RULES FOR CERTIFICATION OF LIFTING APPLIANCES

JANUARY 2007

Reprint of the 1994 issue

DET NORSKE VERITAS

FOREWORD

DET NORSKE VERITAS (DNV) is an autonomous and independent foundation with the objectives of safeguarding life, property and the environment, at sea and onshore. DNV undertakes classification, certification, and other verification and consultancy services relating to quality of ships, offshore units and installations, and onshore industries worldwide, and carries out research in relation to these functions.

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Introduction

- **General**

This document is a reprint of the 1994 edition of the rules for certification of lifting appliances. The document contains some editorial changes from the original. Appendix B – Certificates has been modified to reflect current applicable forms.

CONTENTS

SECTION 1
GENERAL REGULATIONS

A. Certification

A 100 General

101 The rules for Certification of Lifting Appliances aim at a «Conformity Certification» with national and international regulations and standards for lifting appliances but limited to the scope set forth in B200.

Where national or international regulations apply the rules will be applied as a supplement to the relevant national/international regulations.

102 Conformity Certification is in this context a certification scheme comprising:

— design evaluation
— survey during manufacture
— testing.

of the complete lifting appliance or components to a lifting appliance. Det Norske Veritas will act as «competent person».

103 Competent person is a person or Institution acceptable as such to the competent Authority in the country of issue of the Certificates mentioned in A202.

A 200 Acceptance by National Authorities

201 In many cases National Authorities require that cranes, conventional ship cargo gear and loose gear are to be certified. In such cases additional requirements laid down by the pertinent bodies are to be complied with and scope of work as per B200 is — if necessary — to be modified accordingly.

202 The International Labour Organization (ILO) has proposed certificate forms which shall be issued in conjunction with the certification procedure. In Appendix B some of the Society's certificate forms corresponding to the ILO forms are listed. These forms, or other equivalent ILO forms, shall normally be available before a crane or other cargo gear onboard a ship or mobile/fixed offshore installation is taken into use. (This may be required by National Authorities, Harbour Authorities, Longshoremen and Stevedore Unions etc.)

203 The rules for Certification of Lifting Appliances will be applicable — as far as relevant — for the purpose of periodical inspections (as required by Authorities).

A 300 Additional class notation CRANE

301 Det Norske Veritas performs certification of lifting appliances onboard ships and mobile offshore units. The procedure is not a mandatory requirement for the purpose of class assignment apart from units requesting the class notation **Crane Vessel**.

302 Lifting appliances on a ship or mobile offshore unit can, on request, be part of the class assignment (additional class notation **CRANE**). In such cases the lifting appliances will be certified by the Society in accordance with the rules for Certification of Lifting Appliances. The lifting appliances will also be subjected to periodical surveys for the maintenance of class.

See rules for Classification of Ships (Pt.1 Ch.1 Sec.3).

303 In the case of class notation **Crane Vessel** and additional class notation **CRANE** the Society's certificate forms mentioned in A202 will be issued.

B. Rule Application and Scope

B 100 Rule application

101 The rules apply to:

— shipboard cranes
— conventional cargo gear and similar lifting appliances (cargo ramps and movable decks) onboard a ship or other floating vessel
— offshore cranes
— industrial cranes.

The ship or offshore unit in question need not be classified by the Society.

102 The rule application as listed in 101 is to be understood as follows:

a) Shipboard cranes and conventional cargo gear are:

  — lifting appliances onboard ships and similar units intended for cargo handling within harbours
  — lifting appliances on fixed offshore installations, ships and mobile offshore units intended for cargo handling within the deck area.

b) Offshore cranes are:

  — lifting appliances on fixed offshore installations, ships and mobile offshore units intended for cargo handling outside the deck area. Loading and discharging of offshore supply vessels, barges etc. or from the seabed.

c) Industrial cranes are:

  — lifting appliances onshore or offshore and not belonging to the categories mentioned in a) or b) above.

103 The rules also apply to mobile cranes, i.e. cranes which are transported by a vehicle or other means from one location to another, and cranes which can move long distances by road by means of their own machinery and wheel arrangement. In the latter case the moving machinery and arrangement are not covered by the certification.

104 The rules do not apply to cable cranes, personnel lifts (elevators), jacks, overhead drilling equipment, fork lifts, portable hoisting gear etc.

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

B 200 Scope of rules

201 The following parts and systems are covered by the rules:

— all load carrying structural members and components of the lifting appliance
— cargo hooks, chains, rings, blocks, sheaves, shackles, swivels and steel wire ropes
— wire 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

— electrical installation, see Sec.5, Electrical Systems and Components.

C. Documentation

C 100 Documentation for approval

101 For cranes to be certified by the Society, plans and supplementary documentation giving pertinent particulars of the technical matters listed below are to be submitted in triplicate for approval in ample time before fabrication of the lifting appliance:

— rigging plan/reeving plan
— structural drawings
— slewing ring and fasteners (if applied)
— wire ropes, thimbles, shackles, swivels, chains, rings etc.
— hooks and blocks
— pins and sheaves
— drums and brakes
— material specifications
— safety equipment
— fire protection
— extent, type and acceptance criteria for non-destructive testing (NDT)
— programme for functional testing
— programme for load testing
— load charts and/or load tables.

C 200 Documentation for information.

201 Plans and particulars for the matters listed below are to be submitted for information together with the documentation for approval required by 101:

— name and address of:

a) crane manufacturer,

b) vendors,

c) crane owner (if known)

— intended location of the crane
— general arrangement of the lifting appliance including any area classification
— ratings of the lifting appliance
— limitations of use and design ambient and operational conditions for the lifting appliance
— schematic diagrams of:

a) hydraulic systems,

b) electrical systems,

c) pneumatic systems,

— design criteria, including codes and standards etc. applied for the structure, systems and details
— type and make of prime mover or specification of other main power supply
— emergency power supply, if arranged
— type of power systems applied for the various operations and movements
— lists with functional description of applied hydraulic, electrical and pneumatic components
— braking systems
— pertinent calculations
— operational manual.

Table C1 Crane components and accessories. General requirements.

	Design approval required	*Inspection required*	*Type of material certificate EN 10204*		*Load test at manufacturer's*	*Before installation: Required documentation*	
			3.1	*3.2*		*Survey report*	*CG Form No.*
Sheaves	x	x	x			x	
Sheave axles	x	x	x			x	
Hooks, chains, swivel, shackles	x	x	x		x	x	3
Hoisting block	x	x	x		x	x	3
Wire rope					x		4
Winches incl. brakes, drum support	x	x	x			x	
Slewing ring	x	x	1)	2)		x	
Slewing ring bolts	x	x	1)	2)		x	

1) For ship cranes

2) For offshore cranes

Hydraulic components: Manufacturers pressure test certificate **Hydraulic systems:** Design/System review **Electrical systems:** Design/System review **El. cables and accessories:** In accordance with the Societies rules (type approval or case by case approval)	**El. motors:** The Societies certificate in case of class notation CRANE. Otherwise manufacturers' test certificate acceptable. **Diesel engine:** Engine to be in accordance with Ship rules Pt.4 Ch.2. **Transmission gear:** Functional testing. Components in gears which are transmitting braking forces are to be subjected to design approval and inspection.

C 300 Components and accessories

301 General requirements to documentation of components and accessories are listed in Table C1. The table is intended as a easy reference only, and is to be interpreted in conjunction with relevant text.

D. Design Ambient and Operational Conditions

D 100 Design temperature

101 Temperature terms (see also Fig.1)

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

Mean daily temperature is the statistical mean temperature for a specific calendar day, based on a number of years of observations (= MDAT).

Monthly mean temperature is the average of the mean daily temperature for the month in question (= MAMDAT).

Lowest mean daily temperature is the lowest value on the annual mean daily temperature curve for the area in question. For seasonally restricted service the lowest value within the time of operation applies.

Lowest monthly mean temperature is the monthly mean temperature for the coldest month of the year.

102 The design temperature T_D for lifting appliances is defined as the lowest mean daily temperature.

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

104 If not otherwise specified design temperature according to table D1 will be applied

Table D1 Design temperature for Lifting Appliances

Type of lifting appliance	*Design Temperature*	*Corresponding Extreme Low Temperature*
Shipboard/ Industrial Crane	– 10°C	(– 30°C)
Offshore cranes	– 20°C	(– 40°C)

D 200 Design (environmental, operational) conditions for machinery and systems

201 Machinery and systems of lifting appliances are to 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%.

202 Where the rules stipulate requirements to capacity or effect of machinery, these are normally to be determined on the basis of the following:

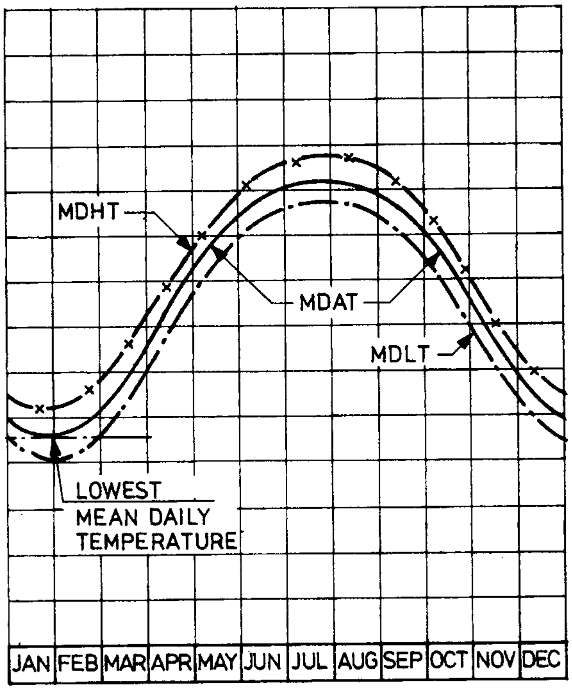
— ambient air temperature: 40°C
— relative humidity of air: 50%

These values will be reconsidered if the crane is to be working 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.

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

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



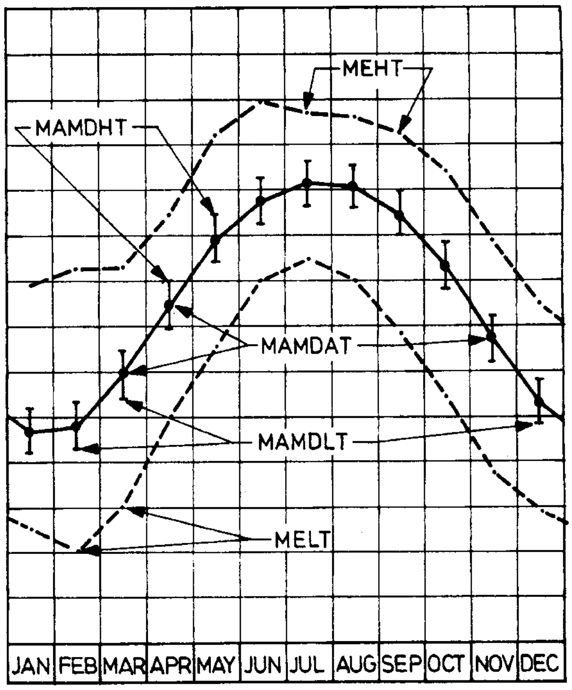


Fig. 1 Commonly used definitions of temperatures.

MDHT = **Mean daily high (or maximum) temperature.**
MDAT = **Mean daily average temperature.**
MDLT = **Mean daily low (or minimum) temperature.**
MAMDHT = **Monthly average of MDHT.**
MAMDAT = **Monthly average of MDAT.**
MAMDLT = **Monthly average of MDLT.**
MEHT = **Monthly extreme high temperature (ever recorded).**
MELT = **Monthly extreme low temperature (ever recorded).**

E. Certification System

E 100 Request for certification and inspection

101 Certification may be requested by:

— manufacturers of a complete lifting appliance
— manufacturers of components or loose gear
— owners/users of a lifting appliance
— owners of the installation e.g. ship or mobile offshore unit etc.
— responsible person for the installations (in case of periodical inspections, damage and/or repairs).

102 Request for certification is to be made in writing.

E 200 Design approval

201 Load carrying and other important components of a lifting appliance are subject to design review with respect to strength and suitability for its purpose.

Strength evaluation can either be calculations or testing to failure.

Strength evaluation of components of power and safety equipment is normally not carried out by the Society.

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» implies that a 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 Det Norske Veritas' Certification Note No. 1.1, «Det Norske Veritas' Certification Services – General Description» November 1988.

E 300 Inspection during fabrication

301 Normally, an inspection during manufacture of each separate lifting appliance is to be carried out by the Society's surveyor, in order to ascertain compliance with the requirements of these rules.

302 As an alternative to inspection 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.

E 400 Testing and marking

401 Components and each completed lifting appliance shall be subjected to functional testing and load testing as specified in Sec.6.

SECTION 2
MATERIALS AND FABRICATION

A. General

A 100 Scope

101 This section stipulates requirements for materials for important structural members and equipment for cranes with design temperature T_D down to -30°C.

Materials for cranes with design temperature below -30° C will be specially considered. For definition of design temperature see Sec.1 D100.

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

A 200 Documentation for approval

201 Specifications of material grades to be used in structural members and important equipment of the crane are to be submitted to the Society for approval.

Material grade designations are to be stated with reference to the Society's rules for Classification of Ships Pt.2 Ch.2 Metallic Materials, or with reference to recognized standards, e.g. ISO or national standards.

A 300 Steel manufacturing process

301 Steel is to be made by the basic oxygen process, open hearth process, electric furnace process, or by other process specially approved by the Society.

A 400 Material certificates and marking

401 Certificates giving the chemical composition and mechanical properties are to be presented for all materials for all load carrying structures and mechanical components. The test values are to show conformity with the approved specification. Test specimens are to be taken from the products delivered.

