



Lifting Appliances

OCTOBER 2011

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FOREWORD

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Standards for Certification

Standards for Certification (previously Certification Notes) are publications that contain principles, acceptance criteria and practical information related to the Society's consideration of objects, personnel, organisations, services and operations. Standards for Certification also apply as the basis for the issue of certificates and/or declarations that may not necessarily be related to classification.

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CHANGES

This issue supersedes Standard for Certification No. 2.22 of October 2008.

Text affected by the main changes is highlighted in red colour. However, where the changes involve a whole section or sub-section, only the title may be in red colour.

Main changes

- Extensive re-organization of the entire Standard, based on new crane type categorizations.
- Change in categorization of lifting appliances.
- Implemented crane design definitions.
- Documentation requirements and certification requirements are moved to chapter 1. The requirements are listed in tables and follows general description given in Ship Rules.
- Change in structural categorization.
- Requirements to mechanical properties for steel forgings are given through reference to ship rules.
- Group classification of lifting appliances has been partly removed and partly moved to Ch.2 Sec.2 C400 Checking with respect to fatigue.
- Added description for operational brake for winch.
- Requirements to gear transmissions implemented.
- Section Conventional cargo gear, cargo ramps and movable cargo decks removed. Requirements to cargo ramps and movable cargo decks included in Ch.2 Sec.3.
- Established new sections for Shipboard and Industrial Cranes, Offshore Cranes, Subsea Cranes, Heavy Lift Cranes, Lifting of Personnel, Launch and Recovery Systems for Diving and Launch and Recovery Arrangement for ROV.
- Appendix E: Description of handling of Pad eyes in A200 replaces description of handling of brackets.

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STANDARD FOR CERTIFICATION OF LIFTING APPLIANCES

NO. 2.22

CHAPTER 1

GENERAL

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SECTION 1 GENERAL INFORMATION

A. Objectives and Principles

A 100 Introduction

101 This Standard for Certification provides criteria and guidance for certification and verification of the design, materials, fabrication, installation, testing and commissioning of lifting appliances.

A 200 Hierarchy of documents

201 The Standard for Certification consists of a three level hierarchy of documents.

- Chapter 1 “General” Provides principles and procedures of DNV classification, certification, verification- and – consultancy services.
- Chapter 2 “Technical Requirements” Provides technical provisions and acceptance criteria as well as the technical basis for the services stated in Chapter 1.
- Appendices. Provide proven technology and sound engineering practice as well as guidance for the higher level documents mentioned in Chapter 1 and Chapter 2.

A 300 Principles for application of requirements

301 The standard selected for the design of a lifting appliance should be applied consequently from concept design through the final construction, including major modifications.

302 Requirements presented herein are minimum requirements to be satisfied, but shall take into account available technological and technical at the time of application for certification. Prescriptive requirements are not intended to inhibit application of practical improvements.

303 The requirements of this Standard for Certification may be supplemented with additional requirements where installation of specific design or assessment shows that higher standards are more appropriate.

A 400 Deviation from the requirements

401 Without prejudice to 302, deviations from the requirements of this Standard may only be substituted where shown to provide an equivalent or higher level of integrity or safer than under this standard.

402 At the Society’s discretion it can accept equivalent solutions and exemptions from the requirements of this Standard.

A 500 Conflicting codes

501 In case of conflict between requirements of this Standard for Certification and a reference document, the requirements of this certification standard shall prevail.

A 600 Date of reference of applied codes

601 Where reference is made to codes other than DNV documents, the valid revision shall be taken as the revision which was current at the date of issue of this Standard, unless otherwise noted.

A 700 Organization of this Standard for Certification

701 It is a principal object of the certification standard to distinguish clearly between:

- information and description of services
- requirements.

Consequently, these two subjects are separated, and the Standard for Certification is divided into three parts:

- Chapter 1: General information, application, definitions and references. Description of applicable services and relations to rules and regulation from institutions other than DNV.
- Chapter 2: Requirements and technical provisions.
- Appendices (included in Ch.2).

B. Application

B 100 Applicable use

101 This standard is mainly intended for cranes and other lifting appliances onboard ships and offshore installations.

102 The Standard also applies to mobile cranes, i.e. crane that are transported by vehicle or other means from

one location to another, and cranes that can move long distances by road by means of their own machinery and wheel arrangement. In the latter case the moving machinery and its arrangement as well as the overturning stability of the mobile crane are not covered by the certification.

103 The Standard does not apply to cable cranes, personnel lifts (elevators), jacks, overhead drilling equipment, fork lifts, portable hoisting gear etc.

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

105 Lifting appliances rated to a safe working load of less than 10 kN will be especially considered.

B 200 Function for lifting appliance

201 Each lifting appliance has its separate intended functions. Examples of intended functions are: Cargo handling in within deck area, loading and discharging of offshore supply vessels, launch and recovery of diving systems, launch and recovery of ROV, loading and discharging from sea or sea bed, personnel handling, handling of ramps and movable cargo decks.

B 300 Categorisation

301 Categorisation will be based on intended function for the lifting appliances. Each lifting appliance shall be categorised as one of the following:

a) Shipboard cranes:

- Lifting appliances onboard vessels intended for cargo handling within and outside the vessel while in harbour or in sheltered waters, and within the vessel while at sea.

b) Offshore cranes:

- Lifting appliances on board vessels intended for cargo handling outside the vessel while at sea.

c) Industrial cranes:

- Lifting appliances onshore or offshore and not belonging to the categories mentioned above.

Guidance note:

Hose handling cranes intended for operation outside the deck area in open sea may normally be categorised as shipboard cranes.

Cranes intended for operating from a vessel in jacked up condition to other fixed installation will be categorised as shipboard cranes.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

C. Definitions, Abbreviations, Symbols and References

C 100 General

101 *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.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

102 *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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103 *Actual hook load*

The static weight of the load attached to the hook; includes the useful load lifted plus any *loose gear* used, such as slings, lifting beams, etc.

104 *Additional Equipment and System Notation*

Code used by the classification societies to confirm that a vessel possesses certain systems, equipment or features covered by the classification. (Examples are **HELDK**, **CRANE**, **E0** and **F-AMC**).

Guidance note:

E0 means that the vessel complies with requirements for having unattended machinery space and **F-AMC** means that the vessel complies with requirements for additional fire protection, in this case both for Accommodation, Machinery space and Cargo space.

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105 Additional Service and Type Notation

Code used by the classification societies to define a type of vessel related to its most typical service. (*Tanker for Oil, Passenger Vessel and Crane Vessel* are typical examples).

106 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.

107 Certificate of Conformity

A document attesting that a product or service is in conformity with specific standards or technical specifications. (ISO “*Certification - Principles and practice.*”, 1980).

108 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.

109 Crane stiffness

Coefficient defined as the weight attached to the hook necessary to obtain a unit deflection at the hook level.

110 Customer

Signifies the party who has requested the Society’s service.

111 Dead loads

All the loads of constant magnitude and position that act permanently on the structure or member and that are not subjected to inertia forces. The *working load* is not included in the dead load.

112 Designer

Signifies a party who creates documentation submitted to the Society for approval or information.

113 Design approval

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

Guidance note:

Only drawings are subject for design approval. Descriptions, specifications, calculations, etc. are not considered for approval.

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Guidance note:

In DNV’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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114 Design approval letter

Written confirmation of a design approval.

115 Design Assessment for Type Approval

Examination 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.

116 Design dynamic factor

The dynamic factor applied to the working load for a specific SWL

Guidance note:

For an offshore crane the design dynamic factor is normally referred to the still water condition for determining the SWL at still water. The design dynamic factor may, however, be defined also to refer to a specified significant wave height.

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117 Design Verification Report (DVR)

Formalized report confirming the result of a completed verification assignment.

118 DNV inspection certificate 3.2

A document signed by a surveyor of the Society and accepted by the manufacturer’s authorized inspection

representative, covering the results of the required tests. It shall certify that the tests have been carried out by the manufacturer in the presence of the surveyor according to the Rules or according to special agreement on samples taken from the delivered products direct.

119 *Dynamic factor*

A variable factor representing the dynamic effects that the working load is exposed to. Also named *dynamic coefficient*.

120 *Dynamic load*

The working load when subjected to (multiplied with) a *dynamic factor*.

121 *Dynamic load chart*

Diagram or table showing rated capacity depending on sea state and on radius or boom angle.

122 *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.

123 *Heavy lift crane*

Crane with SWL above 2500 kN.

124 *Inertia forces*

The forces induced by change of velocity.

125 *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.

126 *Inspection Release Note (IRN)*

Report confirming survey work/results of a provisional phase completed. Often used for a component partially completed by one manufacturer before it is sent for completion by another. Classification Societies will normally use a Survey Report, but IRNs are sometimes preferred, for example by the offshore industry.

127 *Lifting appliance*

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

128 *Lifting accessories*

As for *lifting gear*, see below.

129 *Lifting equipment*

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

130 *Lifting gear*

Load carrying accessories used in combination with a lifting appliance, however, that are not necessarily a part of the permanent arrangement of the lifting appliance, such as:

- attachment rings, shackles, swivels, balls, pins
- sheaves, hook-blocks, hooks, load cells
- loose gear.

Guidance note:

Lifting gear, considered as separate components, shall be designed and tested in accordance with the provisions for loose gear.

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131 *Load chart*

Diagram or table showing rated capacity depending on radius or boom angle.

132 *Loose gear*

Loose gear are equipment used to attach the useful load to the hook, such as slings, nets, baskets, chains, links, rings, shackles, lifting beams and frames, spreaders, grabs, loading pallets, skids, etc., but which do not form a part of the useful load, which is normally not permanently attached to the hook, and which may be stored separately from the crane.

133 *Machinery components*

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

134 *Man riding winch*

Device specially designed for hoisting/lowering of a person.

135 *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.

136 *Mean time to failure (MTTF)*

The mean value of service time until failure occurs.

137 *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.

138 *Overload*

Load which exceeds the Safe Working Load (SWL).

139 *Over-moment*

Load moment which exceeds the maximum load moment (Safe Working Load (SWL) multiplied by radius).

140 *Passive cable tensioning system (PCT)*

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

141 *Passive heave compensation system (PHC)*

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

142 *Probability of failure on demand (PFD)*

Probability of failure on demand.

143 *Product Certificate (general)*

A document signed by a surveyor of the recognised Body stating:

- conformity with rule requirements
- that tests are carried out on the certified product itself
- that tests are performed in presence of the surveyor or in accordance with special agreements.

144 *Product Certificate (DNV's)*

Det Norske Veritas Product Certificate is a document signed by a surveyor of the Society stating:

- conformity with rule or certification standard requirements
- that tests are carried out on the certified product itself
- that tests are made on samples taken from the certified product itself
- that tests are performed in presence of the surveyor or in accordance with special agreements.

145 *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 DNV.

146 *Rated capacity*

Actual hook load that the crane is designed to lift for a given operating condition (e.g. boom configuration, reeving arrangement, off lead/side lead, heel/trim, radius, wave height, etc.)

147 *Risk*

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

148 *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.

149 *ROV*

Remote Operated Vehicle

150 *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.

151 *Reference SWL*

A theoretically increased SWL used for determining of overload for load tests. Used when the *design dynamic factor* (see above) exceeds 1.33. (See Ch.2 Sec.7 B301).

152 *Safe Working Load (SWL)*

The *actual hook load* permitted for a given operating condition (e.g. configuration, position of load). Also called rated load or rated capacity.

153 *Ship Rules*

Det Norske Veritas Rules for Classification of Ships.

154 *Significant wave height H_{sign}*

Average height of the highest one third of the individual wave heights in a short-term constant seastate, typically 3 hours.

155 *Standing rigging*

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

156 *Subsea cranes*

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

157 *Test report, test*

A document signed by the manufacturer stating:

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

158 *Type Approval*

Approval of conformity with specified requirements on the basis of systematic examination of one or more specimens of a product representative of the production.

159 *Verification*

A service that signifies a confirmation through the provision of objective evidence (analysis, observation, measurement, test, records or other evidence) that specified requirements have been met. See also the Note in the introduction to F400.

160 *Vessel*

A common term for ships, craft, offshore units and offshore installations.

161 *Working load (suspended load)*

The static weight of the useful load lifted, plus the weight of the lifting gear. The working load is subjected to *inertia forces*.

162 *Works product certificate*

A document signed by the manufacturer stating:

- conformity with rule requirements
- that tests are carried out on the certified product itself
- that tests are made on samples taken from the certified product itself
- that tests are witnessed and signed by a qualified department of the manufacturers.

C 200 *Crane design definitions*

201 Winch luffing crane: a crane where the boom is controlled by wire ropes through a winch.

202 Cylinder luffing crane: a crane where the boom is controlled by hydraulic cylinder(s).

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

204 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.

205 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.

206 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.

207 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.

C 300 *Design temperature*

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

302 The design temperature T_D for lifting appliances is defined as the *lowest mean daily temperature*. (The average temperature during the coldest twenty-four hours of one year.)

303 For lifting appliances installed on vessels or mobile offshore units classified with the Society, the design temperatures of the appliances and the vessel/unit shall be compatible.

304 If not otherwise specified design temperature according to Table C1 shall be applied.

Table C1 Design temperature for Lifting Appliances.		
<i>Type of Lifting Appliance</i>	<i>Design temperature</i>	<i>Corresponding Extreme Low Temperature</i>
Shipboard/Industrial Cranes	-10°C	(-30°C)
Offshore Cranes	-20°C	(-40°C)
Engine rooms and other similar spaces with controlled temp.	+10°C	(0°C)

C 400 Extreme low temperature

401 The lowest temperature estimated to appear in an area with a corresponding specified design temperature.

Guidance note:

Values given in brackets to indicate that they shall be considered for information only. It is DNV's opinion, however, that crane operations shall not take place at temperatures below the extreme low temperature.

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D. Services

D 100 Objectives

101 The objective is to present an overview of possible combinations of the different services offered. Furthermore, various alternatives are described for DNV confirmation of the various services. See also Table F1.

102 The purpose of the objectives in 101 is to enable the general objectives to be met as described in A200.

103 Documentation of Services are shown in Fig.1

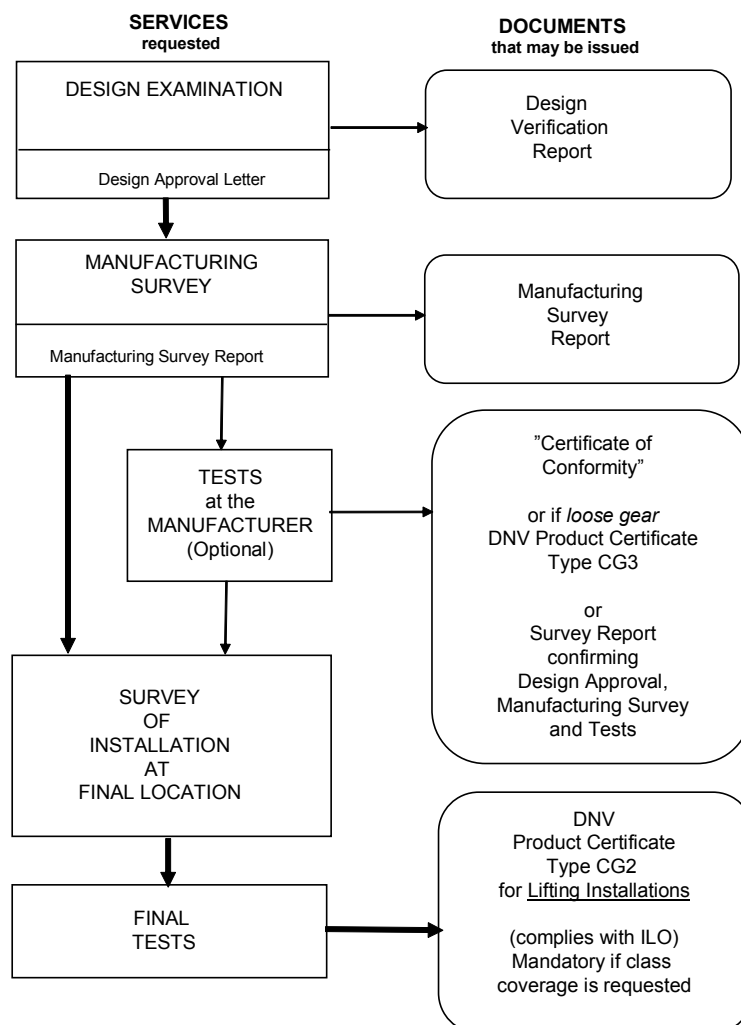


Figure 1
Documentation of Services

Alternatives for documentation that may be issued to Customers depending on type and combination of services requested.

D 200 Regulatory basis

201 The Standard for Certification is based on DNV's understanding and interpretation of the ILO Convention No.152 of 1979.

D 300 Acceptance by National Authorities

301 A number of bodies, such as Port Authorities, Maritime Authorities, Shelf Authorities and Municipal or Governmental Health and Safety Authorities require that lifting appliances and loose gear shall be certified. Normally, DNV's certification in accordance with this certification standard will satisfy the authorities' requirements.

302 In cases where requirements laid down by the pertinent body exceeds the DNV requirements described in Ch.2, DNV may, as a voluntary service, include the additional requirements in the examination and confirm whether or not they are found to be fulfilled

303 The conditions for review in accordance with other bodies' requirements are as set out in F500.

E. Certification procedure

E 100 General

101 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

102 The following activities are covered by this standard:

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

E 200 Design examination

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

The design examination 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 examination 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 Society's splitting of the certification process in the sequences design approval, manufacturing survey (including installation survey) and testing, shall be considered as a part of the Society's internal scheme to organize its work.

The Society's reports covering the separate phases is considered internal documents, and information enabling the progress of the certification project.

The Society's formal documentation of the certification to the Customer will be the product certificate CG2 issued upon completion of the project.

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

203 The design approval may be obtained either on a case-by-case basis or as a general approval, 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.

Reference is made to DNV Certification Note No. 1.2 “Type Approval” April 2009 or later issue.

E 300 Survey during fabrication and installation

301 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 of this certification standard as well as general good workmanship.

302 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.

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

E 400 Testing and marking

401 Components and each completed lifting appliance shall be subjected to functional testing and load-testing as specified in Ch.2 Sec.12.

E 500 Extension of scope of work

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

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

503 In case of disputes regarding interpretations of requirements on which extended work is based, the Customer must 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 must be omitted.

E 600 Safe means of access and personnel safety devices

601 Personnel safety protection devices such as guard rails, shielding, safety of ladders, etc. are not covered by this certification standard and the scope of work. If the Customer requests that such aspects shall be covered, the provisions set out in E 500 shall be followed.

E 700 Reduced scope of work

701 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 certification standard. This will be annotated in the documentary evidence of the completed assignment (certificate).

702 DNV will not agree to limit the scope of work or parts of the suggested services if they are of the opinion that this may lead to hazards or unacceptable lowering of the safety standard.

F. Type of Services

F 100 Basic certification

101 The basic requirements presented in Ch.2 are considered to cover the requirements of the ILO Convention No.152 of 1979 specified in D201. Lifting appliance and loose gear found to comply with these basic requirements are qualified for DNV product certification, whereupon the product certificate may be issued, and the Cargo Gear Register (CG1 if published by the Society) may be endorsed.

102 The basic requirement covers the three categories of lifting appliances a), b) and c) defined in B300 as well as loose gear components allocated the same lifting appliances, as well as personnel lifting as denoted in B104.

103 Some details of the basic requirements in Ch.2 are different for the different category of lifting appliance a), b) and c). Furthermore, some specific requirements are stated for cranes also used for personnel lifting.

F 200 Class covered cranes

201 On a *voluntary* basis, cranes installed onboard DNV classed vessels and offshore installations may be included in the class. In such cases the vessel/ offshore installation will be assigned the *Special Equipment and System Notation* **CRANE**.

In order to obtain this notation at least one of the cranes onboard must have been certified in accordance with the basic requirements of Ch.2 as well as having been assigned the product certificate CG2.

202 Vessels whose main purpose is to support a crane, may be assigned the voluntary *Special Service and Type Notation* **Crane Vessel or Crane Barge** if the crane has been certified in accordance with the basic requirements of Ch.2 and as well as having been assigned the product certificate CG2.

Guidance note:

DNV classed crane units fulfilling the requirements as specified in 202 will get the combined class notation:

1A1 Crane Vessel or 1A1 Crane Barge.

DNV classed crane vessels or crane barges where the crane (major crane) has not been subjected to DNV certification will have the Main Character of Class **1A1**.

For further information regarding e.g. the difference between the notations **1A1**, see Ship Rules Pt.1 Ch.2.

In addition to the requirements specified in Ch.2 for cranes to be certified by DNV, vessels or offshore units having cranes installed will be subjected to a number of obligatory class requirements. These requirements apply independently of whether or not the cranes are certified by DNV and whether or not they are included in the class. They cover such topics as deck support, foundations (pedestals), boom rests (cradles), electrical and hydraulic power supply, earthing as well as trim, stability and ballasting conditioned by the cranes or their lifting operations.

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203 Some of the requirements in this certification standard have been extended with additional detail requirements for cranes to be covered by classification.

F 300 Assignments completed before installation

301 Assignments completed at the manufacturers' premises can be agreed. Such services are normally to be completed with monitoring of tests at the manufacturer, (FAT-tests). Applicable reports or certificates may be issued. See also 302.

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

- Completed certification of loose gear or components. DNV 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*, *Certificate of Conformity* or *Inspection Release Note* (often preferred in the offshore industry) may be assigned.

See also Fig.1.

F 400 Verifications

Guidance note:

Verification constitutes a systematic and independent examination of the product itself or its design and/or manufacturing to determine whether it is in compliance with some or all of the specifications. Verification activities are expected to identify errors or failures in the work and to contribute to reducing the risks to the operation of the product and to the health and safety of personnel associated with it or in its vicinity or other unwanted situations.

Verification shall be complementary to routine design, construction and operations activities and not a substitute for the work, and the assurance of that work, carried out by the Customer and its contractors, it is inevitable that verification will duplicate some work that has been carried out previously by other parties involved.

The Society's verification may be based on risk evaluation. This is founded on the premise that the risk of failure can be assessed in relation to a level that is acceptable and that the verification process can be used to manage that risk. The verification process is therefore a tool to maintain the risk below the acceptance limit. Verification based on risk aims to be developed and implemented in such a way as to minimise additional work, and cost, but to maximise its effectiveness. Society's verification level will be chosen based on experience combined with engineering judgement and the findings from the examination of documents and production activities.

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401 The Society may upon request carry out specified examination or combination of separate services referring to the requirements in Ch.2 or the related standards and services described in D and E and in this item.

402 The depth, thoroughness and completeness of the examinations must be agreed upon for each specific verification assignment, and shall be unambiguously described in the contract and in the documentation of the verification service.

Guidance note:

The Society is flexible in agreeing on type of documentation of verification services performed. Normally, the Society's proposal will be to issue a verification report. For instance, for a completed design examination the Society will suggest issuance of a "Design Verification Report".

The Society endeavours to find the best solution for issuance of required verification documentation.

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403 Whereas the scope, standards and acceptance criteria for a certification or classification assignment is laid down by the Society, the scope, standards and acceptance criteria forming the basis for a verification assignment may, if requested, be adapted to the needs and desires of the Customer. However, the Society will decline to carry out a commission that may be used, intentionally or unintentionally, to mislead a third party with regard to the safety of the object.

404 A verification report may be edited in accordance with the Customer's needs and requests. The Society is, however, not prepared to omit non-conformances or other negative observations or results detected during the examinations.

F 500 Review in accordance with other standards

501 Upon request, additional requirements, other than DNV's own laid down in Ch.2, may be included in the examination work.

Examples on additional standards that have been found applicable are:

- EN13852 Offshore Cranes
- EU Machinery Directive
- EU Machinery Directive Annex 4
- PSA
- API 2C.

Applicable combinations of certification/verification assignments and review of additional requirements are illustrated in Table F1.

502 It is emphasized that the comparisons are based upon DNV's understanding and interpretation of the additional requirements.

In cases where DNV's interpretation is questioned or it gives rise to conflicts between involved parties or for other reasons are considered inappropriate, DNV may refuse to carry out the work based on DNV's own interpretation of the additional requirements. In such cases, the Customer must obtain written interpretation from the legislators/standard publishers.

503 Commissions such as described in D302 and F501 will normally be limited to the topics and aspects covered in the DNV requirements in Ch.2. Upon request, however, the commissions may be extended to cover also additional topics.

Such extensions and amendments of scope of work shall be reflected in written agreements.

504 If it has been agreed to include additional requirements in the certification work and the additional requirement is not complied with, this shall be reported to the Customer in writing.

505 Covering of additional requirements may be limited to; design examination, manufacturing survey, installation survey and testing, or to any combinations of these phases.

506 The measures applied to demonstrate compliance with the additional requirements dealt with in D302 and F501 shall be documented by the Customer.

F 600 Customers who may request certification and verification

601 Certification may be requested by:

- manufacturer of a complete lifting appliance
- manufacturer of components or loose gear
- owner/user of a lifting appliance
- owner of a ship, mobile offshore unit or offshore installation, etc.
- shipyard or offshore installation fabrication site, etc.

602 Verification services may be requested by persons/bodies/institutions/companies possessing legitimate access to the documentation forming the basis for the requested verification.

603 Request for certification and verification shall be made in writing as specified in F700.

F 700 Written confirmation

701 Before a certification or verification assignment is commenced, at least following shall be confirmed in writing:

- Which of the category a), b), or c) in accordance with B300 the lifting appliance or lifting gear belongs to. For category b) it must also be specified whether the crane is to lift loads from decks of other vessels or only from the sea/seabed.
- Whether the assignment shall be extended to cover requirements for lifting of personnel.

- Whether the assignment shall be extended to cover also requirements to qualify the lifting appliance for additional class notations CRANE, Crane Barge, Crane Vessel or CRANE(N).
- Whether the assignment shall be extended to cover any of the additional requirements listed in D302 or F501.

F 800 Certificate annotations

801 Unless otherwise requested by the Customer, compliance with the requirements pertaining to the additional requirements review as described in D302 or F501 shall be confirmed in writing in the relevant documents.

Applicable combinations of DNV certification and verification and additional standards assumed especially relevant.

Table F1 Modular Service Scheme				
	<i>Loose Gear</i>	<i>Industrial Cranes</i>	<i>Shipboard cranes</i>	<i>Offshore cranes</i>
Basic certification (ILO)	X	X	X	X
Certification extended to cover class (CRANE, Crane Vessel, Crane Barge or CRANE(N))			X	X
EN 13852 (verification)				X
EU Mach. Dir. (verification)	X	X	X	X
EU Mach. Dir. ANNEX 4 (verification)		X	X	X
PSA Guidelines (verification)	X	X	X	X
API 2C (verification)				X

SECTION 2 DOCUMENTATION AND CERTIFICATION

A. Documentation to be Submitted

A 100 General

101 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.

A 200 Documentation requirements

201 Documentation shall be submitted as required by Table A1, as applicable for the lifting appliance.

Table A1 Documentation requirements.				
<i>Object</i>	<i>Document type</i>	<i>Additional description</i>	<i>Offshore cranes Info</i>	<i>Other cranes Info</i>
General	C010 - Design criteria	Load charts and/or load tables dynamic factors Environment conditions Category of crane, see definitions Ch.1 Sec.1 B300 Particulars of brake spring performance	FI	FI
	C020 - Assembly or arrangement drawing		FI	FI
	C030 - Detailed drawing	Crane structure and components for slewing, luffing and hoisting. Winches with brakes and lifting gear for shipboard/ industrial cranes are normally not subject to approval. Drawings of gears transmitting braking forces should contain relevant parameters including torque capacity	AP	AP
	C040 - Design analysis		FI	FI
	C050 - Non-destructive testing (NDT) plan		AP	FI
	Z060 - Functional description	Including a filled in verification template, see Appendix G, for offshore cranes	FI	FI
	Z120 - Test procedure at manufacturer		AP	FI
	Z140 - Test procedure for quay and sea trial		AP	FI
	Z160 - Operation manual		FI	FI
Power supply	Z030 - System arrangement plan	Type and maker of prime mover or specification of other main and emergency power supply Including mechanical components.	FI	FI
Electric power system	E170 - Electrical schematic drawing	Including cable list.	AP	FI
	Z090 - Equipment list		FI	FI
Hydraulic power system	S011 - System diagram (P&ID)		AP	FI
	S042 - Hydraulic control diagram		AP	FI
	Z060 - Functional description		FI	FI
	Z090 - Equipment list		FI	FI
Control and monitoring	I200 - Control and monitoring system documentation	Functional description of safety system and the safety equipment to be included	AP	FI
Fire safety	G040 - Structural fire protection drawing		AP	FI

202 For general requirements to documentation, including definition of the Info codes, see Ship Rules Pt.0 Ch.3 Sec.1.

203 For a full definition of the documentation types, see Ship Rules Pt.0 Ch.3 Sec.2.

A 300 Design analysis

301 For structural parts and components specified in A200, the drawings shall be supplemented with calculations demonstrating that the structural strength complies with the requirements.

302 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)
- elastic or plastic analysis performed
- permissible stress or limit state method used.

See also Ch.2 Sec.2 C.

303 For Offshore cranes to be covered by class, the calculations of the dynamic factors shall cover:

- a) The still-water dynamic factor or specification of a possible increased figure chosen as dynamic factor for design purposes. See definition in Sec.1 C.
- b) Calculations of the dynamic factors for all combinations of boom angles and H_{sign} .
- c) The crane-supporting vessel's heave- and roll velocities used in the calculations referred to in b) above, as well as a description of the geometrical location of the crane on board the vessel.
- d) As an alternative to the figures required in c) above, the vertical velocity components at the boom tip caused by the crane-supporting vessel's heave and roll.
- e) For lifts of submerged loads, the maximum acceptable dynamic factors contribution caused by hydrodynamic effects shall be specified. This includes also hydrodynamic effects occurring when the load is lifted through the sea surface.

304 The design calculations for hydraulic cylinders shall be based on the maximum obtainable pressure. Alternatively, if the maximum dynamic force applied on the crane is known, this may be used as basis for the design calculations. Different outreach positions may have to be evaluated.

Based on individual considerations, a buckling safety factor down to 2.3 may be accepted.

B. Certification

B 100 Certificate requirements

101 Certificates shall be issued as required by Table B1 for Shipboard cranes (and industrial cranes) and as required by Table B2 for Offshore cranes, as applicable for the lifting appliance.

