, the breaking load of a wire rope can be determined from the results of tensile tests performed on individual wires (see [8.5.1.1.2]).

SECTION 4 DESIGN AND CALCULATION PRINCIPLES

4.1 General

4.1.1

This section contains provisions of general validity governing the design and calculation of lifting appliances on seagoing ships.

The special provisions contained in the following sections of this standard shall be observed additionally or with priority, respectively.

4.1.2

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

4.2 Design principles

4.2.1 General

4.2.1.1 Prerequisites for the design

4.2.1.1.1 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 shall be consulted as well. The specifications decided upon are of considerable importance for the reliable operation and expected service life.

4.2.1.1.2 The intended use of ships and lifting appliances, the shipping routes and the operational area, high ship speeds and the shape of the ship's hull shall be considered as required.

4.2.1.2 Design criteria for operating lifting appliances

Essential design criteria, in addition to the statements in [4.2.2] to [4.2.5], 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.

4.2.1.3 Design criteria for the status "out of operation"

4.2.1.3.1 Essential criteria for the design are, in relation to [4.2.1.2], increased inclinations of the supporting structure and increased wind loads, as well as ship accelerations.

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

4.2.2 Environmental conditions

4.2.2.1 Special attention shall 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.

4.2.2.2 Machinery and electrical installations shall 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.

4.2.2.3 Vibrations are in general not part of dimensioning of the shipboard lifting appliances. Where shipboard lifting appliances are prone to vibrations, vibration analyses shall be performed.

4.2.2.4 Where necessary, manufacturer, ship yard or operator shall specify the environmental conditions in particular.

4.2.3 Design temperature

4.2.3.1 General

4.2.3.1.1 Design temperature is a reference temperature used as a criterion for the selection of steel grades.

4.2.3.1.2 The design temperature T_D is defined as the lowest service temperature for a lifting appliance (see [4.2.3.2]).

4.2.3.1.3 For shipboard lifting appliances installed on ships with **Crane** notation, the design temperatures of the lifting appliances shall be compatible with the design temperature specified for the ship.

4.2.3.1.4 The design temperature of shipboard lifting appliances shall generally not be higher than -10°C. As an exception from this requirement, for shipboard lifting appliances operated in closed, heated compartments with controlled temperature, a design temperature of +10°C applies.

4.2.3.1.5 If not otherwise specified, design temperatures according to [Table 4-1](#) shall be applied.

4.2.3.1.6 Where the design temperature is specified below the values stated in [Table 4-1](#), this shall be explicitly stated by the shipyard or the manufacturer of the lifting appliance in the drawings or other documents submitted to the *Society* for approval. It shall be considered with respect to material selection and processing (welding) as well as with respect to dimensioning of systems sensitive to low temperatures.

Table 4-1 Design temperature for shipboard lifting appliances

Type of lifting appliance	Design temperature	Lowest acceptable service temperature ¹
Shipboard lifting appliances in general	-10°C	-30°C
Shipboard lifting appliances in closed, heated compartments with controlled temperature	+10°C	0°C

1) Conditions according to [4.2.3.2.3] to be complied with.

4.2.3.2 Lowest service temperature

4.2.3.2.1 Service temperature means the ambient air temperature during lifting operation.

4.2.3.2.2 Service temperature of a lifting appliance shall not fall below its design temperature. Exceptions from this requirement are specified in [4.2.3.2.3].

4.2.3.2.3 Exceptionally, for shipboard lifting appliances, service temperatures below design temperature may be acceptable, if following conditions are complied with:

- a) If the design temperature T_D is -10°C or less, then the lowest acceptable service temperature T_{\min} is 20°C below design temperature.
If the design temperature T_D is $+10^\circ\text{C}$, then the lowest acceptable service temperature T_{\min} is 0°C .
- b) The number n_{low} of lifting operations per year at service temperatures below the design temperature is to be limited as follows:

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

N = total number of all lifting operations in the expected life time for the lifting appliance (to be taken from load assumptions of the fatigue analysis).

If the fatigue analysis for a lifting appliance had been dispensed with, then the number of lifting operations at service temperatures below the design temperature shall be limited to $n_{\text{low}} \leq 20$ per year.

- c) The manufacturer of the lifting appliance shall agree on the low temperature. Where necessary the susceptibility of certain components to low temperatures shall be considered.

4.2.4 Load assumptions

4.2.4.1 General

4.2.4.1.1 Shipboard lifting appliances are subject to other and partly greater loads than lifting appliances onshore. This includes amongst others ship inclinations, seagoing accelerations as well as increased wind loads.

4.2.4.1.2 For the design, in principle all loads shall be considered which act upon the lifting appliance in-operation and in the out-of-operation state.

4.2.4.1.3 The design as well as the calculation and dimensioning of all shipboard lifting appliances shall be based on the following load assumptions, if applicable.

4.2.4.1.4 The following sections of this standard may contain further load assumptions which are then to be observed additionally or given preference where applicable, for the lifting appliance under consideration.

4.2.4.1.5 Where shipboard lifting appliances are exposed to special loads which are not stated in this standard, then these shall be taken as a basis for design and dimensioning.

Special loads shall be indicated expressly by the shipyard or manufacturer of the lifting appliance in the drawings or in other documents submitted to the Society for approval. Regarding the proof according to 4.3.7, the partial safety factor to be considered shall be agreed with the Society.

4.2.4.2 Dead loads

4.2.4.2.1 Dead loads according to 1.1.5.10 shall be calculated using recognized standards such as e.g. EN 1991-1-1, or shall be determined by weighing.

4.2.4.2.2 Dead loads are calculated by multiplying the mass by the acceleration of gravity $g = 9.81 \text{ m/s}^2$.

4.2.4.3 Dynamic forces

4.2.4.3.1 Dynamic forces due to drives

The acceleration of lifting appliance components and/or working loads due to drives generates positive or negative dynamic forces, depending on definition, which shall be calculated as follows:

$$\text{force [N]} = \text{mass [kg]} \cdot \text{acceleration [m/s}^2\text{]}.$$

Braking forces due to drives shall be assumed as negative dynamic forces.

Dynamic forces due to drives may normally be assumed as quasi-static loads. They are specified in [5.3.2.4] as design loads.

4.2.4.3.2 Seagoing dynamic forces

Horizontal dynamic forces due to motions of a floating body shall be considered for shipboard lifting appliances used in occasional sea operations in accordance with the method described in [5.3.2.5].

Vertical dynamic forces due to motions of a floating body shall be considered if the calculation is made in accordance with [5.3.2.5.1]. If App.A is applied, they are included in the method used therein; if Table 5-2 is applied, they may be ignored.

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

4.2.4.4 Inclinations of the supporting structure

4.2.4.4.1 Lifting appliances in operation

Lifting appliances shall be dimensioned for operation at the static minimum inclinations according to Table 4-2.

Dynamic loads due to motions of the supporting structure shall be considered in accordance with [5.3.2.5].

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

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

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

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

Table 4-2 Static minimum inclinations

Type of floating body	Static minimum inclination	
	Heel angle α	Trim angle β
Ships and vessels having ship-shape properties	$\pm 5^\circ$	$\pm 2^\circ$
Barges of length less than four (4) times breadth, and catamarans	$\pm 3^\circ$	$\pm 2^\circ$
Floating docks	$\pm 2^\circ$	$\pm 2^\circ$
Semi-submersibles	$\pm 3^\circ$	$\pm 3^\circ$

The values of [Table 4-2](#) assume sufficient stability of the floating body. Where larger inclinations shall be expected during operation of the lifting appliance, then these shall be taken as the basis.

In special cases, to be proven by measurements or calculations, the values may be lower than those in [Table 4-2](#).

For dimensioning, the inclinations which are determined shall be increased by 1° heel and 0.5° trim.

4.2.4.4.2 Lifting appliances out of operation

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 shall be observed.

For this purpose, the dynamic inclinations of the floating body according to [Table A-1](#) shall be assumed.

Simplifying, the calculation of dynamic forces may be performed according to [App.A](#).

4.2.4.5 Wind loads

4.2.4.5.1 General

Shipboard lifting appliances shall in general only be operated up to a mean wind speed of approximately 80% of the design wind speed.

At higher wind speeds, the lifting appliance shall be taken out of operation and be stowed in the stowing position.

Simplifying, the statements in [\[4.2.4.5.2\]](#) and [\[4.2.4.5.3\]](#) are based on a constant mean wind speed acting in any assumed direction and height.

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 the Society.

4.2.4.5.2 Calculation of wind load

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

$$L_W = q \cdot c_f \cdot A_w \text{ [N]}$$

q = $v^2/1.6$ [N/m²] (dynamic pressure)

v = wind speed according to [\[4.2.4.5.3\]](#) [m/s]

c_f = form coefficient according to [\[4.2.4.5.4\]](#) [-]

A_w = wind area [m²].

4.2.4.5.3 Wind speeds

The determination of wind load shall be based on the wind speeds according to [Table 4-3](#).

Table 4-3 Wind speeds

Mode of operation of the lifting appliance	Wind speed	
	in operation	out of operation
Shipboard lifting appliances harbour operation	20 m/s	50 m/s ¹
Shipboard lifting appliances sea operation	25 m/s	50 m/s ¹
1) Not to apply for topped cranes		

For topped shipboard lifting appliances out of operation, the wind speed shall be calculated as a function of height according to the following formula:

$$v = 44 \cdot \left(\frac{h_L}{10}\right)^{0.15} \geq 50 \text{ [m/s]}$$

h_L = height of the centre of area of the boom above waterline [m].

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

Floating cranes shall be treated like shipboard lifting appliances.

4.2.4.5.4 Form coefficients

The form coefficients may be determined according to [App.C](#) or simplified as follows:

c_f = 1.6 for rolled profiles and box girders

c_f = 1.3 for rectangular areas of closed super structures like e.g. engine houses

c_f = 1.2 for cylindrical structural elements.

4.2.4.5.5 Wind areas located behind one another

The wind loads of areas located behind one another may be determined according to [App.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%.

4.2.4.5.6 Wind load on the working load

The wind load acting on the working load shall be calculated according to [\[4.2.4.5.2\]](#), based on the largest wind area of the working load and acting in the most unfavourable direction.

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

$$WL \leq 50t: \quad c_f \cdot A_w = 1.2 \cdot WL \quad [m^2]$$

$$WL > 50t: \quad c_f \cdot A_w = 8.5 \cdot \sqrt{WL} \quad [m^2]$$

WL = working load [t].

4.2.4.6 Snow and ice loads

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

4.2.4.6.2 Where ice accretion shall 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.

4.2.4.6.3 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 .

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

4.2.4.7 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 shall be agreed with the Society and the temperature loads shall be considered in the calculated strength analyses.

4.2.5 Special provisions

4.2.5.1 Conveyance of persons in the harbour

The following provisions imply safety devices which are required in principle in [Sec.9](#), [Sec.10](#) and [Sec.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.

4.2.5.1.1 The safe working load for conveyance of persons (SWL(M)) of shipboard lifting appliances shall not exceed half of the safe working load (SWL) of the shipboard lifting appliance.

Guidance note:

If a shipboard lifting appliance is designed for conveyance of persons exclusively, its SWL(M) shall be half of the SWL the lifting appliance would have when handling cargo/provisions.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.2.5.1.2 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.

4.2.5.1.3 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.

4.2.5.1.4 The minimum lowering and hoisting speed for the conveyance of persons shall not be less than 0.05 m/s.

4.2.5.1.5 Means of conveying persons shall be attached to the lifting appliance 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 not permissible.

4.2.5.1.6 Hoisting and luffing winches of shipboard lifting appliances for conveying persons shall be equipped with a mechanical second brake. The second brake shall be independent of the primary brake.

4.2.5.1.7 If hydraulic cylinders are used for luffing, knuckling or telescoping of a boom, they shall 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 safe working 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 III₅ as per [5.5.2].

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

4.2.5.2 Conveyance of personnel at sea

For the conveyance of personnel at sea the provisions of [4.2.5.1] apply, with the exception of [4.2.5.1.2] and [4.2.5.1.3]. In addition, the following provisions shall be observed:

4.2.5.2.1 Aside from an emergency, the following environmental conditions shall 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.

4.2.5.2.2 Shipboard lifting appliances for occasional operations at sea, shall be equipped with a manual operational control which allows switching between "normal operation" and "conveyance of personnel", if provided for the conveyance of personnel.

4.2.5.2.3 Shipboard lifting appliances according to [4.2.5.2.2] shall comply with the following conditions in the "conveyance of personnel" mode, if applicable:

- There shall be an automatic de-activation of safety systems for release of the cargo runner (emergency system for hooking on of cargo hooks).
- There shall be an automatic de-activation of active or passive heave compensator's. 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 lifting appliance (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 the Society.

4.2.5.3 Sea lashing

4.2.5.3.1 All mobile parts of shipboard lifting appliances, 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 booms require approval by the Society case by case.

4.2.5.3.2 Special stowage positions shall be provided for mobile lifting appliances. They shall be selected such that the prospective loads, like e.g. ship accelerations, wind and wash, are minimized.

4.2.5.3.3 The lifting appliances, as well as their support and lashing devices, shall be sufficiently dimensioned for the loads in the "out of operation" state.

4.3 Calculation principles

4.3.1 Basic requirements

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

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

4.3.1.3 Mobile loads shall be assumed in the most unfavourable positions for the structural element considered.

4.3.1.4 Where non-linear relations, inherent to the system, exist between loads and stresses, stress determination shall be conducted according to 2nd order theory for γ_p -fold loads with consideration of deformations.

4.3.1.5 Calculations according to 2nd order theory shall be based on a reduced design value of the Young's modulus:

$$E_d = E_k / \gamma_m$$

E_d = design value of Young's modulus

E_k = characteristic value of the Young's modulus

γ_m = partial safety factor for resistance values according to [4.3.7.4.3].

Explanations on this can be found in [4.3.7.1] and [4.3.7.2].

4.3.2 Proofs required

4.3.2.1 Normally, the following proofs shall be submitted for all lifting appliances:

- proof of structural safety according to [4.4]
- proof of safety against overturning according to [4.5]
- proof of fatigue strength according to [4.6]
- proof of suitability for use according to [4.7].

4.3.2.2 The following sections of this standard may contain more detailed and/or additional information on proofs required for the lifting appliance considered there.

4.3.3 Materials

4.3.3.1 General

4.3.3.1.1 The materials intended for use shall be indicated in the calculation.

4.3.3.1.2 Regarding material selection the provisions in [Sec.3](#) apply.

4.3.3.2 Calculated yield strength

4.3.3.2.1 General

The strength analyses according to this standard refer as a failure criterion to the yield strength of the material.

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

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.

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

4.3.3.2.2 Steels

The calculated yield strength f_{yr} shall be determined as follows:

$$f_{yr} = 0.83 \cdot R_m \leq R_{eH} \text{ (or } \leq R_{p0.2}\text{)}$$

R_m = ultimate tensile strength [N/mm²]

R_{eH} = yield strength [N/mm²]

$R_{p0.2}$ = 0.2%-yield strength [N/mm²].

Where austenitic steels are used with a ratio $R_{p0.2}/R_m \leq 0.5$, subject to special approval by the Society, for dimensioning, the 1%-yield strength $R_{p1.0}$ may be applied instead of $R_{p0.2}$.

4.3.3.2.3 Aluminium alloys

If aluminium alloys suitable for seawater according to [DNVGL-RU-SHIP Pt.2 Ch.2 Sec.10](#) are used, the yield strength shall be determined as follows:

$$f_{yr} = 0.37 \cdot (R_{p0.2} + R_m) \leq R_{p0.2}$$

R_m = ultimate tensile strength [N/mm²]

$R_{p0.2}$ = 0.2%-yield strength [N/mm²].

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

4.3.4 Section values

4.3.4.1 Hole weakening by bolts

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

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

- the maximum hole clearance is 1 mm and
- the deformations of the structure shall not be limited.

4.3.4.1.3 Where the conditions according to [\[4.3.4.1.2\]](#) 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, shall be taken. For the centre of gravity, the centre of gravity of the gross section shall be assumed.

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

4.3.4.2 Effective breadth of plating

When determining section values, the effective breadth of plating shall be taken into consideration, if necessary. The calculation of the effective breadth of plating may e.g. be conducted in accordance with Eurocode 3 (EN 1993-1-5).

4.3.5 Particularities

4.3.5.1 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 Figure 4-1, shall be proven separately and superimposed on the global stresses.

Notes regarding local stresses due to wheel loads may be taken from [4.9.5].

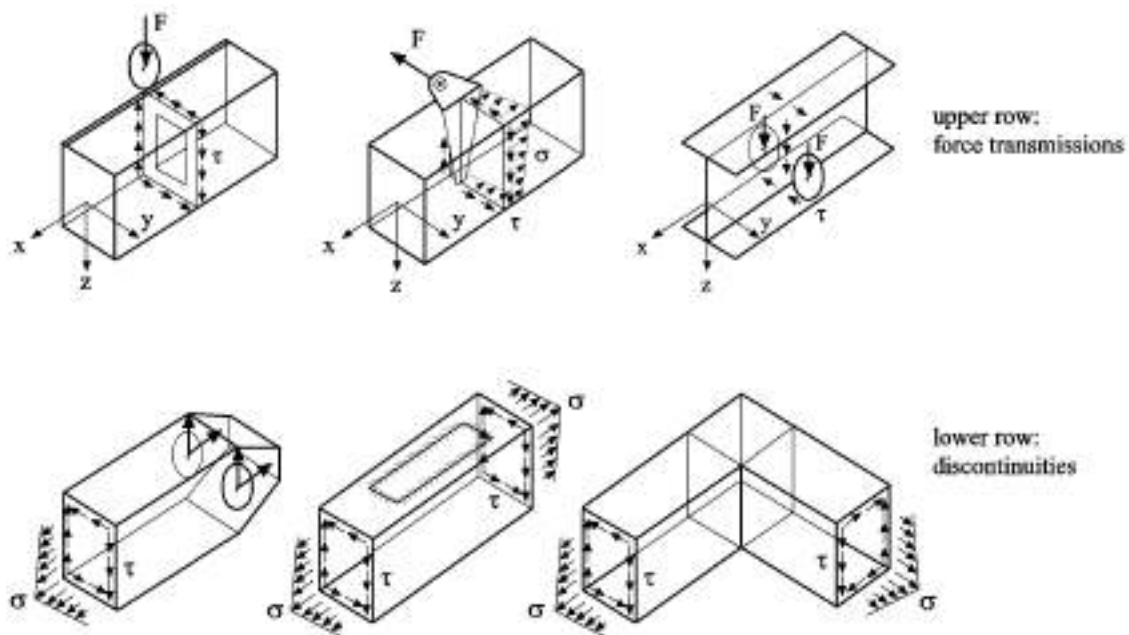


Figure 4-1 Examples for local force transmissions and discontinuities

4.3.5.2 Tie rods

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

4.3.6 Assessment procedures

4.3.6.1 General note

In this standard, the methods of *partial safety factors* and *permissible stresses* are allowed to be used for design assessment.

4.3.6.2 Partial safety factor method

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

4.3.6.3 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 according 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) lifting appliance is not fixed and stability against turn-over has not been proven by tests.

4.3.7 Proof by the method of partial safety factors

4.3.7.1 General

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

4.3.7.2 Definitions

4.3.7.2.1 Loads

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

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

The loads to be considered in each individual case are regulated in the following sections for the respective lifting appliance.

4.3.7.2.2 Stresses

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

Stresses can e.g. be stresses and deformations.

Stresses are marked by the index "S".

4.3.7.2.3 Load bearing capacities

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

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

4.3.7.2.4 Resistance values

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

4.3.7.2.5 Characteristic values

Characteristic values of loads or resistance values do not include safety factors. Characteristic values are marked by the index "k".

4.3.7.2.6 Design values

Design values of loads L are the characteristic values, increased by the partial safety factor γ_p :

$$L_d = \gamma_p \cdot L_k$$

Design values of resistance values WG are the characteristic values, reduced by the partial safety factor γ_m :

$$WG_d = WG_k / \gamma_m$$

Design values are marked by the index "d".

4.3.7.3 General proof format

In general, the degree of utilization (stress/utilization ratio) shall 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 = design value of load, determined from the impacts multiplied by varying partial safety factors γ_p

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

4.3.7.4 Partial safety factors

4.3.7.4.1 For the calculation, the loads which lifting appliance is exposed to, are increased by partial safety factors of varying magnitude.

4.3.7.4.2 The partial safety factors for loads are given in [Sec.5](#), together with the load combinations to be verified.

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

$$\gamma_m = 1.10$$

unless stated otherwise in individual cases.

4.3.7.5 Load combinations

4.3.7.5.1 Loads according to [\[4.2.4\]](#) acting simultaneously, shall be increased by the partial safety factors according to [\[4.3.7.4\]](#) and to be superimposed in load combinations.

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

4.3.8 Proof by the method of permissible stresses

4.3.8.1 General

4.3.8.1.1 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 [\[4.3.6.2\]](#) and [\[4.3.6.3\]](#).

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

4.3.8.2 Proof formats

Without partial safety factors, the following proof formats exist:

$$\begin{array}{ccc} \sigma / \sigma_{zul} \leq 1 & & \sigma \leq \sigma_{zul} \\ \tau / \tau_{zul} \leq 1 & \text{or} & \tau \leq \tau_{zul} \\ \sigma_v / \sigma_{zul} \leq 1 & & \sigma_v \leq \sigma_{zul} \end{array}$$

f_{yr} = calculated yield strength according to [4.3.3.2]

γ_S = global safety factor, depending on the load combinations according to Table 5-4 and Table 5-5
 load combination I: $\gamma_S = 1.48$
 load combination II: $\gamma_S = 1.34$
 load combination III: $\gamma_S = 1.22$

σ_{zul} = permissible stress for normal stresses and equivalent stresses (Mises):

$$\sigma_{zul} = \frac{f_{yr}}{\gamma_S}$$

τ_{zul} = permissible stress for shear stresses:

$$\tau_{zul} = \frac{f_{yr}}{\gamma_S \cdot \sqrt{3}}$$

4.4 Proof of structural safety

4.4.1 General

4.4.1.1 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.

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

4.4.2 Scope of proofs

4.4.2.1 General

4.4.2.1.1 The proof of structural strength consists of two partial proofs:

- the general stress analysis according to [4.4.2.2] and
- the proof of stability according to [4.4.2.3].

4.4.2.1.2 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.

4.4.2.1.3 The proofs of structural safety shall be shown in each case for the most unfavourable load combination according to [4.3.7.5].

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

4.4.2.2 General stress analysis

The general stress analysis is the proof of safety against reaching the calculated yield strength according to [4.3.3.2].

4.4.2.2.1 General

The designations of axes of structural elements used in this standard, as well as forces and moments which may have an impact on a structural element, are illustrated in Figure 4-2.

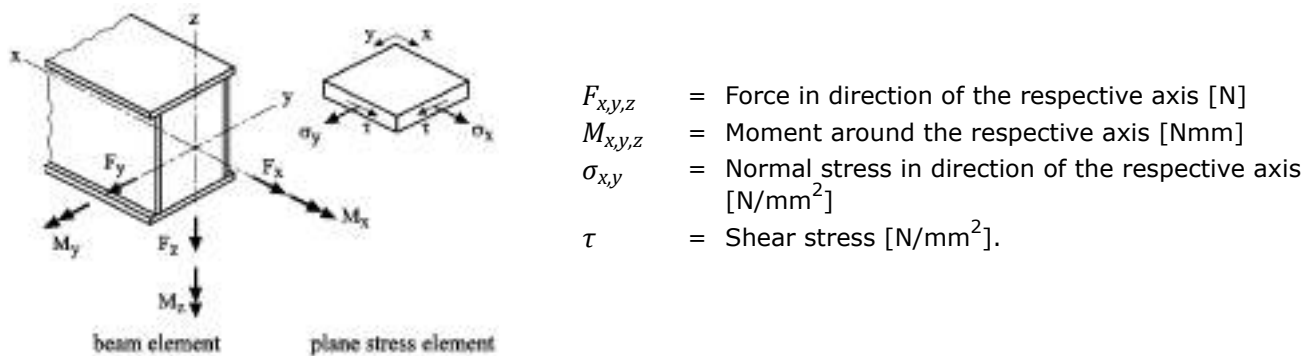


Figure 4-2 Axes of structural elements and possible loads.

4.4.2.2.2 Equivalent stresses

Where normal and shear stresses act simultaneously in a cross-section, the equivalent stress σ_v shall be calculated from the respective allocated stresses. Spatially oriented stresses shall be broken down to the coordinate system according to Figure 4-2.

Generally, the equivalent stress σ_v shall be calculated according to the distortion energy theory (von Mises) as follows:

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

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

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

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

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

4.4.2.2.3 Format of the strength analysis

The strength analysis shall be performed for both the individual stress components as well as the equivalent stresses, analogous to [4.3.7.3] as follows:

$$\begin{array}{ll} \sigma_{Sd} / \sigma_{Rd} \leq 1 & \sigma_{Sd} \leq \sigma_{Rd} \\ \tau_{Sd} / \tau_{Rd} \leq 1 & \text{or} \quad \tau_{Sd} \leq \tau_{Rd} \\ \sigma_{v,Sd} / \sigma_{Rd} \leq 1 & \sigma_{v,Sd} \leq \sigma_{Rd} \end{array}$$

$$\left. \begin{array}{l} \sigma_{Sd} \\ \tau_{Sd} \\ \sigma_{v,Sd} \end{array} \right\} = \text{design values of the stresses based on the loads multiplied by partial safety factors } \gamma_P$$

$$\left. \begin{array}{l} \sigma_{Rd} = \frac{f_{yr}}{\gamma_m} \\ \tau_{Rd} = \frac{f_{yr}}{\gamma_m \cdot \sqrt{3}} \end{array} \right\} = \text{design values of the permissible stresses (load bearing capacity)}$$

f_{yr} = calculated yield strength according to [4.3.3.2]

γ_m = partial safety factor according to [4.3.7.4.3]

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

4.4.2.3 Proof of stability

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

4.4.2.3.2 Proofs of stability for steel constructions may be conducted according to Eurocode 3 (EN 1993-1-1, EN 1993-1-3, EN 1993-1-5, EN 1993-1-7).

4.4.2.3.3 Proofs of stability for aluminium alloy constructions may be conducted according to Eurocode 9 (EN 1999-1-1, EN 1999-1-4, EN 1999-1-5).

4.4.2.3.4 Proofs of stability for constructions made of austenitic steel may be conducted according to Eurocode 3 (EN 1993-1-4).

4.4.2.3.5 When applying Eurocodes for stability proofs, the following shall be taken into consideration:

- Instead of safety factor γ_{M1} according to Eurocode, the value γ_m according to [4.3.7.4.3] shall be used.
- Instead of the yield strength, the calculated yield strength f_{yr} according to [4.3.3.2] shall be used.

4.5 Proof of safety against overturning

4.5.1 General

4.5.1.1 Lifting appliances and parts of lifting appliances not connected integrally to the residual structure, shall be sufficiently safe against overturning at all times.

For mobile lifting appliances, also whereat operating on a circular track, safety against overturning shall be proven in all cases.

4.5.1.2 Safety against overturning of lifting appliances 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.

4.5.1.3 Lifting appliances which travel on rails shall be equipped with devices to prevent overturning, and shall generally be stable even without such devices.

4.5.1.4 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.

4.5.2 Proof of safety against overturning

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

Where the danger of overturning exists for parts of non-mobile lifting appliances, the proof shall be demonstrated analogously to [4.5.2.1].

4.5.2.1 Lifting appliances on rails

4.5.2.1.1 Calculational proof is regarded as sufficient for the safety against overturning of lifting appliances on rails.

This proof shall be conducted using the method of partial safety factors according to [4.3.7].

Thereby the partial safety factors for loads according to [4.3.7] are generally to be considered.

4.5.2.1.2 Lifting appliances are 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 shall be observed:

$$\frac{\sum M_{St}}{\sum M_{Ki}} \geq 1.0$$

ΣM_{St} = sum of restoring moments

ΣM_{Ki} = sum of overturning moments.

4.5.2.1.3 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 the Society, who will also determine the magnitude of the test load and the nature of the test (static and/or dynamic).

4.5.2.1.4 Devices to prevent overturning shall 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.

4.5.2.2 Industrial cargo-handling vehicles

The safety against overturning of industrial cargo-handling vehicles shall be determined on an inclinable platform for each new type.

On the basis of 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).

4.6 Proof of fatigue strength

4.6.1 General

4.6.1.1 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.

4.6.1.2 The fatigue strength analysis shall be conducted according to requirements as given in this section or, subject to agreement with the Society, according to another recognized basic calculation principle.

4.6.2 Application

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

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

4.6.2.3 Low cycle fatigue problems are not subject to the following rules and shall be specially considered, where applicable.

4.6.3 Definitions

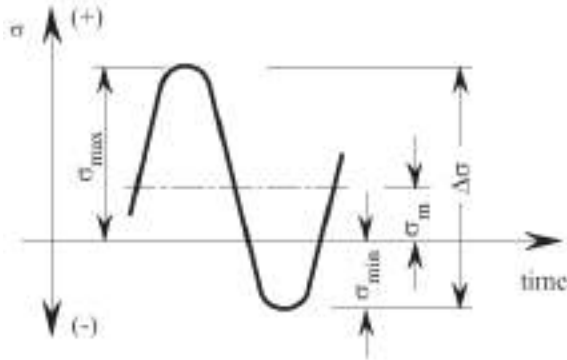


Figure 4-3 Dynamic load cycle

$\Delta\sigma$ = applied stress range [N/mm²] (see also [Figure 4-3](#)), defined as:

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

σ_{\max} = maximum upper stress [N/mm²] of a stress cycle

σ_{\min} = minimum lower stress [N/mm²] of a stress cycle

$\Delta\sigma_{\max}$ = applied peak stress range [N/mm²] within a stress range spectrum

σ_m = mean stress [N/mm²], defined as:

$$\sigma_m = (\sigma_{\max} + \sigma_{\min}) / 2$$

$\Delta\sigma_p$ = permissible stress range [N/mm²]

$\Delta\tau$ = corresponding range for shear stress [N/mm²]

n = number of applied stress cycles

N = number of endurable stress cycles according to S-N curve
(= endurable stress cycles under constant amplitude loading)

$\Delta\sigma_R$ = fatigue strength reference value of S-N curve at $2 \cdot 10^6$ cycles of stress range [N/mm²]
(= FAT class according to [Table B-1](#))

f_n = factor considering stress spectrum and number of cycles for calculation of permissible stress range

$\Delta\sigma_{RC}$ = corrected fatigue strength reference value of S-N curve at $2 \cdot 10^6$ stress cycles [N/mm²]

D = cumulative damage ratio.

4.6.4 Quality requirements (fabrication tolerances)

4.6.4.1 The detail classification of the different welded joints as given in [Table B-1](#) is based on the assumption that the fabrication of the structural detail or welded joint, respectively, corresponds in regard to external defects at least to quality group B according to DIN EN ISO 5817 and in regard to internal defects at least to quality group C.

4.6.4.2 Relevant information shall be included in the manufacturing document for fabrication. If it is not possible to comply with the tolerances given in the standards, this shall be accounted for when designing the structural details or welded joints, respectively. In special cases an improved manufacture as stated in [\[4.6.4.1\]](#) may be required, e.g. stricter tolerances or improved weld shapes, see also [\[4.6.9.2.4\]](#).

4.6.4.3 The following stress increase factors k_m for considering significant influence of axial and angular misalignment are already included in the fatigue strength reference values $\Delta\sigma_R$ [Table B-1](#):

k_m = 1.15 butt welds (corresponding type A1, A2, A11)

k_m = 1.30 butt welds (corresponding type A3 – A10)

k_m = 1.45 cruciform joints (corresponding type D1 – D5)

k_m = 1.25 T-joints (corresponding type D1 – D3)

k_m = 1.25 fillet welds on one plate surface (corresponding type C7, C8).

Other additional stresses need to be considered separately.

4.6.5 Stress range spectrum

4.6.5.1 Definitions

4.6.5.1.1 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 lifting appliance.

4.6.5.1.2 The standard stress range spectrum of lifting appliances describes the frequency of the different working loads to be handled during the lifetime of the lifting appliance.

4.6.5.1.3 Regarding the fatigue strength analysis, it shall be taken into consideration that the standard stress range spectrum of lifting appliances 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.

4.6.5.2 Stress range spectrum for the condition in-operation

4.6.5.2.1 Regarding the fatigue strength analysis for the condition in-operation, lifting appliances are normally to be categorized in groups corresponding to the standard stress range spectra S0 to S7 according to Figure 4-4.

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

4.6.5.2.3 The number n_{max} of stress cycles during operation shall be provided by the manufacturer.

4.6.5.2.4 The stress spectra S0 to S6 are defined by the following equation (see Figure 4-4):

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

$\Delta\sigma$ = stress range

$\Delta\sigma_{max}$ = maximum stress range of the spectrum according to [4.6.4]

n = number of stress cycles

n_{max} = total number of stress cycles

κ = $\frac{1}{(2.5 \cdot p - 2.8) \cdot \log(p)} + 1.5$

p = coefficient according to Table 4-4.

For $p = 0$, $\kappa = 1.5$ shall be assumed.

Table 4-4 Coefficients for the calculation of the κ -value

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

4.6.5.2.5 Applicable for the stress range spectrum S7:

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

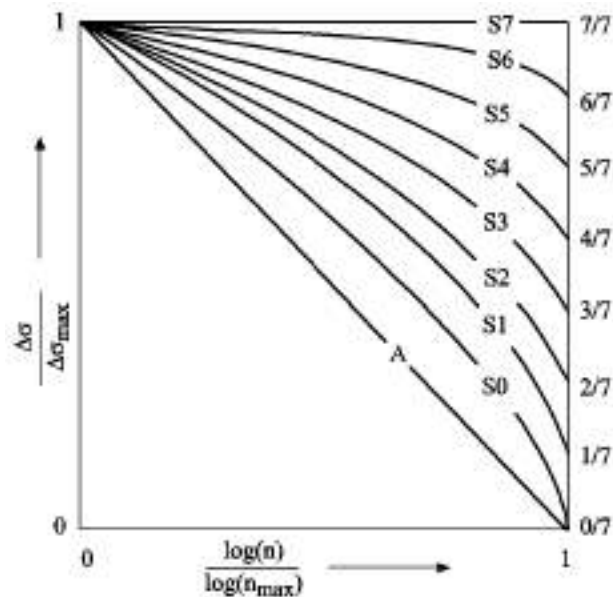


Figure 4-4 Standard stress range spectra

4.6.5.2.6 Where the operating conditions of shipboard lifting appliances 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 shall be proven by the manufacturer.

4.6.5.3 Stress range spectra for the condition out-of-operation

The fatigue strength analysis for the condition "out of operation" shall be conducted for the straight-line spectrum A according to Figure 4-4 and a total number of stress cycles $n_{\max} = 5 \cdot 10^7$.

4.6.6 Calculation of the maximum stress range

4.6.6.1 The fatigue strength analysis is, depending on the detail considered, based on one of the following types of stress:

- For notches of free plate edges the notch stress σ_k , determined for linear-elastic material behaviour, is relevant. The fatigue strength is determined by the FAT class ($\Delta\sigma_R$) according to Table B-1, type E2 and E3.
- For welded joints the fatigue strength analysis is normally based on the nominal stress σ_n at the structural detail considered and on an appropriate detail classification as given in Table B-1, which defines the FAT class ($\Delta\sigma_R$).
- For those welded joints, for which the detail classification is not possible or additional stresses occur, which are not or not adequately considered by the detail classification, the fatigue strength analysis may be performed on the basis of the structural stress σ_s in accordance with [4.6.8].

4.6.6.2 The maximum stress range for a construction detail shall be calculated from the maximum upper stress σ_{\max} and the minimum lower stress σ_{\min} in this detail:

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

4.6.6.3 The maximum upper stress σ_{\max} and the minimum lower stress σ_{\min} shall be determined each from loads of the most unfavourable magnitude, location and direction acting on the lifting appliance in the most unfavourable position.

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

4.6.7 Fatigue strength analysis for free plate edges and for welded joints using detail classification

4.6.7.1 Definition of nominal stress and detail classification for welded joints

4.6.7.1.1 Corresponding to their notch effect, welded joints are normally classified into detail categories considering particulars in geometry and fabrication, including subsequent quality control, and definition of nominal stress. [Table B-1](#) shows the detail classification based on recommendations of the International Institute of Welding (IIW) giving the FAT class ($\Delta\sigma_R$) for structures made of steel or aluminium alloys (Al). It shall be noted that some influence parameters cannot be considered by the detail classification and that a large scatter of fatigue strength has therefore to be expected.

4.6.7.1.2 Details which are not contained in [Table B-1](#) may be classified either on the basis of local stresses in accordance with [\[4.6.8\]](#) or, else, by reference to published experimental work or by carrying out special fatigue tests, assuming a sufficiently high confidence level (see [\[4.6.9.1\]](#)) and taking into account the correction factors as given in [\[4.6.9.2.6\]](#).

Details contained in [Table B-1](#), produced by improved manufacturing technology, may be classified by carrying out special fatigue tests as described above. Such classification of details shall be agreed upon with the Society case by case.

4.6.7.1.3 Regarding the definition of nominal stress, the arrows in [Table B-1](#) indicate the location and direction of the stress for which the stress range shall be calculated. The potential crack location is also shown in [Table B-1](#). Depending on this crack location, the nominal stress range shall be determined by using either the cross sectional area of the parent metal or the weld throat thickness, respectively.

Bending stresses in plate and shell structures shall be incorporated into the nominal stress, taking the nominal bending stress acting at the location of crack initiation.

Guidance note:

The factor K_s for the stress increase at transverse butt welds between plates of different thickness (see type A5 in [Table B-1](#)) can be estimated in a first approximation as follows:

$$K_s = \frac{t_2}{t_1}$$

t_1 = smaller plate thickness

t_2 = larger plate thickness.

Additional stress concentrations which are not characteristic of the FAT class itself, e.g. due to cut-outs in the neighbourhood of the detail, shall also be incorporated into the nominal stress.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.6.7.1.4 In the case of combined normal and shear stress the relevant stress range shall be taken as the range of the principal stress at the potential crack location which acts approximately perpendicular (within $\pm 45^\circ$) to the crack front as shown in [Table B-1](#) as long as it is larger than the individual stress components.

4.6.7.1.5 Where solely shear stresses are acting the largest principal stress $\sigma_1 = \tau$ may be used in combination with the relevant FAT class.

4.6.8 Fatigue strength analysis for welded joints based on local stresses

4.6.8.1 Alternatively to the procedure described in the preceding paragraphs, the fatigue strength analysis for welded joints may be performed on the basis of local stresses. For common plate and shell structures in ships the assessment based on the so-called structural (or hot-spot) stress σ_s is normally sufficient.

The structural stress is defined as the stress being extrapolated to the weld toe excluding the local stress concentration in the local vicinity of the weld, see Figure 4-5.

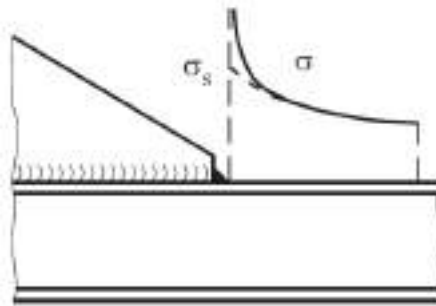


Figure 4-5 Structural stress

4.6.8.2 The structural stress can be determined by measurements or numerically e.g. by the finite element method using shell or volumetric models under the assumption of linear stress distribution over the plate thickness. Normally the stress is extrapolated linearly to the weld toe over two reference points which are located 0.5 and $1.5 \times$ plate thickness away from the weld toe. In some cases the structural stress can be calculated from the nominal stress σ_n and a structural stress concentration factor K_s , which has been derived from parametric investigations using the methods mentioned. Parametric equations should be used with due consideration of their inherent limitations and accuracy.

4.6.8.3 For the fatigue strength analysis based on structural stress, the S-N curves shown in Figure 4-6 apply with the following reference values:

$\Delta\sigma_R = 100$ (resp. 40 for Al) for the butt welds types A1 to A6 and for K-butt welds with fillet welded ends, e.g. type D1 in Table B-1, and for fillet welds which carry no load or only part of the load of the attached plate, type C1 to C9 in Table B-1.

$\Delta\sigma_R = 90$ (resp. 36 for Al) for fillet welds, which carry the total load of the attached plate, e.g. type D2 in Table B-1.

In special cases, where e.g. the structural stresses are obtained by non-linear extrapolation to the weld toe and where they contain a high bending portion, increased reference values of up to 15% can be allowed.

4.6.8.4 In addition to the assessment of the structural stress at the weld toe, the fatigue strength with regard to root failure shall be considered by analogous application of the respective FAT class, e.g. type D3 of Table B-1.

In this case the relevant stress is the stress in the weld cross section caused by the axial stress in the plate perpendicular to the weld. It shall be converted at a ratio of $t/(2 \cdot a)$.

4.6.9 Design S-N curves

4.6.9.1 Description of the design S-N curves

4.6.9.1.1 The design S-N curves for the calculation of the cumulative damage ratio according to [4.6.10.1] are shown in Figure 4-6 for welded joints at steel and in Figure 4-7 for notches at plate edges of steel plates. For aluminium alloys (Al) corresponding S-N curves apply with reduced reference values of the S-N curves (FAT classes) according to Table B-1. The S-N curves represent the lower limit of the scatter band of 95% of all test results available (corresponding to 97.5% survival probability) considering further detrimental effects in large structures.

To account for different influence factors, the design S-N curves shall be corrected according to [4.6.9.2].

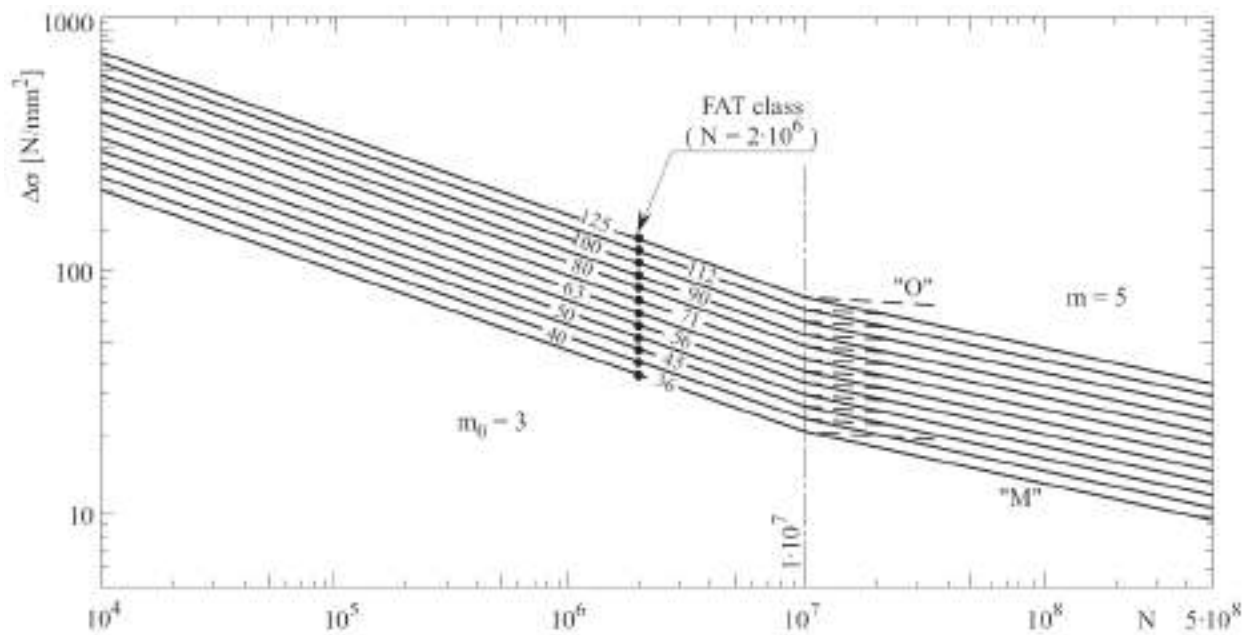


Figure 4-6 S-N curves for welded joints at steel

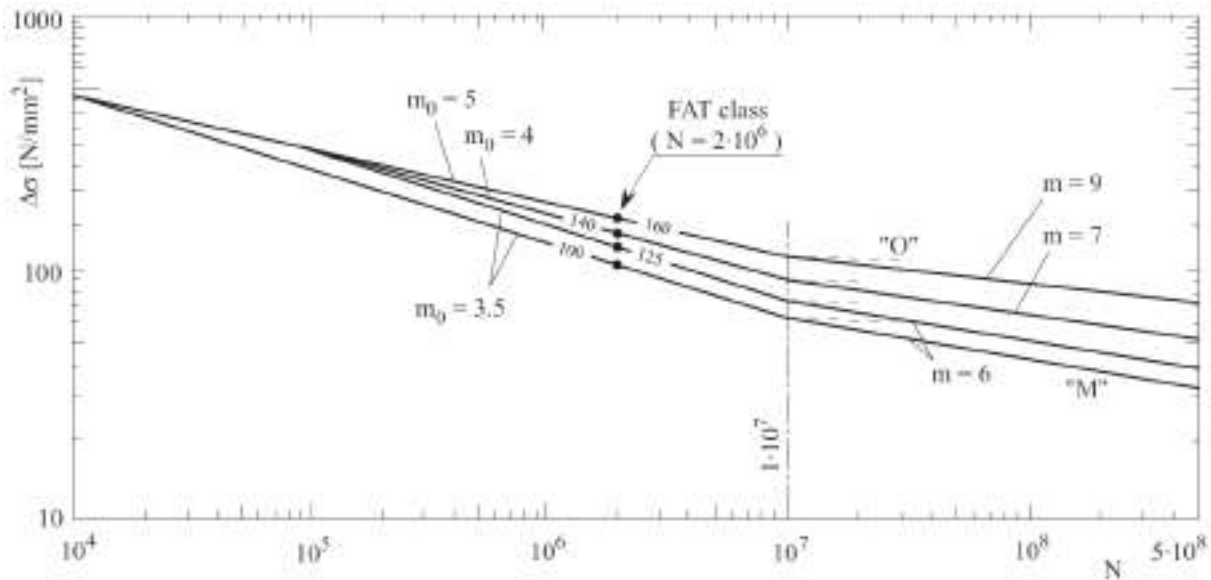


Figure 4-7 S-N curves for notches at plate edges of steel plates

4.6.9.1.2 The S-N curves represent section-wise linear relationships between $\log(\Delta\sigma)$ and $\log(N)$:

$$\log(N) = 7.0 + m \cdot Q$$

Q = coefficient, defined as:

$$Q = \log(\Delta\sigma_R / \Delta\sigma) - 0.69897 / m_0$$

m = slope exponent of S-N curve, see [4.6.9.1.3] and [4.6.9.1.4]

m_0 = inverse slope in the range $N \leq 1 \cdot 10^7$, defined as:

$m_0 = 3$ for welded joints

$m_0 = 3.5 \div 5$ for free plate edges (see Figure 4-7).

The S-N curve for FAT class 160 forms the upper limit for the S-N curves of free edges of steel plates with detail categories 100 – 150 in the range of low stress cycles, see Figure 4-7. The same applies accordingly to FAT classes 32 – 40 of aluminium alloys with an upper limit of FAT 71, see type E1 in Table B-1.

4.6.9.1.3 For structures subjected to variable stress ranges, the S-N curves shown by the solid lines in Figure 4-6 and Figure 4-7 shall be applied (S-N curves of type "M"), i.e.:

$$m = m_0 \quad \text{for } N \leq 10^7 \quad (Q \leq 0)$$

$$m = 2 \cdot m_0 - 1 \quad \text{for } N > 10^7 \quad (Q > 0)$$

4.6.9.1.4 For stress ranges of constant magnitude (stress range spectrum S7) in non-corrosive environment from $N = 1 \cdot 10^7$ the S-N curves of type "O" in Figure 4-6 and Figure 4-7 can be used, thus:

$$m = m_0 \quad \text{for } N \leq 10^7 \quad (Q \leq 0)$$

$$m = 22 \quad \text{for } N > 10^7 \quad (Q > 0)$$

4.6.9.2 Correction of the reference value of the design S-N curve

4.6.9.2.1 A correction of the reference value of the S-N curve (FAT class) is required to account for additional influence factors on fatigue strength as follows:

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

- $\Delta\sigma_R$ = FAT class according to Table B-1 or EN 1993-1-9
 f_m = correction factor for material effect according to [4.6.9.2.2]
 f_R = correction factor for mean stress effect according to [4.6.9.2.3]
 f_w = correction factor for weld shape effect according to [4.6.9.2.4]
 f_i = correction factor for importance of structural element according to Table 4-5
 f_t = correction factor for thickness effect according to [4.6.9.2.5]
 f_s = additional correction factor for structural stress analysis according to [4.6.9.2.6].