402 Works certificates will normally be accepted, except for slewing rings and slewing ring fasteners where Det Norske Veritas' test certificate will be mandatory, unless otherwise agreed upon.

403 Det Norske Veritas' test certificate is a document signed by a surveyor of the Society which contains the results of all the required tests and certifies 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 themselves.

404 Works certificate is a document made out by the manufacturer which contains the results of all the required tests and certifies that the tests have been carried out by the manufacturer on samples taken from the delivered products themselves, i.e. EN 10204 or equivalent.

405 The materials are to be adequately marked for identification. The marking is at least to comprise the name or trade mark of the manufacturer, material grade, heat number and when required also the Society's stamp.

406 Marking and identification of smaller items, e.g. bolts and nuts, to be specially agreed upon between the manufacturer and the Society.

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

A 500 Re-testing

501 Materials proving unsatisfactory during delivery testing may be re-tested. If the standard, with which the materials are to comply, gives no directives for re-tested, the re-testing is to be carried out in accordance with a recognised standard. Provided the new testing results are found to satisfy the prescribed specification, the material can be accepted.

B. Rolled Structural Steel for Welding

B 100 General

101 In addition to the requirements for structural steels stated 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, carbon-manganese steel, carbon-manganese micro-alloyed steel or low alloyed steel. The steels are divided into three groups dependent on the specified yield strength as follows:

— normal strength steels, with specified minimum yield strength $\sigma_y \leq 300$ N/mm^2.
— higher strength steels, with specified minimum yield strength σ_y between 300 and 500 N/mm^2.
— extra high strength steels with specified minimum yield strength $\sigma_y \geq 500$ N/mm^2.

103 Steel with specified minimum yield strength above 750 N/mm^2 are not to be used, unless especially agreed.

104 Steels having through thickness ductility will be required for primary members which will be significantly strained in the thickness direction.

B 200 Normal strength and higher strength steel

201 Normal strength steels may be carbon or carbon-manganese steels. Requirements to chemical composition, mechanical properties etc. are given in Table B1.

Higher strength steels may be carbon-manganese steels, carbon-manganese micro-alloyed steels or low alloy steels. Requirements to chemical composition, mechanical properties etc. for carbon-manganese and carbon-manganese micro-alloyed steels are given in Table B2. For low alloy steels details are to be submitted for consideration.

The normal strength steel group is divided into subgroups dependent on specified impact test temperature.

Table B1 Requirements to normal strength C–Mn structural steel			
Specified min. yield strength N/mm^2	220 – 300		
Specified tensile strength N/mm^2	400 – 560		
Steel grade based on impact test temperature according to Table B4	Impact test not required or impact test specified at 0°C and higher	Impact test specified at temperatures lower than0°C, down to and including –20°C	Impact test specified at temperatures lower than –20°C
Impact energy, Charpy V-notch specimens cut longitudinally to rolling direction. Average value, min. J	According to Fig.1		
Elongation % min. $L_0 = 5.65\sqrt{S}\ or\ \ 5d$	22		
Deoxidation	Semi-killed, fully killed or fully killed fine grain practice		Fully killed fine grain practice
Chemical composition (ladle analysis)	C + 1/6 Mn + 0.03≤ 0.47		
C % max. Mn % min. Si % max. P % max. S % max.	0.23 0.60 0.50 0.040 0.040		
Al % (total content)			0.020 – 0.08
Heat treatment. Controlled rolling may be accepted as a substitute for normalizing	At the option of the steel maker	Normalized for t ≥ 25 mm	Normalized
Mechanical testing, see B500	Extent of testing according to approved standard		

202 Steel grades which according to Table B2 are to be fine-grain treated, are to contain one or more of the elements Al, Nb, Ti and V. Other grain refining elements may be used after agreement with the Society. When grain refining elements are used in combination, the minimum content specified in Table B2 for each element is not applicable.

Table B2 Requirements to higher strength C–Mn steel	
Specified min. yield strength N/mm^2	$300 \leq \sigma_y < 500$
Specified tensile strength N/mm^2	470 – 750
Impact test temperature	According to Table B4, but need not be taken lower than –40°C
Impact energy, Charpy V-notch specimens cut longitudinally to rolling direction. Average value, min. J	According to Fig.1
Elongation % min. $L_0 = 5.65\sqrt{S}\ or\ \ 5d$	18
Deoxidation	Killed
Grain refining treatment	Required except when $\sigma_y < 390$ N/mm^2 and impact test temperature ≥ 0°C

Chemical composition (ladle analysis) max values in % except where a range is given

$$C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Cu + Ni}{15} \leq 0.47$$

C	Mn	Si	P	S	Cu	Cr	Ni	Mo	Al	Nb	Ti	V	N
0.22	0.70–1.60	0.10–0.50	0.040	0.040	0.35	0.20	0.40	0.08	0.025–0.08	0.02–0.05	0.02–0.05	0.05 0.10	0.009 If fine grain treated with Al: 0.015

When grain refining treatment is not required the min. content of Al, Nb, Ti and V is not applicable

Heat treatment. Controlled rolling may be accepted as a substitute for normalizing	Normalized *) or quenched and tempered
Mechanical testing, see B500	Extent of testing according to approved standard
*)Normalizing will not be required following: t ≤ 19 mm if $\sigma_y \leq 355$ N/mm^2 t ≤ 12.5 mm if $355 < \sigma_y \leq 500$	**Note:** Material certificates need not contain other information of chemical elements than specified for a particular steel grade or contained in a given acceptable steel specification standard

203 The content of all elements specified is to be determined for each case, as ladle analysis, and is to be stated in the certificate. For grades that are not fine-grain treated, the determination of Al, Nb, Ti and V may be omitted.

204 The Charpy V-notch energy requirement for steel depends on the specified minimum yield stress of the steel. The average energy absorption for specimens with their axis parallel to the final rolling direction is not to be less than given in Fig.1. For specimens with their axis transverse to the final rolling direction the requirement is 2/3 of that for longitudinally orientated specimens given in Fig.1.

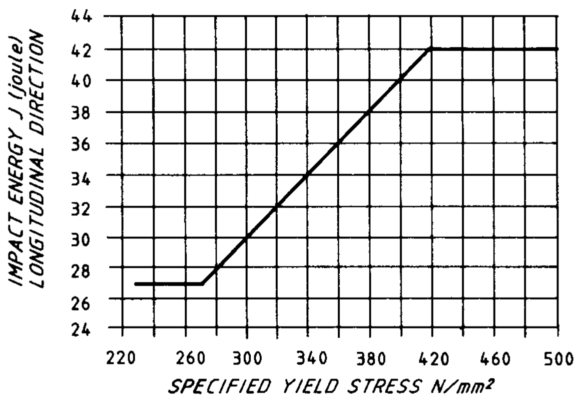


Fig. 1 Charpy V-notch, requirements for steel.

205 When using the Tables B1 or B2 for finding the overall material requirements for a certain structural component, the following directions apply:

- requirement to impact test temperature is taken from Table B4 according to the design temperature and material thickness of the component in question.
- subsequently the remaining material requirements are found in Table B1 for normal strength steel, using the column which represents the impact test temperature in question. If higher strength steel is to be used Table B2 applies.

B 300 Extra high strength steel

301 Extra high strength steel, i.e. steel with yield strength in the range 500 to 750 N/mm^2, may be fine-grain treated carbon-manganese steel or low alloy steel. The requirements are given in Table B3.

Table B3 Requirements to extra high strength steel

Type of steel	C – Mn micro-alloyed steel	Low alloy steel
Specified min. yield strength N/mm^2	$500 \le \sigma_y < 750$	
Measured yield strength N/mm^2 Specified tensile strength N/mm^2	– –	max. 900 max. 1 000
Impact test temperature	0°C or according to table B4 whichever is the lower, but need not be taken lower than – 60°C	
Impact energy, Charpy V-notch specimens cut longitudinally to rolling direction. Average value, min. J	42	
Elongation % min. $L_0 = 5.65\sqrt{S}$ or $5d$	14 for $\sigma_y > 600$ N/mm^2, otherwise 16	
Mechanical testing, see B500	Extent of testing according to approved standard	
Deoxidation, fine grain treatment	Fully killed, fine grain practice	
Chemical composition	According to table B2 except ”Note”	Individual consideration Mn + Cr + Mo + Cu +Ni < 5%
Heat treatment	Quenched and tempered	

B 400 Application of structural steel

401 Required impact test temperatures are dependent on design temperature T_D and the material thickness.

Impact test temperatures are given in Table B4 for structural steel for primary and secondary applications. For definition of design temperature see Sec.1 D100.

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.

Table B4 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*
t ≤ 12	$T_D + 10$	$T_D + 20$	Test not required	Test not required
12 < t ≤ 25	T_D	$T_D + 10$	Test not required	Test not required
25 < t ≤ 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 normal and higher strength C–Mn steels, the test temperature need not be taken lower than – 40°C. For extra high strength steel, the test temperature is not to be taken higher than 0°C and need not be taken lower than – 60°C
2) See G105 for definitions

402 In the case of 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 is to be the lower of the temperatures, according to Table B4, 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) is not to be higher than the required test temperature, based on t_2 according to Table B4, plus 30°C.

B 500 Testing

501 *Test samples*. Unless otherwise required the test samples are to be taken for positions as specified in recognized standards. The sample of material from which test specimens are cut is to be treated together with and in the same way as the material presented. The samples are to be suitably marked for identification.

502 *Test specimens*. Test specimens are to be as specified in the approved standards. The following additional requirements 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 is to be used:

  10 × 7.5 mm or 10 × 5 mm.

  The required impact values are then reduced to respectively 5/6 and 2/3 of the value of the standard 10 × 10 mm test specimen.

C. Rolled Steel not for Welding

C 100 General

101 Rolled steel for important components other than mentioned in 200 and 300 (e.g. machinery parts) is to be specified with reference to a recognized standard. Rolled steel may be accepted with diameter up to 250 mm. The material is to be delivered in the following conditions:

— carbon and carbon/manganese steel in normalized condition. However, for diameter 65 mm and less normalizing may be omitted.
— low alloy steel in quenched and tempered condition.

For all materials proper heat treatment is to be documented by Charpy V-notch impact tests. Testing is to be as required by Table D1, but, in the case of calculated stresses being low, e.g. not exceeding 50 N/mm^2, a test temperature of 20°C will be accepted. For carbon and carbon/manganese steel the carbon content is to be less than 0.35%.

C 200 Bolts and nuts

201 Rolled materials for bolts and nuts considered as important for the structural and operational safety of the assembly in question are to comply with the requirements for chemical composition, mechanical properties and testing of forged steel for bolts and nuts, see D500 and 700.

C 300 Rolled rings

301 Rolled rings for important components such as slewing rings, toothed wheel rims etc. are to comply with the requirements for steel forgings, see D600 and 700.

C 400 Shafts and plates

401 For unwelded load carrying members, e.g. shafts and/or plates, an impact test temperature of 20°C may be applied provided the calculated stresses are less than 50 N/mm^2.

402 In cases where calculated stresses are equal to or exceeding 50 N/mm^2, the impact test temperature for unwelded members are to be as required by Table D2.

D. Steel Forgings

D 100 General

101 The ratio of plastic deformation during hot forming is to be such as to ensure soundness, uniform structure and satisfactory mechanical properties of the material after heat treatment.

102 For certain components where grain flow is required in the most favourable direction with regard to the mode of stressing in service, the proposed method of manufacture may require special approval by the Society. In such cases, tests may be required to demonstrate that the satisfactory structure and grain flow are obtained.

103 The shaping of forgings by flame cutting, scarfing or arc-air gouging is to be undertaken in accordance with recognized good practice and before the final heat treatment. Preheating is to be employed when necessitated by the composition and/or thickness of the steel. Machining of flame cut surfaces may be required for certain components.

104 At an appropriate stage of manufacture, after completion of all hot working operations, forgings are to be suitably heat treated to refine the grain structure and to obtain the required mechanical properties.

Carbon and carbon-manganese steel forgings are to be normalized or normalized and tempered. Quenching and tempering may be applied for smaller dimensions.

Alloy steel forgings are normally to be quenched and tempered.

When it is intended to surface harden forgings, full details of the proposed procedure and specification are to be submitted to the Society for approval.

Details for the heat treatment are to be stated in the manufacturer's certificate.

105 Forgings are to be inspected by the manufacturer by means of appropriate non-destructive testing (NDT) methods to make sure that no significant internal or external defects are present.

For small forgings where mechanical testing is carried out according to batch testing procedure (see 704), NDT may be performed as a random check inspection. When required, a complete procedure for NDT is to be submitted for approval by the Society. It is to be stated in the certificate that NDT has been carried out, specifying the extent of testing and the method applied.

106 Defects are in no case to be covered, and are not to be repaired unless they have first been inspected by the Society's surveyor. Subject to the surveyor's consent, defects may be repaired using an approved procedure. See also G300. Forgings which have been repaired without the surveyor's consent will normally not be accepted.

D 200 Forgings for general application

201 Forgings for applications other than mentioned in 400–600 are to be specified with reference to a recognized standard. As a minimum the standard is to require impact testing at temperatures as indicated in C400.

D 300 Forgings for welding

301 Forgings intended for welded constructions are to comply with the requirements given in B for rolled products regarding chemical composition, heat treatment, mechanical properties, impact toughness, and other relevant particulars, except that only killed steel is to be used. For thicknesses over 100 mm, smaller deviations from the specified mechanical properties may be accepted subject to approval by the Society.