<i>Object</i>	<i>Certificate type</i>		<i>Additional description</i>
Slewing rings	NV-P	DNV product certificate	See Note 1
Hydraulic cylinders	NV-P	DNV product certificate	See Note 2 Applicable also for accumulators
Sheaves	NV-P	DNV product certificate	Works product certificate will be satisfactory for unwelded sheaves
Hoisting blocks	CG3	Certificate of test and thorough examination of loose gear	Alternatively ILO form No. 3
Hooks	CG3	Certificate of test and thorough examination of loose gear	Alternatively ILO form No. 3
Chains	CG3	Certificate of test and thorough examination of loose gear	Alternatively ILO form No. 3
Swivels	CG3	Certificate of test and thorough examination of loose gear	Alternatively ILO form No. 3
Shackles	CG3	Certificate of test and thorough examination of loose gear	Alternatively ILO form No. 3
Wire ropes	CG4	Certificate of test and thorough examination of Wire Rope	Alternatively ILO form No. 4
Winches	W-P	Works product certificate	
Slewing gear	W-P	Works product certificate	Also other transmission gears for non-critical applications
Transmission gears and brakes	W-P	Works product certificate	Applicable when transmitting braking forces for hoisting and luffing
Hydraulic components	TR-T	Test report, test	except mountings

Note 1: cranes with SWL not exceeding 20 tonnes, the slewing ring may be accepted with Works product certificate.

Note 2: cranes with SWL not exceeding 20 tonnes, the cylinders may be accepted with Works product certificate on the following conditions:

- The cylinder is subject to serial production.
- The exception may be agreed on a case-by-case basis and shall be agreed in advance.
- The manufacturer shall apply for such exception in due time by submitting one copy of documentation on the cylinder, including all main dimensions and material specifications enclosed to the application, enabling DNV to carry out an independent review calculation as found appropriate.
- Extent of NDT and pressure testing shall be agreed in each case.

Table B2 Certificate requirements for Offshore cranes.

<i>Object</i>	<i>Certificate type</i>		<i>Additional description</i>
Slewing rings	NV-P	DNV product certificate	
Hydraulic cylinders	NV-P	DNV product certificate	Applicable also for accumulators
Winches	NV-P	DNV product certificate	
Sheaves	NV-P	DNV product certificate	Works product certificate will be satisfactory for unwelded sheaves
Hoisting blocks	CG3	Certificate of test and thorough examination of loose gear	Alternatively ILO form No. 3
Hooks	CG3	Certificate of test and thorough examination of loose gear	Alternatively ILO form No. 3
Chains	CG3	Certificate of test and thorough examination of loose gear	Alternatively ILO form No. 3
Swivels	CG3	Certificate of test and thorough examination of loose gear	Alternatively ILO form No. 3
Shackles	CG3	Certificate of test and thorough examination of loose gear	Alternatively ILO form No. 3
Wire ropes	CG4	Certificate of test and thorough examination of Wire Rope	— Alternatively ILO form No. 4
Transmission gears and brakes	W-P	Works product certificate	Applicable when transmitting braking forces for hoisting and luffing
Slewing gear	W-P	Works product certificate	Also other transmission gears for non-critical applications
Hydraulic components	TR-T	Test report, test	except mountings



STANDARD FOR CERTIFICATION OF LIFTING APPLIANCES

NO. 2.22

CHAPTER 2

TECHNICAL REQUIREMENTS

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SECTION 1 MATERIALS AND FABRICATION

A. General

A 100 Scope

101 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 Ch.1 Sec.1 C300.

102 Materials with properties deviating from the requirements in this section may be accepted upon special consideration.

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

A 200 Structural category

201 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.

Slewing 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 D401.

Guidance note:

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

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A 300 Steel manufacturing process

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

A 400 Material manufacture survey, certification and testing procedures

401 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.

See also Ship Rules Pt.2 Ch.1 “General Requirements for Materials”.

Approved steel manufacturer will not be required.

402 Inspection certificate 3.1 will normally be accepted, except for slewing rings for offshore cranes in which case DNV inspection certificate 3.2 is required, unless otherwise agreed.

Guidance note:

The document designation inspection certificate 3.1 and 3.2 are in accordance with EN 10204: 2004.

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403 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.

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

405 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.

A 500 Retesting

501 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 Ship Rules Pt.2 Ch.1. Provided the new test results are found to satisfy the prescribed specification, the material may be accepted.

B. Rolled Structural Steel for Welding

B 100 General

101 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.

102 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 as follows:

- Normal strength steels, with specified minimum yield stress 265 N/mm².
- High strength steels, with specified minimum yield stress of 265 N/mm² and up to and including 420 N/mm².
- Extra high strength steels with specified minimum yield stress of 420 N/mm² and up to and including 750 N/mm².

103 Application of steel with specified minimum yield strength above 750 N/mm² shall be especially agreed.

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

105 The requirements to chemical composition, mechanical properties etc., are given in DNV's Rules for Ships Pt.2 Ch.2 Sec.1 B for normal strength steels, Pt.2 Ch.2 Sec.1 C for high-strength steels, and Pt.2 Ch.2 Sec.1 D for extra high strength steels.

106 As an alternative to 105, materials that comply with national or proprietary specifications may be accepted provided such specifications give reasonable equivalence to the requirements of this section or are approved for a specific application.

B 200 Impact test temperatures

201 Required impact test temperatures are dependent on design temperature T_D and the material thickness. Impact test temperatures are given in Table B1 for structural steel for primary and secondary applications. For definition of design temperature see Ch.1 Sec.1 C300.

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.

202 Impact test temperature for flanges for slewing bearings shall be as for primary members given in Table B1 based on actual thickness.

203 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 B1, based on t_1 or $0.25 \cdot t_2$ 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 B1, plus 30° C.

Table B1 Impact test temperatures for welded structural steel				
Material thickness t in mm	Impact test temperature in °C ¹⁾			
	Structural steel for primary members ²⁾		Structural steel for secondary members ²⁾	
	Offshore cranes	Shipboard cranes/ Industrial cranes	Offshore cranes	Shipboard cranes/ Industrial cranes
$6 \leq t \leq 12$ ³⁾	$T_D + 10$	$T_D + 20$	Test not required	Test not required
$12 < t \leq 25$	T_D	$T_D + 10$	Test not required	Test not required
$25 < t \leq 50$	$T_D - 20$	$T_D - 10$	T_D	$T_D + 10$
$t > 50$	$T_D - 40$	$T_D - 30$	$T_D - 10$	T_D
¹⁾ For steel with yield stress below 500 MPa, the test temperature need not be taken lower than -40° C. For steel with yield stress above 500 MPa, the test temperature shall not be taken higher than 0° C and not lower than -60° C. ²⁾ See A201 for definitions. ³⁾ For plate thickness less than 6 mm, Charpy V testing will not be required.				

B 300 Testing

301 Test samples

Unless otherwise required the test samples shall be taken for positions as specified in Ship Rules Pt.2 Ch.1 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.

302 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.

C. Rolled Steel not for Welding

C 100 General

101 Rolled steel for special and primary components other than those mentioned in 200 and 300 (e.g. mechanisms) shall be specified with reference to a recognised standard. The material shall be delivered in the following conditions:

- carbon and carbon/manganese steel in normalized condition.
- alloy steel in 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 D1 but, in the case of low calculated stresses, e.g. not exceeding 50 N/mm^2 , a test temperature of 20°C will be accepted. Required minimum impact energy shall be as required for welded parts, ref B105. For carbon and carbon/manganese steel the carbon content shall be less than 0.35%.

C 200 Bolts and nuts

201 Materials for bolts and nuts considered as important for the structural and operational safety of the assembly in question, shall comply with the requirements in D400 for bolts and nuts. This includes requirements for chemical composition and mechanical properties.

C 300 Rolled rings

301 Rolled rings for important components such as slewing rings, toothed wheel rims etc. shall comply with the requirements for steel forgings, see D500.

D. Steel Forgings

D 100 General

101 Forgings shall generally be manufactured in accordance with the requirements of Ship Rules Pt.2 Ch.2 Sec.5 “Steel Forgings”.

102 As an alternative to 101, materials that comply with national or proprietary specifications may be accepted provided such specifications show reasonable equivalence to the requirements in 101 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. For machinery components, see Ship Rules Pt.4 Ch.2 Sec.3.

D 200 Forgings for general application

201 Forgings shall be specified with reference to DNV’s Rules for Ships Pt.2 Ch.2 Sec.5 “Steel Forgings” or other national or proprietary specification. As a minimum the standard shall require impact testing according to Table D4. Other mechanical properties shall minimum be according Rules for Ships Pt.2 Ch.2 Sec.5 Table C2 for unwelded forgings and according to Rules for Ships Pt.2 Ch.2 Sec.5 Table B2 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 of 300 – 500 apply.

D 300 Forged shackles, cargo hooks, swivels, sockets and chains

301 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 200.

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 to impact test temperatures are specified in Table D1.

Table D1 Impact test temperature for shackles, cargo hooks, chains, sockets and swivels	
Material thickness t (mm)	Impact test temperature
$t \leq 10$	Impact test not required
$10 < t \leq 50$	$T_D + 20 \text{ }^\circ\text{C}$
$50 < t \leq 100$	$T_D + 10 \text{ }^\circ\text{C}$
$t > 100$	T_D

T_D = design temperature

D 400 Bolts and nuts

401 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.

402 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.

Additional requirements to testing and inspection of slewing ring bolts are given in Table D2.

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

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

404 Bolts and nuts shall be delivered with the following certificates as per EN10204, verifying compliance with the material requirements and other test requirements:

- DNV Inspection certificate type 3.2 for slewing ring bolts and nuts for offshore cranes.
- Works certificate type 3.1 for slewing ring bolts and nuts for cranes other than offshore cranes.
- 2.2 test report for bolts and nuts in *primary* and *secondary* connections.

405 Slewing ring bolts for offshore cranes shall have rolled threads, and the rolling shall be performed after final quenching and tempering of the bolts. 12.9 bolts are not accepted as slewing ring bolts for offshore cranes.

406 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.

407 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.

D 500 Forged rings for slewing bearings

501 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.

502 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 for Certification. The results shall be submitted to the Society for consideration. The programme for such examination shall be agreed with the Society.

503 All test results shall comply with the approved specifications.

504 Steel for slewing rings shall satisfy the requirements of Table D3.

Table D2 Testing and inspection of slewing ring bolts							
<i>Strength Class, ISO 898, or equivalent</i>	<i>Diameter d in mm</i>	<i>Ultimate strength N/mm²</i>	<i>Yield strength. Minimum. N/mm²</i>	<i>Elongation A5</i>	<i>Required Charpy V energy¹⁾ at test temp. as required for rings Table D3</i>	<i>Fracture mechanics testing (CTOD)</i>	<i>Surface inspection⁴⁾</i>
8.8	d < 25	800 - 1000	640	14	—	—	Visual
	d ≥ 25				Offshore cranes: 42 J Other cranes: 25 J	—	Visual and magnetic particle (MPI)
10.9	d < 25	1000 - 1200	900	12	—	—	Visual
	d ≥ 25				Offshore cranes: 42 J Other cranes: 25 J	—	Visual and magnetic particle (MPI)
12.9 (not allowed for off-shore cranes)	d < 25	1200 - 1400	1080	12 (10) ²⁾	Other cranes: 25 J	To be documented ³⁾	Visual and magnetic particle (MPI)
	d ≥ 25				Other cranes: 25 J	To be tested ³⁾	

1) Average value. Single value accepted to be 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) 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.

Table D3 Slewing materials			
<i>Heat treatment</i>		<i>Offshore cranes</i>	<i>Other cranes</i>
		<i>According to approved Spec.</i>	
<i>Charpy V-notch test temperature</i>		T _D	
	<i>Average</i>	42	25
<i>Charpy V-notch value</i>	<i>Single min. value</i>	27	20
<i>Elongation A5</i>		14%	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	

Table D4 Impact testing for steel forgings		
<i>Design temperature T_D</i>	<i>Test temperature</i>	<i>minimum Charpy Value</i>
T _D ≥ -20°C	0°C	27 J
-20°C > T _D > -30°C	-20°C or (0°C)	27 J (48 J)

E. Steel Castings

E 100 General

101 Steel castings shall generally be manufactured in accordance with Ship Rules Pt.2 Ch.2 Sec.7 “Steel Castings”.

102 As an alternative to 101, materials which comply with national or proprietary specifications may be accepted provided such specifications give reasonable equivalence to the requirements in 101 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. For machinery components, see Ship Rules Pt.4 Ch.2 Sec.3.

E 200 Castings for general application

201 Steel castings shall generally be manufactured in accordance with Ship Rules Pt.2 Ch.2 Sec.7 “Steel Castings” or other national or proprietary specification. As a minimum the standard shall require impact testing and mechanical properties according to Table D4. Other mechanical properties shall minimum be according Ship Rules Pt.2 Ch.2 Sec.7 Table B2 for welded castings and according to Ship Rules Pt.2 Ch.2 Sec.7 Table C2 for unwelded castings.

F. Iron Castings

F 100 General

101 Iron castings shall generally be manufactured in accordance with the Ship Rules Pt.2 Ch.2 Sec.8 “Iron Castings”.

102 As an alternative to 101, materials that comply with national or proprietary specifications may be accepted provided such specifications give reasonable equivalence to the requirements in 101 or are approved for each specific application.

G. Steel Tubes, Pipes and Fittings

G 100 General

101 Reference is made to Ship Rules Pt.2 Ch.2 Sec.4 “Steel Pipes”, or other recognised standard/code. Recognition of other standards shall be evaluated by the Society.

H. Aluminium Alloy Structures

H 100 General

101 Reference is made to Ship Rules Pt.2 Ch.2 Sec.9 “Aluminium Alloys”, ECC’s “European Recommendations for Aluminium Alloy Structures” (last valid edition), or other equivalent recognised standard.

I. Steel Wire Ropes

I 100 General

101 Steel wire ropes and wire locks for cranes shall generally be manufactured and tested in compliance with the requirements stipulated in the following, as well as EN 13414-1 “Steel wire rope slings – Safety” and EN 13411-3 “Terminations for steel wire ropes”, respectively.

I 200 Materials

201 Wire for steel wire ropes shall be made by open hearth electric furnace, LD process, or by other processes especially approved by DNV or other classification society.

Normally, the minimum tensile grade of the wires shall be 1-570 N/mm², 1-770 N/mm², 1-960 N/mm² or 2-160N/mm².

I 300 Construction

301 The strands shall be made in equal lay construction (stranded in one operation).

302 All wire ropes shall be lubricated and impregnated in the manufacturing process with a suitable compound to thoroughly protect ropes both internally and externally to minimize corrosion until the rope is taken into use.

303 The rope lubricant selected shall have no detrimental effect on the steel wires or any fibres (in the core) and shall reduce the friction in the rope.

304 Certain wire-lay types shall be avoided (f. ex. 4×29). Selection of wire type shall be based on manufacturer's recommendations (or catalogue specifications).

I 400 Testing

401 Steel wire ropes shall be tested by pulling a portion of the rope to destruction.

The breaking load shall be according to ISO 2408 or other approved standard or specification.

The testing of wire and wire locks shall be carried out according to EN 13414-1 and EN 13411-3.

402 If facilities are not available for pulling the whole rope to destruction, the breaking load may be determined by testing separately 10% of all wires from each strand. The breaking strength of the rope is then considered to be:

$$P = f t k \text{ [kN]}$$

f = average breaking strength of one wire in kN

t = total number of wires

k = lay factor as given in Table I I or according to special agreement.

Table II Lay factor k		
<i>Rope construction</i>	<i>Rope with FC</i>	<i>Rope with IWRC</i>
6×19 group	0.860	0.801
6×36 group	0.835	0.775
Non-rotating ropes		
17/18 \times 7	0.780	0.758
35/36 \times 7	0.750	0.743

FC = Fibre core

IWRC = Independent wire rope core

403 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.

404 The following individual wire tests shall be performed:

- tensile test
- torsion test
- weight and uniformity of zinc coating.

These tests shall be made in accordance with ISO 6892, ISO 7800 and ISO 7801. If tested before rope manufacture, the tests shall comply with ISO 2232 else the tests shall comply with ISO 2408 Annex E or ISO 10425 Annex I.

J. Crane Manufacturing and Construction

J 100 General

101 The manufacturer shall organize a system for quality control involving competent personnel with defined responsibilities that shall cover all aspects of quality control. For qualification of welders, reference is made to DNV's Ship Rules Pt.2 Ch.3 Sec.3. The materials shall be identifiable during all stages of manufacturing and construction.

102 Manufacturing and construction shall be in accordance with the approved drawings and specifications. The specification shall refer to a recognised code, standards or rules relevant for the structure in question. Supplementary requirements amending the reference documents may be stipulated.

103 Dimensional tolerances specified in the design analysis of the crane structures shall be complied with during manufacturing and construction.

104 All defects and deficiencies shall be corrected before the structural parts and equipment are painted, coated or made inaccessible.

105 Alternative methods making joints may be considered by the Society and will be subject to consideration in each case.

J 200 Welding procedure specifications

201 Reference is made to Ship Rules Pt.2 Ch.3 “Fabrication and Testing of Ship Structures”.

202 As alternatives to the requirements stated in 201, the following standards will also be accepted:

- AWS D.1.1, or
- EN ISO 15614 -1 for steel
- EN ISO 15614 -2 for aluminium.

J 300 Welding consumables

301 Welding consumables type approved by DNV 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 the intranet. On intranet: <http://exchange.dnv.com/tari> under Type Approval/Type Examination.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

302 Welding consumables shall be selected such as to produce a weld with mechanical properties at least equal to that specified for the structural steel type in question. The weld metal shall be compatible with the base material regarding heat treatment and corrosion. Only welding consumables specified in the qualified welding procedure shall be used, or same grading of different brand.

303 Manual welding of high-strength and extra high-strength steels shall be performed with low hydrogen welding processes.

304 Welding consumables shall be supplied in sealed moisture-proof containers or packages. Routines for storage, handling and rebaking of consumables as advised by the manufacturer shall be established and followed.

Consumables that have been contaminated by moisture, rust, oil, grease, dirt etc. shall be discarded.

J 400 Forming of materials

401 Forming of plates, structural shapes, tubes etc. shall be carried out according to a specification outlining the successive and controlled steps.

402 If cold-forming results in a permanent deformation exceeding 5% for primary structural members, thermal stress relieving is normally required unless the notch ductility in the deformed and artificially aged condition is verified as acceptable.

403 Forming of steels at high temperatures shall be effectuated with due regard to adverse effects of the material's properties. Forming of steels above 650 degrees C shall be subject to agreement with the Society.

J 500 Welding preparation

501 Mill scale, rust etc. shall be removed prior to welding, and the grooves shall be dry and clean. The fit-up shall be checked before welding. Deviation of cut edges shall generally be within the standard specified by IACS REC No.47 Shipbuilding and Repair Quality Standard Part 4. Where materials of different thickness are butt welded, material tapering shall be in accordance with recognised codes or standards.

J 600 Welding performance

601 All welding operations, including tack and seal welding, shall be carried out in accordance with an approved welding procedure specification WPS. The WPS shall be supported by a welding procedure qualification test, WPQT, reference is made to DNV's Rules for Classification of Ships Pt.2 Ch.3 Sec.5.

602 Preheating may be required for materials of certain thicknesses and chemical compositions. For welding of extra high-strength steel the preheating and interpass temperature shall be as advised by the steel manufacturer.

603 The weld reinforcement shall have a regular finish and shall merge smoothly into the base material without significant undercutting. The height of weld reinforcement shall not exceed 3 mm for material thickness $t \leq 12.5$ mm and max. 4 mm for greater thickness.

604 Welds which are essentially perpendicular to the direction of applied fluctuating stresses in members important to the structural integrity, shall normally be full penetration type and, if possible, welded from both sides. Dressing of welds by grinding may be required. Joint members subjected to high stress in the thickness direction shall be of Z-quality, alternatively ultrasonically tested for lamellar tearing after welding.

605 The use of permanent steel backing strips may be accepted when properly accounted for in the design analysis. Ceramic and other neutral backing strips may be used when of approved type. A test weld for the intended application shall be produced and subjected to mechanical testing agreed upon in each case.

606 Temporary cut-outs shall be made of sufficient size allowing sound replacement. Corners of cut-outs shall be given appropriate radius minimizing the local stress concentration.

J 700 Repair of welds

701 For every type of repair, a repair welding procedure specification shall be prepared. In addition to the details mentioned in 200 the method for removal of defects, preparation of weld area and subsequent non-destructive testing as well as minimum and maximum repair length/depth shall be specified.

702 Repairs by welding of special and primary structural members and connections of primary to secondary members, shall be carried out in accordance with approved WPS. Documentation shall be presented prior to commencement of repair welding.

703 Weld defects may be rectified by grinding, machining or welding. Welds of insufficient strength, ductility or notch toughness shall be completely removed prior to repair. The mechanical properties of repair welds shall satisfy the minimum specified properties of the steel in question. Repair with arc-air gouging shall be followed by subsequent grinding.

Repair welding in the same area may be carried out twice. Further repairs are subject to the Society's consent.

704 Repair welding shall be carried out with extra hydrogen welding consumables applying an appropriate pre-heating and working/interpass temperature. Generally the preheating and working temperature when making shallow and local repairs shall be raised 25°C above level used for production welding, but is not to be less than 100°C. The working temperature shall be maintained until the repair has been completed ensure sound repair welds. The single repair length shall not be shorter than approx. 100 mm.

705 When repair welding is carried out on heat-treated steel, reheat treatment may be required. When post heat-treated parts need repair by welding, the post heat treatment (PWHT) shall normally be repeated.

J 800 Heat-treatment after forming and welding

801 If heat treatment after forming or welding is specified in procedures or on drawings, a detailed heat treatment procedure shall be sub-mitted to the Society for approval.

802 Thermal stress relieving of cold-worked material, if found necessary, shall be carried out in accordance with the conditions stated below for post-weld heat treatment.

803 Post-weld heat-treatment of C-steels and C-Mn-steels shall be performed with a soaking temperature in the range 550 to 620°C, for a time of 2 minutes per mm thickness. Soaking temperature for low-alloyed steel shall be decided in each case.

804 Post-weld heat-treatment shall, wherever possible, be carried out in an enclosing furnace. Where it is not practical to heat-treat the whole structure in a closed furnace, local heat-treatment may be adopted subject to the Society's consent.

805 The heat-treatment cycle shall be recorded using thermocouples equally spaced externally, and whenever possible internally, throughout the heated region. Heat-treatment records shall be submitted to the Society for consideration.

J 900 Production weld tests

901 *Welding Production Test (WPT)* may be required to be carried out during the production welding under identical condition as that of the production welding in order to verify the properties of the welds. Number and type of tests will be specified in each case.

902 When a WPT fails to meet the requirements, retesting may be carried out in accordance with the following.

If the impact test (3 specimens) fails to meet the requirements, 3 additional impact test specimens may be prepared and tested provided that only one of the below mentioned cases occurred in the first test:

- The average value was below the requirement, one value was below the average requirement but not below the minimum requirement for a single value.
- The average value met the requirement. Two values were below the average requirement but not below the requirement for a single value.
- The average met the requirement. Two values were above or equal to the average requirement and one value was below the requirement for a single value.

The initial 3 impact values and the additional 3 values shall form a new average of six values. If this new average complies with the requirement and no more than two individual results of all six specimens are lower than the required average and no more than one result is lower than the required value for a single specimen, the test may be accepted.

903 Upon special request and at the discretion of the Society, welding production tests may replace welding procedure qualification tests.

J 1000 Inspection and testing of welds

1001 Completed welds shall be subjected to visual inspection and non-destructive testing as manufacturing and construction proceeds. For material grade NV 420 and higher, NDT shall not be carried out before 48 hours

after completion. When post weld heat treatment is performed, the final non-destructive testing shall normally be carried out when the heat-treatment has been carried out/completed.

1002 All welds shall be visually inspected over their full length.

1003 Methods for non-destructive testing (NDT) shall be chosen with due regard to the conditions influencing the sensitivity of the methods. Unless otherwise agreed, structural welds shall be subjected to non-destructive testing to the extent stipulated in Table J1. The specified percentages refer to the total length of weld for each structural assembly in question. The categories of the structural members shall be agreed with the Society in each case, ref. A201.

1004 The non-destructive testing shall include intersection of butt-welds, cruciform joints and other areas where the stress level is high, as well as start and stop-points of automatically welded seams.

1005 If non-destructive testing reveals defects which indicate unacceptable weld quality, the Society's surveyor may require increased extent of testing until the specified overall quality level has been re-established. If serious defects (i.e. cracks and other planar defects, excessive slag lines and cluster porosities) occur repeatedly, all welds made with the same welding procedure during the period in question shall be tested over their full length.

1006 The Society's surveyor shall be the final judge when assessing the weld quality.

1007 All non-destructive testing shall be properly documented and identified in such a way that the tested areas may be easily retraced at a later stage.

J 1100 NDT-procedures and NDT-operators

1101 NDT shall be performed in accordance with agreed written procedures that, as a minimum are in accordance with DNV Classification Notes No.7 and give detailed information on the following aspects:

- materials, dimensions and temperature of tested material
- periodically verification of equipment requirements
- joint configuration and dimensions
- technique (sketches/ figures to be referenced in the NDT report)
- equipment and consumables
- sensitivity, and light conditions for MT and PT
- calibration techniques and calibration references
- testing parameters and variables
- assessment of imperfections and the surfaces from which the examination has been performed
- reporting and documentation of results. The reporting system shall ensure that there is no doubt what is examined, where it is examined and give a clear and exact description of reportable defect location.
- reference to applicable welding procedure(s)
- personnel qualification
- acceptance criteria.

1102 All testing shall be carried out by qualified and certified personnel. The NDT operators shall be certified according to a recognised certification scheme accepted by the Society, e.g. EN 473, ISO 9712. The certificate shall clearly state the qualifications as to which testing method and within which category the operator is certified.

1103 The NDT-operators shall issue reports describing the weld quality. The reports shall clearly distinguish between accepted and rejected welds, and the number of repairs carried out to meet the specified acceptance standard shall be stated. The inspection reports shall specify the NDT-methods and procedures used including all NDT-parameters necessary for a proper assessment.

J 1200 Weld acceptance criteria

1201 All welds shall show evidence of good workmanship. For visual inspection and NDT the acceptance level shall normally comply with ISO 5817 quality level C, intermediate ("primary"). For critical areas more stringent requirements, such as ISO 5817 level B, stringent ("special"), may be applied.

Welds in aluminium shall comply with ISO 10042 level B (applies for category special) or level C (applies for category primary/ secondary).

Level B and level C of ISO 5817 / ISO 10042 are equal to, respectively, acceptance level 2 and level 3 of EN 1712 "Non-destructive examination of welds. Ultrasonic examination of welded joints, acceptance levels."

Ref. correlation given in EN 1712, EN 126062 and EN 17635.

Regarding ultrasonic examination EN 1712 level 2 or level 3 applies. with the following amendment: All imperfections from which the reflected echo amplitude exceeds the evaluation level shall be characterised, and all that are characterised as planar (e.g. cracks, lack of fusion, incomplete penetration) shall be rejected.

Table J1 Minimum NDT of structural welds					
<i>Category of member</i>	<i>Type of connection</i>	<i>Test method</i>			
		<i>Visual inspection</i>	<i>Magnetic particle ³⁾</i>	<i>Radiography ¹⁾</i>	<i>Ultrasonic</i>
Special	Butt weld	100%	100%	100%	
	Cross- and T-joints, full penetration welds	100%	100%	-	100%
	Cross- and T-joints, partly penetration and fillet welds	100%	100%	-	-
Primary	Butt weld	100%	20%	20%	
	Cross- and T-joints, full penetration welds	100%	20%	-	20%
	Cross- and T-joints, partly penetration and fillet welds	100%	20%	-	-
Secondary	Butt weld	100%	spot ²⁾	spot ²⁾	
	Cross- and T-joints, full penetration welds	100%	spot ²⁾	-	spot ²⁾
	Cross- and T-joints, partly penetration and fillet welds	100%	spot ²⁾	-	-
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 thickness less than 10 mm.					

J 1300 NDT acceptance criteria for components machined after forged/cast

1301 Unless otherwise specified in this standard or approved manufacturer's specification, acceptance criteria from the following documents can be used for NDT of machined components:

For forged components:

IACS Recommendation no.68, Inspection zone 1

For cast components:

IACS Recommendation no.69, Quality level 1

NDT testing to be focused on critical areas. Extent to be specified by the manufacturer and shall be according to recognised 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 the designer and accepted by the Society are obtained.

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J 1400 Material protection against corrosion

1401 Steel surfaces exposed to marine atmospheric conditions shall be protected by a suitable coating system.

1402 Steel surfaces to which application of coating are not possible and which are exposed to internal corrosive conditions shall be protected by other protective systems such as oil, grease, grouting etc.

1403 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.

SECTION 2 STRUCTURAL DESIGN AND STRENGTH

A. Design Loads

A 100 General

101 The loads to be considered in the analysis of structures are divided into:

- a) Principal loads (see 200).
- b) Vertical loads due to operational motions (see 300).
- c) Horizontal loads due to operational motions (see 400).
- d) Loads due to motion of the vessel on which the crane is mounted (see 500).
- e) Loads due to climatic effects (see 600).
- f) Miscellaneous loads (see 700).

102 The loads to be considered in the analysis of mechanisms are divided into:

- a) Loads which are directly dependent upon the action of motors or brakes.
- b) Loads which are not directly dependent upon motor or brake action, and which in fact are responses to the loads a) through f) in 101.

Furthermore, the loads may be considered belonging into two other groups; those initially specified by the Customer, and those determined by the designer.

The determination of the loads specified by the designer shall be documented with enclosed calculations, references to standards, or other justification.

103 The loads mentioned in 101 and 102 shall be determined and applied in accordance with 200 through 800. Clearly, for many cranes and components some of the defined loads will never be present. Note that in the following there is not always a clear distinction between loads and responses to loads. A “load” acting on a component may well be an internal “response” in the crane as a whole. Accordingly, terms like “load due to weight” may be used instead of “weight”.

A 200 Principal loads

201 The principal loads are:

- the loads due to dead weight of the components (S_G)
- the loads due to working load (S_L)
- the loads due to prestressing.

Working load (suspended load) is the static weight of the useful load lifted, plus the weight of the accessories (sheave blocks, hooks, lifting beams, grab, etc.).

Safe working load is the static weight of the load lifted (working load exclusive the weight of accessories plus any lifting beam).

Loads due to prestressing are loads imposed on structural items due to prestressing of bolts, wire ropes, etc.

202 Except for prestressing, all the principal loads are due to weight which always acts vertically (in the normal sense). This means that if the crane is mounted on an object which can obtain inclination (heel and/or trim) in any direction, the principal loads may have “horizontal” components when referred to a practical coordinate system of the crane. These components shall be taken into account, and shall be considered as principal loads, also if the angles are due to motions such as rolling and pitching of a vessel. Note that the simultaneous inertia forces are not considered as principal loads, see 101, item d) and 500.

203 For cranes mounted on floating vessels the horizontal components of S_G and S_L shall be taken into account as explained in 202. The angles to be considered are the maximum angles expected during lifting operation with no wind and waves acting. Minimum values to be used, when decisive, are given in Table A1. These values are considered as minimum but may be especially considered provided statistically evidence or separate means/-operational conditions proving that list and trim could be assessed smaller.