For the description of the corrected design S-N curve, the formulae given in [4.6.9.1.2] may be used by replacing $\Delta\sigma_R$ by $\Delta\sigma_{RC}$.

4.6.9.2.2 Material effect (f_m)

For welded joints it is generally assumed that the fatigue strength is independent of steel strength, i.e.:

$$f_m = 1.0$$

For free edges at steel plates the effect of the material's yield strength is accounted for as follows:

$$f_m = 1 + \frac{R_{eH} - 235}{1200}$$

For aluminium alloys, $f_m = 1$ generally applies.

4.6.9.2.3 Effect of mean stress (f_R)

The correction factor f_R shall be determined by the following formulae:

$$\begin{aligned} f_R &= 1.0 && \text{for } \sigma_m \geq (\Delta\sigma_{\max}/2) && \text{(range of tensile pulsating stresses)} \\ f_R &= 1.0 + c \cdot \left(1 - \frac{2 \cdot \sigma_m}{\Delta\sigma_{\max}}\right) && \text{for } -(\Delta\sigma_{\max}/2) \leq \sigma_m \leq (\Delta\sigma_{\max}/2) && \text{(range of alternating stresses)} \\ f_R &= 1 + 2 \cdot c && \text{for } \sigma_m \leq -(\Delta\sigma_{\max}/2) && \text{(range of compressive pulsating stresses)} \end{aligned}$$

c = coefficient, defined as:

- $c = 0$ for welded joints subjected to constant stress cycles (stress range spectrum S7)
- $c = 0.15$ for welded joints subjected to variable stress cycles (corresponding to stress range spectrum A or S0÷S6)
- $c = 0.30$ for unwelded base material.

4.6.9.2.4 Effect of weld shape (f_w)

In normal cases:

$$f_w = 1.0$$

A factor $f_w > 1.0$ applies for welds treated e.g. by grinding. Grinding removes surface defects such as slag inclusions, porosity and crack-like undercuts, to achieve a smooth transition from the weld to the base

material. Final grinding shall be performed transversely to the weld direction. The depth should be about 0.5 mm larger than the depth of visible undercuts.

For ground weld toes of fillet and K-butt welds machined by:

$$f_w = 1.15 \text{ for disc grinder}$$

$$f_w = 1.30 \text{ for burr grinder.}$$

Premise for this is that root and internal failures can be excluded. Application of toe grinding to improve fatigue strength is limited to following details of [Table B-1](#):

- butt welds of type A2, A3 and A5 if they are ground from both sides
- non-load-carrying attachments of type C1, C2, C5 and C6 if they are completed with a full penetration weld
- transverse stiffeners of type C7
- doubling plates of type C9 if the weld throat thickness according to [\[11.3.2.6\]](#) was increased by 30%
- cruciform and T-joints of type D1 with full penetration welds.

The corrected FAT class that can be reached by toe grinding is limited for all types of welded connections of steel to $f_w \cdot \Delta\sigma_R = 100 \text{ N/mm}^2$ and of aluminium to $f_w \cdot \Delta\sigma_R = 40 \text{ N/mm}^2$.

For butt welds ground flush the corresponding reference value of the S-N curve (FAT class) shall be chosen, e.g. type A1, A10 or A12 in [Table B-1](#).

For endings of stiffeners or brackets, e.g. type C2 in [Table B-1](#), which have a full penetration weld and are completely ground flush to achieve a notch-free transition, the following factor applies:

$$f_w = 1.4$$

The assessment of a local post-weld treatment of the weld surface and the weld toe by other methods e.g. ultrasonic impact treatment shall be agreed on in each case.

4.6.9.2.5 Plate thickness effect (f_t)

In order to account for the plate thickness effect, application of the reduction factor f_t is required for butt welds oriented transversely to the direction of applied stress for plate thicknesses $t > 25 \text{ mm}$.

$$f_t = \left(\frac{25}{t}\right)^{n-k} \leq 1.0$$

n = exponent for additional notch effect at weld toe, defined as:

$$n = 0.20 \text{ as welded}$$

$$n = 0.10 \text{ toe-ground}$$

k = exponent for misalignment (see [\[4.6.4.3\]](#)), defined as:

$$k = 0.10 \text{ for butt welds with } k_m = 1.30$$

$$k = 0.05 \text{ for butt welds with } k_m = 1.15$$

k_m = factor according to [\[4.6.4.3\]](#).

For all other weld connections consideration of the thickness effect may be required subject to agreement with the Society.

4.6.9.2.6 Correction factor for structural stress analysis (f_s)

If the fatigue strength analysis for welded joints is based on local stresses according to [\[4.6.8\]](#), then the reference value $\Delta\sigma_{RC}$ of the corrected S-N curve shall be determined according to [\[4.6.4.3\]](#), taking into account the following additional correction factor which describes influencing parameters not included in the calculation model such as e.g. misalignment:

$$f_s = \frac{1}{k'_m - \frac{\Delta\sigma_{s,b}}{\Delta\sigma_{s,max}} \cdot (k'_m - 1)}$$

- $\Delta\sigma_{s,max}$ = applied peak stress range within a stress range spectrum
 $\Delta\sigma_{s,b}$ = bending portion of $\Delta\sigma_{s,max}$
 k'_m = effective stress increase factor due to misalignments under axial loading, defined as:
 $k'_m = k_m - 0.05$
 k_m = stress increase factor due to misalignments under axial loading, at least k_m according to [4.6.4.3].

If the fatigue strength analysis for free plate edges and for welded joints is based on detail classification according to [4.6.7], then $f_s = 1,0$.

Table 4-5 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 or fall-down of the load.

4.6.10 Proof

4.6.10.1 Calculation of the cumulative damage ratio

4.6.10.1.1 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" shall 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 endurable stress cycles determined from the corrected S-N curve (see [4.6.9]) 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 according to [4.6.5.2.4] or [4.6.5.2.5] or individually determined stress range spectra according to [4.6.5.2.6] may be applied. For the condition "out of operation", the straight-line stress range spectrum according to [4.6.5.3] shall be applied.

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

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

4.6.10.2 Permissible stress range

4.6.10.2.1 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 according to [4.6.5.2.4] or [4.6.5.2.5] shall be applied, for the condition "out of operation", the straight-line stress range spectrum according to [4.6.5.3].

The requirements given 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 shall be conducted on the basis of the calculated cumulative damage ratios according to [4.6.10.1] or upon agreement with the Society.

4.6.10.2.2 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 according to [4.6.6]

$\Delta\sigma_p$ = permissible stress range according to [4.6.10.2.3]

4.6.10.2.3 The permissible stress ranges shall be calculated by the following formula:

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

$\Delta\sigma_{Rc}$ = corrected FAT class according to [4.6.9.2.1]

f_n = factor for the shape and extent of the spectrum according to Table 4.6 to Table 4-10.

Table 4-6 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 4-7 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}										
	$2 \cdot 10^4$	$5 \cdot 10^4$	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	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 according to [Table B-1](#) or EN 1993-1-9)

Table 4-8 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}										
	$2 \cdot 10^4$	$5 \cdot 10^4$	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	7.78 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	1.20	0.92	0.77	0.68	0.54	0.49
1) For $\Delta\sigma_R < 150$ [N/mm ²] 2) For $\Delta\sigma_R < 140$ [N/mm ²] ($\Delta\sigma_R$ = FAT class according to Table B-1 or EN 1993-1-9)											

Table 4-9 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 4-10 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

4.7 Proof of suitability for use

4.7.1 General

4.7.1.1 Shipboard lifting appliances as well as its structural elements and equipment shall 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 lifting appliance drives, by ship machinery or influences of sea state)
- heat
(e.g. expansion, overheating of drives or brakes)
- highest position of boom
(see [12.2.1.1]).

4.7.1.2 Suitability for use shall be demonstrated in the course of the initial testing on board.

4.7.2 Permissible deformations

4.7.2.1 Compression members

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

4.7.2.1.2 The uniform deflection of unloaded compression members or compression members loaded by dead load only, which are special or primary structural elements (see [3.1.2.1]), shall not be larger than the rod length divided by 500.

4.7.2.1.3 The uniform deflection of unloaded compression members or compression members loaded by dead load only, which are secondary structural elements (see [3.1.2.1]), e.g. wind or framework bracings, shall not be larger than the rod length divided by 350.

4.7.2.2 Tension members

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

4.8 Joints

4.8.1 Proof of weld joints

4.8.1.1 Prerequisites

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

For further general prerequisites see [Sec.11](#).

4.8.1.2 General strength analysis

4.8.1.2.1 General

Weld thickness's, which are the basis of the strength analysis, are given in [11.4] for various shapes of welds.

4.8.1.2.2 Welds located in the plate plane

The permissible stress of welds located in the plate plane is the design value of the permissible stress of the adjoining plate according to [4.4.2.2.3].

4.8.1.2.3 Fillet welds

For fillet welds, the strength analysis may be conducted according to [DNVGL-RU-SHIP Pt.6 Ch.13](#) or according to a recognized basic principle of calculation or standard.

4.8.1.2.4 Plates loaded by tension transversely to the direction of rolling

Steels having through thickness ductility ("Z-steel") may be required for plates and wide flat bars, see also [3.2.1.4].

4.8.1.3 Proof of fatigue strength

Regarding the proof of fatigue strength, the statements in [4.6] apply.

4.8.2 Proofs for bolted connections

4.8.2.1 General

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

4.8.2.1.2 The approaches according to [4.8.2.2] and [4.8.2.3] in principle imply that:

- connected areas are secured against distortion, e.g. by use of at least two (2) bolts
- contacting areas are smooth and free from grease
- the use of bolts of strength class 12.9 is agreed with the Society.

4.8.2.2 Gusset connections with fitting-bolts (fitting-bolt shear connections)

4.8.2.2.1 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.

4.8.2.2.2 Construction

Figure 4-8 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) according to ISO 286-2.
- Bolt shafts shall be as long as the thickness of the parts to be connected. Where, due to the cylindrical shaft length, it is not possible to tighten the bolts, washers shall 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 five (5) (strength classes 4.6 and 5.6) or three (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.

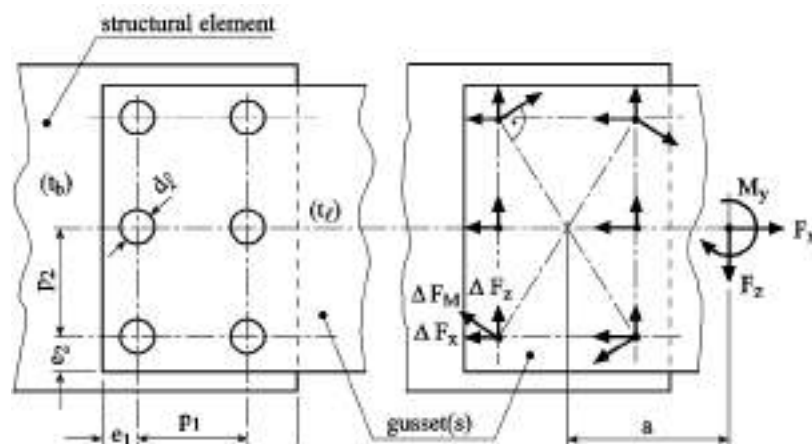


Figure 4-8 Example of a gusset connection

Regarding the edge and hole distances according to [Figure 4-8](#), the limit values according to [Table 4-11](#) apply.

Table 4-11 Limit values for edge and hole distances

	<i>Min.</i>	<i>Max.</i> ¹
Edge distances e_1 and e_2	$1.5 \cdot d_t$	$4 \cdot t + 40$ mm
Hole distances p_1 and p_2	$3.0 \cdot d_t$	The lesser value of: $14 \cdot t$ or 200 mm
1) t – thickness of the thinnest external plate		

4.8.2.2.3 Permissible stresses for bearing stress and shearing-off

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

$$\sigma_{zul} = \alpha_{\sigma} \cdot \frac{R_{eH}}{\gamma_m \cdot 0.7} \text{ (bearing stress)}$$

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

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

$R_{eH,s}$ = yield strength of bolts according to [Table 4-12](#).

Correction coefficients α_{σ} , α_{τ} :

a) Multishear bolt connections

$$\alpha_{\sigma m} = \min \left\{ \begin{array}{l} \frac{c_1}{3 \cdot d_t} \\ \frac{p_1}{3 \cdot d_t} - 0.25 \\ \frac{R_{m,s}}{R_m} \\ 1.0 \end{array} \right\}$$

$$\alpha_{\tau m} = 1.0$$

$R_{m,s}$ = ultimate tensile strength of bolts according to [Table 4-12](#) [N/mm²]

R_m = ultimate tensile strength of structural elements according to material standard (nominal value) [N/mm²].

b) Single-shear bolt connections

$$\alpha_{\sigma e} = 0.78 \cdot \alpha_{\sigma m}$$

$$\alpha_{\tau e} = 0.77.$$

Table 4-12 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

4.8.2.2.4 Proofs for transmissible bolt forces

To determine the largest bolt forces for the example in [Figure 4-8](#), the following forces shall be added geometrically:

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

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

$$\Delta F_{M,d} = \frac{M_{y,d} + F_{z,d} \cdot a}{4 \cdot \sqrt{0.25 \cdot p_1^2 + p_2^2}}$$

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 shall be provided:

- bearing stresses: $F_{r,d} \leq d_s \cdot t_{min} \cdot \sigma_{zul}$
- shearing-off: $F_{r,d} \leq A_s \cdot n_f \cdot \tau_{zul}$

- $F_{r,d}$ = largest resulting bolt force (rectangular to the bolt axis)
- 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 multishear)
- $\sigma_{zul} \tau_{zul}$ = permissible stresses according to [\[4.8.2.2.3\]](#) [N/mm²].

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

Stress spectra shall be determined according to [\[4.6\]](#).

The maximum stress range of the shear stress $\Delta\tau_{max}$ shall be determined according to [\[4.6\]](#) for the shaft cross-section of the fitting-bolt.

The design S-N curve for shear stress of fitting-bolts is shown in [Figure 4-9](#).

The fatigue strength analysis may be conducted on the basis of calculated damage ratios according to [\[4.6\]](#).

As an alternative, the fatigue strength analysis may be conducted on the basis of permissible stress ranges for the standard spectra S0 to S7 according to [4.6] 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;
 $\Delta\tau_R = 100 \text{ N/mm}^2$
- f_n = factor for the shape and extent of the spectrum according to Table 4-13
- f_i = influence of the importance of the structural element according to Table 4-5.

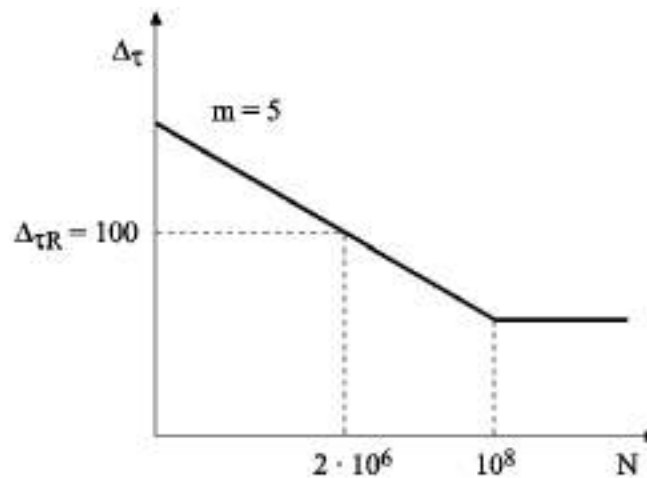


Figure 4-9 Design S-N curve for shear load of fitting-bolts

4.8.2.2.5 Proofs for structural elements and gussets

The strength analyses for the structural elements and gussets connected with each other shall be based on the cross-sections designed for tension, compression, shear and bending according to [4.3.4].

For the permissible stresses, see [4.4.2.2].

4.8.2.3 Gasket connections with prestressed bolts (friction-grip connections)

4.8.2.3.1 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 4-13 Factor f_n for standard stress range spectra S0 to S7 according to [4.6.5] and design S-N curve according to Figure 4-9

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	0.46

4.8.2.3.2 Construction

Figure 4-8 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 shall 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 $\alpha_s = 0.7$. Well-founded deviations in the range of $0.6 \leq \alpha_s \leq 0.8$ 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 shall be applied.
- For the contact areas, a special surface treatment is required according to [4.8.2.3.3].
- 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.
- The forces to be submitted may be distributed over 3 rows of bolts at a maximum.
- The hole distances shall comply with the requirements according to [4.8.2.2.2].
- 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.

4.8.2.3.3 Friction coefficient μ

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

$\mu = 0.50$ for surfaces:

- of shining metal layers, steel shot or sand blasted without unevenness
- 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.

$\mu = 0.40$ for surfaces steel shot or sand blasted and coated with a 50 μm to 80 μm thick alkali-zinc-silicate layer

$\mu = 0.30$ for surfaces shiny metallic, cleaned with a steel brush or by flame deseaming

$\mu = 0.20$ for surfaces free of rust, oil and dirt.

4.8.2.3.4 Proof of transmissible forces

A sufficient slide resistance shall be proven for the most unfavourable bolt in a connection or joint, see example in [4.8.2.2.4], using the following condition:

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

$$F_{\mu,d} = \left(\frac{1}{\alpha_A} \cdot \alpha_s \cdot R_{eH} \cdot A_\sigma - \Delta F_{\text{Setz}} - F_a \right) \cdot \frac{\mu}{\gamma_m \cdot 1.25}$$

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

n_r = number of effective friction area

A_σ = stress section-area of the bolt according to Table 4-14

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

μ = friction coefficient according to [4.8.2.3.3]

ΔF_{Setz} = loss of pre-stress force by setting according to [4.9.1.4.2]

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 according to [4.8.2.2] shall be proven, including the calculation of the shear capability of the stress cross-section A_σ .

4.8.2.3.5 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, shall be to carried out in the following way:

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

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

$\sigma_{p,zul}$ = permissible surface pressure in according with Table 4-15 [N/mm²]

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

$F_{a,d}$ = design value of the external tensile force in the direction of the bolt axis
 Φ = tensioning factor according to [4.9.1.3.2].

4.8.2.3.6 Proofs for structural elements and gussets

For the strength analyses the statements according to [4.8.2.2.5] apply. It may be assumed, that 1/3 of the force $F_{\mu,d}$ transmissible by friction, has already been transmitted before the bolt hole, see [4.8.2.3.4].

Table 4-14 Stress and core sections of bolts

<i>Diameter [mm]</i>	<i>Stress section A_{σ} [mm²]</i>	<i>Core section A_K [mm²]</i>
Metric ISO thread, according 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
Metric thread with large clearance, according 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 4-15 Permissible surface pressure under heads and nuts of bolts

Material	$\sigma_{p\ zul} [N/mm^2]$
S235	260
S355, C45N, 46G2N, 46Cr4N	420
C45V, 46Cr4V, 42CrMo4V	700
GG25	800

4.8.3 Proofs for rivet connections

For proof of rivet/shear connections, the statements in [4.8.2.2] apply analogously. Instead of shaft diameter, the hole diameter shall be used.

Only hydraulic riveting is permissible. The clamping length of the rivet shall be restricted to the value $6.5 \cdot d_{rivet}$, where d_{rivet} is the nominal diameter of the rivet.

4.9 Special structural elements

4.9.1 Flange connections with pre-stressed bolts

4.9.1.1 General

4.9.1.1.1 In the case of flange connections with pre-stressed bolts, the forces to be sustained are transmitted by tensional load of the bolts and possibly by friction fitting.

4.9.1.1.2 The provisions under [4.9.1.3] and [4.9.1.4] do not apply to flanges for the connection of large slewing bearings. In this respect [5.7.4.1] shall be observed.

4.9.1.2 Construction

Figure 4-10 shows a typical flange connection. For construction purposes, the following notes shall be observed:

- Bolt holes may be larger than the shaft diameter d_s by the value Δd :
 $\Delta d \leq 0.1 \cdot d_s \leq 3.0 \text{ mm}$
- In general, the bolt distance s (see Figure 5-4) 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 shall 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 according to [4.8.2.3.3].
- 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.
- Bolts of strength class 12.9 require a highly accurate layout in the supporting areas under the head and nut.

4.9.1.3 Forces acting on a flange connection

4.9.1.3.1 Figure 4-10 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} shall be determined from the location of the zero point of the bending moment curve of the system, which is the nearest to the bolt.

4.9.1.3.2 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.

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:

$$\Phi = \alpha \quad \text{for proofs in [4.9.1.4.1], [4.9.1.4.3], [4.9.1.5.1] and [4.8.2.3.5]}$$

$$\Phi = 0 \quad \text{for proofs in [4.9.1.4.2] and [4.9.1.5]}$$

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

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

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

$$D_A = \min \left\{ \begin{array}{l} g \\ f \\ l_k/2 + d_w \end{array} \right\}$$

- 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/mm²]
- E_p = Young's modulus of the tensioned structural elements [N/mm²]
- d_w = head bearing diameter [mm]
- g = flange dimension according to Figure 4-10 [mm]
- f = bolt distance [mm].

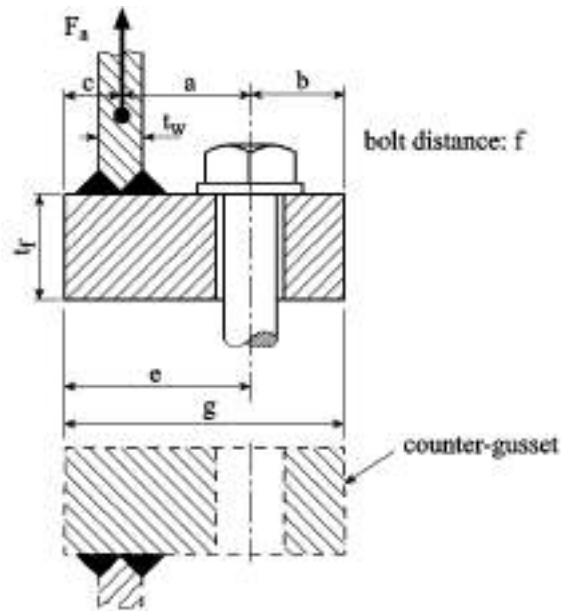


Figure 4-10 Flange connection

4.9.1.4 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 according to [4.9.1.3.1] 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 shall 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, shall be proven separately.

4.9.1.4.1 Proof of yield strength of the bolt

In the mounted condition, the following condition shall be observed:

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

$$F_{M,zul} = \frac{v \cdot A_\sigma \cdot R_{eH,s}}{\sqrt{1 + 3 \cdot \left[\frac{2}{3} \cdot \frac{d_2}{d_\sigma} \cdot \left(\frac{P}{\pi \cdot d_2} + 1.155 \cdot \mu_G \right) \right]^2}}$$

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

$$F_{M,zul} = v \cdot A_{\sigma} \cdot R_{eH,s}$$

- $F_{M,max}$ = maximum installation force
- $F_{M,zul}$ = permissible installation force
- $R_{eH,s}$ = yielding strength of the bolt
- v = predefined degree of utility of the yield strength in the mounted condition
- A_{σ} = stress cross-section of the bolt according to [Table 4-14](#)
- 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 shall be estimated conservatively, e.g. according to VDI 2230 Part 2 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.

4.9.1.4.2 Proof against open gap

The following condition shall be met for the proof against open gap (see Figure 4-10):

$$F_{a,d} \leq \frac{F_{v,min}}{\frac{f_{eff} \cdot g_{eff} + 9.4 \cdot (e+z) \cdot (a_{ers} + z)}{f_{eff} \cdot g_{eff} + 9.4 \cdot (e+z) \cdot z} - \phi}$$

$$F_{v,min} = F_{M,min} - \Delta F_{Setz}$$

$$F_{M,min} = \frac{F_{M,max}}{\alpha_A}$$

$$\Delta F_{Setz} = 3.29 \cdot 10^{-3} \cdot \left(\frac{l_k}{d}\right)^{0.34} \cdot \frac{1}{\delta_s + \delta_p}$$

$F_{v,min}$ = lowest pre-stressing force of the bolt

$F_{M,min}$ = smallest installation force

α_A = tightening factor of the tightening procedure used (see [4.8.2.3.4])

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 according to [4.9.1.3.2] [mm/N]

a_{ers} = distance between the compensating line of action from F_a and the bolt axis according to [4.9.1.3.1]

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 = for $g \leq d_w + t_f$ the smaller value of 0 or $((g_{eff} / 2) - e)$
for $g > d_w + t_f$ the smaller value of 0 or $(g - (g_{eff} / 2) - e)$.

In the case of through-bolt connections, for t_f the thickness of the thinner gusset plate shall 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.

4.9.1.4.3 Proofs of fatigue strength

In the case of dynamic loads, proof of fatigue strength of the bolts shall be conducted as stated in the following.

Stress range spectra shall be determined according to [4.6].

The maximum stress range of the normal stress $\Delta\sigma_{max}$ shall be determined according to [4.6] 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, $\Delta\sigma_{max}$ shall 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 shall be taken into consideration. For the bending stress in the cross-section of the thread's stress cross-section the following applies:

$$\sigma_b = \frac{1}{\kappa} \cdot \frac{E_s}{E_p} \cdot \frac{32 \cdot F_a \cdot (a_{\text{ers}} + z)}{\pi \cdot d_s^3}$$

$$\kappa = 1.7 \cdot \frac{f_{\text{eff}} \cdot g_{\text{eff}}^3}{d_s^4} - 1$$

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 [Figure 4-11](#).

The proof of fatigue strength may be conducted on the basis of calculated cumulative damage ratios according to [\[4.6\]](#).

Alternatively, the proof of fatigue strength may be conducted based on permissible stress ranges for the standard spectra S0 to S7 according to [\[4.6\]](#) as follows:

$$\Delta\sigma_{\max} \leq f_n \cdot k_s \cdot f_i \cdot \Delta\sigma_R$$

k_s = 1 for $d \leq 30$ 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

$\Delta\sigma_R$ = 71 N/mm² for bolts either tempered or rolled as final treatment

$\Delta\sigma_R$ = 50 N/mm² for all other bolts

f_n = factor for shape and extent of the spectrum according to [Table 4-16](#)

f_i = influence of importance of structural element according to [Table 4-5](#)

k_s = influence factor for size

d = nominal thread diameter.

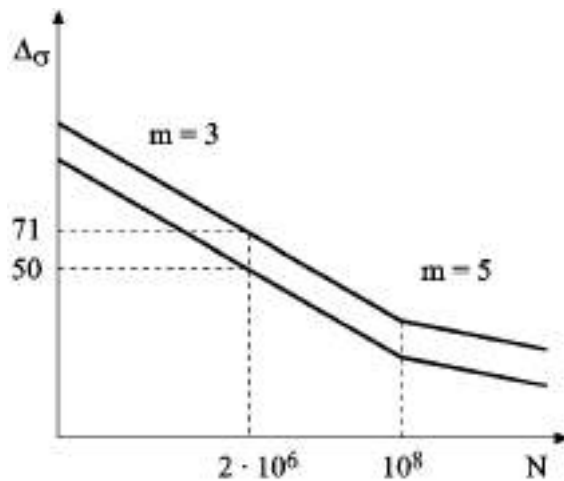


Figure 4-11 Design S-N curves for prestressed bolts

Table 4-16 Factor f_n for standard stress range S0 to S7 according to [4.6.5] and design S-N curve according to Figure 4-11

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

4.9.1.5 Proof of transmissible forces in the clamping gap

The statements in [4.8.2.3.4] apply, where $n_r = 1$.

Normally, this proof shall not be conducted for the connection of large diameter slewing rings.

4.9.1.5.1 Proof of surface pressure below head and nut of bolt

The statements in [4.8.2.3.5] apply.

4.9.1.5.2 Construction and calculation of flanges

Construction

The dimensions a, b and c in [Figure 4-10](#) shall comply with the following requirements:

- 1) a — not larger than necessary for clamping tools
- 2) b — sufficiently large for generating the supporting force
- 3) c — sufficiently large for the weld, including the excess length required for the welding process
- 4) $b / a \geq 0.75$.

The workmanship of the weld next to the connecting bolts requires special diligence.

Calculation of flange thickness

The gusset thickness t_f may, simplified, be calculated as follows:

$$t_f \geq \sqrt{\alpha_e \cdot \frac{\sigma_{w,d} \cdot t_w \cdot a}{\sigma_{Rd}}}$$

α_e = coefficient for the construction of the wall
5.0 for cylindric walls
6.0 for flat walls

t_w = wall thickness according to [Figure 4-10](#)

$\sigma_{w,d}$ = design value of the stress in the wall (including partial safety factors γ_{pi})

σ_{Rd} = design value of the permissible stress in the flange according to [\[4.4.2.2\]](#).

4.9.2 Hydraulic cylinders

4.9.2.1 General

Hydraulic cylinders shall be designed and manufactured in accordance with [DNVGL-CG-0194](#), design loads shall be determined on basis of the operating conditions "lifting appliance in operation" and "lifting appliance out of operation".

Following deviations from [DNVGL-CG-0194](#) shall be observed:

- proof of stability according to [\[4.4.2.3\]](#) and [\[4.9.2.3\]](#)
- proof of wall thickness according to [\[4.9.2.2\]](#)
- proof of eye strength/geometry according to [\[7.3.4.3\]](#)
- proof of fatigue strength according to [\[4.6\]](#).

4.9.2.2 Simplified dimensioning of cylinder pipes

4.9.2.2.1 For thin-walled cylinder pipes, the required wall thickness $t_{w,erf}$ may be calculated as follows, if the requirement according to [\[4.9.2.2.2\]](#) is complied with:

$$t_{w,erf} = \frac{1.7 \cdot D_a \cdot p_c}{20 \cdot f_{yr} + 1.7 \cdot p_c}$$

D_a = outer diameter [mm]

p_c = setting pressure of the relief valves according to [\[9.6.2.2\]](#) [bar]

f_{yr} = calculated yield strength according to [\[4.3.3.2\]](#) [N/mm²].

4.9.2.2.2 The formula in [4.9.2.2.1] 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:

$$-p_c \leq \sigma_\ell \leq p_c \cdot \left(\frac{D_a}{2 \cdot t_w} - 1 \right)$$

σ_ℓ = longitudinal stress in the cylinder pipe (characteristic value without partial safety factors γ_{pi}).

4.9.2.2.3 The wall thickness t_w of the cylinder pipe shall comply with the following requirement:

$$t_w \geq t_{w,erf} + c$$

t_w = wall thickness of the cylinder pipe

$t_{w,erf}$ = required wall thickness according to [4.9.2.2.1]

c = corrosion allowance, minimum 0.3 mm.

4.9.2.2.4 Cylinder pipes, not complying with the condition according to [4.9.2.2.2], shall be proven according to [4.4].

In this case, the partial safety factor for the internal pressure (= setting pressure p_c of the safety valves) is:

$$\gamma_p = 1.34$$

4.9.2.2.5 A calculated strength analysis shall be conducted for the connecting welds of the pipes.

4.9.2.2.6 In order to avoid local bending stresses, the head and bottom plate of the cylinder pipes shall not fall below the following minimum thickness:

$$t_p \geq 3 \cdot t_w$$

t_p = thickness of head or bottom plate, respectively

t_w = wall thickness of the cylinder pipe.

4.9.2.3 Proof of stability

4.9.2.3.1 The proof of stability is according to [4.4.2.3] to be conducted for the most unfavourable combination of buckling length l_{ki} and respective pressure (depending on the kinematics of the lifting appliance).

4.9.2.3.2 The design force shall include the partial safety factors γ_p as well as any dynamic coefficients (ψ) and shall be calculated for the most unfavourable load combination.

4.9.2.3.3 As an imperfection for the proof of stability, a distortion of the hydraulic cylinder of $l_{ki}/300$ shall be taken into consideration.

4.9.2.3.4 At the ends of the cylinder, the following moment shall be assumed due to friction of the carrier bolts:

$$M = N_d \cdot \mu \cdot \frac{d_B}{2}$$

N_d = design force (pressure) in the hydraulic cylinder including the partial safety factors γ_p

μ = 0.08 (= friction coefficient)
 d_B = bolt diameter.

4.9.2.3.5 If a buckling proof of a hydraulic cylinder will be conducted according to Eurocode 3, Equivalent Member Method, the rod geometry shall be laid down for the entire buckling length.

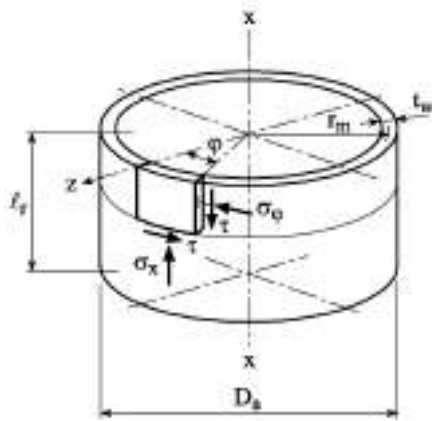
4.9.2.4 Tensile stresses

In the case of tensile-stressed hydraulic cylinders, particular attention shall be paid to the thread of the piston rod during strength analysis.

4.9.3 Large cylindric pipes

4.9.3.1 Dimensions and loads

Figure 4-12 shows the dimensions and loads of circular cylinder shells.



r_m = radius, related to the middle of wall thickness [mm]
 t_w = Wall thickness [mm]
 r = pipe length [mm]
 D_a = outer diameter (nominal diameter) [mm]
 σ_x = longitudinal stress [N/mm²]
 τ = shear stress [N/mm²]
 σ_ϕ = circumferential stress [N/mm²].

Figure 4-12 Dimensions and loads of circular cylinders

4.9.3.1.1 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].

4.9.3.2 Proofs of stability

4.9.3.2.1 Proofs against buckling shall be performed according to [4.4.2.3]. Proofs against shell buckling may be conducted according to EN 1993-1-6.

4.9.3.2.2 Regarding the application of the proofs of stability according to EN 1993-1-6, the following shall be observed:

- Instead of safety factor γ_{M1} according to the Euro-code the value γ_m according to [4.3.7.4.3] shall be used.
- Instead of the yield strength, the calculated yield strength f_{yr} according to [4.3.3.2] shall be used.

4.9.3.2.3 Proofs against shell buckling need not be conducted, if the following requirements are complied with:

a) pipes loaded by stress in circumferential direction

$$\frac{r_m}{t_w} \leq 0.21 \cdot \sqrt{\frac{E}{R_{eH}}}$$

E = Young's modulus [N/mm²]
2.06 · 10⁵ N/mm² for steel

R_{eH} = yield strength according to material standards [N/mm²]

b) pipes loaded by compression in longitudinal direction

$$\frac{r_m}{t_w} \leq 0.03 \cdot \frac{E}{R_{eH}}$$

c) pipes loaded by shear

$$\frac{r_m}{t_w} \leq \left(\frac{E}{15 \cdot R_{eH}} \right)^{2/3}$$

d) very long pipes, loaded by compression

$$\frac{\ell_{ki}}{r_m} \geq 10 \cdot \sqrt{\frac{r_m}{t_w}}$$

ℓ_{ki} = buckling length of the pipe [mm].

Guidance note:

These proofs apply provided that the edges are radially undisplacable.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

4.9.3.2.4 The requirements according to a) to d) apply, provided that the imperfections according to [4.9.3.3] are not exceeded during manufacture.

4.9.3.3 Imperfections due to manufacture

4.9.3.3.1 Curvatures

In the case of outward or inward curvatures caused by manufacture, the depth gauge f according to Figure 4-13 shall not exceed 1% of the smallest gauge length. The following gauge lengths apply:

- gauge length in longitudinal direction of the pipe [mm]

$$\begin{aligned} \ell_{mx} &= 4 \cdot \sqrt{r_m \cdot t_w} \text{ (in the unwelded area)} \\ &= 25 \cdot t_{\min} \leq 500\text{mm} \text{ (in the area of welds)} \end{aligned}$$

- gauge length in circumferential direction [mm]

$$\begin{aligned} \ell_{m\phi} &= \frac{2.3 \cdot r_m}{(r_m / \ell_r)^{1/2} \cdot (r_m / t_w)^{1/4}} \leq r_m \text{ (in the unwelded area)} \\ &= 25 \cdot t_{\min} \leq 500\text{mm} \text{ (in the area of welds)} \end{aligned}$$

$$t_{\min} = \text{thickness of the thinner plate adjacent to the weld.}$$

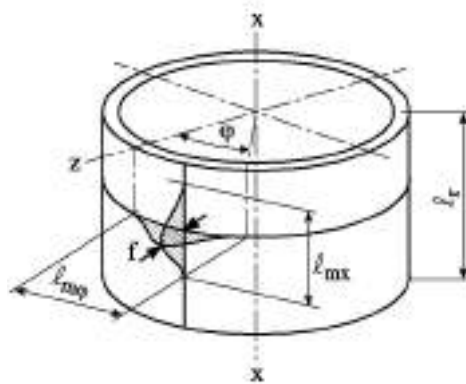


Figure 4-13 Curvature including designations

4.9.3.3.2 Out-of-roundness

The out-of-roundness is defined as follows:

$$U = \frac{d_{\max} - d_{\min}}{d_{\text{nom}}} \cdot 100 [\%]$$

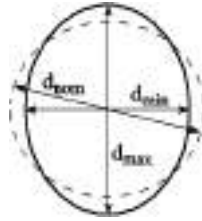


Figure 4-14 Measurement of the diameters for determination of out-of-roundness

The permissible out-of-roundness U_{adm} may be calculated as follows:

$$\begin{aligned}
 U_{adm} &\leq 2.0 \% && \text{for} && d_{nom} \leq 500 \text{ mm} \\
 &\leq 2.0 - \frac{d_{nom} - 500}{750} [\%] && \text{for} && 500 < d_{nom} \leq 1250 \text{ mm} \\
 &\leq 1.0 \% && \text{for} && d_{nom} \geq 1250 \text{ mm}
 \end{aligned}$$

Proof format: $U \leq U_{adm}$

4.9.3.3.3 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 :

$$e_x \leq 0.2 \cdot t_{min} \leq 3 \text{ mm}$$

t_{min} = the smaller of the two plate thicknesses.

4.9.4 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 according to the following formula:

$$t_p \text{ or } a \geq \frac{\gamma_m \cdot \sqrt{12}}{D \cdot f_{yr} \cdot \pi} \cdot \left(F_z + \frac{M_x}{D} \right) [\text{mm}]$$

- 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 according to [4.3.3.2] [N/mm^2]
- γ_m = partial safety factor for resistance values according to [4.3.7.4.3] [-]
- 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 design values and include the partial safety factors γ_p for loads according to [4.3.7.4].

Regarding the designation of axes see Figure 4-12.

4.9.5 Local loads due to wheel loads

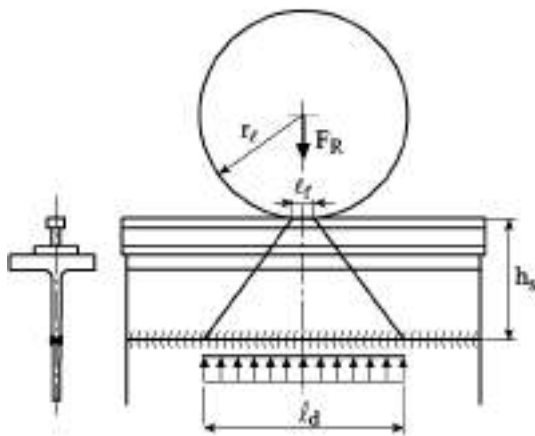
4.9.5.1 General

4.9.5.1.1 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 shall be treated analogously.

4.9.5.1.2 Local loads shall be taken into consideration, when the proof of structural safety according to [4.4] as well as the proof of fatigue strength according to [4.6] are conducted.

4.9.5.2 Girders of crane rails

4.9.5.2.1 For the calculation of the local compression stresses, the relationships as shown in Figure 4-15 apply.



- l_d = length of pressure distribution [mm]
 $l_d = 2 \cdot h_s + l_f$
- h_s = distance between contact area of the wheel and intersection line considered [mm]
- f = length of contact area of the wheel [mm]
 $f = 0.2 \cdot r_l \leq 50 \text{ mm}$
- r_l = running radius [mm]
- F_R = wheel load [N].

Figure 4-15 Pressure distribution of wheel loads

4.9.5.2.2 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.

4.9.5.3 Girders of trolleys

4.9.5.3.1 In Figure 4-16, typical local deformations are shown highly magnified.

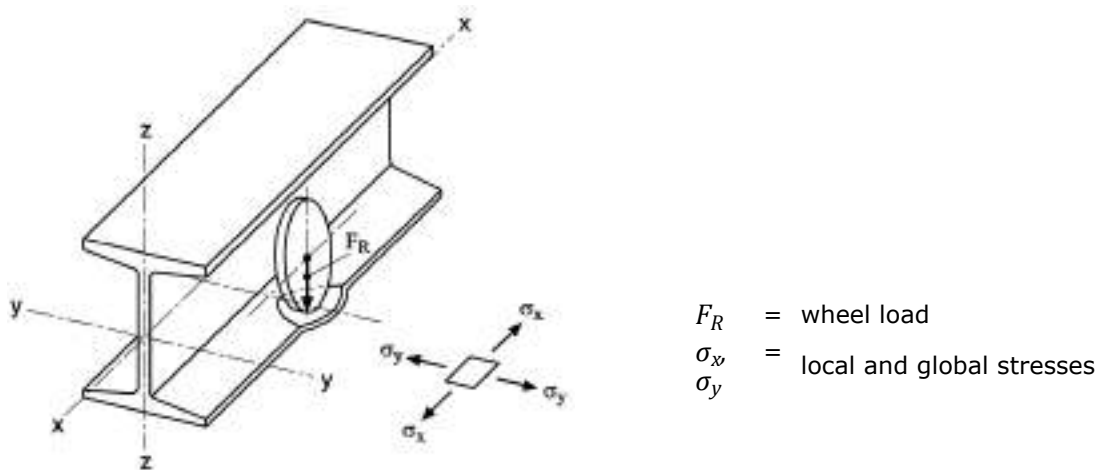


Figure 4-16 Local deformation of girders of trolleys (highly magnified)

4.9.5.3.2 Calculation of local stresses in the lower flanges of girders for trolleys may be conducted in accordance with a recognized calculation method or standard, e.g. *Federation Europeenne de la Manutention (F.E.M), Section IX, book 9.341*.

4.9.5.3.3 For general strength analysis, local and global stresses shall be superimposed, with the local stresses reduced to 75%.

4.9.5.3.4 In the case of lower flanges welded to the web, for the connecting weld a proof of fatigue strength may possibly be required.

4.9.6 Bolt connections

4.9.6.1 Bolts shall be secured against falling out. Outer bearing plates and gussets shall be secured against gapping.

4.9.6.2 Bolt connections shall be proven according to [4.8.2].

4.9.7 Eye plates and eye rods

4.9.7.1 Proof of eye plates may be conducted according to [7.3.4.3].

4.9.7.2 Eye rods according to Figure 4-17 may be dimensioned as follows:

$$a \geq \frac{F}{2 \cdot t} \cdot \frac{Y_m}{f_{yr}} + \frac{2}{3} \cdot d_\ell$$

$$b \geq \frac{F}{2 \cdot t} \cdot \frac{Y_m}{f_{yr}} + \frac{1}{3} \cdot d_\ell$$

$$d_{\ell} = d_b + \Delta d$$

F = design value of the tensile force (including partial security factor γ_p according to [4.3.7.4])

f_{yr} = calculated yield strength according to [4.3.3.2]

γ_m = partial safety factor for resistance values according to [4.3.7.4.3].

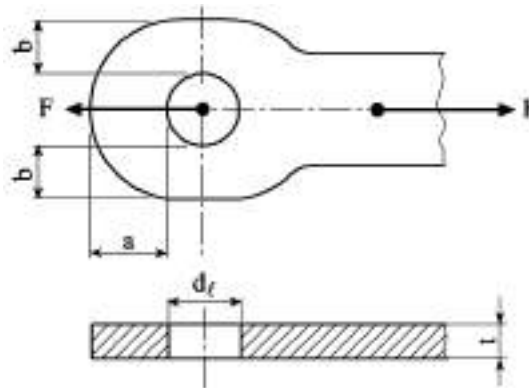


Figure 4-17 Example of an eye rod

4.9.8 Joints of hollow profile girders

Dimensioning of hollow profile girder joints may be performed according 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.

4.9.9 Stairs, ladders, platforms and railings

4.9.9.1 Load assumptions

4.9.9.1.1 Accesses, platforms etc. shall be dimensioned for a distributed load of at least 3000 N/m² or for a movable single load of 1500 N.

4.9.9.1.2 Guard-rails and toe boards shall be dimensioned for a lateral load in the form of a movable single load of 300 N.

4.9.9.1.3 The loads according to [4.9.9.1.1] and [4.9.9.1.2] need not be considered for the global calculation of lifting appliances.

4.9.9.2 Proof of structural safety

4.9.9.2.1 Proof of structural safety shall be conducted according to [4.4].

4.9.9.2.2 The partial safety factor for the loads is $\gamma_p = 1.34$.

SECTION 5 CRANES AND SUPPORTING STRUCTURES

5.1 General

5.1.1 Description of contents

5.1.1.1 This section contains requirements for design and dimensioning of cranes and their supporting structures onboard ships which are also correspondingly applicable to other lifting appliances and their supporting structures according to [1.1.3.1].

5.1.1.2 The type of design is not subject to restrictions. However, the requirements given in [5.7] shall be taken into account.

5.1.1.3 The dimensioning is based on Sec.4 and distinguishes between the conditions "in service" and "out of service" for all proofs.

5.1.2 Influences caused by the ship and the ship's operation

5.1.2.1 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.

5.1.2.2 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 the Society. The values of Table 4-2 shall be complied with.

5.1.3 Dimensioning of cranes

The cranes listed in the following shall be dimensioned according to different criteria.

5.1.3.1 Shipboard cranes

5.1.3.1.1 Cranes for harbour operation.

5.1.3.1.2 Cranes for sea operation.

5.1.3.2 Floating cranes

Depending on their use, floating cranes shall be dealt with like shipboard cranes for harbour or sea operation, respectively.

5.1.3.3 Lifting appliances not handling cargo

Shipboard lifting appliances not handling cargo shall be dealt with like shipboard cranes for harbour operation, taking into consideration their service or environmental conditions.

5.1.4 Dimensioning of supporting structures

5.1.4.1 The principal supporting structures are:

- crane columns
- crane foundations
- runways for mobile cranes
- crane boom supports
- structural transits into the ship's hull.

5.1.4.2 Crane columns and crane foundations shall be dimensioned similarly like the allocated cranes, where applicable also according to [5.4.1.2].

5.1.4.3 When dimensioning runways, the requirements given in [4.9.5] as well as according to [5.7.4.4] shall be observed.

5.1.4.4 Crane boom supports shall be dimensioned according to [5.6.6].

5.2 Crane groups

5.2.1 General

5.2.1.1 The allocation to crane groups may be of influence on the determination of hoist load coefficients, the main aspect, however, is the fatigue strength.

5.2.1.2 Non-distinct allocations shall be agreed with the Society. This applies in particular to side and auxiliary hoists.

5.2.1.3 The following allocations to crane groups in each case refer to the main hoist of a crane.

5.2.2 Crane group A

5.2.2.1 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 safe working load. Such cranes are characterized by irregular use and longer rest periods.

5.2.2.2 Cranes of group A1, which also launch and recover life-saving appliances, shall be dimensioned in addition according to the LSA-Code.

5.2.2.3 Crane group A is further subdivided as follows:

5.2.2.3.1 Crane group A1 includes cranes for the operation of the ship in the harbour, such as e.g.:

- provision cranes
- engine room cranes/workshop cranes
- hatch cover cranes
- hose cranes.

5.2.2.3.2 Crane group A2 includes cranes for the operation of the ship at sea such as e.g.:

- service cranes
- engine room cranes (used at sea state).

5.2.2.3.3 Crane group A3 includes floating cranes not used for cargo-handling, like e.g.:

- mounting cranes.