Table D1 Requirements to shackles, cargo hooks, chains, sockets and swivels

Type of steel	Normal strength steel	Higher strength steel		Extra high strength steel	
Specified yield strength N/mm^2	$235 \leq \sigma_y < 300$	$300 \leq \sigma_y < 355$	$355 \leq \sigma_y < 500$	$500 \leq \sigma_y < 690$	$\sigma_y \geq 690$
Tensile strength	400 – 560	max. 620	max. 770	max. 940	$\sigma_u > 940$
Yield strength to tensile strength ratio max.		0.85	0.85	0.90	According to approved specification
Elongation % min. 1) ($L_0 = 5.65\sqrt{S}$ or $5d$) Reduction of area % min.	22 (25) 40	20 (23) 35	16 (18) 35	14 (16) 35	
Impact test temperature	According to Table D2				
Charpy V-notch value (joule) 2)	According to Fig.1				
Mechanical testing	Extent according to approved standard				
Chemical composition % Max values unless otherwise stated C Mn Si P S Al, other grain refiners may be accepted Cu Cr Mo Ni	 0.25 0.30 – 1.50 0.15 – 0.45 0.040 0.040 min. 0.025 0.30 0.30 0.15 0.40		According to approved specification		
Heat treatment	Normalizing	Quenched and tempered or normalized			

1) Values in brackets are for specimens with a gauge length/diameter ratio of 4, e.g. the ASTM A370–77 standard specimen (0.5 in dia. × 2 in gauge length).

2) Average of 3 specimens. No individual value to be less than 2/3 of the specified average.

D 400 Forged shackles, cargo hooks, swivels, sockets and chains

401 Carbon and carbon-manganese steel forgings are to 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 are to be as stipulated in Table D1.

402 Chemical composition and mechanical properties for alloy steels are to be specified with reference to a recognized standard and are subject to individual consideration and approval by the Society. The chemical composition is to be suitable for the thickness in question. Alloy steels are to be delivered in quenched and tempered condition. Requirements to impact properties are given in Table D2.

Table D2 Impact test temperature for shackles, cargo hooks, chains, sockets and swivels

Material thickness t in mm	*Impact test temperature in °C*	
	Offshore cranes	*Shipboard cranes/ Industrial cranes*
$t \leq 50$	$T_D + 10$	$T_D + 20$
$50\ t \leq 100$	T_D	T_D
$t > 100$	$T_D - 10$	T_D

T_D = design temperature in °C

D 500 Forged bolts and nuts

501 Bolt assemblies considered as essential for structural and operational safety are to conform to a recognized standard, e.g. ISO 898. For fasteners for slewing rings the additional requirements given in 502–503 also apply.

502 Bolts and nuts are to be tested according to recognized standard e.g. ISO 898. Additional requirements to testing and inspection of fasteners for slewing rings are given in Table D3.

Magnetic particle testing is to be carried out at least 48 hours after completion of quenching and tempering. Inspection is to be in accordance with ASTM E 709–80.

Table D3 Testing and inspection of slewing ring fasteners

Strength class ISO 898	*Diameter d in mm*	*Ultimate strength N/mm²*	*Yield strength Minimum N/mm²*	*Elongation % $L_0 = 5d$*	*Min, Charpy V energy at test temp. as required for rings Table D4*	*Fracture mechanics testing*	*Surface inspection*
8.8	d < 25	800 1 000	640	14	–	–	Visual
	d ≥ 25				42 J	–	Visual and magnetic particle (MPI)
10.9	d < 25	1 000 1 200	900	14	–	–	Visual
	d ≥ 25				42 J	–	Visual and magnetic particle (MPI)
12.9	d < 25	1 200 1 400	1 080	14	42	To be documented	
	d ≥ 25				42 J	To be tested	

Depth of longitudinal discontinuities is not to 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.

503 Bolts and nuts for marine applications are normally to 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 are to be followed by immediate hydrogen relief (degassing) treatment to eliminate embrittling effects.

D 600 Forged rings for slewing bearings

601 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 are to 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 is to be indicated. Method and extent of non-destructive testing is to be specified and the testing procedures are to be stated.

Detailed information about method of manufacture is to be submitted.

602 For every new material of which the manufacturer has no previous experience and for any change in heat treatment of a material previously used, a principal material examination is to be carried out. The results are to he submitted to the Society for consideration. The programme for such examination is to be agreed with the Society.

603 All test results are to comply with the approved specifications.

604 Steel for slewing rings is to satisfy the requirements in Table D4.

Table D4 Slewing material

	Offshore cranes	Other cranes
Heat treatment	*According to approved spec.*	
Charpy V-notch test temperature	-20°C or T_D -10°C wichever is the lower	-10°C or T_D wichever is the lower
Charpy V-notch value		
Average	42	25
Single min. value	27	20
Elongation on gauge length 5 d or $5.65\sqrt{S}$	14%	14%
Fatigue properties	Documentation may be required by type tests on specimen of ring section	
Fracture toughness	Documentation may be required by type tests on specimen of ring section in question	

D 700 Testing

701 A set of tests as required by these rules is to consist of one tensile test specimen, three impact test specimens and specimens necessary for additional tests if such are required for the forging in question.

If not otherwise specified, test material sufficient for one set of tests, and for possible re-test purposes, is to have a cross-sectional area not less than that of the main body of the forging.

702 Test material is to be integral with each forging, and is not to be detached from the forging until the final heat treatment has been completed. For heavy forgings and forgings of complex design at least two test samples are to be provided.

703 Where the shape or the manufacturing process of the forgings makes it impossible to procure test material integral with the forging, one extra forging representative for the specified one is to be made for testing purposes. One test forging may represent several identical forgings made from the same heat. In such cases details about the testing are to be agreed with the Society.

704 Where a number of small forgings of about the same size are made from one heat and treated in the same furnace charge, a batch testing procedure may be adopted, using one of the forgings for test purposes or alternatively using separately forged test samples. These test samples are to have a forging reduction similar to that of the forging which they represent. One test forging or one forged test sample is to be tested for each 2.5 tonnes of materials or fraction thereof. A set of tests is to be taken from each test forging or forged test sample.

705 When a forging is subsequently divided into a number of components, all of which are heat treated together in the same furnace charge, then for test purposes this may be regarded as one forging and the number of tests required is to be related to the total length and mass of the original multiple forging.

706 Where not otherwise specified, tensile as well as impact test specimens are to be cut with their longitudinal axes parallel to the principle grain flow.

Where possible, the distance from the surface of the forging to the nearest surface of the specimen is to be at least 10% of the diameter or the thickness of the forging.

E. Castings

E 100 General

101 The following requirements cover steel castings and nodular cast iron castings.

102 Castings are to be free from defects which may be detrimental to their proper application in service.

103 Defects are in no case to be covered by welding or in any other manner, and are not to be repaired unless they have first been inspected by the Society's surveyor. Subject to the surveyor's consent, defects may be repaired using an approved procedure.

Castings which have been repaired without the surveyor's consent will not be accepted.

104 Castings are to be inspected by the manufacturer by means of appropriate non-destructive testing methods to make sure that no significant internal or external defects are present.

For small castings where mechanical testing is carried out according to a batch testing procedure (see 500) the non-destructive testing may be carried out as a random check inspection.

When required, a complete description of the procedure for non-destructive testing is to be submitted to the Society for approval.

It is to be stated in the certificate that non-destructive testing has been carried out, specifying the extent of testing and the method applied.

105 For certain components the method of manufacture, chemical composition, mechanical properties and test programme may require special approval by the Society.

E 200 Steel castings

201 Castings are to be made of killed steel. The chemical composition is to be appropriate for the type of steel, dimensions and the required mechanical properties of the castings.

202 Chemical composition and mechanical properties of steel castings for structural members are to comply with the requirements for rolled material given in B if welding is to be applied. The requirements are otherwise as stipulated for forgings for the same type of component except for machinery parts where requirements are given in Table E1.

Table E1 Requirements to steel castings for machinery parts

Type of steel	Carbon-manganese steel	Alloy steel
Mechanical properties	According to approved specifications	
Impact test	May be required for certain components	
Mechanical testing	Extent according to approved specification	
Chemical composition % Max. values unless otherwise stated		According to approved specification
C	0.40	
Mn	0.50 – 1.60	
Si	0.60	
P	0.040	
S	0.040	
Cu	0.30	
Cr	0.30	
Mo	0.15	
Ni	0.40	
Heat treatment	Normalizing	Quenching and tempering

203 If a casting is locally reheated or any straightening operations are performed after the final heat treatment, a subsequent stress relieving heat treatment, carried out in a furnace if practicable, may be required in order to avoid the possibility of harmful residual stresses.

204 All flame cutting, scarfing or arc-air gouging to remove surplus metal is to be undertaken in accordance with recognized good practice and is to be carried out before the final heat treatment.

E 300 Nodular cast iron castings

301 Suitable mechanical methods are to be employed for the removal of surplus material from castings. Thermal cutting processes are not acceptable, except as a preliminary operation prior to mechanical methods.

302 The chemical composition of the iron used is to be suitable to obtain the required mechanical properties of the castings. Special restrictions may be stipulated by the Society, e.g. see Sec.5 B503.

303 When not otherwise required, castings may be supplied in either the cast or heat treated condition.

304 When it is proposed to harden the surface of a casting locally full details of the proposed procedure and specification are to be submitted to the Society for approval.

305 Specified mechanical properties are to be in accordance with a recognized standard, and are subject to approval by the Society. Impact testing may be required for castings for special purposes.

306 All test results are to be in accordance with the approved specification.

E 400 Grey cast iron

401 Grey cast iron is to have a granular, grey fracture and is to have good machining properties. It is to be free from cracks, pores or other defects which may affect the service performance of the casting.

402 The chemical composition is to be suitable for the dimension and mechanical properties for the casting being manufactured.

E 500 Testing of cast steel

501 Test sample with sufficient dimensions for the required tests and for possible re-test purposes is to be provided for each casting or batch of castings. Unless otherwise approved by the Society or except as stated in 404 the test samples are to be cast integrally with the casting and are to have a thickness of not less than 30 mm.

502 At least one test sample is to be provided for each casting or batch of castings. For heavy castings or castings of complex design at least two test samples are to be provided.

503 For castings where the method of manufacture has been specially approved by the Society in accordance with 105, the number and position of test samples is to be agreed with the Society with regard to the method of manufacture employed.

504 Where a number of small castings of about the same size are made from one cast and heat treated in the same furnace charge, batch testing procedures may be adopted using separately cast test samples. One test sample is to be provided for each 2.5 tonnes or fraction thereof.

E 600 Testing of nodular cast iron

601 For parts weighing less than 1000 kg, at least one separately cast test sample is to be taken from each ladle of metal, treated to produce nodular iron. The test samples are to be cast immediately following the last pouring, and are to be of approved shape and dimensions.

For castings which are subjected to a heat treatment, the test samples are to be heat treated together with the casting. If the whole charge is not heat treated at the same time, one test sample is to be taken for each part of the charge which is heat treated simultaneously.

602 For parts weighing 1 000 kg or more, at least one test sample is to be integrally cast with each casting, and not cut from the casting until the final heat treatment has been completed.

603 Photo-micrographs are to be provided for every ladle of metal, treated to produce nodular graphite. At least 90% of the graphite is to be in spheroidal form.

Graphite types I and II according to plate I of ASTM A247 are considered to have a spheroidal form.

E 700 Testing of grey cast iron

701 At least one test sample is to be taken from each charge (ladle) used in the casting. The samples are to be separately cast and to have a diameter of 30 mm.

F. Steel Wire Ropes

F 100 General

101 Steel wire ropes for cranes are generally to be manufactured and tested in compliance with the requirements stipulated in the following.

F 200 Materials

201 Wire for steel wire ropes is to be made by open hearth electric furnace, LD process, or by other processes specially approved by the Society.

Normally, the minimum tensile strength of the wires is to be 1 570 N/mm^2, 1 770 N/mm^2 or 1 960 N/mm^2. The minimum tensile strength is normally not to exceed 2 200 N/mm^2.

202 The wires in a steel core are to be of similar tensile strength to that of the main strand.

F 300 Construction

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

302 All wire ropes are to 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 put in service.

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

F 400 Testing

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

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

The testing is to be carried out according to ISO 3108.

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:

$$P = f\,t\,k \ \{kN\}$$

f = average breaking strength of one wire in kN.
t = total number of wires.
k = lay factor as given in Table F1 or according to special agreement.

Table F1 Lay factor k

Rope construction	Rope with FC	Rope with IWRC
6 × 19 group	0.860	0.801
6 × 36 group	0.835	0.755
Non-rotation ropes		
17/18 × 7	0.780	0.758
35/36 × 7	0.750	0.743
FC = Fibre core IWRC = Independent wire rope core		

403 Individual wire tests are to be performed for every wire dimension represented in the strands. The number of tests for each wire dimension is to be the same as the number of strands in the rope. It is to be made a representative selection of the entire rope.

404 The following individual wire tests are to be performed:

— tensile test
— torsion test
— reverse bend test
— weight and uniformity of zink coating.

These tests are to be made in accordance with ISO 6892, 7800 and 7801 and are to comply with ISO 2232.

The average tensile value is not to exceed the minimum tensile strength 1 570 N/mm^2, 1 770 N/mm^2 or 1 960 N/mm^{2}by more than the values given in Table F2.

Table F2 Plus tolerance on tensile strength

Nominal diameter		*Plus tolerance on min. tensile strength N/mm^2*
from	*to*	
–	0.5	390
0.5	1	350
1	1.5	320
1.5	2	290
2	–	260

G. Crane Manufacturing and Construction.

G 100 General

101 The manufacturer is to organize a system for quality control involving competent personnel with defined responsibilities covering all aspects of quality control.

The materials are to be identifiable during all stages of manufacturing and construction.

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

103 Dimensional tolerances assumed in the design analysis of the crane structures are to be complied with during the manufacturing and construction.

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

105 For further reference primary structures are main load carrying members and components subjected to high stresses.

Where no redundancy and/or no redistribution of stresses are regarded possible, a member is to be regarded as essential. Secondary structures are structures other than primary structures and essential members.