Table A1 Minimum heel and trim angles, still water		
<i>Type of vessel</i>	<i>Heel</i>	<i>Trim</i>
Ships and vessels having ship-shape hull properties	Min. 5°	Min 2°
Barges of length less than 4 times breadth, and catamarans	Min. 3°	Min. 2°
Semi-submersibles	Min. 3°	Min. 3°
Submersibles and jack-ups	Min. 1°	Min. 1°

A 300 Vertical loads due to operational motions

301 Vertical refers to the coordinate system of the crane. For a crane onboard a floating unit it is assumed that vertical state is so defined that it corresponds to physical vertical state in the ideal position with zero "heel" and "trim" of the "unit" on which the crane is mounted.

The vertical loads due to operational motions shall be taken into account by multiplying the working load by a "dynamic factor", ψ .

The dynamic factor covers inertia forces and shock.

302 The dynamic factor can be assessed by

$$\psi = 1 + V_R \sqrt{\frac{C}{W \cdot g}}$$

C = geometric stiffness coefficient referred to hook position (also called "spring constant" defined as force at hook to produce unit deflection at hook (kN/m))

g = standard acceleration of gravity
= 9.81 m/s²

W = working load (see 201) (kN)

V_R = relative velocity (m/s) between load and hook at the time of pick-up.

For the purpose of assessing the C-value, the modulus of elasticity of steel wire ropes shall be as specified by the wire manufacturer for an un-used wire rope. The crane stiffness (C-value) shall be calculated taking into account all elements from the hook to the pedestal support structure.

303 For grab duty the dynamic factor shall be increased by 20% for use of self-closing grabs (closed by lifting wire pull) and with 30% for use of grabs with motor closing.

304 For cranes located on the barges or the bulk carriers from where the load is lifted (picked up), the cranes may be considered as shipboard crane.

A 400 Horizontal loads due to operational motions

401 Horizontal refers to the coordinate system of the crane. It is assumed that horizontal is so defined that it corresponds to physical horizontal in the ideal position with zero "heel" and "trim" on which the crane is mounted.

The horizontal loads (S_H) due to operational motions are:

- inertia forces due to acceleration or deceleration of horizontal motions (see 402)
- centrifugal forces (see Sec.5 B300 and Sec.6 B300)
- forces transverse to rail resulting from reeling and skew motion (see 403)
- buffer loads (S_T) (see 404).

It should be noted that these horizontal forces act in addition to possible simultaneously acting horizontal components of the principal loads, see 202.

402 Forces 1) stated in 401 shall be determined on the basis of the maximum possible acceleration with the given machinery, and on the basis of the maximum possible deceleration with the given brakes. Typically, forces of this type occur by starting and stopping of travelling-, traversing- and slewing motions. The inertia due to angular acceleration (deceleration) of rotating machinery components shall be taken into account when this effect is significant.

For travelling cranes (and trolleys) it will normally be sufficient to consider horizontal forces corresponding to 15% of maximum vertical load on each wheel with brakes, or on each driven wheel.

403 Horizontal forces transverse to rail due to travelling motion occur in two ways, of which the more unfavourable one is to be considered:

- Horizontal inertia forces - to be taken as 10% of the weight of the travelling unit - balanced by lateral wheel reactions (Reeling).

- A lateral force acting on one of the “forward” wheels (or bogies) - to be taken as λ times the wheel load - balanced by other physically possible horizontal wheel reactions (skew motion). λ is to be taken according to Fig.1.

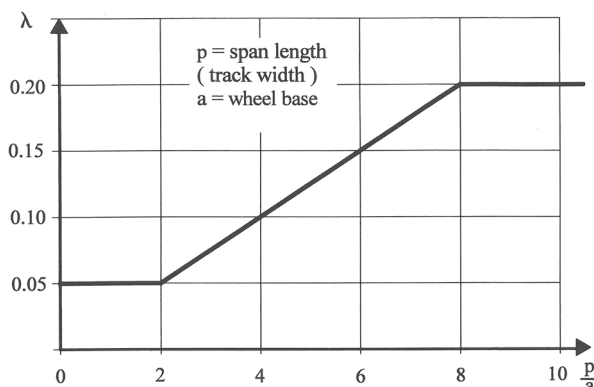


Figure 1
Lateral wheel force

404 The following requirements for determination of buffer effects are based on the assumption that the buffers are capable of absorbing the kinetic energy of the crane (or trolley) at a travelling (or traversing) speed of 0.7 times rated speed. If the suspended load can swing, the kinetic energy of it need not be taken into account. Buffer effects need not be taken into account for speeds below 0.7 m/sec.

For speeds in excess of 0.7 m/s the resulting loads set up in the structure are to be calculated on the basis of the deceleration, which in turn shall be based upon the buff characteristics.

If automatic decelerating devices are used, the speed of the crane after deceleration upon approach to the end of the track may be used, instead of the rated speed, in the determination of buffer effects. Thus, if the speed is reduced, by the decelerating device, to a value of 0.7 m/sec or less, buffer effects need not be considered

A 500 Loads due to motion of vessel on which the crane is mounted

501 Inertia forces due to ship motion shall be calculated in accordance with the Rules for Classification of Ships, Pt.3 Ch.1 Sec.4 B “Ship Motions and Accelerations”. The forces shall be combined to 10^{-8} probability level to correspond with safety factors as specified for Load Case III. See also Appendix C.

Guidance note:

Horizontal inertia forces due to motion of the mobile offshore unit (semi-submersibles, self-elevating units in transit, etc.) shall be calculated, but need normally not be taken larger than $0.5g$ [m/s^2]

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A 600 Loads due to climatic effects

601 The possible loads due to climatic effects are

- loads due to wind
- loads due to snow and ice
- loads due to temperature variations.

602 Loads due to wind shall be calculated in accordance with Appendix A or a recognised code or standard.

603 Snow and ice loads may be neglected in the design calculations except for cranes working under exceptional conditions, or for cranes of special designs being particularly sensitive to such effects.

604 Loads due to temperature variations shall be considered only in special cases, such as when members are not free to expand. In such cases the maximum temperature fluctuation for outdoor cranes shall normally not be taken less than 65°C . For indoor cranes possible special sources of heat shall be considered. (Note that the maximum and minimum temperatures shall always be taken into account when selecting the materials).

A 700 Miscellaneous loads

701 Access gangways, driver's cabins and platforms shall be designed to carry the following concentrated loads in arbitrary (most unfavourable) position:

- 3000 N for maintenance gangways and platforms where materials may be placed
- 300 N as the horizontal lateral force which may act outwards or inwards on handrails and toe-boards.

702 The loads given in 701 need not be taken into account in the strength evaluation of the main structural system of the crane, except as far as necessary for the connection between this system and the structures mentioned in 701. The dead weight of the latter structures however, shall be included in the principal loads, see 201.

A 800 Loads for strength analysis of mechanisms

801 A mechanism will always have to transmit forces when it is in motion, i.e. it shall be considered for the most unfavourable motor or brake action (102, a). The loads of this type are those associated with:

- vertical displacement of centres of gravity of load and parts moved by the mechanism
- friction between moving parts
- acceleration (or braking) of the motion
- effect of wind acting on the parts moved by the mechanism.

802 A mechanism may have to transmit forces even when it is stationary. In such a case the function of the mechanism is similar to that of a structural component. Consequently, the loads to be considered are the same as those to be considered in the analyses of structures.

B. Cases of Loading

B 100 General

101 For the purpose of making the nominal safety dependent upon the probability of occurrence of the loading, three general cases of loading are defined, for which the required safety margins are different:

Case I: Crane working without wind. (See 200).

Case II: Crane working with wind. (See 300).

Case III: Crane subjected to exceptional loadings. (See 400).

102 For the various types of cranes the detailed loading to be considered for each case may be different. For instance, Case III may include different conditions for stationary cranes, mobile cranes and ship-mounted cranes.

B 200 Case I: Crane working without wind

201 Case I is the main case of loading and includes the loads that necessarily will occur under normal operation:

- The principal loads (S_G and S_L) according to A 200.
- The vertical loads due to operational motions according to A 300.
- The horizontal loads due to operational motions (S_H), according to A 400. The two most unfavourable effects are used, excluding buffer loads.

By use of symbols Case I may be defined as follows:

$$S_G + \psi \cdot S_L + S_H$$

202 For cranes mounted on floating vessels horizontal components of S_G and S_L shall be taken into account as explained in A202 and A203.

203 With regard to S_H the following should be noted: Maximum two of the effects mentioned in A 401 (excluding buffer loads) need be considered simultaneously. Further, in cases where travel motion takes place only for positioning the crane and is not used for moving loads, the effect of this motion shall not be combined with the effect of other motions.

B 300 Case II: Crane working with wind

301 Principally, Case II includes the same loads as Case I, with the addition of loads (S_W) due to “working” wind:

$$S_G + \psi \cdot S_L + S_H + S_W$$

S_W shall be determined in accordance with A 600. The meaning of the other symbols is as given in 201, with the exceptions given in 302.

302 The actual difference between Case I and Case II will depend on type and use of the crane. For indoor cranes there will be no difference, meaning the Case II need not be considered. For outdoor, stationary, land cranes the difference is normally S_W only. For cranes mounted on floating vessels the “horizontal” components of S_G and S_L shall be based on increased angles compared with Case I. Minimum angles are to be 1.5 times the values given in Table A1.

303 “Working” wind acting on the suspended load shall be taken into account if the effect is significant. The wind force shall be determined by taking into account the largest area which can face the wind, taking $C=1.2$ for containers and similar shapes, and $C=1$ for more arbitrary shapes.

B 400 Case III: Crane subjected to exceptional loadings

401 Any loading condition where one or more exceptional loads are included belongs to Case III. The following loads are defined as exceptional loads:

- Buffer loads, according to A406 (Symbol S_T).
- Inertia forces due to motion of the vessel on which the crane is mounted, according to A500 (Symbol S_M). For the vessel’s transit condition special attention must be given to how the crane is secured. See Appendix C which presents an example on how this may be dealt with.
- Loads due to “out of service” wind according to A600 (Symbol S_W).

Other forces which necessarily must act together with the above exceptional loads are included in Case III.

402 Defined by symbols, the following load combinations are to be considered in Case III:

IIIa: $S_G + S_L + S_T$

IIIb: $S_G + S_M + S_{W \max}$

For land cranes S_M will be zero. For indoor cranes combination IIIb is not considered. For cranes mounted on floating vessels the horizontal components of S_G and S_L shall be considered for estimated maximum rolling and pitching angles, including possible initial heel and trim.

C. Strength Calculations

C 100 General

101 It shall be shown that structures and components have the required safety against the following types of failure:

- excessive yielding (see 200)
- buckling (see 300)
- fatigue fracture (see 400).

102 The safety shall be evaluated for the three cases of loading defined in C. For each of these cases and for each member or cross section to be checked, the most unfavourable position and direction of the forces shall be considered.

103 The strength calculations shall be based on accepted principles of structural strength and strength of materials. When applicable, plastic analysis may be used. If elastic methods are not suitable to verify safety, for instance due to pre-stressing, plastic analysis may be required.

104 The verification of safety may be based on the permissible stresses method or the limit state method. With the factors given in this standard there will be only a formal difference between the two methods. The relation is

Safety Factor = Load Factor times Material Factor.

$$S_F = \gamma_f \cdot \gamma_m$$

For structures with nonlinear behaviour, however, significant differences may occur. In such cases the limit state method shall be used, or the safety factor shall refer to load and not to stresses.

C 200 Checking with respect to excessive yielding

201 For members made of structural steel the requirements for the various cases of loading are given. With reference to method of analysis and method of verification of safety given in Table C1, σ_y is the guaranteed minimum yield strength (or 0.2% proof stress). If σ_y is higher than 0.8 times the ultimate strength σ_u use in this connection $0.8 \cdot \sigma_u$ instead of σ_y .

202 When using elastic analysis, the permissible stresses (or the required safety factors) given in Table C1 refer in cases of combined stresses to the equivalent stress according to von Mises. Local peak stresses in areas with pronounced geometrical changes may be accepted by case by case evaluation.

203 For components made of other materials than structural steel, and for other special components, refer to E.

204 Joints shall not be weaker than the minimum required strength of the members to be connected. For riveted joints, bolted joints, friction-grip joints, and welded joints refer to F.E.M./I or other recognised codes.

C 300 Checking with respect to buckling

301 The guiding principle is that the safety against buckling shall be the same as the required safety against the yield limit load being exceeded. This principle indicates that the factors given in the second line of Table C1 should represent the normal requirement. However, other values may be required or allowed, for instance due to uncertainty in the determination of the critical stresses (or load) or due to the post-buckling behaviour. Required factors are given for various types of buckling in Table C2.

302 The safety factors given in Table C2 are based on the assumption that the critical stresses (or loads) are determined by recognised methods, taking possible effects of geometrical imperfections and initial stresses into account. Elastic buckling in Table C2 means that elastic buckling stress does not exceed the yield strength.

303 Calculation methods and corresponding required safety factors as specified by other crane standards/ codes or other specialized literature may also be used.

Table C1 Criteria for the checking with respect to excessive yielding				
Method of verification		Load Case I	Load Case II	Load Case III
Safety Factor	Elastic analysis	1.50	1.33	1.10
	Plastic (ult. str.) analysis	1.69	1.51	1.25
Permissible stresses	Elastic analysis	$\sigma_y/1.50$	$\sigma_y/1.33$	$\sigma_y/1.10$
Limit state method	Load factor		1.30	1.16
	Material factor	Elastic analysis	1.15	1.15
		Plastic analysis	1.30	1.30

Table C2 Safety factors for the checking with respect to buckling			
Type of buckling	S_F or $\gamma_F \cdot \gamma_m$		
	Load Case I	Load Case II	Load Case III
Elastic buckling	1.86	1.66	1.38
Elastic-plastic buckling	1.69	1.51	1.25

C 400 Checking with respect to fatigue

401 For fatigue calculations normally the latest edition of F.E.M. standard (Federation Europeenne de la Manutention), DNV-RP-C203 or equivalent national standards for cranes may be referred to.

Guidance note:

If F.E.M. 1.001 3rd edition Rev.1998.10.01. is used, and if not otherwise documented by statistical evidence and/or limitation with respect to operational performance Table C3 applies as guidance. (terminology as in F.E.M. 1.001 3rd edition Rev.1998.10.01.)

Table C3 Group classification of lifting appliances		
Definition of crane	Particulars concerning nature of use ¹⁾	Appliance Group ²⁾
Cranes for exceptionally low service time, e.g. BOP cranes		A2
Workshop and similar industrial cranes with hook		A4
Overhead travelling cranes for maintenance purpose		A3
Pipe rack cranes	hook	A3
Pipe rack cranes	magnet	A6-A8
Store room cranes		A4
Jib or gantry cranes for container service		A5
Dock side and ship-yard jib cranes	hook	A5
Dock side and ship-yard jib cranes	grab or magnet	A6-A8
Shipboard cranes for cargo-, provision- or hose handling	hook	A4
Shipboard cranes	grab or magnet	A5
Offshore cranes, whip hoist		A5
Offshore cranes, main hoist		A3
For cranes with safe working load more than 250 tonnes, the group-classification can normally be set at the lower alternative or one group lower, but at least group A2.		
¹⁾ Only a few typical cases of use are shown, by way of guidance, in this column.		
²⁾ See F.E.M. 1.001 3 rd edition Rev.1998.10.01. Item 2.1.2.4.		

402 The method of fatigue calculation, for example by using group classification in accordance with F.E.M. 1.001 3rd edition Rev.1998.10.01. on one side and calculation procedure and the specific requirements on the other, shall be consistent.

The crane group chosen for the calculation shall also be specified in the Crane Manual.

403 The fatigue strength, expressed as the critical amplitude of a fluctuating or alternating stress, shall be determined on the basis of the following information:

- component group according to table C3
- the material used and the notch effect at the point being considered
- the fluctuation factor = $\sigma_{\min}/\sigma_{\max}$
- whether the maximum stress is tension or compression.

With the above data given, the critical amplitude is defined as that which corresponds to 90% probability of survival. Regarding detailed procedure for the determination of the critical stress amplitude, see F.E.M./I or other specialized literature.

404 Fatigue considerations shall be made for Case I for all types of cranes. In addition, for ship mounted cranes where the transit condition may be of considerable duration, it may be required to consider fatigue effect on certain components in Case III. The effect of wind need not be taken into account.

405 The calculated maximum stress amplitude shall not exceed the permissible stress for fatigue, which is critical stress amplitude divided by a safety factor of 1.33.

$$\sigma_{allow} = \sigma_{crc} / 1.33$$

D. Design and Strength of Particular Components

D 100 General

101 This Standard for Certification does not attempt to make a clear distinction between structural and mechanical components. A mechanism, as defined in Ch.1 Sec.1 C137 may well contain components which could be defined as structural components. Such components shall be evaluated according to C. The only difference from an ordinary structural component is that Cases I and II have to include forces acting on the component when the mechanism to which it belongs is in motion, see A801. The term “particular components” may mean structural as well as mechanical components.

102 Components that transmit forces, whether “structural” or “mechanical”, and that are not directly or completely covered by this Standard for Certification, shall be designed and calculated in accordance with applicable recognised codes or standards. To the extent applicable, FEM/I is advised.

D 200 Buckling stability of jibs

201 The buckling problems of a jib may be solved by determining slenderness ratios and by considering the permissible stress as a function of these ratios. Hence the determination of effective lengths with respect to the possible buckling modes may become a key problem.

202 The effective length of the jib depends on its support and of whether the jib is of latticed design or battened design.

203 The effective length of the jib – considering support effect at jib head – may e.g. be estimated in accordance with British Standard BS 2573:Part 1:1983.

For a rope supported jib the effective length may, with reference to Fig.2, be taken as

$$l_{eff} = L \left(2 - \frac{B}{A} \right) \quad \text{for lateral buckling}$$

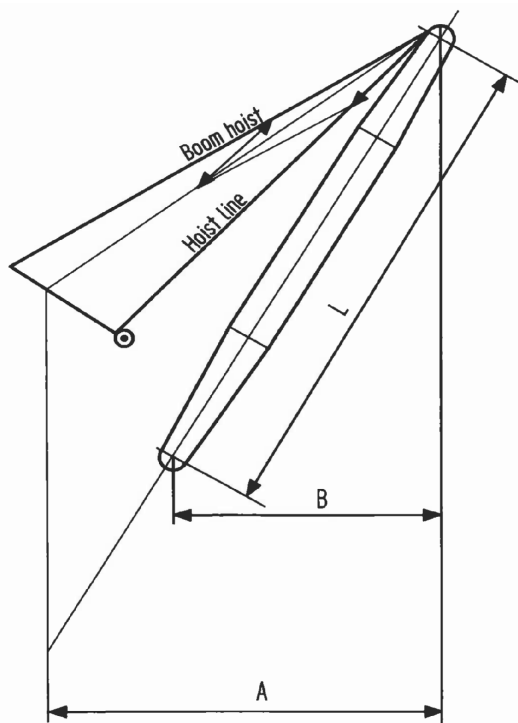


Figure 2
Effective length of jib

204 For jibs having solid webs in the considered plane of buckling, the above values of l_{eff} may be used without correction. Jibs that are latticed or battened in the considered plane of buckling l_{eff} (or the slenderness ratio) according to 203 shall be increased due to shear deformation of the jib. Recognised, simplified methods for this correction may be accepted.

The following correction factor may be used for latticed jibs:

$$\sqrt{1 + \frac{300}{(l_{eff}/i)^2}} \text{ for } \frac{l_{eff}}{i} > 40$$

$$1.1 \text{ for } \frac{l_{eff}}{i} \leq 40$$

i = radius of gyration, see 205.

205 The overall slenderness ratio l_{eff}/i of the jib in each plane may be obtained by dividing the effective length of the jib by the smallest radius of gyration of the complete cross section of the jib. Correction shall be made for tapering off cross section towards jib ends.

206 Stresses arising from axial compression and bending shall comply with the requirements of recognised combination formulae.

D 300 Slewing bearing for jib cranes

301 For slewing bearings of the ball and roller type the following aspects shall be examined:

- 1) Plastic deformation of rolling elements and raceways (raceway capacities).
- 2) Bolt capacity.
- 3) Ultimate carrying capacity of the slewing ring as a whole, based on the capacities of the bolts and cross sections – with due regard to the rigidity of the structures supporting the (fixed and revolving) rings.
- 4) Fatigue of critical sections of the outer and inner rings, i.e. the "nose" for multi-row bearings.

The slewing bearings are specialized components, and the design criteria for a given type shall as far as practicable be based on tests carried out for the particular type. Item 2), 3) and 4), however, will normally be required to be checked by calculations as indicated/specified in the following.

For design loads note special requirements in Sec.6 B204 (offshore cranes) and Sec.8 B103 (heavy lift cranes).

302 The vertical component of rolling element forces on the raceway (roller element track) is assumed to vary linearly across the diameter of the raceway, i.e. a sinuous distribution with reference to the raceway circumference.

The maximum vertical force per unit length is then

$$q_A = \frac{4M_k}{\pi D^2} \pm \frac{F_a}{\pi D}$$

respectively at the front (+) and rear (-) of the crane (front is regarded the side on which the boom is fitted).

M_k = overturning design moment on the slewing bearing. Dynamic factor is included.

F_a = axial design force on the slewing bearing. Dynamic factor is included.

D = raceway (track) diameter.

303 Slewing ring fasteners (bolts) shall have a yield capacity per bolt (i.e. stress area of bolt, A_s , times the material yield stress, f_y) not less than

$$(F_B)_{0.2} \geq \frac{0.75}{pr} \cdot F_A \left(\frac{a + \chi b + c}{c} \right)$$

pr = degree of permanent pre-stressing related to yield (100% = 1.0)

F_A = maximum vertical raceway load per bolt sector at the rear of the ring

χ = F_R/F_A

F_R = maximum horizontal (radial) load per bolt sector.

a , b and c as per Fig.3.

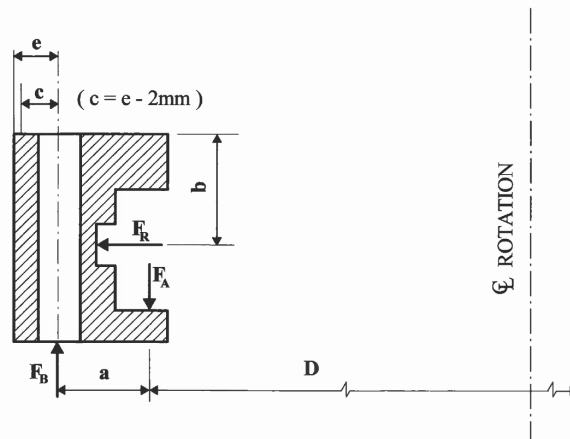


Figure 3
Slewing ring measures

304 The effective bolt length shall be at least 4.5 times the bolt diameter.

Guidance note:

Effective bolt length is the part of the bolt that may be free to be elongated at tension. In other words, it does not include the part of the bolt being constrained by the treads.

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305 Slewing ring fasteners shall be pre-stressed according to a written procedure. The degree of permanent prestressing shall be as high as possible without producing permanent elongation in bolt during prestressing. The degree of permanent prestressing shall at least be 65% but normally not more than 80% of bolt material yield strength. If documented by testing, procedures claiming a degree of permanent prestressing up to 90% of bolt material yield strength may be credited.

306 The holding-down bolts shall - as far as practical - be equally spaced over the 360° circumference.

Guidance note:

With equally spaced bolts, F_A and F_R in 303 becomes

$$F_A = \left(\frac{4M_k}{D} - F_a \right) \frac{1}{m}$$

Normally, the following formula applies to the rear “element” of all the bearing.

$$F_R = \frac{1}{m} \left[4F_r + \left(\frac{4M_k}{D} + F_a \right) \tan \beta \right]$$

where:

$\beta = 0^\circ$ for “multi-row” bearings

$\beta = 30^\circ$ for single-row bearings

$\beta = 45^\circ$ for cross roll bearings

m = is number of bolts

F_r = radial force on the slewing bearing.

(Note that F_r is here assumed to act horizontally in the direction of the jib).

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307 Yield limit load (capacity) of the slewing bearing shall be evaluated considering equilibrium between rolling element forces and the following “reactions” acting on an “element” of the ring:

- Bolt forces acting on the considered “element” possible shear included.
- Possible interface pressure between the considered “element” and the structure supporting the ring.
- Forces acting in the cross section of the ring (i.e. the “end surfaces” of the considered “element”).

308 The ratio between the ultimate carrying capacity (ring and bolts) and calculated load on the slewing bearing shall not be less than 1.5.

309 Penetration of aggressive materials into the raceways must be prevented. For bearings that are often exposed to splash and surge water, the use of an adequate seal is recommended.

310 The vertical support in the bearings companion structure should preferably be in the vicinity of the track diameter in the heaviest loaded areas (main tension/compression zones). If this is not the case, DNV will normally require use of bracket plates. DNV may, upon evaluation of each actual bearing and companion structure design, ask for detailed calculations of any deflection of the support surfaces under maximum operating load together with documentation of the permissible limits as specified by the bearing manufacturer.

See also comments on desired avoidance of brackets in 402.

Guidance note:

Slewing bearings of the ball or roller type are required to be opened up periodically for inspection.

However, for cranes on which a retention device (with minimum capacity equivalent to the slewing bearing) is arranged, or the slewing bearing has been specially adapted and approved for non-destructive crack detection, or a procedure for regular clearance measurements, grease sampling and fatigue evaluations are adopted in agreement with the crane and slewing bearing manufacturer, the requirement to opening up may be waived.

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D 400 Flanges

401 The thickness of connecting flanges shall be checked locally according to

$$t_{\min} = \sqrt{\frac{6 \cdot S_F \cdot \left(\frac{2M_k}{r_x} - F_a \right) \cdot \left(|r_b - r_x| - \frac{1}{2} d_h \right)}{m \cdot \left(s - \frac{1}{2} d_h \right) f_y}}$$

where

S_F = required safety factor, given in table C1

r_b = bolt circle radius for the flange in question

r_x = pedestal radius or kingpost radius measured to middle of plate

d_h = bolt hole diameter

s = centre /centre spacing for boltholes

f_y = yield strength flange material.

402 For excessive moments (when the raceway diameter differs from the diameter of a cylindrical pedestal/kingpost and/or radial forces act on the rings), supporting brackets may be required under the flange.

Brackets and their welding attachments “will be felt” by the slewing ring when rotating. Consequently, it is

preferable to eliminate the difference of the above mentioned diameters as much as possible (vertical load on ball/rollers in line with pedestal/kingpost plate), thereby minimizing the warping moment and contributing to enable the leaving out of brackets.

403 Normally there shall be a full penetration weld between the pedestal/kingpost shell and the flanges.

404 Flatness of the connecting flange mating surface to the slewing bearing shall comply with the slewing bearing manufacturer's specification.

No surface levelling compound shall be used in order to obtain required flatness.

D 500 Pedestal and pedestal adapter for jib cranes

501 Pedestals and pedestal adapters shall be designed for the same crane group as that of the crane.

For design loads, note special requirements in Sec.6 B204 (offshore cranes) and Sec.8 B103 (heavy lift cranes).

502 Fatigue evaluation of pedestal/pedestal adapter shall be carried out in accordance with FEM or other acceptable crane standard.

SECTION 3 MACHINERY AND EQUIPMENT

A. Basic Requirement

A 100 Design Conditions (environmental, operational) for Machinery and Systems

101 Machinery and systems for lifting appliances shall be designed to operate under the following environmental conditions if not otherwise specified in the detail requirements for the component or system:

- ambient air temperature between the design temperature and 35°C
- ambient air temperature inside machinery housing or other compartments containing equipment between 5°C and 55°C
- relative humidity of air up to 96%.

102 Where the certification standard stipulates requirements to capacity or effect of machinery, these shall normally be determined on the basis of the following:

- ambient air temperature: 40°C
- relative humidity of air: 50%.

These values will be reconsidered if the crane shall work in tropical or sub-tropical areas.

Guidance note:

Consideration should be taken to the heat generated by machinery or other equipment and also to the heat caused by sun radiation on surrounding bulkheads.

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103 The effect of ice on an appliance installed in cold weather areas shall be considered for the parked/stowed position.

A 200 Materials

201 The materials applied shall be in compliance with Sec.1 or relevant recognised code or standard.

202 Materials with low heat resistance shall be applied where a fire may cause unacceptable consequences of damage, such as collapse, outflow of flammable fluids etc.

Non-metallic materials shall be flame-retardant in accordance with recognised standard.

A 300 Arrangement and general design of components and equipment

301 All components in a system shall be adequately matched with regard to strength, capacity and functional performance.

302 Relative movements due to load variations, thermal expansion, misalignment, vibration and interaction from foundations shall be allowed to avoid detrimental effects.

303 Bolts and nuts exposed to dynamic forces and vibrations shall be properly secured or pre-stressed.

304 All operational equipment shall be arranged for easy access. Components and equipment normally subject to inspection and maintenance shall be installed so as to provide easy access.

305 Arrangement for adequate lubrication of bearings and gears shall be provided.

306 All means of access shall be of a permanent nature and have to be considered in each case with due respect to type of crane and its intended service.

307 Protection against rain, sea-spray, snow, ice and sand shall be provided (essential for brakes, clutches etc.). Provisions shall be made to prevent accumulation of water in any construction. Rapid drainage is to be ensured.

308 Crane seatings and their supporting structures shall be of rigid design. As far as relevant tolerances of travelling cranes and gantry cranes and their tracks shall at least comply with FEM/I regulations. Tolerances of mating surfaces of seatings shall meet the standard required by the manufacturer of the slewing ring and general engineering standards.

309 Cranes shall be arranged with emergency escape in addition to the main access. Portable escape equipment may be accepted.

A 400 Ventilation

401 Forced ventilation (heating/cooling) shall be provided - when necessary - to ensure inside temperatures within the range required by 101.

402 Higher temperatures inside cubicles, desks etc. will be accepted provided installed equipment is regarded as suitable for such higher temperature.

403 Verification of temperature and final acceptance shall be based on loads and operational sequence relevant to the lifting appliance.

A 500 Strength

501 The strength of components and equipment shall generally be in compliance with C and D of Sec.2. Specific requirements for some important components are given in the following. Recognised codes and standards may be applied as a supplement to this Standard for Certification.

502 If acceptable accuracy cannot be obtained by strength calculations, special tests may be required for determination of the strength of a design.

B. Components

B 100 Winches

101 For design of the support of the winch to its foundation, relevant forces from crane operations are understood to having been evaluated at their maximum.

102 Winches shall be fitted with an operational brake, which normally absorbs energy through the winch power system. The operational brake is used to brake normal operating movements. Capacity and strength for the operational brake shall be documented through testing. In addition there shall be a mechanical brake, which satisfy requirements given in B300.

103 The direction of motion of the operating devices shall be such that the load is raised by clockwise movement of a hand-wheel or crank handle, or alternatively movement of a hand-lever towards the operator.

104 The operating device shall be arranged to return automatically to the braking position when the operator releases the control. However, for cranes operating in constant tension or active heave compensation modus – the brake shall remain off when the operator releases the control.

B 200 Drums

201 Drum diameters shall be determined with due respect to:

- type of reeving
- state of loading
- daily operating time

and shall be suitable for the selected steel wire rope, as directed by the rope manufacturer.