5.2.3 Crane group B

5.2.3.1 Crane group B primarily includes cranes used for cargo-handling, and which are not always exposed to the full safe working load. These cranes are characterized by regular use and longer rest periods.

5.2.3.2 Crane group B is further subdivided as follows:

5.2.3.2.1 Crane group B1 includes shipboard cranes for cargo-handling in the harbour using spreaders or hooks, such as e.g.:

- container cranes
- general cargo cranes.

5.2.3.2.2 Crane group B2 includes cranes for cargo-handling at sea using hooks, such as e.g.:

- general cargo cranes.

5.2.3.2.3 Crane group B3 includes floating cranes for cargo-handling using hooks, such as e.g.:

- floating cargo cranes.

5.2.4 Crane group C

5.2.4.1 Crane group C primarily includes cranes for cargo-handling and which are regularly exposed to the full or nearly full safe working load.

5.2.4.2 Crane group C is further subdivided as follows:

5.2.4.2.1 Crane group C1 includes shipboard cranes for cargo-handling in the harbour using grabs, hooks or special load-handling devices, such as e.g.:

- grab cranes
- pallet cranes.

5.2.4.2.2 Crane group C2 includes ship cranes for cargo-handling at sea using grabs, such as e.g.:

- grab cranes
- lighter cranes.

5.2.4.2.3 Crane group C3 includes floating cranes for cargo-handling using grabs, such as e.g.:

- grab floating cranes
- lighter floating cranes.

5.2.5 Change of crane group

5.2.5.1 In the cases of a change of crane group, change to the safe working load or change to the load radius, in addition to an assessment of drawings, the manufacturer shall calculate the estimated residual lifetime, where applicable.

5.3 Design loads

5.3.1 General

5.3.1.1 The loads acting on the structural components of cranes and their supporting structures are subdivided as follows:

- regular loads
- irregular loads
- special loads.

5.3.1.2 Cranes for the conveyance of persons shall comply with the requirements given in [4.2.5.1] and [4.2.5.2].

5.3.1.3 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 shall be agreed with the Society.

5.3.2 Regular loads

5.3.2.1 Dead loads (L_E)

Dead loads shall be determined in accordance with [4.2.4.2]. A distinction should be made between loading and unloading dead loads acting on each structural element.

5.3.2.2 Hoist load (L_H)

The definition of hoist load is given in [1.1.5.22]. Regarding the crane dimensioning, the safe working load (SWL) shall be regarded as part of the hoist load.

Depending on the type of operation and considering a dead weight portion (L_{EA}) according to Figure 1-1, hoist load shall be determined as follows:

- harbour operation: $L_H = L_{EA} + SWL$
- sea operation: $L_{Hsee} = L_{EA} + SWL_{see}$

SWL_{see} shall be calculated according to [5.4.3.2.1].

5.3.2.3 Loads from driving over an uneven runway

Where the design conditions according to [5.7.4.4] 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 shall be agreed with the Society.

5.3.2.4 Dynamic forces due to drive systems

5.3.2.4.1 General

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 designations "vertical" and "horizontal" refer to the coordinate system of the cranes.

5.3.2.4.2 Vertical dynamic forces due to lifting of a load

The acceleration forces generated by the lifting of a resting load during harbour operation shall be considered by application of the hoist load coefficient ψ according to [5.4.3.1].

The acceleration forces generated by the lifting of a resting or moving load during sea operation shall be considered by application of the hoist load coefficient ψ_{see} according to [5.4.3.2].

5.3.2.4.3 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.

5.3.2.4.4 Horizontal dynamic forces due to lifting of a load

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 4-2, shall be assumed as horizontal dynamic forces, see also [5.3.2.6.2].

In the case of lifting a resting or moving load during sea operation, the horizontal component of the load $L_{H_{see}} \cdot \psi_{see}$, resulting from the ship's inclinations according to Table 4-2 and the cargo runner deflection angle according to [5.3.2.6.3], shall be assumed as horizontal dynamic forces.

5.3.2.4.5 Horizontal dynamic forces due to suspended load

The accelerations at the crane boom peak due to rotating, slewing, pivoting and telescoping motions shall be indicated by the manufacturer.

If no other proof is given, the radial acceleration b_r for rotating and slewing cranes may be calculated as follows:

$$b_r = \omega^2 \cdot r = \frac{v^2}{r} \approx \frac{r \cdot n^2}{91} \text{ [m/s}^2\text{]}$$

ω = $(\pi \cdot n) / 30$ = angular speed [1/s]

r = rotating/slewing radius [m]

v = $\omega \cdot r$ = circumferential speed [m/s]

n = 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.

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 , if no other proof is given.

The horizontal forces of the working load and the dead load of the crane boom due to the ship's inclination ϵ and the rotating or slewing acceleration may be added vectorially. For ϵ see [4.2.4.4.1].

5.3.2.4.6 Horizontal dynamic forces with mobile cranes

Horizontal dynamic forces, caused by starting and braking in the direction of travelling, shall 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 shall 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, shall be considered as well.

5.3.2.5 Dynamic forces generated by ship motions

5.3.2.5.1 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 given in [5.4.7] apply.

5.3.2.5.2 Cranes in service

Vertical dynamic forces

Generally, vertical dynamic forces during operation of cranes at sea, need not be allocated any load combination according to [5.5.2] and they also need not be explicitly proven.

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 4-2 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.

Horizontal dynamic forces due to the acceleration of the crane basis

For the sea operation of cranes, in addition to the horizontal forces, the following horizontal accelerations b_h shall be assumed, if cranes are operated at significant wave heights of $H_{1/3} > 2$ m:

- barges and catamarans: $b_h = 0.75 \cdot (H_{1/3} - 2) \geq 0$ [m/s²]
- ships: $b_h = 0.5 \cdot (H_{1/3} - 2) \geq 0$ [m/s²]
- semi-submersibles: $b_h = 0.25 \cdot (H_{1/3} - 2) \geq 0$ [m/s²].

$H_{1/3}$ = significant wave height [m].

5.3.2.5.3 Cranes out of service

In the condition "out of service at sea", the vertical and horizontal dynamic forces may be calculated according to App.A.

5.3.2.6 Diagonal pull forces due to cargo runner deflection angles

5.3.2.6.1 General

Diagonal pull forces may be generated when a load is hoisted, due to a relative shift between load and crane boom peak. They shall be superimposed to the ship inclinations of Table 4-2.

Cargo runner deflection angles in the longitudinal and transverse direction of a crane boom shall be considered as occurring simultaneously in the dimensioning process.

5.3.2.6.2 Harbour operation

In general, diagonal pull forces due to cargo runner deflection angles need not be taken into consideration during harbour operation.

5.3.2.6.3 Sea operation

Shipboard cranes

When not determined more precisely, the cargo runner deflection angle shall be assumed as:

$$\varphi_l = \varphi_q = H_{1/3} [^\circ]$$

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 given in [5.7.3.2.1] is met.

Floating cranes

For floating cranes with a safe working load $SWL \leq 60$ t the requirements given in this subsection apply. In the case of higher safe working loads the requirements given in [5.7.3.2.2] shall be met additionally.

5.3.2.7 Partial dropping of the working load during normal operation

5.3.2.7.1 When a part of the working load WL 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 .

5.3.2.7.2 The load F_{Sa} which shall be used for dimensioning, see Figure 5-1, shall be calculated as follows:

$$F_{Sa} = f_a \cdot WL$$

$$f_a = 1 - \left(1 + \varphi\right) \cdot \frac{\Delta WL}{WL}$$

$\varphi = 0.5$ for grabs or slow load dropping
 $\varphi = 1.0$ for load magnets or fast load dropping.

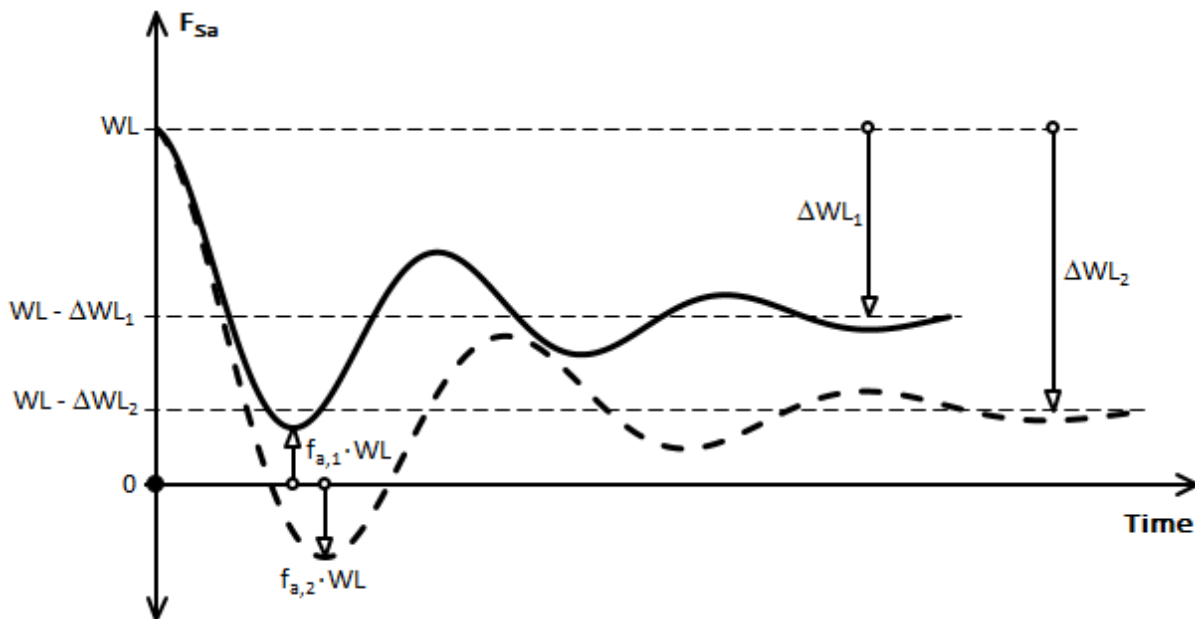


Figure 5-1 Dropping of a part of the working load (examples)

5.3.2.7.3 When the dropping factor is $f_a < 0$, the load F_{Sa} may become negative as well. This corresponds to a load directed upwards.

5.3.2.8 Tie-down force of the cargo hooks

When cargo hooks are tied-down for the load condition "crane out of service", this load shall be considered as the tie-down force. This load shall be indicated by the manufacturer. If no information is available, this load may be assumed to be 10% of the safe working load (SWL).

5.3.3 Irregular loads

5.3.3.1 Wind loads

Wind loads shall be assumed according to [4.2.4.5].

The total wind load acting on a crane structure is the sum of the single wind loads acting on its various structural components.

5.3.3.2 Snow and ice loads

For snow and ice loads, the requirements given in [4.2.4.6] apply.

5.3.3.3 Temperature loads

For temperature loads, the requirements given in [4.2.4.7] apply.

5.3.3.4 Side forces when driving (diagonal drive)

5.3.3.4.1 The side forces occurring when the crane or trolley is being driven shall be taken into consideration.

5.3.3.4.2 When two (2) wheels or wings are mounted for one (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 Figure 5-2. The side force coefficient γ_{Sk} depends on the ratio between span b_s and wheel spacing l_r .

5.3.3.4.3 Two-sided guidances or more than two (2) wheels or wings on one (1) rail shall be considered separately.

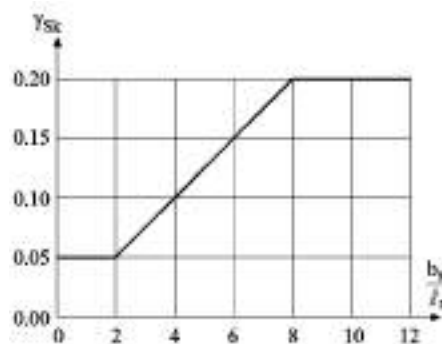


Figure 5-2 Side force coefficient γ_{Sk}

5.3.4 Special loads

5.3.4.1 Dynamic test loads

The dynamic test loads $L_{p\text{dyn}}$ for cranes shall be taken from [Table 13-2](#). The hoist load coefficient ψ may be reduced using the following formula:

$$\psi_p = (1 + \psi) / 2$$

5.3.4.2 Buffering forces

5.3.4.2.1 At the ends of carriage ways of cranes and trolleys, arrestors shall be mounted with buffers attached either to them or to the cranes.

Buffers shall be dimensioned such, that they are capable to absorb 70% of the kinetic energy of the lifting appliance driving at maximum speed. The mass of oscillatingly suspended hoist loads are not considered.

5.3.4.2.2 The impact force on the buffer shall 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 :

$$\begin{aligned} f_p &= 1.25 \text{ for buffer with linear characteristic} \\ &= 1.60 \text{ for buffer with rectangular characteristic.} \end{aligned}$$

5.3.4.2.3 Lower speeds than according to [\[5.3.4.2.1\]](#) may be assumed, if reliable (redundant) appliances reduce the speed in way of the runway ends.

5.3.4.3 Loads on stairs, ladders, platforms and railings

For access loads, see the requirements given in [\[4.9.9\]](#).

5.3.4.4 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).

shall be indicated by the crane manufacturer.

5.3.4.5 Tear-off of the hoist load

In the catastrophic case of the hoist load torn off, this results in $f_a = -1$, according to [\[5.3.2.7.2\]](#) and [Figure 5-3](#), f_a and with this, the calculated load, directed upwards, becomes $-L_H$.

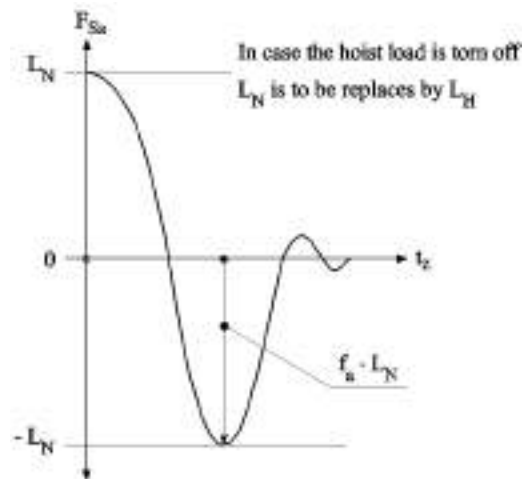


Figure 5-3 Hoist load torn off (see [5.3.4.5])

5.4 Hoist load coefficients

5.4.1 General

5.4.1.1 The hoist load or the loads resulting from it shall 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 shall be allocated to each of them.

5.4.1.2 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.

5.4.2 Hoist load coefficient ψ as a function of crane group and hoisting speed

5.4.2.1 For harbour operations, the hoist load coefficient may be simplified taken from Table 5-1.

5.4.2.2 An individual calculation of the hoist load coefficient according to [5.4.3] may be necessary or advisable.

Table 5-1 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	$\alpha + \beta \cdot v_h$	$1.2 - \frac{3 \cdot SWL}{10000t}$ ≥ 1.05
	$\alpha = 1.15 - \frac{SWL}{5000t}$ $\beta = 0.5 - \frac{SWL}{1500t}$	
C1	$1.15 + 0.51 \cdot v_h$	1.35
For descriptions of crane groups, see [5.2.2] to [5.2.4]. v_h according to Table 5-2		

Table 5-2 Hoisting speed in the course of lifting the load

Load combination	Hoisting gear type and hoisting speed v_h			
	HD 1	HD 2	HD 3	HD 4
LK I + LK II	v_{hmax}	v_{hF}	v_{hF}	$0.5 \cdot v_{hmax}$
LK III ¹	–	v_{hmax}	–	v_{hmax}
1) For hoisting gear types HD 2 and HD 4, the hoist load coefficient ψ calculated from v_{hmax} shall 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].

5.4.3 Calculation of the hoist load coefficient ψ as a function of the crane stiffness

5.4.3.1 Harbour operation

5.4.3.1.1 Calculation of the hoist load coefficient ψ

The hoist load coefficient shall be calculated as follows:

$$\psi = 1 + \frac{v_h}{9.81} \cdot \sqrt{\frac{c_s}{SWL}} \geq \psi_{\min}$$

ψ_{\min} = minimum value according to [Table 5-1](#)

v_h = hoisting speed in the course of lifting of the safe working load according to [Table 5-2](#) [m/s]

c_s = crane stiffness according to [\[5.4.3.3\]](#) [kN/m]

SWL = safe working load [t].

5.4.3.1.2 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:

$$\psi = 1 + 0.9 \cdot \frac{v_h}{9.81} \cdot \sqrt{\frac{c_s}{SWL}} \geq \psi_{\min}$$

5.4.3.2 Sea operation

5.4.3.2.1 Calculation of the hoist load coefficient ψ_{see}

$$\psi_{\text{see}} = 1 + \frac{v_r}{9.81} \cdot \sqrt{\frac{c_s}{SWL_{\text{see}}}} \geq \psi$$

v_r = relative speed between load and hook in the course of lifting the load [m/s] according to [\[5.4.3.2.2\]](#)

c_s = crane stiffness [kN/m] according to [\[5.4.3.3\]](#)

SWL_{see} = safe working load at sea [t]

ψ = hoist load coefficient for harbour operation.

With the exception of cranes dimensioned only for sea operation, the following condition shall be observed:

$$SWL \cdot \psi \geq SWL_{\text{see}} \cdot \psi_{\text{see}}$$

5.4.3.2.2 Relative speed between load and hook

$$v_r = 0.5 \cdot v_h + v_{\text{see}} \text{ [m/s] for LC I [5.5.2.1.1]}$$

$$v_r = v_h + v_{\text{see}} \text{ [m/s] for LC III [5.5.2.3.1]}$$

v_h = hoisting speed in the course of lifting the respective safe working load (SWL_{see}) according to [Table 5-2](#) [m/s]

(The minimum hoisting speed according to [\[5.7.3.1.1\]](#) shall be taken, if larger than v_h .)

v_{see} = speed induced by seastate according to [Table 5-3](#).

Table 5-3 Speed induced by seastate v_{see}

From the location of the crane (v_a)	to the cargo deck or to the sea surface (v_d)						
$v_{see} = \sqrt{v_a^2 + v_d^2}$	Fixed installation	Semi-submersible	FSO / FPSO	Large barge	Small barge	Supply ship	Sea surface
Fixed installation	0	$0.25 \cdot (H_{1/3})^{0.75}$	$0.32 \cdot (H_{1/3})^{0.75}$	$0.38 \cdot (H_{1/3})^{0.75}$	$0.50 \cdot (H_{1/3})^{0.75}$	$0.70 \cdot (H_{1/3})^{0.75}$	$0.85 \cdot (H_{1/3})^{0.67}$
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	$0.60 \cdot H_{1/3}$	$0.65 \cdot H_{1/3}$	$0.70 \cdot (H_{1/3})^{0.94}$	$0.75 \cdot (H_{1/3})^{0.94}$	$0.85 \cdot (H_{1/3})^{0.94}$	$0.90 \cdot (H_{1/3})^{0.94}$	$1.20 \cdot (H_{1/3})^{0.80}$
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].							

5.4.3.3 Calculation of the crane stiffness c_s

5.4.3.3.1 Principals of calculation

The stiffness of a crane depends on the load radius and the height of the load hook.

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 shall be taken into consideration, with the exception of [5.4.3.1.2].

Regarding the approach of the rope stiffness, the Young's modulus indicated by the rope manufacturer shall be taken.

5.4.3.3.2 Permissible simplification for the calculation

For round strand ropes, without a more precise proof a Young's modulus of $1.0 \cdot 10^5$ N/mm², based on the gross cross-section, may be taken.

Curve-shaped load radius diagram

If the load radius diagram is curve-shaped, the crane stiffness shall 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.

Step-shaped load radius diagram

If the load radius diagram is step-shaped, the stiffness shall be calculated for each load level. 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.

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 seastate conditions it may be assumed that the cargo hook is 6 m above the water surface, except for underwater operations.

5.4.4 Calculation of the hoist load coefficient for hoists onboard the ship

For hoists onboard the ship, the simplified hoist load coefficient for sea operations may be assumed to be:

$$\psi_{\text{see}} = 1.15 + 0.51 \cdot v_h \geq \psi$$

v_h = hoisting speed in the course of lifting the safe working load according to [Table 5-2](#) [m/s]

ψ = hoist load coefficient for harbour operation.

5.4.5 Calculation of the hoist load coefficient for auxiliary hoists

The hoist load coefficient for auxiliary hoists is calculated (simplified) to be:

$$\psi = 1.20 + 0.68 \cdot v_h \geq \psi_{\text{min}} = 1.45$$

5.4.6 Calculation of the hoist load coefficient by means of hydrodynamic analysis

5.4.6.1 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.

5.4.6.2 The calculation shall 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.

5.4.6.3 The calculation shall include at least the following influences, if applicable:

- vertical and horizontal motions of the cargo deck
- motion behavior of 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.

5.4.6.4 The calculation shall be submitted to the Society for the design assessment of the crane as a document for information. In particular, the influences listed in [\[5.4.6.3\]](#) shall be represented clearly in the document.

5.5 Load combinations and partial safety factors

5.5.1 General

5.5.1.1 The load combinations regarded as essential for cranes and their supporting structures are listed in the [Table 5-4](#) (cranes in service) and [Table 5-5](#) (cranes out of service).

Further load combinations may be relevant, if necessary.

5.5.1.2 Only those load combinations from [Table 5-4](#), [Table 5-5](#) and further load combinations, if necessary, which are essential or necessary for the actual structural element under consideration, shall be verified.

5.5.1.3 Regarding load combinations for operation at sea, instead of ψ the hoist load coefficient ψ_{see} , for underwater operations the hoist load coefficient ψ_{ur} , shall be taken.

5.5.1.4 The load combinations for the proof of safety against overturning are listed in [Table 5-6](#).

5.5.1.5 The partial safety factors γ_{pi} shall be taken from [Table 5-4](#) to [Table 5-6](#).

5.5.2 Explanations regarding load combinations for cranes in service according to [Table 5-4](#)

5.5.2.1 Load combinations I

The load combinations I include regular loads in normal service.

5.5.2.1.1 I_1 – Lifting and setting-down of the safe working load

All regular loads, which occur during lifting and setting-down of a load, shall be superposed, as required, for the load combination I_1 .

For vertical and horizontal dynamic forces, the requirements given in [\[5.3.2.4\]](#) and [\[5.3.2.5\]](#) apply.

5.5.2.1.2 I_2 – Suspended load

All regular loads, which are generated by acceleration and deceleration forces of hoisting gear, luffing gear and travelling gear, when a load is positioned, shall be superposed, as required, for the load combination I_2 taking into consideration static ship inclinations and possible diagonal pull.

5.5.2.2 Load combinations II

The load combinations II include regular loads during normal service combined with non-regular loads.

5.5.2.2.1 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 or temperature loads are only to be assumed upon agreement.

5.5.2.2.2 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 or temperature loads are only to be assumed upon agreement.

5.5.2.2.3 II_3 – Constant drive including diagonal pull

For load combination II_3 all loads shall be superimposed, as required, which occur at constant drive including diagonal pull. Snow, ice or temperature loads are only to be assumed upon agreement.

Table 5-4 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	[5.3.2.1]	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	[5.3.2.2]	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	[5.3.2.4]	1.34	—	1.0	1.22	—	1.0	—	—	—	—	—	—	—
	Diagonal pull	4	[5.3.2.6]	1.34	ψ	1.0	1.22	ψ	1.0	—	—	—	—	—	—	—
Non-regular loads	Wind loads in operation	5	[5.3.3.1]				1.22	1.0	1.0	1.0	1.10	—	0.2	—	—	1.0
	Snow and ice loads	6	[5.3.3.2]				1.22	1.0	1.0	1.0	—	—	—	—	—	—
	Temperature loads	7	[5.3.3.3]				1.16	1.0	1.0	1.0	—	—	—	—	—	—
	Side forces during drive	8	[5.3.3.4]				1.16	—	—	1.0	—	—	—	—	—	—
Special loads	Hoisting of hoist load at v_{hmax}	9	Table 5-2							1.10	ψ_{max}	—	—	—	—	
	Dynamic test load $L_{p,dyn}$ (including inclination of crane base)	10	[5.3.4.1]							1.10	—	ψ_p	—	—	—	
	Buffing forces	11	[5.3.4.2]							1.10	—	—	1.0	—	—	
	Loads caused by safety systems ^{4, 5}	12	[5.3.4.4]							1.10	—	—	—	1.0	—	
Partial safety factor γ_m for resistance values				1.10			1.10			1.10						
Global safety factor γ_s				1.48			1.34			1.22						
<p>1) When load components have a favourable effect, $\gamma_{pi} = 0.95$. If masses and centres of gravity are determined by weighing, $0.95 \cdot \gamma_{pi}$ may be assumed.</p> <p>2) Components caused by inclination of crane base may be neglected.</p> <p>3) Applicable for load components from dead load and hoist load</p> <p>4) Emergency stop shall be verified by a practical test with a test load of $L_{p,dyn}$, see [13.2.4.2.2].</p> <p>5) Loads which may be generated by activated safety systems, shall be indicated by the manufacturer</p> <p>6) For load combination III5 $L_H = SWL (M)$.</p>																

5.5.2.3 Load combinations III

Load combinations III include special load combinations.

5.5.2.3.1 III₁ – Hoisting of the safe working load at maximum hoisting speed

Complementing load combination I₁, load combination III₁ includes operating errors during hoisting of the load. The hoist load coefficient shall be determined for the maximum possible hoisting speed/relative speed between load and hook and the respective load level.

5.5.2.3.2 III₂ – Test loads

Load combination III₂ includes hoisting of the dynamic test load at 20% wind load.

5.5.2.3.3 III₃ – Buffer forces

Load combination III₃ comprises the impact of a crane with hoist load against the end buffers.

5.5.2.3.4 III₄ – Safety systems

Load combination III₄ comprises loads which may result from activated safety systems.

5.5.2.3.5 III₅– Failure of hydraulic cylinder

Load combination III₅ contains special load combinations covering a cylinder failure of a lifting appliance conveying persons.

Table 5-5 Load combinations and partial safety factors for cranes out of service

Load categories	Loads	i	Reference	Load combinations			
				I _A		III _A	
				γ _{pi}	I _{A1}	γ _{pi}	III _{A1}
Regular loads	Dead loads L _E	1	[5.3.2.1]	1.22 ¹	1.0	1.10 ¹	1.0
	Dynamic forces due to ship motions	2	[5.3.2.5.3]	1.34	1.0	1.10	1.0
	Tie-down force of the cargo hook	3	[5.3.2.8]	1.22	1.0	1.10	1.0
Non-regular loads	Snow and ice loads	4	[5.3.3.2]			1.10	1.0
	Temperature loads	5	[5.3.3.3]			1.05	1.0
Special loads	Wind loads out of operation	6	[5.3.3.1]			1.10	1.0
Partial safety factor γ _m for resistance values				1.10		1.10	
Global safety factor γ _s				1.48		1.22	
1) Where load components have a favorable effect, γ _{pi} = 0.95.							

5.5.3 Explanations regarding load combinations for cranes out of service according to Table 5-5

5.5.3.1 Load combination I_A

Load combination I_A includes regular loads for cranes out of service.

5.5.3.1.1 I_{A1} – Combination of regular loads

For load combination I_{A1}, all regular loads shall be superimposed, as required.

5.5.3.2 Load combination III_A

Load combination III_A includes special load combinations for cranes out of service.

5.5.3.2.1 III_{A1} – Special load combination

For load combination III_{A1}, the wind loads out of operation shall 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 5-6 Load combinations and partial safety factors for proof of safety 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	[5.3.2.1]	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	[5.3.2.2]	1.34	1.0	1.22	1.0	1.10	–	1.0
	Dynamic forces due to drives ²	3	[5.3.2.4]	1.34	1.0	1.22	1.0	1.10	–	1.0
	Diagonal pull	4	[5.3.2.6]	1.34	1.0	1.22	1.0	–	–	–
Non-regular loads	Wind loads in operation	5	[5.3.3.1]			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	[5.3.4.1]					1.16	1.0	–
	Buffer forces	7	[5.3.4.2]					1.10	–	1.0

1) Where load components have a favourable effect, $\gamma_{pi} = 0.95$.
2) Applicable for load components from dead load and hoist load.

5.5.4 Explanations regarding load combinations for the proof of safety against overturning according to Table 5-6

5.5.4.1 Load combination I

Load combination I includes regular loads under normal operation.

5.5.4.1.1 I_1 - Combination of regular loads

For load combination I_1 , all regular loads shall be superimposed, as necessary.

5.5.4.2 Load combination II

Load combination II includes regular loads in normal operation together with non-regular load.

5.5.4.2.1 II_1 - Load combination I_1 with wind loads

Load combination II_1 results from load combination I_1 plus allocated wind loads.

5.5.4.3 Load combination III

Load combinations III comprise special load combinations.

5.5.4.3.1 III₁ - Test loads

Load combination III₁ considers the hoisting of the dynamic test load at a 20% wind load.

5.5.4.3.2 III₂ - Buffer forces

Load combination III₂ comprises the impact of a crane with hoist load against the end buffers.

5.6 Proofs

5.6.1 General

5.6.1.1 The following proofs shall 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 [4.4] and [4.8]
- proof of stability according to [4.4]
- fatigue strength analysis according to [4.6].

5.6.1.2 The following proofs shall be conducted for a complete crane, as required:

- proof of safety against overturning according to [4.5]
- proof of suitability for use according to [4.7].

5.6.1.3 For the proof of crane boom supports and rectangular crane columns, the requirements given in [5.6.6] and [5.6.7] apply.

5.6.2 Strength analyses and proofs of stability

5.6.2.1 Strength analyses and proofs of stability shall be conducted using the partial safety factors of Table 5-4 or Table 5-5, respectively, for the load combinations of [5.5].

5.6.3 Fatigue strength analyses

5.6.3.1 In general, fatigue strength analyses shall be conducted for the load combination I of Table 5-4 and Table 5-5 with the partial safety factors $\gamma_{pi} = 1.0$.

As a basis for dimensioning regarding fatigue strength analyses the crane manufacturer shall provide load cycles and the respective load spectrum (see also Table 5-7).

Table 5-7 Load spectra and load cycles (examples, application not mandatory) for shipboard and floating cranes in harbour operation

<i>Crane group according to [5.2]</i>	<i>Crane type</i>	<i>Load spectrum according to [4.6.5]</i>	<i>No. of load cycles</i>	
A1 Shipboard cranes	Hatch cover crane	S6	20.000	
	Engine room/workshop crane	S2	10.000	
	Provision crane	S2	20.000	
	Hose crane	S6	50.000	
A3 Floating cranes	Mounting crane	SWL ≤ 60 t	S2	80.000
		60 t < SWL ≤ 500 t	S3	50.000
		SWL > 500 t	S4	20.000
B1 Shipboard cranes	Container crane	SWL ≤ 60 t	S3	350.000
		SWL ≤ 60 t	S2	250.000
		60 t < SWL ≤ 250 t	S3	100.000
		250 t < SWL ≤ 500 t	S4	70.000
		SWL > 500 t	S4	50.000
B3 Floating cranes	Cargo-handling crane	SWL ≤ 60 t	S2	300.000
		60 t < SWL ≤ 250 t	S3	125.000
		250 t < SWL ≤ 500 t	S4	80.000
		SWL > 500 t	S4	60.000
C1 Shipboard cranes	Grab crane	SWL ≤ 60 t	S5	600.000
		SWL > 60 t	S5	450.000
	Pallet crane	S6	600.000	
C3 Floating cranes	Grab crane	SWL ≤ 60 t	S5	700.000
		SWL > 60 t	S5	500.000
	Lighter crane	S5	2.000.000	

5.6.3.2 For cranes with load cycle numbers ≤ 20000, a fatigue strength analysis may be dispensed with.

5.6.3.3 The fatigue strength analysis for the condition "out of service" shall be conducted for a load cycle number of $5 \cdot 10^7$. This assumes a straight-line spectrum A according to [Figure 4-4](#).

5.6.3.4 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 shall be agreed with the Society.

5.6.4 Proof of safety against overturning

5.6.4.1 The proof of safety against overturning shall be conducted with the partial safety factors and load combinations according to [Table 5-6](#), unless not shown in practice, see [\[4.5.2.1.3\]](#).

5.6.5 Proof of suitability for use

5.6.5.1 Proof procedures

5.6.5.1.1 Proofs of suitability for use may be performed in the course of the initial testing on board, mathematically or as a combination of both procedures.

5.6.5.1.2 In general, the mathematical proof of suitability for use shall be conducted for the load combination I according to [Table 5-4](#) and [Table 5-5](#) using partial safety factors $\gamma_{pi} = 1.0$.

5.6.5.2 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.

For special crane types (e.g. telescopic cranes, knuckle boom cranes) and cranes made from extra high strength steels higher boom peak lowering may be accepted by the Society based on single case approvals.

5.6.5.3 Proof against remaining in the highest crane boom position

5.6.5.3.1 Where no restoring or warning devices according to [\[12.2.1.1.2\]](#) are provided, a proof of suitability for use shall be shown for crane booms handled by luffing ropes under the following boundary conditions:

- dead load coefficient $\phi_e = 0.95$ for all load components of the crane boom, unless they are confirmed by weighing. Else $\phi_e = 1.0$
- static ship inclinations according to [Table 4-2](#)
- hoist load coefficient $\psi = 1.0$
- wind load acting unfavourably, calculated from 80% of the mean design wind speed in service according to [\[4.2.4.5\]](#)
- consideration of all friction and guide losses.

5.6.5.3.2 For crane booms handled by cylinders, the requirements given in [\[12.2.1.1.3\]](#) apply.

5.6.6 Proof of crane boom supports

Crane boom supports shall be proven for the load combinations in [Table 5-5](#) and the allocated partial safety factors. In addition, the following shall 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 shall be considered, with a friction coefficient of at least $\mu = 0.15$.
- tie-down force of a cargo hook (see [\[5.7.5\]](#)).

5.6.7 Proof for rectangular crane columns

A general strength analysis shall 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.

5.7 Requirements for design and equipment

5.7.1 General

The following statements complement the requirements given in this and other sections of this standard. Structural elements, details of equipment and design, which are not covered, shall be dealt with according to the "Generally recognized rules of good practice".

5.7.2 Supporting structures

5.7.2.1 Design requirements for crane columns

5.7.2.1.1 Access to cranes

Regarding the accesses to cranes inside or outside of crane columns, the statements in [10.6.2.2] and [12.2.1.4] apply.

5.7.2.1.2 Design and calculation

In the case of tapered transition components, which transit from a cylindrical crane connection to a rectangular column, special attention shall be paid to the knuckle line between the cambered parts and the plane gussets. If necessary, thicker plates shall be provided.

In way of connections of tapered or trapezoid transitions of crane columns, knuckle lines, especially of even plates shall be stiffened, if necessary by bulkheads, in order to absorb the deviation forces.

The transition parts and their connection areas described above, require special care regarding fabrication and suitable mathematical proofs.

The connection of container supports to crane columns requires special care regarding design and calculation.

5.7.2.1.3 Execution of cylindrical crane columns welds

In the case of cylindrical crane columns, all transverse and longitudinal welds shall be the full penetration type.

5.7.2.1.4 Execution of rectangular crane columns welds

All transverse welds of rectangular crane columns shall be the full penetration type. Regarding longitudinal welds, the following applies:

- a) Longitudinal welds in the plates shall be the full penetration type.
- b) The connecting welds at the corners may be dimensioned for the maximum shear force and may be executed as fillet welds.

5.7.2.1.5 Connection to the ship hull

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.

Supporting structures interrupted by decks, shall have well aligned connections. If necessary, control bores shall be provided, which shall be welded up after the control.

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 [4.9.4].

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, shall have suitable taper brackets, as required.

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.

5.7.2.2 Requirements for the design of the stowage trough of crane boom supports

5.7.2.2.1 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.

5.7.2.2.2 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, shall be counteracted by a suitable design.

5.7.2.2.3 Where a luffing rope operated crane boom is not fixed downwards by tying-down of the cargo hook, locking devices shall 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.

5.7.2.2.4 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.

5.7.3 Hook speeds when operating under sea state

5.7.3.1 Minimum hoisting speed

5.7.3.1.1 Cranes with a safe working load ≤ 60 t

When operating under sea state conditions, the hoisting speed shall be high enough to avoid repeated contact between load and cargo deck after hoisting.

It is recommended that the uniform minimum hoisting speed v_{hmin} does not fall below the following value:

- multiple-reeved cargo runner: $v_{hmin} \geq 0.3 \cdot v_{see}$ [m/s]
- single-reeved cargo runner: $v_{hmin} \geq 0.5 \cdot v_{see}$ [m/s]

v_{see} = sea state-induced speed according to [Table 5-3](#) [m/s].

5.7.3.1.2 Cranes with a safe working load > 60 t

When operating under sea state 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.

5.7.3.2 Horizontal hook speed

5.7.3.2.1 Revolving cranes with a safe working load ≤ 60 t

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.

It is recommended that the uniform slewing speed v_{ω} at the crane boom peak at about $\frac{3}{4}$ of the maximum load radius does not fall below the following value:

$$v_{\omega} \geq 0.60 \cdot v_{see} \text{ [m/s]}$$

v_{see} = sea state-induced speed according to [Table 5-3](#) [m/s].

5.7.3.2.2 Revolving cranes with a safe working load > 60 t

The luffing speed and luffing acceleration shall be sufficient to ensure control of transverse load oscillation. Load arresting ropes which limit the swinging of the load may be taken into consideration according to their effectiveness.

5.7.3.3 Luffing speed

It is recommended that the uniform vertical luffing speed v_W at the crane boom peak at about $\frac{3}{4}$ of the maximum load radius does not fall below the following value:

$$v_W \geq 0.10 \cdot v_{see} \text{ [m/s]}$$

5.7.4 Design details

5.7.4.1 Connection of slewing bearings

5.7.4.1.1 Proof of bolts

The bolt connection shall 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 2230.

The global safety factors according to [\[4.3.8.2\]](#) shall be proven.

Special care shall be taken over the determination of the maximum bolt force, as e.g. an opening of the gap increases the bolt force non-linear.

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 [Figure 5-4](#) shall be determined according to a recognized calculation procedure (e.g. FEM calculation under consideration of the connecting structure's stiffness) or by measurement.

A simplified bolt proof according to [\[5.7.4.1.2\]](#) can be conducted on condition the restrictions for application according to [\[7.4.1.2.1\]](#) are complied with.

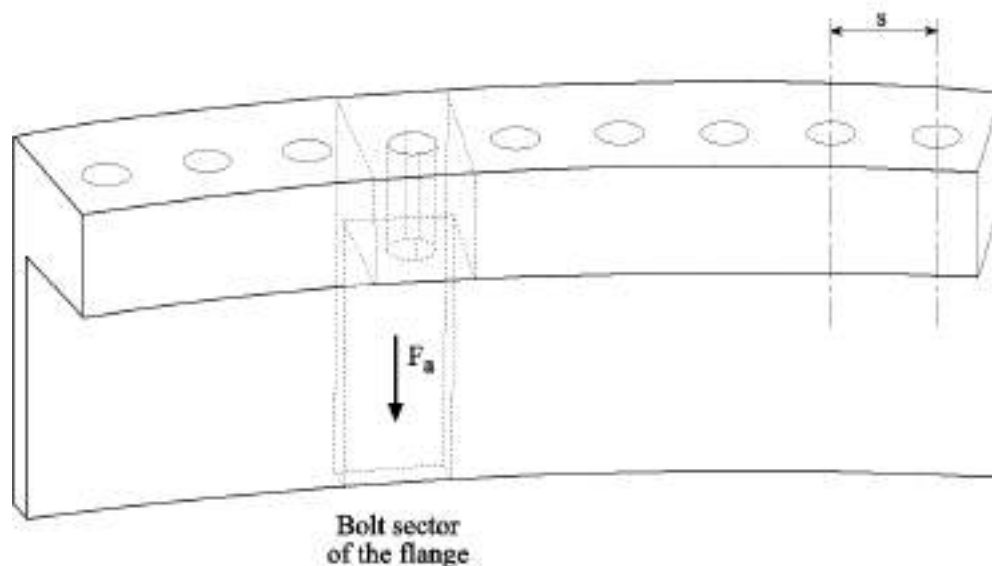


Figure 5-4 Bolt sector and sector force

5.7.4.1.2 Simplified bolt proof

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:
 - $a \leq 2 \cdot d_t$
 - $b \geq 1.5 \cdot d_t$
 - $b/a \geq 0.75$

a , b , d_t according to [Figure 5-6](#)

d = thread diameter of bolt.

Format of proof

The following relations shall be kept:

$$Z_{max} / Z_{limit} \leq 1 \text{ or } Z_{max} \leq Z_{limit}$$

Z_{max} = maximum tensile force in bolt [kN]

Z_{limit} = limit value of tensile force in bolt [kN].

Maximum tensile force in bolt

The maximum tensile force in the bolt is calculated as follows:

$$Z_{\max} = f \cdot Z_{\text{nom}} \text{ [kN]}$$

Z_{nom} = nominal tensile force of the highest loaded bolt of a multiple bolt connection [kN]

f = form factor according to Table 5-8 [-].

Table 5-8 Form factors

Kind of flange connection		Tensile class of bolt		
		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	

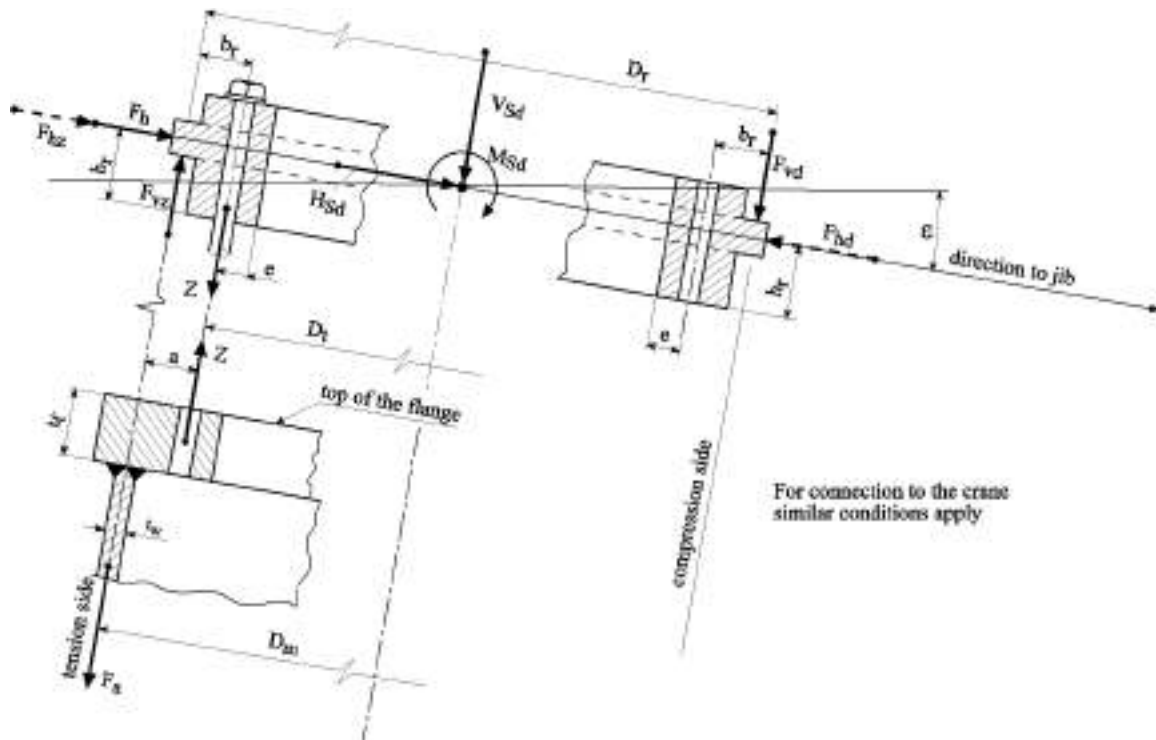


Figure 5-5 Forces on a large slewing bearing

Forces on a large slewing bearing

For the terms and forces in [Figure 5-5](#) 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].

Load from the crane

The following loads shall be determined including the global safety factor γ_s according to [\[4.3.8.2\]](#) for the most unfavourable load combination according to [Table 5-4](#) and [Table 5-5](#):

- M_{Sd} = tilting moment [Nmm]
- V_{Sd} = vertical force [N]
- H_{Sd} = horizontal force [N].

Forces acting on the ring per bolt sector

According to [Figure 5-5](#) the following forces are valid in case V_{Sd} is pointing in that direction shown in [Figure 5-5](#) (compressive force):

$$F_{vd} = \left(\frac{4 \cdot M_{Sd}}{D} + V_{Sd} \right) \cdot \frac{1}{n_s} \text{ [N]}$$

$$F_{vz} = \left(\frac{4 \cdot M_{Sd}}{D} - V_{Sd} \right) \cdot \frac{1}{n_s} \text{ [N]}$$

$$F_h = \frac{4 \cdot H_{Sd}}{n_s} \text{ [N]}$$

- 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.

Calculation of maximum nominal tensile force

Based on the dimensions according to [Figure 5-5](#) and on the forces acting on the bearing ring the maximum nominal tensile force is calculated as follows:

$$Z_{nom} = F_{vx} + (F_h + F_{3x}) \cdot \frac{h_r}{a + e}$$

Limit value of tensile force of bolt

The limit value of tensile force of the bolt shall be calculated as follows:

$$Z_{limit} = \sigma_{limit} \cdot A_k / 1000 \text{ [kN]}$$

- σ_{limit} = limit stress according to [Table 5-9](#) [N/mm²]
- A_k = core section of bolt according to [Table 4-14](#) [mm²].

Table 5-9 Limit stresses of bolts

<i>Tensile class</i>	8.8	10.9	12.9
Limit stress σ_{limit} [N/mm ²]	560	768	912

5.7.4.1.3 Requirements for the flange

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 [Figure 5-6](#). In the case of an inner bore circle, the same conditions apply.

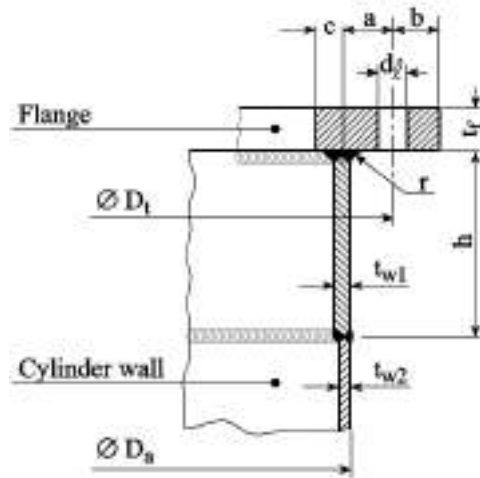


Figure 5-6 Upper part of crane column

Dimensioning of the flange

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 = $\frac{D_a - D_t - t_{w1}}{2}$ 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.

The flanges shall be designed and dimensioned according to [4.9.1.5.2]. As far as no proof by FE-computation has been conducted in addition the following conditions shall be met:

$$t_f \geq 3 \cdot t_{w1}$$

$$t_{w1} \geq 1.5 \cdot t_{w2}$$

Facing

The flange thickness shall still be warranted after the facing.

Flange evenness

The evenness of the connecting areas on a slewing bearing shall meet the requirements given by the manufacturer of this bearing.

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 the Society and slewing bearing manufacturer.

5.7.4.1.4 Requirements for the cylinder wall in the connection area

Dimensioning

The wall thickness t_1 and the connection weld shall be dimensioned with regard to fatigue strength.

Height of connection

As far as no proof by FE-computation has been conducted the height of the uppermost cylinder section according to [Figure 5-6](#) 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.

5.7.4.1.5 Revolving circle diameter of the slewing bearings

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.

Where brackets shall be attached, they shall not be spaced further than two bore distances.

5.7.4.1.6 Requirements for bolts and bores

In general, the span length of bolts shall be at least $5 \cdot d_s$.

At least 6 thread turns shall remain free.

The connecting bolts of slewing bearings of cranes of the groups B2, B3 and C shall have rolled threads.

The size of bolt bores shall be indicated by the bearing manufacturer (in general according to [\[4.9.1.2\]](#)).

5.7.4.2 Doubling plates

Doubling plates for the transmission of tension forces and bending moments are not permissible.

5.7.4.3 Cruciform joints

Regarding cruciform joints for the transmission of forces perpendicular to the roll direction, the requirements given in [\[4.8.1.2.4\]](#) apply.

5.7.4.4 Joints of runways

Runways shall be welded continuously and the welds shall be executed such, that no vertical dynamic forces can be induced when travelling.