G 200 Welding procedure specifications

201 Welding procedure specifications (WPS) are to be prepared, detailing steel grades; joint/groove design, thickness range, welding process, welding consumable, welding parameters, principal welding position, preheating/working temperature and post weld heat treatment.

202 The extent of WPS is to be approved by the surveyor.

G 300 Welding procedure qualification

301 Welding procedure qualification test (WPQ) is a test carried out in order to demonstrate that a weld made according to a specific procedure specification meets the given requirements.

302 For all primary structures and connections of primary to secondary structures, WPQs are to be demonstrated or documented. Such documentation is to be presented prior to commencement of welding. For secondary structures WPS will in most cases be acceptable.

303 The qualification programme specified in the following is applicable to manual metal arc welding, gas metal arc welding with solid or flux cored electrode and submerged arc welding. Other welding processes are subject to special consideration.

304 The qualification tests are to be witnessed by a surveyor to the Society and conducted under actual or simulated conditions, based upon the welding procedure specification. Materials with chemical composition in the upper range are to be selected for the test assembly.

305 The qualification of welding procedures is to be based on non-destructive and mechanical testing of welded joints, as stipulated in Table G1.

Table G1 Non-destructive and mechanical testing of welded joints

Joint	*Non-destructive testing*	*Tensile test*	*Bending test*	*Charpy V-notch test*	*Hardness test*
Butt welds	X-ray or US + MP	x	x	x	x
T-joints	US + MP			x	x
Tubular joints	US + MP			x	x
Fillet welds	MP				x

X-ray = Radiographic
US = ultrasonic
MP = magnetic particle

Methods and acceptance criteria for the non-destructive testing are to be suitable for the welding process, joint configuration and the design conditions for the crane.

Mechanical testing is to include determination of tensile properties, bending capacity, notch ductility and hardness of the welded joints. Generally, the tensile properties and notch ductility are to meet the requirements for the base material. For normal strength steel the hardness at the joint is not to exceed 325 HV5. For higher strength steel the hardness at the joint is normally not to exceed 350 HV5, but higher values may be accepted upon special consideration. For extra high strength steel and low alloy steel the hardness limit is to be agreed with the Society in each case.

306 Fracture mechanics evaluation, including testing may be required for establishing of defect tolerances in highly stressed welded joints, in heavy sections and/or for application of materials not previously used by the crane manufacturer.

Fracture mechanics testing may also be used for documentation of acceptable defect tolerances where post weld heat treatment is unfeasible or Charpy V-notch tests have failed to meet the specified values.

307 When a welding procedure qualification test (WPQ) fails to meet the requirements, a new WPQ has to be carried out. Prior to any new WPQ the welding procedure specifications (WPSs) have to be re-evaluated. However, if some of the test specimens fail to meet the requirements due to a minor weld failure which is acceptable according to group blue in IIW collection of Reference Radiographs of Welds in Steel or equivalent, new test specimens may be cut from the original test plate.

G 400 Limitation of welding procedure qualification

401 Qualification of a welding procedure is restricted to the manufacturer where the test weld was produced. If a WPQ has not been used in the production within 2 years, a re-qualification by new procedure tests or by production tests if appropriate (see G1200), will normally be required.

402 A welding procedure qualification is valid only within the limitations of the essential variables as specified by the applicable code, standard or rules and the approved welding procedure specification. If the tolerances are exceeded, new welding procedure tests are to be carried out.

G 500 Welder qualification

501 Welders using the manual metal arc, the gas metal arc, the flux cored arc welding process, or other processes when accepted are subject to qualification tests for the welding process and welding positions which will be applied in the fabrication.

502 Welding operators using a fully mechanized or an automatic welding process with minimal influence on weld soundness and mechanical properties are to have thorough training, and may then be exempted from qualification tests.

503 If a welder has discontinued his work for more than 6 months or cannot document a valid certificate relevant to the work in question, a new performance test must be conducted. Re-qualification may also be required if the welder's performance has not been documented by regular non-destructive testing on relevant fabrication.

504 Welder qualification tests will be based on the agreed code, standard or rules.

G 600 Welding consumable

601 Welding consumable type approved by Det Norske Veritas or accepted based on welding procedure tests are to be used.

Guidance note:

Welding consumable type approved by the Society are recommended. The currently type approved welding consumable are listed in the latest edition of Det Norske Veritas' publication *Welding Consumable, Shop Primers and Welding Shops* of the publication series *Type Approved Products and Approved Manufacturers.* In this publication the general relationship between the various grades of welding consumable and the steel grades to be welded is shown.

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

602 Welding consumable are to be selected such as to produce a weldment with mechanical properties at least equal to that specified for the structural steel type in question. The weld metal is to be compatible with the base material regarding heat treatment and corrosion. Only welding consumable specified in the qualified welding procedure are to be used.

603 Manual welding of higher strength and extra high strength, low alloy steel, is to be performed with low hydrogen welding processes. For normal strength steel with carbon equivalent less than 0.41 other process/ consumable may be accepted.

604 Welding consumable are to be supplied in sealed moisture proof containers or packages. Routines for storage, handling and rebaking of consumable as advised by the manufacturer are to be established and followed.

Consumable which have been contaminated by moisture, rust, oil, grease, dirt etc. are to be discarded.

G 700 Forming of materials

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

702 If cold forming results in a permanent deformation exceeding 3% 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. If the steel is Al fine-grain treated and normalized or quenched and tempered, and the cold forming takes place prior to welding, a 5% permanent deformation may be accepted without thermal stress relieving.

703 Hot forming is to be carried out within the minimum and maximum temperatures advised for post weld heat treatment of the steel.

When heat treated steel are hot formed, the initial heat treatment is to be repeated, unless it is demonstrated by suitable tests that the temperature control during hot forming and subsequent cooling ensures a treatment equivalent to the initial heat treatment.

The specified mechanical properties are to be attained in the final worked condition.

G 800 Welding preparation

801 Mill scale, rust etc. is to be removed prior to welding, and the groove is to be dry and clean. The fit-up is to be checked before welding. Any misalignment between parallel members is not to exceed 10% of the material thickness or maximum 3 mm. Where materials of different thicknesses are butt welded, material tapering is to be in accordance with recognized codes or standards.

G 900 Welding performance

901 All welding operations, including tack and seal welding are to be carried out in accordance with the appropriate welding procedure specification.

902 Preheating to and maintenance of an elevated interpass temperature will be required for materials of certain thicknesses and chemical compositions. Unless otherwise documented by welding procedure tests on the actual or corresponding materials, the temperatures stipulated in Table G2 are to be applied when welding normal and higher strength steel.

Table G2 Recommended minimum preheating and working/ interpass temperature. Normal and higher strength steel.

Carbon equivalent CE	*Maximum thickness at weld area mm*		
	t ≤ 20	*20 < t ≤ 30*	*t > 30*
CE ≤ 0.41	5°C	5°C	75°C
CE ≤ 0.43	5°C	50°C	100°C
CE ≤ 0.45	50°C	100°C	125°C
CE ≤ 0.47	100°C	125°C	150°C
CE ≤ 0.50	125°C	150°C	175°C

The carbon equivalent is defined as:

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Cu + Ni}{15}$$

(ladle analysis)

For welding of extra high strength steel the preheating and interpass temperature is to be as advised by the steel manufacturer.

903 The weld reinforcement is to have a regular finish and is to merge smoothly into the base material without significant undercutting. The height of weld reinforcement is not to exceed 3 mm for material thickness t ≤ 12.5 mm and max. 4 mm for greater thicknesses.

904 Welds which are essentially perpendicular to the direction of applied fluctuating stresses in members important to the structural integrity, are normally to be full penetration type, and if possible, welded from both sides. Dressing of welds by grinding may be required.

905 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 is to be produced and subjected to mechanical testing agreed upon in each case.

906 Temporary cut outs are to be made of sufficient size allowing sound replacement. Corners of cut outs are to be given appropriate radius minimizing the local stress concentration.

G 1000 Repair of welds

1001 For every type of repair, a repair welding procedure specification is to 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 are to be specified.

1002 For all repair welding of primary structural members and connections of primary to secondary members, WPQs are to be demonstrated or documented. Such documentation is to be presented prior to commencement of repair welding.

1003 Weld defects may be rectified by grinding, machining or welding. Welds of insufficient strength, ductility or notch toughness are to be completely removed prior to repair. The mechanical properties of repair welds are to satisfy the minimum specified properties of the steel in question.

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

1004 Repair welding is to be carried out with extra low hydrogen welding consumable applying an appropriate preheating and working/interpass temperature. Generally the preheating and working temperature when making shallow and local repairs is to be raised 25°C above the level used for production welding, but is not to be less than 100°C (see Table G2). The working temperature is to be maintained until the repair has been completed. To ensure sound repair welds, the single repair length should not be shorter than approx. 100 mm.

1005 When repair welding is carried out on heat treated steel, reheat treatment may be required. When post weld heat treated parts need repair by welding, the post weld heat treatment (PWHT) is normally to be repeated.

G 1100 Heat treatment after forming and welding

1101 Heat treatment may be required to restore acceptable mechanical properties of the material after forming and welding operations.

1102 Heat treatment is to be performed in accordance with a procedure specification detailing heating and cooling rates, temperature gradients, soaking temperature range and time, heating facilities, insulation, control devices and recording equipment. The specification is to be submitted to the Society for approval.

1103 Thermal stress relieving of cold worked materials is to be carried out in accordance with the conditions stated below for post weld heat treatment.

1104 The reference thickness for post weld heat treatment is the thickness of the welds i.e. in most cases the thinner of two members to be connected.

1105 Post weld heat treatment (PWHT) is normally to be carried out where welded joints have a reference thickness at the weld of 50 mm or more. This limit may be modified dependent on the minimum design temperature for the crane and the stress level, provided it is documented by fracture mechanics analysis that the material's resistance to initiation of brittle fracture is adequate.

1106 Post weld heat treatment of C–steels, C–Mn–steels and C–Mn fine-grain treated steels is to be performed at a soaking temperature in the range 550–600°C, for a time of 2 minutes per mm thickness. Soaking temperature for low-alloyed steel is decided in each case.

1107 Post weld heat treatment is, wherever possible, to be carried out in an enclosing furnace. Where it is impractical to heat treat the whole structure in a closed furnace, local heat treatment may be adopted subject to the Society's consent.

1108 The heat treatment cycle is to be recorded using thermocouples equally spaced externally, and whenever possible internally, throughout the heated region. Heat treatment records are to be submitted to the Society for consideration.

G 1200 Production weld tests

1201 Welding Production Test (WPT) is a test which is to be carried out during the production welding under the same condition as the production welding in order to check whether the WPS used during production produce welded joints that meet the application and specification requirement. Number and type of tests will be specified in each case.

1202 When a welding production test (WPT) fails to meet the requirements, re-testing 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 three cases occurred in the first test:

- the average value was below the requirement, one value being 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 are to 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.

1203 Upon special request and to the discretion of the Society, welding production tests may replace welding procedure qualification tests.

G 1300 Inspection and testing of welds

1301 Completed welds are to be subjected to visual inspection and non-destructive testing as manufacturing and construction proceeds. Final non-destructive testing is normally to be carried out not earlier than 48 hours after completion of the welds in question. When post weld heat treatment is performed, the final non-destructive testing is normally to be carried out when all heat treatments' have been completed.

1302 All welds are to be visually inspected over their full length.

1303 Methods for non-destructive testing (NDT) are to be chosen with due regard to the conditions influencing the sensitivity of the methods. Unless otherwise agreed, structural welds are to be subjected to non-destructive testing to the extent stipulated in Table G3. The specified percentages refer to the total length of weld for each structural assembly in question. The categories of the structural members are to be agreed with the Society in each case.

1304 When gas metal arc welding (short-type arc) is applied, ultrasonic and magnetic particle testing will normally be required in addition to radiographic inspection.

1305 The non-destructive testing is to 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.

1306 Areas which have been highly stressed in the thickness direction by the welding process are to be ultrasonically tested for lamellar tearing.

1307 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 are to be tested over their full length.

1308 The Society's surveyor is reserved the right of being final judge in assessment of weld quality.

1309 All non-destructive testing is to be properly documented and identified in such a way that the tested areas may be easily retraced at a later stage.

G 1400 NDT-procedures and NDT-operators

1401 Procedure specifications for intended NDT-methods are to be established according to recognized codes and standards.

1402 The operators are to document formal training and experience, preferably by being certified in accordance with a recognized certification scheme accepted by the Society.

1403 The NDT-operators are to issue reports describing the weld quality. The reports are clearly to distinguish between accepted and rejected welds, and the number of repairs carried out to meet the specified acceptance standard is to be stated. The inspection reports are to specify the NDT-methods and procedures used including all NDT-parameters necessary for a proper assessment.

G 1500 Weld acceptance criteria

1501 Normally the welds are at least to meet the requirements stated in Tables G4, G5 and G6. As the test methods differ in their limitations and/or possibilities of recording and documentation, special acceptance criteria are given for each method where necessary.

Alternative evaluations ensuring an equivalent level of quality may be considered.

1502 Calibration procedures and construction of reference curves for ultrasonic tests are to be as specified in Det Norske Veritas' Classification Note No. 7 or equivalent standards.

G 1600 Material protection against corrosion

1601 Steel surfaces exposed to marine atmospheric conditions are to be protected by a suitable coating system.

1602 Steel surfaces to which application of coating are not possible and which are exposed to internal corrosive conditions are to be protected by other protective systems such as oil, grease, grouting etc.

1603 Bolts, nuts and associated elements are to 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 filled with inhibited oil, grease etc.

Other protection methods may be accepted upon special consideration by the Society.