The ratio D_p/d shall normally not be less than 18 where

D_p = pitch diameter of drum

d = nominal diameter of steel wire rope.

202 As far as practicable and suitable for the arrangement, drums shall be designed with a length sufficient to reel up the rope in not more than 3 layers.

More than 3 layers may be accepted if the wire rope has an independent wire rope core (IWRC) and one of the following conditions is complied with:

- spooling device is provided
- drum is grooved
- fleet angle is restricted to 2°
- split drum is arranged
- separate traction drum is fitted.

However, when the number of layers exceeds 7, special consideration and approval will be required.

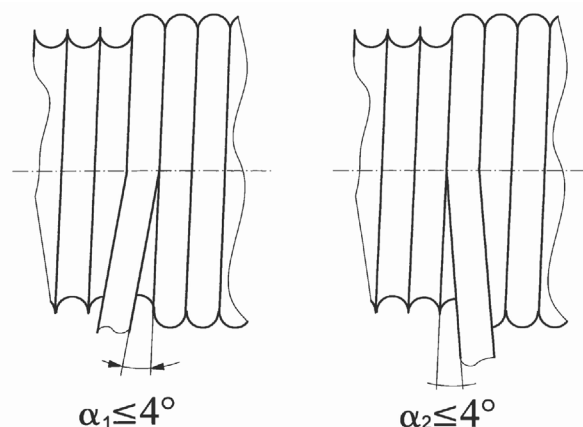


Figure 1
Wire rope fleet angles

203 For all operating conditions, the distance between the centre of the top layer of the wire rope on the drum and the outer edge of the drum flanges shall be at least 2.5 times the diameter of the wire rope, except in the cases where wire rope guards are fitted to prevent over spilling of the wire.

Guidance note:

It is advised that the drums have grooves to accept the rope. Where a grooved rope drum is used the drum diameter shall be measured to the bottom of the rope groove. To avoid climbing of the rope on the grooves the angles α_1 and α_2 shall not exceed 4° , see Fig.1. The groove shall be smooth. Advised radius of groove is $0.53 d$ (d = nominal rope diameter) and should be between $0.52d < r < 0.57d$.

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204 Drums shall either be fabricated from steel plates or be castings.

Ferritic nodular cast iron with minimum elongation (A_5) 10% may be accepted. By special consideration a lower elongation may be acceptable. Impact testing of ferritic nodular cast iron will for this application be waived.

205 Drums shall be checked with respect to their overall equilibrium situation and beam action, with the maximum rope tension acting in the most unfavourable position. The effect of support forces, overall bending, shear and torsion shall be considered. The rope tension shall in this case include any amplifying coefficient and the dynamic factor ψ . If more unfavourable however, the situation with forces directly dependent upon motor or brake action shall be considered.

206 The drum barrel shall be designed to withstand the surface pressure acting on it due to maximum number of windings. The rope is assumed to be spooled under maximum uniform rope tension. Maximum uniform rope tension means the tension due to safe working load without taken into account the amplification factors and dynamic factor. If the rope tension varies systematically, such as when an object is lifted from bottom and out of water, this variation shall be taken into account.

207 Unless comprehensive tests justify a lower value, the hoop stress in the barrel shall not be taken less than

$$\sigma_h = C \cdot \frac{S}{p \cdot t_{av}}$$

σ_h = hoop stress in drum barrel

S = maximum rope tension under spooling

p = pitch of rope grooving (the distance between ropes, centre to centre, within one layer)

t_{av} = average wall thickness of drum barrel

C = 1 for one layer

= 1.75 for two layers

= Special consideration, for more than two layers (thorough documentation or special testing may be required).

Guidance note:

The value of the C-factor depends on variables such as drum design, rope characteristics, type of operations, load characteristics and spooling. For 5 layers and above, a C-factor of 3 will normally be accepted for subsea retrieval operations with the full load from the first layer, applying “stiff” wire ropes. However, in some cases, and special for

winches with constant layer pull, the C-factor may be even higher. Between two and 5 layers, linear interpolation may be applied.

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The calculated hoop stress σ_h shall not exceed 85% of the material yield stress.

208 The drum flanges shall be designed for an outward pressure corresponding to the necessary lateral support of the windings near the drum ends. Unless a lower pressure is justified by tests (special tests may be required), the pressure is assumed to be linearly increasing from zero at the top layer to a maximum value of

$$p_f = \frac{2 \cdot t_{av}}{3 \cdot D} \cdot \sigma_h$$

near the barrel surface. (The pressure p_b acting on the barrel surface is assumed to be three times this value. D is the outer diameter of the barrel.)

The calculated flange stress shall not exceed 85% of the material yield stress.

It is assumed proper spooling and low flange deflections, avoiding cutting/burying of the wire rope into the underlying layers. Further, wire rope crushing is not covered.

B 300 Brakes

301 Unless a crane operates in constant tension or active heave modus, automatic braking systems shall be arranged and shall be activated when the operating device is brought to zero or braking position.

302 Brake mechanisms shall be so designed that the brakes are activated upon failure of the power drive or the control system. Means shall, however, be provided for overriding such systems at any time.

303 Braking systems shall be such as not to introduce shock loads.

304 Brakes shall preferably act directly on the drum. Where a brake is arranged in front of a transmission, the components in the transmission subjected to loads due to braking shall be designed to comply with the requirements to strength of the brake itself.

305 Brakes shall exert a torque not less than 80% in excess of the maximum torque on the brake caused by the loads being regarded as static loads. If the dynamic factor exceeds 1.8, the braking capacity shall be increased accordingly. The lowest expected coefficient of friction for the brake lining with due consideration to service conditions (humidity, grease, etc.) shall be applied in the design calculation of braking torque capacity, but this coefficient of friction shall not be taken higher than 0.3.

306 Automatic braking is assumed to be obtained by a spring force (or equivalent) and that the brake is released by hydraulic, pneumatic or electric means. The spring force shall be such that the braking torque capacity required by 305 will be obtained.

307 Components of brakes shall be designed to fulfil strength requirements as given in Sec.2 for actual load cases. The inertia due to angular acceleration of rotating components shall be taken into account when this effect is significant.

308 Brakes shall be designed with due regard to inspection, adjustments and maintenance. Brake surface (e.g. on drum) should not be recessed.

B 400 Gear transmissions

401 Gears transmitting braking forces for mechanical brakes shall be considered with respect to excessive yielding according to actual loads, see 307, and with respect to fatigue based on a recognised code and according to a relevant load spectrum (i.e. load-time characteristics).

402 When DNV's classification note 41.2 "Calculation of gear rating for marine transmissions" are used for dimensioning of the gears, safety factors as specified in the table B1 should be used.

Table B1 Safety factors for gear	
Type of stress	Safety factor
Tooth root stresses	1.4
Contact stresses	1.0
Scuffing	1.0

B 500 Steel wire rope with fittings and anchorages

501 For wire and rope materials and construction of steel wire ropes, see Sec.1.

For testing of steel wire ropes, see Sec.12.

502 Length of wire rope for a lifting appliance shall be such that there is not less than 3 turns of wire rope on the drum with the hook at the lowest position and the boom in the most adverse position. Normally the ropes for hoisting and derricking shall be in one length.

503 Steel wire rope safety factor for running application or forming part of sling and for mast stays, pendants and similar standing applications shall be the greater of:

Not less than the greater of 3 and

$$S_F = \frac{10^4}{0.885 \cdot SWL + 1910}$$

but need not exceed 5.

$S_F = 2.3 \psi$

ψ = dynamic factor for the crane

SWL = Safe Working Load (kN).

For cranes with wire rope suspended jibs, the same safety factor will be required for hoisting and luffing.

504 For safety factor of wire ropes used for lifting people or manned objects see Sec.9 E201.

505 The minimum breaking load B of steel wire ropes shall not be less than

$$B = S_F \cdot S$$

where S is the maximum load in the rope resulting from the effect of the working load (suspended load) and loads due to any applicable dead weights. The number of parts and friction in sheaves shall be considered.

506 Where not otherwise demonstrated by testing, a combined allowance for friction and bending of the wire ropes, taken as

- 1.5% for each sheave with ball or roller bearings
- 5% for each sheave with plain bearings

shall be applied for calculation purpose of S in 505.

507 In wire ropes for running application the number of wires shall not be less than 114 (6 strands with 19 wires each).

In the case of one part hoist line (whip hoist) non-rotation wire shall be used or ball bearing swivel shall be provided for preventing accumulation of twist.

Guidance note:

A swivel should always be fitted between the hoist rope and the hook or other lifting attachment, and, except in the case of a ship's derrick, the swivel should be fitted with ball- or roller bearings that can be lubricated regularly

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508 For rope anchorage properly designed rope sockets like spelter sockets, ferrule secured-eyes (with thimble only) or self-locking wedge sockets shall preferably be used.

Socketing of wire ropes shall be carried out in accordance with a recognised standard and the socket manufacturer's instruction.

509 Where wire rope clamps are used, the free length of rope end shall be at least 5 times the rope diameter and the rope end shall be prevented from fraying. Only properly designed wire rope clamps with two gripping areas shall be used (the U-bolt type is not acceptable). The number of clamps depends on the diameter of the wire rope and shall comply with maker's specification. The number of clamps shall in no case be less than 3.

510 A thimble or loop splice shall have at least five tucks, three tucks with the whole strand of the rope, and two tucks with one-half of the wires cut out of each strand. The tucks shall be under and over against the lay of the rope. Splices shall be tightly drawn and neatly made. These requirements will not prevent the use of another form of splice that can be shown to be as efficient.

511 Where other connections are fitted, the method of splicing shall be according to recognised codes and standards.

512 The efficiency of the applicable wire rope termination shall comply with an EN-or ISO standard or be documented by the test certificate/report covering the actual wire rope being used. If the efficiency of the end termination is below 80%, the loss shall be compensated for up to minimum 80% efficiency.

513 The rope anchorage of the boom rope to the drum shall not be taken less than the maximum design rope pull. Anchorage including friction of the remaining turns on the drum when the boom is in the lowest allowed position shall withstand the breaking load of the boom wire rope. The friction force shall be based on a coefficient of friction of 0.1.

514 All wire rope anchorages shall be accessible for inspection.

B 600 Sheaves

601 Sheaves shall comply with a recognised code or standard. Normally, the sheave diameter for steel wire

ropes shall at least correspond to a ratio $D_p/d = 18$, where D_p is the pitch diameter of the sheave and d is the wire rope diameter. Further, the sheave groove shall comply with the corresponding guidance for grooves in drums as specified in 203.

For non-rotating sheaves (e.g. equaliser sheaves) and similar arrangements where the wire is not moving the ratio D_p/d shall be at least 10.

602 Sheaves shall either be castings, forgings, welded or be gas cut and machined from steel plate. However, sheaves made from nylon castings or other composite material may be accepted after special considerations.

603 Castings and plates for sheaves shall comply with Sec.1. However, for non-welded sheaves the required impact testing of the material will be waived.

604 All sheaves and blocks shall be so arranged that the wire rope cannot run off the sheave.

B 700 Anti-breakdown device for slewing mechanism

701 Slewing mechanism shall be so designed that it will not be damaged by heavy braking or reversal of the motion.

Guidance note:

This may be achieved either by designing the drive mechanism to resist the torque imposed by the above conditions or by the insertion of a torque limiting device (e.g. a slipping clutch) which will protect the mechanism from excessive shock loading. The torque limiting device should also allow the brake to slip if the horizontal load on the boom exceeds the load for which the boom has been designed.

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B 800 Lifting gear, including loose gear and grabs

801 For definition of lifting gear, including loose gear, see Ch.1 Sec.1 C.

802 Material shall be as specified in the applied codes or standards. If the codes or standards used do not cover applicable material requirements, or a design is not covered by code or standard, the material requirements given in Sec.1 shall be complied with.

Where certification by other Competent Persons (for example the manufacturer) is accepted, the material certificates shall be filed by the Competent Person and shall be presented upon the Society's request.

803 Design and strength of lifting gear shall comply with recognised codes or standards. Where applicable codes or standards are not followed, the safety factor for chain as given in 801 will normally be acceptable.

Lifting and spreader beams/frames will normally be accepted calculated as outlined in Sec.2. Load Case II stress acceptance level, with dynamic factor not less than the overload test factor as given in Sec.12 shall be satisfied in addition to Load Case I and applied ψ .

804 Design load for lifting gear as well as grabs shall be the greater of:

- $0.75 \times \psi \times \text{SWL}$, and
- SWL

ψ is the dynamic factor for which the crane is designed.

805 The main and auxiliary hook (whip hoist) for offshore cranes shall at least meet the requirements in DIN 15400 machinery group 1 AM and 2M respectively. However, in cases where the design hook load corresponds to that caused by the dynamic response for significant wave heights exceeding 3 metres, machinery group 1 AM may also be accepted for the auxiliary hook.

806 Hooks shall be fitted with a safety latch or be so designed that the ring or sling cannot fall out.

Irrespective of design, hooks for offshore cranes shall be fitted with a safety latch.

807 Hook blocks shall have protective plates and shall be easy to handle from any side.

808 In cases where, upon special agreement see Ch.1 Sec.1 E700, the damping effect of a hydraulic damper shall be included in the approval, the damping effect shall be documented by both calculations submitted and practical tests. The test program shall be submitted by the Customer, accepted by DNV's approval unit, and monitored by the certifying surveyor to the extent agreed before the tests are initiated.

809 Lifting gear and grabs shall be marked with the safe working load. The crane manual shall contain information of necessary specifications for ordering replacements.

B 900 Chains

901 The safety factor for chains, measured against the minimum specified breaking strength, shall not be less than the greater of:

- $4 \times 0.75 \psi \times \text{SWL}$
- $4 \times \text{SWL}$

where ψ is the dynamic factor for which the crane is designed.

902 The material of the chains and/or the grade shall be documented with a certificate, for example an inspection certificate of type 3.1, referring to a recognised standard.

903 Before being taken into use for the first time the chains shall be load tested as for loose gear, and the tests shall be documented by ILO Form No.3 or CG3 certificate.

B 1000 Skids

1001 Skids designed for lifting of varying loads as well as skids designed for a specific load and/or a specific transport assignment may be certified in accordance with the requirements in 800, however with observation of the conditions outlined in Appendix E A300.

C. Cargo Ramps and Movable Cargo Decks

C 100 Structural strength

101 Requirements to structural strength and design are given in Ship Rules Pt.5 Ch.2.

C 200 Mechanism and operational safety

201 Requirements to hoisting, fittings, safety devices and testing are covered by Sec.3, 4 and 12.

D. Power Systems

D 100 Prime movers

101 Prime movers shall be designed to accept normal load conditions such as running at load levels characteristic for the expected use of the crane, and to accept frequent and large load variations.

102 The crane prime mover shall be such that the full power demands of any loading and speed combinations associated with the various motions are compatible with the operations that the crane is designed for.

103 For operation within hazardous (gas-dangerous) areas, prime movers and their installation shall meet additional pertinent requirements.

104 Adequate insulation and shielding shall be provided for the protection of personnel during performance of their normal duties and to prevent ignition of flammable fluids.

105 The internal combustion engines shall normally not be located in hazardous areas. The exhaust gas outlet of the engines shall have an effective spark arrestor. The outlet shall be led to the atmosphere at a safe distance from any hazardous area.

D 200 Power independency

201 Hoisting and derricking functions shall be independent of travelling and slewing functions.

202 The crane and its load shall be able to remain in unchanged position in the event of power failure, see also B302.

E. Electrical Installations, Equipment and Systems

E 100 General

101 Electrical installation shall comply with relevant and recognised codes or standards pertinent to the location of the crane.

102 Electrical installations of DNV certified lifting appliances onboard vessels classed by DNV shall comply with Ship Rules Pt.4 Ch.8 “Electrical installations”. However, the documentation requirements are still to be taken from Ch.1 Sec.2 A201 in this crane standard. Further, the certification requirements are still to be taken from Ch.1 Sec.2 B101 in this crane standard.

103 For cranes covered by class notations **CRANE, Crane Vessel, Crane Barge or CRANE(N)**; the electrical equipment and systems supporting the crane main functions shall comply with Ship Rules Pt.4 Ch.8 “Electrical installations” and will generically be defined as “essential”. Specifically equipment and systems having impact on the Risk Contributors listed in Sec.6 D202 shall fulfil requirements with respect to essential installations.

F. Hydraulic, Pneumatic, Instrumentation, Automation and Wireless Remote Control Systems

F 100 Hydraulic systems

101 Hydraulic systems and their lay-out shall satisfy recognised codes or standards and engineering principles and shall as far as relevant or applicable comply with pertinent rules of DNV.

102 When designing hydraulic circuits, all aspects of possible methods of failure (including control supply failure) shall be considered. In each case, components shall be selected, applied, mounted and adjusted so that in the event of a failure, maximum safety to personnel shall be the prime consideration, and damage to equipment minimized. (Fail-safe concept)

103 All parts of the system shall be designed or otherwise protected against pressures exceeding the maximum working pressure of a system or any part of the system or the rated pressure of any specific component.

104 Systems shall be designed, constructed and adjusted to minimize surge pressures and intensification pressures. Surge pressure and intensified pressure shall cause no hazards.

105 Loss of pressure or critical drops in pressure as well as missing hydraulic refilling shall not cause a hazard.

106 Leakage (internal or external) shall not to cause a hazard.

107 Whatever type of control or power supply used (e.g., electrical, hydraulic, etc.), the following actions or occurrences (unexpected or by intention) shall create no hazard:

- switching the supply on or off
- supply reduction
- supply cut-off or re-establishment.

108 Hydraulic systems and other machinery in connection with the hydraulic system shall be designed to protect personnel from surface temperatures that exceed touchable limits by either insulating or guarding.

109 To facilitate maintenance, means shall be provided or components so fitted that their removal from the system for maintenance:

- shall minimize the loss of fluid
- shall not require draining of the reservoir
- shall not necessitate extensive disassembly of adjacent parts.

110 The fluid reservoir shall be designed with respect to:

- dissipation of heat from the oil
- separation of air
- settling of contamination in the oil
- maintenance work

Indicators showing the fluid level shall be permanently marked with system “high” and “low” levels.

Air breathers on vented reservoirs should be provided which filter air entering the reservoir to a cleanliness level compatible with the system requirements, taking into consideration the environmental conditions in which the system is to be installed.

111 Effective means for filtration and cooling of the fluid shall be incorporated in the system.

A means of obtaining a representative fluid sample shall be provided to allow for checking fluid cleanliness condition.

Valves for fluid sampling shall be provided with sealing and with warning signs marked “System under pressure”

112 Flexible hoses and couplings shall be of approved type (Type Approval Certificate issued by DNV is recommended).

113 Flexible hoses shall only be used

- between moving elements
- to facilitate the interchange of alternative equipment
- to reduce mechanical vibration and/or noise.

114 Flexible hoses shall be located or protected to minimize abrasive rubbing of the hose cover.

115 Accumulators shall be separately approved.

116 Materials for hydraulic cylinders shall fulfil the requirements in *DNV Standard for certification No. 2.9*.

117 Requirements regarding cylinder wall thickness are described in the Type Approval Programme mentioned in 116.

Requirements regarding wall thickness of tubes are described in Ship Rules Pt.4 Ch.6 Sec.6 A Tables A1, A2 and A3.

118 Welds shall normally be full penetration welds. Other than full penetration welds may be accepted on a case-to-case basis provided that acceptable stresses (both with respect to fatigue and static) can be documented. This will primarily be applicable for cylinders used for pushing only (e.g. jib cylinders).

F 200 Testing of hydraulic systems

201 Except for mountings, each component shall be pressure tested to 1.3 times the design pressure.

202 The test pressure need not to be more than 70 bar in excess of the design pressure. Consequently the requirement for pressure testing of the complete hydraulic system of a crane is not considered satisfactorily complied with by the overload testing of the crane.

203 Hydraulic testing of the assembly shall be performed in the presence of a surveyor, unless otherwise agreed. The test pressure shall be maintained for a time sufficient for check of leakage. The assembly shall exhibit no sign of defects or leakage.

F 300 Pneumatic systems

301 Air intakes for compressors shall be so located as to minimize the intake of oil- or water-contaminated air.

302 When designing pneumatic circuits, all aspects of possible methods of failure (including control supply failure) shall be considered. In each case, components shall be selected, applied, mounted and adjusted so that in the event of a failure, maximum safety to personnel shall be the prime consideration, and damage to equipment minimized. (*Fail-safe concept*.)

303 Loss of pressure or critical drops in pressure shall cause no hazard.

304 Leakage (internal or external) shall create no hazard.

305 Whatever type of control or power supply used, the following actions or occurrences (unexpected or by intention) shall not create a hazard:

- switching the supply on or off
- supply reduction
- supply cut-off or re-establishment

306 Air supply to instrumentation equipment shall be free from oil, moisture and other contaminants. The dew point shall be below 5°C for air in pipes located in crane engine room. In pipes outside the engine room the air shall have a dew point below $(T_D - 5)^\circ\text{C}$.

307 Components requiring extremely clean air shall not be used.

308 Main pipes shall be inclined relative to the horizontal, and drainages are to be arranged.

309 Piping and pressure vessels shall comply with relevant recognised codes and shall generally comply with DNV Rules.

F 400 Control and monitoring systems

401 For cranes covered by class notations CRANE, Crane Vessel Crane Barge or CRANE(N); components and installations shall comply with Ship Rules Pt.4 Ch.9 "Control and monitoring systems".

Control and monitoring systems supporting the crane main functions are generically defined as "essential" according to Ship Rules Pt.4 Ch.9.

Specifically equipment and systems having impact on the Risk Contributors listed in Sec.6 D202 shall fulfil requirements with respect to essential installations.

402 Wireless remote control systems

Guidance note:

- 1) The principles for wireless remote control should be:

Safe state for the crane and for the wireless remote control operation should be defined. In general, all over systems have a defined fail-safe mode. This means that all outputs returns to normal mode (normally open/normally closed depending of type of output) in case of an emergency stop situation, communication error, loss of power-supply or other defined failure modes. Wiring diagram and test-reports for all inputs/outputs are delivered with each system.

Normally we will assume that safe state is immediate stop of all crane movements. The crane brake capacities should be sufficient to hold the crane and the cargo at any position within a given response time.

(Some cranes are equipped with heave compensation, automatic overload protection, emergency operation, etc. In such cases safe state may not be complete stop). The reaction of the complete system (crane) related to a stop-situation will depend of the functionality of the connection of the remote control system, and is the responsibility of the crane-builder.

Furthermore:

- The system should prevent operation if the operator leaves the normal operating area for the crane. Prevention of this have to be implemented by the crane-builder
- The data sent to/from the remote control unit should be subjected to error detection and/or error correction.

- Transmitting of radio data should also be made possible by “handshaking”.
- 2) The wireless communication with the crane should not be disturbed by any other external communication signals, and it should be designed in accordance with accepted standards for emission. Radio solutions shall be tested in accordance to ETSI EN 301 489 “Electromagnetic compatibility and radio spectrum matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services”.
- 3) If it cannot be proven that the frequencies allocated for the wireless communication for a specific crane are unique in all areas where the crane will be operated, and that such communication will never be interrupted by external communication signals, some kind of unique cryptation or ID of the wireless communication or similar is strongly recommended. The main concern is that such arrangements should prevent other signals from controlling the crane movements.
- 4) Loss of communication with the unique remote control should cause the crane to go into a safe state as outlined in item 1 above.
- 5) Additionally an emergency stop independent of the wireless remote control should be installed. Responsibility of the crane-builder
Furthermore:
 - By starting of the remote control unit a self-check must be conducted in order to prevent movements if the control has been left in such mode.
 - The lifting unit should also be provided with a hardwired emergency stop easily accessible. Responsibility of the crane-builder.
 - The remote control unit should be provided with a keyswitch for closing when not in use. This issue is depending of customer requirement (order). In those cases where a keyswitch is not ordered, The customer is responsible for solution.
 - When used for lifting of persons, the remote control unit should also be provided with a “dead man button”. This issue is depending of customer requirement (order). In those cases where a keyswitch is not ordered, The customer is responsible for solution.
- 6) The planned operation should be subjected to an analysis where special hazards and risks should be identified. For high-risk operations caused by mal-operation or equipment failure, the risk and the safety measures should be documented in a detailed analysis. Responsibility of the crane-builder.

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SECTION 4

SAFETY AND SAFETY EQUIPMENT

A. Safety

A 100 Operator's cabin

101 On deck cranes an operator's cabin will normally be required. This may also apply to other types of cranes. National authorities may require a cabin on cranes for the protection of the operator against noise and weather.

102 If required or fitted, the cabin shall satisfy the following overall requirements:

- Be of adequate size and give adequate protection against weather and other environmental exposure.
- Give the operator an adequate view of the area of operation including hook and hook position.
- Have windows capable of being readily and safely cleaned inside and outside and to have defrosting and defogging means. Outdoor cranes shall have windscreen wipers fitted to all windows necessary for the crane operator's free view when operating the crane.
- Be adequately tempered (heated, cooled) and ventilated according to local conditions.
- Be of fireproof construction, have doors that can be readily opened from both inside and outside.
- In the case of a derrick crane access/exit shall not be obstructed by any boom elevation.
- Noise and vibration shall remain within acceptable limits.
- Have a comfortable and purpose-designed seat from which all operations can easily be controlled. Foot rests shall be arranged where necessary.
- Have the crane controls marked and lit to show their respective function.

Guidance note:

It is recommended that the design complies with international recognized standard/code (i.e. EN-13557).

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103 Where the operator's cabin is attached to and travels with the crab, the cabin suspension gear shall be so designed that the cabin cannot fall if the cabin or the crab is accidentally displaced from its rails.

104 Cranes shall be arranged with emergency escape in addition to the main access. Portable escape equipment may be accepted.

A 200 Platforms, access gangways and operator's cabins

201 For documentation of satisfactory structural strength, see Sec.2 A700.

Guidance note:

It is recommended that the design complies with international recognized standard/code (i.e. EN-13586).

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A 300 Parking and precautions against wind loads

301 Lifting appliances shall be provided with means to secure the appliance in the "out of service condition" in a safe manner. The effect of wind and wind gusts and any roll, list and trim shall be considered.

A 400 Protection and precautions against fire

401 Necessary protection and precautions against fires and explosions shall be considered in each case.

The number, capacity and location of fire extinguishers shall be adequate for the type of crane and its intended service. However, at least one fire extinguisher shall be provided in the operator's cabin.

402 Air pipes from fuel tanks shall be led to open air.

403 **Drip trays** shall be arranged at fuel filling pipe.

404 It shall be possible to stop/close the following components from a central place outside the crane engine room:

- valves on tanks for flammable fluids
- pumps for flammable fluids
- flaps (shutters) in air ducts to engine room
- fans for ventilation
- engines.

405 Reference is made to Ship Rules Pt.4 Ch.3 Sec.1 for fire protection of diesel engines and other combustion engines.

SECTION 5 SHIPBOARD CRANES AND INDUSTRIAL CRANES

A. Material and fabrication

A 100 General

101 Material and fabrication requirements are given in Sec.1.

B. Structural strength

B 100 General

101 General description of structural strength is given in Sec.2. This section specifies supplementary information for structural strength valid for shipboard cranes and industrial cranes.

B 200 Loads due to operational motions

201 The dynamic factor ψ for design purposes need not be greater than:

$\psi = 1.3$ for jib cranes

$\psi = 1.6$ for overhead travelling cranes or cranes of similar design

The dynamic factor shall not be taken less than:

$\psi = 1.15$ for $10 \text{ kN} < W \leq 2\,500 \text{ kN}$

For hose handling cranes intended for operation outside the deck area in open sea, categorized as shipboard cranes, the dynamic factor ψ for design purposes shall not be taken less than 1.3.

202 For cranes used for internal load handling in open sea, due considerations are to be taken to ensure that the resultant impact on the crane is within the crane's design limitations.

B 300 Horizontal loads due to operational motions

301 For revolving cranes a lateral force of

$(W/100) \cdot [2.5 + 0.1 \cdot r \cdot n]$

may be assumed at the jib head where:

r = load radius (m)

(distance from revolving axis to load W)

n = revolution per minute (RPM)

302 Radial force on revolving cranes may be determined on the basis of maximum angular velocity and radius to the considered mass. Radial force equal to $(W/1\,000) n^2 \cdot r$ may be assumed at the jib head.

C. Machinery and Equipment

C 100 General

101 General requirements are given in Sec.3. This section specifies supplementary requirements valid for shipboard cranes and industrial cranes.

C 200 Steel wire rope anchorage

201 The strength of the anchorage of the hoist rope to the drum shall have strength not less than the smallest of 80% of the breaking load of the hoist wire rope or 2.5 times the maximum design tensile force in the rope. The force may include the friction of the turns remaining on the drum, based on coefficient of friction of 0.1.

D. Safety and safety equipment

D 100 General

101 Basic requirements are given in Sec.4.

D 200 Specific requirements

201 General

As an alternative to document safety as outlined in for offshore cranes, ordinary shipboard cranes, industrial cranes and cargo decks/ramps will be accepted based on fulfilment of the prescriptive requirements as set out below.

Monitoring of safety equipment shall be as required in Table D1.

202 List of required functionality

Lifting appliances/cranes shall generally to be provided with:

- safety brakes on all movements (see Sec.3 B300)
- overload protection (see 203)
- load indicator or load moment indicator (see 204)
- limit switches (see 205)
- safety valves on all main circuits of the hydraulic system (see Sec.3 F100)
- emergency stop system (see 206)
- boom stopper on derrick cranes (see 206)
- end stoppers for travelling cranes (see 207)
- audible warning alarm (see 208)
- slack wire rope detection (see 209)
- means for emergency lowering of load (see 210).

203 Overload protection

All cranes/lifting appliances shall be provided with automatic overload protection, arresting the hoisting movement if overload is detected.

The overload protection shall be activated if the response of the load being raised or lowered exceeds a predetermined amount which shall not be greater than the effect of a static load equal to the safe working load times the dynamic factor for which the lifting appliance has been designed.

When activated, the overload protection shall not prevent the load or crane to be moved to a better position (e.g. lower the load or hoist the boom).

204 Load/load moment indicator

A rated capacity indicator giving continuous information shall be provided when the working load is 50 kN or greater except for cranes where the allowed maximum rated load is constant (i.e. independent of load radius).

205 Limit switches

As specified for limit switches in Sec.6 D205. For cranes with SWL not exceeding 20 tonnes without cabin, the requirement to indication will be omitted.

206 Emergency stop system

As specified for emergency stop in Sec.6 D207.

207 End stops

End stoppers shall be fitted to prevent over-running where movements are restricted. Shut-down of the power shall be arranged before the end stoppers are activated. The end stoppers or the moving parts shall be fitted with buffers made of timber, rubber, etc. If the nominal speed exceeds 1 m/s, the buffers shall be of spring type or similar energy absorbing type. If practicable, the buffers shall be fitted on the main sill and not on the bogies.

208 Audible warning alarm

Gantry cranes and similar cranes shall be provided with a horn or other audible warning device operated by the crane operator to warn or attract the attention of any personnel within the operational area.