5.7.5 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 safe working load SWL only in cases where this was a basis for the dimensioning.

SECTION 6 SPECIAL LIFTING APPLIANCES AND MEANS OF TRANSPORT

6.1 General

6.1.1

This section deals with the requirements for the design and dimensioning as well as for the manufacture and operation of special lifting appliances and means of transport.

6.1.2

With respect to requirements for the materials to be used as well as for manufacture and welding, the provisions in [Sec.3](#) and [Sec.11](#) apply.

6.1.3

Calculation and dimensioning shall be based on [Sec.4](#) and [Sec.8](#) as well as further sections as required. Deviating requirements given in this section shall be observed.

6.1.4

For machinery components and the electrical fittings on special lifting appliances and means of transport, the requirements given in [Sec.9](#) and [Sec.10](#) shall be complied with, if applicable.

6.1.5

Interchangeable components shall be selected using recognized standards. The dimensioning of non-standard interchangeable components can be carried out in accordance with [Sec.7](#).

6.2 Rope and chain hoists

6.2.1 General

6.2.1.1 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.

6.2.1.2 Handling of goods for ship operation is not regarded as cargo handling.

6.2.2 Manufacture

6.2.2.1 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.

6.2.2.2 Dimensioning

The requirements given in [\[6.1.3\]](#) also apply to foundations or runway girders of rope and chain hoists produced in series.

6.2.3 Equipment and safety regulations

For all types of drive, the requirements given in [Sec.12](#) shall also be observed, if applicable. In addition, the following applies:

6.2.3.1 Overload protection

6.2.3.1.1 Series production

For hydraulic, pneumatic and electrical hoist drives, effective overload protection devices shall be provided. In the case of hydraulic hoist drives, pressure relief valves are permissible up to a safe working load of 1000 kg.

As regards response limits and response tolerances of overload protection devices, the settings or parameters given by the manufacturer apply.

6.2.3.1.2 Individual production

For rope and chain hoists manufactured by individual or special production, the requirements given in [\[12.4.1.1\]](#) apply.

6.2.3.2 Hook travel limits

6.2.3.2.1 General requirements

Rope and chain hoists shall have limit switches for the upper and lower hook position.

In the case of power-operated rope and chain hoists, the limit switches shall act mechanically and/or electrically on the hoist drives.

6.2.3.2.2 Series production

For hydraulic, pneumatic and electrical hoist drives, effective limit switches for the hook travel shall be provided.

6.2.3.2.3 Individual production

For rope and chain hoists manufactured by individual or special production, limit switches for the upper and lower hook position shall be provided which function electrically.

6.2.3.3 Runway limit

As regards runway limit, the requirements given in [\[5.3.4.2\]](#) and [\[12.4.2\]](#) apply, if applicable.

6.2.3.4 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.

6.2.3.5 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.

6.2.4 Means of suspension

6.2.4.1 Hoisting ropes

6.2.4.1.1 General

Hoisting ropes and their end attachments are covered by the requirements given in [Sec.8](#).

Wire ropes made of stainless materials, as well as synthetic fibre ropes, may be allowed for special purposes if suitable, and if the design of the hoist rope is verified accordingly.

6.2.4.1.2 Safety against fracture

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 shall be applied to the maximum static hoisting rope force.

When using rope hoists below deck γ_{D1} may be ≤ 4.0 .

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 ≤ 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](#) shall be used without limitation of γ_{D1} or γ_F .

6.2.4.2 Hoisting chains

6.2.4.2.1 General

Hoisting chains shall comply with recognized standards.

Chain wheels of hoisting chains as well as their end links or fasteners for leading-in the tow chain shall conform to standards.

6.2.4.2.2 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 shall be applied:

$$\gamma_K \geq 5.0 \text{ (power-driven)}$$

$$\gamma_K \geq 4.0 \text{ (operated manually).}$$

6.2.4.3 Interchangeable components

6.2.4.3.1 Interchangeable components 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](#).

6.2.4.3.2 The dimensions of the eye plates on normal strength and high strength shackles shall comply with the Tables in [Sec.7](#).

6.2.4.3.3 Regarding the use of detachable rope end attachments (rope sockets or rope clamps), the requirements given in [\[8.4.2.3\]](#) apply.

6.2.5 Assessment of drawings and manufacturing survey

6.2.5.1 Series production

6.2.5.1.1 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 shall be submitted, if applicable:

- designation of manufacturer and type
- safe working load(s) and dead weight(s)
- hoist speed and operating speed, if applicable
- type of drive
- type(s) of electrical protection, see [\[10.6.1.7\]](#)
- further information as required.

6.2.5.1.2 For the Society's type approval [DNVGL-CP-0338](#) applies.

6.2.5.2 Individual production

6.2.5.2.1 Rope and chain hoists manufactured by individual or special production are subject to assessment of drawings and manufacturing survey by the Society.

6.2.5.2.2 For the assessment of drawings, the list of documents to be submitted in [\[2.1\]](#) shall be applied as and where relevant. In addition, the following drawings and information shall 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.

6.2.5.2.3 For manufacturing survey, the requirements given in [\[13.2\]](#) apply.

6.2.6 Tests and examinations on board

6.2.6.1 For the initial test and examination, the requirements given in [\[13.3\]](#) apply.

6.2.6.2 For the periodic testing and examinations, the requirements given in [\[13.4\]](#) apply.

6.2.7 Documentation

6.2.7.1 Identification

For the identification of rope and chain hoists, the requirements given in [\[13.2.4.2.1\]](#), [\[13.2.5\]](#) and [\[13.2.6\]](#) and [\[13.3.5\]](#) apply.

6.2.7.2 Certificates

6.2.7.2.1 Certificates for production

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 interchangeable components.

Individual production

For rope and chain hoists manufactured by individual or special production, the Society's product certificate based on an examination before delivery is required.

The Society's product certificates shall be submitted for all means of suspension such as ropes, chains and interchangeable components.

6.2.7.2.2 Certificate for load tests

Certificates to be issued after every load test, due to national regulations, are described in [\[13.7\]](#).

For rope and chain hoists which shall not be subjected to ongoing control by the Society, the Society may recognize deviating forms or certificates not issued by the Society's surveyor.

6.2.7.3 Register book

6.2.7.3.1 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 [13.7].

6.3 Ramps and car decks

6.3.1 General

6.3.1.1 Testing, investigation and certification of ramps and car decks fixed to the ship is part of the classification of the ship.

6.3.1.2 As regards naval-architectural concerns such as ship's strength, water-tightness, impact stress by the sea, etc. the requirements given in [DNVGL-RU-SHIP Pt.3](#) apply.

6.3.1.3 The following requirements relate to mobile shipboard ramps and car decks operated under load.

6.3.2 Production

6.3.2.1 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 shall be selected in accordance with the DNV GL rules.

6.3.2.2 Dimensioning

6.3.2.2.1 The dimensioning of steel or aluminium ramp or car deck construction shall comply with the requirements given in [6.3.1.2].

6.3.2.2.2 For the dimensioning of structural or machinery components of rope or chain drives, a hoist load coefficient of $\psi = 1.15$ shall be applied to moved masses consisting of safe working load (SWL) and dead weight.

Guidance note:

Concerning safe working load for conveyance of persons, see [4.2.5.1.1].

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

6.3.3 Equipment and safety regulations

6.3.3.1 Scratch boards, railings and barriers

6.3.3.1.1 Ramps and car decks shall be fitted with scratch boards, railings and barriers, as necessary. For the dimensioning of railings [4.9.9.2] applies.

Scratch boards for motor vehicles shall be designed to meet the line loads according to [Table 6-1](#).

Table 6-1 Loading scratch boards

<i>Vehicle type</i>	<i>Line load</i>	<i>Height of load application</i>
Passenger vehicles	2 kN/m	0.3 m

<i>Vehicle type</i>	<i>Line load</i>	<i>Height of load application</i>
Trucks	5 kN/m	0.5 m

6.3.3.1.2 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 assessment by the Society.

6.3.3.2 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.

6.3.3.3 Ramp inclination

Ramp inclination shall not in general exceed the ratio 1:10.

6.3.3.4 Permissible deflection

6.3.3.4.1 The permissible deflection of ramps and car decks under safe working load in the stowed position shall not exceed:

$$f = \frac{b_s}{200}$$

where

f = deflection (depth gauge)

b_s = spacing of supports (span).

6.3.3.4.2 In the stowed position, the deflection may not endanger either the water-tightness of the ship or any cargo (e.g. vehicles) underneath.

6.3.3.5 Stowage positions

6.3.3.5.1 In the stowage positions provided, ramps and car decks shall not be hung on ropes or chains but shall have mechanical supports and locks.

6.3.3.5.2 Supports and locks shall be dimensioned according to the requirements given in [6.3.1.2] and safeguard the water-tightness of the ship, where ramps are part of the shell.

6.3.4 Means of suspension

6.3.4.1 Hoisting rope and suspension rope

6.3.4.1.1 General

For hoisting ropes and suspension ropes and their end attachments, the requirements given in [Sec.8](#) apply.

Wire ropes of stainless materials as well as synthetic 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.

Synthetic fibre ropes for the transport of persons are only permitted under special conditions.

6.3.4.1.2 Safety against fracture

Safety against fracture is defined by the coefficient of utilization γ_{D1} or γ_{D2} according to [Table 8-2](#) and shall be applied to the maximum static towing rope force.

For hoisting ropes, the following safety factors shall be applied, depending on the mode of operation, in accordance with [Table 8-2](#):

- operation without working load = $\gamma_{D1} \geq 3.6$
- operation with working load = γ_{D1}
- operation involving persons = $\gamma_{D1} \cdot 2.0$.

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 shall be used:

- hoisting ropes or guided suspension ropes = $\gamma_{D1} \cdot 2.0$
- suspension ropes, not guided = $\gamma_{D2} \cdot 2.0$.

6.3.4.2 Hoisting chains and suspension chains

6.3.4.2.1 General

Hoisting chains and suspension chains shall comply with recognized standards.

Chain wheels as well as their end links or fasteners for leading in the tow chain shall be selected in conformance with standards.

6.3.4.2.2 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 shall be applied:

- operation without working load = $\gamma_K \geq 2.8$
- operation with working load = $\gamma_K \geq 4.0$
- operation involving persons = $\gamma_K \geq 8.0$.

6.3.4.3 Interchangeable components

[6.3.4.3.1](#) The requirements given in [\[6.2.4.3.1\]](#) and [\[6.2.4.3.2\]](#) shall be observed.

[6.3.4.3.2](#) Detachable rope end attachments (rope sockets or rope clamps) are not permitted for rope drives of ramps and car decks.

6.3.4.4 Hydraulic cylinders

Hydraulic cylinders shall be dimensioned in accordance with [\[4.9.2\]](#).

6.3.5 Assessment of drawings and manufacturing survey

Ramps and car decks are subject to design assessment of drawings and manufacturing survey.

6.3.5.1 Assessment of drawings

For the assessment of drawings, the list of documents to be submitted in [\[2.1\]](#) shall be applied as and where relevant. In addition, the following drawings and information shall 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.

6.3.5.2 Manufacturing survey

For the manufacturing survey the requirements given in [13.2] apply.

6.3.6 Tests and investigations on board

6.3.6.1 Initial test and investigation

6.3.6.1.1 For the initial test and investigation, the requirements given in [13.3] apply.

6.3.6.1.2 The load tests with test loads according to Table 13-2 shall be performed statically in the stowage positions and dynamically for the movable installations.

6.3.6.2 Periodic testing and investigations

6.3.6.2.1 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.

6.3.6.2.2 Where required by national regulations, ramps and car decks shall be treated like cargo gear. The requirements given in [13.4] apply in this case. During the 5-years load tests, [6.3.6.1.2] shall be observed.

6.3.7 Documentation

6.3.7.1 Identification

For the identification of ramps and car decks, the requirements given in [13.2.5], [13.2.6] and [13.3.5] apply.

6.3.7.2 Certificates

6.3.7.2.1 Manufacturing certificates

The manufacturer of ramps and car decks shall supply the Society's product certificates for all means of suspension such as ropes, chains, interchangeable components and hydraulic cylinders as well as for winches.

As confirmation of investigation before delivery, the Society's manufacturing survey report is required for every ramp and every car deck or for every series of such ship components.

6.3.7.2.2 Certificates for load tests

As a confirmation of the load tests, the Society's product certificate is required for every ramp and every car deck or for every series of such ship components.

Where, due to national regulations, ramps and car decks shall be treated like cargo gear, the requirements given in [13.3.6] and [13.4.6] apply.

6.3.7.3 Register book

6.3.7.3.1 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 [13.7].

6.3.7.3.2 Confirmation of the class surveys according to [6.3.6.2.1] is effected within the scope of ship classification. Relevant excerpts of the survey report for the ship may be added to the documentation file.

6.4 Lifting appliances for research work

6.4.1 General

6.4.1.1 Lifting appliances for research work are 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.

6.4.1.2 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.

6.4.1.3 Lifting appliances for research work are e.g.:

- stern gantry crane
- slewing gallows
- lateral outrigger
- hatch beam
- lifting appliances with special functions
- A-frames.

6.4.2 Treatment of lifting appliances for research work

Lifting appliances for research work is treated like lifting appliances not intended for the handling of cargo. The following specific features, however, shall be considered.

6.4.3 Special features

6.4.3.1 Dimensioning

6.4.3.1.1 Lifting appliances for research work shall be dimensioned for the breaking loads of ropes or cables. For the dimensioning, the following load combination shall be assumed, following [Table 5-4](#), load combination III:

- dead loads $\gamma_{pi} = 1.10$
- rope/cable breaking load $\gamma_{pi} = 1.10$
- diagonal pull $\gamma_{pi} = 1.10$
- partial safety factor for resistance values $\gamma_m = 1.10$.

In general, for this purpose the diagonal pull shall be assumed for the most unfavourable direction as follows:

- lifting 15°
- towing longitudinally to the ship 30°
- towing transversely to the ship 45°.

6.4.3.1.2 Where lifting appliances for research work are also intended for handling goods for ship operation, it shall also be dimensioned accordingly.

6.4.3.1.3 Interchangeable components shall be selected in such a way that the breaking load of ropes or cables corresponds to the test loads of the interchangeable components stated in [Table 7-4](#).

6.4.3.2 Marking

6.4.3.2.1 When marking lifting appliances for research work, the requirements given in [13.2.5] 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] shall be used.

6.4.3.2.2 Where several ropes or cables are attached to one lifting appliance, marking is required on every single rope or cable.

6.4.3.2.3 Where lifting appliances for research work are also intended for handling goods for ship operation, it shall also be marked with *SWL*.

When determining the quantity to be indicated, the breaking load of the rope shall be divided by the coefficient of utilization γ_{D1} in accordance with Table 8-2, and then to be converted into kg or t.

6.4.3.3 Operating manual

6.4.3.3.1 An individual operating instruction shall be prepared for every lifting appliance for research work, in which the special features of operation and control are described.

6.4.3.3.2 Operating manuals are subject to design assessment and shall remain permanently on board as part of the lifting appliance documentation.

6.5 Industrial cargo-handling vehicles

6.5.1 General

6.5.1.1 The following requirements apply to industrial cargo-handling vehicles (e.g. fork lift trucks or wheel loader) in series production which are certified in a legally-binding or recognized manner, unless otherwise provided by national regulations.

6.5.1.2 Prerequisites for use on board are proofs of safety against overturning, see [4.5.2.2], and, at a minimum, the existence of test reports.

6.5.1.3 The requirements given in [6.5.3] and [6.5.4] apply only to industrial cargo-handling vehicles which remain in permanent employment on board.

6.5.2 Safety regulations

6.5.2.1 The employment of industrial cargo-handling vehicles on board presupposes that decks and hatch covers are adequately dimensioned to be run over.

6.5.2.2 Where industrial cargo-handling vehicles remain permanently on board, fastening arrangements (e.g. eye plates) for securing for use at sea shall be fitted both to the vehicle and to the hull.

6.5.2.3 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.

6.5.2.4 Industrial cargo-handling vehicles run on fuel may only be used in cargo spaces if there is adequate ventilation. Otherwise, only battery-powered vehicles shall be employed.

6.5.2.5 The use of fuels with a flash point below 60°C is not permitted.

6.5.2.6 In general fork-lift trucks to be used on board shall have a tiltable lifting frame.

6.5.3 Control measures

6.5.3.1 Initial control

Before start of operation, the following measures are required at a minimum:

- check the information documents included with delivery
- function check with safe working load
- test run over the operational areas with safe working load as proof the deck or hatch covers are sufficiently strong.

6.5.3.2 Regular controls

Industrial cargo-handling vehicles are subject to inspection and regular control by the ship's management at intervals not exceeding six (6) months.

These controls shall be confirmed in a suitable manner and added to the documentation.

6.5.4 Documentation

6.5.4.1 Certification

For the control as per [6.5.3.1], the Society's surveyor issues a Society's product certificate.

6.5.4.2 Identification

For stamping, correlating to the product certificate, the requirements given in [13.3.5] apply.

6.5.4.3 Register book

6.5.4.3.1 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 [13.7].

6.5.4.3.2 In addition to the certificate as per [6.5.4.1], the manufacturer's documentation shall be included in the register book. This also applies to all confirmations of control measures by the ship's management, see [6.5.3.2].

6.6 Means of conveying persons or personnel

6.6.1 Shipborne working baskets

6.6.1.1 Newly-manufactured working baskets shall meet the requirements given in EN 14502-1.

6.6.1.2 Shipborne working baskets shall be treated in all respects similarly to lifting appliances not handling cargo. Their dimensioning and testing shall however be subject to the static test loads according to Table 7-2.

6.6.2 Requirements for lifting appliances for conveying persons or personnel

Lifting appliances for conveying persons or personnel shall comply with the requirements given in [4.2.5.1] and 4.2.5.2 with respect to dimensioning, operation and control.

6.6.3 Landing booms

6.6.3.1 General

6.6.3.1.1 The provision and the arrangement of landing booms (swinging booms for conveying persons) are required by the St Lawrence seaway authority.

6.6.3.1.2 Landing booms shall only be used for conveying one single person at a time.

6.6.3.1.3 Landing booms shall be treated as lifting appliances, not handling cargo, except where otherwise determined in what follows.

6.6.3.2 Dimensioning

6.6.3.2.1 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).

6.6.3.2.2 Ropes and interchangeable components shall be designed, in addition to the dead loads, for a static boom load of 150 kg at a minimum.

6.6.3.2.3 The slenderness ratio of a landing boom may not exceed a value of 200.

The following equations apply:

$$\lambda = \frac{l_k}{i}$$

$$i = \sqrt{\frac{I_L}{A_L}}$$

I_L = moment of inertia of boom
 A_L = cross-section area of boom.

6.6.3.3 Construction and layout

6.6.3.3.1 The load radius of landing booms shall be about 9 m.

6.6.3.3.2 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).

6.6.3.3.3 Landing booms shall be operated exclusively by hand. The lowering system shall allow gentle set-down.

6.6.3.3.4 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.



6.6.3.4 Assessment of drawings and manufacturing survey

6.6.3.4.1 Landing booms together with the associated posts shall be constructed according to the drawings approved by the Society.

6.6.3.4.2 Because all components are normally easily accessible for subsequent controls, manufacturing survey is not required in general. Test reports shall be included in the delivery.

6.6.3.5 Tests and investigations on board

6.6.3.5.1 For the tests and investigations on board, the requirements given in [13.3] and [13.4] apply with the following deviations:

6.6.3.5.2 Landing booms shall 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.

6.6.3.6 Documentation

With respect to identification, certification and documentation, the requirements for lifting appliances not handling cargo apply, see [Sec.13](#).

SECTION 7 LOAD-HANDLING DEVICES AND INTERCHANGEABLE COMPONENTS

7.1 General

7.1.1

This section covers the requirements for design and calculation as well as production and employment of load-handling devices and interchangeable components.

7.1.2

With respect to requirements for the materials to be used as well as for production and welding, the provisions in [Sec.3](#) and [Sec.11](#) apply.

7.1.3

For machinery components and electrical equipment of load-handling devices, the requirements given in [Sec.9](#) and [Sec.10](#) shall be complied with, where relevant.

7.2 Load-handling devices

7.2.1 General

The following requirements apply to load-handling devices according to [\[1.1.5.32\]](#) as well as to suspensions which are integral part of a load-handling device, see [\[1.1.5.59\]](#).

Guidance note:

Suspensions which are not integral part of a load-handling device are not subject to this standard.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

7.2.2 Design principles

7.2.2.1 General

Relevant requirements given in [Sec.4](#) shall be complied with.

7.2.2.1.1 Suspension ropes, rope slings and their rope attachments shall comply with the requirements given in [Sec.8](#).

If a product certificate (CG4/LA4) for the rope is submitted and proof is provided that the rope connections have been produced by manufacturers with the Society's 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 shall be taken into account.

7.2.2.1.2 Suspension chains and their end attachments shall comply with recognized standards.

7.2.2.1.3 Regarding the suspension height of loose gear, it shall be pointed out that the opening angle of suspension ropes or chains shall not exceed 120° and of ramshorn hooks shall not exceed 90° .

7.2.2.1.4 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 given in this section that both the loose gear and the loads have a positive stability height, see illustration in Figure 7-1.

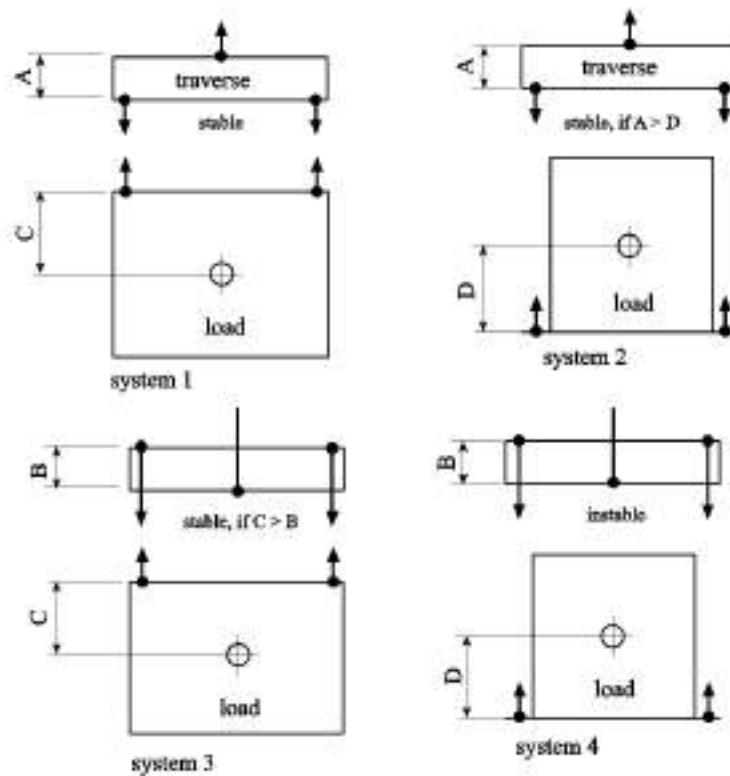
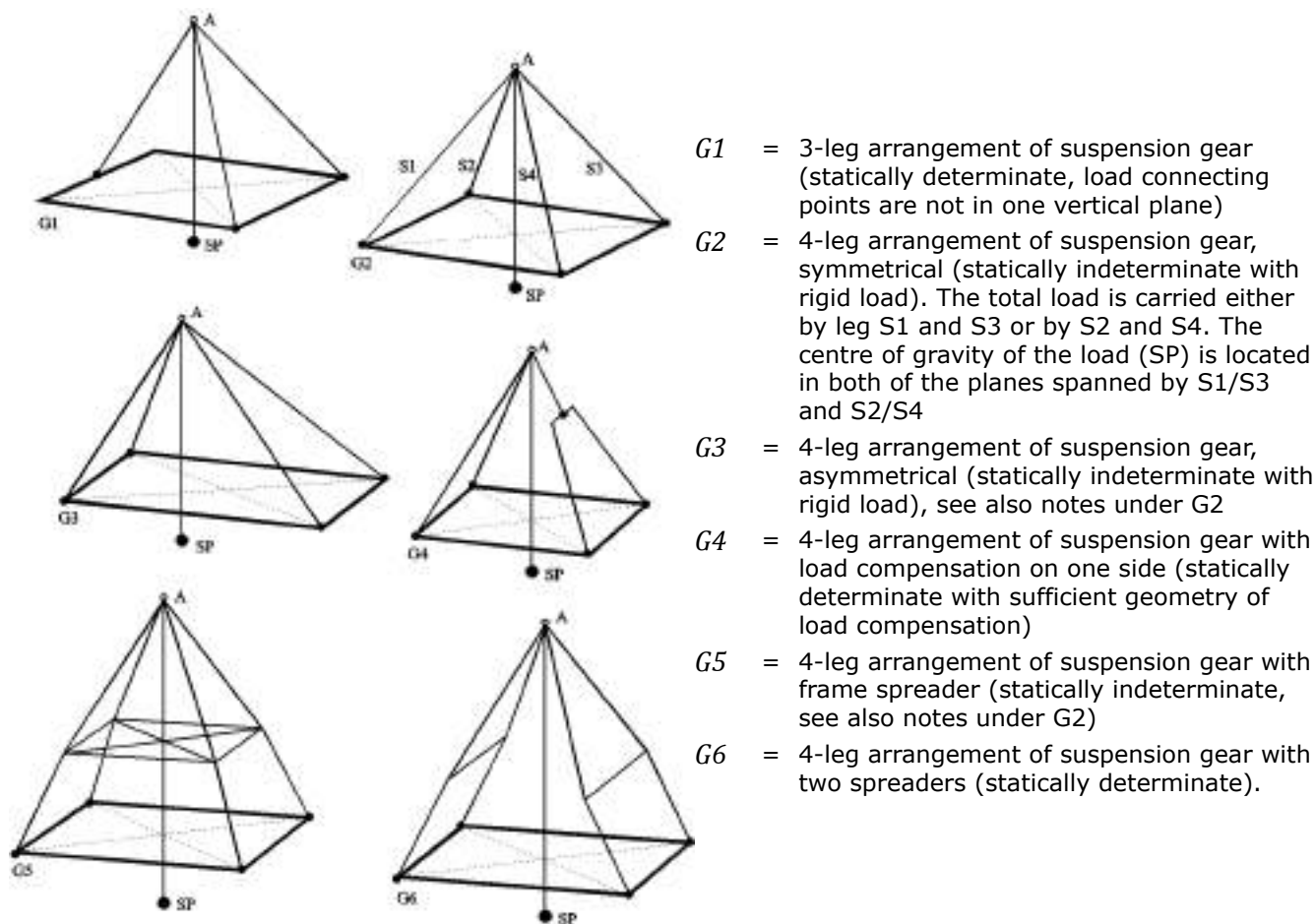


Figure 7-1 Balance conditions

7.2.2.1.5 Arrangement of suspension gear

A predefined arrangement of suspension gear may be considered as load-handling device. Examples are shown in Figure 7-2.

Regarding 4-leg arrangements of suspension gear without load equalisation it shall be taken into consideration that these systems are statically indeterminate. The individual legs of the arrangement are stressed depending on the rigidity of the load or the load-handling device to be handled. Where the load or the load-handling device has high rigidity the load distribution on each leg of the arrangement of suspension gear shall be verified by static calculation. Without verification of the actual load distribution in the complete system (arrangement of suspension gear and load or load-handling device) only 2 legs shall be assumed as load-bearing.



- G1* = 3-leg arrangement of suspension gear (statically determinate, load connecting points are not in one vertical plane)
- G2* = 4-leg arrangement of suspension gear, symmetrical (statically indeterminate with rigid load). The total load is carried either by leg S1 and S3 or by S2 and S4. The centre of gravity of the load (SP) is located in both of the planes spanned by S1/S3 and S2/S4
- G3* = 4-leg arrangement of suspension gear, asymmetrical (statically indeterminate with rigid load), see also notes under G2
- G4* = 4-leg arrangement of suspension gear with load compensation on one side (statically determinate with sufficient geometry of load compensation)
- G5* = 4-leg arrangement of suspension gear with frame spreader (statically indeterminate, see also notes under G2)
- G6* = 4-leg arrangement of suspension gear with two spreaders (statically determinate).

Figure 7-2 Suspending systems for typical arrangements of suspension gear

7.2.2.2 Traverses

7.2.2.2.1 Traverses may only be loaded symmetrically to the centre of gravity of the load, unless they are dimensioned for asymmetric loading and marked accordingly.

If there are more than two (2) attachment points between the traverse and the load, the strength analysis shall be conducted with consideration of rigidity of the load (statically indeterminate system).

Alternatively, devices may be fitted which indicate the load.

7.2.2.2.2 Where longitudinal lifting beams have under-slung transverse lifting beams using tension elements, this system shall be designed for safe operation in accordance with the static degrees of freedom. Sufficient strength shall be proven by a strength analysis.

7.2.2.2.3 Telescopic traverse parts shall be lockable in their working positions.

7.2.2.3 Frame traverses/spreader

7.2.2.3.1 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.

7.2.2.3.2 Container spreaders shall be equipped with indicators showing in a suitable manner whether the twist locks are locked or unlocked.

7.2.2.3.3 Locking pins which automatically unlock when unloaded are not acceptable.

7.2.2.4 Grabs and lifting magnets

7.2.2.4.1 The structural design and operating mode of grabs and lifting magnets shall be suited to the intended type of cargo.

7.2.2.4.2 The mechanical strength and electrical equipment of grabs and lifting magnets shall comply with the requirements given in this standard.

7.2.2.4.3 Closing ropes of grabs shall be protected in a suitable way against excessive wear.

7.2.2.4.4 Lifting magnets shall comply with the requirements given in EN 13155.

7.2.3 Calculation principles

7.2.3.1 General

7.2.3.1.1 Calculations and dimensioning of load-handling devices are subject to the requirements given in [Sec.4](#) and [Sec.5](#).

7.2.3.1.2 Regarding the loads to be considered and the proofs to be provided, the following requirements shall be observed.

7.2.3.2 Design loads

7.2.3.2.1 General

The loads acting on load-handling devices are subdivided as follows:

- regular loads
- irregular loads
- special loads.

If necessary, loads not addressed in the following shall be considered additionally in a suitable way. The grading of such loads and the consideration of them in the corresponding load combinations shall be agreed with the Society.

7.2.3.2.2 Regular loads

Dead load L_E

Dead loads shall be determined in accordance with [\[4.2.4.2\]](#).

Working load (WL)

The working load is defined in [\[1.1.5.66\]](#). When dimensioning the load-handling device, this is assumed to be the safe working load (SWL).

Dynamic forces caused by drives

Regarding the dynamic forces caused by drives, the provisions of [5.3.2.4] apply, including the following additions:

- For dimensioning, in general only those vertical dynamic forces shall be considered, which are covered by the hoist load coefficient ψ . Therefore the working loads shall be multiplied by the maximum hoist load coefficient ψ for this application, of the allocated lifting appliances.
- SWL shall be always relevant for dimensioning. This shall be ensured by the conditions in [5.4.3.2].
- If load-handling devices or interchangeable components cannot be allocated to lifting appliances, the following hoist load coefficient shall be used:

SWL	≤ 10 t	≤ 160 t	≤ 500 t	≤ 1000 t	> 1000 t
ψ	1.6	1.4	1.3	1.2	1.15

This is only permissible if the lifting appliance is used in harbour operations. When used under seaway conditions, the increased requirements given in the lifting appliance used thereby shall be considered.

7.2.3.2.3 Irregular loads

Wind loads

Wind loads shall be assumed according to [4.2.4.5].

Snow and ice loads

If snow loads shall be considered, these shall be provided by the manufacturer.

If ice loads shall be considered, these shall be determined according to [4.2.4.6].

7.2.3.2.4 Special loads

Test loads

Load-handling devices shall be dimensioned for a static test load L_{Pstat} according to Table 7-2 or, if more unfavourable, for the dynamic test load of the lifting appliance according to [5.3.4.1] including the reduced hoist load coefficient ψ_p :

$$\max (L_{Pstat}; L_{Pdyn} \cdot \psi_p)$$

Lateral impact

For frame-type traverses/spreader, a lateral impact of 1/10 of the maximum vertical load in the frame level shall be assumed:

$$H_S = (SWL + L_E) / 10$$

7.2.3.3 Load combinations and partial safety factors

7.2.3.3.1 General

The load combinations deemed to be essential for load-handling devices in operation are compiled in Table 7-1.

For the condition "cranes out of operation" the load combinations and partial safety factors according to Table 5-5 shall be assumed regarding strength analysis.

According to circumstances further load combinations may arise.

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, shall be proved.

Table 7-1 Load combinations for load-handling devices 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	[7.2.3.2.2.1]	1.22 ¹	1.0	1.16 ¹	1.0	1.10 ¹	1.0	1.0	1.0
	Working load WL	2	[7.2.3.2.2.2]	1.34	Ψ	1.22	Ψ	1.10	-	-	Ψ
Irregular loads	Wind loads under operating conditions	3	[7.2.3.2.3.1]			1.22	1.0	1.10	-	0.2	-
	Snow and ice loads	4	[7.2.3.2.3.2]			1.22	1.0	-	-	-	-
Special loads	Hoisting the hoist load at v_{hmax}	5	Table 5-2					1.10	ψ_{max}	-	-
	Test load	6	[7.2.3.2.4.1]					1.10	-	ψ_p	-
	Lateral impact	7	[7.2.3.2.4.2]					1.10	-	-	1.0
Partial safety factor γ_m for resistance values				1.10		1.10		1.10			
Global safety factor γ_s				1.48		1.34		1.22			
1) Where load combinations have a favourable effect, $\gamma_{pi} = 0.95$ may be assumed. If the component's masses and centre of gravity is determined by weighing, $0.95 \cdot \gamma_{pi}$ may be assumed.											

7.2.3.3.2 Comments on the load combinations for load-handling devices under operating conditions, Table 7-1

The load combinations I_1 , II_1 , III_1 and III_2 correspond to those given in [5.5.2].

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 load-handling devices shall be considered, assuming an inclined position deviating 6° from the ideal location in relation to both main axes. This load condition shall be examined additionally.

III₃ - Lateral impact

The load combination comprises the loads due to hoisting of the hoist load including a lateral impact.

7.2.3.4 Proofs

7.2.3.4.1 General

The load-handling devices shall be dimensioned taking into consideration the following points:

The centre of gravity is located in the axis of symmetry of the suspension.

Regarding frame-type traverses or spreaders, the bending rigidity of the load shall also 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.

7.2.3.4.2 Strength analyses

Regarding the strength analyses, in general the statements in [4.4] and [4.8] apply. The load combinations shall be formed using the values for the partial safety factors according to Table 7-1.

Telescopic parts of traverses or spreaders

In the case of the telescopic parts of traverses or spreaders, careful attention shall 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.

7.2.3.4.3 Proof of stability (buckling, lateral torsional buckling, warping)

For proof of stability, the statements in [4.4] apply in general. The load combinations shall be formed using the partial safety factors according to Table 7-1.

Special boundary conditions for traverses

Regarding the proof of stability of traverses, special boundary conditions shall be assumed for the determination of the critical buckling load. It shall 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 traverses suspension and the load's suspension can be applied, which are activated by the eigenmode of the traverse. In determining the ideal lateral torsional buckling moment (M_{ki}) these boundary conditions shall be applied.

System assumptions for the determination of M_{ki} for traverses (ideal lateral torsional buckling moment)

See Figure 7-3 to Figure 7-5.

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 eigenmode), see Figure 7-3
- limitation of the torsional angle $\Phi \leq 0.3$ rad, see Figure 7-4 and Figure 7-5.

7.2.3.4.4 Fatigue strength analyses for load-handling devices

For fatigue strength analyses, in general the statements in [5.6] apply. Generally, they shall be conducted for the load combination I of Table 7-1 using a partial safety factor of $\gamma_{pi} = 1.0$.

For load-handling devices with stress cycles ≤ 20000 , a fatigue strength analysis may be dispensed with.

7.2.3.4.5 Proofs of suitability for use

For proofs of suitability for use, in general the statements in [4.7] apply. Generally, they shall be conducted for the load combination I of Table 7-1 using a partial safety factor of $\gamma_{pi} = 1.0$.

Traverse

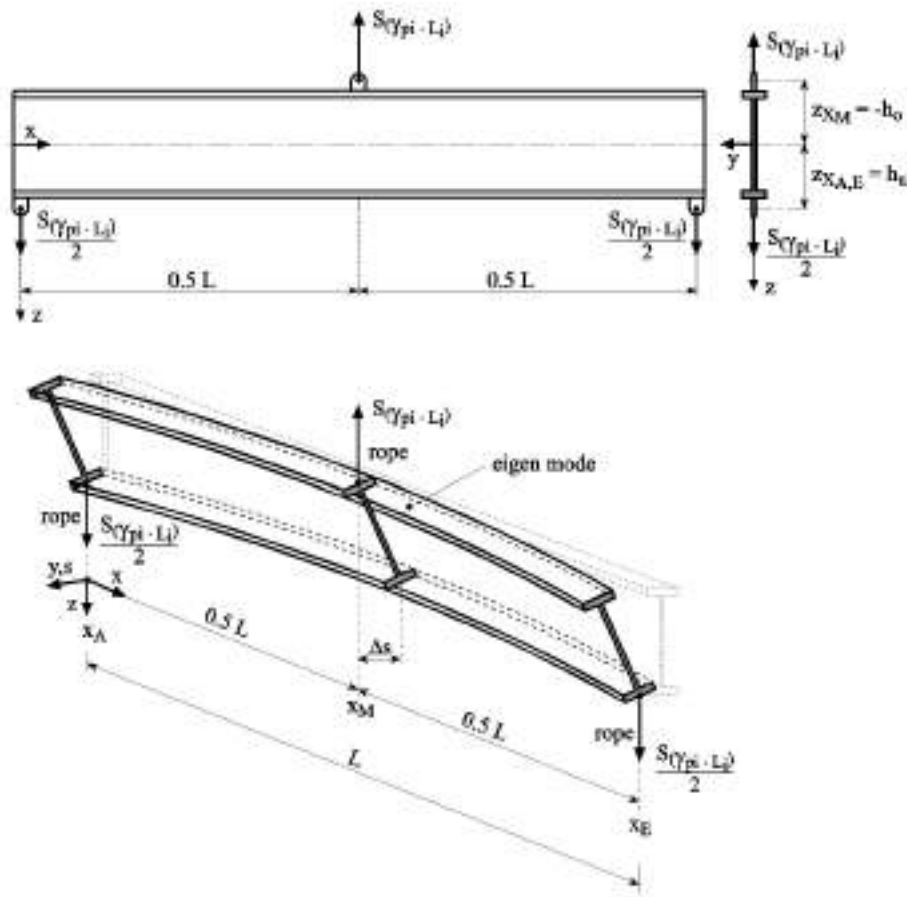
The maximum deformation shall be limited to $\leq L/500$, related to the traverses' length.

Frame-type traverse/spreader

The maximum bending deformation due to the dead weight shall be limited to $\leq L/1000$, related to the spreaders' length, the maximum bending deformation shall be limited to $\leq L/500$, related to the spreader's length.

Container spreader

The maximum bending deformation (bending stiffness) of the spreader shall be limited such, that the lift locks cannot unlock under operational conditions.



Assumption: Three points are always located in a vertical plane $S_{XA(z_{be})} = S_{XM(-h_0)} = S_{XB(z_{be})} = 0$

Figure 7-3 Eigenmode of the traverse

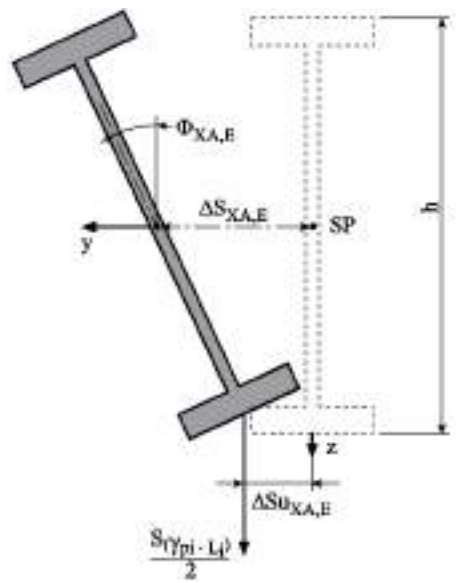
7.2.4 Assessment of drawings and manufacturing survey

7.2.4.1 Assessment of drawings

7.2.4.1.1 The general requirements given in [Sec.13](#) shall be observed.

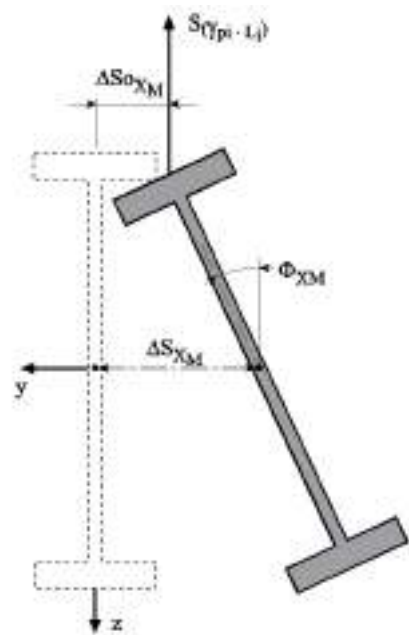
7.2.4.1.2 Regarding the documents to be submitted for design assessment, [\[2.1\]](#) shall be applied as and where relevant. In addition, the following documents shall be submitted:

- 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 load-handling devices
- additional documents as required.



Assumption: $\Delta S_{UXA,E} = \Delta S_{XA,E} - \Phi_{XA,E} \cdot 0.5 \cdot h = 0$

Figure 7-4 Eigenmode of the traverse



Assumption: $\Delta S_{UXA,E} = \Delta S_{OXM} = \Delta S_{XM} + \Phi_{XM} \cdot 0.5 \cdot h = 0$

Figure 7-5 Eigenmode of the traverse

7.2.4.2 Manufacturing survey

7.2.4.2.1 The general requirements given in [Sec.1](#) shall be observed.

7.2.4.2.2 The manufacturing survey and acceptance testing before delivery is required in principle.

7.2.4.2.3 For load-handling devices which are still accessible for comprehensive examination after completion, manufacturing survey may be dispensed with, subject to the consent of the Society's surveyor. Acceptance testing is required in every case, where appropriate together with the first load test.

7.2.4.2.4 The requirements to be met by the manufacturer are set out in [\[11.2\]](#).

7.2.5 Tests and examinations

7.2.5.1 Tests

7.2.5.1.1 Before being put into use, and after every major modification or repair to load-bearing parts, load-handling devices shall be subjected to a functional and load test in the presence of the Society's surveyor.

7.2.5.1.2 Regularly repeated load testing of load-handling devices is not prescribed internationally by ILO. It shall be noted, however, that various flag administrations do have regulations on this.

7.2.5.1.3 The static test loads given in [Table 7-2](#) are applicable to load-handling devices according to the definition in [\[1.1.5.32\]](#).

Table 7-2 Static test loads for load-handling devices

<i>Safe working loads (SWL) of load-handling devices</i>	<i>Static test loads¹ "L_{Pstat}"</i>
up to 10 t	2 × SWL
above 10 t up to 160 t	(1.04 × SWL) + 9.6 t
above 160 t	1.1 × SWL

¹if applicable to be multiplied with f_d according to [\[7.3.3.3\]](#)

7.2.5.2 Examinations

7.2.5.2.1 Before being put into use, after each load test, and after each modification or repair to load-bearing parts, all load-handling devices shall be subjected to a thorough examination by the Society's surveyor and, where necessary, a functional test in his presence.

7.2.5.2.2 In addition to the regulations according to [\[7.2.5.2.1\]](#), all load-handling devices shall be subjected to a visual examination by the Society's surveyor at least every 12 months, as well as a thorough examination every five (5) years and, where necessary, a functional test.

For due dates of examinations the provisions in [\[13.4.2\]](#) are applicable.

7.2.6 Documentation

For marking, see [\[7.4\]](#).

7.2.6.1 Certification

7.2.6.1.1 After each load test using the prescribed test load according to [Table 7-2](#), the Society's surveyor issues one of the two following certificates. Functional tests are not specially certified.

7.2.6.1.2 For a ship's load-handling device, a product certificate Form CG3 will be issued. For use on board more than one ship, additional copies may be issued.

7.2.6.1.3 For load-handling devices which cannot be allocated to a particular ship, a Society's product certificate will be issued.

For use on board, the Society's product certificate requires to be transcribed by the Society's surveyor into Form CG3, in order to warrant international acceptance. In addition, the load-handling device shall be stamped with the new certificate number.

7.2.6.2 Register book

7.2.6.2.1 As described in [\[13.7\]](#), the product certificates Form CG3 are added to the register book of lifting appliances carried on board.

Upon request by the operator, an individual register book for load-handling device can be issued for use on board more than one ship.

7.2.6.2.2 For all examinations according to [\[7.2.5.2\]](#), the Society's survey report will be compiled. In addition, the examinations are confirmed in the register book of lifting appliances.

7.2.6.2.3 The Society's product certificates will be handed out to the operator without a register book. The operator shall add these certificates and survey reports according to [\[7.2.6.2.4\]](#) to his own documentation.

7.2.6.2.4 The confirmation of examinations of load-handling devices, for which a Society's product certificate has been issued, is effected by the survey report.

7.3 Interchangeable components

7.3.1 General

7.3.1.1 Although not stated in [\[1.1.5.28\]](#), eye plates and bolt connections shall be treated as interchangeable components.

7.3.2 Design and construction

7.3.2.1 Block frames shall be designed in such a way that ropes cannot get caught between the sheave and the block cheeks.

7.3.2.2 Cargo hooks, shackles, swivels and rings shall be forged. Exceptions to this rule require the consent of the Society.

7.3.2.3 Grades of cast steel shall be selected according to recognised standards. The consent of the Society is required in every instance for other grades of cast steel.

7.3.2.4 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 shall be documented that a stress test has been conducted at the manufacturer under application of the minimum test loads, in accordance with DNV GL rules, including crack test.

7.3.2.5 The galvanizing of cold-formed components is permitted only if the suitability of the material for this purpose has been proved.

7.3.3 Interchangeable components conforming to recognized standards

7.3.3.1 Determination of the safe working load

The safe working load shall be determined without partial safety factors and hoist load coefficients, depending on the location of use:

- in the lifting appliance: according to [Sec.5](#), load combination I
- in the loose gear: according to [\[7.2.3.3\]](#), load combination I.

Where applicable, the safe working load, determined as above, shall be increased by additional multiplication with dynamic factor f_d according to [\[7.3.3.3\]](#).

7.3.3.2 For interchangeable components conforming to standards, a choice shall be made according to the indicated nominal sizes. The nominal sizes correspond to the safe working load according to [\[7.3.3.1\]](#).

7.3.3.3 In all cases where the hoist load coefficient ψ is greater than the value of ψ_{zul} , the permissible load, on which the choice of the nominal size is based, shall be increased by the following dynamic factor f_d :

$$f_d = \frac{\psi}{\psi_{zul}} \geq 1.0$$

ψ = hoist load coefficient according to [\[5.2\]](#)

ψ_{zul} = permissible hoist load coefficient according to [Table 7-3](#).

Table 7-3 Permissible hoist load coefficient ψ_{zul}

SWL	ψ_{zul}
up to 60 t	1.6
above 60 t to 160 t	$1.6 - \frac{SWL - 60t}{200t}$
above 160 t	1.1

7.3.4 Basic principles for proofs for interchangeable components not corresponding to a recognized standard

7.3.4.1 General

7.3.4.1.1 For the calculation and the dimensioning of interchangeable components the requirements given in [Sec.4](#) and [Sec.5](#) apply.

7.3.4.1.2 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 lifting appliance according to [\[5.5\]](#)
- using load combinations for the load-handling devices according to [\[7.2.3.3\]](#).

Additionally, the static test load L_{pstat} according to [Table 7-4](#) with a partial safety factor of $\gamma_{pi} = 1.10$ shall be observed for the determination of the load for dimensioning.

7.3.4.2 Proofs

7.3.4.2.1 General

Basis for the dimensioning is the applicable design load for dimensioning which shall be determined according to [\[7.3.4.1.2\]](#).

The calculation of non-standardized interchange-able components may be carried out using suitable calculation methods according to the provisions in [Sec.4](#).

A method to determine the strength of non-standardized eye plates is given in [\[7.3.4.3\]](#).