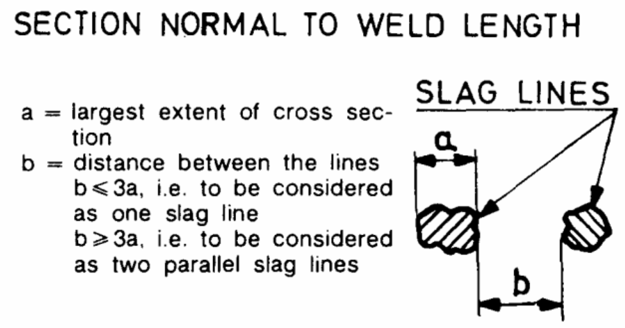


Fig. 2 Slag line(s).

Table G3 Minimum NDT of structural welds

Category of member	*Type of connection*	*Test method*			
		Visual inspection	*Magnetic particle* 3)	*Radiography* 1)	*Ultrasonic*
Essential/ Non-redundant	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 by agreement (e.g. for large plate thickness)
2) Approximately 2 – 5%
3) Liquid penetration testing to be adopted for non-ferromagnetic materials

Table G4 Visual, magnetic particle and liquid penetration testing

Type of defect	*Category of member*		
	Essential	*Primary*	*Secondary*
Incomplete penetration or lack of fusion	Not accepted		On the root side of welds for which back welding is not required: Length < $t_0/2$, max. 10 mm
Cracks	Not accepted		
Undercut, max. depth, mm	Not accepted	0.3 1)	1.0 1)

1) Provided round shape and insignificant notch effect (regardless of length)

Table G5 Radiographic testing

Type of defect	*Category of member*		
	Essential	*Primary*	*Secondary*
Porosity 1) 2) Isolated Largest pore diameter Cluster: Largest pore diameter, mm Max. length along the weld of projected pore area, mm	 t/5, max. 4 2 20	 t/4, max. 6 3 25	 t/3, max. 6 4 30
Slag inclusion 1) 3) Max. width, mm Max. length, mm	 t/5, max. 4 t	 t/4, max. 6 2t	 t/3, max. 6 4t
Incomplete penetration, length 5) 6), mm	Not accepted in connections where full penetration is required	$\leq t_0$, max. 25	$\leq 2t_0$, max. 50
Lack of fusion, length 5) 6), mm	Not accepted		$\leq 2t_0$, max. 50
Cracks	Not accepted		

1) If the distance between similar defects (pore or slag) is less that the largest extent of the defects, they are to be considered as one continuous defect. If the amounts of pores or slag may mask other defects, the examination is to be supplemented with radiographic or ultrasonic testing.

2) It the distance between pores is less than 3 times the diameter, the pores are said to form a line or a cluster. Pores on a line must not e located in the weld surface.

3) Defects of lengths in direction of the weld exceeding 3 times their widths, form a line. If the distance between slag lines is less than 3 times the largest extent of the cross section of the defect, the lines are considered as one defect. See Fig.2.

4) If parallel slag lines are found, the examination is to be supplemented with ultrasonic tests.

5) Defects on a line where the distance between the defects is shorter than the longest defect, are to be regarded as one continuous defect.

6) Not surface open. For incomplete penetration or lack of fusion on root side of welds for which back welding is not required, see Table G4.

Table G6 Ultrasonic testing

Indication	*Category of member*		
	Essential	*Primary*	*Secondary*
Echo height above (ref. level) Max. length 1), mm	50% t/3, max. 10	100% t/2, max. 20	100% t, max. 20
Cracks in transverse weld direction not acceptable regardless of echo height above 20% of reference level			

1) Length defined as distance where indication reach or pass the stated percentage or reference level

SECTION 3
STRUCTURAL DESIGN AND STRENGTH OF CRANES

A. Group Classification of Lifting Appliances

A 100 General

101 For the purpose of applying requirements concerning strength of structural and mechanical components, cranes and components are to be classified into groups according to the duty performed.

The group to which a crane as a whole or a component belongs depends on the utilisation of the crane or component with respect of frequency of use as well as with respect to magnitude of loads in relation to maximum load.

102 For the crane as a whole and normally also for several of the structural components the frequency of use may be expressed by the expected (calculated) number of hoist cycles (n) during the planned life (t_1). The magnitude of loads in relation to maximum load may be expressed by, for instance, a number indication to what extent the crane lifts the maximum load (Safe Working Load) or only a lesser load.

For cranes where the safe working load depends on the allowed maximum overturning moment or allowed maximum moment on the structure, the group classification may also be based on the frequency with which the allowed maximum moment can be expected.

103 For structural components in which the stress variation is significantly different from the hoist load variation, stress cycles are to be considered instead of hoist cycles, and stress to maximum stress ratios are to be considered instead of the load to maximum load ratios. Otherwise the method of specifying utilisation is as given in 102.

104 For mechanisms the frequency of use may normally be expressed by assumed average daily operating time. (A mechanism is considered to be in operation only when it is in motion).

The utilisation with respect to magnitude of loads may be expressed by a number indicating to what extent the mechanism operates with maximum load or only with a reduced load.

A 200 Definition of groups of cranes and components and application to strength calculations

201 For the purpose of group classification the FEM/I–12–1970 (Federation Europeenne de la Manutention) or equivalent national standards for cranes may be referred to.

The method of group classification on one side and the calculation procedure and the specific requirements on the other, are to be consistent.

Guidance note:
If not otherwise documented by statistical evidence and/or limitation with respect to operational performance the following guidance apply (terminology as per FEM/1–12–1970).

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

Table A1 Group classification of lifting appliances

Definition of crane	*Class of utilisation*	*State of loading*	*Group*
Cranes for exceptionally low service time, e.g. BOP cranes	A	0	1
Workshops and similar industrial cranes with hook	B	1	3
Overhead travelling cranes for maintenance purpose	A	1	2
Pipe rack cranes	A	1	2
Store room cranes	A	2	3
Jib or gantry cranes for container service	B	2	4
Dock side and ship-yard jib cranes	B	2	4
Shipboard cranes	B	2	4
Offshore cranes, whip hoist	B	2	4
Offshore cranes, main hoist	A	1	2
Hose handling crane	A	2	3
Provision crane	A	2	3
For cranes with safe working load more than 250 tons the group-classification can normally be one group lower, but at least group 1, and for cranes fitted with grab or magnet instead of hook, the group classification shall be one group higher than according to the table.			

B. Design Loads

B 100 General

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

a) Principal loads (see B200).

b) Vertical loads due to operational motions (see B300).

c) Horizontal loads due to operational motions (see B400).

d) Loads due to motion of the vessel on which the crane is mounted (see B500).

e) Loads due to climatic effects (see B600).

f) Miscellaneous loads (see B700).

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

a) The loads which are directly dependent upon the action of motors or brakes, and

b) The 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.

103 The loads mentioned in 101 and 102 are to be determined and applied in accordance with B200 through B800 below. Evidently, for many cranes and components some or other of the defined loads will never be present. Note that in the following it is not always distinguished clearly 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».

B 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 of 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 are to be taken into account, and are to 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 600.

203 For cranes mounted on floating vessels the horizontal components of S_G and S_L are to 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 B1. These values are considered as minimum but may be specially considered provided statistically evidence or separate means/operational conditions prove that list and trim could be assessed smaller.

Table B1 Minimum heel and trim angles, still water

Type of vessel	*Heel*	*Trim*
Ships and vessels having ship-shape hull proportions	Min. 5°	Min. 2°
Barge of length less than 4 times breath, and catamarans	Min. 3°	Min. 2°
Semi-submersibles	Min. 3°	Min. 3°
Submersibles and jack-ups	Min. 1°	Min. 1°

B 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 is so defined that it corresponds to physical vertical 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 are to be taken into account by multiplying the working load by a «dynamic coefficient», Ψ.

The dynamic coefficient covers inertia forces and shock.

302 The dynamic coefficient 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
= 9.80665 m/s
W = working load (see B201) (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 may be equal to $0.75 \cdot 10^5$ N/mm^2 based on metallic area of rope.

303 For shipboard cranes and industrial cranes the dynamic coefficient Ψ for design purposes need not to be greater than:

ψ = 1.3 for wire rope suspended systems e.g. jib
ψ = 1.6 for overhead travelling cranes or cranes of similar design.

The dynamic coefficient shall not be taken less than:

ψ = 1.15 for $10\text{kN} < W \leq 2\,500$ kN
ψ = 1.10 for $W > 2\,600$ kN.

304 For offshore cranes the dynamic coefficient Ψ for design purposes shall not be taken less than:

ψ = 1.3 for $10 \text{ kN} < W \leq 2\,500$ kN
ψ = 1.1 $W \geq 5\,000$ kN

Linear interpolation to be used for intermediate values of W.

When the dynamic coefficient Ψ is calculated by the formula given in 302, the following shall be taken into account when assessing the relative velocity between load and hook at the time of pickup, V_R:

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

V_L = hoisting speed (m/s)
V_{in} = downward velocity (m/s) of the load at the time of pick-up (due to movement of the deck of a supply vessel from which the load is picked)
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 vessels/offshore unit or hydrodynamic response of an underwater object to be handled.

305 The hoisting speed should normally not be less than

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

for cranes used for unloading and loading supply vessels.

Where

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

The crane will not be certified for handling loads from a supply vessel in significant wave heights which – included in the formula – would require a hook speed exceeding the available hook speed.

306 For cranes located on fixed offshore platforms or semi-submersible platforms the following values for V_L and V_{in} may be used for the calculation of the dynamic coefficient when picking up loads from a supply vessel.

V_L = available hoisting speed or 0.6 H_{sign},
whichever is the smaller.

$$V_{in} = \begin{Bmatrix} 0.6H_{sign}\ (\text{m/s}) & \text{for} \quad 0 < H_{sign} \leq 3(\text{m}) \\ \left[1.8 + 0.3(H_{sign} - 3)\right](\text{m/s}) & \text{for} \quad H_{sign} \geq 3(\text{m}) \end{Bmatrix}$$

307 For offshore jib cranes, for loading and unloading of supply vessels etc. and where the operator is placed above the slewing bearing, the dynamic coefficient Ψ to be applied for the design of the crane foundation including pedestal and slewing bearing with fasteners is to be taken as minimum 1.3 times the dynamic coefficient applied for the design of the crane members, but is not to be taken less than 2.0.

308 For practical purposes an offshore crane may be designed for a dynamic coefficient equal to the minimum values given above, provided the capacity of the crane is referred to «zero sea state» or platform capacities.

In such cases the crane is, at its operating stand, to have dynamic load charts or tables, i.e. chart or table giving the safe working load for various wave heights and boom angles or load radii.

B 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:

1) Inertia forces due to acceleration or deceleration of horizontal motions (see 402).
2) Centrifugal forces (see 403 and 404).
3) Forces transverse to rail resulting from reeling and skew motion (see 405).
4) Buffer loads (S_T) (see 406).

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 are to 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 under starting and stopping of travelling-, traversing- and slewing motions. The inertia due to angular acceleration deceleration) of rotating machinery components is to 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 having brakes, or on each driven wheel.

For revolving cranes except offshore cranes a lateral force of

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

Can be assumed at the jib head where:

r = load radium (m)
(distance from revolving axis to load W)
n = revolution per minute (BPM).

403 Radial force on revolving cranes may be determined on the basis of maximum angular velocity and radius to the considered mass. Except for offshore cranes, a radial force equal to $(W/1000)n^2 \cdot r$ can be assumed at the jib head.

404 For offshore cranes the following horizontal forces at jib head should be assumed.

Lateral force (side lead):

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

Radial force (off lead):

$$(W/1000)\ n^2\ r$$

or

$$\psi \cdot W = \left[\frac{2.5 + 1.5 H_{sign}}{H_W + l \cdot \sin\theta}\right]$$

whichever is the greater.

L = length of jib.
H_W = distance from jib heel bearing to supply boat deck.
θ = jib angle to the horizontal.

405 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.

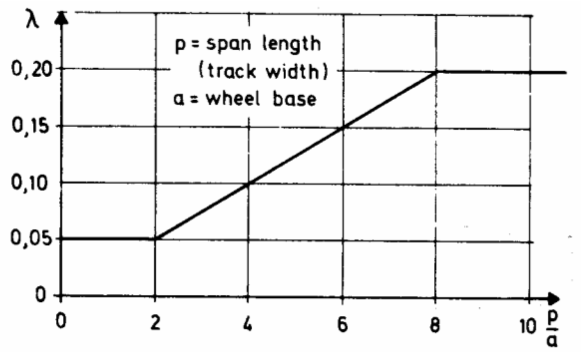


Fig. 1 Lateral wheel force.

406 The following rules 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 to 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 is to be based upon the buffer 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 to be considered.

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

501 Inertia forces due to ship motion are to be calculated in accordance with the rules for Classification of Steel Ships, Pt.3 Ch.1 Sec.4 B «Ship Motions and Accelerations».

502 Inertia forces due to motion of the mobile offshore unit (semi submersible, self-elevating unit, etc.) are to be calculated in accordance with the rules for Classification of Mobile Offshore Units, Pt.3 Ch.1 Sec.4 D600 and Ch.2 Sec.2 C100 and Sec.3 C100.

B 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, and
— loads due to temperature variations.

602 Loads due to wind are to be calculated in accordance with Appendix A or a recognized 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 are to 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 is normally not to be taken less than 65°C. For indoor cranes possible special sources of heat are to be considered. (Note that the maximum and minimum temperatures are always to be taken into account when selecting the materials).

B 700 Miscellaneous loads

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

— 300 da N for maintenance gangways and platforms where materials may be placed
— 150 da N for gangways and platforms intended only for access of personnel
— 30 da N as the horizontal lateral force which may act outwards or inwards on handrails and toeguards.

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, is to be included in the principal loads, see 201.

B 800 Loads for strength analysis of mechanisms

801 In these rules mechanism means the devices needed to cause or to stop a relative motion between two rigid parts of the 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.

802 A mechanism will always have to transmit forces when it is in motion, i.e. it has to 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.

803 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.