In case of travelling cranes moving at ground level, a continuous audible warning shall automatically be given when the crane is to move/is moving along the track/rails. The warning signal shall be distinctly different from other audio signals on the installation.

209 Slack wire rope detection

As specified for slack wire rope detection in Sec.6 D210. However, auto stop for arresting the slack wire rope is not required.

210 Emergency lowering

Means shall be provided for safe lowering of hanging load to a safe position in the event of power failure. In addition emergency slewing will be required where slewing is necessary to obtain a safe position.

Guidance note:

If the emergency lowering is achieved by external means, this means shall be readily available or easily retrievable in any area where the crane is intended to be operated.

If it is satisfactorily documented in a risk evaluation that the risk is acceptable without any means for emergency operating, the requirements in this paragraph will not apply.

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211 *Cargo ramps and movable cargo decks*

Cargo ramps and movable cargo decks shall be provided with:

- Overload protection of hoisting system.
- Means to ensuring that power is not disconnected before all retractable locks securing the ramp/deck are engaged.
- Means to ensure that locks securing a ramp/deck are disengaged before any lowering is possible.
- Alarm in the event of failure on a remote control system for locking or latching.
- Automatic stop of movement when the cargo ramp/stern door has reached the upper position.
- Alarm if the inclination of an access ramp in its working position exceeds a predetermined angle to the horizontal.

212 *Mobile cranes*

In addition to the requirements in 202, mobile cranes shall be provided with:

- means to secure stability of the crane in operational conditions
- means to enable and control that the crane is level.

Table D1 Monitoring of safety equipment						
<i>Required monitoring (stated by an x)</i>	<i>Industrial and shipboard cranes</i>			<i>Cargo decks and ramps</i>		
<i>Event</i>	<i>Indication</i>	<i>Alarm</i>	<i>Auto stop</i>	<i>Indication</i>	<i>Alarm</i>	<i>Auto stop</i>
Load high or Over-turning moment high (see 203)			x			
Hook position, upper and lower (see 205)	x		x			
Boom/jib position, upper and lower			x			
Travelling motion, end stops			x			
Warning		x				
Slack wire rope (see 209)	x					
Remote control:						
Position of ramp:				x	x	
— upper						x
— inclination.	X	x		x	x	x
Power failure to safety system						
Emergency stop (see 206)	X			x		

SECTION 6 OFFSHORE CRANES

A. Material and fabrication

A 100 General

101 Material and fabrication requirements are given in Sec.1. This section specifies supplementary information valid for offshore cranes.

A 200 Bolts for main slewing ring

201 Bolt material having yield strength exceeding 940 N/mm² (10.9 ISO strength class) will normally not be accepted.

B. Structural strength

B 100 General

101 General description of structural strength is given in Sec.2. This section specifies supplementary information valid for offshore cranes.

B 200 Loads due to operational motions

201 The dynamic factor ψ for design purposes shall not be taken less than:

$\psi = 1.3$ for $10 \text{ kN} < W \leq 2\,500 \text{ kN}$

$\psi = 1.1$ for $W > 5\,000 \text{ kN}$.

Linear interpolation shall be used for intermediate values of W between 2 500 kN and 5 000 kN.

When the dynamic factor ψ is calculated by the formula given in Sec.2 A302, the following shall be taken into account when assessing the relative velocity between load and hook at the time of lift-off, V_R :

$$V_R = 0.5 \cdot V_L + \sqrt{V_{in}^2 + V_t^2}$$

Where the value $0.5 \cdot V_L$ above is less than V_H , as given in 202, then V_H shall be used instead of $0.5 \cdot V_L$.

V_L = maximum steady hoisting speed (m/s) for the rated capacity to be lifted.

V_{in} = downward velocity (m/s) of the load at the time of lift off (due to movement of the deck of a supply vessel from which the load is lifted).

V_t = velocity (m/s) from motion of the crane jib tip if the crane is located on a mobile offshore unit or other floating unit.

V_{in} is to be determined as a function of sea state and motion parameters (roll, pitch and heave response) of the vessel/offshore unit or hydrodynamic response of an underwater object to be handled.

202 Unless otherwise agreed to by the purchaser, the hoisting speed should normally not be less than

$$V_H = 0.1 \cdot (H_{sign} + 1)$$

for cranes used for cargo operations towards supply boats.

where

H_{sign} = Significant wave height (m).

The V_L used for calculation of dynamic factors for derating shall be the actual maximum available hook speed attainable, and shall normally be equal to or larger than V_H . For significant wave heights where the hoisting speed V_L is less than V_H , the derating chart will be shaded and giving information that it is dependent upon the crane driver's skill to avoid re-entry of the next wave.

203 For cranes located on crane vessels, semi submersibles units and bottom supported platforms the following values for V_L and V_{in} may be used for the calculation of the dynamic factor when lifting off loads from a supply vessel.

V_L = Available hoisting speed or $0.6 H_{sign}$

whichever is the smaller.

$V_{in} = 0.6 H_{sign}$ (m/s) for $0 < H_{sign} \leq 3$ (m)

or

$$V_{in} = [1.8 + 0.3 (H_{sign} - 3)] \text{ (m/s) for } H_{sign} > 3 \text{ (m)}$$

204 Where the operator cabin is attached above the slewing bearing, the design loads for the crane foundation including pedestal and slewing bearing with fasteners, shall, for structural strength calculations, be taken as the design loads as applied for the crane members multiplied with an additional offshore safety factor SF1. For mast cranes, this requirement is valid for the mast up to and including the lower bearing support.

- For cranes with lifting capacity up to 2500 kN, minimum required SF1= 1.3
- For cranes with lifting capacity of 2500 kN and more, minimum required SF1= 1.1.

205 For cranes located on barge or bulk carrier, the dynamic factor ψ may be calculated as in Sec.2 A302. The hoisting speed V_L may be taken as given in 203.

The relative velocity V_R may be calculated in accordance with the formula in 201, where:

V_{in} = downward velocity (m/s) of the barge or bulk carrier from which the load is unloaded at the moment of pickup. (It is foreseen that the crane is located on the other vessel involved.)

V_t = velocity (m/s) of the jib tip of the crane located on the barge or bulk carrier to which the load is brought at the moment of pickup from the other vessel.

V_{in} is to be documented by calculations, or*) may be taken as $1/10 \cdot k \cdot H_{sign}$

V_t is to be documented by calculations, or*) may be taken as $1/6 \cdot k \cdot H_{sign}$

*) The two formulas above are valid only for vessels with DWT between 10 000 and 100 000 tonnes.

$$k = 5.5 - \frac{DWT}{20000}$$

DWT = the deadweight tonnage in metric tonnes of the barges or bulk carriers used in the operation.

B 300 Horizontal loads due to operational motions

301 The following horizontal force at jib head should be assumed.

Lateral force (side lead):

$$(W/100) \cdot [2.5 + 0.1 \cdot r \cdot n + H_{sign}]$$

Radial force (off lead):

$$(W/1\ 000) n^2 \cdot r \text{ (when the load is airborne)}$$

or

$$\psi \cdot W \cdot \frac{2.5 + 1.5 H_{sign}}{H_w + L_{vert}} \quad \text{(at lift-off)}$$

which ever is the greater.

L_{vert} = vertical distance from jib heel bearing to outer jib sheave

H_w = distance from jib heel bearing to supply boat deck

θ = jib angle to the horizontal

B 400 Load chart or table

401 A load chart or table shall be available at operating stand, and where applicable the load chart or table shall give the safe working load for boom angles or load radii for the various wave heights.

C. Machinery and equipment

C 100 General

101 General requirements are given in Sec.3. This section specifies supplementary requirements valid for offshore cranes.

C 200 Brakes

201 The mechanical brake shall not be arranged in front of same gear transmission as the operational brake. Alternative a 30% increase of gear capacity may be applied.

C 300 Steel wire rope anchorage

301 The load carrying capacity of the fixed hoist rope anchorage to the drum shall approximately equal the wire

rope line pull. However, including the frictional force being applied through the turns of rope always to remain on the drum, the total capacity of anchorage shall be equal to the breaking load of the rope. In order to achieve this frictional force it may be necessary to increase the minimum remaining turns on the drum to more than 3.

C 400 Control and monitoring systems

401 Components and installations shall comply with Ship Rules Pt.4 Ch.9 “Control and monitoring systems”. Control and monitoring systems supporting the crane main functions will generically be defined as “essential” according to Ship Rules Pt.4 Ch.9.

Specifically equipment and systems having impact on the Risk Contributors listed in D202 shall fulfil requirements with respect to essential installations.

402 For offshore cranes covered by class notations **CRANE, Crane Vessel Crane Barge or CRANE(N)**, testing at manufacturer’s works and issuance of product certificate will, as addressed in Ship Rules Pt.4 Ch.9 “Control and monitoring systems”, be required.

403 For offshore cranes onboard mobile offshore units (semi submersibles, jack-ups, etc.), additional requirements as specified by the governing DNV Offshore Codes shall be applied as far as relevant.

C 500 Power systems

501 Hoisting, slewing and luffing shall have such response to the controls that minimum required speed from stand still shall be obtained within 2 seconds from activation of the control lever. The control levers shall have predictable smooth motions proportional to their position.

502 Cranes intended for supply boat/barge operations shall have enough power to satisfy the following speed requirements:

- Minimum hoisting speed, see B202.
- Minimum steady slewing speed at $\frac{3}{4}$ of maximum radius, empty hook: 2 m/s.
- Minimum steady radial speed at $\frac{3}{4}$ of maximum radius, empty hook: 0.4 m/s.

C 600 Electrical equipment and systems

601 The electrical equipment and systems supporting the crane main functions shall comply with Ship Rules Pt.4 Ch.8 “Electrical installations” and will generically be defined as “essential”. Specifically equipment and systems having impact on the Risk Contributors listed in D202 shall fulfil requirements with respect to essential installations.

602 For cranes onboard mobile offshore units (semi submersibles, jack-ups, etc.), additional requirements as specified by the governing DNV Offshore Codes shall be applied as far as relevant.

Guidance note:

The following codes and standards are recognised:

- Norwegian Standard NS 5513 - Cranes and Lifting Appliances.
- Ship Rules Pt.4 Ch.8, “Electrical Installations”.
- British Standard BS 5345 - Selection, Installation Maintenance of Electrical Apparatus for use in Potentially Explosive Atmospheres.
- NEK 420.

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Other codes and standards may after special consideration be recognised by the Society.

D. Safety and safety equipment

D 100 General

101 Basic requirements are given in Sec.4. This section specifies supplementary requirements valid for offshore cranes.

D 200 Specific requirements

201 General

All lifting appliances categorised as *Offshore cranes* shall be provided with safety functions, reducing the risk connected to crane operations. The subsequent safety function requirements are founded on a risk based approach. It is up to the customer to select the technological platform for the safety functions. In principle, all alternatives providing equivalent safe operation will be accepted.

In the following, the safety function requirements are organised as follows:

- listing of generic (i.e. standard) risk contributors, ref. 202
- description of the generic risk contributors and corresponding required generic safety functions, ref. 204-219

- monitoring of the safety functions, ref. Table D1
- ranking of the safety functions, ref. 220
- verification, ref. 221
- handling of deviations and extended risk, ref. 222

The corresponding documentation- and verification requirements are specified in the “Verification Guideline for Safety Functions, Offshore Cranes”, ref. Appendix G.

202 *Generic risk contributors.*

The following hazards are identified as *generic risk contributors* for offshore cranes:

- over-loading (see 204)
- crane movements outside operational limitations (over travel) (see 205)
- dangerous lifting gear/cargo movements (see 206)
- dangerous crane movements (see 207)
- lack of visibility (see 208)
- lack of communication (see 209)
- slack wire rope at drum (see 210)
- failure in control systems (see 211)
- failure in safety components/systems (see 212)
- lack of braking capacity (see 213)
- lack of load holding capacity (see 214)
- blackout/shutdown of power (see 215)
- unintended activation of safety functions (see 216)
- spurious trip of safety functions (see 217)
- hazards due to activation of safety functions (see 218)
- fire/fire ignition (219)

The maximum consequence assumed for each of the above listed generic risk contributors is *one fatality*, with the exception of “Fire/fire ignition” (219). For lifting appliances where the *specific risk* exceeds one fatality (not including “Fire/fire ignition”), or where the *specific risk* contributors deviates from the above, ref. 222 “Handling of deviations/extended risk”.

203 *Description of risk contributors and corresponding required generic safety functions*

The following description of the generic risk contributors and corresponding required *generic safety functions* applies.

For lifting appliances with *specific safety functions* that deviates from the following *generic safety functions*, ref. 222 “Handling of deviations/extended risk”.

Guidance note:

Note:

The below *bold/italic* number references in parentheses refer to applied numbering in the “Text reference” row of the tables in Appendix G B300.

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204 *Over-loading*

Generic risk contributors:

Over-loading due to crane hook entangled to the supply boat or other moving objects, due to load sucked to the seabed, due to heave compensation not working properly, or other overload situations, may lead to crane structure collapse.

Generic risk control measures:

Cranes shall therefore be provided with overload protection. The safety functions for overload protection shall be implemented by means of an automatic overload protection system (204.a and 204.c) and a manual overload protection system (MOPS) (204.b). The automatic overload protection shall be implemented by means of an “Overload limiting device” (204.a) and - additional for supply boat and barge handling cranes operating in nautical zones with short wave characteristics - an AOPS (“Automatic Overload Protection System”) (204.c).

- a) For cranes intended for supply boat/barge operations and for subsea handling cranes, an “Overload limiting device”, stopping the boom from being luffed further out (204.a) will be required. The “Overload limiting device” shall automatically be activated when the crane is subject to an over-load response close to the crane’s design load (given by the safe working load times the dynamic factor). When activated, any movement reducing the overturning moment shall stay intact.
- b) MOPS (204.b) will generally be required for all offshore cranes, including subsea operating cranes. The MOPS shall operate under all conditions, including failure in the main power supply and failure in the control system, and shall override all other functions when activated. The system shall be arranged for manual activation for all reeving configurations. The activation switch or handle shall be located for rapid access at the control station, permanently marked with yellow colour, and protected against inadvertent use.

At any time, the system shall be able to be reset by the crane operator, without causing significant damage to the crane. The system, when activated, shall maintain a retaining force in the hoisting system of approx. 10% to 25% of the maximum rated capacity for internal lift. The capacity of the system shall be sufficient for activating/reset for at least 3 times in succession, and for continuous activation for at least 5 minutes.

- c) The requirement to provision of AOPS (204.c) for supply boat and barge handling operations will be based on due consideration to which nautical zone, with corresponding wave parameters, the crane will operate. Provision of AOPS will be required for operations in nautical zones with a short wave characteristic, for instance the North Sea, whereas operations in nautical zones with a long wave characteristic will not require AOPS. AOPS will generally not be required for subsea handling cranes. The AOPS, when installed, shall be operational for all reeving configurations. The trigger load shall not be less than rated capacity for internal lift, giving an appropriate response time to avoid significant damage to the crane.

Automatic overload protection for lateral boom loads exceeding the design limits for the slew system shall also be provided (not required for heavy lift cranes). The lateral overload protection shall be independent of the AOPS.

The AOPS - with the exception of the lateral overload system - shall include sector limitation and height limitation, preventing system activation when the load is positioned above the platform. The requirement to automatic application of the brakes when the motion control lever is returned to neutral position may be omitted when the hook is within the AOPS sector. Manual overriding of the AOPS shall not be possible unless for the purpose of lifting of personnel. The AOPS shall be designed with respect to response time and retaining force in the hoisting rope, protecting the crane from any structural damage.

When the system is activated, the crane shall maintain a retaining force at the hook sufficient to suspend a load corresponding to the rated capacity for internal lift. If the hook load increases beyond this value, the minimum payout hook speed due to the increased actual hook load shall not be less than the velocity given in the expression $(V_{in}^2 + V_t^2)^{0.5}$, see B201 (the velocities as indicated in EN 13852-1 Annex B may be used as a simplified method). When the overload/-moment situation no longer exists, the system shall automatically deactivate. However, due to possible oscillation,, delayed deactivation of the AOPS shall be considered.

- d) When subjected to an overload response equal to the activation load for the shut-down device or the trigger load for the AOPS, an alarm warning all the personnel within the working area, including all personnel onboard the attending supply vessel, shall automatically be activated.
- e) When the AOPS or the MOPS is activated, the end stop at the winch drum (limiting the residual windings to minimum 3) shall be overridden, allowing the wire rope to be spooled completely off the drum.
- f) Both the AOPS and MOPS shall have control indicators in the cabin, i.e. a continuous visual signal to indicate whether the system is operational or not. A different continuous visual and acoustic signal shall be given when the system is activated. In addition, an external acoustic alarm giving a sound level of approx. 110 dB (A) measured at 1 m from the alarm when the MOPS is activated, shall be provided.
- g) A rated capacity indicator and a crane inclinometer (if the crane is installed on a floating unit) to display the pedestal inclination in the longitudinal and traverse direction of the crane, giving continuous information to the operator, shall be provided. The load indicator shall include a display of the selected crane configuration and the significant wave height. Further, cranes with a variable rated capacity dependent on the radius shall be provided with a radius indicator clearly visible from the control station. An audible and visual warning/alarm, giving a continuous warning to the crane operator when the load response exceeds 90% of the crane's rated capacity/overturning moment for internal lift, shall be fitted.

205 Crane movements outside operational limitations

Generic risk contributors:

Crane movements outside operational limits may lead to stress beyond the crane's structural strength and to operational hazards.

Generic risk control measures:

All crane movements are therefore to be kept within safe operational limitations, either by means of limit switches/alarms or physical layout (205.a). The hoisting and luffing winches shall be equipped with upper and lower limiters, stopping the winch movements within safe margins to avoid collision with other parts of the crane and keeping safe number of retaining wire rope turns on the drum - usually minimum 3. Special consideration shall be paid to the crane boom's upper limit protection (205.b) for wire rope suspended booms, where redundancy by means of 2 independent limit switches is required.

Limit switches shall be positively activated and be of failsafe type, i.e. the crane shall go to a defined safe condition in case of failure (power failure, cable defect, etc.). Activation of limit switches shall lead to indication in the crane cabin. After activation of a limiting device, movement in the reverse direction - to a more safe position - shall not be prevented. Where more than one movement cause over-travel, all limit switches limiting such over-travel shall be activated simultaneously (e.g. hoist block over-travel at boom top may be caused either by hoisting or luffing). A manually operated "over-ride" system, provided positive and maintained action combined with indication and alarm, may be fitted.

206 *Dangerous lifting gear/cargo movements*

Generic risk contributors:

Unintended lifting gear/cargo movements may lead to hazardous situations for personnel involved in crane operations.

Generic risk control measures:

- a) Means for keeping constant tension in the hoisting wire rope (“constant tension”) when carrying out supply boat operations, compensating for the relative movement between the lifting gear/cargo and the supply boat, may be provided (optional) (206.a). The constant tension system shall, when installed, be designed with due consideration to the retaining force (usually in the area of 2 – 3 tonnes), response time and unintentional activation. It shall not be possible to activate the system outside a defined zone close to the supply boat - neither horizontal nor vertical, and shall not be possible to activate when the crane is loaded. The winch shall automatically return with soft characteristic to normal hoisting, braking or holding condition when the constant tension is disengaged. An indication, informing when the constant tension system is active, shall be present in the cabin.
- b) Special consideration shall also be paid to dangerous lifting gear movements when lifting or lowering the boom/lifting gear to or from the boom rest/cradle. Only slow motions of the boom shall be possible.
- c) An audible warning (horn or similar device) (206.c) to warn or attract the attention of any person within the operational area of the crane, operated by the crane operator, shall be provided.

207 *Dangerous crane movements*

Generic risk contributors:

Dangerous crane movements or unintentional crane movements due to malfunction in the crane’s control system may lead to operational risks.

Generic risk control measure:

A manually operated emergency stop function, leading to shut-down and stop of the crane movements, shall therefore be fitted. Simultaneously, the brakes shall be engaged in a progressive and safe manner. The emergency stop shall retain its function regardless of any malfunction in the crane’s control system. Emergency stop actuators shall be located at convenient locations at control station for immediate use by personnel in the event of a hazardous situation occurring.

The emergency stop shall function as, or stopping by:

- immediate removal of power to the machine actuators, or
- mechanical disconnection (declutching) between the hazardous elements and their machine actuators.

The emergency stop shall be so designed that deciding to actuate the emergency stop actuator shall not require the operator to consider the resultant effects (stopping zone, deceleration rate, etc.). The emergency stop command shall over-ride all other commands except the MOPS (ref. 220). The emergency stop function shall not impair the effectiveness of the safety devices or devices with safety related functions. Resetting the control device shall only be possible as the result of a manual action on the control device itself. Resetting the control device shall not cause a restart command.

The emergency stop actuators shall be designed for easy actuation. Types of actuators that may be used include:

- mushroom type push button.
- wires, ropes, bars.
- handles.
- in specific applications, foot pedals without protective cover.

Measures against inadvertent operation shall not impair the accessibility of the emergency stop actuator. The emergency stop actuator shall be coloured red. The background shall be coloured yellow, as far as practicable. If the emergency stop actuator is not located directly on the machine, labels shall be provided addressing the actuator to the machine. A warning/alarm and an indication in the crane cabin shall inform the crane operator that the emergency stop has been activated.

208 *Lack of visibility*

Generic risk contributors:

Lack of visibility due to poor sight or due to crane operations in the crane driver’s blind zone may lead to operational hazards.

Generic risk control measure:

Consequently, a boom tip camera is normally required for all offshore cranes intended for supply boat or barge handling. The camera and camera installation shall be designed with due consideration to environmental factors (wind, salt, moisture, vibrations, etc.) and operational suitability.

209 *Lack of communication*

Generic risk contributor:

Lack of communication between the crane operator and the other participants in the crane operation may lead to operational hazards.

Generic risk control measure:

Two-way communication equipment, enabling the crane operator to communicate with the participants in the crane operation in a safe way, shall be provided. The crane operator shall be able to operate the communication system without moving his hands from the main control levers.

210 *Slack wire rope at drum*

Generic risk contributor:

Slack wire rope at the drum may lead to improper spooling and entangled wire rope.

Generic risk control measure:

The drums - both for the hoisting winch and the luffing winch - shall therefore be equipped with a slack wire rope detection device which will be activated automatically if the wire rope becomes slack during lowering. The device shall stop the winch lowering motion until the wire rope is re-tightened, before automatically returning to normal operation. When activated, a visual and acoustic signal/indication shall be given in the crane cabin. Where the crane driver has a full view of the drums from his normal position, the slack wire rope detection device may be omitted.

211 *Failure in control systems*

Generic risk contributor:

Failure in the crane's control system may result in unintentional crane response and movements.

Generic risk control measures:

Control system design and components shall therefore be selected, applied, mounted and adjusted so that in the event of a failure, maximum safety shall be the prime consideration (fail-safe concept). All aspects of possible methods of failure – including power supply failure - shall be considered. If any failure occurs, the control system shall always return to the safest condition with respect to stabilising the crane and the load. Special consideration shall be paid to the below points if subjected to failure in the control system:

- unintended start of machinery shall not be possible
- safety devices or devices with safety related functions shall be impaired to a minimum degree.

An alarm and an indicator revealing any detectable failure in the control system affecting the operation shall be present in the crane cabin.

212 *Failure in safety components/system*

Generic risk contributors:

Failure in safety components and the safety system may result in hazardous situations due to override of safety limits.

Generic risk control measures:

The safety components/system shall therefore be so designed that all aspects of failure – including power supply failure – shall lead to indication and alarm in the crane cabin (monitoring), or – alternatively – safeguarded by redundancy design.

213 *Lack of braking capacity*

Generic risk contributor:

Insufficient braking capacity may lead to falling load and uncontrolled crane movements (falling boom, etc.).

Generic risk control measures:

All driving mechanisms and winches intended for hoisting and luffing shall be fitted with fail-safe brakes, i.e. failure of the brake's control system shall normally lead to automatic application of the brake, ref. Sec.3 B104 and Sec.3 B301.

If a single geared transmission is placed between the operational brake (ref. Sec.3 B 102) and the drum for the load hoisting and boom hoisting winches, redundancy in case of breakage in the gear transmission shall be provided by fitting an additional brake with an independent load path to the drum.

In case of multiple gear transmissions, redundancy shall be provided by increasing the number of gear and brake sets at least 30% above required, however, more than 3 additional sets will not be required. As an alternative to redundancy, a 30% increase of the gear design loads may be applied (both with respect to static and fatigue loads).

214 *Lack of load holding capacity*

Generic risk contributors:

Lack of load holding capacity due to missing hydraulic refilling or loss/drop of hydraulic pressure, may lead to falling load or boom.

Generic risk control measures:

The crane's hydraulic system shall therefore be designed such a way that missing hydraulic refilling shall not occur. Further, the hydraulic system shall be fitted with safety or load holding valves on all main circuits protecting against unintended movements in case of hose rupture.

215 *Blackout/shutdown of power*

Generic risk contributor:

Blackout/shutdown may lead to crane stop with the crane and the load in unfavourable and unsafe position.

Generic risk control measures:

- a) Power failure/blackout or unintended shut-down shall lead to automatic application of the brakes (215.a) and an alarm at the operator's stand.
- b) Facilities for emergency operation (215.b), bringing the crane and the load to safe condition, shall be provided by means of an independent standby system rated to handle full SWL under all conditions. The activation switches or handles for emergency operation shall be of "hold to run" type and clearly and permanently marked for their purpose.

216 *Unintended activation of safety functions*

Generic risk contributors:

Unintended activation of safety functions may lead to crane response giving unintentional hazards/risks.

Generic risk control measures:

Handling devices for safety functions shall be protected against inadvertent use and positioned away from ordinary operating handles. Interlock devices, preventing inadvertent activation in dangerous zones (water zone only, etc.) shall be fitted when possible.

217 *Spurious trip of safety functions*

Generic risk contributors:

Initiation of a safety functions in no-hazardous situations and where there is no true demand for safety activation due to safety- or control system failure, may cause other types of hazards/risks.

Generic risk control measures:

Consideration to spurious trip shall be taken in the design of the safety- and control systems. A risk assessment may be required for identification and possible elimination/reduction of spurious trip and corresponding hazards/risks.

218 *Hazards due to activation of safety functions*

Generic risk contributors:

Activation of safety functions may lead to secondary effects that may be harmful to the crane and/or the load.

Generic risk control measures:

Design of safety systems and components shall be done with consideration to dangerous secondary effects, even if the crane/load movements are stopped from full speed and/or full load. Sector limitations for some safety functions shall be considered.

219 *Fire/fire ignition*

Generic risk contributors:

Fire/fire ignition may arise from the crane itself or from the ship/installation, and thereby lead to disaster.

Generic risk control measures:

Generally, necessary protection and precautions against fires and explosions shall be separately considered in each case, with consideration to the hazardous area classification in which the crane or parts of the crane will operate and to the requirements to the crane's emergency preparedness. The application of fire extinguishers and/or automatic fire fighting system shall be considered in each case.

- a) An automatic acoustic alarm in case of detection of fire or explosive atmosphere shall be provided (219.a). The alarm shall be connected to and initiated by the ship's or the installation's fire/gas detectors and alarm system.

- b) Automatic crane shut-down in case of detection may be provided (219.b), however, the requirement to crane's emergency preparedness shall be considered in each case.

Table D1 Monitoring of safety functions				
<i>Event</i>	<i>Ref.</i>	<i>Indication</i>	<i>Alarm</i>	<i>Auto stop</i>
Load high	204	X	X	
Overturning moment high	204	X	X	X
Hook position (upper, lower)	205	X		X
Boom/jib position (upper, lower)	205	X		X
Constant tension	206	X		
Emergency stop	207	X	X	X
Slack wire rope detection	210	X		X
Failure in control system	211	X	X	
Failure in safety system	212	X	X	
Blackout/shut-down	215		X	X
Fire/gas	219		X	X

220 *Ranking of the safety functions*

The manual overload protection (MOPS) and the emergency stop function shall be the preferred safety functions and have equal priority, before other safety devices/limiters.

221 *Verification*

The verification will be carried out according to the “Verification Guideline for Safety Functions”, as given in Appendix G. This document enables verification by means of verification templates, leading to effective and time-saving verification.

222 *Handling of deviations and extended risks*

In cases where the risk deviates from the generic by means of:

- assumed maximum consequence for one hazard/risk contributor that will exceeds one fatality (with the exception of “fire/fire ignition”), or where the specific risk contributors deviates from the specification in 202,

identification of the specific risk and risk contributors is the customer's responsibility and shall be shown in the verification templates and submitted documentation.

Further, when the specific safety functions deviates from the generic as specified in 204-219, this shall appear from the verification templates, and Customer's proposal to functional and technical requirements to the safety functions shall be submitted for review and agreement.

223 Handling of deviations is also described in Appendix G “*Verification Guideline for Safety Functions*”, B200.

SECTION 7 SUBSEA CRANES

A. General

A 100 Basic requirements

101 Generally the requirements given in Sec.6 for offshore cranes are valid for subsea cranes. This section specifies additional requirements and it points out requirements which normally deviate from Sec.6.

102 This section is valid for handling of unmanned submersibles or for lowering to and retrieval from below sea level.

103 Restrictions for loads and dynamic factor given in B below will be disregarded, when a subsea handling operation is handled as an engineered lift.

104 The below requirements are based on conditions for operating at a significant wave height of up to 2 m. Special considerations will be given when operating at higher sea states.

B. Structural strength

B 100 Principal loads

101 Working load (measured at the crane tip) is to be taken as maximum possible static tension in wire rope, taking buoyancy into account.

B 200 Loads due to operational motions

201 The dynamic factor should normally not be taken less than 1.7.

B 300 Horizontal loads due to operational motions

301 The only horizontal loads (S_H) due to operational motions for subsea operations are regarded caused by relative horizontal movement between load and vessel in the sea. These forces are assumed to be 9% of working load acting both as off lead and as side lead.

C. Machinery and equipment

C 100 Drums

101 Documentation of drum and flange strength as given in sec.3 B208 will normally be accepted also when the number of layer exceeds 7.

102 The factor C given in equation in Sec.3 B207 is normally not needed to be taken higher than 3.

C 200 Steel wire rope

201 Where the static submersed load measured at the crane tip (F_{sub}) exceeds SWL, SWL should be substituted by F_{sub} in equation for SF given in Sec.3 B403.

C 300 Sheaves

301 The sheave diameter for steel wire ropes intended to work in heave compensation mode shall at least correspond to a ratio $D_p/d = 20$.

C 400 Power systems

401 Requirements to hoisting, slewing and luffing speeds given in Sec.6 C500 are not applicable.

D. Testing

D 100 Load testing

101 The winch strength shall normally be tested through a retrieval of SWL from full retrieval depth. If not tested to full depth, the actual test depth may be specified in the crane certificate as an operational limitation. Prototype testing, winch to winch testing, or other methods ensuring sufficient design may suffice.