Proof of bolt connections may be provided according to [\[4.8.2\]](#).

7.3.4.2.2 Strength analyses and proofs of stability

For strength analyses generally the statements in [\[4.4\]](#) and [\[4.8\]](#) apply. They shall be conducted using the design load for dimensioning.

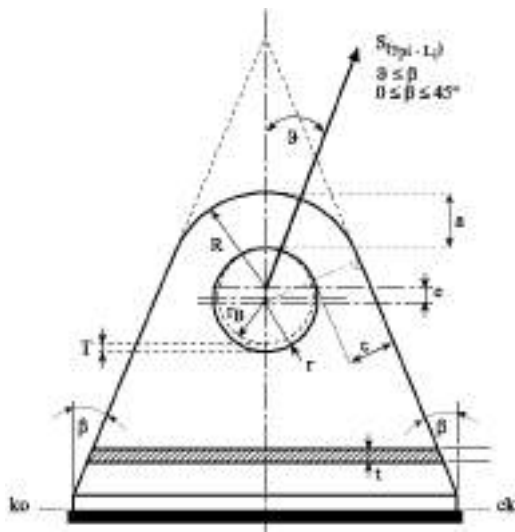
7.3.4.2.3 Proofs of fatigue strength

For the proofs of fatigue strength the statements in [\[4.6\]](#) apply. In general, they shall be conducted using the load combination I of [Table 5-4](#) or [Table 5-1](#) with the partial safety factor $\gamma_{pi} = 1.0$.

For interchangeable components with load cycles ≤ 20000 the proof of fatigue strength may be dispensed with.

7.3.4.3 Non-standardized eye plates

7.3.4.3.1 The determination of the design stress for eye plates which correspond to [Figure 7-6](#) and to the boundary conditions according to [\[7.3.4.3.2\]](#) may be performed using the following method, unless a more precise proof is provided.



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].

Figure 7-6 Eye plate

7.3.4.3.2 Boundary conditions

For the dimensioning, the following boundary conditions shall be adhered to:

- i) Radii ratio ρ of the eye:

$$2 \leq \frac{R}{r} \leq 3$$

- 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 shall be increased by 5%.

- iii) For moving bolt connections a wear of $\Delta T = 2$ mm shall be taken into consideration in the strength analysis.
- iv) Inclination angle of flanks: $0^\circ \leq \beta \leq 45^\circ$
- v) Angle of load application: $0^\circ \leq \vartheta \leq \beta$.

7.3.4.3.3 Determination of the stress for dimensioning and stress proof

The stress for dimensioning is calculated as follows:

$$\sigma_{d, \max} = \alpha \cdot \sigma_N$$

- α = form factor as per [7.3.4.3.5]
- σ_N = nominal stress as per [7.3.4.3.4].

It shall be proven that:

$$\sigma_{d, \max} \leq R_d$$

with

$$R_d = \frac{f_{y,k}}{1.0}$$

7.3.4.3.4 Nominal stress due to design load

The nominal stress due to design load without friction component is calculated as follows:

$$\sigma_{ns} = \frac{S_{(\gamma_{pi} \cdot L_i)}}{2 \cdot ct}$$

with

$$S_{(\gamma_{pi} \cdot L_i)} = \gamma_{pi} \cdot \psi \cdot SWL$$

(see also [Table 7-1](#))

SWL = safe working load on eye plate

$$c = R + e \sin \beta - r$$

The nominal stress component due to friction (friction coefficient μ) between bolt and bore is calculated as follows:

$$\sigma_{n,\mu} = \frac{8\mu}{\pi \left(1 + \frac{R}{r}\right)} \sigma_{n,S}$$

Consequently, the nominal stress due to the design load including friction component is calculated as follows:

$$\sigma_N = \sigma_{n,S} + \sigma_{n,\mu}$$

7.3.4.3.5 Determination of form factor

In general the form factor is calculated as follows:

$$\alpha = \sum_i \alpha_i = \alpha_p + \alpha_\beta + \alpha_\varepsilon + \alpha_\vartheta$$

with:

$$\alpha_p = \frac{3}{4}\rho + \frac{5}{2} \quad (\text{base value})$$

$$\alpha_\beta = -\left(\frac{1}{2} - \varepsilon\right)(4 - \rho)\sin\beta \quad (\text{components due to inclination of flanks})$$

$$\alpha_\varepsilon = -(3 - \rho)\varepsilon \quad (\text{components due to change of head height})$$

$$\alpha_\vartheta = \rho^{-1} \cos\beta \sin\vartheta \quad (\text{components due to angle of load application})$$

and: $\rho = \frac{R}{r}$ (radii ratio)

$$\varepsilon = \frac{2e}{R} \quad (\text{change of head height ratio}).$$

7.3.4.3.6 Connection to supporting structure

The connection to the supporting structure (see [Figure 7-6](#) cross section ko-ck) shall be proven separately in accordance with [Sec.4](#).

7.3.5 Assessment of drawings and manufacturing survey

7.3.5.1 Assessment of drawings

7.3.5.1.1 Assessment of drawings is not required for interchangeable components and eye plates which conform to recognized standards.

7.3.5.1.2 Details or drawings shall be submitted for interchangeable components or eye plates which are made of materials and/or to designs which do not conform to a recognized standard.

7.3.5.2 Manufacturing survey

The manufacturing survey is not required for interchangeable components and eye plates.

7.3.6 Tests and examinations

7.3.6.1 Tests

7.3.6.1.1 Interchangeable components

Product certification of interchangeable components requires the following tests:

- Each interchangeable component in the unpainted and, as far as possible, ungalvanized condition shall be subjected to a static load test, performed on a calibrated and approved testing machine using the test loads given in [Table 7-4](#).
- Destructive testing of product samples may be required as deemed necessary by the Society's surveyor.

Guidance note:

For example, destructive testing of product samples may be required if interchangeable components are subject to heat treatment.

The requirement for destructive testing may be independent from the interchangeable component conforming to a recognized standard or not.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

After modifications or repairs to interchangeable components, a static load test according to a) shall be repeated for the single interchangeable component disconnected from its designated shipboard lifting appliance. A repeated dynamic load test according to [\[13.3.3\]](#) is not required.

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 load-handling device to which they are fastened.

7.3.6.1.2 Eye plates

Eye plates which are integral parts of lifting appliances and load-handling devices are included in the load tests of them.

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 assessment of drawings.

Load tests with agreed static test loads may be conducted on request of the ship's owner.

Table 7-4 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 25.0 t over 25.0 t	2 × SWL (1.22 × SWL) + 20 t
2	single-sheaved blocks with and without becket	all	2 × SWL
3	multi-sheaved blocks	up to 25.0 t over 25.0 t up to 160.0 t over 160.0 t	2 × SWL (0.933 × SWL) + 27 t 1.1 × 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 [\[7.3.3.3\]](#).

7.3.6.2 Examinations

7.3.6.2.1 Interchangeable components

The manufacturer and dealer shall present all interchangeable components to the Society's surveyor, in an unpainted and, if possible, ungalvanized condition, for examination of the dimensions and workmanship, together with the certificates covering the materials used.

After the static load test, each component is thoroughly examined by the Society's surveyor, and shall, if the surveyor considers it necessary, be taken apart for closer scrutiny.

After start of operation, every interchangeable component shall be subjected to an examination by the Society's surveyor at least every 12 months, as well as to a thorough examination every five (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.

7.3.6.2.2 Eye plates

Eye plates, which are integral parts of lifting appliances and load-handling devices, are examined together with them.

Eye plates according to [7.3.6.1.2], including their joints, are examined before their first employment, after every load test and at agreed intervals.

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.

7.3.7 Documentation

7.3.7.1 Interchangeable components

For marking, see [7.4].

7.3.7.1.1 Certificates

The Society's 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 (extra high strength/low temperature), the size of the test load and the permissible load.

The Society's Form CG3 is used for shipboard lifting appliances gear or interchangeable components and the Society's product certificate for all others.

For the transcription of the Society's product certificate into Form CG3 for use on board, the requirements given in [7.2.6.1.3] apply as and where relevant.

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 shall 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.

Where interchangeable components are manufactured according to approved drawings, the certificates also indicate the relevant drawing, together with the date and the Society's reference number of the approval.

7.3.7.1.2 Register book

In accordance with the requirements given in [13.7], the product certificates Form CG3 are added to the register book of lifting appliances on board.

Interchangeable components which are integral parts of lifting appliances or load-handling devices are examined together with them.

For the devices survey reports are compiled and the examinations are confirmed in the register book of lifting appliances.

For interchangeable components which are certified by the Society's product certificate, the requirements given in [7.2.6.2.3] and [7.2.6.2.4] apply as and where relevant.

7.3.7.2 Eye plates

7.3.7.2.1 Eye plates in accordance with [7.3.6.1.2] are included in the documentation of the devices stated there.

7.3.7.2.2 The tests and examinations of eye plates in accordance with [7.3.6.1.2] are confirmed by survey reports.


7.4 Marking of load-handling devices and interchangeable components

7.4.1 Manufacturer's plate

Load-handling devices according to [1.1.5.32] shall be fitted with a manufacturer's plate, which shall include at least the following information, if applicable:

- manufacturer's name
- type of load-handling device
- serial number
- year of construction
- characteristics, where applicable, such as e.g. nominal pressure, nominal voltage, filling volume, etc.
- safe working load(s)
- dead load
- with lifting beams, traverses and spreaders: a symbol for the inclination angle of the allocated suspension ropes or chains.

Table 7-5 Examples of stamping and marking

Documentation		Load-handling devices	Interchangeable components
Stamping	Certificate Form: The Society's product certificate	Acceptance testing	L 6743 H 02  15 SWL 15 t rope 5 t (single-sheaved block with becket)
	Certificate Form: CG3 or the Society's product certificate	Load test	
Marking	Rigging plans		---
Abbreviations:		Safe working load: SWL Weight: WT	Permissible load: SWL

With interchangeable components made of special materials, the stamp is extended with the following letters, if applicable:

- H for extra 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.

7.4.2.3.2 Stamp location

The stamp shall 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 Society's stamp
- suspension ropes and slings:
 - to a permanently fastened small metal plate
- chains:
 - to the last link at each end.

7.4.2.3.3 Special features

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.

For the galvanization of forged interchangeable components, the requirements given in [7.3.2.4] apply. The stamp shall still be recognizable after galvanization, or where required, it shall be re-stamped.

The stamp height shall be at least 6 mm, or 4 mm for small parts.

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 [7.4.2.3.1].
- components with a SWL between 0.25 t and 1.0 t:
These only receive the Society's stamp, and where required, also the permissible load.
- components with a SWL of less than 0.25 t:
These only receive the Society's stamp, and where required, the stamp shall be waived.

7.4.3 Marking of load-handling devices

7.4.3.1 Load-handling devices shall be permanently marked in a prominent position on both sides in the manner described in [7.4.3.2] and [7.4.3.3].

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.

7.4.3.2 Lifting beams, traverses and spreaders shall be marked as follows:

- safe working load "SWL" in t or kg
- dead load "WT" in t or kg (mandatory, if over 100 kg)
- special types of fastening or loading.

7.4.3.3 Grabs and lifting magnets shall be marked as follows:

- safe working load "SWL" in t or kg
- dead load "WT" in t or kg
- capacity in m³ for grabs.

7.5 Wear, damage, repair

7.5.1 Load-handling devices

7.5.1.1 With respect to tolerable reduction in the plate thickness due to rusting or wear, the requirements given in [13.6.2] apply.

7.5.1.2 With respect to a reduction in the safe working load of load-handling devices covered by [1.1.5.32], as an alternative to removal from service in the event of damage, inadmissible wear or other causes, the requirements given in [13.6.9] apply.



7.5.2 Interchangeable components

7.5.2.1 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%.

7.5.2.2 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 load-handling devices.

The Society reserves the right to approve such repairs in special cases. Then the following shall be observed:

7.5.2.2.1 After repair of forged interchangeable components, evidence shall be provided that heat treatment has been carried out.

7.5.2.2.2 After repair of interchangeable components, a load test in accordance with [7.3.6.1.1] is required.

7.5.2.2.3 Renewal of axles, bolts and rope-sheaves in general does not require rerunning of the load tests.

SECTION 8 ROPES AND ROPE ACCESSORIES

8.1 General

8.1.1 Scope

8.1.1.1 The following requirements apply to wire ropes and synthetic fibre ropes used as running and standing rigging for shipboard lifting appliances and load-handling devices.

8.1.2 Certification requirements

8.1.2.1 CG4 certificates will be issued by a DNV GL surveyor based on individual tests and examinations as laid down in [8.5.1].

8.1.2.2

LA4 certificates will be issued by wire rope manufacturer/fitter based on DNVGL manufacture survey arrangement (MSA).

8.2 Wire ropes

8.2.1 General requirements

8.2.1.1 Wire ropes shall conform to recognized standards, such as e.g. EN 12385.

8.2.1.2 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.

8.2.1.3 Galvanized wire ropes with diameters of less than 8 mm are not permitted for shipboard lifting appliances and loose gear exposed to the weather.

8.2.1.4 Free rope ends shall be seized, tapered or socketed to prevent fraying of the rope ends or to prevent changes in the lay lengths of the rope and strands.

8.2.1.5 Special rope designs, Lang lay ropes, ropes with a nominal tensile strength of more than 1960 N/mm², and ropes of austenitic or stainless materials may, on application, be approved, provided that they are suitable for the proposed use.

8.2.1.6 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:

$$W = \text{Cr} [\%] + 3.3 \cdot \text{Mo} [\%] \geq 29$$

8.2.1.7 Ropes with a nominal diameter exceeding 5 mm shall at least consist of 100 single wires, running rigging shall at least have six (6) strands.

8.2.2 Definitions

8.2.2.1 "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.

8.2.2.2 "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.

8.2.2.3 "Rope slings" refer to ropes forming an integral part of lifting appliances or load-handling devices, which are used to attach loads.

8.2.2.4 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.

8.2.2.5 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 .

8.2.2.6 The actual breaking load F_{wi} of a rope is the load determined by a tensile test to destruction of the complete rope.

8.2.2.7 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 .

8.2.2.8 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.

8.2.2.9 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.

8.2.3 Dimensioning

8.2.3.1 The breaking load F_{Br} of wire ropes for lifting appliances 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

8.2.3.2 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:

8.2.3.2.1 For the partial safety factors, $\gamma_{pi} = 1.0$ may be applied.

8.2.3.2.2 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 shall be performed with smaller frictional coefficients, special proof of these shall be provided.

8.2.3.2.3 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 a vessel, result in an increase in the hoisting rope force. They can, however, within the scope of this standard, be ignored when dimensioning hoisting ropes or rope slings.

8.2.3.2.4 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.

8.2.3.2.5 For shipboard lifting appliances and load-handling devices, where an increased hoist load coefficient ($> \psi_{zul,S}$) shall be applied, the rope tension F_S shall be multiplied by the dynamic factor $f_{d,S}$. For $\psi_{zul,S}$ and $f_{d,S}$ see [8.2.3.2.6] and Table 8-1. This applies in particular to lifting appliances which will be dimensioned only for sea operation (see [5.4.3.2]) or for lifting appliances in grab operation.

8.2.3.2.6 The factor for consideration of an increased dynamic to be used for calculation of the rope tension shall be determined as follows:

$$f_{d,S} = \frac{\psi}{\psi_{zul,S}}$$

ψ = hoist load coefficient according to [5.4]

$\psi_{zul,S}$ = permissible hoist load coefficient according to Table 8-1.

Table 8-1 Permissible hoist load coefficient $\psi_{zul,S}$

SWL	$\psi_{zul,S}$
up to 10 t	1.6
over 10 t up to 160 t	$1.6 - \frac{SWL}{1600t}$
over 160 t	1.5

8.2.3.2.7 Where the efficiency of rope end joints is below 80%, the loss of breaking force shall be compensated up to 80%.

8.2.3.2.8 Wire ropes for multi-rope grabs shall be dimensioned, in addition to the dead weight of the grab, for the following loads:

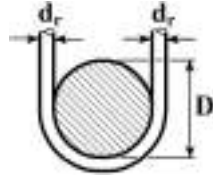
- closing rope, double lever control: SWL
- closing rope, single lever control: 2/3 SWL
- holding cable: 2/3 SWL.

Table 8-2 Safety factors for wire ropes

<i>Safety factors γ_{D1}¹</i>	
<i>Safe working load (SWL) of lifting appliances and loose gear²</i>	<i>Running rigging</i>
up to 10 t	5
over 10 t up to 160 t	$\frac{10^4 \text{ t}}{(8.85 \times \text{SWL}) + 19101}$
over 160 t	3
<i>Safety factors γ_{D2}¹</i>	
<i>Safe working load (SWL) of lifting appliances and loose gear²</i>	<i>Standing rigging</i>
up to 10 t	4
over 10 t up to 160 t	$\frac{10^4 \text{ t}}{(5.56 \times \text{SWL}) + 24441}$
over 160 t	3
<i>Safety factors γ_{D3}¹</i>	
<i>Weight of load</i>	<i>Rope slings³</i>
up to 10 t	6
over 10 t up to 160 t	$\frac{1.2 \cdot 10^4 \text{ t}}{(8.85 \times \text{SWL}) + 19101}$
over 160 t	3.6
<p>1) If applicable, to be multiplied with $f_{d,S}$ (see [8.2.3.2.5]).</p> <p>2) For lifting platforms, ramps and car decks the following loads shall be applied:</p> <ul style="list-style-type: none"> – operation without working load: moved dead loads – operation with working load: moved dead loads + safe working load (SWL). <p>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.</p>	

8.2.3.3 Reduction in breaking load of the rope

Where wire ropes are wound around design elements with a small diameter (e.g. shackle bolts, crane hooks, load connecting elements, etc.), the permissible breaking load shall be reduced.



D = diameter of the slung part

d_r = rope diameter.

The breaking load of the wire rope shall be reduced for the following range of diameters:

$$1 \leq D/d_r \leq 9$$

($D/d_r < 1$ is not permissible).

The reduced breaking load shall be determined according to the following formula:

$$F_{Br, redu} = \left[1 - \frac{\left(\frac{D}{d_r} - 9 \right)^2}{128} \right] \cdot F_{Br}$$

$F_{Br, redu}$ = reduced breaking load

F_{Br} = breaking load of the non-deformed rope (no rope bending).

Within spliced sections, the rope shall not be slung with small radii.

Alternative provisions for the dimensioning of wire ropes for ramps and car decks can be found in [\[6.3.4.1\]](#).

8.2.4 Requirements for rope drives

8.2.4.1 Interaction between ropes and rope drums

8.2.4.1.1 In determining the necessary length of wire ropes, and the length of drum, it shall be borne in mind that at least three (3) safety turns shall remain on the drum at all times.

The requirement for three (3) safety turns also applies to luffing ropes with respect to the stowing position of the crane boom.

8.2.4.1.2 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 three (3) layers of rope may be wound on top of each other.

Where the number of layers exceeds three (3), a special coiling device, or other system or equipment, shall be provided.

8.2.4.1.3 Uncut rope drums may only be used with the consent of the Society.

8.2.4.1.4 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.

8.2.4.1.5 Design requirements for rope drums are described in [9.5.2].

8.2.4.1.6 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.

8.2.4.1.7 The first rope layer shall be tension loaded.

8.2.4.1.8 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.

8.2.4.2 Rope-sheaves

8.2.4.2.1 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.

8.2.4.2.2 If rope sheaves made of metallic material are not manufactured according to a recognized international standard (e.g. DIN 15063), case by case design approvals or type approvals are required and material requirements according to Sec.3 apply.

8.2.4.2.3 Where plastic rope-sheaves are used, they shall 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 shall be produced from steel. Alternatively, defined criteria for scrapping or usage periods may be approved.

8.2.4.2.4 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°.

8.2.4.3 Pitch diameter of sheaves and rope drums

The required rope sheave and rope drum pitch diameters relative to rope diameter "d_r" shall be as shown in Table 8-3.

For all other types of wire ropes the ratio shall be agreed with the Society in each individual case.

Table 8-3 Minimum pitch diameter ¹ of rope sheaves and rope drums for standardized wire ropes

Application/ crane group ²	Minimum pitch diameter for rope sheaves ³	Minimum pitch diameter for rope drums ³		Nominal tensile strength of wire ropes ⁴
		Ungrooved drums	Grooved drums	
Wire ropes not operated under load	10 d _r	11 d _r	10 d _r	1770 N/mm ²
A	19 d _r	21 d _r	17 d _r	1960 N/mm ²
B	21 d _r	not permitted	19 d _r	1960 N/mm ²
C1	23 d _r	not permitted	21 d _r	1960 N/mm ²
C2 + C3	26 d _r	not permitted	23 d _r	1960 N/mm ²

1) The pitch diameter is the sum of the nominal diameter of a sheave or drum and the nominal wire rope diameter. In case of rope sheaves and machined drums the nominal diameter is measured in the bottom of the groove.
 2) For crane group definition, see [5.2].
 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 shall be increased proportionally.

8.2.4.4 Lateral deflection angle of the rope

8.2.4.4.1 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°).

8.2.4.4.2 In the case of poorly-rotating ropes, the lateral deflection angle shall not be greater than 1:28 (2°).

8.2.4.4.3 Exceptions to the above requirements are made for unwinding hoist ropes. Special wear-reducing design measures shall be taken for lifting appliances at sea frequently.

8.2.4.5 Employment of swivels

Non-rotation-resistant ropes shall not be used with a swivel.

For rotation-resistant ropes the use of a swivel is recommended.

8.3 Synthetic fibre ropes

8.3.1 General requirements

8.3.1.1 Synthetic fibre ropes shall comply with recognized standards (e.g. DNVGL-OS-E303).

8.3.1.2 Synthetic fibre ropes except carbon fibre ropes may be used for "standing rigging" and for "running rigging" of special lifting appliances which is stressed moderately subject to agreement with the Society.

Synthetic fibre ropes may also be used for the cargo tackles of landing booms according to [6.6.3], with the exception of carbon fibre ropes. The agreement of the Society is required for other applications.

8.3.1.3 Synthetic fibre ropes shall be stabilized with respect to light and heat.

8.3.1.4 Free rope ends shall be yarn-wound to prevent disintegration of the rope structure. Synthetic fibre ropes may be partially melted.

8.3.2 Definitions

8.3.2.1 The terms "running rigging", "standing rigging" and "rope sling" as well as the term "actual breaking load" F_{wi} , are defined in [8.2.2].

8.3.2.2 The "proven breaking load" F_n of a synthetic fibre rope is the load calculated from the breaking load of the yarns contained in the rope multiplied by a reduction factor or that load determined by testing in accordance with the requirements of [DNVGL-OS-E303](#).

8.3.2.3 The "reduction factor" is an empirical value which takes account of the loss of strength due to stranding.

The reduction factors shall be taken from recognized standards.

8.3.3 Dimensioning

In the case of synthetic fibre ropes used for lifting appliances or load-handling devices, 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 [8.2.3.1]

F_S = rope tension according to [8.2.3.2].

Table 8-4 Safety factors for standardized synthetic fibre ropes

<i>Nominal diameter of rope [mm]</i>	<i>Coefficient of utilization γ_F</i>
10 – 13	12
14 – 17	10
18 – 23	8
24 – 39	7
40 and over	6

For non-standardized synthetic fibre ropes γ_F shall be agreed with the Society.

Synthetic fibre ropes shall be dimensioned with respect to their 3-T endurance and shall comply with [DNVGL-OS-E303](#).

Synthetic fibre ropes shall be operated according to their designated service. The designated service for synthetic fibre ropes shall assure that adequate margins are maintained towards exceeding the 3-T endurance and other relevant failure modes. [DNVGL-ST-E407](#) can be taken as guidance.

The 3-T endurance and other aspect of dimensioning of synthetic fibre ropes are outlined in [DNVGL-RP-E305](#).

8.3.4 Requirements for rope drives

8.3.4.1 Synthetic fibre ropes shall not be used on capstan heads or other devices, where a major slippage may occur.

8.3.4.2 Synthetic fibre ropes shall only be wound up in one layer. Winding shall be performed under tension.

8.3.4.3 The required rope sheave diameters relative to the nominal rope diameter " d_r " shall be as shown in Table 8-5.

For non-standardized synthetic fibre ropes the rope sheave pitch diameter shall be agreed with the Society.

Table 8-5 Minimum pitch diameter ¹ of rope sheaves for standardized synthetic fibre ropes

<i>Rope material</i>	<i>Minimum pitch diameter for rope sheaves</i>
polypropylene	4 d_r
polyamide	6 d_r
polyester	6 d_r

1) The pitch diameter is the sum of the nominal diameter of the sheave and the nominal rope diameter. The nominal diameter of a sheave is measured in the bottom of the groove.

8.3.4.4 The required diameters of rope drums shall be agreed with the Society in each case.

8.3.4.5 The lateral deflection of synthetic fibre ropes relative to the plane of the groove of rope sheaves or rope drums shall not be greater than 1:14 (4°).

8.3.4.6 The number of safety turns remaining on rope drums shall be as specified by the manufacturer of the winch, but not less than:

- five (5) safety turns in general
- three (3) safety turns, if the rope is connected positive locking with the rope drum.

8.4 Rope-end attachments

Rope-end attachments shall be designed in accordance with recognized standards, e.g. the following.

8.4.1 Splices for wire ropes and synthetic fibre ropes

8.4.1.1 Wire ropes and synthetic fibre ropes shall not be made up of parts spliced together.

8.4.1.2 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 DIN 6899 (*Steel thimbles for fibre ropes*), as appropriate.

8.4.1.3 Provided that [8.2.4.1.1] and [8.3.4.6] are met, rope ends connected to winches may be spliced without thimbles, see [9.5.2.6].

8.4.1.4 Splices of any kind are not permitted for cranes of types B and C, because of their inadequate fatigue strength.

8.4.1.5 Splices shall not be sheathed.

8.4.2 End attachments for wire ropes

8.4.2.1 Rope sockets

8.4.2.1.1 Rope sockets (open and closed sockets), into which wire rope ends shall be socketed, shall conform to standard EN 13411. On application, other designs may be approved.

8.4.2.1.2 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 by national accredited certification bodies.

Only approved cast materials may be used. Rope sockets shall be marked with the code letter of the manufacturing company.

8.4.2.2 Wrought ferrules

8.4.2.2.1 Wrought aluminium alloy ferrules shall conform to EN 13411-3.

Flemish eyes as per DIN 3095 shall be used wherever possible for the end attachments of the hoisting and luffing ropes of lifting appliances, if the lifting appliances are working with grabs.

8.4.2.2.2 On application, swaged or rolled end fittings (terminals) may be approved.

8.4.2.2.3 Application of ferrules in accordance with [8.4.2.2.1] and [8.4.2.2.2] may only be carried out by approved companies. Ferrules shall be marked with the code letter of the manufacturing company.

8.4.2.3 Detachable end joints

8.4.2.3.1 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.

8.4.2.3.2 Rope sockets as per EN 13411-5 are not permitted. This does not apply to the securing of free rope ends to cable joints.

8.4.2.3.3 With regard to the attachment of rope ends to winch drums, the requirements given in [9.5.2.6] and [9.5.2.7] apply.

8.5 Tests and examinations

8.5.1 Manufacturing survey

8.5.1.1 Wire rope and synthetic fibre ropes

8.5.1.1.1 General

With regard to testing and examination of ropes, the requirements given in the DNV GL rules as stated in [8.1.2.1] apply.

Instructions for the testing and use of ropes, and an excerpt from the Society's rules for wire ropes and synthetic fibre ropes, shall be found on the reverse sides of the Society's certificates CG4 and LA4.

8.5.1.1.2 Tensile tests

After manufacturing, ropes shall be subjected to a tensile test, which is mandatory for the issue of the Society's certificate. The following applies:

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.

From every manufactured length of a wire rope up to 10 000 m a test sample shall be tensile tested in its entirety to destruction. The test length shall be equal to 30 times the diameter of the rope, subject to a minimum of 600 mm. The minimum breaking load shall achieve the value specified for the rope in question in the standard. In the case of manufactured lengths of more than 10 000 m, a second test sample shall be taken and tested.

Where the tensile loading capacity of the testing machine is insufficient to test the wire rope in its entirety, the breaking load of the rope shall be determined from the results of tests performed on the individual wires. For this purpose a strand shall be taken from every manufactured length of rope of 5000 m or less, and its constituent wires shall be individually subjected to a tensile test, e.g. to EN 12385. The wire test specimens shall have an initial measured length of 100 mm or 200 mm. The nominal tensile strength shall be determined on the basis of the nominal wire diameter.

The test shall be deemed successful if:

- the calculated breaking load achieves the values specified in the relevant standard and
- at least 95 % of the rope wires meet the requirements stated in [3.10.2.2].

For this purpose, the individual test values shall be applied to the total number of wires in the rope and multiplied by the realization factor shown in Table 8-6.

Table 8-6 Realization factors

<i>Rope construction</i>	<i>Ropes with fibre core</i>	<i>Ropes with steel core</i>
6 x 7	0.9000	0.8379
6 x 19	0.8600	0.8007
6 x 24	0.8700	--
6 x 36	0.8400	0.7821
6 x 37	0.8250	0.7681

The results of the tensile tests of the ropes shall achieve the values prescribed in the relevant rope standards.

Tensile tests of ropes shall be performed in the presence of the Society's surveyor, if:

- the manufacturer is not approved by the Society to test and issue certificates on his own authority
- special rope designs are not covered by the Society's approval
- the customer requests it.

Before each tensile test, the protocols on the checks performed by the manufacturer shall be presented to the Society's surveyor.

Following every tensile test, checking the diameter tolerances, method of manufacture and manufacturers' protocols, the Society's surveyor will issue a certificate of test and thorough examination of wire rope or synthetic fibre rope using one of the forms stated in [8.6.2.1].

8.5.1.1.3 Dimensional check of wire ropes

The diameter of each wire rope shall be measured at two points located at least 1 m apart in two directions approximately perpendicular to each other. The difference between the smallest and the largest result may not be more than 4%.

The average value of the four measurements shall be considered to be the actual rope diameter and shall lie within the permitted tolerances. The number and diameter of the individual wires shall also be verified.

Marking

8.5.1.1.4 Ropes shall be marked by woven-in identification bands and coloured identification threads. The following shall be taken into account:

The identification band shall carry the name or mark of the manufacturer, and in the case of the Society's approval, in addition the manufacturer's identification number, assigned by the Society.

The colour of the identification thread gives information about the nominal tensile strength of wires or the type of yarn used (identification colour).

For steel wire ropes the colour of the identification threads shall be as follows:

- nominal tensile strength 1570 N/mm² - white
- nominal tensile strength 1770 N/mm² - green
- nominal tensile strength 1960 N/mm² - yellow

The coloured identification thread may be dispensed with, if the identification band itself carries the identification colour.

8.5.1.2 End attachments

8.5.1.2.1 End attachments which are not standardized, or do not correspond to standards, are subject to an assessment of drawings.

8.5.1.2.2 With regard to tests and examinations of rope sockets, cable joints and terminals, the requirements given in [7.3.5] apply. For terminals, it may be required to produce specimens connected to a small length of rope.

8.5.1.2.3 In the case of short, ready-made units, the rope sockets and terminals can be load-tested together with the rope.

8.5.2 Initial testing

Ropes and their end attachments are subject to a visual inspection and a check of the relevant certificates within the scope of the initial testing of lifting appliances.

8.5.3 Periodic testing

8.5.3.1 Wire ropes and synthetic fibre ropes

8.5.3.1.1 In the scope of the periodic testing of lifting appliances and load-handling devices, the ropes shall be examined by the Society's surveyor with regard to condition and fitness for use.

8.5.3.1.2 When ropes are examined, attention shall be paid to deformation, crushing, corrosion/rottenness and broken wires. If necessary the ropes shall be twisted open for an internal examination.

8.5.3.1.3 Special attention shall be paid to the end attachments. There, broken wires or yarns shall be expected, with wire ropes also corrosion, especially with downward hanging end attachments. Sheathings shall be removed for examination.

8.5.3.1.4 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.

8.5.3.1.5 Where splices have become loose, the ropes shall be shortened and spliced again or, where required, replaced.

8.5.3.2 End attachments

With regard to end attachments, the requirements given in [8.5.3.1.1] apply. Attention shall be paid to wear, cracks and corrosion.

8.5.3.3 Discard criteria for wire ropes

8.5.3.3.1 Generally, discard criteria according to ISO 4309 shall apply.

8.5.3.3.2 Wire ropes which are regularly employed under water shall be shortened in the vicinity of the fixed load-lifting attachment (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 (initial) actual breaking load, the rope shall be discarded. If the remaining breaking load is 80% or above the (initial) actual breaking load, an estimate shall be made, based on the condition and the period of employment, whether the rope may be employed for another year.

8.5.3.3.3 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.


8.6 Documentation

8.6.1 Marking

8.6.1.1 Wire ropes and synthetic fibre ropes

8.6.1.1.1 Ropes are marked by the method described in [8.5.1.1.3].

8.6.1.1.2 With regard to ropes, the rope tension " F_s ", calculated according to [8.2.3.2], shall not be less than the permissible load SWL, stamped on the end attachments.



8.6.1.1.3 With regard to ropes with splices, a small metal plate, stamped in accordance with [7.4.2.3] shall be fastened near an end attachment.

8.6.1.2 End attachments

End attachments for wire ropes are stamped like interchangeable components, see [7.4.2.3]. Where applicable, this is also possible on ferrules or terminals, taking account of [8.4.2.3.3].

8.6.2 Certificates

8.6.2.1 Wire ropes

After the tension test in cases described in [8.5.1.1.2], the Society's surveyor will issue the following Society's product certificate:

- Form CG4.

Wire rope manufacturers approved by the Society will issue the following product certificate:

- Form LA4.

8.6.2.2 End attachments

With regard to certification of end attachments, the requirements given in [7.3.6.1.1] apply.

8.6.3 Storage of rope certificates

As described in [13.7], product certificates for ropes and product certificates for end attachments will be added initially and after each re-issue to an allocated register book on board.

8.6.4 Confirmation of examinations

8.6.4.1 Ropes and end attachments which are integral parts of lifting appliances or load-handling devices, will be included in the annual thorough examination of them.

8.6.4.2 The confirmation of examinations of ropes and end attachments which cannot be allocated to particular lifting appliances or load-handling devices, will be effected by a survey report Form 40.9a for these parts.

SECTION 9 MECHANICAL PARTS

9.1 General

9.1.1 General

9.1.1.1 This section contains requirements for the mechanical parts of shipboard lifting appliances and, where required, also load-handling devices.

9.1.1.2 Complementary or more comprehensive requirements, in particular for mechanical parts not covered hereafter shall be taken from the following rules:

- DNV GL rules
- recognized standards and requirements, where applicable to lifting appliances, unless contrary to the provisions in this section.

9.1.1.3 The requirements given in [Sec.1](#) shall be observed, if applicable.

9.1.1.4 The provisions in [Sec.3](#), [Sec.11](#) and [Sec.12](#) apply to the materials, the manufacture and the safety requirements of mechanical parts.

9.1.2 Scope of application

9.1.2.1 [Table 2-1](#) to [Table 2-3](#) indicate the essential mechanical parts which are subject to assessment of drawings as deemed necessary by the Society, and which shall be delivered in the designated manner, together with test reports or inspection certificates.

9.1.2.2 The requirement for an assessment 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 lifting appliances.

9.1.2.3 [Table 2-1](#) to [Table 2-3](#) reflect the general requirements given by the Society. The Society reserves the right to impose additional requirements or to permit deviations.

9.1.2.4 The Society 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.

9.2 Design criteria and operational requirements

9.2.1 General

9.2.1.1 Mechanical parts of shipboard lifting appliances and load-handling devices shall be designed for the environmental conditions agreed on or prescribed, and be capable of being operated without problem under these conditions.

9.2.1.2 The effects of deformation of the supporting structure on machinery and equipment shall be observed.

9.2.1.3 Mechanical parts shall be designed in such a way that repairs and regular maintenance are easy to perform using on-board tools.

9.2.2 Dimensioning

9.2.2.1 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 shall 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.

Proof of fatigue strength may be provided in accordance with the section I of F.E.M.

9.2.2.2 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.

9.2.2.3 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 [\[9.2.3.1\]](#).

9.2.3 Effects of vibration

9.2.3.1 Machinery and equipment shall not cause any vibrations and shocks which may unduly stress other components, or the structure of the lifting appliance and load-handling device. The permissible amplitudes and accelerations are stated in the [DNVGL-RU-SHIP Pt.4 Ch.2](#).

9.2.3.2 If compliance with the permissible values of amplitude and acceleration cannot be ensured by structural measures, damping measures are required.

9.2.3.3 Within the frequency ranges which occur, there shall be no resonance phenomena in components, support- and suspension arrangements - nor within equipment.

9.2.4 Lubrication

9.2.4.1 Lubrication of the moving parts of lifting appliances and load-handling devices shall be guaranteed under all operating conditions.

9.2.4.2 Each grease-lubricated bearing shall be provided with its own proven type of grease nipple.

9.2.4.3 Accessibility to manual greasing points shall be ensured.

9.2.5 Corrosion protection

Components at risk of corrosion shall be given suitable corrosion protection.

9.3 Power drives

The requirements given in [9.2] shall be observed. In addition, the following applies:

9.3.1 Drives in general

9.3.1.1 Power drives shall be adequately dimensioned for the working conditions laid down, to allow trouble-free and low-vibration operation.

9.3.1.2 For electrical drives and electrical controls in general, the requirements given in Sec.10 are applicable.

9.3.2 Main drives

9.3.2.1 Main drives of shipboard lifting appliances shall be dimensioned in such a way that the installed power meets the requirements given in [9.3.1.1] 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.

9.3.2.2 Diesel engines shall not be capable of running at excessive speeds or being stalled.

9.4 Slewing gears and slew rings

9.4.1 Slewing gears

9.4.1.1 Slewing gears shall be designed for maximum operating torque and, where the gears are of a self-locking type, they shall be equipped with a slewing gear brake.

9.4.1.2 Slewing gears on board ships shall 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.

9.4.1.3 In the case of slewing gears on board ships, it shall 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.

9.4.1.4 Slewing gears of shipboard cranes working at sea state shall 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 two (2) independent drives.

9.4.2 Slew rings

9.4.2.1 Large roller bearings

9.4.2.1.1 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.

9.4.2.1.2 The connecting flanges on the lifting appliance 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 the Society's approval in each individual case, see [5.7.4.1.2].

9.4.2.1.3 Large roller bearings shall be designed in such a way that a failure of important runway elements does not result in a total loss of the lifting appliance.

9.4.2.1.4 If large roller bearings have to be dismantled during employment for an internal examination, special dismantling equipment shall be available which can hold the lifting appliance and raise it after the connecting bolts have been unscrewed.

As an alternative, the lifting appliance shall have special eyebolts for lifting by another appliance, and a safe place for setting-down.

9.4.2.1.5 Where an interchange of seals is intended, large roller bearings shall be designed such that this is enabled without dismantling of the bearings or loosening of the connecting bolts.

9.4.2.1.6 With respect to the materials to be used, as well as their heat treatment and proof of mechanical properties, the requirements given in [13.4] apply.

9.4.2.2 Bolting of large roller bearings

In addition to [5.7.4.1] the following applies:

9.4.2.2.1 The fixed ring at the foundation or at the crane column shall be bolted at even intervals around its circumference.

9.4.2.2.2 For bolting of the rotating ring to the lifting appliance, uneven bolt intervals may be applied if the safety of such bolting is verified by calculation or measurement.

9.4.2.2.3 The distance between the bolts shall in general not exceed six (6) times the bolt diameter.

9.4.2.2.4 The requirements for the bolts are as follows:

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. With respect to the materials to be used for the bolts as well as the proof of their mechanical properties.

9.4.2.3 King pins and support rolls

9.4.2.3.1 If not safe by design, lifting appliances shall be secured against overturning by king pins and support rolls, also with rolls which engage from below where required.

9.4.2.3.2 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 lifting appliance shall still be capable of being turned into a secure position.

9.5 Winches

9.5.1 Design

9.5.1.1 Winches shall be of a reversible type, i.e. the lowering process shall also be motor-controlled.

9.5.1.2 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.).

9.5.1.3 The use of belts or friction discs to transmit power between the winch drum and the reverse travel prevention device referred to in [9.5.1.2] is not allowed.

9.5.2 Rope drums

9.5.2.1 The drum diameter shall be determined in accordance with the intended purpose of the winch, in accordance with [8.2.4.3] or a recognized standard.

9.5.2.2 The calculated hoop stress of winch drums σ_h shall not exceed 85% of the material yield stress.

9.5.2.3 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 shall be ensured that ropes can wind onto drums properly and without excessive deviation.

9.5.2.4 The number of safety-turns left on the rope drum shall not be less than three (3).

9.5.2.5 Rope grooves shall comply with the following requirements:

- groove diameter: $\geq 1.05 \cdot$ rope diameter d_s
- groove depth: $\geq 0.33 \cdot$ rope diameter d_s .

9.5.2.6 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 $\leq 1.5^\circ$
- cable guides
- lebus grooving.

9.5.2.7 Rope-end attachments at the winch drum shall 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 three (3) clamping plates shall be used.

The construction of end attachments for synthetic fibre ropes shall be agreed with the Society.

For nominal loads up to 12 t and lifting appliances which are only occasionally loaded, spliced rope loops can also be used.

9.5.2.8 The following conditions shall be met for the minimum required rope tension force "F_a" at the drum:

9.5.2.8.1 Shipboard lifting appliances:

$$F_a \geq F_S \cdot \frac{\gamma_{D1}}{2 \cdot e^{\mu\alpha}}$$

F_S = rope tension as per [8.2.3.2]

γ_{D1} = safety factor for wire ropes as per Table 8-2 (where applicable, [8.2.3.3] shall 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
 - $\alpha = 6 \cdot \pi$.

9.5.2.8.2 Shipboard lifting appliances working at sea state:

$$F_a \geq \frac{F_{Br}}{e^{\mu\alpha}}$$

F_{Br} = rope breaking load according to [8.2.3.1].

The Society's may also demand this rope tension for other lifting appliances, if this is employed under similar operational conditions, e.g. for floating cranes operating at sea.

9.5.3 Brakes

9.5.3.1 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 shall not exceed 0.3 in the design calculation.

The winch and its substructure shall be able to safely withstand the forces set up during braking.

9.5.3.2 Having regard to the dynamics of the braking action, the braking torque shall 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 [8.2.3.2.6] shall be considered.

9.5.3.3 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.

9.5.3.4 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 [9.6.2.4], which shall 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 [9.6.2.4] shall be capable of absorbing the pressure impacts caused by braking.

9.5.3.5 Electromotive brakes additionally require a mechanical holding brake (drum brake or spring-loaded motor brake).

9.5.3.6 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.

9.5.3.7 The following requirements apply to shipboard cranes and floating cranes which transport persons.

9.5.3.7.1 In addition to the normal working brake, hoisting and luffing winches shall be fitted with a secondary brake which is independent in terms of mechanical and operational layout.

9.5.3.7.2 Secondary brakes shall have their own, independent control circuit and at least be dimensioned to withstand loads as per [4.2.5.1] and [4.2.5.2].

9.5.4 Winch drives

9.5.4.1 Power drives

For power drives, the requirements given in [9.3] and [9.6.1.4] apply.

9.5.4.2 Manual drives

9.5.4.2.1 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.

9.5.4.2.2 Where winches are constructed for both powered and manual operation, the power- and manual systems shall be mutually interlocked.

9.5.5 Couplings

9.5.5.1 Clutch couplings between the drive and the rope drum are only permitted where one of the means to prevent runback stipulated in [9.5.1.2] has been provided.

9.5.5.2 Where winches have more than one disengageable drum, only one drum shall be in operation at any time.

9.5.5.3 Control levers shall be safeguarded against unintentional operation.

9.5.6 Gearing

9.5.6.1 The design of gearing shall conform to established engineering practice; location, positioning and mode of operation shall be taken into account.

9.5.6.2 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.

9.5.7 Controls and monitoring instruments

9.5.7.1 The controls and monitoring instruments shall be clearly arranged on the control platform.

9.5.7.2 Controls and monitoring instruments shall be permanently, clearly and intelligibly marked with the direction or the function of the movements they control, see [12.4.2].

9.5.7.3 The arrangement and direction of movement of controls and monitoring instruments shall match the direction of the movement which they control.

9.5.7.4 The operating movement range of control levers shall be less than 300 mm, and when released, they shall return automatically to the neutral position.

9.5.7.5 In the case of push-button controls there shall be a separate button for each direction of movement.

9.6 Hydraulic systems

9.6.1 General requirements

9.6.1.1 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.

9.6.1.2 Hydraulic systems shall be protected against overpressure and against overspeed of the load by a corresponding limitation of flow rate and pressure.

9.6.1.3 Instead of pipes, high pressure hoses may be used. These shall comply with the requirements given in EN 13135-2 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.

9.6.1.4 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.

9.6.2 Hydraulic cylinders

9.6.2.1 Hydraulic cylinders shall be dimensioned for $1.1 \times$ relief pressure p_c and dynamic forces which may occur in and out of service.

9.6.2.2 The relief pressure p_c of the safety relief valves shall be set at a sufficiently high level, that dynamic forces which may occur can be absorbed and hoist load coefficients are considered.

9.6.2.3 Piston rods shall be sufficiently rigidly connected to the piston or telescopic rod, in order to meet the requirements for calculation given in [4.9.2.3].

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 shall be provided.

9.6.2.4 With telescopic cylinders, extending and run-in of the telescopic rods shall be conducted in a specified order.

9.6.2.5 Load-bearing hydraulic cylinders, e.g. for lifting, luffing, folding and telescoping of crane booms as well as for slewing of lifting appliances, shall be provided with a device which maintains the position of the load, the crane boom or the lifting appliance 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.

9.6.2.6 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.

9.6.3 Hydraulic tanks

9.6.3.1 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.

9.6.3.2 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.

9.6.3.3 Pressure tanks shall be capable of withstanding a 2-fold maximum working pressure and shall have a safety valve against overpressure.

9.7 Protective measures and safety devices

9.7.1 Protective measures

9.7.1.1 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.

9.7.1.2 Measures shall be taken to provide power supply lines with effective protection against mechanical damage.

9.7.1.3 Cranks for starting internal combustion engines shall disengage automatically once the engine starts running.

9.7.1.4 Machinery employed in potentially explosive areas shall comply with the requirements given in EN 13463-1.

9.7.2 Safety devices

9.7.2.1 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.

9.7.2.2 Devices provided to unlock slewing or hoisting gear are only permissible for special operational purposes or as emergency measures, e.g. on offshore cranes.

9.7.2.3 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.

9.8 Assessment of drawings and manufacturing survey

9.8.1 Assessment of drawings

9.8.1.1 The general requirements given in [Sec.2](#) shall be observed.

9.8.1.2 In addition, the mechanical parts indicated in [Table 2-1](#) to [Table 2-3](#) are subject to assessment of drawings within the scope indicated there.

9.8.2 Manufacturing survey

9.8.2.1 General

9.8.2.1.1 Mechanical parts shall be manufactured by staff qualified in handling the installations and devices necessary. During manufacture and before delivery the parts shall undergo the quality tests required in accordance with state-of-the-art technology and experience.

9.8.2.1.2 All materials shall be suited to the intended purpose. Proof of the mechanical properties of the materials used shall be furnished. Identification of the materials shall be possible on the basis of test certificates or reports.

9.8.2.1.3 Mechanical parts which require a Society's product certificate according to [Table 2-2](#) and [Table 2-3](#), are subject to manufacturing survey by the Society.

The Society inspection in charge decides in coordination with the manufacturer on type and scope of manufacturing survey and certification, taking the in-house quality control and/or approval for production into consideration.

With respect to assistance by the manufacturer during manufacturing survey by the Society, the requirements given in [\[13.2.2\]](#) shall be observed.

9.8.2.2 Tests and examinations

The following requirements contain general test requirements, and in addition, provisions for the manufacturing survey by the Society.

9.8.2.2.1 General

For the acceptance tests before delivery and, if applicable, also for the manufacturing survey, the Society's surveyor shall be given material test and internal control certificates, test reports and manufacturing documents, in particular approved drawings, including the relevant design approval letter, as a prerequisite for the tests and examinations described below.

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.

For series-production components, other test procedures may be agreed with the Society instead of the prescribed ones, if they are accepted to be equivalent.

The Society 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 this standard.

Where mechanical parts shall be used for the intended purpose for the first time, the Society may ask for a type approval.