C. Cases of Loading

C 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 C200).
— Case II: Crane working with wind. (See C300).
— Case III: Crane subjected to exceptional loadings. (See C400).

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

C 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 B200.
— the vertical loads due to operational motions according to B300.
— the horizontal loads due to operational motions (S_H), according to B400.
— the two most unfavourable effects are used, excluding buffer loads.

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

$$S_G + \psi S_L + S_H$$

202 For cranes mounted on floating vessels horizontal components of S_G and S_L to be taken into account as explained in B202 and B203.

203 With regard to S_H the following should be noted: Maximum two of the effects mentioned in B401 (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 is not to be combined with the effect of other motions.

C 300 Case 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:

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

S_W is to be determined in accordance with B600. 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 and the difference is normally S_W only. For cranes mounted on floating vessels the “horizontal” components of S_G and S_L are to be based on increased angles compared with Case I. Minimum angles are to be 1.5 times the values given in Table B1.

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

C 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 B406 (Symbol S_T).
— inertia forces due to motion of the vessel on which the crane is mounted, according to B500 (Symbol S_M).
— loads due to «out of service» wind according to B600 (Symbol $S_{W\,max}$).

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:

$$\text{IIIa} : S_G + S_L + S_T$$

$$\text{IIIb} : S_G + S_M + S_{Wmax}$$

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 and S_G and S_L are to be considered for estimated maximum rolling and pitching angles, including possible initial heel and trim.

D. Strength Calculations

D 100 General

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

— excessive yielding (See D200)
— buckling (See D300)
— fatigue fracture (See D400).

102 The safety is to be checked 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 are to be considered.

103 The strength calculations are to be based on accepted principles of statics and strength of materials. When applicable, plastic analysis may be used. If elastic methods are not suitable to verify safety, for instance due to prestressing, 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 these rules there will be only a formal difference between the two methods. The relation is simply that

Safety Factor = Load Factor times Material Factor.

$$(F_S = \gamma_f \cdot \gamma_m)$$

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

D 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, in Table D1, 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 connection 0.8 σ_u instead of σ_y.

202 When using elastic analysis the permissible stresses (or the required safety factors) given in Table D1 refer in case of combined stresses to the equivalent stress according to von Mises.

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

204 Joints are not to 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 recognized codes.

D 300 Checking with respect to buckling

301 The guiding principle is that the safety against buckling is to 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 D1, should represent the normal requirement. However, other values may be required or allowed, for instance due to uncertainty in the determination of the critical stress (or load) or due to the post-buckling behaviour. Required factors are given for various types of structures and conditions in Table D2.

302 The safety factors given in Table D2 are based on the assumption that the critical stresses (or loads) are determined by recognized methods, taking possible effects of geometrical imperfections and initial stresses into account. Elastic buckling in Table D2 means that the elastic buckling stress does not exceed the yield strength.

D 400 Checking with respect to fatigue

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

1) Component group according to A.
2) The material used and the notch effect at the point being considered.
3) The fluctuation factor = $\sigma_{min}/\sigma_{max}$
4) 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 specialised literature.

402 Fatigue considerations are to be made for Case I for all types of cranes. In addition, for shipmounted cranes where the transit condition may have considerable duration, it may be required to consider fatigue effect on certain components in Case III. The effect of wind, however, needs not to be taken into account.

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

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

Table D1 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
Safety factor, plastic (ult. str.) analysis	1.69	1.51	1.25
Permissible stress, elastic analysis	$\sigma_y/1.50$	$\sigma_y/1.33$	$\sigma_y/1.10$
Load factor, limit state method	1.30	1.16	0.96
Material factor, limit state method			
Elastic analysis	1.15	1.15	1.15
Plastic analysis	1.30	1.30	1.30

Table D2 Safety factors for the checking with respect to buckling			
Type of structure member	F_S or $\gamma_f \cdot \gamma_m$		
	Load Case I	*Load Case II*	*Load Case III*
Bars, frames and stiffening systems of plates and shells Elastic buckling Elastic plastic buckling	 1.86 1.69	 1.66 1.51	 1.38 1.25
Plates redistribution not possible Elastic buckling Elastic plastic buckling	 1.86 1.69	 1.66 1.51	 1.38 1.25
Plates, redistribution possible Elastic buckling Elastic plastic buckling	 1.59 1.45	 1.42 1.29	 1.18 1.07
Shells, redistribution not possible Elastic buckling Elastic plastic buckling	 2.20 1.69	 1.96 1.51	 1.63 1.25
Shells, redistribution possible Elastic buckling Elastic plastic buckling	 1.98 1.52	 1.77 1.36	 1.46 1.13

E. Design and Strength of Particular Components

E 100 General

101 These rules do not attempt to make a clear distinction between structural and mechanical components. A mechanism, as defined in B801, may well contain components which could be defined as structural components. Such components are to be checked according to D. 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 B802. The term «particular components» may mean structural as well as mechanical components.

102 Components which transmit forces, whether «structural» or «mechanical», and which are not directly or completely covered by these rules, are to be designed and calculated in accordance with applicable recognized codes or standards. To the extent applicable, FEM/I is advised.

E 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 – can e.g. estimated in accordance with British Standard 2573 :Part l :1983.

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

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

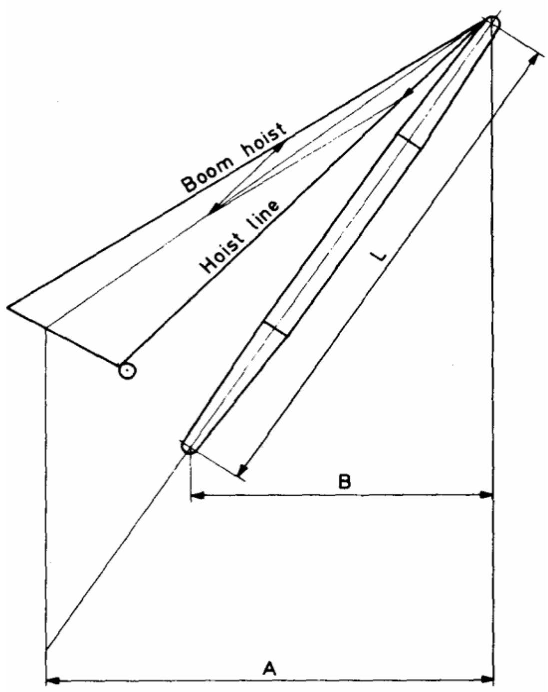


Fig.2 Effective length of jib.

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

The following correction factors may be used for latticed jibs:

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

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

i = radius of gyration, see 205

205 The overall slenderness ratio l_{eff}/i of the jib in each plane can 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 is to be made for tapering off of cross section towards jib ends.

206 Stresses arising from axial compression and bending are to comply with the requirements of recognized combination formulae.

E 300 Slewing bearing for jib cranes

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

1) Plastic deformation of rolling elements and raceways (raceway capacities).
2) Fatigue of critical local sections of outer and inner rings.
3) Fatigue of bolts.
4) Yield limit load (capacity) of the slewing bearing as a whole, based on the capacities of bolts and ring cross sections – with due regard to the rigidity of the structures supporting the (fixed and the revolving) rings.

The slewing bearings are specialized components, and the design criteria for a given type are as far as practicable to be based on tests carried out for that particular type. Item 4), however, will normally not be sufficiently covered by tests, and is to be checked by calculations as indicated in 302.

For design loads see also B307.

302 The vertical component of rolling element forces on the raceway (roller element track) is assumed to vary linear 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

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

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

M_k = overturning design moment on the slewing bearing. Design dynamic coefficient is included.
F_a = axial design force on the slewing bearing. Design dynamic coefficient is included.
D = raceway (track) diameter.

303 Slewing ring fasteners (bolts) are to have a yield capacity per bolt (i.e. stress area of bolt, A_S, times the material yield stress, f_Y) not less than

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

pr = degree of permanent prestressing related to yield (100% = 1.0)
F_A = maximum vertical raceway load per bolt sector at the rear ring
χ = F_R/F_A
F_R = maximum horizontal (radial) load per bolt sector

a, b and c as per Fig.3.

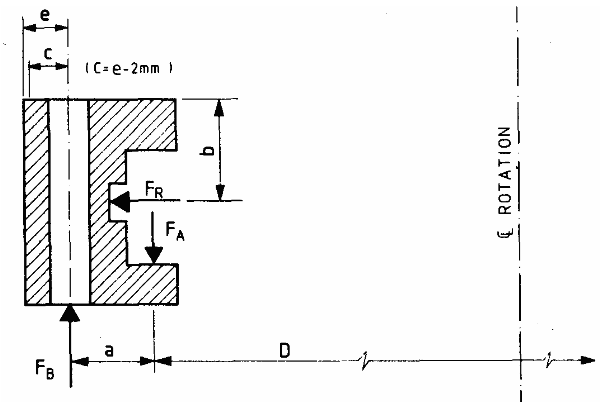


Fig.3 SLEWING RING MEASURES

304 Bolt material having yield strength exceeding 900 N/mm (10.9 ISO strength class) should be avoided.

Bolts for offshore crane bearings shall have rolled threads and rolling should preferably be performed after quenching and tempering of the bolts.

305 Slewing ring fasteners are to be prestressed according to a written procedure. The degree of permanent prestressing is to be as high as possible without producing yield in bolt material during prestressing. The degree of permanent prestressing is at least to 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.

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

where

β = 0° for «multi-row» bearings.
β = 30° for single-row bearings.
β = 45°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).

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

307 Yield limit load (capacity) of the slewing bearing shall be evaluated considering equilibrium between the 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. on the «end surfaces» of the considered «element»).

308 The safety factors for slewing rings are not to be less than:

1.50 = against yield (stress evaluation)
1.70 = $\gamma_f \cdot \gamma_m$ i.e. ratio between ultimate carrying capacity (ring and bolts) and calculated load on the slewing ring.
1.5 = against fatigue referred to stresses (90% probability) applying a load spectrum factor of 0.7.

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 is arranged this requirement may be waived.

The retention device shall at least have the equivalent carrying capacity as the slewing bearing.

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

E 400 Pedestal and pedestal adapter for jib cranes

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

For design loads, see also B307.

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

403 Local bending moments due to load on the raceway shall be considered with respect to thickness of the connecting flanges and connecting pedestal elements.

404 The thickness of the connecting flange shall at least be the greater of

$$t = \sqrt{\frac{10F_A\left[a - 1/2d_b + \chi \cdot b\right]}{s \cdot \sigma_y}}$$

and

$$t = 1.75\ d_b$$

d_b =Diameter of bolt hole.
s =Bolt spacing minus diameter of bolt hole.

405 When the raceway diameter is not equal to the pedestal diameter of a cylindrical pedestal and/or radial forces act on the rings, supporting brackets may be required under the flange.

Normally there shall be a full penetration weld between the pedestal shell and the flange.

406 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.

SECTION 4
CONVENTIONAL CARGO GEAR, CARGO RAMPS AND MOVABLE CARGO DECKS

A. General

A 100 Definitions

101 Conventional cargo gear or derrick systems are lifting appliances comprising:

— mast or derrick posts
— shrouds and stays
— cargo runners and cargo chains
— span tackle (topping wire rope systems)
— guys
— hooks, sheaves and blocks
— fittings (shackles, swivels, eye plates, rings, triangle plates etc.).

102 Ramps are movable ramps for vehicles onboard ships.

103 Movable cargo decks are decks onboard ships for the transport of vehicles.

A 200 Scope

201 The requirements of this section shall be complied with in cases where the issue of a «Register of ship Cargo Gear» is requested. See also Sec.l.

A 300 Classification

301 The structural strength and support of masts, derrick posts, standing rigging and movable cargo decks are class items and shall always be approved by the Society for ships classified with the Society.

A 400 Operational limitations

401 The cargo handling systems are presumed only to be operated in harbours or within sheltered waters.

B. Basic Requirements

B 100 Materials

101 Selection of material grades for plates and section is to be based on material thickness and should basically comply with Sec.2.

However, NV-steel grades as given in Table B1 will normally be accepted.

Table B1 Plate material grades

Thickness in mm	*Normal strength structural steel*	*Higher strength structural steel*
$t \leq 12$	A	A
$12 < t \leq 25$	B	A
$25 < t \leq 50$	D	D
$t > 50$	E	E

B 200 Wire ropes

201 For wire and rope materials and construction of steel wire ropes, see Sec.2.

For testing of steel wire ropes, see Sec.6.

B 300 Welding and workmanship

301 Welding and workmanship shall generally comply with Sec.2 G.

Radiographs shall normally meet the requirements to group blue according to «IIW Collection of Reference Radiographs of Welds». However, scattered porosity according to group green may be accepted.

C. Derrick Systems

C 100 Rigging plan and force diagram

101 Lay out of swinging derricks, heavy lift derricks or whether union purchase system is intended shall be indicated on the rigging plan.

102 Arrangement plan of shroud and stays on stayed masts/derrick posts shall be submitted.

103 A diagram of forces for each derrick rig shall be submitted containing the following combinations:

— number of derricks working simultaneously on one hatch
— number of derricks working simultaneously outboard to one side of the ship
— whether one or two pair of derricks where the derricks are arranged for operation in union purchase.

104 In the case of union purchase the following shall be included in the rigging plan:

— minimum headroom below the triangle plate.
— maximum included angle between the cargo runners.

C 200 Basic design assumptions

201 A basic angle of heel of 5° and angle of trim of 2° are assumed for the ship. Provided these angles are not exceeded the effect of heel and trim may in most cases be ignored in the strength calculations.

For angle of heel and trim exceeding above figures the effect shall be taken into consideration.

202 The cargo handling system shall be designed for the forces exerted in the system from the safe working load, SWL multiplied by a design coefficient.

$$k = 1.25 \quad \text{for SWL} \leq 50 \text{ kN}$$

$$k = 1.1 \quad \text{for SWL} \geq 600 \text{ kN}$$

For intermediate values of the SWL linear interpolation is applied.