SECTION 8 HEAVY LIFT CRANES

A. General

A 100 Definition

101 All cranes except subsea cranes with lifting capacity of 2500 kN and more are considered as heavy lift crane. Heavy lift cranes are categorised as shipboard cranes or offshore cranes.

A 200 Basic requirements

201 Generally the requirements given in Sec.5 for shipboard cranes and in Sec.6 for offshore cranes are valid for heavy lift cranes. This section specifies additional requirements for heavy lift cranes and it points out requirements which normally deviate from Sec.5 and Sec.6.

202 All operations are taken to be engineered lifts.

B. Structural Strength

B 100 Loads due to operational motions

101 When categorised as offshore crane, the dynamic factor ψ shall not be taken less than:

$\psi = 1.3$ for $W = 2\,500$ kN

$\psi = 1.5 - W/12500$ for $2500 \text{ kN} < W < 5\,000 \text{ kN}$

$\psi = 1.1$ for $W \geq 5\,000 \text{ kN}$

102 When categorised as shipboard crane, the dynamic factor ψ shall not be taken less 1.1.

B 200 Strength

201 Offlead/sidelead to be special considered.

B 300 Horizontal loads due to operational motions

301 Forces due to rotation of the crane will be special considered.

B 400 Load chart or table

401 Load charts tables shall give the safe working load for boom angles or load radii for various dynamic amplifications.

C. Safety and safety equipment

C 100 Overload system

101 Overload protection as described in Sec.5 D203 will be satisfactory.

D. Machinery and equipment

D 100 Power systems

101 Requirements to hoisting, slewing and luffing speeds given in Ch.2 Sec.6 C500 are not applicable.

SECTION 9 LIFTING OF PERSONNEL

A. General

A 100 Basic requirements

101 Lifting of personnel may be done by all crane types. General requirements to the crane type are given in previous sections. This section specifies additional requirements to cranes used for lifting of personnel.

102 Attention is drawn to the fact that many national shelf authorities, as well as maritime authorities, have their own requirements pertaining to lifting of persons.

103 The requirements specified below are aiming at lifting persons with ordinary crane arrangements and are not intended for *man riding winches* (lifting/lowering of one person) and other specialised equipment.

B. Documentation

B 100 Documentation requirements

Status for documentation will be as for offshore cranes.

C. Certification

C 100 Certification requirements

101 Offlead/sidelead to be special considered.

102 DNV product certificates will be required for the following items:

- winches for hoisting and luffing
- transmission gears and brakes (applicable when transmitting braking forces for hoisting and luffing).

D. Loads

D 100 Rated capacity

101 The rated capacity shall not exceed 50% of the rated capacity for lifting of loads at the actual radius and wave height. This information shall be given in the instructions, load chart and by the safe load indicator whenever the mode for lifting of persons is selected.

E. Machinery and equipment

E 100 Brakes

101 Hoisting and luffing winches shall be equipped with two mechanically and functionally independent brakes.

102 Means shall be provided for separate testing of each brake.

103 Mechanical brakes shall fulfil the requirements for brakes as given in Sec.3 B300 based on SWL for the actual load cases. SWL will be replaced by rated capacity for personnel handling provided the brake is used in personnel handling mode only.

104 Hydraulic restriction may be considered as one of the required two brakes, provided the rated capacity does not exceed 50% of the rated capacity for lifting of loads, ref. D101.

105 Where hydraulic restriction is used as a brake, the following applies:

- The hydraulic motor shall have a closing valve directly at the high-pressure (load) connection (no pipe or hose connection in between).
- The closing valve shall close as a result of pressure loss at the low-pressure connection (inlet connection during lowering). This function shall be accomplished by direct bore or piping between the closing valve and the low-pressure connection.
- The hydraulic motor shall always be ensured sufficient working fluid, also in the event of power failure, i.e. gravity feeding.

106 Where cylinders are used for luffing, folding or telescopic, they shall be provided with a hydraulic shut-off valve. Alternatively each motion shall have two independent cylinders where each cylinder is capable of holding the rated capacity for lifting of persons.

E 200 Steel wire ropes

201 Steel wire ropes for hoisting shall have a minimum safety factor of 8 and chains shall have a minimum safety factor of 6, related to the rated capacity for the lifting of persons.

E 300 Shock absorbers

301 Where a shock absorber is installed it shall be fail-safe and automatic in operation.

F. Safety

F 100 Mode selection for lifting of persons

101 The control station shall be equipped with a manual key selection switch for the purpose of lifting persons. The switch shall be lockable in both positions with a removable key and have an adjacent warning light which continuously shall indicate when it is activated. The light shall not illuminate unless selection for personnel lifting is made. When the mode for personnel lift is selected, the following functions shall be maintained:

- All brakes shall automatically be activated when the controls are in neutral position and in cases where the emergency stop has been activated.
- Where fitted, automatic overload protection system (AOPS) shall be overridden; i.e. it shall not be possible that this system is activated.
- Where fitted, motion compensators; i.e. cable tensioning systems and heave compensator systems shall be overridden.
- Where fitted, emergency release systems shall be overridden; i.e. it shall not be activated regardless of the position of the emergency release switch or handle.
- Manual overload protection system (MOPS) shall be overridden; i.e. shall not be possible to activate.

F 200 Operational limitation

201 Except for emergency operations, the operational limitations for lifting of personnel shall be as follows:

- mean wind velocity: 10 m/s
- significant wave height: 2 m
- visibility: daylight or equivalent.

SECTION 10

LAUNCH AND RECOVERY SYSTEMS FOR DIVING

A. General

A 100 Basic requirements

101 Generally the requirements given in Sec.6 (offshore cranes) and Sec.9 (personnel lifting) are valid for launch and recovery systems for diving. This section specifies additional requirements for launch and recovery systems for diving and it points out requirements which normally deviate from Sec.6 and Sec.9.

A 200 Design principles

201 The normal handling system shall be designed for a safe, smooth and easily controllable transportation of the bell.

The lowering of bells is, under normal conditions, to be controlled by the drive system for the winches, and not by mechanical brakes.

Bell and guide-wire winches used for dry transfer into a habitat shall include a heave compensation and constant tension system.

Guidance note:

Care must be taken when designing handling systems with heave compensation and constant tension systems incorporated, as the added systems often contribute to the increase in the stiffness of the overall system.

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202 Manoeuvring systems shall be arranged for automatic stop when the operating handle is not operated (dead man's handle).

203 Hoisting systems shall be fitted with a mechanical brake, which shall be engaged automatically when the hoisting motor stops. In the event of failure of the automatic brake a secondary means shall be provided to prevent the load from falling.

204 The handling system shall be designed so that the systems are locked in place if the energy supply fails or is switched off.

205 The hoisting system shall be equipped with a device which stops the bell at its lowermost and uppermost positions. Travelling cranes and trolleys shall be equipped with mechanical stops at their end positions. The system shall be equipped with limit switches preventing the handling of the bell, wet bell or basket outside of the handling area.

206 Precautions shall be taken to avoid exceeding the design load in any part of the handling system including hoisting ropes and umbilical due to:

- large capacity of the power unit
- motions of the supporting vessel when the bell or weights are caught or held by suction to the sea floor
- failure on umbilical winch during launching of bell.

207 Structural members of the handling system might be subjected to forces imposed by separate units of a power system. (e.g. A-frame tilted by hydraulic actuator on each leg.) The structural members are therefore either to be strong enough to sustain the resulting forces when one of the power units fails, or the power units shall be synchronised and an automatic alarm and stop system shall be activated when the synchronising is out of set limits.

A 300 Power

301 The bell hoisting power system shall be designed and tested to lift a load of 1.25 times the working weight.

302 The power of horizontal transportation systems shall be designed and tested for safe handling at list and trim as specified in Table B1.

303 The strength of the mechanical brake for the bell hoisting system shall be based on holding of the design load. After the static test, however, the brake may be adjusted to the working weight of the bell plus 40%.

B. Structural strength

B 100 Design loads

101 The design load shall be taken as the largest most probable, resultant load over 24 hours in the operational design sea-state due to the following:

- working weight of bell and structural members of the handling system,
- dynamical amplification due to list, trim and motion of the vessel,
- operation and response of the handling system,
- hydrodynamic forces,
- jerks in the hoisting ropes and impact on the system.

102 In locked positions on a vessel, the handling system shall have a structural strength at least sufficient for the environmental conditions described in Sec.2. In addition to the motions and accelerations in the operational design sea-state, the minimum inclinations given in Table B1 shall be taken into account:

Table B1 Permanent inclinations		
<i>Vessel type</i>	<i>Permanent list</i>	<i>Permanent trim</i>
Ship	5°	2°
Semi-submersible	3°	3°

103 Dynamic loads due to start, stop, or a slack wire rope followed by a jerk, and hydrodynamic loads shall be determined.

B 200 Strength Calculations

201 The safety to be checked for Case I of loading defined in Sec.2 C using design load as specified in 100.

C. Machinery and Equipment

C 100 Steel wire rope

101 Steel wire rope safety factor shall be according to Sec.9 E200.
Ropes shall be of a type that minimises rotation.

C 200 Cross hauling

201 In the case of cross hauling, such equipment shall fulfil the same requirements for strength as the rest of the handling system.

C 300 Testing After Completed Installation

301 Handling systems shall be subjected to tests for structural strength and for function and power.

- A static load test to a load equal to the design load shall be carried out
- Functional and power testing of normal and emergency systems shall be carried out with a functional test load of 1.25 times the working weight in the most unfavourable position. It shall be demonstrated that the systems are capable of carrying out all motions in a safe and smooth manner
- Monitoring of functional parameters during the test, e.g. pressure peaks in hydraulic systems may be required
- A recovery test of the bell shall be carried out simulating emergency operations conditions.

SECTION 11 LAUNCH AND RECOVERY ARRANGEMENT FOR ROV

A. General

A 100 Basic requirements

101 Generally the requirements given in Sec.6 for offshore cranes are valid for launch and recovery arrangement for ROV. This section specifies additional requirements for launch and recovery arrangement for ROV and it points out requirements which normally deviate from Sec.6.

B. Documentation

B 100 Documentation requirements

101 Status for documentation will be as for “other cranes” in Ch.1 Sec.2 Table A1.

C. Certification

C 100 Certification requirement

101 Hydraulic cylinders with a load carrying capacity not exceeding 20 tonnes may be accepted with Works product certificate on the following conditions:

- The cylinder is subject to serial production.
- The exception may be agreed on a case-by-case basis and shall be agreed in advance.
- The manufacturer shall apply for such exception in due time by submitting one copy of documentation on the cylinder, including all main dimensions and material specifications enclosed to the application, enabling DNV to carry out an independent review calculation as found appropriate.
- Extent of NDT and pressure testing shall be agreed in each case.

D. Safety and safety equipment

D 100 General

101 Requirements given in Sec.6 D200 (offshore cranes) are not applicable. Specific requirements as defined for shipboard cranes in Sec.5 D200 are valid.

SECTION 12

TESTING AND TEST CERTIFICATES MARKING

A. Functional Testing of Completed Lifting Appliances

A 100 General

101 Each completed crane shall be thoroughly tested to confirm that all the safety, power and control functions are correctly implemented onboard.

If complete functional testing has been documented to have been carried out at the test bed at manufacturers' location, limited functional testing may be carried out after final installation.

In such case, the proposed test plan shall specify the extent of the limited functional testing to be done after final installation.

102 The functional testing shall be carried out in accordance with a detailed programme, which shall be submitted well in advance of the actual testing. The programme shall specify in detail how the respective functions shall be tested and how observations during the test can be ensured. The tests specified below shall be included in the test programme.

103 A copy of the approved test programme shall be kept in the crane manual. It shall be completed with final results and endorsed by the "competent person".

104 The significant characteristics of power and braking systems as well as the safety equipment shall be considered. Braking systems and safety equipment shall be checked by function testing. Pressure testing of hydraulic components is normally not required to be witnessed by the surveyor. The tightness of the systems shall be checked after the installation of the components and during functional testing.

A 200 Prime movers and fluid power systems

201 Relevant parameters such as power, ambient temperature and pressure, exhaust gas temperature etc. shall be measured and recorded.

202 Automatic control, remote control and alarm systems connected with power systems shall be tested.

203 After the test, the lubricating and/or hydraulic oil filters shall be checked for solid particles. Other components of machinery may be required opened up by the surveyor.

A 300 Governing and monitoring systems

301 It shall be verified that control systems function satisfactorily during normal load changes.

302 Failure conditions or boundary conditions shall be simulated as realistically as possible, preferably letting the monitored parameters pass the alarm safety limits.

A 400 Electrical installations

401 Insulation-resistance test shall be carried out for all outgoing circuits between all insulated poles and earth and, where practicable, between poles. Under normal conditions a minimum value of 1 mega ohm shall be obtained. This also applies to instrumentation and communication circuits with voltages above 30 V A.C. or V D.C.

The insulation resistance of a motor shall not be less than:

$$\frac{3 \cdot \text{rated voltage}}{\text{rated kVA} + 1000} \text{ megaohms}$$

tested on a clean and dry motor when hot.

402 When found necessary by the surveyor, switchgear shall be tested on load to verify its suitability and that operating of over-current release and other protective measures are satisfactory. Short circuit tests in order to verify the selectivity may also be required.

A 500 Brakes

501 Brakes shall be tested with safe working load applied on crane by braking each motion from maximum speed to full stop. In addition, each brake for the hoisting and derricking motions shall be tested for three such stops in quick succession during lowering motion.

502 The emergency stop system is to be tested. The test may be carried out at reduced speed and with reduced load.

A 600 Safety equipment

601 Safety functions as presented in Table D1 in Sec.5 and Table D1 in Sec.6 shall be tested.

B. Load Testing

B 100 General

101 Lifting appliance shall be load tested after it has been installed at its operational location:

- before being taken into use the first time
- after any substantial alteration or renewal, or after repair of any stress bearing part
- at least once in every five years (preferably at regular five-yearly intervals after the data on which the appliance was first taken into use).

Above requirements are in compliance with international and national regulations.

102 Every item of loose gear shall be load tested:

- before being taken into use first time
- after substantial alteration or renewal
- after repair of any stress bearing part.

B 200 Test weights

201 Movable, certified weights shall be used by initial load-testing and by all load-testing where SWL exceeds 15 tonnes.

202 A mechanical or hydraulic precision dynamometer may be used:

- in cases of periodical retesting and after repair/renewal of mechanical parts of lifting appliances with $SWL \leq 15$ tonnes.
- in cases where a test that follows repair/renewal of a structural part is carried out.

The accuracy of the dynamometer shall be within +2 per cent and the indicated load of such dynamometers under test load shall remain constant for approximately 5 minutes.

203 Test equipment used for the testing of loose gear, either assembled units or components of loose gear, is to have been checked for accuracy (calibrated) at least once during the 12 months preceding the test.

B 300 Test loads

301 The test load applied to a lifting appliance shall exceed the safe working load (SWL) of the appliance as follows:

Table B1 Test load for cranes and derrick rigs	
Safe working load	Test load
Up to 20 tonnes	25% in excess of the SWL
Exceeding 20, but not exceeding 50 tonnes	5 tonnes in excess of the SWL
Above 50 tonnes	10% in excess of the SWL
Note: Where the dynamic factor ψ exceeds 1.33, the reference SWL in the table shall be taken as $0.75 \times \psi \times SWL$	

302 For hydraulic cranes where, due to limitation of hydraulic oil pressure by the safety valve, it is not possible to lift a test load in accordance with Table B1, it will suffice to lift the greatest possible load. Generally this should not be less than 10 per cent in excess of the SWL.

303 The test load applied to a cargo or pulley block and to loose gear shall exceed the safe working load (SWL) of the block and gear as follows:

Table B2 Test load for loose gear and other accessories	
Item	Test load, in tonnes ⁴⁾
Chains, hooks, shackles, swivels, etc.:	
SWL ≤ 25 t	$2 \cdot SWL$
SWL > 25 t	$(1.22 \cdot SWL) + 20$
Multi-sheave blocks: ²⁾	
SWL ≤ 25 t	$2 \cdot SWL$
$25 \text{ t} < SWL \leq 160 \text{ t}$	$(0.933 \cdot SWL) + 27$
SWL $> 160 \text{ t}$	$1.1 \cdot SWL$
Single-sheave blocks: ^{1) 3)}	
Lifting beams, etc.: ⁵⁾	
SWL $\leq 10 \text{ t}$	$2 \cdot SWL$

Table B2 Test load for loose gear and other accessories (Continued)	
10 t < SWL ≤ 160 t	(1.04 · SWL) + 9.6
SWL > 160 t	1.1 · SWL
Notes:	
1) For single sheave blocks with or without becketts the SWL shall be taken as one half of the resultant load on the head fitting. See also Appendix B. 2) The SWL of a multiple sheave block shall be taken as the resultant load on the head fitting. 3) For single sheave blocks with a permissible load at the head fitting exceeding 25 tonnes, the test load may be reduced as permitted for the chains, hooks, shackles, swivels, etc. in the table. In this case the SWL notation shall be the resultant load on the head fitting. 4) Where the dynamic factor ψ exceeds 1.33: See Note to Table B1. 5) The fittings to a lifting beam or frame such as hooks, rings and chain shall be tested independently before they are fitted to the beam.	

304 Built-in sheaves and other items permanently attached to the lifting appliance are not considered loose gear. The test of the lifting appliance "as rigged" will be accepted as the load test of these items.

305 Where hand-operated blocks are used with pitched chains and permanently attached rings, hooks, shackles or swivels, the hand-operated blocks, the pitched chains and the permanently attached rings, hooks, shackles and swivels shall be tested with a test load 50% in excess of the safe working load.

B 400 Examination after testing

401 After testing, the lifting appliance including gear accessories are to be examined thoroughly to observe whether any part has been damaged or permanently deformed by the test. Dismantling and/or non-destructive testing may be required if deemed necessary by the surveyor.

The above also applies to blocks and loose gear.

402 Any overload protection system and automatic safe load indicators that may have been disconnected during load testing shall be reconnected. Accordingly safety valves and/or electrical circuit-breakers shall be adjusted. Set points shall be verified and sealed by the surveyor.

B 500 Certificates

501 When a lifting appliance or component to a lifting appliance after testing and examination have been found satisfactory the following certificates (CG forms) shall be issued (as far as applicable and relevant):

Form No. CG2: Certificate of test and thorough examination of lifting appliances.

Form No. CG3: Certificate of test and thorough examination of loose gear.

Form No. CG4: Certificate of test and thorough examination of wire rope.

502 As final documentation (certificate) for a lifting appliance installed and to be taken into use for the first time, Form No. CG1 "Register of Lifting Appliances and Items of Loose Gear" shall be presented. See also Appendix F.

Guidance note:

The Forms Nos. CG2, CG3 and CG4 shall be attached to Form No. CG 1 in completed order.

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B 600 Procedure for load testing of a lifting appliance

601 Before load testing, the surveyor shall ensure that:

- support of the lifting appliance is acceptable
- for a ship or other vessel, necessary pre-cautions with respect to stability, ballasting or similar conditions have been taken
- for a mobile crane, the crane has a sufficient margin of stability against overturning
- required test certificates for blocks and loose gear are available and acceptable
- for a new installation, design approval and survey during fabrication of the lifting appliance are documented.

602 A written test programme acceptable to the surveyor should preferably be available.

603 The test weights shall be lifted by the lifting machinery used for the regular handling of loads. Testing a lifting appliance driven by electrical motor(s) the regular electrical supply shall be used. For ships, electrical shore connection is acceptable when the power is distributed through the ship's main switchboard and distribution panels.

604 For cranes, the test load is to be hoisted, slewed and luffed at slow speed. Gantry and travelling cranes together with their trolleys, where appropriate, shall be traversed and travelled over the full length of their track.

605 For variable load-radius cranes, the tests are generally to be carried out with the appropriate test load at maximum, minimum and at an intermediate radius.

606 Additional winch testing for subsea cranes, see Sec.7 D.

C. Testing of Steel Wire Ropes

C 100 Cross reference

101 Steel wire ropes are to be tested as required by Sec.1 I400.

C 200 Certificates

201 After testing of steel wire ropes certificates of type CG4 shall be issued.

202 A manufacturer or supplier who has obtained a certificate for a coil of wire rope, shall, when he resells the coil or part of it, issue a certificate to the buyer. The certificate shall be a copy of the original certificate additionally dated and signed by the supplier.

D. Marking and Signboards

D 100 General

101 Cranes and all items of fixed and loose gear and accessories shall be marked with their safe working load (SWL) in a legible and durable way. To prevent effacement of the inscriptions, they shall normally be incised, punched or marked as specified below.

102 All blocks and all items of loose gear and accessories shall be marked with an identification mark to enable them to be readily related to their appropriate test certificates, with the stamp of institution, society, body or manufacturer who carried out the load test.

103 Cranes on board vessels shall be marked with a reference number to enable them to be related to their location onboard.

D 200 Cranes

201 The markings of SWL and allowed radii (and the reference number in case of shipboard cranes) be painted in a conspicuous place on the crane.

The identification numbers and stamp of the Surveyor shall be punched or incised.

202 Cranes with constant SWL for all radii shall be marked with possible crane reference number, SWL and minimum and maximum radii for this load. Example: No.5 SWL 5 t 4 - 14 m.

203 Cranes with SWL depending on one variable only shall be marked with possible crane reference number and with SWL for two or more instances of the variable, including the ones giving extreme values of SWL. If possible, the variable shall be expressed as radius. Example: No.5 SWL 15 t 5 m, SWL 3 t 12 m.

204 Cranes with SWL depending on two or more variables (e.g. knuckle boom crane) shall be marked with possible crane reference number and SWL range together with a reference to load chart. Example: No.5 SWL 3 t to 15 t, See load chart.

Guidance note:

The SWL range is a) to b) where a) is the minimum SWL for the most unfavourable combination of the variables in any operating mode and b) is the maximum SWL for the most favourable combination of the variables in any operating mode.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

205 Reference numbers and SWL shall be marked in letters and figures of at least 80 mm height and the radii in letters and figures of at least 60 mm height.

206 Cranes with dual function, e.g. hook duty and grab duty, shall be marked for both alternatives. Clear instructions/signboard shall be available for the crane driver.

Guidance note:

Self weight of loose gear/grab shall be deducted from cranes' SWL before deciding suitability of lifting gear/grab.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

D 300 Launch and recovery systems for diving

301 The handling system shall, in an easily visible place, be fitted with a nameplate giving the following particulars:

— identification number

- static test load
- functional test load
- working weight
- surveyor's mark and identification.

The above loads shall be specified for each transportation system involved.

D 400 Blocks

401 The SWL of blocks together with the identification numbers and the Surveyor's/Manufacturer's stamp shall be marked on one of the plates of the blocks.

For definition of SWL of blocks, see Notes to Table B2.

D 500 Slings and lifting tackles

501 Slings and lifting tackles are considered as "loose gear" and shall comply with Sec.3 B800.

502 Slings and lifting tackles shall be marked with SWL, identification number and the certifying authorities' stamp on a legibly and durably fitted ring or plate.

503 Where wire rope slings are fitted with pressure locks the markings shall be located on the locks.

504 For wire rope slings the SWL by 0° shall be marked for single slings.

The safe working load marked on a multi-legged sling shall be:

- In the case of a two-legged sling, the safe working load of the sling when the included angle between the legs is 90°.
- In the case of a three-legged sling, the safe working load of the sling when the included angle between any two adjacent legs is 90°.
- In the case of a four-legged sling the safe working load of the sling when the included angle between any two diagonally opposite legs is 90° and the total load is carried by 3 of the four legs.

505 Instead of marking of slings as stated in 503 above, displayed information on use of the slings may be accepted. The display shall be easily seen and the slings shall be easily identified in accordance with the display.

506 Lifting gear and grabs shall be marked with SWL, own weight, identification number and the certifying authority's stamp.

APPENDIX A WIND LOADS ON CRANES

A. Wind Load Calculation

A 100 General

101 A simplified method of wind load calculation is presented below. The method will be acceptable for all normal crane designs and applications where the wind loads are of significant less importance than the other design loads.

102 In the design of cranes the distribution of wind pressure and suction around the structure need not be considered in detail, and wind loads may normally be determined in terms of resulting forces on each of the larger parts of the crane, or on each «assembly» of smaller members, such as a truss. A basic assumption is that wind pressure and suction will act normal to surfaces. As a consequence the resulting wind force on a prismatic member will act normal to the axis of the member, irrespective of wind direction. This applies to long prismatic members and, if the ends are not exposed to wind, also to short prismatic members.

A 200 Wind force on flat surfaces

201 The wind force normal to a flat surface of area A is taken as:

$$P = A \cdot q \cdot C \cdot \sin \alpha$$

where:

P = wind force in N.

A = exposed area in m²

q = air velocity pressure = $\rho v^2/2$. See 500.

C = average «pressure coefficient» for the exposed surface.

α = angle between the wind direction and the exposed surface

ρ = mass density of the air (1.225 kg/m³)

v = wind velocity in m/sec.

A 300 Wind force on bodies of flat surfaces

301 For a body bounded by flat surfaces, such as a machinery house or the like, the resulting wind force may be determined as the vector sum of one force acting on each surface, each force being determined according to 201. In general, A, C and α will be different for the different surfaces, and on the leeward surfaces there will be suction. In most practical cases, however, it is more convenient to use values of C which represent the sum of pressure and suction on two opposite sides. Such values of C are given in Table A1.

A 400 Wind force on structural members

401 For flat-sided structural members, such as rolled sections, the equation in 201 may be used for both of the possible components normal to the member axis:

$$P_1 = A_1 \cdot q \cdot C_1 \cdot \sin \alpha_1$$

$$P_2 = A_2 \cdot q \cdot C_2 \cdot \sin \alpha_2$$

Referring to Fig.1, P₁ is the total force acting normal to the flanges (resulting from pressure and suction on both flanges) and P₂ is the total force acting normal to the web.

Further $A_1 = l \cdot h_1$ and $A_2 = l \cdot h_2$.

α_1 = angle between velocity vector and flange plane and

α_2 = angle between velocity vector and web plane.

Applicable values of C are given in Table A1. Note that C is used as a common symbol for «pressure coefficient» (pressure or suction) and «force coefficient» (sum of pressure and suction).

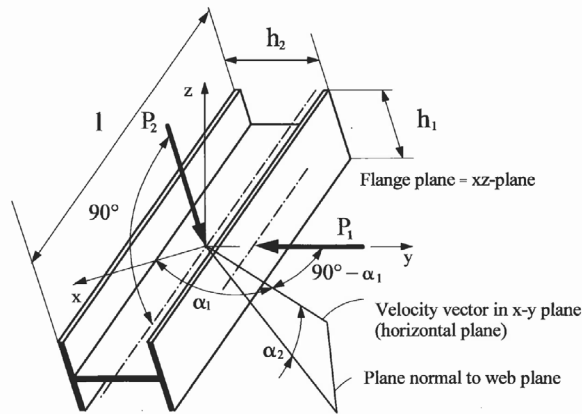


Figure 1
Wind force on H-shaped members

Table A1 Coefficient C			
<i>Type of member</i>	<i>Coefficient C</i>		
	<i>Pressure</i>	<i>Suction</i>	<i>Total</i>
Flat-sided section			2.0
<i>Tubular member:</i>			
diameter < 0.3 m			1.2
diameter ≥ 0.3 m			0.7
Trusses of flat-sided sections			1.8
Trusses of tubular members			1.1
For leeward truss in case of two trusses behind each other			2/3 of above values
Machinery houses, cabins, counterweights and the like	Max:1.0 Average:0.7	Max:1.0 Average:0.7	1.2
<i>Working load:</i>			
Containers and similar shapes	(0.7)	(0.5)	1.2
Other shapes			1.0

402 For members of circular (or nearly circular) cross section the equation in 201 may be used for the resulting force, taking $A = ld$, C as force coefficient, and α as angle between wind direction (velocity vector) and member axis, see Fig.2.

P acts in the plane defined by the member axis and the velocity vector, in the direction normal to the member axis. For values of C , see Table A1.

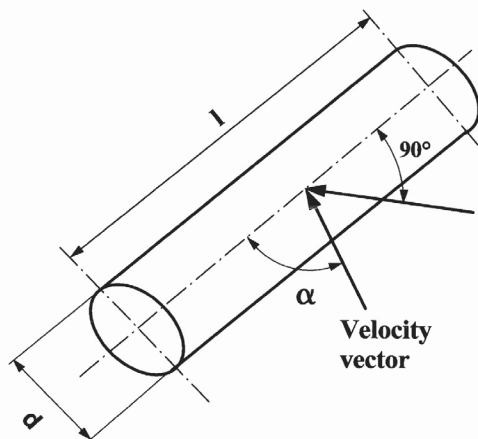


Figure 2
Wind force on tubular members

A 500 Air velocity pressure

501 The velocity pressure q to be used as design parameter shall be based on expected conditions for each particular crane or part of crane. The variation with height above ground (or sea level) may be taken as:

$$q = q_{10}(0.9 + 0.01H)$$

where

q_{10} is the velocity pressure 10 metres above ground (or sea level) and H is the considered height in metres. General minimum values of q_{10} are given in Table A2. The corresponding «free-stream» wind velocity v_{10} (m/sec) is also given.

Table A2 Design velocity pressure in N/m ²			
<i>Location</i>	<i>Crane condition</i>	v_{10}	q_{10}
Inland and sheltered conditions	“Working”	≈ 20	250
Ship in harbour	“Out of service”	≈ 36	800
Offshore and open areas	“Working”	≈ 24	360
Ship at sea	“Out of service”	≈ 44	1200

APPENDIX B MARKING OF SINGLE-SHEAVE BLOCKS

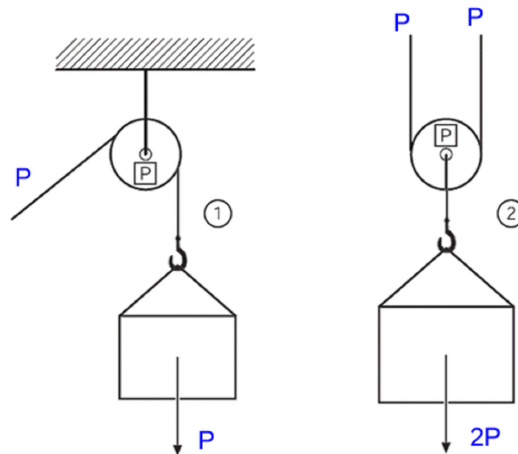
A. General

A 100 Method of marking the safe working load

101 This Appendix explains the method of marking the safe working load (SWL) of single-sheave blocks with or without a becket. Experience shows that this subject is frequently discussed and often misunderstood.

102 The text is an excerpt from ILO's Code of Practice "*Safety and health in ports*", 2005, Item 4.4.5 "Blocks", published by the International Labour Office, Geneva, Switzerland.

- The safe working load of a single-sheave block is the maximum load that can be safely lifted by that block when it is suspended by its head fitting and the load is secured to a wire rope passing round its sheave (Fig. 1 ①).
- When a single-sheave block is rigged with the load to be lifted secured to its head fitting and the block is suspended by a wire rope passing around its sheave, it should be permissible to lift a load twice the safe working load marked on the block (Fig. 1 ②).
- The safe working load of a multi-sheave block is the maximum force that may be applied to its head fitting.
- The design of blocks to be used with wire ropes should be based on a wire rope having a tensile strength of 180 to 220 kg/mm² (1 770 to 2 160 N/mm²).