9.8.2.2.2 Winches

After completion, winches shall 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 shall be tested and adjusted.

Where winches are designed for a holding force greater than the nominal rope tension, the nominal rope tension shall be tested dynamically and the holding force statically.

Where winches are designed with a constant tension device, the maintenance of constant tension shall be proven for all levels of tension set by the design.

The above tests, including the setting of the overload protection, can also be performed on board, together with the functional testing of the lifting appliance. In this case, a functional test at available load shall be performed at the manufacturer's.

Testing of winches at test load will be performed within the scope of initial tests of the lifting appliance, see [\[13.3.3\]](#).

9.8.2.2.3 Load-bearing hydraulic cylinders

Hydraulic cylinders for hoisting, luffing, telescoping and slewing are load-bearing components.

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.

See [9.6.2.5], in the case of series-production of lifting appliances 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 Society's surveyor is entitled to ask for cylinders to be tested which are selected at random.

9.8.2.2.4 Large roller bearings

The material properties of forged rings shall be tested according to [3.4.5] by tensile tests and by notched-bar impact tests and shall comply with the requirements given 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.

Rings shall be heat-treated as appropriate to the material, and the running surfaces shall 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 Society's surveyor may demand the crack test be performed in his presence.

The hardened runways shall undergo a hardness test at least eight (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.

For the acceptance test before delivery, the large roller bearing shall be assembled and presented to the Society's 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.

9.8.2.2.5 Bolts and nuts for large roller bearings

With respect to tests and examinations of bolts and nuts, the DNV GL rules for metallic materials [DNVGL-RU-SHIP Pt.2](#) applies.

9.8.2.2.6 Mechanical and hydromechanical parts

With respect to tests and examinations of mechanical and hydromechanical parts [DNVGL-RU-SHIP Pt.4](#) apply, where relevant.

Parts not covered by DNV GL rules shall be tested and examined using appropriate procedures agreed with the Society's surveyor.

Instead of testing at the manufacturer's, tests can also be performed on board within the scope of initial tests of the lifting appliance, if practicable.


9.9 Documentation

9.9.1 Marking

9.9.1.1 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.

9.9.1.2 If, after the acceptance test before delivery, the requirements for issuing a Society's product certificate 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
- 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.

9.9.1.3 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.

9.9.2 Certificates

9.9.2.1 [Table 2-2](#) and [Table 2-3](#) show the required types of certificates for essential mechanical parts.

The lifting appliance manufacturer shall order the stated parts together with the required certificates, the parts manufacturer shall include them in the delivery.

9.9.2.2 The certificates listed in [Table 2-2](#) and [Table 2-3](#) are not part of the lifting appliance documentation on board.

SECTION 10 ELECTRICAL EQUIPMENT

10.1 General

10.1.1 General

10.1.1.1 This section contains the requirements for electrical equipment of shipboard lifting appliances and, where applicable, also of load-handling devices.

10.1.1.2 Additional or more comprehensive requirements, e.g. for switch cabinets and for electrical equipment not covered hereafter can be taken from the following:

- DNVGL-RU-SHIP Pt.4 Ch.8
- DNVGL-RU-SHIP Pt.4 Ch.9
- recognized standards and regulations where applicable to shipboard lifting appliances, unless contrary to the requirements given in this section.

10.1.1.3 The requirements given in [Sec.1](#) shall be observed where relevant.

10.1.2 Scope of application

10.1.2.1 [Table 2-1](#) is a list of the essential electrical equipment which is subject to assessment of drawings as deemed necessary by the Society, and which shall be delivered together with test reports or inspection certificates.

10.1.2.2 The requirement for an assessment 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 shipboard lifting appliances.

10.1.2.3 In case of founded exceptions also the approval and certification of electrical equipment not listed in [Table 2-1](#) to [Table 2-4](#) can be required if they are exceedingly relevant for the safety and/or reliable function of the lifting appliance.

10.2 Design criteria and operational requirements

10.2.1

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.

10.2.2

Switch and control cabinets as well as motors arranged on deck shall be provided with adequate heating for the standstill condition, if sufficient internal space is available.

10.2.3

When choosing electrical equipment, the expected environmental conditions such as humidity, heat, cold and vibrations shall receive special consideration. In addition, the following applies:

10.2.3.1 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.

10.2.3.2 Plug-in cards with electronic controls may have to have extra fastenings.

10.2.4

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 lifting appliance is switched off, special measures shall be taken in the switchgear to prevent direct contact with live parts. A double feed shall be indicated by labels.

10.2.5

For supply lines fixed laid to shipboard lifting appliances, including the external fixed cabling, marine cable shall be used, as per [DNVGL-RU-SHIP Pt.4 Ch.8](#).

10.2.6

An adequate power supply shall be provided on board or, if applicable, onshore. Onshore power supply shall be adapted to the supply system onboard.

10.3 Drives and brakes

10.3.1 Driving power

10.3.1.1 All motors shall be dimensioned in accordance with their envisaged purpose and expected use.

10.3.1.2 In the case of shipboard lifting appliances, the working speeds laid down for the safe working load shall be maintained, also at the vessel's prescribed minimum inclinations.

10.3.1.3 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.

10.3.2 Winch drives

For winch drives, the following operating modes S_i are defined:

10.3.2.1 For drives up to about 5 t SWL 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.

10.3.2.2 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.

10.3.2.3 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.

10.3.2.4 In the case of hydraulic drives, the electric motors driving the pumps shall 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 shall be paid to the mode of operation of the hydraulic unit, e.g. the power required during idling.

10.3.2.5 The driving motors shall 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 shall 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.

10.3.2.6 The duty types S1 to S3, S5 and S6 are defined in IEC 60034-1. In addition the following applies:

10.3.2.6.1 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.

10.3.2.6.2 Where the requirements are more stringent than [10.3.2.6.1], the drives shall be designed for 240, 320 or 400 starts per hour.

10.3.2.7 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 shall be considered. In addition the following applies:

10.3.2.7.1 In the case of more stringent requirements than given in [10.3.2.7] (shorter intervals between the separate hoisting operations), duty times of 40%, 60% or 75% shall be chosen.

10.3.2.7.2 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 shall be shared out between the individual switching steps.

10.3.2.7.3 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.

10.3.3 Brakes

10.3.3.1 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.

10.3.3.2 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.

10.4 Cables and lines

10.4.1 Supply line

10.4.1.1 As a matter of principle, power shall 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 the Society, possibly UV-radiation resistant and, where hydraulic systems are concerned, oil resistant.

10.4.1.2 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: five (5) times the cable diameter
- in the case of cables with an external diameter exceeding 21.5 mm: 6.25 times the cable diameter.

10.4.2 Wire cross-sections

10.4.2.1 Dimensioning shall take the load into account, possibly giving consideration to an utilisation factor and the expected ambient temperature.

10.4.2.2 For lifting appliances with only one driving motor, particularly with electro-hydraulic drive systems, the power supply shall be dimensioned as appropriate to the rated current at the maximum operating stage, for continuous operation.

10.4.2.3 For lifting appliances 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 shall be applied as the continuous operation value.

These values also apply to the dimensioning of slip ring bodies and brushes.

10.4.3 Laying of cables

10.4.3.1 General

10.4.3.1.1 Fastening for cables shall measure up to the vibrations expected during lifting appliance operation.

10.4.3.1.2 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.

10.4.3.1.3 Openings for passing through cables shall be deburred and lined so that the cable sheathing cannot be damaged by sharp edges.

10.4.3.1.4 Leakage of hydraulic oil into control cabinets, switchgear and cable boxes shall be avoided; therefore wherever practicable, cables shall 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.

10.4.3.2 Cable trays

10.4.3.2.1 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.

10.4.3.2.2 Cable trays shall be arranged so that hydraulic oil from hydraulic systems cannot drip onto the cables. Where this is not possible, oil guards shall be provided.

10.4.3.3 Cable bundles

10.4.3.3.1 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.

10.4.3.3.2 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.

10.4.3.3.3 Cable bundles shall not strike or rub against anything during slewing and in the event of movement of the lifting appliance, lifting appliance parts, or the ship.

10.4.4 Cable drums and cable trolley trays

10.4.4.1 Drum-wound cables shall 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.

10.4.4.2 For cable trolleys, minimum bend radii are as follows:

- cable up to 8 mm outside diameter:
- three (3) times the conductor diameter
- cable up to 12.5 mm outside diameter:
- four (4) times the conductor diameter
- cable over 12.5 mm outside radii:
- five (5) times the conductor diameter.

10.4.4.3 In the case of flat cables, the thickness of the cable corresponds to the outside diameter of round cables.

10.5 Switches

10.5.1 Crane main switches/crane circuit breakers

10.5.1.1 Shipboard lifting appliances 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.

10.5.1.2 A circuit breaking device may also be used as a load switch if it permits the maximum short-circuit power to be switched off safely. Dimensioning shall be carried out in accordance with IEC Publication 60947-4-1 "Type 2".

10.5.1.3 In the case of electro-hydraulic lifting appliances, the load switch shall also switch off power to the hydraulic pump motor(s).

10.5.2 Limit switches

10.5.2.1 The control circuits of the safety limit switches shall be designed on the closed-circuit current principle, or shall be self-regulating.

10.5.2.2 In the case of automated, or programme-controlled motion processes (including use of microprocessor systems), the continued safe functioning of movement limitation systems shall 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 the Society, and the switching has been qualified as "safe" by the Society as regards its safety aspect (fault elimination assessment).

10.5.2.3 In programme-controlled movement processes, limit switches may not be used for operational speed or movement measurement.

10.5.2.4 Where the hazard analysis has shown that a second movement limiter shall be provided, failure of the first limiter shall be indicated to the crane driver.

10.6 Protective measures and safety devices

10.6.1 Protective measures

10.6.1.1 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.

10.6.1.2 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:

10.6.1.2.1 For cable cross-sections up to 16 mm², its cross-section shall match that of the main conductors; for those exceeding 16 mm², it shall be at least half that of the main conductors.

10.6.1.2.2 If power is supplied via slip rings, the protective conductor shall be provided with a separate slip ring.

10.6.1.3 Any non-earthed conductor shall be provided with overload and short-circuit protection in accordance with [DNVGL-RU-SHIP Pt.4 Ch.8](#).

10.6.1.4 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.

10.6.1.5 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 shall be provided.

10.6.1.6 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.

10.6.1.7 As a minimum, the following protective systems (contact-, foreign body- and water protection) shall be provided:

10.6.1.7.1 For electrical installations below deck or in the enclosed spaces of shipboard lifting appliances, the protective system shall be at least IP 44, in dry spaces at least IP 20.

10.6.1.7.2 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.

10.6.1.8 Where required, electrostatic discharges shall be prevented by earthing and/or connection of metallic components.

10.6.1.9 Control stands, crane driver's cabins and hand-operated equipment shall be fitted with mechanically locked emergency shut-down switches or push-buttons. See also the requirements given in [12.4.3].

10.6.1.10 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.

10.6.1.11 Electrical appliances which are employed in areas with a potentially explosive atmosphere shall comply with the requirements given in respective international or national regulations regarding explosion protection, e.g. the directive 94/9/EG and IEC 60079.

10.6.2 Safety devices

10.6.2.1 Controls

10.6.2.1.1 Control handles shall 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.

10.6.2.1.2 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.

10.6.2.1.3 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.

10.6.2.1.4 Radio controls, programmed control mechanisms or microprocessor systems shall have been type tested by the Society. Alternatively their operational safety may be proved in a different way recognized by the Society.

10.6.2.2 Lighting

10.6.2.2.1 In addition to an adequate main lighting system for the lifting appliance working area, an emergency lighting system shall 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.

10.6.2.2.2 Emergency lighting systems should be guaranteed to last about 30 min. and shall preferably be connected to the emergency power supply. As an alternative, the Society may approve a battery-operated emergency power supply.

10.6.2.2.3 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.

10.7 Assessment of drawings and manufacturing survey

10.7.1 Assessment of drawings

10.7.1.1 The general requirements given in [Sec.13](#) shall be observed.

10.7.1.2 In addition to the requirements given in [Sec.13](#), the electrical equipment listed in [Table 2-1](#) are subject to assessment of drawings in the scope indicated there.

10.7.2 Manufacturing survey

10.7.2.1 General

10.7.2.1.1 Electrical equipment shall be manufactured by qualified staff handling the necessary installations and devices. During manufacture and before delivery, the parts shall undergo the quality tests required in accordance with state-of-the-art technology and experience.

10.7.2.1.2 Electrical equipment which requires a Society's product certificate according to [Table 2-2](#) to [Table 2-4](#), is subject to manufacturing survey by the Society, where required.

The Society inspection in charge decides, in conjunction with the manufacturer, on type and scope of manufacturing survey and certification, taking into consideration the in-house quality control and/or approval for production.

With respect to assistance by the manufacturer during manufacturing survey by the Society, the requirements given in [\[13.2.2\]](#) shall be observed.

10.7.2.2 Tests and examinations

The following requirements contain general test requirements and, in addition, provisions for the manufacturing survey by the Society.

10.7.2.2.1 General

For the acceptance tests before delivery and, if applicable, also for the manufacturing survey, the Society's surveyor shall receive certificates for material tests and internal controls, test reports and manufacturing documents, in particular approved drawings, including the allocated design approval letter, if required according to [Table 2-2](#) to [Table 2-4](#), as a prerequisite for the tests and examinations described below.

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.

For series-production electrical equipment, other test procedures may be agreed with the Society instead of the prescribed ones, if they are accepted as equivalent.

Where electrical equipment shall be used for the intended purpose for the first time, the Society may ask for a type approval.

10.7.2.2.2 Electrical equipment

Electrical equipment shall be tested according to [DNVGL-RU-SHIP Pt.4 Ch.8](#) and to undergo a functional test, if possible.

10.8 Documentation

10.8.1 Marking

10.8.1.1 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.

10.8.1.2 If after the acceptance test, and before delivery, the requirements for issuing a Society's product 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
- stamp with the month and year of testing.

10.8.2 Certificates

10.8.2.1 [Table 2-2](#) to [Table 2-4](#) show the required types of certificate for essential electrical equipment.

The lifting appliance manufacturer shall order the stated equipment, together with the required certificates, and the equipment manufacturer shall include them in the delivery.

10.8.2.2 The certificates listed in [Table 2-2](#) to [Table 2-4](#) are not part of the ILO lifting appliance documentation on board and shall not be filed in the CG1.

SECTION 11 CONSTRUCTION OF STEEL COMPONENTS

11.1 General

11.1.1

This section contains requirements for the construction of steel components for shipload lifting appliances and load-handling devices with a special focus on welding.

11.1.2

Complementary or more comprehensive requirements and special details shall be taken from the following:

- DNVGL-RU-SHIP Pt.3
- DNVGL-RU-SHIP Pt.2
- recognized standards or regulations.

11.1.3

The requirements given in [Sec.1](#) shall be observed where relevant.

11.1.4

With respect to materials to be used, the requirements given in [Sec.3](#) apply.

11.2 Requirements for manufacturers

11.2.1 General requirements

11.2.1.1 Manufacturers shall be equipped with installations and devices suitable for professional and proper handling of the individual materials, manufacturing methods, components, etc.

The Society 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.

11.2.1.2 The manufacturer shall have a sufficiently qualified staff of experts. The supervising and controlling personnel shall be indicated to the Society, including their areas of responsibility. The Society reserves the right to ask for certified proof of qualifications.

11.2.2 Quality control

11.2.2.1 By means of an effective internal quality control, the manufacturing works shall ensure that construction and assembly comply with this standard, the approved documents (drawings, specifications, etc.) or with the conditions stated in the approvals.

11.2.2.2 It is the responsibility of the manufacturing works to observe this standard and to meet the special requirements associated with the assessment of documents or the conditions imposed with the approval. Examinations carried out by the Society do not release the manufacturing works from this responsibility.

11.2.2.3 It is the responsibility of the manufacturing works to make sure that production conditions and quality correspond to those of the approval test. The Society cannot take any responsibility that products comply with this standard which have been tested in an approval test or at random during production, in all parts or during the entire production process.

11.2.2.4 The Society 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.

11.2.3 Workmanship

11.2.3.1 Details in the production documents

11.2.3.1.1 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.

11.2.3.1.2 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, the Society may require submission of a welding schedule.

11.2.3.1.3 Where quality or functional capability of a component is not assured or dubious, the Society 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 assessment of drawings, or were not required due to poorly detailed presentation.

11.2.3.2 Cut-outs, edges of plates

11.2.3.2.1 Openings, boreholes and other cut-outs shall be rounded with a sufficiently large radius.

11.2.3.2.2 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.

11.2.3.2.3 Exposed edges of plates or flanges cut by flame-cutting or a shearing machine shall not be sharp-edged and shall be reworked where required as stated in [11.2.3.2.2], just as notches and the like due to flame-cutting. This applies as and where relevant to welded joints, transitional sections or similar discontinuities.

11.2.3.3 Cold forming

11.2.3.3.1 Where plates are formed at low temperatures (bending, flanging, beading) the inner bending radius r_i 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 without welding in the cold formed areas.

11.2.3.3.2 Before cold forming, flame- or shear-cut burrs shall be removed in order to avoid cracks. Following cold forming, the components, in particular the lateral ends of bent plates (plate edges) shall be checked for cracks. Affected components shall be disqualified (minor cracks excepted). Repair by welding is not permitted.

11.2.3.3.3 Forming of plates, structural shapes, tubes etc. shall be carried out according to a specification outlining the successive and controlled steps. Forming of steel above 650°C shall be subject to agreement (adverse effects on material properties).

11.2.3.4 Assembly, straightening work

11.2.3.4.1 During assembly of single components, excessive force shall be avoided. If possible, major deformations of single components shall be straightened prior to further assembly.

11.2.3.4.2 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.

11.2.3.4.3 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, the Society may require a type approval or production test samples.

11.2.3.5 Corrosion protection

11.2.3.5.1 All steel components shall be provided with suitable corrosion protection. For shop primer see [11.5.1.4] and [11.5.1.5].

11.2.3.5.2 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.

11.2.3.5.3 The wall thickness of load-bearing parts shall be at least 4 mm. Lower wall thickness's are subject to the consent of the Society in each individual case.

11.2.3.5.4 Welded-on reinforcing rings shall be protected against rusting underneath.

11.2.3.5.5 Bolts, nuts and associated elements shall be protected by hot-dip galvanizing according to relevant standards, i.e. BS 729 or ASTM A 153-82. Alternatively they may be fully encapsulated and the open space be filled with inhibited oil, grease etc. Other protection methods may be accepted upon special consideration by the Society.

Spring washers of corrodible materials shall not be used if exposed to the marine atmosphere.

11.2.4 Conditions for welding

11.2.4.1 Approval to weld

11.2.4.1.1 All works, including subcontracting firms, wishing to carry out welding operations on parts of shipboard lifting appliances and load-handling devices shall have at their disposal the necessary equipment and qualified personnel, and be approved by the Society for this work, see [DNVGL-RU-SHIP Pt.2](#).

11.2.4.1.2 Approval for fabrication shall be applied for from the Society, with the appropriate documentation. Existing approval by other independent testing institutions may be taken into account if the relevant documents are submitted.

11.2.4.1.3 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.

11.2.4.1.4 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/inspectors responsible for the professional execution of the welding tasks.

11.2.4.1.5 The suitability of the welding method used in conjunction with the materials in question shall be proved to the Society in an appropriate way. The Society may to this end require method checks (test welds, non-destructive and mechanical-technological tests) in presence of the Society's surveyor.

11.2.4.1.6 The (non-destructive) testing of weld connections shall be conducted by appropriately qualified testers following a suitable test procedure. The Society may demand a test of ultrasonic testers in presence of the Society's surveyor. The scope of tests shall be indicated in the test documentation. The test reports shall be submitted to the Society.

11.2.4.2 Welders

11.2.4.2.1 Welders for manual or semiautomatic welding shall be examined according to recognized standards (e.g. EN 287 or 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.

11.2.4.2.2 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/inspectors at all times.

11.2.4.2.3 The required number of qualified welders depends on the size of the works and the scope of welding tasks in presence of the Society's surveyor. At least two qualified welders are required per welding method.

11.2.4.3 Supervision of welding

11.2.4.3.1 Every work carrying out welding shall employ its own welding supervisor/inspector. This supervisor/inspector shall have a suitable deputy in the welding shop. The welding supervisor/inspector shall be responsible for supervising the preparation and execution of the welds, and if applicable, their testing.

11.2.4.3.2 Welding supervisors/inspectors shall have training and the experience appropriate to the production requirements, and furnish the necessary proofs to the Society.

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.

11.2.4.3.3 The names of the responsible welding supervisors/inspectors and their deputies shall be made known to the Society.

11.2.4.3.4 Changes in the personnel responsible for supervising welding shall automatically be reported to the Society.

11.2.4.4 Welding consumables, auxiliary materials

11.2.4.4.1 Welding consumables type approved by the Society or accepted based on welding procedure tests shall be used.

Guidance note:

Welding consumables type approved by the Society are recommended. The type approved welding consumables are listed on internet: <https://approvalfinder.dnvgl.com/>

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

11.2.4.4.2 For highly stressed components and parts stressed at low temperatures, for high- and extra high strength steels, steel castings and forgings and for low-temperature welding work, hydrogen-controlled welding consumables and auxiliary materials are preferable.

11.2.4.4.3 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.

11.2.4.5 Welding methods, procedure tests

11.2.4.5.1 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.

11.2.4.5.2 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 shipbuilding steels A to D, or comparable structural steels, forging steels and types of casting steel shall be welded, or welding methods other than manual arc welding (E) or partly-mechanised inert gas shielded welding (MAG) shall 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 [DNVGL-RU-SHIP Pt.2 Ch.4 Sec5 \[2.2\]](#).

11.2.4.5.3 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 [DNVGL-RU-SHIP Pt.2 Ch.4 Sec.5](#). Account may be taken of procedure tests carried out elsewhere (on submission of the reports).

Guidance note:

As alternatives to the requirements given in [11.2.4.5.3], the following standards will be accepted:

- ASW D.1.1
- EN ISO 15614-1 (for steel)
- EN ISO 15614-2 (for aluminium).

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

11.2.4.5.4 Welders employed for procedure tests are, on successful completion of the test, deemed qualified for the procedure employed, or the materials concerned.

11.3 Design details

11.3.1 General

11.3.1.1 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 shall be adopted.

11.3.1.2 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.

11.3.1.3 The following requirements refer only to welded joints. For the design of screw joints, the requirements given in [\[4.8.2\]](#) apply.

11.3.2 Configuration of welded joints

11.3.2.1 Welded joints in general

11.3.2.1.1 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.

11.3.2.1.2 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.

11.3.2.1.3 All welded connections shall 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.

11.3.2.1.4 The requirements given in [11.3.2.1.3] 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.

11.3.2.1.5 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.

11.3.2.1.6 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.

11.3.2.1.7 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.

11.3.2.2 Welded nodes in tubular structures

11.3.2.2.1 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 [11.4.2.4].

11.3.2.2.2 The nodes of relatively large tubes, where the wall thickness of the branches exceeds about 8 mm, shall be designed in the form of full-penetration single bevel welds as shown in Figure 11-1. Where the stress is lower, single-bevel welds with a backing strip as in [11.4.2.4] may also be used.

11.3.2.2.3 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.

11.3.2.3 Transitions between differing dimensions

11.3.2.3.1 Differing dimensions shall 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.

11.3.2.3.2 Where the joint is between plates of differing thicknesses, thickness differences of more than 3 mm (see Figure 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.

11.3.2.3.3 For connection to plates or other relatively thin-walled elements, steel castings and forgings, as shown in Figure 11-3, shall be provided with matching tapered elements or cast, or forged-on welding flanges respectively.

11.3.2.4 Localised closely grouped welds, minimum spacing

11.3.2.4.1 Local close grouping of welds and short distances between welds shall be avoided. Adjacent butt welds shall be separated by at least

$$50 \text{ mm} + 4 \times \text{plate thickness}$$

Fillet welds shall be separated from each other and from butt welds by at least

$$30 \text{ mm} + 2 \times \text{plate thickness}$$

11.3.2.4.2 The width of plate areas (strips) subject to replacement shall however be at least 300 mm or 10 × plate thickness, whichever is the greater.

11.3.2.4.3 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.

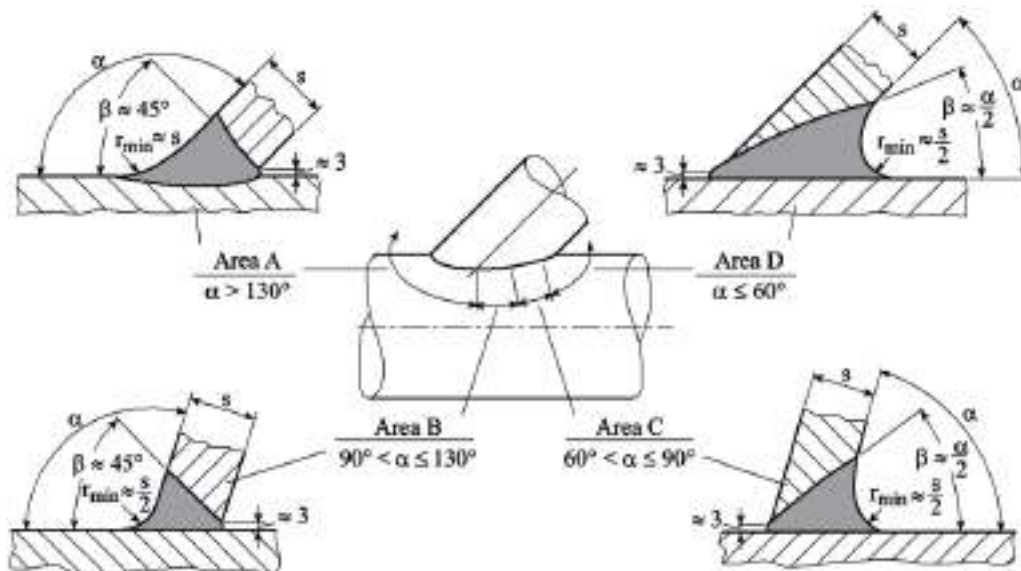


Figure 11-1 Single-sided weld connections (tube connections not accessible from inside)

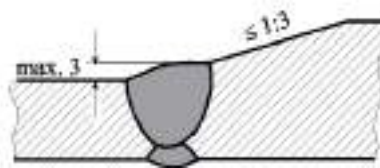


Figure 11-2 Accommodation of different thickness

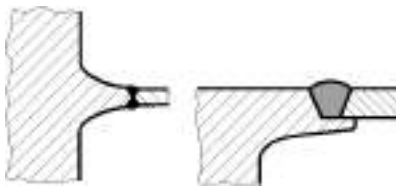


Figure 11-3 Welding flange on steel castings or forgings

11.3.2.5 Welding cut-outs

11.3.2.5.1 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 [Figure 11-4](#).

11.3.2.5.2 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.

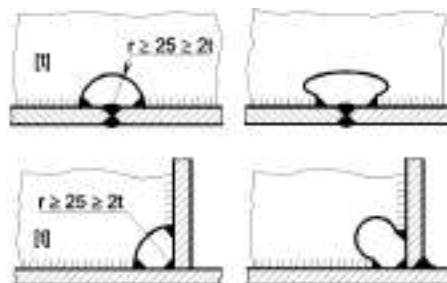


Figure 11-4 Welding cut-outs

11.3.2.6 Local reinforcements, doubling-plates

11.3.2.6.1 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 [\[11.2.4.3\]](#).

11.3.2.6.2 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.

11.3.2.6.3 Doubling-plates shall be welded along their (longitudinal) edges by continuous fillet welds with a thickness

$$a = 0.3 \times \text{thickness } t \text{ of the doubling-plate}$$

At the ends of doubling plates, as shown in Figure 11-5, thickness "a" along the terminal edges shall be

$$a = 0.5 \times \text{thickness } t \text{ of the doubling plate}$$

though it shall not exceed the plate thickness.

The weld transition angles between the terminal edge and the plating shall be 45° or less.

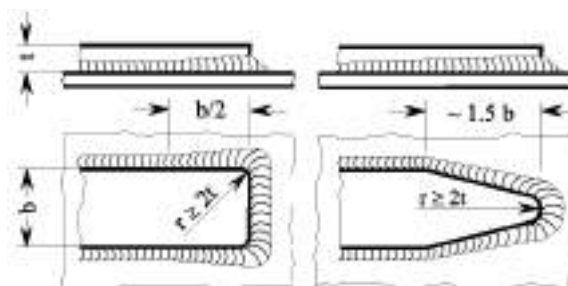


Figure 11-5 Weldings at the ends of doubling plates

Where proof of fatigue strength is required, the configuration of the end of the doubling plate shall correspond with the detail category selected.

11.3.2.7 Welding in cold-formed areas

11.3.2.7.1 Welding is permitted at and close to cold-formed structural areas, provided that the following maximum degrees of cold deformation are not exceeded.

The degree of cold deformation of special and primary structural elements shall be less than 5% ($r_i \geq 10 \times$ plate thickness) for carbon-manganese steel and less than 20% ($r_i \geq 2 \times$ plate thickness) for austenitic and ferritic-austenitic steel.

For carbon-manganese steels the allowable inside bending radius may be reduced below the above values. For additional requirements see [DNVGL-RU-SHIP Pt.3 Ch.3 Sec.1 \[2.7.3\]](#).

Guidance note:

Welding of cold formed hollow sections made of normal and high strength steel with increased degree of cold deformation might be permitted, providing acceptance of the respective profile standard. Special consideration shall be taken for the risk of cold cracking in the welded zone, e.g. reduce level of diffusible hydrogen in the weld material, preheating. In general, hot formed hollow sections are recommended.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

11.3.2.7.2 For extra high strength steels, the necessary minimum bending radius shall, in case of doubt, be determined by qualification tests or be given by the steel manufacturer.

11.3.2.8 Bend reinforcements

11.3.2.8.1 Bent structural elements, e.g. the chords of girders, where the change of direction means that forces are generated or shall be transmitted perpendicular to the bend, shall be adequately supported at the bending location. The conditions set out in [11.3.2.7.1] shall be complied with.

11.3.2.8.2 Where welded joints at bending locations cannot be avoided, three-plate welds generally as in [11.4.2.6] may be used. Such connections shall be depicted in detail on the drawings.

11.4 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.

11.4.1 Butt joints

11.4.1.1 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).

11.4.1.2 Where other forms of weld are envisaged, these shall 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.

11.4.1.3 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 rule, 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.

11.4.1.4 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 Figure 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.

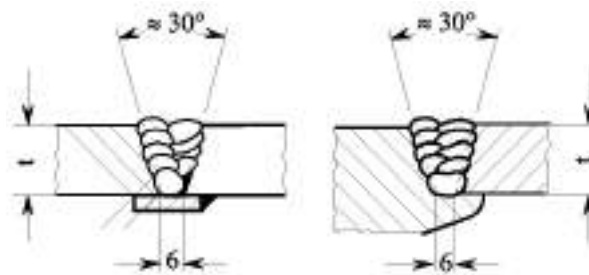


Figure 11-6 Single-side welds with permanent weld pool supports (backings)

11.4.2 Corner-, T- and double-T- (cross) welds

11.4.2.1 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 [Figure 11-7](#). The root shall be grooved out and welded from the reverse side.

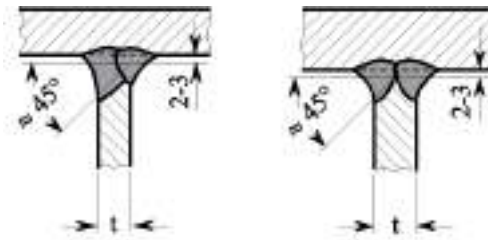


Figure 11-7 Single- and double-bevel welds with full root penetration

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.

11.4.2.2 Corner-, T- and double-T- (cross) welds with a defined root defect f as shown in [Figure 11-8](#) shall take the form of single- or double-bevel welds as described in [\[11.4.2.1\]](#), with reverse-side welding but without grooving-out of the root.

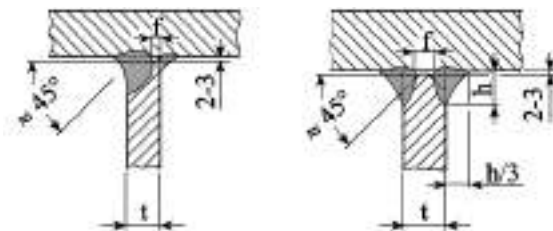


Figure 11-8 Single- and double-bevel welds with defined incomplete root penetration

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.

11.4.2.3 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 [Figure 11-9](#).

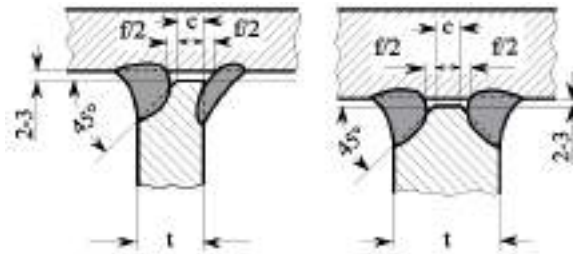


Figure 11-9 Single- and double bevel welds with an unwelded root face and a defined incomplete root penetration

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.

11.4.2.4 Corner-, T- and double-T- (cross) welds accessible from one side only may, as shown in [Figure 11-10](#), be made either as butt joints with a weld pool support analogous to those described in [\[11.4.1.4\]](#), or as one-sided single-bevel welds analogous to those in [\[11.4.2.2\]](#).

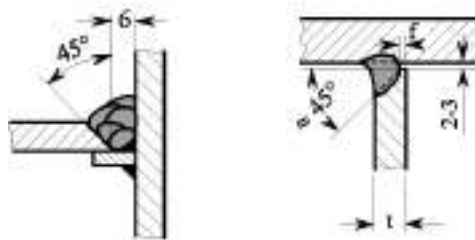


Figure 11-10 Single-side welded T-joints

The theoretical weld thickness shall similarly be determined in accordance with [\[11.4.1.4\]](#) or [\[11.4.2.2\]](#). Where proof of fatigue strength is required, use of these welds shall be avoided if possible.

11.4.2.5 In the case of flush corner joints, i.e. where neither of the plates projects, joint configurations as shown in [Figure 11-11](#) shall be used with bevelling of the plates shown as upright, to avoid the danger of lamellar rupture (stepwise cracking).

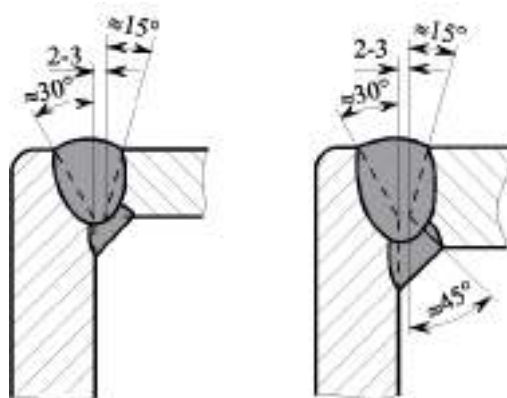


Figure 11-11 Flush fitted corner joints

11.4.2.6 Where in T-joints the main stress acts in the plane of the plates shown in the horizontal position in Figure 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 Figure 11-12 may be used.

The theoretical weld thickness of the joint connecting the horizontal plates shall be determined in accordance with [11.4.1.3]. 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.

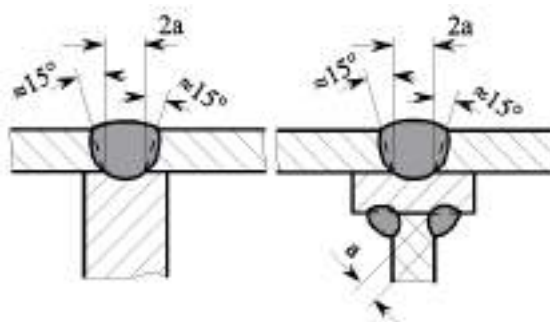


Figure 11-12 Three-plate welds

11.4.3 Fillet welds

11.4.3.1 Fillet welds shall, as a matter of principle, be made on both sides. Exceptions to this rule (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 Figure 11-13, shall not be less than 1.4 times the fillet weld thickness "a".

11.4.3.2 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:

$$a_{\min} = \sqrt{\frac{t_1 + t_2}{3}} \text{ [mm]} \text{ (but not less than 3 mm)}$$

t_1 = the lesser plate thickness [mm] (e.g. the web thickness)

t_2 = the greater plate thickness [mm] (e.g. the chord thickness).

11.4.3.3 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.

11.4.3.4 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:

$$a_{\text{tief}} = a + \frac{2 \text{ min } e}{3} \text{ [mm]}$$

shall be determined by reference to the configuration shown in [Figure 11-13](#) and shall take into account the value of "min e" which shall 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 [\[11.4.3.2\]](#).

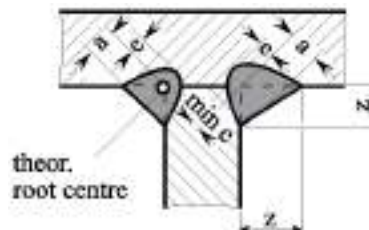


Figure 11-13 Fillet welds with increased penetration

11.4.3.5 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 [DNVGL-RU-SHIP Pt.2](#). The same applies in turn to welding processes too, in which there is a likelihood of insufficient root penetration.

11.5 Workmanship and testing of weld joints

Welding workmanship shall comply with [DNVGL-RU-SHIP Pt.2](#).

11.5.1 Weld preparation and assembly

11.5.1.1 When preparing and assembling structural parts, care shall 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.

11.5.1.2 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 [DNVGL-RU-SHIP Pt.2](#).

11.5.1.3 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.

11.5.1.4 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.

11.5.1.5 Only those weldable production coatings shall be applied for which the Society's report of no objection exists, based on a pore formation tendency test.

11.5.2 Protection against the weather, preheating

11.5.2.1 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.

11.5.2.2 In low temperatures (component temperatures below 5°C) suitable measures shall 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.

11.5.3 Welding positions and sequence

11.5.3.1 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.

11.5.3.2 Vertical downward welding of fillet welds shall not be applied to lifting appliance components and lifting appliances, including supporting structure (e.g. crane columns), even after a successful welding procedure test.

11.5.3.3 Obstruction of weld shrinkage shall be minimized by the choice of a suitable construction and welding sequence.

11.5.4 Workmanship

11.5.4.1 The welds shall have sufficient penetration and clean, regular weld surfaces with "soft" transitions to the base material. Excessive overthickness and grooves as well as notches at the edges of plates or cut-outs shall be avoided.

11.5.4.2 Cracked tacks may not be welded over but shall be removed by machining. In multi-pass welding, the slag from preceding passes shall be removed completely. Pores, visible slag inclusions and cracks may not be welded over, but shall be removed by machining and repaired.

11.5.5 Repair of defects

Repair of major defects of workmanship may only be undertaken after agreement with the Society. This applies similarly to the repair by welding of worn, broken or otherwise damaged parts. Prior to repair work on load-bearing structural parts, a sketch of the repair shall be submitted.

11.5.6 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 [DNVGL-RU-SHIP Pt.2](#).

11.5.7 Heat treatment

11.5.7.1 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 shall be followed.

11.5.7.2 Depending on the type of material concerned, flash butt welds shall be subjected to normalising or quenching and tempering treatment.

11.5.7.3 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, the Society may call for production tests.

11.5.7.4 Any non-destructive tests required shall be carried out after heat treatment.

11.5.8 Non-destructive tests

11.5.8.1 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.

11.5.8.2 By way of example, in [Table 11-1](#), the tests required for the important parts of shipboard lifting appliances and load-handling devices have been compiled. Additionally, as a guide, requirements imposed on welded connections in the form of assessment categories according to EN ISO 5817 have been added.

Welds in aluminium shall comply with ISO 10042 level B (applies for category special) or level C (applies for category primary/secondary).

Where proof of fatigue strength is required, the test requirements given 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.

Table 11-1 Test specifications for welded connections

Category of member	Type of connection	Test method				Requirements
		Visual	Magnetic particle ³⁾	Radiography ¹⁾	Ultrasonic ⁴⁾	ISO 5817
Special	Butt weld	100%	100%	100%	-	B
	Cross- and T-joints, full penetration welds	100%	100%	-	100%	B
	Cross- and T-joints, partly penetration and fillet welds	100%	100%	-	-	B
Primary	Butt weld	100%	20%	20%	-	C
	Cross- and T-joints, full penetration welds	100%	20%	-	20%	C
	Cross- and T-joints, partly penetration and fillet welds	100%	20%	-	-	C
Secondary	Butt weld	100%	Spot ²⁾	Spot ²⁾	-	C
	Cross- and T-joints, full penetration welds	100%	Spot ²⁾	-	Spot ²⁾	C
	Cross- and T-joints, partly penetration and fillet welds	100%	Spot ²⁾	-	-	C

1) May be partly or wholly replaced by ultrasonic testing upon agreement
2) Approximately 2-5%
3) Liquid-penetrant testing to be adopted for non-ferromagnetic materials
4) Ultrasonic testing shall not be used for thicknesses less than 10 mm.

Remarks:

- With the Society's 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.
- The Society's 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.

11.5.8.3 Non-destructive tests shall be carried out by suitably qualified personnel.

11.5.8.4 The tests shall be carried out in accordance with accepted practice. The results shall be presented to the Society's surveyor at the latest at the acceptance testing of the components.

11.5.8.5 NDT acceptance criteria for components machined after forged/cast

Unless otherwise specified in this standard or approved manufacturer's specification, acceptance criteria from following documents can be used for NDT of machined components:

- IACS Recommendations No.68,
Guidelines for non-destructive examination of hull and machinery steel forgings
(acceptance criteria for inspection zone I to be applied)
- IACS Recommendation No.69,
Guidelines for non-destructive examination of marine steel castings
(acceptance criteria for quality level 1 to be applied).

NDT testing shall be focused on critical areas. Extend shall be specified by manufacturer and shall be according to recognized standards.

Guidance note:

The objective and scope of quality control for materials, material testing and documentation thereof is to verify that the relevant properties as specified by designer and accepted by the Society are obtained.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

11.5.9 Production tests

11.5.9.1 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, the Society may stipulate production tests to prove that the mechanical qualities remain adequate.

11.5.9.2 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/mm², 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:

$$\epsilon = \frac{100}{1+2r/t} [\%]$$

r = internal bending radius

t = plate thickness.

11.6 Assessment of drawings and manufacturing survey

11.6.1 Assessment of drawings

For the assessment of drawings of steel components the requirements given in [Sec.13](#) shall be observed. In addition to the welding diagrams and test plans stated there, the following applies:

11.6.1.1 Details on welded joints in the documents to be verified

11.6.1.1.1 In the documents to be verified and to be submitted for approval, production details shall be included which are relevant to the quality of the welded joint and the verification by the Society. 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.

11.6.1.1.2 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, this standard and other recognized standards, the Society may waive a special description or details in the test documentation.

11.6.1.2 Description of welded joints

11.6.1.2.1 The description of welded joints including the gap and weld geometry shall e.g. comply with the standards EN 12345, EN 22553/ISO 2553, EN ISO 9692-1, -2, -3 or -4. The designations in the documents to be verified (drawings, etc.) shall be well-defined e.g. by standard symbols.

11.6.1.2.2 Deviating weld geometries or symbols in the documents to be verified (drawings, welding diagrams or specifications) shall be presented or commented on in detail and require approval by the Society (e.g. in connection with the assessment of drawings or with a procedure test).

11.6.2 Manufacturing survey

Regarding manufacturing survey by the Society, the requirements given in [\[1.3.3\]](#) and the following requirements apply.

11.6.2.1 Surveillance of production

11.6.2.1.1 Steel components shall be surveyed during production with respect to workmanship and compliance with the approved drawings. The start of production shall be indicated in good time to the Society inspection in charge, in order to enable the Society's surveyor to survey the complete production process.

11.6.2.1.2 Professional, proper and complete execution of the joining processes shall be ensured by means of thorough controls by the factory.

11.6.2.1.3 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, the Society may stipulate in-production tests to prove that the mechanical qualities remain adequate.

11.6.3 Acceptance test

11.6.3.1 Before delivery of steel components, a suitable date for the acceptance test shall be agreed with the Society inspection in charge.


11.6.3.2 For the acceptance test before delivery, the manufacturer shall have ready the following documents:

- purchase and order documents
- workshop drawings
- drawings approved by the Society including design approval letter
- results of internal checks
- material test certificates
- certificates or protocols of welding tests
- further documents as required.

11.7 Documentation

11.7.1 Marking

11.7.1.1 Where the Society acceptance test before delivery has not given reason for complaint, the steel component shall be stamped as follows:

- stamp  with the month and year of testing
- the Society's certificate number as per [11.7.2.1], together with the code letter(s) of the examining inspection office.

11.7.1.2 Where the steel components are produced in the lifting appliance manufacturer's works, 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 lifting appliance.

11.7.2 Certification

11.7.2.1 The Society's surveyor will issue a Society's product 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.

11.7.2.2 The certificate issued according to [11.7.2.1] is not part of the lifting appliance documentation on board.

SECTION 12 TECHNICAL AND OPERATIONAL SAFETY REQUIREMENTS

12.1 General

12.1.1

This section contains selected provisions in addition to the previous sections as regards safety of shipboard lifting appliances and the protection of persons, based on the following requirements for design, fitting and operation of these devices.

Further requirements or measures shall be taken from the relevant standards and regulations, if applicable.

12.1.2

A general precondition for the safe operation of shipboard lifting appliances is first of all its dimensioning and its design and equipment in accordance with [Sec.6](#) to [Sec.13](#) of this standard.

Complementary details regarding rope drives, mechanical parts and electrical equipment are given in [Sec.8](#) to [Sec.10](#).

12.1.3

For load-handling devices, the requirements given in this section apply similarly, where relevant.

12.2 Design requirements

12.2.1 Shipboard lifting appliances in general

12.2.1.1 Highest boom position

12.2.1.1.1 General

Each boom shall be capable of being lowered in the highest position, with or without working load. Combinations of different influences shall be taken into account.

12.2.1.1.2 Rope-operated booms

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.

To prevent remaining in the highest boom position a restoring device may be provided, which shall 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.

12.2.1.1.3 Cylinder-operated booms

With cylinder-operated booms, the cylinder force shall be great enough to comply with the requirements given in [\[12.2.1.1.2\]](#).

12.2.1.2 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 shall be furnished.

12.2.1.3 Access to crane drivers' cabins

12.2.1.3.1 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.

12.2.1.3.2 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.

As an alternative to an emergency exit a personnel descent device, type approved by a recognized organization, may be used. Suspension points of personnel descent devices shall be designed and tested in accordance with EN 795.

12.2.1.3.3 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.

12.2.1.3.4 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.

12.2.1.4 Accesses in general

12.2.1.4.1 Unobstructed access to all essential components of the lifting appliance shall be ensured for maintenance and repair purposes, by means of suitable accesses, platforms, ladders and standing spaces.

12.2.1.4.2 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.

12.2.1.4.3 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 shall be provided.

12.2.1.4.4 Ladders

The inclination of ladders, measured from the horizontal, shall be at least 65°.

Ladder rungs and climbing irons shall be of 20/20 ($L = 300$) or 22/22 ($300 < L \leq 350$) 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.

The distance of the lowest ladder rung from the deck or platform shall be between 100 mm and 400 mm.

Climbing irons shall have a uniform distance of 300 mm from each other.

The minimum distances and spaces to be kept clear for movement within the reach of a ladder (see also [Figure 12-1](#) and [Figure 12-2](#)) are:

- 750 × 750 mm in front of the climbing irons, excluding obstacles extending into this space (in exceptional cases a limit down to 550 × 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.

A fall arresting device (safety cage or guide rail for a safety harness) shall be provided if:

- a) the mounting height exceeds 2.5 m or
- b) a falling height of more than 3.0 m is possible.

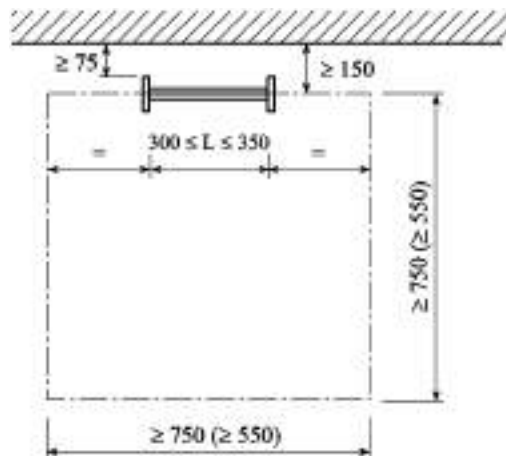


Figure 12-1 Minimum clearances and movement space

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 five (5) longitudinal struts.
- The clearance between climbing iron and rear cage shall be between 550 mm and 750 mm.