203 The most unfavourable position of derrick booms shall be considered in the strength evaluation of the cargo handling system.

C 300 Allowable stresses

301 The total stress at any particular location in the mast (derrick post) shall not exceed the allowable stress considering the following:

— global overturning moment = $\Sigma(k \cdot SWL \cdot l_d \cos\alpha)$
— vertical (axial) forces
— bending moments and torsional moments resulting from cross trees (if fitted) and from offset of the forces.

l_d = length of derrick boom.
α = boom angle to the horizontal.
k = the design factor.

Σ = the vector sum of external moments on the mast resulting from the SWL and derricks being operated simultaneously.

302 α is the lowest angle – for practical considerations – of the boom to the horizontal, but shall not be less than 15º where SWL ≤ 100 kN or 25º where SWL > 100 kN

303 For members made of structural steels the safety factors for load case 1 of Tables D1 and D2 in Sec.3 shall be applied. See also Sec.3 D400.

Stresses according to load case 2 of Table D1 and D2 in Sec.3 may be allowed for SWL > 600 kN provided special detailed calculations are found acceptable taking into account:

— effect of weight of the various members
— effect of heel and trim
— eccentricities of forces acting
— preload of any stays and means for controlling the tension in stays are available.

304 The safety factor for steel wire ropes shall not be less than

$$SF = \frac{10^4}{0.885SWL + 1910} \cdot \frac{1}{k}$$

but shall not be less than 3 or need not be taken more than 5.

The SWL (kN) applied in the formula shall be the highest SWL for which the derrick system is designed.

305 Where not otherwise demonstrated by testing a combined allowance for friction and bending of the wire ropes equal to:

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

shall be considered in the calculation of the load in cargo runner, span tackle and slewing guys.

306 The minimum plate thickness of masts and derrick posts is normally 7.5 mm. Masts and posts are to be increased in thickness or additionally stiffened at the deck, goose-neck and hounds.

C 400 Union purchase arrangement

401 Where the derricks are arranged for operation in union purchase the scantlings and arrangement of the derrick system shall also be suitable for single slewing derricks.

402 The maximum load in the system shall be determined based on:

— minimum operational angle of either derrick but not less than 15º to the horizontal
— maximum included angle between the cargo runners not exceeding 120º
— outreach beyond the midship breadth of the ship. Minimum outreach is 4.0 metres
— minimum headroom to the triangle plate from top of hatch or bulwark whichever is the higher – of not less than
4 metres where SWL(u) does not exceed 20 kN
5 metres where SWL(u) exceeds 20 kN.

403 The working range of the rig shall be indicated on a separate plan and be attached to Form No. CG 2U.

C 500 Stayed masts and derrick posts

501 The mast (derrick post) and stays will share the load acting on the system in the ratio of stiffness of stays respectively stiffness of the mast to the total stiffness of mast and stays.

From the force diagram and/or by calculations the load on the mast resulting from the cargo runner, span tackle and derrick boom including the effect of cross trees if fitted are to be established by considering the equilibrium between the elastic elongation of the stays related to the deflection of the mast caused by the above mentioned forces. The forces in the stays can be calculated.

Stays or shrouds of wire rope which will be subjected to a «negative» force i.e. being compression members, shall be ignored in the calculations.

The buckling strength of steel members acting as stays where subjected to compression shall be checked.

502 The combined stress from bending, compression and shear in each section of the mast shall not exceed the allowable stress.

Further, the overall stability of the mast due to axial compression and bending shall be checked to satisfy

$$\frac{\sigma_{ac}}{(\sigma_{ac})_{allow}} + \frac{\sigma_{bc}}{(\sigma_{bc})_{allow}} \le 1$$

Where

σ_{ac} = the calculated axial compression stress.
$(\sigma_{ac})_{allow}$ = the permissible compression stress in axially loaded compression member i.e. the critical flexural buckling stress divided by the safety factor.
σ_{bc} = the calculated maximum compressive stress due to bending.
$(\sigma_{bc})_{allow}$ = the permissible compression stress.

503 The maximum compressive stress due to bending of the mast can be assessed by:

$$\sigma_{bc} = \frac{C_m \Delta l (l_m - H)}{Z_m} (N/mm^2)$$

C_m = stiffness of mast (N/mm).
Δl = total deflection of mast and stays (mm).
l_m = Length of mast from deck or top of mast house to hounds (mm).
H = height of derrick heel above deck or top of mast (mm).
Z_m = section modulus of mast at the derrick heel fitting (mm^3)
The diameter d_0 and the plate thickness t_0 of the mast are supposed to be maintained from the deck and not less than 1m above the derrick heel fitting. Above this level, the diameter and the plate thickness may be gradually reduced to 0.75 d_0 and 0.75t_0 at the hounds.

The total deflection of mast and stays can be assessed by:

$$\Delta l = \frac{P_H \cdot 10^3}{C_m + C_W} (mm)$$

Using stiffness of mast,

$$C_m = \frac{2.4 E_m I_m}{l_m^3} \qquad (N/mm)$$

E_m = modulus of elasticity of mast (N/mm^2)
I_m = modulus of inertia of mast (mm^4)

Stiffness of wire rope stays/shrouds:

$$C_w = E_w \cdot G$$

E_w = modulus of elasticity of wire, $7.5 \cdot 10^4$ N/mm^2.

G = the smaller of

$$\sum \frac{f_c^2}{l_s^3} \quad \text{and} \quad 1/4 \sum \frac{f(1.7a + c)^2}{l_s^3}$$

f = area (mm) equal to minimum breaking load of the wire rope divided by the tensile strength of the wires.
a = athwartship distance in mm from the mast to the deck attachment of shroud in question, see Fig.1.
c = longitudinal distance in mm from the mast to the deck attachment of shroud in question, see Fig.1.

With reference to a transverse plane through the mast, c is to be taken negative (–) for shrouds fitted on the same side as the derricks in question and positive (+) for those fitted on the opposite side.

l_s = length shrouds (mm).
Σ = summation of:

a) Load functions for derricks simultaneously serving one hatch
b) Support function for effective shrouds when loads are as indicated in a), i.e. all shrouds forward or aft of the mast whichever is opposite to the hatch in question.
c) Load functions for derricks simultaneously working outboard.
d) Support functions for effective shrouds when loads are as indicated in c), i.e. all shrouds on one side of the ship; however, the attachment to the deck is not to exceed 0.3 B forward or aft of the mast.

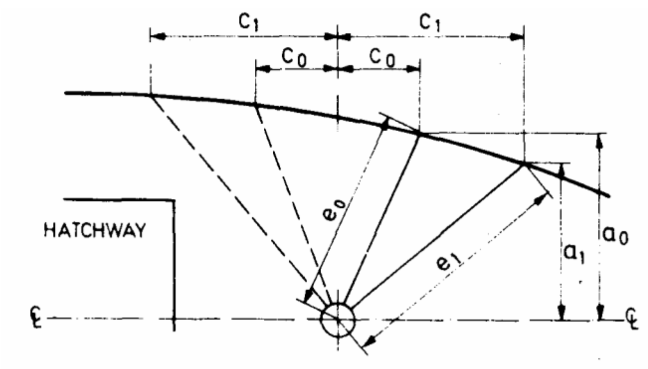


Fig. 1 Arrangement of shrouds.

and

$$P_H = \frac{SWL \cdot k \cdot l_d}{l_m - H} (kN)$$

l_d = length of derrick in mm. Where the working position of the derrick is such that the angle between the centre line of the derrick and the horizontal always exceeds 15°, l_d is taken as the greatest horizontal projection of the derrick.

504 The maximum axial compression stress in the mast can be assessed by:

$$\sigma_{ac} = \frac{P_A \cdot 10^3}{A_m}$$

P_A = total axial compression force in the mast (kN).
A_m = cross-sectional area of the mast (mm^2).

The total axial compression force in the mast is to be

$$P_A = \Sigma P_{stay} \cos \beta + Q_1$$

Where:

β = angle between the stay and the mast.
P_{stay} = forces in the stays due to the deflection of mast and stays (kN).

$$Q_1 = \sum SWL \cdot k + \frac{\sum SWL \cdot k}{n} \sqrt{1 + \left(\frac{l_d}{l_m - H} \right)^2} \; (kN)$$

n = 1, 2, 3 etc. for single, double and treble blocks etc., respectively.

The forces in the stays due to the deflection of mast and stays and stays can be assessed by:

$$P_{stay} = E_W \, \Delta l \, F \, l_s \cdot 10^{-3} \text{ (kN)}$$

using

F = the greater of

$$\frac{fc}{l_s^{\,3}} \quad \text{and} \quad \frac{1}{2} \frac{f(1.7a + c)}{l_s^{\,3}}$$

505 Where masthead span blocks are attached to outriggers, the section modulus of the mast at the level of the outrigger is no to be less than:

$$Z = 12 \, r \, Q \text{ (mm}^3\text{)}$$

r = horizontal distance in mm from mast to masthead span blocks on outrigger.

$$Q = \sum SWL + \frac{\sum SWL}{n} \sqrt{1 + \left(\frac{l_d}{l_m - H} \right)^2} \; (kN)$$

ΣSWL= total load in kN which may be lifted by the derrick on one side of the centre line of the ship.

C 600 Unstayed masts and derrick posts

601 Where SWL ≤ 100 kN, and there is no crosstree of exceptional spread, the sectional modulus of unstayed masts or posts from deck level and to approximately 1 metre above the gooseneck can be assessed by

$$Z = \frac{2.3 \cdot 10^3}{\sigma_y} \sum \cdot SWL \cdot l_d \left\{ mm^3 \right\}$$

(SWL (kN), l_d (mm) as defined in 503, σ_y = material yield strength in N/mm.)

C 700 Derrick booms

701 The derrick booms shall be designed with due respect to:

— compression and bending stresses.
— overall stability.

702 The axial thrust in the boom and bending caused by offset of the forces are to be determined from the force diagram and/or direct calculation. The vector sum of bending moments shall be taken into account.

703 The maximum compression σ_N = (T/A) and bending stress σ_B = (M/Z) shall satisfy the following equation:

$$\frac{\sigma_N}{\sigma_R} + \frac{\sigma_B}{1.2\sigma_y} \le 1$$

T = axial force (N) in the derrick boom.
M = bending moment at derrick head.
Z = sectional moment at half length of derrick.

A = sectional area (mm) at half length of derrick.

$$\sigma_R = \frac{8\sigma_y - \left[l_d/(i \cdot 10^3)\right]^2}{3.6\sigma_y \left[l_d/(i \cdot 10^3)\right]^2 + 14} \text{ for} \left[l_d/(i \cdot 10^3)\right] \leq \frac{2}{\sqrt{\sigma_y}}$$

$$= \frac{1}{1.7\left[l_d/(i \cdot 10^3)\right]^2} \text{ for} \left[l_d/(i \cdot 10^3)\right] > \frac{2}{\sqrt{\sigma_y}}$$

l_d = length of derrick boom (mm).
i = minimum radius of gyration (mm).

For derricks manufactured from pipes with diameter d (mm) the formulae becomes

$$\sigma_R = \frac{\sigma_y - \left[l_d/(d \cdot 10^3) \cdot \sigma_y\right]^2}{3.6\sigma_y \left[l_d/(d \cdot 10^3)\right]^2 + 1.7} \text{ for} \left[l_d/(d \cdot 10^3)\right] \leq \frac{2}{\sqrt{\sigma_y}}$$

$$= \frac{1}{13.5\left[l_d/(d \cdot 10^3)\right]^2} \text{ for} \left[l_d/(d \cdot 10^3)\right] > \frac{0.705}{\sqrt{\sigma_y}}$$

704 The formulae in 703 apply to derrick booms with constant sectional area. Where the sectional area varies, σ_R should be corrected.

In the case of a boom built up by 3 pipes, the mid pipe being of length «a» and diameter «d_2», the end pipes having diameter «d_1», σ_R in 703 shall be multiplied by a correction factor « m», given in Table C1.