① Load attached to rope passing around the pulley

② Load attached directly to the block

P Safe working load of the block

Figure 1
Safe working load of a single-sheave block

APPENDIX C

SHIP MOUNTED CRANES WITHOUT JIB SUPPORT IN TRANSIT CONDITION

A. Example on Checking for Compliance with the Structural Strength

A 100 General

The requirements to ship mounted cranes with respect to transport condition are dealt with on a general bases in Ch.2 Sec.2. For jib cranes where the jib rests in a cradle in transport condition, the transport condition is generally not critical with respect to excessive yielding. The contribution to fatigue damage from this condition is, for a normal crane design, insignificant compared to the crane operating condition. The use of jib cradle is the most frequently used way of securing the crane in transport condition.

However, for a jib crane without a jib cradle, the situation is quite another. This document describes how DNV, in general, ensures that the requirement in this Standard is fulfilled when a jib crane in transport condition is secured in the following way:

- Slewing column rotation is prohibited by applying locking bolts in the slewing ring.
- The jib is secured by tension in the crane's hoisting wire and tension in the crane's luffing cylinders.

Design checks that apply to jib cranes generally are not included here, only the special checks that follow from the special securing of the crane in transport condition are covered.

A 200 Case of loading to be considered

The case of loading that shall be considered when accounting for ship movement, is described in Ch.2 Sec.2 B400:

$$S_G + S_M + S_{W_{\max}}$$

where:

- S_G = loads due to dead weight of the components
- S_M = inertia forces due to motion of the vessel on which the crane is mounted
- $S_{W_{\max}}$ = loads due to out-of-service wind.

The procedure followed when calculating the loading is independent of how the crane is secured in transport condition. However, some explanations to how S_M and $S_{W_{\max}}$ are calculated are presented in the items below.

The above load case, denoted IIIb in our Standard, is actually not one single load case. The reason is that the inertia forces caused by the ship motion, in accordance with Ship Rules, are dealt with as four different load combinations:

- vertical force alone
- vertical and transverse force
- vertical and longitudinal force
- vertical, transverse and longitudinal force.

For these four load combinations it may be easy to foresee what direction of the accelerations will give the highest loading, and thereby decide what the four load combinations shall look like when checking for static strength. When checking for fatigue, however, it is the stress ranges that are of interest. The crane must therefore be analysed for both directions of the accelerations, giving 8 different load combinations.

In addition to the above, the crane is preferably analysed for both initial heel/trim and no heel/trim. The total number of load combinations will therefore be 16.

A 300 Calculation of vessel motion

The vessel motion is calculated in accordance with Ship Rules Pt.3 Ch.1 Sec.4. The ship accelerations thus calculated are extreme values (i.e., probability level = 10^{-8}). The crane's location onboard the ship is accounted for. To be sure to avoid shock loads in the crane, it is important to check that the upward vertical acceleration never exceeds $1.0 \cdot g$. (If the upward vertical acceleration exceeds $1.0 \cdot g$, special considerations must be made regarding requirements to tension in the jib luffing cylinders and redundancy of the same.)

Typical values for the calculated accelerations may, for a ca. 180 m ship with 60 000 tonnes displacement and the crane near the bow, be:

- Combined¹⁾ vertical acceleration: $a_V = 0.6 \cdot g$
- Combined¹⁾ transverse acceleration: $a_T = 0.7 \cdot g$

Combined¹⁾ longitudinal acceleration: $a_L = 0.3 \cdot g$

¹⁾ Combined means that the acceleration is a result of all the ship motion (surge, sway/yaw, heave, roll and pitch). Gravity is, however, not included.

A 400 Calculation of loading due to vessel motion

The forces acting on the crane due to vessel motion are calculated in accordance with Ship Rules Pt.3 Ch.1 Sec.4 C501. This means that the forces are based on the extreme response as calculated above, but are modified to a probability level of approximately 10^{-4} . The four load case combinations calculated are:

- vertical force alone:
 $P_V = (g_0 \pm 0.5 \cdot a_V) \cdot M$
- vertical and transverse force:
 $P_V = g_0 \cdot M$
 $P_T = \pm (0.67 \cdot a_T) \cdot M$
- vertical and longitudinal force:
 $P_V = (g_0 \pm 0.5 \cdot a_V) \cdot M$
 $P_L = \pm (0.67 \cdot a_L) \cdot M$
- vertical, transverse and longitudinal force:
 $P_V = (g_0 \pm 0.5 \cdot a_V) \cdot M$
 $P_T = \pm (0.27 \cdot a_T) \cdot M$
 $P_L = \pm (0.67 \cdot a_L) \cdot M$

where M = total mass of unit.

A 500 Calculation of wind load

The procedure for calculation of wind load is the same as for the working condition, except that the wind pressure 10 metres above the sea level, q_{10} , is increased from 250 N/m² for working conditions in sheltered locations, to 1 200 N/m² for ship at open sea. The critical wind direction will in most cases be normal to the plane spanned by the crane slewing column and the jib.

A 600 Checking with respect to excessive yielding

By calculating the acting forces in the crane for the above load combinations, remembering the special conditions with tension in both luffing cylinders and in the hoisting wire, stress calculations and check with respect to excessive yielding may be performed. The requirement to safety factor is given in Ch.2 Sec.2 Table C1.

For cranes with a long jib that are designed for small SWL, a transport condition with the jib not supported may tend to be the critical condition. However, the shorter the jib and the higher the SWL for which the crane is designed, the less critical the transport condition becomes compared to the working condition of the crane. An example; for a typical design of a crane with 26 meter jib and a SWL of 36 tonnes, the lowest safety factors calculated by applying elastic analysis were approximately 3.0 for both the critical spot in the jib and in the housing (our requirement is $S_F \geq 1.10$).

A 700 Checking with respect to buckling

Based on consideration of the static system of the crane in transport condition, the acting forces and the calculated stresses in the transport condition as compared to the stresses in the working condition, it may be concluded that the transport condition will normally not be critical with respect to buckling. Consequently, it is normally not necessary to perform buckling check.

A 800 Checking with respect to fatigue

The fatigue check is based on the stress ranges found by applying the \pm altering of the accelerations as shown in A400. Conservatively, for each hot spot, the maximum stress ranges from the four load combinations may be selected: $\Delta \sigma_0$. The $\Delta \sigma_0$ value is the stress range (for a particular hot spot) that has a probability of 10^{-4} of being exceeded (ref. A400). $\Delta \sigma_0$ therefore represents the maximum stress range within $n_0=10^4$ cycles.

In the following we will calculate the fatigue damage for a ship service life of 20 years. We will need to know the number of cycles within 20 years. By assuming a mean wave period of 6 seconds (the mean wave period will vary depending on sheltered condition, open sea, on which ocean the ship operates, etc., 6 seconds is assumed to be a sufficient good estimate for the actual purpose) the number of cycles in 20 years may be calculated:

$$n_{20} = \frac{20 \text{ years} \cdot 365 \text{ days} / \text{year} \cdot 24 \text{ hours} / \text{day} \cdot 3600 \text{ seconds} / \text{hours}}{6 \text{ seconds} / \text{cycle}} = 10^{8.0}$$

After deciding which SN curve applies to a particular hot spot, an estimate for the fatigue damage in a 20 year period for the given hot spot may be calculated by applying a closed form fatigue formula:

$$D_{tr20} = \frac{n_0}{a} \cdot \frac{(SCF \cdot \Delta\sigma_0)^m}{(\ln n_0)^m} \cdot \Gamma(1+m) \cdot \frac{n_{20}}{n_0}$$

For Weibull shape parameter $h = 1.0$ and with a one slope S–N curve, where:

D_{tr20} = Accumulated fatigue damage over a 20 year period for the actual hot spot, as caused by ship movement only.

n_0 = Number of cycles corresponding to the calculated $\Delta\sigma_0$.

\bar{a} = Parameter in S–N curve.

SCF = Stress concentration factor (in addition to that included in the S–N curve).

$\Delta\sigma_0$ = Stress range found as explained above.

m = Parameter in S–N-curve.

Γ = Gamma function.

$m = 3.0 \quad \Gamma = 6.00$

$m = 3.5 \quad \Gamma = 11.63$

$m = 4.0 \quad \Gamma = 24.00$

n_{20} = Number of cycles in a twenty year period.

For the crane's working condition, the fatigue check is normally done by comparing the actual stress level with allowed stress levels in accordance with the FEM standard. This check does not account for the special fatigue damage as caused by supporting the jib in transport condition without a cradle. It is therefore of interest to calculate how the fatigue check for the working condition may be performed in such a way that the special damage from the transport condition is accounted for. This is done by calculating the factor that the stress level in the working condition must be reduced by, to still keep the fatigue damage below the acceptable level (remembering that this Standard requires for fatigue: $\sigma_{\text{allowed}} = \sigma_{\text{cr}} \cdot \frac{3}{4}$):

$$k = \left[1 - D_{tr20} \cdot \left(\frac{4}{3} \right)^m \right]^{\frac{1}{m}}$$

where:

k = Factor to multiply the allowed fatigue stress for working condition with to account for both working condition and transport condition.

D_{tr20} = Fatigue damage from transport condition (without accounting for required safety factor) calculated as shown above

m = Parameter in S–N curve.

The procedure for checking fatigue is then:

- 1) Select a hot spot.
- 2) Select applicable S–N curve.
- 3) Calculate possible SCF (only the stress concentration that comes in addition to the stress concentration built into the SN curve).
- 4) Calculate the stress range for the transport condition: $\Delta\sigma_0$.
- 5) Calculate the fatigue damage for transport condition (without accounting for the required safety factor on stress level of 1.33).
- 6) Calculate the allowed fatigue stress in working condition factor k .
- 7) Check fatigue for working condition. Multiply the allowed stress as found in accordance with the FEM standard by factor k .
- 8) Repeat step 1 to 7 for all actual hot spots.

Example of calculated k values for a typical design of a crane with 26 meter jib and a SWL of 36 tonnes: The factor k is calculated for the most highly stressed area of the housing and jib respectively. Assuming $SCF=1.0$ (i.e., no SCF except for that included in the SN curve) and SN curve F, the following values were found:

Jib: $k = 0.96$

Housing, tension side: $k = 0.93$

Housing, compression side: $k = 0.89$

A 900 Considerations not included in DNV's approach

The above approach to special transport condition support for the jib covers the safety of the crane in transport condition and contributes to the overall fatigue damage of the crane. Some typical items that are not covered are:

- Increased abrasion on part of the crane system. The hydraulic luffing cylinders are a typical example of parts that may be exposed to increased abrasion. As part of a normal ship crane, the hydraulic cylinders are exposed to $2 \cdot 10^5$ load cycles in the crane's working condition. As the hydraulic cylinders are part of the system supporting the jib in transport condition, they are exposed to additionally 10^8 load cycles due to ship movement. Even if the loading in transport condition is smaller than those in working condition, the transport condition may, due to the large amount of cycles (500 times more cycles than that for working condition) be of significance when considering the expected life duration of the cylinders.
- The design check of a crane does not cover investigations whether the crane interferes with other equipment onboard the ship. For example, if the jib points along the ships longitudinal axis, the transverse displacement of the jib tip in a storm may be significant. The ship buyer/owner should, when ordering cranes, ensure (or ask the crane manufacturer to assure him) that the cranes do not interfere with each other or other equipment, not only for working condition, but also for transport condition.

Calculation of natural-frequencies and Eigenmodes is normally not covered. The natural period of the jib is quite different when the jib rests in a cradle compared to when it is supported by hoisting wire and luffing cylinders. If, for instance, the ship movement has the same period as a natural period for the jib, quite a dynamic amplification of the displacements in the jib may occur. Additional securing systems for the jib may be required if the in-service experience of the crane shows that large vibrations may occur under transport condition.

Guidance note:

Most S-N curves for air environment are presented as two-slope S-N curves. The presented closed form fatigue equation will, for the present purpose, give a reasonable estimate while used together with the part of the S-N curve that is to the left of 10^7 cycles.

Alternatively, the damage may be calculated by a more direct integration of fatigue damage using the actual S-N curves.

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APPENDIX D

EXAMPLES ON BASIS FOR ACCEPTANCE OF WORKS PRODUCT CERTIFICATES

A. Winches for Shipboard Cranes

A 100 Designed in accordance with this Certification Standard or other applicable, recognised standard

101 The following shall be confirmed:

General

- name of manufacturer
- type designation
- serial number
- marking
- type of marking (e.g. chiselled, painted or on attached plate) and place on the component on which the mark is attached

Testing

- date and place of functional testing
- special observations made or remarks to be made to the functional testing

General design

- design standards applied including information on Crane Appliance Group* or equivalent (*used for fatigue calculations in accordance with the FEM Standard)
- structural standard applied in combination with the design standard
- material types used in all primary load-carrying parts
- maximum static and dynamic pull and torque accounted for in the design
- wire diameter(s) considered in the design
- if available, breaking strength of the most heavily loaded steel wire rope allowed attached to the winch (for design capacity of attachment to foundation) to be specified
- if available, type and dimension of holding-down bolts to be specified

Brake design

- type and description of braking systems and brake(s)
- confirmation that the following requirements are complied with (or comments), see Ch.2 Sec.3 B301-B306 (to be separately confirmed for each item)
- maximum torque on brake caused by load regarded as static load by automatic braking (see Ch.2 Sec.3 B305)
- maximum torque which can be exerted by the brake by automatic braking (see Ch.2 Sec.3 B305)
- maximum coefficient of friction applied in the braking calculation for automatic braking (see Ch.2 Sec.3 B305)

102 The following drawings and documents shall be attached:

- arrangement and sectional drawings including material denotations

103 Signatures and qualifications:

- date and place of issuance of documentation
- name in printed letters and signature of person responsible for the certification (preferably a person related to quality assurance work and who is in a unit unrelated to production)

104 Components of the winches delivered by sub-vendors (e.g. brakes or gears) shall be documented as for the winch.

B. Transmission gears

B 100 Designed in accordance with this Certification Standard or other recognised standard

101 The following shall be confirmed:

General

- name of manufacturer
- type designation
- serial number
- marking
- type of marking (e.g. chiselled, painted or on attached plate) and place on the component on which the mark is attached

Testing

- date and place of functional testing
- special observations made or remarks to be made to the functional testing

General design

- applied standard

102 The following drawings and documents shall be attached:

- sectional drawings
- calculations documenting necessary and available torque capacity

103 Signatures and qualifications:

- date and place of issuance of documentation
- name in printed letters and signature of person responsible for the certification (preferably a person related to quality assurance work and who is in a unit unrelated to production)

C. Hydraulic cylinders exempted from DNV certification

C 100 Conditions for use

101 May be used provided the following two conditions are met:

- for *shipboard cranes* not to be covered by class (CRANE, Crane Vessel, Crane Barge or CRANE(N)) and with load-carrying capacity not exceeding 20 tonnes
- the cylinder is subject to serial production

102 The following shall be confirmed:

General

- name of manufacturer
- type designation
- serial number
- marking
- type of marking (e.g. chiselled, painted or on attached plate) and place on the component on which the mark is attached.

Agreement for exception

- date of application for exception
- the following submitted as attachments to the application:
 - One copy of documentation on the cylinder, including all main dimensions and material specifications (yes or no)
 - Suggested extent of NDT and pressure testing procedure (yes or no)
- date when the extent of NDT and pressure testing was agreed
- DNV unit that agreed on extent of NDT and pressure testing
- date when the exception was granted
- DNV unit that granted the exception

Testing

- date and place of pressure testing

- special observations made or remarks to be made to the pressure testing
- date of acceptance of NDT

General design

- design standard applied
- structural standard applied in combination with the design standard (in cases where the design standard does not state acceptable structural design utilization)
- material used in all primary load-carrying parts
- dynamic design load
- design pressure
- design temperature
- the cylinder is accepted for pushing only (yes or no)
- the cylinder is certified for use in lifting appliances only (yes or no)

103 Signatures and qualification:

- date and place of issuance of documentation
- name in printed letters and signature of person responsible for the certification (preferably a person related to quality assurance work and who is in a unit unrelated to production)

APPENDIX E EXAMINATION OF PAD EYES AND SKIDS

A. Purpose

A 100 Questions related to specific lifting appliances and fundamentals

101 This Appendix aims to present clarifications to some frequently addressed questions related to a few specific lifting appliances and fundamentals.

A 200 Pad eyes (lifting lugs)

201 For pad eyes (lifting lugs) and their supporting structures, DNV is prepared to carry out verification, based on the procedures below:

- design approval of the bracket and its fixation to its support
- manufacturing survey including examination of material certificates and NDT
- monitoring of load testing (if agreed)
- check of marking.

202 The design of pad eyes is preferably to be based on an applicable recognised standard for pad eyes.

Design drawings shall be submitted for examination. Unless the details comply completely with a standard referred to, structural strength calculations shall be submitted for DNV's design examination.

203 Although not subject to certification, DNV will base possible necessary design examination on the structural requirement of this Certification Standard. The customer may, however, choose another applicable structural strength standard as basis.

204 The verification will be documented with reports. Certificates will normally not be issued.

205 Norwegian Maritime Directorate has introduced requirements for certificates (NIS/NOR Circular no.1/2006), DNV has decided to offer issuance of certificates upon specific request related to this circular.

Guidance note:

Often a number of such pad eyes exist on a ship. When standardized pad eyes are used, testing of different sizes may be accepted to follow the guide as outlined at the end of this Appendix, provided in agreement with flag state requirements.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

A 300 Skids

301 Both skids designed for transport of different varying loads as well as skids designed for a specific load may be certified by DNV. For special offshore services one should consider whether certification as *offshore portable unit* might be an alternative to certification as loose gear. Reference is made to DNV's Certification Note. 2.7-3 "Portble Offshore Units".

302 If *certification* as loose gear is requested, the skid will, in principle, be certified in accordance with the ILO Convention. By DNV this implies that this Certification Standard will form the basis for certification. The certification work will be documented by DNV's certificate CG3.

303 The certification work will include the same four steps as listed in 201. The load test will be mandatory in the case of certification.

304 Any limiting design conditions for the operation of the skid shall be defined and annotated on the CG3 and will normally also be required to be included in the marking. This may, in addition to the SWL, include such details as limitations for the centre of gravity of the load and angles of the lifting slings that may be attached.

305 DNV receives requests to certify separately only the pad eyes on the top corner of the skids where the lifting slings are connected.

This is not considered feasible. Certification of skids must include the complete structure.

It is possible, however, to request a separate verification limited only to the pad eyes, in line with the principles for *verification* as stated in 200.

306 DNV is frequently requested to certify skids designed for one specific load, sometimes for one specific transport operation only – and sometimes for a skid on which the load (piece of equipment, motor, etc.) shall be permanently installed. Such commissions are accepted according to the procedures set out above. In most such cases, however, verification of the design will suffice.

307 For *offshore lifting operations* it is advisable (care shall be taken) to ascertain that the load stipulations include necessary reserves for dynamic amplifications that follow from lifting in waves. The same applies in cases of general certification for issuing of CG3, as well as for verification.

Reference is made to Ch.2 Sec.3 B804.

For verification assignment of a one-off operation it might be possible to specify the exact necessary dynamic amplification factor. Where, for example, the deck crane to be used is known it will be possible to retrieve the dynamic amplification from the crane's dynamic derating table. Such tables are required for all deck cranes for offshore operations certified by classification societies. Derating tables are also required by most shelf legislators and maritime authorities.

A 400 Testing of pad eyes (lifting lugs)

401

Guidance note:

- 1) Pad eyes with SWL equal or less than 1 tonne:
 - a) Visual inspection by a DNV surveyor (support and welding).
 - b) Surveyor's on-the-spot evaluation of pad eyes scantling if not a standard type.
 - c) Marking of individual pad eyes by SWL or group marking (i.e. common signboard in each room/space with several identical pad eyes. In case of pad eyes with different SWL in the same room/space individual marking or for instance a colour distinguishing system for the pad eyes shall be applied).
 - d) Description of location, SWL and loading directing shall be included in the operations manual.
- 2) Pad eyes with SWL above 1 tonne and less or equal to 3 tonnes as for item 1 a), c) and d):
Drawing approval locally, and
 - load test + spot NDT, alternatively
 - spot load test + 100% NDT

If spot load-test is chosen, it will be decided after visual inspection which pad eyes shall be load tested.
- 3) Pad eyes with SWL above 3 tonnes as for item 1 a) and d):
 - drawing approval by DNV, local approval centre
 - load test
 - NDT extent to be included in the NDT programme
 - individual marking

Load factor for pad eyes (lifting lugs):

Pad eyes (lifting lugs) are to be designed with a load factor relative to the SWL in question:

<i>Safe Working Load</i>	<i>Load Factor</i>
Up to 3 tonnes	2.0
3 – 20 tonnes	1.75
Above 20 tonnes	1.5

Load testing of pad eyes (lifting lugs):

Where load testing of pad eyes (lifting lugs) are required the testing shall be carried out according to the following:

<i>Safe Working Load</i>	<i>Test Load</i>
Up to 20 tonnes	$1.25 \times \text{SWL}$
20 – 50 tonnes	5 tonnes + SWL
Above 50 tonnes	$1.10 \times \text{SWL}$

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

APPENDIX F REGISTER AND CERTIFICATE FORMS

A. List Forms

A 100 General

101 The sample forms shown in this Appendix are those current at the time of publishing. Latest version of these forms should be used.

A 200 Relevant forms


201 The following forms are relevant:

Form No.	Title
CG1	Register of Lifting Appliances and Cargo handling Gear
CG2	Certificate of Test and Thorough Examination of Lifting Appliances
CG3	Certificate of Test and Thorough Examination of Loose Gear
CG4	Certificate of Test and Thorough Examination of Wire Rope

B. Sample Copies

CG 1: Register of Lifting Appliances and Cargo handling Gear

(Front page of booklet)

	DET NORSKE VERITAS	Register No. _____
		Construction to which this register relates: _____
		Name of Ship (Platform, Rig etc.) _____
		Call Sign _____ Id No. _____
		Port of Registry _____
		Name of Owner _____
REGISTER OF LIFTING APPLIANCES AND CARGO HANDLING GEAR		
Note: This Register is the standard international form as recommended by the International Labour Office in accordance with ILO Convention No. 152		Date of Issue _____
DET NORSKE VERITAS AS, VERITASVEIEN 1, N-1322 HØVIK, NORWAY, TEL. INT: +47 67 57 99 00, TELEFAX: +47 67 57 99 11 Form No.: CG.1 Issue: April 98		Issued by _____
		Signature and Stamp _____
		Page 1 of 16

CG2: Certificate of Test and Thorough Examination of Lifting Appliances



DET NORSKE VERITAS

Certificate No.

CERTIFICATE OF TEST AND THOROUGH EXAMINATION OF LIFTING APPLIANCES (CG2)

Location (Name of Ship, Platform etc.)		Call sign	
		Dnv ID. No	
Owners		Port of Registry	
(1) Situation and description of lifting appliances (with distinguishing numbers or marks, if any) which have been tested and thoroughly examined	(2) Angle to the horizontal or radius at which test load is applied	(3) Test load tonnes	(4) Safe working load (SWL) at angle or radius shown in column 2 (tonnes)
<div style="transform: rotate(-30deg); opacity: 0.3; font-size: 100px; pointer-events: none;">SAMPLE</div>			
Reason for issuing the certificate: <input type="checkbox"/> Initial certification <input type="checkbox"/> Recertification <input type="checkbox"/> Repair <input type="checkbox"/> Other, (give reason):			
DNV station employing the competent person:			
I certify that on the date to which I have appended my signature, the gear shown in column (1) was tested and thoroughly examined and no defects or permanent deformation were found; and that the safe working load is as shown. Place: <u>Høvik, Norway</u> Signature: _____ <div style="text-align: right;">(Name) Surveyor</div> Date: _____ Note: This Certificate is based on the standard international form as recommended by the International Labour Office in accordance with ILO Convention No. 152. <input type="checkbox"/> Tick off here if an appendix is issued			
<small>If any person suffers loss or damage which is proved to have been caused by any negligent act or omission of Det Norske Veritas, then Det Norske Veritas shall pay compensation to such person for his proved direct loss or damage. However, the compensation shall not exceed an amount equal to ten times the fee charged for the service in question, provided that the maximum compensation shall never exceed USD 2 million. In this provision "Det Norske Veritas" shall mean the Foundation Det Norske Veritas as well as all its subsidiaries, directors, officers, employees, agents and any other acting on behalf of Det Norske Veritas.</small>			

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Form No.: CG2 Issue: July 1999

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CG2: Certificate of Test and Thorough Examination of Lifting Appliances (page 2)

INSTRUCTIONS

1. Every lifting appliance shall be tested with a test load which shall exceed the safe working load (SWL) as follows:

SWL	Test Load
Up to 20 tonnes	25 per cent in excess
20 to 50 tonnes	5 tonnes in excess
over 50 tonnes	10 per cent in excess

2. In the case of derrick systems the test load shall be lifted with the ship's normal tackle with the derrick at the minimum angle to the horizontal for which the derrick system was designed (generally 15 degrees), or at such greater angle as may be agreed. The angle at which the test was made should be stated in the certificate of test. After the test load has been lifted it should be swung as far as possible in both directions.

2.1. The SWL shown is applicable to swinging derrick systems only. When derricks are used in union purchase the SWL(U) is to be as shown on Form No. CG.2U.

2.2. In the case of heavy derricks, care should be taken that the appropriate stays are correctly rigged.

3. In the case of cranes, the test load is to be hoisted, slewed and luffed at slow speed. Gantry and travelling cranes together with their trolleys, where appropriate, are to be traversed and travelled over the full length of their track.

3.1. In the case of variable load-radius cranes, the tests are generally to be carried out with the appropriate test load at maximum, minimum and at an intermediate radius.

3.2. In the case of hydraulic cranes where limitations of pressure make it impossible to lift a test load 25 per cent in excess of the safe working load, it will be sufficient to lift the greatest possible load, but in general this should not be less than 10 per cent in excess of the safe working load.

4. As a general rule, tests should be carried out using test loads, and no exceptions should be allowed in the case of initial tests. In the case of repairs, replacement or when the periodic examination calls for re-test, consideration may be given to the use of spring or hydraulic balances provided the SWL of the lifting appliance does not exceed 15 tonnes. Where a spring or hydraulic balance is used, it shall be calibrated and accurate to within 2 per cent and the indicator should remain constant for five minutes.

4.1. If test weights are not used this is to be indicated in column (3).

5. The expression 'tonne' shall mean a tonne of 1000 kg.

6. The terms 'competent person', 'thorough examination' and 'lifting appliance' are defined in Form No.CG.1.

Note: For recommendations on test procedures, reference may be made to the ILO document 'Safety and Health in Dock Work'.

CG3: Certificate of Test and Thorough Examination of Loose Gear



DET NORSKE VERITAS CERTIFICATE OF TEST AND THOROUGH EXAMINATION OF LOOSE GEAR (CG3)

Certificate No.

Location (name of ship, platform etc.)			Call sign		
			DNV ID. No.		
Owners		Port of registry			
(1) Distinguish number or mark	(2) Description of gear (the dimension of the gear, the type of material of which it is made, and where applicable, the heat treatment received in manufacture should be stated)	(3) Number tested	(4) Date of test	(5) Test load applied (tonnes)	(6) Safe working load (SWL) (tonnes)
Name and address of makers or suppliers:					
Reason for issuing the certificate: <input type="checkbox"/> Initial certification <input type="checkbox"/> Recertification <input type="checkbox"/> Repair					
<input type="checkbox"/> Other, (give reason:					
DNV station employing the competent person:					
I certify that the above items of loose gear were tested and thoroughly examined and no defects affecting their SWL were found.					
Place: <u>Høvik, Norway</u>			Signature: (Name) Surveyor		
Date:					
Note: This Certificate is the standard international form as recommended by the International Labour Office in accordance with ILO Convention No. 152.					
<small>If any person suffers loss or damage which is proved to have been caused by any negligent act or omission of Det Norske Veritas, then Det Norske Veritas shall pay compensation to such person for his proved direct loss or damage. However, the compensation shall not exceed an amount equal to ten times the fee charged for the service in question, provided that the maximum compensation shall never exceed USD 2 million. In this provision "Det Norske Veritas" shall mean the Foundation Det Norske Veritas as well as all its subsidiaries, directors, officers, employees, agents and any other acting on behalf of Det Norske Veritas.</small>					

CG3: Certificate of Test and Thorough Examination of Loose Gear (page 2)

INSTRUCTIONS	Certificate No.												
<p>1. Every item of loose gear is to be tested and thoroughly examined before being put into use for the first time and after any substantial alteration or repair to any part liable to affect its safety. The test loads to be applied shall be in accordance with the following table:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 60%;">Item</th> <th style="width: 40%;">Test load (tonnes)</th> </tr> </thead> <tbody> <tr> <td>Single sheave blocks (see Note 1)</td> <td>$4 \times \text{SWL}$</td> </tr> <tr> <td>Multi sheave blocks (see Note 2): SWL \leq 25 tonnes 25 tonnes < SWL \leq 160 tonnes SWL > 160 tonnes</td> <td>$2 \times \text{SWL}$ $(0.933 \times \text{SWL}) + 27$ $1.1 \times \text{SWL}$</td> </tr> <tr> <td>Chains, hooks, rings, shackles, swivels etc.: SWL \leq 25 tonnes SWL > 25 tonnes</td> <td>$2 \times \text{SWL}$ $(1.22 \times \text{SWL}) + 20$</td> </tr> <tr> <td>Lifting beams, spreaders, frames, and similar devices: SWL \leq 10 tonnes 10 tonnes < SWL \leq 160 tonnes SWL > 160 tonnes</td> <td>$2 \times \text{SWL}$ $(1.04 \times \text{SWL}) + 9.6$ $1.1 \times \text{SWL}$</td> </tr> <tr> <td colspan="2"> <p>1. The SWL for a single sheave block, including single sheave blocks with becketts, is to be taken as one half of the resultant load on the head fitting.</p> <p>2. The SWL of a multi sheave block is to be taken as the resultant load on the head fitting.</p> </td> </tr> </tbody> </table>		Item	Test load (tonnes)	Single sheave blocks (see Note 1)	$4 \times \text{SWL}$	Multi sheave blocks (see Note 2): SWL \leq 25 tonnes 25 tonnes < SWL \leq 160 tonnes SWL > 160 tonnes	$2 \times \text{SWL}$ $(0.933 \times \text{SWL}) + 27$ $1.1 \times \text{SWL}$	Chains, hooks, rings, shackles, swivels etc.: SWL \leq 25 tonnes SWL > 25 tonnes	$2 \times \text{SWL}$ $(1.22 \times \text{SWL}) + 20$	Lifting beams, spreaders, frames, and similar devices: SWL \leq 10 tonnes 10 tonnes < SWL \leq 160 tonnes SWL > 160 tonnes	$2 \times \text{SWL}$ $(1.04 \times \text{SWL}) + 9.6$ $1.1 \times \text{SWL}$	<p>1. The SWL for a single sheave block, including single sheave blocks with becketts, is to be taken as one half of the resultant load on the head fitting.</p> <p>2. The SWL of a multi sheave block is to be taken as the resultant load on the head fitting.</p>	
Item	Test load (tonnes)												
Single sheave blocks (see Note 1)	$4 \times \text{SWL}$												
Multi sheave blocks (see Note 2): SWL \leq 25 tonnes 25 tonnes < SWL \leq 160 tonnes SWL > 160 tonnes	$2 \times \text{SWL}$ $(0.933 \times \text{SWL}) + 27$ $1.1 \times \text{SWL}$												
Chains, hooks, rings, shackles, swivels etc.: SWL \leq 25 tonnes SWL > 25 tonnes	$2 \times \text{SWL}$ $(1.22 \times \text{SWL}) + 20$												
Lifting beams, spreaders, frames, and similar devices: SWL \leq 10 tonnes 10 tonnes < SWL \leq 160 tonnes SWL > 160 tonnes	$2 \times \text{SWL}$ $(1.04 \times \text{SWL}) + 9.6$ $1.1 \times \text{SWL}$												
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<p>2. This form may also be used for the certification of interchangeable components of lifting appliances.</p>													
<p>3. The expression 'tonne' shall mean a tonne of 1000 kg.</p>													
<p>4. The terms 'competent person', 'thorough examination' and 'lifting appliance' are defined in Form No.CG.1.</p>													
<p>Note: For recommendations on test procedures, reference may be made to the ILO document 'Safety and Health in Dock Work'.</p>													

CG4: Certificate of Test and Thorough Examination of Wire Rope



DET NORSKE VERITAS CERTIFICATE OF TEST AND THOROUGH EXAMINATION OF WIRE ROPE CG4

Certificate No.