The maximum vertical length of a ladder between two platforms is 6 m.

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).

The rails of the ladder shall extend past the upper platform by at least 1 m or hand grips shall be fixed up to this height.

12.2.1.4.5 Landings/platforms

Outer edges of platforms or floors shall be provided with a coaming, unless people and/or items slipping is prevented by other means.

Floors and their coverings respectively shall be skid-proof.

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.

12.2.1.4.6 Guard rails

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 shall be provided.

Where guard-rails are used to separate working areas from traffic areas, their clearance from moveable parts shall be at least 0.10 m.

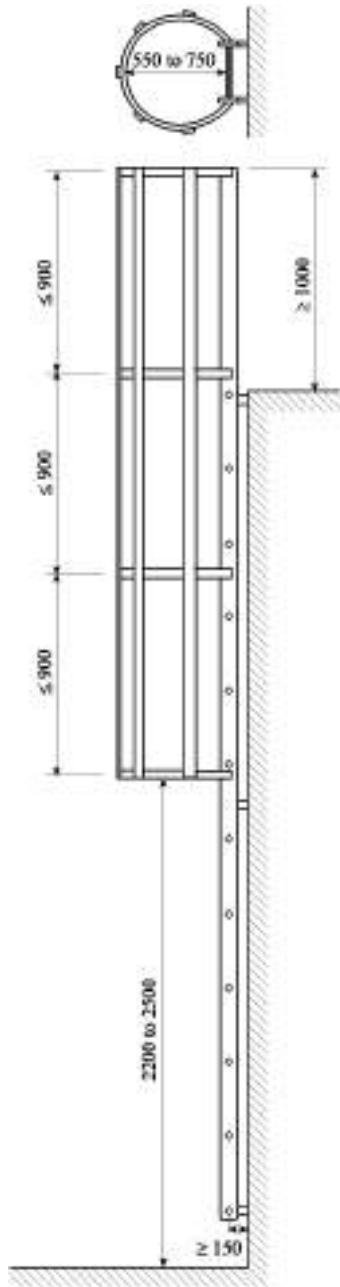


Figure 12-2 Safety cage

12.2.2 Mobile shipboard lifting appliances

12.2.2.1 General requirements

12.2.2.1.1 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 lifting appliances on deck shall be provided.

12.2.2.1.2 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.

12.2.2.1.3 For cranes and trolleys in engine and pump rooms up to a safe working load of 1.0 t which can be moved athwartships, the requirement given in [12.2.2.1.2] 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).

12.2.2.1.4 Cranes and trolleys which can be moved fore and aft shall be fitted with a self-locking drive or with brakes. For such cranes, calculations shall be submitted proving that the cranes are able to move against a 2° inclination and against a wind load 50% higher than specified in [5.3.3.1] for operation at sea and with or without load, by friction contact.

12.2.2.1.5 Cranes and trolleys with a safe working load over 1.0 t which can be moved fore and aft shall be fitted with a direct drive as given in [12.2.2.1.2], if they shall be employed for working at sea state. This predominantly includes cranes and trolleys above the main engine.

12.2.2.1.6 Each crane rail shall be arranged parallel to the design waterline of the ship.

12.2.2.1.7 Where the operator has to move with the crane or trolley control unit, the speed of travel may not exceed 0.5 m/s.

12.2.2.2 Industrial cargo-handling vehicles

For industrial cargo-handling vehicles the requirements given in [6.5] apply.

12.3 Equipment

12.3.1 Highest boom position

12.3.1.1 Shipboard lifting appliances whose booms are held by luffing ropes shall be equipped with buffers for the uppermost position.

12.3.1.2 The requirements given in [12.4.7.2] shall be observed when designing buffers.

12.3.2 Control stands and controls

12.3.2.1 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.

12.3.2.2 The control stands of cranes for cargo handling 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.

12.3.2.3 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.

12.3.2.4 Additional requirements for the controls and the control mechanism are given in [10.6.2.1].

12.3.3 Load radius diagram

Cranes with load radius-dependent safe working loads shall have a load radius diagram in the driver's cabin. The actual load radius shall be continually visible to the driver.

12.3.4 Working hours counter

Cranes belonging to crane group Band C (see [5.7]) shall be provided with working hours counting mechanisms.

12.3.5 Lighting

For the main and emergency power lighting of shipboard lifting appliances, the requirements given in [10.6.2.2] apply.

12.3.6 Fresh air supply

For closed control stands sufficient supply of fresh air shall 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.

12.3.7 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.

12.4 Safety devices

12.4.1 Overload protection

12.4.1.1 Load limit

12.4.1.1.1 Lifting appliances shall have overload protection devices. These shall be activated if the response of the load being raised or lowered exceeds a pre-determined amount which shall not be greater than the effect of a static load equal to the SWL times the hoist load coefficient for which the lifting appliance has been designed.

12.4.1.1.2 Where lifting appliances have variable safe working loads, the overload protection device shall adjust automatically to the actual load radius.

12.4.1.1.3 For rope and chain hoists manufactured by series production, the manufacturer's settings and tolerances apply, see [6.2.3.1.1].

12.4.1.2 Load moment limitation

12.4.1.2.1 Where lifting appliances have variable safe working loads, a load moment limitation device is also required in addition to the overload protection device.

12.4.1.2.2 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.

12.4.1.3 Load reduction after an overload

After the overload protection devices are activated, the load or load moment reducing motions of the lifting appliance and its mobile components shall still be possible.

12.4.2 Motion limiter

12.4.2.1 General requirements

12.4.2.1.1 The end positions of all motions which can be performed by lifting appliances or their 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.

12.4.2.1.2 For conventional derrick boom systems, exceptions from the requirements given in [12.4.2.1.1] can be permitted.

12.4.2.1.3 It shall not be possible for end positions to be overridden. Exceptions, e.g. for maintenance and boom stowage, require written approval by the Society.

12.4.2.1.4 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 [12.4.7.2].

12.4.2.2 Motion limitation by limit switches

12.4.2.2.1 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.

12.4.2.2.2 Limit switches shall be located and adjusted in such a way that no damage can occur, even if they are approached at maximum speed and with full safe working load. If necessary, pre-limit switches shall be used.

12.4.2.2.3 Regarding additional requirements for limit switches see [10.5.2].

12.4.2.3 Motion limitation by design measures

12.4.2.3.1 Limit switches

For hydraulically operated lifting appliances with low operating speeds and safe working loads up to 1000 kg, limit stops, with damping if required, may be permitted as a motion limitation.

For rope and chain hoists from series-production, the requirements given in [6.2.3.2.2] apply.

12.4.2.4 Runway limit

For limit stops of movable cranes the provisions in [5.3.4.2] are applicable.

12.4.3 Emergency switches/keys

12.4.3.1 On control stands, inside cabins or at manual controls, an emergency switch or emergency cut-out with mechanical locking device shall be provided.

12.4.3.2 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.

12.4.3.3 Emergency switches/keys shall meet the requirements given in EN 418 and continue to function in the event of any failure of the control system.

12.4.4 Slack rope limiter

12.4.4.1 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.

12.4.4.2 For shipboard lifting appliances and floating cranes operating at sea, 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 shipboard cargo cranes operating at sea shall stop the winch(es) automatically.

12.4.5 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 given in [4.2.5.1], [4.2.5.2] and [9.5.3.7] apply.

12.4.6 Alarm devices

12.4.6.1 Outside the driver's cabin on cranes used for the handling of cargo, a signal horn shall be provided by which the crane driver can raise an acoustic signal which can definitely be heard in the working area of the crane.

12.4.6.2 Mobile deck cranes shall give an optical and acoustic alarm while moving.

12.4.7 Strain of shipboard lifting appliances due to safety devices

12.4.7.1 The movements and dynamic loads occurring following the response of safety devices shall be kept to a minimum if possible.

12.4.7.2 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.

12.5 Passive protective measures

12.5.1 Safety distances

12.5.1.1 In accessible areas, the distance between fixed parts of the ship and moving parts of the lifting appliance 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 shall be fitted.

12.5.1.2 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.

12.5.2 Safety of access and transport

12.5.2.1 Working passages, operating platforms, stairs and other areas accessible during operation shall be secured by railings.

12.5.2.2 All lifting appliances shall be fitted with a signboard forbidding access or ascent by unauthorized persons.

12.5.2.3 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.

12.5.2.4 To permit load tests on shipboard lifting appliances inside utility spaces, eye plates shall be provided at suitable points, see [6.2.3.5].

12.5.3 Corrosion protection

12.5.3.1 For general requirements regarding corrosion protection, the provisions of [11.2.3.5] apply for steel components and [8.2.1.2] for wire ropes.

12.5.3.2 Components which are employed for hoisting services under water, e.g. load-handling devices, shall be designed in such a way that, as far as possible, no seawater can ingress.

12.6 Stowage and lashing devices

12.6.1 General requirements

12.6.1.1 It shall be possible for all wheeled shipboard lifting appliances and mobile components of shipboard lifting appliances to be positioned, or where required, supported, for sea use, as well as to be fastened securely by suitable devices or guys, see [4.2.5.3].

12.6.1.2 Supporting or fastening devices shall be designed in such a way that inadmissible forces or loads may not be transmitted to the lifting appliance or the components thereof, caused by deformations of the ship's hull in a seaway.

12.6.2 Wheeled lifting appliances

12.6.2.1 Wheeled lifting appliances shall be located in stowage positions which, as far as possible, are expected to suffer the least loads in a seaway.

12.6.2.2 For free-travelling lifting appliances, such as e.g. industrial cargo-handling vehicles, suitable stowage spaces and lashing eyes or other suitable devices shall be provided.

12.6.3 Revolving cranes

12.6.3.1 Revolving cranes with booms or projecting machinery rooms require supporting structures for these components and a special blocking device to relieve the slewing gear.

12.6.3.2 Where booms or projecting machinery rooms with an "out of operation" status shall not be stowed or supported, written approval by the Society is required.

12.6.3.3 Booms with luffing ropes shall be guyed downwards, either hanging free or supported. Where the brakes of the lifting appliance are designed for it, this requirement can be complied with by proper fastening of the cargo hook and prestressing of the hoisting ropes. Prestressing shall be specified by the manufacturer. Supported booms may also be fastened properly to the boom support, see [5.7.2.2].

For booms with luffing cylinders, the guy or fastening may be dispensed with, provided that a corresponding approval is at hand.

12.6.3.4 Where not serving to guy the boom cargo hooks shall 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.

12.6.4 Design and dimensioning

12.6.4.1 Boom supports, supporting, stowage and lashing devices shall be designed and dimensioned with the same diligence and to the same criteria which apply to lifting appliances.

12.6.4.2 Stowage and lashing devices shall be dimensioned like lifting appliances out of operation according to [5.6].

12.7 Operational requirements

12.7.1 Shipboard lifting appliances in general

12.7.1.1 Marking of hoisting capacity

12.7.1.1.1 All lifting appliances shall be marked permanently and prominently with the safe working load "SWL" and the corresponding load radius.

In the case of load-radius dependent safe working loads, lifting appliances shall be marked in several places. Detailed information regarding marking of shipboard lifting appliances is given in [13.2.5].

12.7.1.1.2 All loose gear shall be marked permanently and prominently with the safe working load "SWL" and the dead load "WT", the latter if $WT \geq 100$ kg.

Detailed information regarding marking of loose gear is given in [7.4.3].

12.7.1.2 Ship stability

12.7.1.2.1 In the absence of any special measures, the ship's stability alone shall suffice to ensure simultaneous operation of all shipboard lifting appliances for transshipment, 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 lifting appliance, shall not be exceeded.

12.7.1.2.2 Special measures as per [12.7.1.2.1] 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 monitoring devices. These requirements also apply to fully automated operation.

12.7.1.2.3 The influence of lifting appliances on the ship's stability shall be verified by calculation. These calculations shall be included in the stability documentation of the ship.

12.7.1.3 Failure of the drive power

12.7.1.3.1 A design shall be employed, auxiliary means shall be available, and measures shall be taken to set down suspended loads as safely as possible, in the event of a failure of the drive power.

Mobile lifting appliances and/or mobile lifting appliance components may for this purpose possibly be transferred into a more favourable load position.

12.7.1.3.2 If no other lifting appliances are available, the following auxiliary means/measures may e.g. be employed:

- plug-on auxiliary drives/manual pumps
- eye plates attached to the lifting appliance 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.

12.7.1.3.3 Shipboard lifting appliances used for the conveyance of persons shall be equipped with suitable rescue equipment. Descender devices may be employed for the descent from work-baskets.

12.7.1.4 Conveyance of persons or personnel

Shipboard lifting appliances used for the conveyance of persons or personnel shall comply with the requirements given in [4.2.5.1] and [4.2.5.2] with regard to dimensioning, control and operation.

Persons or personnel may only be transported at daylight or sufficient illumination and under environmental conditions (wind/seaway), which are considered to be acceptable by the supervisor in charge.

12.7.1.5 Communication

12.7.1.5.1 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 [12.3.2.1].

12.7.1.5.2 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.

12.7.2 Wheeled lifting appliances

For wheeled lifting appliances, the operational requirements given in [12.2.2], [12.4.6.2] and [12.5.1] apply.

12.7.3 Floating cranes

12.7.3.1 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.

12.7.3.2 The transport of loads suspended from the crane hook across unprotected waters is subject in each case to approval by the Society, who may for this purpose issue a "Conveyance certificate" if necessary.

12.7.3.3 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.

12.7.4 Responsibility of the ship's management

12.7.4.1 Special working conditions, operational restrictions, release and safety measures shall be recorded in writing and included with the corresponding lifting appliance documentation.

12.7.4.2 Maintenance and control measures performed by the ship's management and/or external personnel shall be confirmed properly in the lifting appliance documentation or added to it.

In the Society's register book for lifting appliances, Form CG1, Part 4 is provided for entries of this kind, see [13.7].

12.7.4.3 If the limit values for wind, ship inclination, ship motion or temperature, specified in [4.2.4] are reached, lifting appliances shall be put out of operation and, where required, be stowed in a special way and/or be lashed for sea, see [12.6].

Deviating limit values may be specified for shipboard lifting appliances operating in a seaway or at low temperatures.

SECTION 13 TESTING AND EXAMINATION OF SHIPBOARD LIFTING APPLIANCES

13.1 General

13.1.1 Description of content

13.1.1.1 Subsections [13.2] to [13.5] contain requirements for testing, examination, marking and certification of shipboard lifting appliances used for cargo handling.

These provisions apply analogously to shipboard lifting appliances not handling cargo, which are only expressly mentioned if required.

13.1.1.2 The requirements given in [13.6] apply for the evaluation and treatment of worn-out or damaged lifting appliance components.

13.1.1.3 The lifting appliance documentation described in [13.7] includes the following items:

- types and systems of certification
- compilation of product certificates in register books (certification of lifting appliances)
- 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.

13.1.2 Supplementary requirements

Supplementary/deviating requirements apply to the following lifting appliances, equipment and means of transport:

13.1.2.1 Lifting appliances

- rope and chain hoists ([6.2])
- ramps and car decks ([6.3])
- lifting appliances for research work ([6.4])
- industrial cargo-handling vehicles ([6.5]).

13.1.2.2 Equipment

- interchangeable components (Sec.7)
- wire ropes and synthetic fibre ropes (Sec.8)
- mechanical parts (Sec.9)
- electrical equipment (Sec.10).

13.1.2.3 Means of transport

- load-handling devices (Sec.7)
- shipborne working baskets ([6.6.1])
- landing booms ([6.5.3]).

13.1.3 Definitions

In addition to [1.1.5], the following definitions apply:

13.1.3.1 Tests

13.1.3.1.1 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.

13.1.3.1.2 Load test

The designation "load test" is given to the test with the prescribed test load $L_{p\text{dyn}}$ or $L_{p\text{stat}}$.

The purpose of the load test is to prove adequate strength, safety against hidden defects and - if applicable - adequate safety against overturning.

13.1.3.2 Examination

13.1.3.2.1 Thorough examination

A thorough examination means a detailed visual inspection, 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 Society's surveyor, parts of the interchangeable components, of the load-handling device or of the lifting appliance shall be dismantled and, where required, dismantled.

13.1.3.2.2 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.

13.2 Manufacturing survey

13.2.1 General

13.2.1.1 In addition to the following provisions, the general requirements given in [Sec.1](#) and, for steel construction, the requirements given in [\[11.6.2\]](#) shall be observed.

13.2.1.2 Manufacturing survey is required in principle. The Society may however dispense with it for lifting appliances manufactured in series, which is not used for cargo handling and which fulfils the requirements for omitting assessment of drawings, see [\[1.3.2\]](#). In this case, manufacturer's test reports may be accepted, deviating from the certificates stated in [\[13.2.7.1\]](#).

13.2.1.3 Commencement of construction of a lifting appliance shall be advised to the Society in sufficient time for the Society's surveyor to attend the construction process from the very beginning.

13.2.1.4 The basis for the manufacturing survey at the manufacturer of the lifting appliance is the approved documentation according to [Sec.2](#), plus, if applicable, further documentation, certificates, reports and information from the manufacturer which the Society's surveyor needs for assessment of the parts to be examined.

13.2.1.5 Regarding manufacturing survey and lifting appliance documentation, subcontracting firms shall provide certificates and test reports in the scope specified in [Sec.6](#) to [Sec.10](#).

13.2.2 Participation by manufacturers

13.2.2.1 As far as necessary and advisable, the works shall check all components during and after manufacture for completeness, dimensional accuracy and proper workmanship.

13.2.2.2 Following checking and, if required, repair by the works, the components shall be presented to the Society's surveyor for inspection during appropriate phases of construction, normally in easily accessible and unpainted condition.

Certificates for components and equipment delivered by subcontractors shall be submitted.

13.2.2.3 The Society's surveyor may reject components not adequately pre-checked, and stipulate that they be presented again following checking by the works and, if required, repair.

13.2.2.4 Components to be tested shall be indicated for the Society's inspection in good time for examination.

13.2.2.5 In order to enable the Society's surveyor to perform his duties, he shall be given access to the workshops in which components for testing are manufactured and assembled. Manufacturers shall make available to the surveyor the personnel and material support required to carry out the prescribed tests.

13.2.3 Manufacturing survey

13.2.3.1 The Society's surveyor examines the components constructed at the manufacturer's, or supplied, with regard to condition, marking and certification. He surveys the assembly of the lifting appliance and examines workmanship and agreement with approved documents, and witnesses the test runs and functional tests as appropriate or agreed.

13.2.3.2 Testing of materials for the manufacture shall be proven to the Society's surveyor in accordance with the Society's rules for materials.

The certificates/reports for the materials used, as well as proofs on welding and non-destructive material tests, shall be presented to the Society's surveyor.

13.2.3.3 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 Society's surveyor in an agreed scope or as prescribed by this standard.

Regarding series production, instead of the prescribed tests, other testing methods can be agreed with the Society, provided that they are accepted to be equivalent.

13.2.3.4 Where machines, devices or electrical equipment are provided for the intended purpose for the first time, the Society may demand a type-test.

13.2.4 Factory acceptance test (FAT)

13.2.4.1 General

13.2.4.1.1 Shipboard lifting appliances assembled ready for operation, or completely equipped assembly groups, shall be presented to the Society's surveyor before they leave the manufacturer's works.

13.2.4.1.2 After completion of agreed test runs or tests, lifting appliances or lifting appliance assembly groups shall be subjected to a thorough examination. The testing methods applied are at the discretion of the Society's surveyor. Following tests on the test plant, lubricating and hydraulic oil filters shall be checked for impurity.

13.2.4.2 Tests and examinations to be carried out

13.2.4.2.1 General

- 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
 - safe working load(s) and load radius (radii)
- examination of marking, see [13.2.5]
- additional tests and/or examinations as required.

13.2.4.2.2 Test run

Newly designed lifting appliances shall be test-run in the presence of the Society's surveyor according to a programme approved by the Society. If possible, this shall take place at the manufacturer's, but with the Society's consent, it may also take place elsewhere, or at the place of operation.

Guidance note:

Newly designed lifting appliances can typically be characterized by:

- significant change or new design of mechanism (e.g. wire rope reeving) and/or
- significant increase of safe working load (enlargement of an old design) and/or
- significant change or new design of load-bearing structure and/or
- significant change or new design of machinery and/or
- significant change of safety devices/systems and/or
- additional application of new safety devices/systems (e.g. AOPS, MOPS, ELRS).

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Shipboard lifting appliances subject to special operating conditions shall undergo test runs under these conditions. At least one of every different type of lifting appliance shall be tested in this way.

This for instance means that the test run shall be performed with the ship also at the stipulated inclination.

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
- emergency brake test with dynamic test load according to Table 13-2 (see also [13.3.3.2.4])
- checking the emergency load release device
- endurance tests on all power units under safe working load, with heating measurement
- noise measurement (also in the cabin)
- measurement of power consumption and contractually agreed speeds under safe working 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.

Guidance note:

Brake tests with test load shall be restricted to the required number. Emergency tests shall as far as possible be performed only once.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Easing of testing requirements shall be agreed with the Society.

13.2.4.2.3 Proof of safety against overturning

For the proof of safety against overturning for wheeled lifting appliances, the requirements given in [4.5.2.2] and [6.5.1.2] apply.

13.2.5 Marking of the lifting appliance

13.2.5.1 Lifting appliance number

13.2.5.1.1 The sequential numbering of shipboard lifting appliances shall agree with the details in the certificates and rigging plans.

13.2.5.1.2 The following rule for numbering shall be applied:

- first all lifting appliances for cargo handling, starting from the fore and arranged in pairs, progressing from port to starboard, starting on deck, then below deck
- next all lifting appliances needed for operating the ship, but none of the gear exclusively for launching life-saving equipment. Here also: starting on deck, then below deck.

13.2.5.1.3 The number of the lifting appliance shall be preceded by "Nr." or also "No.".

13.2.5.2 Safe working load(s)

13.2.5.2.1 The safe working load(s) of lifting appliances for cargo handling shall be indicated in metric tonnes "t", on other lifting appliances, especially with lower safe working loads, the indication may also be in kilograms "kg".

The safe working load(s) of lifting appliances shall be preceded by the letters "SWL", where applicable with the following additions:

- SWL (P) for pairs of lifting appliances
- SWL (G) for lifting appliances with grabs
- SWL (M) for conveyance of persons.

13.2.5.3 Load radius (radii)

13.2.5.3.1 The load radius (radii) of lifting appliances shall be indicated in metres "m". When variable, the minimum and the maximum value each.

13.2.5.3.2 Gantry and bridge cranes with trolleys are not given a load radius indication.

13.2.5.4 Details of execution

13.2.5.4.1 The marking giving details of the safe working load shall be in writing at least 80 mm high, and that regarding lifting appliance number or boom inclination at least 50 mm high.

13.2.5.4.2 This marking shall 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.

13.2.5.4.3 The marking for the safe working load and, if applicable, the load radius shall be located clearly apart from the lifting appliance number.

Table 13-1 Examples of markings

<i>Item No. on board the ship</i>	<i>Safe working load</i>	<i>Load radius</i>	<i>Lifting appliance type</i>	<i>Meaning of the marking</i>
Lifting appliance with boom				
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	3.5 – 12 m		Crane with 3 load steps. The load radius limits of the allocated safe working loads shall not be exceeded ¹⁾
	SWL 120 t	3.5 – 25.5 m		
	SWL 60 t	3.5 – 34 m		
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	3.6 – 14 m	revolving crane	Crane with variable load range ³⁾
	SWL 18.6 t	3.6 – 40 m		Marking for the auxiliary hoist
	SWL 5 t	4.4 – 42 m		
Lifting appliance without boom				
No. 10	SWL 16 t	–	bridge crane, lifting platform	Safe working load of the lifting appliance
No. 18	SWL 3 – 6 t	–	rope hoist	Where the hoisting rope has a single reeve, loads up to 3 t may be lifted, up to 6 t in the case of double reeve ⁴⁾
<p>1) In the crane driver's cabin, a load radius diagram shall be visibly displayed.</p> <p>2) The difference between SWL (G) and SWL results from the different hoist load coefficients, see Table 5-2. The safe working 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.</p> <p>3) Information about the curve-type variation of the safe working loads can be taken from the load radius diagram displayed in the crane driver's cabin.</p> <p>4) The types of reeve shall be marked properly on the lifting appliance. In the case of more than double reeve, an operating instruction is required.</p>				

13.2.5.5 Location

13.2.5.5.1 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.

13.2.5.5.2 In the case of lifting appliances which can be combined in pairs, additional marking shall be applied at a suitable location for the combined load.

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.

13.2.5.6 Examples of marking

13.2.5.6.1 Marking is part of the safety measures for the operation of lifting appliances and therefore subject to examination.

Where variable equipment and reeve options exist, operating instructions are required.

13.2.5.6.2 In [Table 13-1](#), some typical marking examples are listed, including explanations. Special marking requires agreement with the Society.

13.2.6 Stamping of lifting appliances

13.2.6.1 Prior to the Society's issuance of the product certificate or manufacturing survey report as per [\[13.2.7.1\]](#), the lifting appliance shall be stamped as follows:

- the certificate/report number with the distinguishing letters of the Society
- the stamp with month and year of test.

13.2.6.2 An additional stamp covering the safe working load is not applied until after the load test has been carried out.

13.2.6.3 Cranes shall be stamped at the bottom end of the left-hand jib spar, next to the point where it joins the crane house.

Lifting appliance assembly groups and lifting appliances other than cranes shall be stamped in a prominent position.

13.2.7 Certification and reporting of manufacturing surveys and tests

13.2.7.1 For all shipboard lifting appliances, cargo winches, luffing and slewing cylinders completed and tested (FAT) in accordance with [\[13.2.4\]](#), a Society's product certificate is issued by the Society's surveyor.

Where lifting appliances or their assembly groups are manufactured and surveyed without FAT, they receive a manufacturing survey report each.

Where interchangeable components and loose gear are already a part of the lifting appliance during the manufacturing survey, product certificates of form CG3 shall be provided.

For wire ropes which are already part of the lifting appliance at the manufacturing survey, product certificates of form CG4/LA4 shall be provided.

This paragraph does not apply to chain and rope hoists manufactured in series production.

13.2.7.2 Apart from explanatory notes concerning the acceptance procedures, the Society's product certificates and survey reports as per [\[13.2.7.1\]](#) may contain notes regarding other certificates (e.g. CG3, CG4/LA4), protocols, etc. such as e.g. the following details:

- manufacturer's name
- type designation and production number

- safe working load(s) and, if applicable, load radius (radii)
- date and the Society's reference number of the design approval
- associated ship (yard no. or DNV GL Ship ID No.)
- stamp.

13.3 Initial test and examination

13.3.1 General

13.3.1.1 Prior to commissioning, an initial test and examination within the scope described in [13.3.2] to [13.3.4] at the place of operation is required.

The sequence of steps for the test and examination is as deemed necessary by the Society's surveyor, who also decides the scope of his examination.

13.3.1.2 During practical testing of lifting appliances dependent on an external power supply, care shall 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 shoreside power supply, shore and ship power shall be compatible.

13.3.1.3 The certificates and rigging plans stated in [13.3.4.1.2] shall be presented as proof of manufacturing survey, and as an integral part of the lifting appliance documentation.

13.3.2 Function test

13.3.2.1 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 Society's surveyor's discretion.

13.3.2.2 In the case of permanently installed lifting appliances, 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.

13.3.2.3 The function test to be carried out for the Society's 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.

13.3.2.4 With the exception of the test on the overload protection devices, the function test may be carried out with any given load, see also [13.1.3.1.1].

13.3.2.5 A function test using a test load requires the manufacturer's consent.

13.3.3 Load test

13.3.3.1 General requirements

13.3.3.1.1 All shipboard lifting appliances 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.

13.3.3.1.2 In the case of lifting appliances below deck which are difficult to access, load tests may alternatively be conducted using a calibrated load measuring instrument, whose indication of measured values shall remain constant for five minutes.

The instrument shall have an accuracy of $\pm 2.5\%$ or better.

If the safe working load SWL of any lifting appliance exceeds 15 t, use of load measuring instruments shall be avoided.

13.3.3.1.3 Lifting appliances shall 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 shipboard lifting appliances

Application range		Test loads ($L_{p_{dyn}}$) ¹⁾
Shipboard lifting appliances in general	SWL ≤ 20 t	1.25 · SWL
	20 t < SWL ≤ 50 t	SWL + 5 t
	50 t < SWL	1.10 · SWL
Ramps, car decks and lifting platforms ²⁾	(SWL + WT) ≤ 20 t	1.25 · SWL + 0.25 · WT
	20 t < (SWL + WT) ≤ 50 t	SWL + 5 t
	50 t < (SWL + WT)	1.10 · SWL + 0.10 · WT
<p>SWL = safe working load according to [1.1.5.54] WT = dead weight of moved masses of ramps, car decks or lifting platforms</p> <p>1) If applicable to be multiplied with f_d according to [7.3.3.3]. 2) If ramps, car decks or lifting platforms are designed for conveyance of persons exclusively, the dynamic test load may be calculated with SWL(M) instead of SWL. In this case an additional static load test with test load based on SWL is required.</p>		

13.3.3.2 Load test performance

For the dynamic load test to be performed for the Society's surveyor, the test load shall be lifted slowly, and if possible also slewed and luffed. In detail, the following applies:

13.3.3.2.1 For lifting appliances generally, the test load shall be lowered rapidly and braked in various positions and/or settings. Braking shall be effected by releasing the control levers.

13.3.3.2.2 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 shall be tested, and in the case of cranes with radius dependent safe working loads, also an intermediate value.

13.3.3.2.3 Regarding crane columns and their integration into the ship's hull, as well as lifting appliance foundations in general, tests according to [\[13.3.3.2.1\]](#) are required in longitudinal and transverse directions of the ship, i.e. to fore and aft and to port and starboard each.

13.3.3.2.4 For lifting appliances used for cargo handling, one emergency brake test with the test load, by operating the emergency switch or button, shall be carried out either at the manufacturer's or at the place of operation.

13.3.3.2.5 When carrying out the load test, care shall be taken to ensure that all movable parts are able to operate freely in all the lifting appliance and/or derrick boom's positions, all ropes are unobstructed by any other parts, and the ropes can wind satisfactorily onto the winch drums.

13.3.3.2.6 In the case of ramps, the test load arrangement shall conform to the intended operating mode.

13.3.3.3 Requirements for hoisting winches

13.3.3.3.1 If the pull of the hoisting-winch is insufficient to lift the test load, a second winch or other lifting appliance may be brought in to assist with the hoist. Braking and holding the test load, however, shall be accomplished using solely the winch belonging to the lifting appliance.

13.3.3.3.2 Where hoisting-winchs have not lifted the test load by themselves, proof shall be obtained by testing that with the maximum number of layers of rope on the winch drum, the safe working load is hoisted satisfactorily by the winches.

13.3.3.3.3 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 [13.6.8.2.4].

13.3.3.3.4 Hydraulic cranes

If hydraulic cranes are unable to lift a test load 25% greater than the safe working load because of the pressure limit, lifting the maximum possible load is sufficient. This shall however exceed the safe working load by at least 10%.

13.3.4 Examination

13.3.4.1 Documentation check

13.3.4.1.1 Priority shall be given to checking if the assessment of drawings for lifting appliances, crane columns, 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.

13.3.4.1.2 Manufacturing survey shall be documented by product certificates and/or manufacturing survey reports. The lifting appliance documentation remaining onboard shall include:

- rigging plans
- product certificates for interchangeable components and load-handling devices
- product certificates for ropes.

13.3.4.1.3 Regarding the certificates stated in [13.3.4.1.2], 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.

13.3.4.2 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 shall 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 lifting appliances and to control stands
- accesses to driver cabins and working and control platforms inside and outside the lifting appliance and to boom supports
- emergency descents
- condition and equipping of control stands and driver cabins
- working area of the lifting appliance

- range(s) of sight for the operator from inside the driver cabin.

13.3.4.3 Examination after the load test

After the load test, the load-bearing components of lifting appliance shall undergo a visual inspection.

This examination shall, if possible, exclude the formation of possibly permanent deformations or cracks at force application points or at special design details.

13.3.5 Stamping

13.3.5.1 If the initial tests and examinations have not given rise to any objections, the lifting appliance shall be stamped before the relevant certificates are issued.

13.3.5.2 Cranes with boom shall 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 lifting appliances.

13.3.5.3 The stamp shall contain the following information:

- shipboard number of the lifting appliance
- stamp with the month and year of test
- safe working load of the lifting appliance in [t] or where required in [kg] and the permissible minimum and maximum crane load radius in [m]. Where the safe working load varies with the load radius, the safe working load and the corresponding load radius shall be stated for the maximum and minimum values
- certificate number and distinguishing letters of the Society.

13.3.6 Certification of the initial tests and examinations

13.3.6.1 Following performance of the tests and examinations and stamping, the Society's surveyor issues the certificate Form CG2 for load-tested lifting appliances handling cargo and OLA201 for load tested lifting appliances not handling cargo.

CG2 or OLA201 for shipboard lifting appliances covered by **Crane** notation shall be endorsed with additional remark "COVERED BY CRANE NOTATION".

13.3.6.2 The tests and examinations of the lifting appliance are confirmed by the Society's surveyor in a register book of Form CG1, to which the certificate and the survey report are added.

13.3.6.3 The certification and documentation system for shipboard lifting appliances is described in [13.7].

13.4 Periodic tests and examinations

13.4.1 General

13.4.1.1 Shipboard lifting appliances subject to periodic tests and examinations by the Society shall be examined at regular intervals by the Society's surveyor and subjected to load tests in his presence.

13.4.1.2 The intervals between examinations, and between the load tests, described below are customary internationally. Deviating national requirements shall be taken into account if applicable.

13.4.1.3 In cases where a lifting appliance dependent on an external power supply is tested, the requirements given in [13.3.1.2] apply.

13.4.2 Due dates

13.4.2.1 Examinations

13.4.2.1.1 Lifting appliances and load-handling devices shall be examined annually by the Society's surveyor, unless other intervals are required by national regulations.

The operator is, as a matter of principle, obliged to give the Society due notice of the examination.

13.4.2.1.2 The following examinations vary, depending on type and scope:

- annual examinations, see [13.4.3]
- five-yearly examinations, see [13.4.4].

13.4.2.2 Load tests

13.4.2.2.1 No later than five years after the load test, a further load test is required for shipboard lifting appliances, to be performed in the presence of the Society's surveyor.

The operator is, as a matter of principle, obliged to give the Society due notice of the load test.

A regular recurrent load test of loose gear is not required internationally by ILO.

13.4.2.2.2 For practical reasons, load tests shall coincide if possible with the five-yearly examination.

13.4.2.3 Exceeding the due date

13.4.2.3.1 In the case of shipboard lifting appliances 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 load-handling devices.

13.4.2.3.2 In the case of lifting appliances not subject to the ILO regulations, the interval stated in [13.4.2.3.1] may be exceeded by up to three months when admitted by the Flag State Administration. This applies also to related load-handling devices.

This does not, however, postpone the due date of the next examination. The same applies inversely to tests performed before the due date.

13.4.2.3.3 Where the intervals stated in [13.4.2.3.1] and [13.4.2.3.2] are exceeded, the validity of entries on examinations performed and the validity of product certificates expires in the register book.

In the case of classified shipboard lifting appliances, the respective class notation is suspended once the five year interval has been exceeded by more than three months.

13.4.3 Annual examinations

The purpose of annual examinations shall confirm technical safety of operation within the periods of five-yearly examinations.

13.4.3.1 Scope of examinations

13.4.3.1.1 The scope of examinations depends on age, condition and frequency of use of lifting appliances.

Normally, lifting appliances need not be unrigged and dis-mantled for the performance of yearly examinations.

13.4.3.1.2 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 of the records done by responsible person in the form CG1 in the Part III and Part VI
- 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.

13.4.3.1.3 The list in [13.4.3.1.2] is by way of an example. The actual scope of tests and examinations is at the discretion of the Society's surveyor, whereby negative findings may require further examinations or measures, see [13.4.4.2].

13.4.3.2 Dealing with components

13.4.3.2.1 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.

13.4.3.2.2 Components which do not comply with these rules, or which are worn to the permitted limits, shall be replaced by new ones with the prescribed dimensions.

13.4.3.2.3 Any parts renewed since the last examination shall be submitted to the Society's surveyor, together with the certificates required.

13.4.4 Five-yearly examinations

13.4.4.1 General

13.4.4.1.1 The purpose of five-yearly tests and examinations shall confirm or generate a solid technical basis for the upcoming annual examinations.

13.4.4.1.2 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.

13.4.4.2 Scope of examinations

In accordance with these rules, five-yearly examinations shall extend and complement the examinations described in [13.4.3.1] and, where required, the measures described thereafter, which may, if necessary, be extended:

13.4.4.2.1 Examination of structural and interchangeable components

If deemed necessary by the Society's 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.

The Society's surveyor is entitled to demand a load test or a load test repeat for lifting appliances, interchangeable components or load-handling devices, if deemed necessary.

13.4.4.2.2 Examination of slew rings

Slew rings shall be examined with respect to bearing clearance, noise, lubrication and corrosion.

The tight fit of the pins shall be checked by at least one random hammer test.

Where increased internal wear is suspected, extruded grease shall be checked by an appropriate method for abraded particles.

Slew rings of shipboard cargo cranes operating at sea 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.

The associated drives and brakes shall be checked with respect to wear, function and general condition.

13.4.4.2.3 Examination of hydraulic cylinders

Apart from a thorough visual inspection 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.

13.4.4.2.4 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 safety turns
- tight fit and absence of corrosion of the rope-end attachment(s).

Guidance note:

For wire ropes the number of required safety turns is specified in [8.2.4.1.1], for synthetic fibre ropes the number of required safety turns is specified in [8.3.4.6].

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

13.4.4.2.5 Crack tests

Where a visual inspection gives reason for this, the Society's 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.

13.4.4.2.6 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 [8.5.3.1.3]
- contact areas without watertight sealing, e.g. in case of welded eye plates
- special areas of design where water may accumulate.

13.4.5 Load tests

13.4.5.1 For the performance of load tests, the requirements given in [13.3.3] apply, however no emergency shut-down test is required, nor tests with several different safe working loads, load radii and ship directions.

13.4.5.2 At the five-yearly load tests of shipboard lifting appliances, solely testing with test load based on the maximum safe working load at the associated maximum load radius will suffice.

13.4.5.3 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.

13.4.5.4 The magnitude of test load shall correspond to Table 13-2. In exceptional cases, a lower test load may be used, with hydraulically driven lifting appliances, where the working pressure cannot be correspondingly increased, see [13.3.3.3.4].

13.4.5.5 Five-yearly load tests of lifting appliances under deck may alternatively be conducted using a calibrated load measuring instrument, whose indication of measured values shall remain constant for five minutes.

The instrument shall have an accuracy of $\pm 2.5\%$ or better.

If the safe working load SWL of any lifting appliance exceeds 15 t, use of a load measuring instrument as far as possible shall be avoided.

13.4.6 Confirmation of periodic tests and examinations

13.4.6.1 Following performance of the tests and examinations, the Society's surveyor will issue the certificate, Form CG2 for load-tested lifting appliances handling cargo and OLA201 for load tested lifting appliances not handling cargo.

13.4.6.2 The tests and examinations of the lifting appliances used for cargo handling and associated load-handling devices will be certified by the Society's surveyor in the register book, Form CG1, Part I, II and the certificate CG2 will be added to the register book.

13.4.6.3 The tests and examinations of the lifting appliances not used for cargo handling and associated loosed gear will be certified by the Society's surveyor in the register book, Form CG1, Part IV, V.

13.4.6.4 The stamping required according to [13.3.5] in advance of the issuing of certificates is in general not required for periodic load tests.

13.4.6.5 The system of certification and documentation for lifting appliances is described in [13.7].

13.5 Extraordinary tests and examinations

Modifications, damage, renewals and special occasions may require extraordinary load tests and/or examinations, as described in the following.

13.5.1 General

13.5.1.1 The operator shall inform the Society if essential modifications are intended to be made to lifting appliances or load-handling devices, when damage affecting safety has occurred, or renewal of load-bearing structural elements shall be carried out.

13.5.1.2 In the cases described above, the Society decides on the respective measures, examinations and load tests.

13.5.1.3 Any essential modification and any repair or renewal of load-bearing components, with the exception of ropes and interchangeable components, shall be subject to manufacturing surveys according to [13.2]. Where this is not possible in individual cases because of the circumstances, a re-examination shall be carried out on a suitable date.

13.5.1.4 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.

13.5.1.5 All load tests shall be performed using weights, in the manner described in [13.4.5]. Regarding certification of tests and examinations, the requirements given in [13.4.6] apply.

13.5.2 Essential modifications

13.5.2.1 Essential modifications are subject to the same tests and examinations as the initial manufacture.

13.5.2.2 Essential modifications include, besides renewal of load-bearing components, modifications of:

- safe working load
- load radius
- hoisting and/or luffing systems
- cable tackle system, unless different types of reeve are provided in the design
- load-bearing components.

13.5.2.3 Non-essential modifications include modifications which will in no way affect safety and/or function of lifting appliances or load-handling devices. Such modifications shall be presented to the Society surveyor on his first visit to the ship after the modification has been carried out.

13.5.3 Damage

13.5.3.1 The requirements given in [13.6] shall be observed when an evaluation is made whether damage unduly affects the safety of lifting appliances or load-handling devices.

13.5.3.2 Damage affecting safety requires an examination of the damage and a repair plan with specific details, which is subject to approval by the Society.

Following repair, an examination within the necessary scope and a load test are required.

13.5.3.3 Depending on the evaluation of the damage, lifting appliances or load-handling devices shall be put out of operation or, where required, be operated at reduced safe working load and/or load radius.

Regarding repairs and operation at reduced safe working load, the requirements given in [13.6.9] apply.

13.5.3.4 Damage which does not affect safety shall be presented to the Society's surveyor at the first visit to the ship after the occurrence of the damage.

13.5.4 Renewals

13.5.4.1 Following each renewal of load-bearing components of lifting appliances or load-handling devices, a load test and an associated examination of this gear is required.

13.5.4.2 The requirements given in [13.5.4.1] do not apply to ropes and interchangeable components, because these are tested, examined and certified independently.

Renewal of axles, 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 Society's surveyor on the occasion of the following examination.

13.5.4.3 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.

13.5.4.4 Special occasions

The Society reserves the right to ask for extraordinary load tests and/or examinations in specially justified cases.

13.6 Wear, damage, repair

13.6.1 General

13.6.1.1 The details which follow regarding deformation, wear, tolerances, etc. shall be considered as reference values to assess the remaining margin of safety of damaged, corroded or worn components.

In the case of major damage of shipboard lifting appliances, or in cases of doubt, the Society shall be consulted.

13.6.1.2 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 safe working load, see [13.6.9.1].

13.6.1.3 For worn or corroded parts which are close to reaching the tolerance limits, the Society's surveyor may determine a time period for repair or replacement.

13.6.1.4 Regarding load-handling devices, interchangeable components and ropes, see also [7.5] and [8.5.3.3].

13.6.2 Acceptable reduction of plate thickness

13.6.2.1 For plates, profiles and pipes, the acceptable reduction of plate thickness is 10%.

13.6.2.2 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.

13.6.2.3 In cases of isolated pitting, a reduction of plate thickness of up to 30% is acceptable.

13.6.2.4 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%.

13.6.3 Acceptable cracks

13.6.3.1 In special or primary components (see [3.1.2]), no cracks can be tolerated.

13.6.3.2 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
- $3 \times$ 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 shall be considered separately as a connection length.

13.6.4 Acceptable deformations

13.6.4.1 Deflections

13.6.4.1.1 Compression bars

Under the maximum permissible loading, compression bars may not display uniform deflection greater than the equivalent of the bar length divided by 250.

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.

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.

13.6.4.1.2 Tension bars

Tension bars shall not, when unstressed, display uniform deflection greater than the equivalent of the bar length divided by 50.

13.6.4.1.3 Booms/jibs

For booms subject to compressive stress under permissible load, the requirements given in [13.6.4.1.1] 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.

The lowering of the top of the boom under load and/or dead weight is not limited when the permissible load is observed.

13.6.4.2 Deformation of chords and flanges

13.6.4.2.1 I-Beams

Each half-flange may individually or together be deformed by up to 15% of its breadth, measured from web to outer edge.

13.6.4.2.2 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.

13.6.5 Acceptable indentations

The following requirements presuppose smooth transition pieces and apply provided that no bends, folds, cracks or thinning have developed.

13.6.5.1 Compression bars

13.6.5.1.1 Cylindrical pipes

Pipes forming category 1 components

The following conditions shall 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.

Pipes forming category 2 components

The following conditions shall be observed:

a) central range (1/3 ℓ)

$$\ell \leq d$$

$$b \leq 0.5 \cdot d$$

$$f \leq t$$

b) outer range

$$\ell \leq 1.5 \cdot d$$

$$b \leq 0.7 \cdot d$$

$$f \leq 2 \cdot t$$

13.6.5.1.2 Rectangular tubes and box girders

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.

For acceptable indentations of plates, the requirements for cylindrical pipes similarly apply. Instead of the diameter, the side dimension of the plate under consideration shall be taken.

13.6.5.1.3 I-Beams

The webs of I-beams may not have any indentations.

13.6.5.1.4 Angle profiles

Angle profiles may not have any indentations at the corners.

13.6.5.2 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 given in [4.3.5.2] shall be observed.

13.6.5.3 Girders subject to bending

13.6.5.3.1 Indentations at bearing or load introduction points are not acceptable.

13.6.5.3.2 In areas other than mentioned in [13.6.5.3.1], the rule is that indentations up to the dimensions in [13.6.5.1.1] and [13.6.5.1.2] are acceptable on the tension side; on the compression side, only dimensions of half that size.

13.6.6 Acceptable wear on rope-sheaves

13.6.6.1 The side wall thickness of rope sheaves made from normal-strength materials shall meet the following condition at the bottom of the groove:

$$t \geq \sqrt{0.85 \cdot F_S}$$

t = side wall thickness [mm]

F_S = static rope pull according to [8.2.3.2] [kN].

13.6.6.2 The details at [13.6.6.1] apply to single 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.

13.6.6.3 The wall thickness according to [13.6.6.1] may reduce in an upward direction to 1/3 at the outermost edge.

13.6.6.4 Rope imprints located at the bottom of the rope groove require a change to the pairing of rope and rope-sheave.

13.6.7 Acceptable wear on pins/increase of bearing clearances

13.6.7.1 Pins

From the point of view of load-bearing capacity a reduction in diameter of 10% is acceptable.

13.6.7.2 Bearing clearance

13.6.7.2.1 Foot bearings

The tolerable increase of bearing clearance is two times the initial clearance.

13.6.7.2.2 Bearings in general

Greater clearances than stated in [13.6.7.2.1] are acceptable if the pin's load-carrying capacity and ability to function are not adversely affected, and if no alternating load exists.

13.6.7.2.3 Rope-sheave bearings

The following bearing clearances are acceptable:

- 1 mm in antifriction bearings
- 2 mm in sliding bearings.

13.6.8 Acceptable wear of mechanical parts

13.6.8.1 Gearing

13.6.8.1.1 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.

13.6.8.1.2 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).

13.6.8.1.3 Wedges or fitting keys shall be renewed if there are visible signs of wear.

13.6.8.2 Brakes

13.6.8.2.1 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.

13.6.8.2.2 Electric or hydraulic winches with automatic standstill brakes may not have any slip, not even under test load.

13.6.8.2.3 Winches with manually-applied standstill brakes may not have any slip when the brake has been applied, not even under test load.

13.6.8.2.4 Hydraulic winches without standstill brakes may not, under safe working 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.

13.6.9 Reduction of safe working load(s) and/or load radius (radii)

13.6.9.1 If a repair or replacement is not performed immediately, a reduction of safe working load(s) and/or 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.

13.6.9.2 A reduction according to [13.6.9.1] 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.

13.6.9.3 The marking on the lifting appliance or load-handling device shall be correspondingly changed for the time of reduction of the safe working load(s) and/or load radius (radii).

Where the reduction is intended to last an unlimited period of time, the rigging plans of the affected lifting appliance shall also be modified accordingly.

13.6.10 Repairs

13.6.10.1 If the acceptable limiting values described above have been achieved, or are expected to be achieved soon, the components shall be properly repaired or replaced.

13.6.10.2 In the case of repairs, care shall be taken to restore the initial condition as far as possible and to avoid any adverse micro-structure changes in the materials involved as a result of heating.

13.6.10.3 Any repairs shall be entered into the register book and the survey report.

13.7 Lifting appliance documentation

13.7.1 General

13.7.1.1 The central element of all lifting appliance documentation is a register book, in which all appropriate certificates and information are collected and/or noted.

13.7.1.2 The different register books and certificates to be issued by the Society's surveyor are based on international or national regulations, in a form as interpreted by the Society.

13.7.1.3 Secure storage of the lifting appliance documentation throughout the entire working life of the lifting appliance, and the presentation of register books, certificates, rigging plans and survey reports to the Society's surveyor or authorized persons before the start of any test and/or examination, is the responsibility of the ship's management.

13.7.1.4 When the register book, Form CG1 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.

13.7.1.5 When ships are entered into class with the Society, register books and certificates of recognized societies or organizations are accepted and continued until the next 5-yearly thorough examination and load test.

13.7.2 Register books

13.7.2.1 Explanatory

13.7.2.1.1 The purpose of register books for lifting appliances shall provide information at any time about the actual situation as regards general data, plus the test, examination and maintenance status.

13.7.2.1.2 On completion of successful initial tests and examinations, the register books described below are handed over by the Society's 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.

13.7.2.1.3 In the register books, certificates, results of examinations and, where required, survey reports and other information are collected. They shall be stored at the place of operation and submitted to the Society's surveyor or to authorized persons on demand.

13.7.2.1.4 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 the Society's files (supply of certified true copies, etc.).

13.7.2.1.5 A register book normally includes several sets of lifting appliances. If it is reasonable, register books may also be issued individually for lifting appliances, interchangeable crane boom systems on board floating cranes, loose gear, etc.

13.7.2.1.6 Special versions differing from the register books described below may be issued by the Society or the operator (e.g. authority), if this is required or desired.

13.7.2.2 Register book for shipboard lifting appliances (Form CG1)

13.7.2.2.1 For shipboard lifting appliances, the Society's surveyor issues a *Register of lifting appliances and ship's cargo handling gear*, Form CG1.

13.7.2.2.2 Together with the relevant certificates, the register book is handed over in a protective cover which also contains the rigging plans described in [13.7.4] and further serves to accommodate the survey reports.

13.7.2.2.3 Parts I and II of the register book are reserved for entries by the Society's surveyor concerning cargo gear, whereas the inspection of load-handling devices belonging to the cargo gear in part III shall be conducted and confirmed by the ship's management.

13.7.2.2.4 Parts IV and V of the register book are reserved for entries by the Society's surveyor concerning lifting appliances not handling cargo, whereas the inspection of load-handling devices belonging to other lifting appliances in part VI shall be conducted and confirmed by the ship's management.

Entries by the Society's surveyor refer to the recording of newly added certificates, the confirmation of examinations carried out and to special notes.

13.7.3 Certificates

13.7.3.1 Recognition of certificates

Certificates for lifting appliances, 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, the Society may recognize deviating forms or certificates not issued by the Society's surveyors.

13.7.3.2 Certificates for shipboard lifting appliances used for cargo handling

The following forms of certificates are based on ILO model certificates:

- Form CG2
Certificate of test and thorough examination of lifting appliances, product certificate
- Form CG2 (U)
Certificate of test and thorough examination of derricks used in union purchase, product certificate
- Form CG3
Certificate of test and thorough examination of loose gear, product certificate
- Form CG4/LA4
Certificate of test and thorough examination of wire rope, product certificate.

13.7.3.2.1 Load tests are confirmed by Forms CG2 to CG3, tensile tests by Form CG4/LA4.

13.7.3.2.2 Forms CG2 to CG3 are issued new after each load test and subsequent thorough examination of shipboard lifting appliances or load-handling devices made for this equipment.

Interchangeable components used in the tests receive no new certificate.

13.7.3.2.3 The certificates, Forms CG2 to CG3, may include several sets of lifting appliances, interchangeable components or load-handling devices.

13.7.3.2.4 The certificate, Form CG4/LA4, is issued after the stipulated tensile breaking test and examination by the Society's surveyors or firms approved by the Society.

13.7.3.2.5 Newly procured interchangeable components, load-handling devices and ropes shall be taken on board together with their certificates.

13.7.3.2.6 The numbers of all certificates issued on forms CG2 to CG3 shall be entered by the Society's surveyor in the appropriate parts of the register book, Form CG1. This provides the connection between register book and certificates.

13.7.3.2.7 The application of the certification system described in [13.7.3.2] shall be prescribed or agreed.

13.7.3.3 Certificates for shipboard lifting appliances not handling cargo

The following forms of certificates are based on ILO model certificates:

- Form OLA201
Certificate of test and thorough examination of lifting appliances not subject to ILO 152 Convention, product certificate
- Form CG3
Certificate of test and thorough examination of loose gear, product certificate
- Form CG4/LA4
Certificate of test and thorough examination of wire rope, product certificate.

13.7.3.3.1 Load tests are confirmed by Forms OLA201 and CG3, tensile tests by Form CG4/LA4.

13.7.3.3.2 Forms OLA201 and CG3 are issued new after each load test and subsequent thorough examination of shipboard lifting appliances not subject to ILO 152 Convention or load-handling devices made for this equipment.

Interchangeable components used in the tests receive no new certificate.

13.7.3.3.3 The certificates, Forms OLA201 and CG3, may include several sets of lifting appliances, interchangeable components or load-handling devices.

13.7.3.3.4 The certificate, Form CG4/LA4, is issued after the stipulated tensile breaking test and examination by the Society's surveyors or firms approved by the Society.

13.7.3.3.5 Newly procured interchangeable components, load-handling devices and ropes shall be taken on board together with their certificates.

13.7.3.3.6 The numbers of all certificates issued on forms OLA201 and CG3 shall be entered by the Society's surveyor in the appropriate parts of the register book, Form CG1. This provides the connection between register book and certificates.

13.7.3.3.7 The application of the certification system described in [13.7.3.3] shall be prescribed or agreed.

13.7.3.4 Special certificate forms

13.7.3.4.1 The Society's product certificate (general form)

The following certificate form is issued by the Society to confirm tests and examinations of all kinds:

- Society's product certificate.

The Society's product certificate is also issued in conjunction with load tests of load-handling devices and interchangeable components, insofar as these are not put into use on ships, or if the ship is not known.

In special cases, e.g. for particular register books issued by authorities, the Society's product certificate may replace all certificates described in [13.7.3.2] and [13.7.3.3.1].

13.7.3.4.2 Cargo gear inspection certificate (Saudi Arabia)

Following an inspection of shipboard lifting appliances used for cargo-handling, the Society's surveyor may on application issue the following form of certificate:

- Form CGS.301a - Cargo gear inspection certificate (Saudi Arabia).

The certificate Form CGS.301a is based on the national regulations of Saudi Arabia for ships more than 15 years old.

On request by the ship's management, the inspection may be expanded accordingly and counted as the annual examination.

13.7.4 Rigging plans

13.7.4.1 Rigging plans are required by the ILO for derricks used for cargo handling. Lifting appliances not used for cargo handling, are not covered there.

Rigging plans contain information useful for operation and maintenance, and for the procurement of spare parts and repair.

13.7.4.2 Rigging plans, for instance, have information on safe working loads and load radii, ropes, reeving of ropes, marking, arrangement of the lifting appliances on board the ship, working ranges, etc.

13.7.4.3 In the rigging plan examples given in [App.D](#):

- arrangement of lifting appliances, and
- reeving of ropes for lifting appliance,

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 shall be indicated clearly.

13.7.4.4 For construction of the ship, the plans for the arrangement of lifting appliances shall be prepared by the yard, the plans for the reeving of ropes for the lifting appliance by the lifting appliance manufacturer.

13.7.5 Survey reports

13.7.5.1 For each test and/or examination of lifting appliances and load-handling devices, a Survey Report is prepared by the Society's surveyor.

This report may be part of the overall report for the ship.

13.7.6 Documentation for the operator

13.7.6.1 General

13.7.6.1.1 For shipboard lifting appliances, the documentation handed over by the Society consists of the register books including certificates, rigging plans, lists and survey reports in the scope described below.

13.7.6.1.2 Flag administration requirements may prescribe deviating national register books, and authorities may keep their own register books.

13.7.6.2 Scope of documentation

13.7.6.2.1 The Society's register book, Form CG1 (Cargo gear)

In accordance with its intended purpose, this register book contains:

- the Society's certificate(s) Form CG2, where required additionally Form CG2 (U)
- the Society's certificate(s) Form CG3
- the Society's certificate(s) Form CG4/LA4
- rigging plans
- survey reports.

APPENDIX A CALCULATION OF DYNAMIC FORCES DUE TO MOTIONS OF THE SHIP

A.1 General

A.1.1

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 [A.1.2] or [A.1.3].

A.1.2

For the sake of simplification the calculation of the dynamic forces can be conducted according to [A.2.1.2] and [A.2.2.2] with the ship's inclinations in Table A-1 or with agreed ship's inclinations.

A.1.3

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 [A.2.1.3] and [A.2.2.3].

A.1.4

The dynamic forces for rolling and pitching each including also a force component of 20% for heaving shall be considered separately, i.e. as not acting simultaneously.

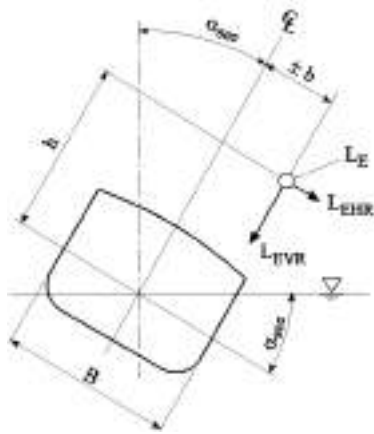
A.1.5

The following approaches apply to monohull ships. With regard to other ship forms such as semi-submersibles, it is recommended that DNV GL be consulted.

A.2 Dynamic forces generated by ships and similar floating bodies

A.2.1 Dynamic forces due to rolling

A.2.1.1 Designations of the dimensions and forces are shown in Figure A-1.



- L_E = dead load [kN]
 α_{sec} = roll angle according to Table A-1 [°]
 b = distance from centre line of ship [m]
 h = height above waterline [m].

Figure A-1 Vertical and horizontal forces due to rolling

A.2.1.2 Calculation of dynamic forces acc. to [A.1.2]

$$L_{EIVR} \approx L_E \cdot \left(1,2 \cdot \cos \alpha_{sec} + \frac{\alpha_{sec} \cdot b \cdot L}{10^3 \cdot B^2} \right) \quad [\text{kN}]$$

$$L_{EHR} \approx L_E \cdot \left(1,2 \cdot \sin \alpha_{sec} + \frac{\alpha_{sec} \cdot h \cdot L}{10^3 \cdot B^2} \right) \quad [\text{kN}]$$

- B = breadth of ship [m]
 L = length of ship between perpendiculars [m].

A.2.1.3 Calculation of dynamic forces acc. to [A.1.3]

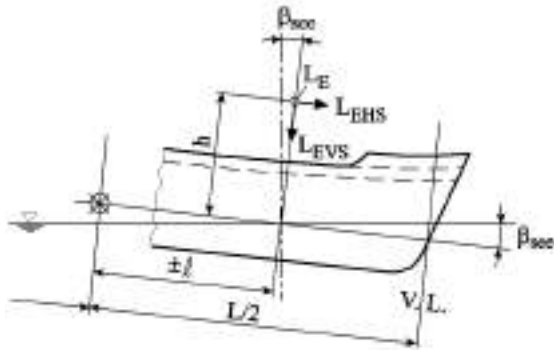
$$L_{EIVR} = L_E \cdot \left[\left(1 + \frac{L}{20 \cdot T_T^2} \right) \cdot \cos \alpha_{sec} + \frac{\alpha_{sec} \cdot b}{14,3 \cdot T_R^2} \right] \quad [\text{kN}]$$

$$L_{EHR} = L_E \cdot \left[\left(1 + \frac{L}{20 \cdot T_T^2} \right) \cdot \sin \alpha_{sec} + \frac{\alpha_{sec} \cdot h}{14,3 \cdot T_R^2} \right] \quad [\text{kN}]$$

- T_T = natural period of heaving [s]
 T_R = natural period of rolling [s].

A.2.2 Dynamic forces due to pitching

A.2.2.1 Designations of the dimensions and forces are shown in [Figure A-2](#).



β_{sec} = pitch angle according to [Table A-1](#) [°]
 = distance from midship section, ahead or astern [m]
 V.L. = fore perpendicular.

Figure A-2 Vertical and horizontal forces due to pitching

A.2.2.2 Calculation of dynamic forces according to [\[A.1.2\]](#)

$$L_{EVS} \approx L_E \cdot \left(1.2 \cdot \cos \beta_{sec} + \frac{\beta_{sec} \cdot \ell}{3.6 \cdot L} \right) \quad [\text{kN}]$$

$$L_{EHS} \approx L_E \cdot \left(1.2 \cdot \sin \beta_{sec} + \frac{\beta_{sec} \cdot h}{3.6 \cdot L} \right) \quad [\text{kN}]$$

A.2.2.3 Calculation of dynamic forces according to [\[A.1.3\]](#)

$$L_{EVS} = L_E \cdot \left[\left(1 + \frac{L}{20 \cdot T_p^2} \right) \cdot \cos \beta_{sec} + \frac{\beta_{sec} \cdot \ell}{14.3 \cdot T_p^2} \right] \quad [\text{kN}]$$

$$L_{EHS} = L_E \cdot \left[\left(1 + \frac{L}{20 \cdot T_p^2} \right) \cdot \sin \beta_{sec} + \frac{\beta_{sec} \cdot h}{14.3 \cdot T_p^2} \right] \quad [\text{kN}]$$

T_p = natural period of pitching [s].

A.3 Dynamic forces due to pontoons or barges

The following requirements are based on the calculations in [A.2.1] and [A.2.2].

A.3.1 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 [A.2.1.3]).

A.3.2 Dynamic forces due to pitching

For the calculation of dynamic forces due to pitching, the approaches in [A.2.4] 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	$\pm 30^\circ$	$\pm 12 \cdot e^{(-L / 250)}$
Pontoons/ barges	$\pm (3^\circ + \Delta\alpha_{see})^1$	$\pm (1.5^\circ + \Delta\beta_{see})^2$
Semi-submersibles ³	$\pm 6^\circ$	$\pm 6^\circ$

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 DNV GL, see [A.1.5]

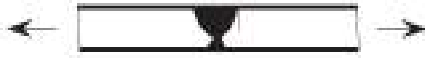

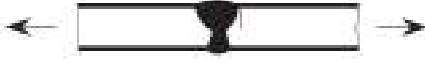


APPENDIX B DETAIL CLASSIFICATION FOR FATIGUE STRENGTH ANALYSIS (FAT CLASSES)

B.1

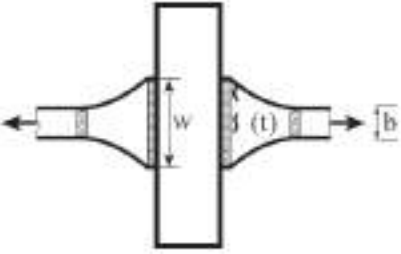
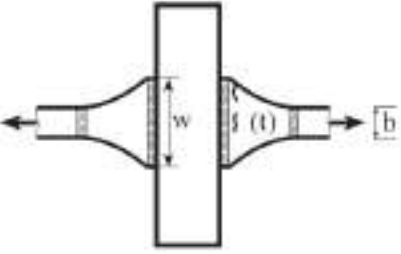
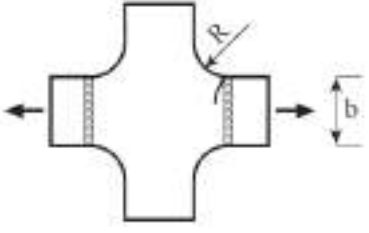
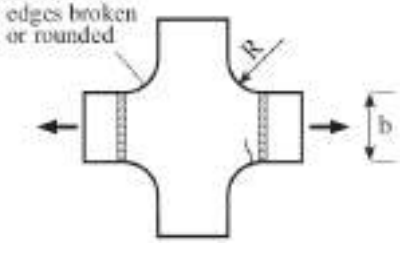
Following tables specify FAT classes of typical structural details.

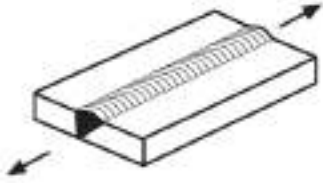
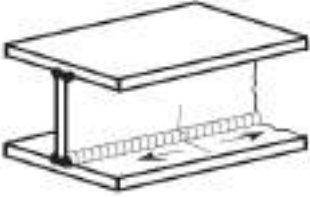
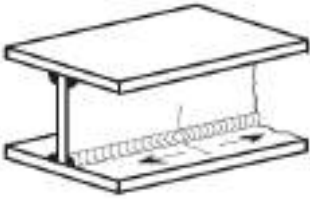
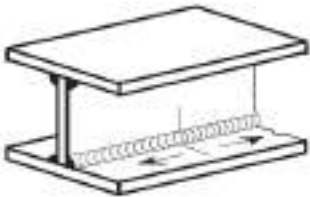
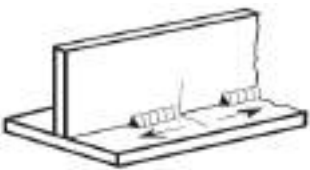
Further detail classifications as stated in EN 1993-1-9 can be used as well.

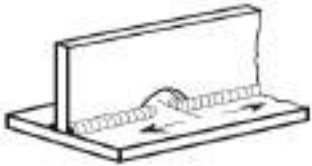
Table B-1 Catalogue of details

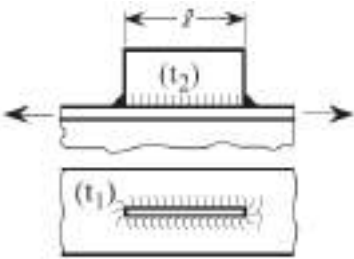
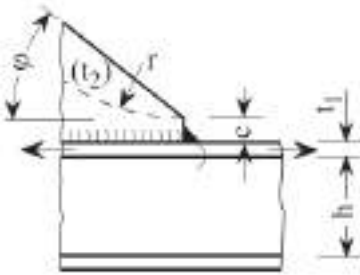
<i>Butt welds, transverse loaded (A)</i>				
<i>Type No.</i>	<i>Joint configuration showing mode of fatigue cracking and stress σ considered</i>	<i>Description of joint</i>	<i>FAT class $\Delta\sigma_R$</i>	
			<i>Steel</i>	<i>Al</i>
A1		Transverse butt weld ground flush to plate, 100% NDT (Non-Destructive Testing)	112	45
A2		Transverse butt weld made in shop in flat position, max. weld reinforcement 1 mm + 0.1 · weld width, smooth transitions, NDT	90	36
A3		Transverse butt weld not satisfying conditions for joint type No. A2, NDT	80	32
A4		Transverse butt weld on backing strip or threeplate connection with unloaded branch Butt weld, welded on ceramic backing, root crack	71	25
			80	28

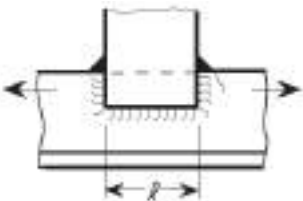
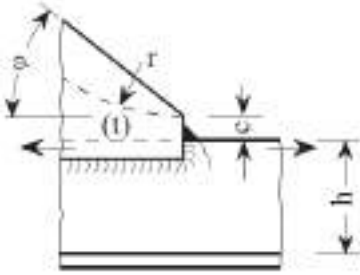
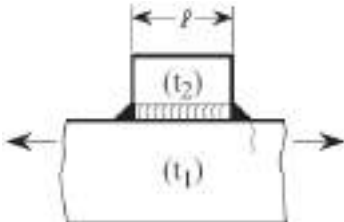
<i>Butt welds, transverse loaded (A)</i>				
<i>Type No.</i>	<i>Joint configuration showing mode of fatigue cracking and stress σ considered</i>	<i>Description of joint</i>	<i>FAT class $\Delta\sigma_R$</i>	
			<i>Steel</i>	<i>Al</i>
A5		Transverse butt welds between plates of different widths or thickness, NDT as for joint type No. A2: slope 1:5 slope 1:3 slope 1:2 as for joint type No. A3: slope 1:5 slope 1:3 slope 1:2 For the third sketched case the slope results from the ratio of the difference in plate thicknesses to the breadth of the welded seam. Additional bending stress due to thickness change to be considered.	90	32
			80	28
			71	25
A6		Transverse butt welds welded from one side without backing bar, full penetration root: — controlled by NDT — not controlled by NDT For tubular profiles $\Delta\sigma_R$ may be lifted to the next higher FAT class. Laser ($t \leq 8$ mm) and laser hybrid ($t \leq 12$ mm) butt welds	71	28
			36	12
			80	28
A7		Partial penetration butt weld; the stress shall be related to the weld throat sectional area, weld overfill not to be taken into account	36	12
A8		Full penetration butt weld at crossing flanges Welded from both sides	50	18

Butt welds, transverse loaded (A)				
Type No.	Joint configuration showing mode of fatigue cracking and stress σ considered	Description of joint	FAT class $\Delta\sigma_R$	
			Steel	Al
A9		<p>Full penetration butt weld at crossing flanges Welded from both sides Cutting edges in the quality according to type E2 or E3 Connection length $w \geq 2 \cdot b$ Nominal stress $\sigma_{nominal} = \frac{F}{b \cdot t}$</p>	63	22
A10		<p>Full penetration butt weld at crossing flanges Welded from both sides, NDT, weld ends ground, butt weld ground flush to surface Cutting edges in the quality according to type E2 or E3 with $\Delta\sigma_R = 125$ Connection length $w \geq 2 \cdot b$ Nominal stress $\sigma_{nominal} = \frac{F}{b \cdot t}$</p>	80	32
A11		<p>Full penetration butt weld at crossing flanges Welded from both sides made in shop at flat position, radius transition with $R \geq b$ Weld reinforcement $\leq 1 \text{ mm} + 0.1 \times \text{weld width}$, smooth transitions, NDT, weld ends ground Cutting edges in the quality according to type E2 or E3 with $\Delta\sigma_R = 125$</p>	90	36
A12		<p>Full penetration butt weld at crossing flanges, radius transition with $R \geq b$ Weld from both sides, no misalignment, 100% NDT, weld ends ground, butt weld ground flush to surface Cutting edges broken or rounded according to type E2</p>	100	40

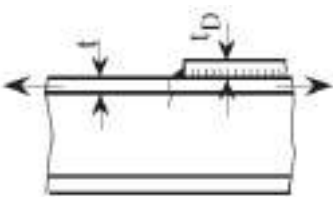
<i>Longitudinal load-carrying weld</i>				
<i>Type No.</i>	<i>Joint configuration showing mode of fatigue cracking and stress σ considered</i>	<i>Description of joint</i>	<i>FAT class $\Delta\sigma_R$</i>	
			<i>Steel</i>	<i>Al</i>
B1		Longitudinal butt welds both sides ground flush parallel to load direction without start / stop positions, NDT with start / stop positions	125 125 90	50 50 36
B2		Continuous automatic longitudinal fully penetrated K-butt without stop / start positions (based on stress range in flange adjacent to weld)	125	50
B3		Continuous automatic longitudinal fillet weld penetrated K-butt weld without stop/start positions (based on stress range in flange adjacent to weld)	100	40
B4		Continuous manual longitudinal fillet or butt weld (based on stress range in flange adjacent to weld)	90	36
B5		Intermittent longitudinal fillet weld (based on stress range in flange at weld ends) In presence of shear τ in the web, the FAT class has to be reduced by the factor $(1 - \Delta\tau / \Delta\sigma)$, but not below 36 (steel) or 14 (Al).	80	32

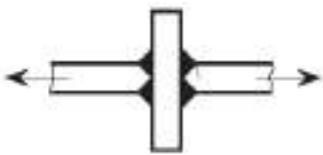
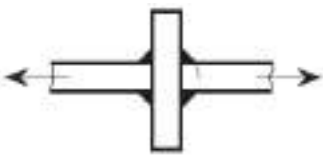
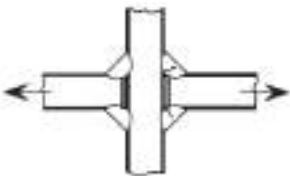
Longitudinal load-carrying weld				
Type No.	Joint configuration showing mode of fatigue cracking and stress σ considered	Description of joint	FAT class $\Delta\sigma_R$	
			Steel	Al
B6		<p>Longitudinal butt weld, fillet weld or intermittent fillet weld with cut outs (based on stress range in flange at weld ends)</p> <p>If cut out is higher than 40% of web height</p> <p>In presence of shear τ in the web, the FAT class has to be reduced by the factor $(1 - \Delta\tau / \Delta\sigma)$, but not below 36 (steel) or 14 (Al).</p> <p>Note</p> <p>For Ω-shaped scallops, an assessment based on local stresses is recommended.</p>	71	28
			63	25

Non-load-carrying attachments				
Type No.	Joint configuration showing mode of fatigue cracking and stress σ considered	Description of joint	FAT class $\Delta\sigma_R$	
			Steel	Al
C1		<p>Longitudinal gusset welded on beam flange, bulb or plate:</p> <p>$t \leq 50$ mm</p> <p>$50 \text{ mm} < t \leq 150$ mm</p> <p>$150 \text{ mm} < t \leq 300$ mm</p> <p>$t > 300$ mm</p> <p>For $t_2 \leq 0.5 t_1$, $\Delta\sigma_R$ may be increased by one class, but not over 80 (steel) or 28 (Al); not valid for bulb profiles.</p> <p>When welding close to edges of plates or profiles (distance less than 10 mm) and/or the structural element is subjected to bending, $\Delta\sigma_R$ shall be decreased by one class.</p>	80	28
			71	25
			63	20
			63	20
			56	18
C2		<p>Gusset with smooth transition (sniped end or radius) welded on beam flange, bulb or plate;</p> <p>$c \leq 2 \cdot t_2$, max. 25 mm</p> <p>$r \geq 0.5 h$</p> <p>$r < 0.5 h$ or $\phi \leq 20^\circ$</p> <p>$\phi > 20^\circ$ see joint type C1</p> <p>For $t_2 \leq 0.5 t_1$, $\Delta\sigma_R$ may be increased by one class; not valid for bulb profiles.</p> <p>When welding close to the edges of plates or profiles (distance less than 10 mm), $\Delta\sigma_R$ shall be decreased by one class.</p>	71	25
			63	20

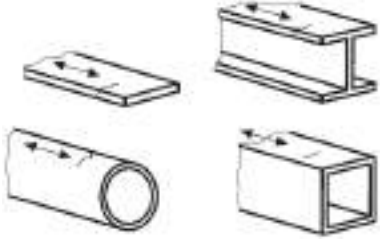

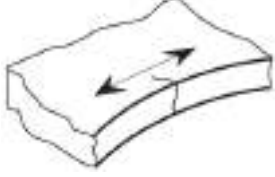
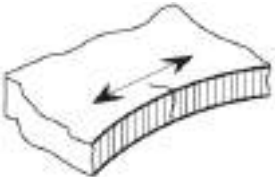
Non-load-carrying attachments				
Type No.	Joint configuration showing mode of fatigue cracking and stress σ considered	Description of joint	FAT class $\Delta\sigma_R$	
			Steel	Al
C3		<p>Fillet welded non-load-carrying lap joint welded to longitudinally stressed component.</p> <ul style="list-style-type: none"> — flat bar — to bulb section — to angle section <p>For $l > 150$ mm, $\Delta\sigma_R$ has to be decreased by one class, while for $l \leq 50$ mm, $\Delta\sigma_R$ may be increased by one class.</p> <p>If the component is subjected to bending, $\Delta\sigma_R$ has to be reduced by one class.</p>	56	20
			56	20
			50	18
C4		<p>Fillet welded lap joint with smooth transition (sniped end with $\varphi \leq 20^\circ$ or radius) welded to longitudinally stressed component.</p> <ul style="list-style-type: none"> — flat bar — to bulb section — to angle section <p>$c \leq 2 \cdot t$, max. 25 mm</p>	56	20
			56	20
			50	18
C5		<p>Longitudinal flat side gusset welded on plate or beam flange edge</p> <ul style="list-style-type: none"> — $l \leq 50$ mm — $50 \text{ mm} < l \leq 150$ mm — $150 \text{ mm} < l \leq 300$ mm — $l > 300$ mm <p>For $t_2 \leq 0.7 t_1$, $\Delta\sigma_R$ may be increased by one class, but not over 56 (steel) or 20 (Al).</p> <p>If the plate or beam flange is subjected to in-plane bending, $\Delta\sigma_R$ has to be decreased by one class.</p>	56	20
			50	18
			45	16
			40	14

Non-load-carrying attachments				
Type No.	Joint configuration showing mode of fatigue cracking and stress σ considered	Description of joint	FAT class $\Delta\sigma_R$	
			Steel	Al
C6		<p>Longitudinal flat side gusset welded on plate edge or beam flange edge, with smooth transition (sniped end or radius):</p> <p>$c \leq 2 \cdot t_2$, max. 25 mm</p> <p>$r \geq 0.5 h$</p> <p>$r < 0.5 h$ or $\phi \leq 20^\circ$</p> <p>$\phi > 20^\circ$ see joint type C5</p> <p>For $t_2 \leq 0.7 t_1$, $\Delta\sigma_R$ may be increased by one class.</p>	50 45	18 16
C6a		<p>Longitudinal flat side gusset welded on plate edge or beam flange edge, with smooth transition radius</p> <p>$r / h > 1 / 3$ or $r \geq 150$ mm</p> <p>$1 / 6 < r / h < 1 / 3$</p> <p>$r / h < 1 / 6$</p> <p>Smooth transition radius formed by grinding the full penetration weld area in order to achieve a notch-free transition area. Final grinding shall be performed parallel to stress direction.</p>	90 71 50	36 28 22
C7		<p>Transverse stiffener with fillet welds (applicable for short and long stiffeners)</p>	80	28
C8		<p>Non-loaded stud welding on a plate or bulb profile</p> <p>Note</p> <p>For an adequate workmanship on bulb profile a centric connection is required.</p> <p>For load carrying studs an additional assessment acc. to detail D7 is required.</p>	80	28

Non-load-carrying attachments				
Type No.	Joint configuration showing mode of fatigue cracking and stress σ considered	Description of joint	FAT class $\Delta\sigma_R$	
			Steel	Al
C9		End of long doubling plate on beam, welded ends (based on stress range in flange at weld toe)		
		$t_D \leq 0.8 \cdot t$	56	20
		$0.8 \cdot t < t_D \leq 1.5 \cdot t$	50	18
		$t_D > 1.5 \cdot t$	45	16
		The following features increase $\Delta\sigma_R$ by one class accordingly: <ul style="list-style-type: none"> reinforced ends according to Section 10, Figure 5 weld toe angle $\leq 30^\circ$ length of doubling ≤ 300 mm 		
		For length of doubling ≤ 150 mm, $\Delta\sigma_R$ may be increased by two classes.		

Cruciform joints and T-joints				
Type No.	Joint configuration showing mode of fatigue cracking and stress σ considered	Description of joint	FAT class $\Delta\sigma_R$	
			Steel	Al
D1		Cruciform or tee-joint K-butt welds with full penetration or with defined incomplete root penetration. cruciform joint tee-joint	71	25
			80	28
D2		Cruciform or tee-joint with transverse fillet welds, toe failure (root failure particularly for throat thickness $a < 0.7 \cdot t$, see joint type D3) cruciform joint tee-joint	63	22
			71	25
D3		Welded metal in transverse load-carrying fillet welds at cruciform or tee-joint, root failure (based on stress range in weld throat), see also joint type No. D2 $a \geq t / 3$ $a < t / 3$ Note Crack initiation at weld root	36	12
			40	14

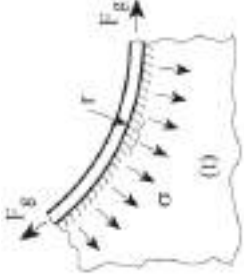

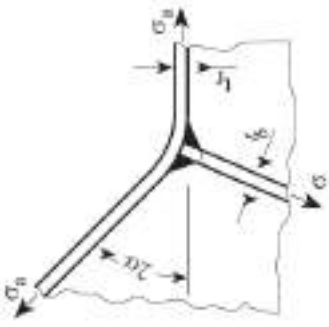

<i>Cruciform joints and T-joints</i>				
<i>Type No.</i>	<i>Joint configuration showing mode of fatigue cracking and stress σ considered</i>	<i>Description of joint</i>	<i>FAT class $\Delta\sigma_R$</i>	
			<i>Steel</i>	<i>Al</i>
D4		<p>Full penetration weld at the connection between a hollow section (e.g. pillar) and a plate, for tubular section</p> <p>for rectangular hollow section</p> <p>For $t \leq 8$ mm, $\Delta\sigma_R$ has to be decreased by one class.</p>	56 50	20 18
D5		<p>Fillet weld at the connection between a hollow section (e.g. pillar) and a plate, for tubular section</p> <p>for rectangular hollow section</p> <p>The stress shall be related to the weld sectional area. For $t \leq 8$ mm, $\Delta\sigma_R$ has to be decreased by one class.</p>	45 40	16 14
D6		<p>Continuous butt or fillet weld connecting a pipe penetrating through a plated</p> <p>≤ 50 mm</p> <p>$d > 50$ mm</p> <p>Note</p> <p>For large diameters an assessment based on local stress is recommended.</p>	71 63	25 22
D7		<p>Axially loaded stud welding on a bulb profile</p> <p>Note</p> <p>For an adequate workmanship a centric connection is required</p>	45	16

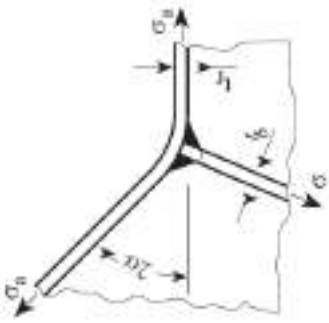
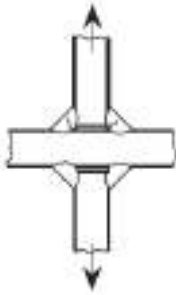
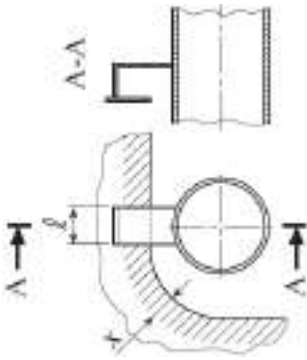
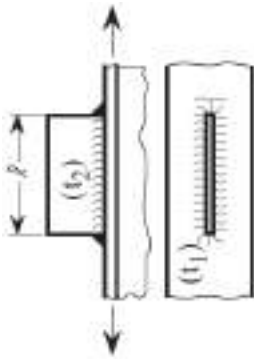
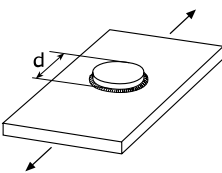
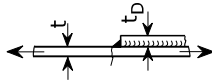
Cruciform joints and T-joints				
Type No.	Joint configuration showing mode of fatigue cracking and stress σ considered	Description of joint	FAT class $\Delta\sigma_R$	
			Steel	Al
E1		Rolled or extruded plates and sections as well as seamless pipes, no surface or rolling defects	160 ($m_0 = 5$)	71 ($m_0 = 5$)
E2a		Plate edge sheared or machine-cut by any thermal process with surface free of cracks and notches, cutting edges chamfered or rounded by means of smooth grinding, groove direction parallel to the loading direction. Stress increase due to geometry of cut-outs to be considered by means of direct numerical calculation of the appertaining maximum notch stress range.	150 ($m_0 = 4$)	---
E2		Plate edge sheared or machine-cut by any thermal process with surface free of cracks and notches, cutting edges broken or rounded. Stress increase due to geometry of cut-outs to be considered. ¹	140 ($m_0 = 4$)	40 ($m_0 = 4$)
E3		Plate edge not meeting the requirements of type E2, but free from cracks and severe notches. Machine cut or sheared edge: Manually thermally cut: Stress increase due to geometry of cut-outs to be considered. ¹	125 ($m_0 = 3.5$) 100 ($m_0 = 3.5$)	36 ($m_0 = 3.5$) 32 ($m_0 = 3.5$)

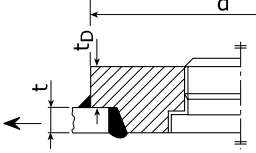
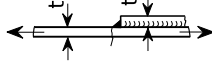
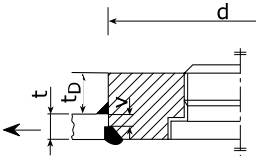
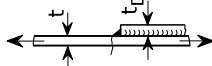

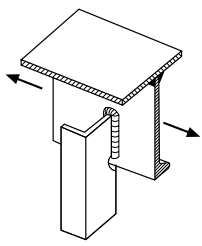
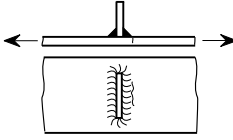


<i>Cruciform joints and T-joints</i>					
<i>Type No.</i>	<i>Joint configuration showing mode of fatigue cracking and stress σ considered</i>	<i>Description of joint</i>	<i>FAT class $\Delta\sigma_R$</i>		
			<i>Steel</i>	<i>Al</i>	
1)	Stress concentrations caused by an opening to be considered as follows: $\Delta\sigma_{max} = K_t \cdot \Delta\sigma_N$ K_t = Notch factor according to a recognized standard (subject to agreement with DNV GL) $\Delta\sigma_N$ = Nominal stress range related to net section Alternatively direct determination of $\Delta\sigma_{max}$ from FE-calculation, especially in case of hatch openings or multiple arrangement of openings.				
Partly based on Recommendations on Fatigue of Welded Components, reproduced from IIW document XIII-2151-07 / XV-1254-07, by kind permission of the International Institute of Welding.					

Table B-2 Examples of details

Structure or equipment detail	Description of structure or equipment detail	Type No.	Joint configuration showing mode of fatigue cracking and stress σ considered	Description of joint	FAT class $\Delta\sigma_R$ steel
	<p>Unstiffened flange to web joint, to be assessed according to type D1, D2 or D3, depending on the type of joint.</p> <p>The stress in the web is calculated using the force F_G in the flange as follows: $\sigma = F_G / (r \cdot t)$</p> <p>Furthermore, the stress in longitudinal weld direction has to be assessed according to type B2 – B4. In case of additional shear or bending, also the highest principle stress may become relevant in the web.</p>	D1		<p>Cruciform or tee-joint K-butt welds with full penetration or with defined incomplete root penetration</p> <p>cruciform joint</p> <p>tee-joint</p>	71 80
	<p>Joint at stiffened knuckle of a flange, to be assessed according to type D1, D2 or D3, depending on the type of joint.</p> <p>The stress in the stiffener at the knuckle can normally be calculated as follows: $\sigma = \sigma_a (t_f / t_b) \cdot 2 \cdot \sin \alpha$</p>	D2		<p>Cruciform or tee-joint with transverse fillet welds, toe failure (root failure particularly for throat thickness</p> <p>$a < 0.7 \cdot t$, see joint type D3)</p> <p>cruciform joint</p> <p>tee-joint</p>	63 71

Structure or equipment detail	Description of structure or equipment detail	Type No.	Joint configuration showing mode of fatigue cracking and stress σ considered	Description of joint	FAT class $\Delta\sigma_R$ steel
	<p>Joint at stiffened knuckle of a flange, to be assessed according to type D1, D2 or D3, depending on the type of joint.</p> <p>The stress in the stiffener at the knuckle can normally be calculated as follows:</p> $\sigma = \sigma_a (t_f / t_b) \cdot 2 \cdot \sin \alpha$	D3		<p>Welded metal in transverse load-carrying fillet welds at cruciform or tee-joint, root failure (based on stress range in weld throat), see also joint type no. D2</p>	36
	<p>Holder welded in way of an opening and arranged parallel to the edge of the opening</p> <p>not valid for hatch corner</p>	D4		<p>$l \leq 150$ mm</p> <p>In way of the rounded corner of an opening with the radius r a minimum distance x from the edge to be kept (hatched area):</p> $X[\text{mm}] = 15 + 0.175 \cdot r[\text{mm}]$ <p>$100 \text{ mm} \leq r \leq 400 \text{ mm}$</p> <p>In case of an elliptical rounding the mean value of both semiaxes to be applied</p>	71
	<p>Circular doubler plate with maximum 150mm diameter</p>	C9		<p>$t_d \leq 0.81 t$</p> <p>$0.8 t < t_d \leq 1.5 t$</p> <p>$t_D > 1.5 t$</p>	<p>71</p> <p>63</p> <p>56</p>

Structure or equipment detail	Description of structure or equipment detail	Type No.	Joint configuration showing mode of fatigue cracking and stress σ considered	Description of joint	FAT class $\Delta\sigma_R$ steel
	Drain plugs with full penetration weld $d \leq 150$ mm Assesment according to doubling plate	C9		$t_d \leq 0.81 t$ $0.8 t < t_d \leq 1.5 t$ $t_D > 1.5 t$ For $d > 150$ mm $\Delta\sigma_R$ shall be increased by one class	50 63 56
	Drain plugs with partial penetration butt weld and defined root gap $d \leq 150$ mm For $v < 0.4 t$ or $v < 0.4 t_D$	C9		$0.2 t < t_D \leq 0.8 t$ $0.8 t < t_D \leq 1.5 t$ $1.5 t < t_D \leq 2.0 t$ For $d > 150$ mm $\Delta\sigma_R$ shall be increased by one class	50 45 40
	For $v \geq 0.4 t$ and $v \geq 0.4 t_D$	A7		For partial penetration butt weld; the stress shall be related to the weld throat sectional area, weld overfill shall not be taken into account	36
	The detail category is also valid for not fully circumferential welded holders For stiffeners loaded in bending $\Delta\sigma_R$ shall be downgraded by one class	C7		Transverse stiffener with fillet welds (applicable for short and long stiffeners)	80



APPENDIX C WIND LOADS, FORM AND SHELTERING COEFFICIENTS

C.1 General

C.1.1

For the determination of wind loads acting on shipboard lifting appliances, it is normally sufficient to use simplified form coefficients and to consider wind load reductions of areas arranged behind one another according to [4.2.4.5.4] and [4.2.4.5.5].

C.1.2

Using form and sheltering coefficients from this appendix, which depend on various parameters, may lead to a reduction of wind loads, if compared to the statements in Sec.5.

C.2 Form coefficients c_f

C.2.1

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.

C.2.2

The form coefficients in Table C-1 depend on the aerodynamic slenderness ratio, see Figure C-1.

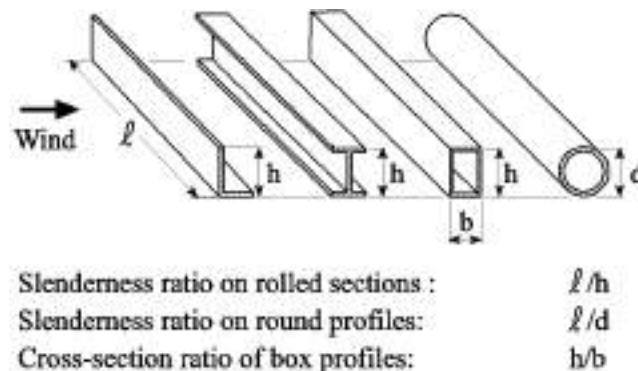
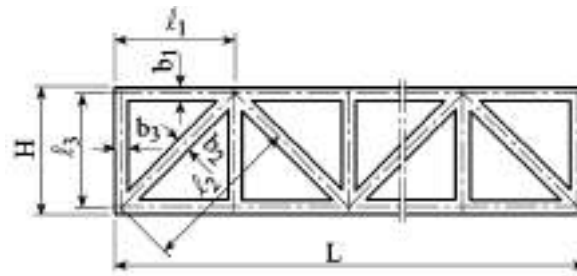


Figure C-1 Aerodynamic slenderness ratio and section ratio

C.2.3

Where, in the case of lattice constructions, the distance between nodes is defined as the length of the individual structural elements, see Figure C-2, normally dimensioned gusset plates need not be considered.



$$\text{Area ratio} = \frac{A_B}{A_U} = \sum_1^n \frac{l_1 \cdot b_1}{L \cdot H}$$

A_B = Area of components [m²]
 A_U = Contour area [m²]

Figure C-2 Area ratio

C.2.4

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.

C.2.5

As an alternative to [\[C.2.4\]](#), 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.3 Sheltering coefficients η

C.3.1

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 according to [Table C-2](#).

C.3.2

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.

Table C-1 Form coefficients c_f

Component groups	Description	Aerodynamic slenderness ratio l/h or l/d ¹						
		≤ 5	10	20	30	40	≥ 50	
Components	rolled profiles 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 $d \cdot v < 6 \text{ m}^2/\text{s}$ $d \cdot v \geq 6 \text{ m}^2/\text{s}$	0.7	0.75	0.8	0.85	0.9	1.0	
	box profiles square $h \geq 0.4$ m rectangular $h \geq 0.5$ m	h/b ¹						
		≥ 2	1.55	1.75	1.95	2.10	2.2	
		1	1.5	1.55	1.75	1.85	1.9	
0.5		1.0	1.2	1.3	1.35	1.4		
	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 $d \cdot v < 6 \text{ m}^2/\text{s}$	1.1						
	$d \cdot v \geq 6 \text{ m}^2/\text{s}$	0.8						
Machine houses, etc.	rectangular, enclosed constructions on a solid bottom plate	1.1						
1) See Figure C-1 2) v = wind speed according to [4.2.4.5.3]								

C.3.3

The wind load on areas arranged one after another is calculated as follows:

- first area: $L_{W1} = q \cdot c_f \cdot A_w$ ([\[4.2.4.5.2\]](#))
- second area: $L_{W2} = L_{W1} \cdot \eta$
- n^{th} area: $L_{Wn} = L_{W1} \cdot \eta^{(n-1)} \geq L_{W1} \cdot 0.1$
- 9^{th} and following areas: $L_{W9} = L_{W1} \cdot \eta^8 \geq L_{W1} \cdot 0.1$.

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 [Figure C-2](#)
- 2) See [Figure C-3](#)

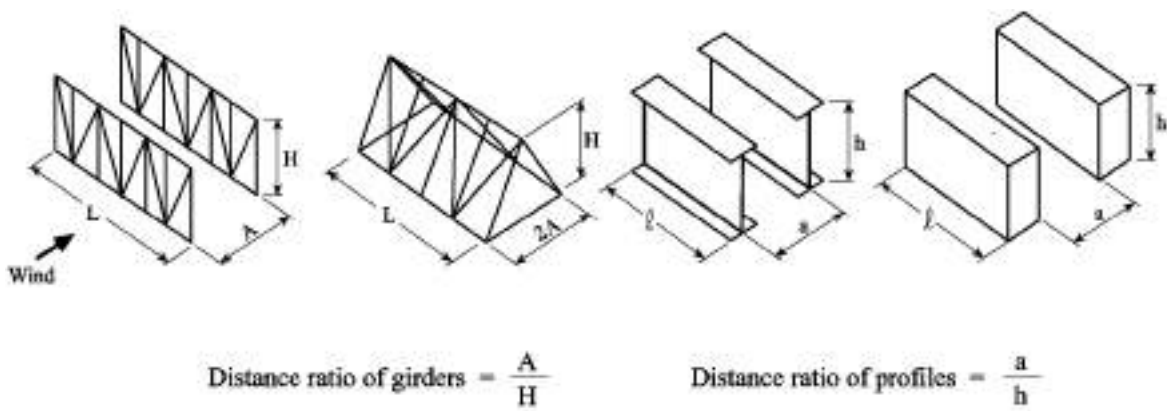


Figure C-3 Distance ratio



CHANGES – HISTORIC

May 2016 edition

This is a new document

About DNV GL

DNV GL is a global quality assurance and risk management company. Driven by our purpose of safeguarding life, property and the environment, we enable our customers to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas, power and renewables industries. We also provide certification, supply chain and data management services to customers across a wide range of industries. Operating in more than 100 countries, our experts are dedicated to helping customers make the world safer, smarter and greener.

SAFER, SMARTER, GREENER