Location (name of ship, platform etc.)		Call sign
		DNV ID. No.
Owners	Port of registry	
Name and address of makers or suppliers		
Nominal diameter of rope (mm)	Number of strands	Number of wires per strand
Core	Lay	Quality of wire (N/mm ²)
Date of test of sample		
Load at which sample broke (tonnes)	Safe working load of rope (tonnes)	
Intended use		
Remarks		
<p style="text-align: center; font-size: 4em; opacity: 0.3; transform: rotate(-30deg);">SAMPLE</p>		
DNV station employing the competent person:		
<p>I certify that the above particulars are correct, and that the rope was tested and examined and no defects affecting its SWL were found.</p> <p>Place: <u>Høvik, Norway</u> Signature:</p> <p style="text-align: right;">(Name) Surveyor</p> <p>Date:</p> <p>Note: This Certificate is the standard international form as recommended by the International Labour Office in accordance with ILO Convention No. 152.</p> <p><small>If any person suffers loss or damage which is proved to have been caused by any negligent act or omission of Det Norske Veritas, then Det Norske Veritas shall pay compensation to such person for his proved direct loss or damage. However, the compensation shall not exceed an amount equal to ten times the fee charged for the service in question, provided that the maximum compensation shall never exceed USD 2 million. In this provision "Det Norske Veritas" shall mean the Foundation Det Norske Veritas as well as all its subsidiaries, directors, officers, employees, agents and any other acting on behalf of Det Norske Veritas.</small></p>		

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Form No.: CG4 Issue: October 2000

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CG4: Certificate of Test and Thorough Examination of Wire Rope (page 2)

INSTRUCTIONS																					
1.	Wire rope shall be tested by sample, a piece being tested to destruction.																				
2.	The test procedure should be in accordance with an international or recognized national standard.																				
3.	The SWL of the rope is to be determined by dividing the load at which the sample broke, by a coefficient of utilisation, determined as follows:																				
<table border="1"> <thead> <tr> <th>Item</th> <th>Coefficient</th> </tr> </thead> <tbody> <tr> <td>Wire rope forming part of a sling:</td> <td></td> </tr> <tr> <td>SWL of the sling</td> <td></td> </tr> <tr> <td>SWL ≤ 10 tonnes</td> <td>5</td> </tr> <tr> <td>10 tonnes < SWL ≤ 160 tonnes</td> <td>$\frac{10^4}{(8.85 \times \text{SWL}) + 1910}$</td> </tr> <tr> <td>SWL > 160 tonnes</td> <td>3</td> </tr> <tr> <td>Wire rope as integral part of a lifting appliance:</td> <td></td> </tr> <tr> <td>SWL of the lifting appliance</td> <td></td> </tr> <tr> <td>SWL ≤ 160 tonnes</td> <td>$\frac{10^4}{(8.85 \times \text{SWL}) + 1910}$</td> </tr> <tr> <td>SWL > 160 tonnes</td> <td>3</td> </tr> </tbody> </table>		Item	Coefficient	Wire rope forming part of a sling:		SWL of the sling		SWL ≤ 10 tonnes	5	10 tonnes < SWL ≤ 160 tonnes	$\frac{10^4}{(8.85 \times \text{SWL}) + 1910}$	SWL > 160 tonnes	3	Wire rope as integral part of a lifting appliance:		SWL of the lifting appliance		SWL ≤ 160 tonnes	$\frac{10^4}{(8.85 \times \text{SWL}) + 1910}$	SWL > 160 tonnes	3
Item	Coefficient																				
Wire rope forming part of a sling:																					
SWL of the sling																					
SWL ≤ 10 tonnes	5																				
10 tonnes < SWL ≤ 160 tonnes	$\frac{10^4}{(8.85 \times \text{SWL}) + 1910}$																				
SWL > 160 tonnes	3																				
Wire rope as integral part of a lifting appliance:																					
SWL of the lifting appliance																					
SWL ≤ 160 tonnes	$\frac{10^4}{(8.85 \times \text{SWL}) + 1910}$																				
SWL > 160 tonnes	3																				
These coefficients should be adopted unless other requirements are specified by a national authority.																					
4.	The expression 'tonne' shall mean a tonne of 1000 kg.																				
5.	The terms 'competent person', 'thorough examination' and 'lifting appliance' are defined in Form No.CG.1.																				
Note:	For recommendations on test procedures, reference may be made to the ILO document 'Safety and Health in Dock Work'.																				

APPENDIX G

VERIFICATION GUIDELINE FOR SAFETY FUNCTIONS

A. Application, Scope and Objective

A 100 Application

This guideline provides a recommended and simplified method for *1. part verification* (see definition in 200) of safety functions and equipment for lifting appliances subject to design verification in accordance with the requirements as presented in this Certification Standard, see Ch.2 Sec.6 D200.

If so preferred, Customer may use other verification methods.

Successful verification will serve as a condition for issuance of DNV's CG2 "Certificate of Test and Thorough Examination of Lifting Appliances".

The guideline is intended, primarily, for designers, manufacturers, yards, operators, and owners applying for DNV certification of lifting appliances in accordance with the above requirements.

A 200 Verification

1. Part verification is the supplier's responsibility.

The definition of verification: *Confirmation by examination and provision of objective evidence that the requirements have been fulfilled (ISO 8402, IEC 61508-4, 3.8.1.).*

A 300 Scope

This guideline provides an introduction to the recommended verification method and corresponding documentation requirements.

The basis for this guideline is the requirements to safety functions as specified in this Certification Standard (Ch.2 Sec.6 D200), based on the IMO-FSA method for development of risk-based rules.

The intention of this guideline is to provide an introduction and specification of:

- the safety function verification method
- the verification sheet templates
- the basic documentation requirements

A 400 Objective

The objective of this guideline is to provide a practical and adequate method for verification of safety functions and equipment as well as to provide the corresponding documentation requirements for lifting appliances in accordance with the DNV requirements.

B. Verification Procedure

B 100 General

Ch.2 Sec.6 D204 – D219 requires a set of generic risk reduction measures (safety functions) as follows:

- overload limiting device (Ch.2 Sec.6 D204.a)
- Manual Overload Protection System MOPS (Ch.2 Sec.6 D204.b)
- Automatic Overload Protection System AOPS (Ch.2 Sec.6 D204.c)
- operational limit protection, general (Ch.2 Sec.6 D205.a)
- operational limit protection, boom up (Ch.2 Sec.6 D205.b)
- constant tension system (optional) (Ch.2 Sec.6 D206.a)
- reduced boom lifting/slewing speed (Ch.2 Sec.6 D206.b)
- audible alarm (Ch.2 Sec.6 D206.c)
- emergency stop function (Ch.2 Sec.6 D207)
- boom tip camera (Ch.2 Sec.6 D208)
- communication equipment (Ch.2 Sec.6 D209)
- slack wire rope detection (Ch.2 Sec.6 D210)
- failure in control systems, protection and precautions (Ch.2 Sec.6 D211)
- failure in the safety systems, precautions (Ch.2 Sec.6 D212)
- maintenance of braking capacity (Ch.2 Sec.6 D213)
- maintenance of holding capacity (Ch.2 Sec.6 D214)
- blackout/shutdown, precautions (Ch.2 Sec.6 D215.a)
- blackout/shutdown, emergency operation (Ch.2 Sec.6 D215.b)
- unintended activation of safety functions, protection (Ch.2 Sec.6 D216)

- spurious trip of safety functions, precautions (Ch.2 Sec.6 D217)
- hazards due to activation of safety functions, precautions (Ch.2 Sec.6 D218)
- gas alarm (Ch.2 Sec.6 D219.a)
- gas alarm, shut-down (Ch.2 Sec.6 D219.b).

Above safety functions are required for reducing the assumed generic risk.

In this guideline, most of the above safety functions are represented by a *verification form* stating a subset of the main functional and technical requirements.

The verification process obliges the Customer to fill in (or tick off, whatever is appropriate) the verification papers and send them in completed order to DNV together with corresponding documents verifying that the requirements have been complied with. Requirements for documentation are specified in C at the end of this Appendix.

However, some of the more detailed functional and technical requirements to the safety functions, as specified in Ch.2 Sec.6 D204 - D219, are not included in the verification forms. It is assumed that fulfilment of these requirements also is properly documented.

As a part of the verification of compliance with the Standard, it shall be confirmed that the maximum consequence of the stated hazard/risk contributor is *one fatality* (ref. Ch.2 Sec.6 D202), with the exception of the hazard “Fire, fire ignition” (Ch.2 Sec.6 D219).

In case the maximum consequence exceeds one fatality, this shall appear from the filled-in verification papers. The basis for the generic requirements to the safety functions is thereby not fulfilled, and the requirements to the safety functions will be subjected to deviation handling.

Further, also for other cases of deviation from the generic risk/risk contributors as specified by Ch.2 Sec.6 D202, and/or from the generic safety functions as specified in Ch.2 Sec.6 D204 – D219, this shall appear from the verification papers and lead to deviation handling of the requirements to the safety functions.

In such cases, the customer shall document in detail the actual safety functions with respect to functional and technical specifications. The actual solution will be subjected to a risk based assessment where the specific requirements to the safety functions will be developed and agreed with the customer.

Generally, there are no requirements to establish detailed information for verifying target reliability by means of PFD or MTTF values.

A complete verification of target reliability may be applied, if preferred by the Customer, and may be based on methods described in different standards. Examples on applicable standards are IEC 61508 (SIL), IEC 62061 (SIL), ISO 13849 (PL).

B 200 Explanation of the verification templates elements

<i>Text in verification sheet</i>	<i>Explanation of element</i>
Hazard and risk	The generic hazard and initial risk briefly explained in a text.
Type of safety function	Textual name of safety function.
Safe state	Specification of the assumed safe state.
Energy principle (NE,NDE, CE)	Energy principle for normal operation (not activated). NE means “Normally Energised”, NDE means “Normally De-Energised” and CE means “Continuous Energised”.
On demand/continuous	On demand means that the safety function shall be activated when a given demand or state occurs. In this case the safety function shall establish the safe state as described above. Continuous means that the function is assumed to be working during normal operation of the facility.
Automatic/manual activation	Automatic activation means that the safety function shall be triggered by the safety system without manual operator intervention. Manual activation means that operator shall trigger the activation by means of button or joystick
Response time	Maximum time from system has been triggered to safe state is achieved.
Test procedure	Name and reference to periodic test procedure. Test procedure should at least include how the test should be carried out and the success criterion for the test.
Test interval	Length of test interval between tests.
Detector 1	Reference to the detector or activation unit for triggering the safety function.
Detector 2	Reference to the redundant or secondary means for triggering the safety function.
Actuator 1	Reference to actuating device (valve, brake, etc.) for establishing the safe state. The safe state of the actuator shall be given.
Actuator 2	Reference to redundant or secondary means for establishing the safe state. The safe state of the actuator should be given.
Monitoring of safety function	Specifies how the safety function, when active, is monitored - by means of indication and/or alarm. Ref. also Ch.2 Sec.6 Table D1.
Independency to other functions	Reference to other specific functions that shall not be impaired by the safety function.

B 300 Verification sheet templates

301 Automatic overload shut-down device (Ch.2 Sec.6 D204.a)

<i>Hazard and risk</i>	Overloading			
<i>Type of safety function</i>	Overload limiting device			
<i>Safe state</i>	Boom luffing out movement stop			
<i>Main items</i>	<i>Requirement/ Specification</i>	<i>Customer's verification of compliance with the requirements ("tick-off"), or reference to other solution</i>	<i>Customer's document reference to objective evidence verifying compliance</i>	<i>DNV check</i>
<i>Energy principle (NE, NDE, CE)</i>	CE (monitoring)			
<i>On demand/continuous</i>	On demand			
<i>Automatic/manual activation</i>	Automatic			
<i>Response time</i>	Immediately			
<i>Test procedure</i>	Designer's specification			
<i>Test interval</i>	12 months			
<i>Detector 1</i>	Load cell or similar			
<i>Detector 2</i>	NA			
<i>Actuator 1</i>	Boom luffing out stop			
<i>Actuator 2</i>	NA			
<i>Monitoring of safety function</i>	Indication and alarm			
<i>Independency to other functions</i>	Shall not prevent lowering the load and boom luffing in safe direction			

302 Manual overload protection MOPS (Ch.2 Sec.6 D204.b)

<i>Hazard and risk</i>	Overloading			
<i>Type of safety function</i>	Manual overload protection MOPS			
<i>Safe state</i>	Load paid out / released or clutched out. Holding force of 10–25% of internal lift			
<i>Main items</i>	<i>Requirement/ Specification</i>	<i>Customer's verification of compliance with the requirements ("tick-off"), or reference to other solution</i>	<i>Customer's document reference to objective evidence verifying compliance</i>	<i>DNV check</i>
<i>Energy principle (NE,NDE, CE)</i>	CE (monitoring)			
<i>On demand/continuous</i>	On demand			
<i>Automatic/manual activation</i>	Manual			
<i>Response time</i>	Immediately			
<i>Test procedure</i>	Designer's specification			
<i>Test interval</i>	12 months			
<i>Detector 1</i>	Operator switch/handle			
<i>Detector 2</i>	NA			
<i>Actuator 1</i>	Designer's specification			
<i>Actuator 2</i>	NA			
<i>Monitoring of safety function</i>	Indication and alarm			
<i>Interdependency to other functions</i>	NA			

303 Automatic overload protection system AOPS (Ch.2 Sec.6 D204.c)

<i>Hazard and risk</i>	Overloading			
<i>Type of safety function</i>	Automatic overload protection system AOPS			
<i>Safe state</i>	Load paid out/released or clutched out, holding force of internal lift capacity. Boom luffing out movement stopped			
<i>Main item</i>	<i>Requirement/ Specification</i>	<i>Customer's verification of compliance with the requirements ("tick-off"), or reference to other solution</i>	<i>Customer's document reference to objective evidence verifying compliance</i>	<i>DNV check</i>
<i>Energy principle (NE, NDE, CE)</i>	CE (monitoring)			
<i>On demand/continuous</i>	On demand			
<i>Automatic/manual activation</i>	Automatic			
<i>Response time</i>	Immediately			
<i>Test procedure</i>	Designer's specification			
<i>Test interval</i>	12 months			
<i>Detector 1</i>	Load cell or similar			
<i>Detector 2</i>	Not applicable (NA)			
<i>Actuator 1</i>	Designer's specification			
<i>Actuator 2</i>	Boom luffing out stop			
<i>Monitoring of safety function</i>	Indication and alarm			
<i>Interdependency to other functions</i>	Shall not prevent boom luffing in safe direction			

304 Operational limit protection, general (Ch.2 Sec.6 D205.a)

<i>Hazard and risk</i>	Crane movements outside operational limits			
<i>Name of safety function</i>	Operational limit protection, general			
<i>Safe state</i>	Stop of movements outside given limitations			
<i>Main item</i>	<i>Requirement/ Specification</i>	<i>Customer's verification of compliance with the requirements ("tick-off"), or reference to other solution</i>	<i>Customer's document reference to objective evidence verifying compliance</i>	<i>DNV check</i>
<i>Energy principle (NE,NDE, CE)</i>	NE			
<i>On demand/continuous</i>	On demand			
<i>Automatic/manual activation</i>	Automatic			
<i>Response time</i>	Immediately			
<i>Test procedure</i>	Manual test procedure			
<i>Test interval</i>	12 months/Daily			
<i>Detector 1</i>	Limit switch, physical barrier			
<i>Detector 2 (required)</i>	NA			
<i>Actuator 1</i>	Stop movement			
<i>Actuator 2</i>	NA			
<i>Monitoring of safety function</i>	Indication			
<i>Interdependency to other functions</i>	Shall not prevent movement in safe direction			

305 Operational limit protection, boom up (Ch.2 Sec.6 D205.b)

<i>Hazard and risk</i>	Boom up movement outside limits (wire luffing cranes)			
<i>Name of safety function</i>	Operational limit protection, boom up			
<i>Safe state</i>	Stop of boom movement			
<i>Main item</i>	<i>Requirement/ Specification</i>	<i>Customer's verification of compliance with the requirements ("tick-off"), or reference to other solution</i>	<i>Customer's document reference to objective evidence verifying compliance</i>	<i>DNV check</i>
<i>Energy principle (NE,NDE, CE)</i>	NE			
<i>On demand/continuous</i>	On demand			
<i>Automatic/manual activation</i>	Automatic			
<i>Response time</i>	Immediately			
<i>Test procedure</i>	Test to be carried out manually			
<i>Test interval</i>	6 months/Daily			
<i>Detector 1</i>	Limit switch			
<i>Detector 2 (required)</i>	Boom high high detection, fail safe detect			
<i>Actuator 1</i>	Boom up winch stop			
<i>Actuator 2</i>	NA			
<i>Monitoring of safety function</i>	Indication			
<i>Interdependency to other functions</i>	Shall not prevent movement in safe direction			

306 Constant tension system (Ch.2 Sec.6 D206.a)

<i>Hazard and risk</i>	Dangerous lifting gear/cargo movements			
<i>Name of safety function</i>	Constant tension system (optional)			
<i>Safe state</i>	Constant tension provided before lift off. Wire rope tension set to 1-3 tonnes			
<i>Main item</i>	<i>Requirement/Specification</i>	<i>Customer's verification of compliance with the requirements ("tick-off"), or reference to other solution</i>	<i>Customer's document reference to objective evidence verifying compliance</i>	<i>DNV check</i>
<i>Energy principle (NE,NDE, CE)</i>	NDE			
<i>On demand/continuous</i>	On demand			
<i>Automatic/manual activation</i>	Manual			
<i>Response time</i>	Immediately			
<i>Test procedure</i>	Test to be carried out manually			
<i>Test interval</i>	12 months/Daily			
<i>Detector 1</i>	Crane operator activation/button			
<i>Detector 2</i>	NA			
<i>Actuator 1</i>	Designer's specification			
<i>Actuator 2</i>	NA			
<i>Monitoring of safety function</i>	Indication			
<i>Interdependency to other functions</i>	NA			

307 Audible alarm (Ch.2 Sec.6 D206.c)

<i>Hazard and risk</i>	Dangerous lifting gear/cargo movements			
<i>Name of safety function</i>	Audible alarm			
<i>Safe state</i>	Alarm signal given			
<i>Main item</i>	<i>Requirement/Specification</i>	<i>Customer's verification of compliance with the requirements ("tick-off"), or reference to other solution</i>	<i>Customer's document reference to objective evidence verifying compliance</i>	<i>DNV check</i>
<i>Energy principle (NE,NDE, CE)</i>	NDE			
<i>On demand/continuous</i>	On demand			
<i>Automatic/manual activation</i>	Manual			
<i>Response time</i>	Immediately			
<i>Test procedure</i>	Test to be carried out manually			
<i>Test interval</i>	12 months/Daily			
<i>Detector 1</i>	Crane operator activation/button			
<i>Detector 2</i>	NA			
<i>Actuator 1</i>	Audible alarm/horn			
<i>Actuator 2</i>	NA			
<i>Monitoring of safety function</i>	Alarm			
<i>Interdependency to other functions</i>	NA			

308 Emergency stop function (Ch.2 Sec.6 D207)

<i>Hazard and risk</i>	Dangerous crane movements			
<i>Name of safety function</i>	Emergency stop function			
<i>Safe state</i>	Crane movements stopped			
<i>Main item</i>	<i>Requirement/ Specification</i>	<i>Customer's verification of compliance with the requirements ("tick-off"), or reference to other solution</i>	<i>Customer's document reference to objective evidence verifying compliance</i>	<i>DNV check</i>
<i>Energy principle (NE,NDE, CE)</i>	NE			
<i>On demand/continuous</i>	On demand			
<i>Automatic/manual activation</i>	Manual			
<i>Response time</i>	Immediately			
<i>Test procedure</i>	Test to be carried out manually			
<i>Test interval</i>	12 months			
<i>Detector 1</i>	Crane operator button			
<i>Detector 2</i>	Working personnel activation (button)			
<i>Actuator 1</i>	Removal of power or mechanical disconnection (declutching)			
<i>Actuator 2</i>	Application of brakes			
<i>Monitoring of safety function</i>	Indication and alarm			
<i>Independency to other functions</i>	NA			

309 Slack wire rope detection (Ch.2 Sec.6 D210)

<i>Hazard and risk</i>	Slack wire rope at drum			
<i>Name of safety function</i>	Slack wire rope detection			
<i>Safe state</i>	Stop winch motion and re-tighten of slack wire rope before automatically returning to normal operation.			
<i>Main item</i>	<i>Requirement/ Specification</i>	<i>Customer's verification of compliance with the requirements ("tick-off"), or reference to other solution</i>	<i>Customer's document reference to objective evidence verifying compliance</i>	<i>DNV check</i>
<i>Energy principle (NE,NDE, CE)</i>	NE			
<i>On demand/continuous</i>	On demand			
<i>Automatic/manual activation</i>	Automatic			
<i>Response time</i>	Immediately			
<i>Test procedure</i>	Test to be carried out manually			
<i>Test interval</i>	12 months			
<i>Detector 1</i>	Wire rope tension measuring device			
<i>Detector 2</i>	NA			
<i>Actuator 1</i>	Stop winch movement			
<i>Actuator 2</i>	Start winch movement			
<i>Monitoring of safety function</i>	Indication			
<i>Independency to other functions</i>	NA			

310 Failure in control systems, protection and precautions (Ch.2 Sec.6 D211)

<i>Hazard and risk</i>	Failure in control system			
<i>Name of safety function</i>	Failure in control systems, protection and precautions			
<i>Safe state</i>	Auto stop and automatic application of brakes and alarm signal to operator.			
<i>Main item</i>	<i>Requirement/ Specification</i>	<i>Customer's verification of compliance with the requirements ("tick-off"), or reference to other solution</i>	<i>Customer's document reference to objective evidence verifying compliance</i>	<i>DNV check</i>
<i>Energy principle (NE,NDE, CE)</i>	CE (monitoring)			
<i>On demand/continuous</i>	Continuous monitoring, alarm on demand			
<i>Automatic/manual activation</i>	Automatic			
<i>Response time</i>	Immediately			
<i>Test procedure</i>	Designer's specification			
<i>Test interval</i>	12 months			
<i>Detector 1</i>	Failure in control system monitoring			
<i>Detector 2</i>	NA			
<i>Actuator 1</i>	Auto stop and automatic application of brakes.			
<i>Actuator 2</i>	Alarm signal to operator.			
<i>Monitoring of safety function, when active</i>	Indication and alarm			
<i>Interdependency to other functions</i>	Shall not override MOPS			

311 Monitoring of safety systems (Ch.2 Sec.6 D212)

<i>Hazard and risk</i>	Failure in safety systems			
<i>Name of safety function</i>	Monitoring of safety systems			
<i>Safe state</i>	Indication and alarm signal to crane operator			
<i>Main item</i>	<i>Requirement/ Specification</i>	<i>Customer's verification of compliance with the requirements ("tick-off"), or reference to other solution</i>	<i>Customer's document reference to objective evidence verifying compliance</i>	<i>DNV check</i>
<i>Energy principle (NE,NDE, CE)</i>	CE (monitoring)			
<i>On demand/continuous</i>	Continuous monitoring, alarm on demand			
<i>Automatic/manual activation</i>	Automatic			
<i>Response time</i>	Immediately			
<i>Test procedure</i>	Test to be carried out manually			
<i>Test interval</i>	12 months			
<i>Detector 1</i>	Failure in safety systems detector			
<i>Detector 2</i>	NA			
<i>Actuator 1</i>	Indicator and alarm signal to crane operator			
<i>Actuator 2</i>	NA			
<i>Monitoring of safety function</i>	Indication and alarm			
<i>Interdependency to other functions</i>	Shall not affect/override other crane functions			

312 Maintenance of holding capacity, hydraulic cranes (Ch.2 Sec.6 D214)

<i>Hazard and risk</i>	Lack of holding capacity			
<i>Name of safety function</i>	Maintenance of holding capacity			
<i>Safe state</i>	Holding capacity retained			
<i>Main item</i>	<i>Requirement/ Specification</i>	<i>Customer's verification of compliance with the requirements ("tick-off"), or reference to other solution</i>	<i>Customer's document reference to objective evidence verifying compliance</i>	<i>DNV check</i>
<i>Energy principle (NE,NDE, CE)</i>	CE			
<i>On demand/continuous</i>	Continuous			
<i>Automatic/manual activation</i>	Automatic			
<i>Response time</i>	Immediately			
<i>Test procedure</i>	Test to be carried out manually			
<i>Test interval</i>	12 months/Daily			
<i>Detector 1</i>	Customer's specification			
<i>Detector 2</i>	NA			
<i>Actuator 1</i>	Hydraulic system designed to avoid insufficient hydraulic refilling			
<i>Actuator 2</i>	Safety/holding valves on all main circuits			
<i>Monitoring of safety function</i>	NA			
<i>Interdependency to other functions</i>	NA			

313 Blackout/shutdown, precautions (Ch.2 Sec.6 D215.a)

<i>Hazard and risk</i>	Blackout / shutdown			
<i>Name of safety function</i>	Blackout/shutdown, precautions			
<i>Safe state</i>	Stop all movements			
<i>Main item</i>	<i>Requirement/ Specification</i>	<i>Customer's verification of compliance with the requirements ("tick-off"), or reference to other solution</i>	<i>Customer's document reference to objective evidence verifying compliance</i>	<i>DNV check</i>
<i>Energy principle (NE,NDE, CE)</i>	CE			
<i>On demand/continuous</i>	On demand			
<i>Automatic/manual activation</i>	Automatic			
<i>Response time</i>	Immediately			
<i>Test procedure</i>	Test to be carried out manually			
<i>Test interval</i>	12 months			
<i>Detector 1</i>	Loss of power supply			
<i>Detector 2</i>	NA			
<i>Actuator 1</i>	Brakes applied			
<i>Actuator 2</i>	NA			
<i>Monitoring of safety function</i>	Alarm			
<i>Interdependency to other functions</i>	Shall not override MOPS			

314 Blackout / shutdown, emergency operation (Ch.2 Sec.6 D215.b)

<i>Hazard and risk</i>	Blackout / shutdown			
<i>Name of safety function</i>	Blackout / shutdown, emergency operation			
<i>Safe state</i>	Hoisting/slewing/luffing out/load lowering to safe position			
<i>Main item</i>	<i>Requirement/Specification</i>	<i>Customer's verification of compliance with the requirements ("tick-off"), or reference to other solution</i>	<i>Customer's document reference to objective evidence verifying compliance</i>	<i>DNV check</i>
<i>Energy principle (NE,NDE, CE)</i>	NDE			
<i>On demand/continuous</i>	On demand			
<i>Automatic/manual activation</i>	Manual			
<i>Response time</i>	Max 30 sec.			
<i>Test procedure</i>	Test to be carried out manually			
<i>Test interval</i>	12 months			
<i>Detector 1</i>	Loss of power supply			
<i>Detector 2</i>	NA			
<i>Actuator 1</i>	Operator controlled power unit			
<i>Actuator 2</i>	NA			
<i>Monitoring of safety function</i>	Alarm			
<i>Independency to other functions</i>	NA			

315 Gas alarm (Ch.2 Sec.6 D219.a)

<i>Hazard and risk</i>	Fire/fire ignition			
<i>Name of safety function</i>	Gas alarm			
<i>Safe state</i>	Alarm signal to operator upon gas in area			
	<i>Requirement/Specification</i>	<i>Customer's verification of compliance with the requirements ("tick-off"), or reference to other solution</i>	<i>Customer's document reference to objective evidence verifying compliance</i>	<i>DNV check</i>
<i>Energy principle (NE,NDE, CE)</i>	CE (monitoring)			
<i>On demand/continuous</i>	On demand			
<i>Automatic/manual activation</i>	Automatic			
<i>Response time</i>	Immediately			
<i>Test procedure</i>	Test to be carried out manually			
<i>Test interval</i>	6 months			
<i>Detector 1</i>	Gas/explosive atmosphere detector			
<i>Detector 2</i>	NA			
<i>Actuator 1</i>	Acoustic fire/gas alarm to operator			
<i>Actuator 2</i>	NA			
<i>Monitoring of safety function</i>	Alarm			
<i>Independency to other functions</i>	NA			

316 Shutdown (Ch.2 Sec.6 D219.b)

<i>Hazard and risk</i>	Fire/fire ignition			
<i>Name of safety function</i>	Shutdown			
<i>Safe state</i>	Shut down of crane			
	<i>Requirement/ Specification</i>	<i>Customer's verification of compliance with the requirements ("tick-off"), or reference to other solution</i>	<i>Customer's document reference to objective evidence verifying compliance</i>	<i>DNV check</i>
<i>Energy principle (NE,NDE, CE)</i>	CE (monitoring)			
<i>On demand/continuous</i>	On demand			
<i>Automatic/manual activation</i>	Automatic			
<i>Response time</i>	Immediately			
<i>Test procedure</i>	Test to be carried out manually			
<i>Test interval</i>	6 months			
<i>Detector 1</i>	Fire/explosive atmosphere detector			
<i>Detector 2</i>	NA			
<i>Actuator 1</i>	Shut down of crane			
<i>Actuator 2</i>	NA			
<i>Monitoring of safety function</i>	NA			
<i>Independency to other functions</i>	NA			