Table C1 "m" factor

a/l_d $(d_1/d_2)^3$	*0.4*	*0.6*	*0.8*
0.4	0.67	0.85	0.97
0.6	0.82	0.92	0.98
0.8	0.92	0.96	0.98

D. Cargo Ramps and Movable Cargo Decks

D 100 Structural strength

101 Requirements to structural strength and design are given in rules for Classification of Steel Ships Pt.5 Ch.2.

D 200 Mechanism and operational safety

201 Requirements to hoisting, fittings and safety devices are covered by Sec.5.

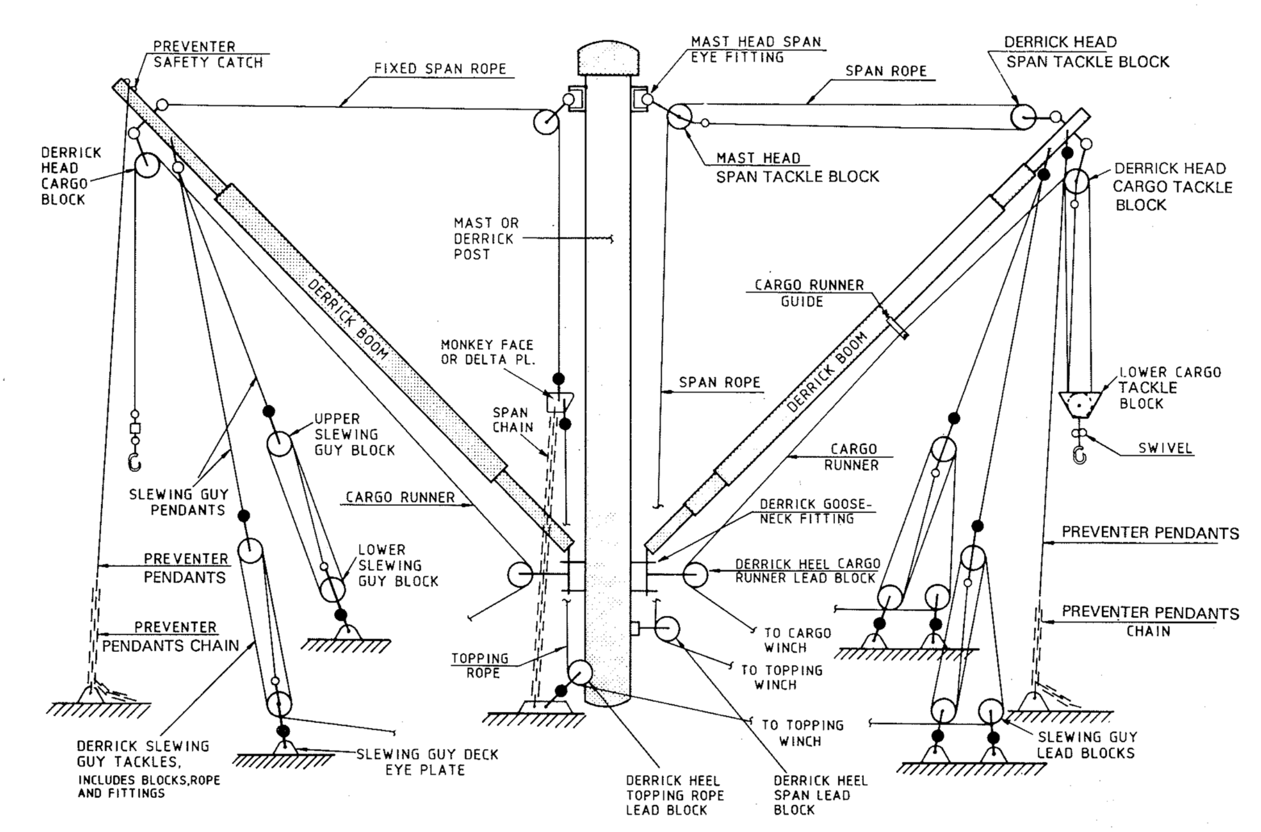


Fig. 2 TYPICAL RIGS FOR LIGHT LIFTS

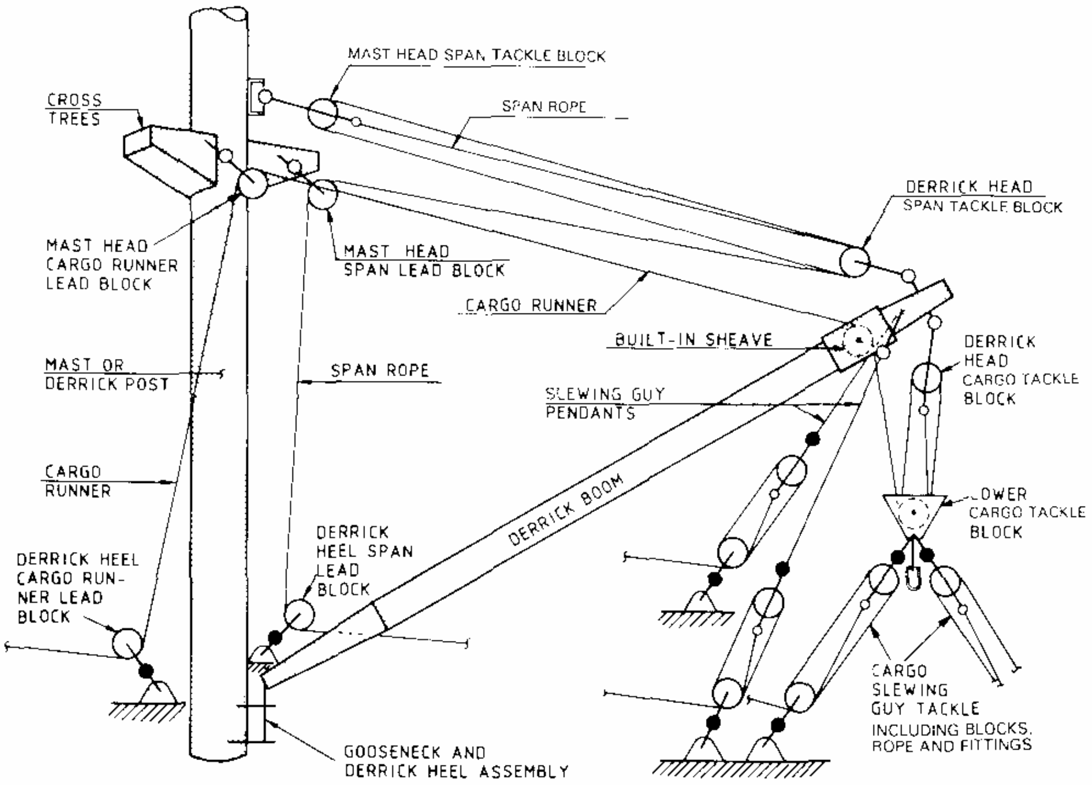


Fig. 3 ALTERNATIVE RIG FOR HEAVY LIFTS

SECTION 5
MACHINERY AND EQUIPMENT

A. Basic Requirements

A 100 Materials

101 The materials applied are to be in compliance with Sec.2 or relevant recognized codes or standards.

102 Materials with low heat resistance are not to be applied where a fire may cause unacceptable consequences of a damage, such as collapse, outflow of flammable fluids etc.

Non-metallic materials are to be flame retardant in accordance with a recognized standard.

A 200 Arrangement and general design of components and equipment

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

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

203 Bolts and nuts exposed to dynamic forces and vibrations are to be properly secured or prestressed.

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

205 Arrangement for adequate lubrication of bearings and gears is to be provided.

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

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

208 Crane seating and their supporting structures are to 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 seating are to meet the standard required by the manufacturer of the slewing ring and general engineering standards.

209 Cranes are to be arranged with emergency escape way in addition to the main access.

A 300 Functional capability

301 Components, systems and equipment are in general to be so arranged that a single failure of any active component will not cause total loss of the operational functions for a longer period of time. Active components in this context are any components transforming energy, e.g. pumps, electrical or hydraulic motors and brakes.

302 A single operational error is not to cause operational conditions which will reduce the safety for personnel, equipment or cargo.

303 Machinery or equipment normally operated by remote or automatic control is to have override possibility at the local operating position.

A 400 Ventilation

401 Forced ventilation (heating/cooling) is to be provided — when necessary — to ensure temperatures within the range required by Sec.1 D201.

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

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

A 500 Strength

501 The strength of components and equipment is generally to be in compliance with the rule requirements for the Duty Group of the crane in question (for duty group classification see Sec.3 A300).

Specific requirements for some important components are given in the following. Recognized codes and standards may be applied as a supplement to the rules.

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 Attachment of winches to their foundations are to be such that, for all possible load arrangement, the holding down bolts will have a higher load carrying capacity than the most heavily loaded steel wire rope attached to the winch.

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

103 The operating device is to be arranged to return automatically to the braking position when the operator releases the control.

B 200 Drums

201 Drum diameters are to be determined with due respect to:

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

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

The ratio D_p/d is normally not to 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 are to 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 considerations and approval will be required.

203 For all operating conditions, the distance between the top layer of the wire rope on the drum and the outer edge of the drum flanges is to be at least 2.5 times the diameter of the wire rope, except in the cases where wire rope guards are fitted to prevent overspilling 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 is to 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 are not to exceed 4°, see Fig.1. The groove is to be smooth. Advised radius of groove is 0.53 d (d = nominal rope diameter) and should be between 0.52 d <r <0.57 d.

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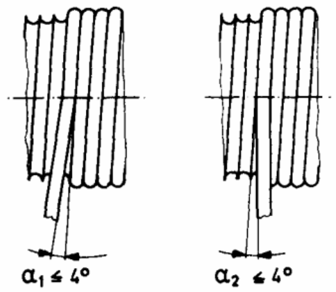

Fig. 1 Wire rope fleet angles.

204 Drums are either to 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 are to 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 is to be considered. The rope tension is in this case to include any amplifying coefficient and the dynamic coefficient ψ. If more unfavourable, however, the situation with forces directly dependent upon motor or brake action is to be considered.

206 The drum barrel is to 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 the amplification factors and dynamic coefficient taken into account. If the rope tension may vary systematically, such as when an object is lifted from the sea bottom and out of the water, this variation is to be taken into account.

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

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

σ_h = hoop stress in drum barrel
S = rope tension under spooling
p = pitch of rope grooving (= distance between ropes, centre to centre, within one layer)
t_{av} = average wall thickness of drum barrel
C = 1 for 1 layer
= 1.75 for more than 1 layer

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

208 The drum flanges are to 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, the pressure is assumed to be linearly increasing from zero at the top layer to a maximum value of

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

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.

B 300 Brakes

301 Apart from the slewing motion of a crane automatic braking systems are to be arranged and are to be activated when the operating device is brought to zero or braking position.

Winches and similar units used for the purpose of lifting people (man-riding winches) are to be provided with 2 brake systems, of which one may be manually operated.

302 Brake mechanisms are to be so designed that the brakes are activated upon failure of the power drive or the control system. Means are, however, to be provided for over-riding such systems at any time, if for reasons of safety this should be desirable.

303 Brake systems are to be designed in such a way that the operator cannot allow any load to fall freely or at a speed exceeding the design speed.

304 Means is also to be provided for lowering the loads in the event of power failure or control system failure.

305 Braking systems are to be such as not to induce shock loads.

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

307 Brakes are to exsert a torque not less than 80% in excess of the maximum torque on the brake caused by the loads being regarded as static loads. The lowest expected coefficient of friction for the brake lining with due consideration of service conditions (humidity, grease, etc.) is to be applied in the design calculations of braking torque capacity, but this coefficient of friction is not to be taken higher than 0.3.

308 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 is to be such that the braking torque capacity required by 307 will be obtained.

Particulars of spring performance are to be submitted.

309 Components of safety brakes shall be designed on the basis of a torque exerted on the brake by the maximum static loads applying a coefficient of friction which is the expected highest obtainable for the brake lining material. However, the coefficient of friction is not to be taken less than 1.5 times the coefficient of friction applied in the calculation of required torque as per 307. The material stresses in the components are not to exceed the allowable stresses for «load case 1» in Sec.3.

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

B 400 Steel wire ropes with fittings and anchorages

401 For wire and rope materials and construction of steel wire ropes, see Sec.2.

For testing of steel wire ropes, see Sec.6.

402 Length of wire rope for a lifting appliance is to 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 are to be in one length.

403 Steel wire rope safety factors for running application or forming part of sling and for mast stays, pendants and similar standing applications are to be the greater of:

— not less than the greater of 3 and

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

but need not exceed 5.

— SF = 2.3 • ψ

Ψ = design dynamic coefficient for the crane
SWL = Safe Working Load (kN)

404 The safety factor for wire ropes used for lifting people or manned objects is not to be less than 1.6 times the safety factor according to 403.

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

$$B = SF \cdot S$$

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.

406 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

is to be made for calculation purpose of «S» in 405.

407 In wire ropes for running application the number of wires is not to 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 is to 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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408 For rope anchorage properly designed rope sockets or self-locking wedge sockets shall preferably be used. Where wire rope clamps are used, the free length of rope end shall at least be 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.

409 A thimble or loop splice is to 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 are to be under and over against the lay of the rope. Splices are to 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.

410 Where other connections are fitted, the method of splicing is to be according to recognized codes and standards.

411 Except for offshore cranes taking loads from supply vessels, anchorage of the hoist rope to the drum is to have strength not less than 80% of the breaking load of the hoist wire rope.

412 For offshore cranes taking load from supply vessels 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 is to 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.

413 The rope anchorage for the boom hoist is at least to withstand the breaking load of the boom hoist rope.

414 All wire rope anchorages are to be easily accessible for inspection.

B 500 Sheaves

501 Sheaves shall comply with a recognized code or standard. In any case shall the sheave diameter for steel wire ropes 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 B203.

502 Sheaves are either to be castings or be gas cut and machined from steel plate. However, sheaves made from nylon castings may be accepted after special considerations.

503 Castings and plates for sheaves are to comply with Sec.2. However, for non-welded sheaves the required impact testing of the material will be waived.

Nodular cast iron used for sheaves shall have a minimum elongation (A_5) of 10%.

B 600 Hooks, shackles, sockets, swivels etc. (loose gear)

601 «Loose gear» is defined as a hook, ring, shackle, link, lifting beam, lifting frame or any similar article of equipment by means of which a load may be attached to a lifting appliance and which does not form an integral part of the lifting appliance.

602 Material requirements are given in Sec.2.

603 Design and strength of load hooks, shackles, sockets, swivels etc. are to comply with recognized codes or standards. Design load for hooks and corresponding loose gear is to be the greater of:

— 0.75 ψ SWL
— SWL.

Ψ is the dynamic coefficient for which the crane is designed.

604 The main and auxiliary hook (whip hoist) for offshore cranes are at least to meet the requirements in DIN 15400 machinery group 1 AM and 2M respectively. However, in the case 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.

605 Hooks are to be fitted with a safety latch or to 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.

606 Hook blocks are to have protective plates and are to be easy to handle from any side.

607 Hooks, shackles, chains, swivels etc. are to be marked with the safe working load. The crane manual is to contain information of necessary specifications for ordering replacements of hook, chains, shackles and swivels.

C. Power Systems

C 100 Prime movers

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

102 Dependent on the intended crane application emergency power supply may be required.

Guidance note:

Offshore deck cranes powered solely by diesel engine should preferably have 2 engines so arranged that functional capability will be maintained even in the case of failure to one engine.

Temporarily reduced capacity of the crane should in such failure mode be accepted.

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

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

105 The exhaust gas outlet of internal combustion engines is to have an effective spark arrestor. The outlet is to be led to the atmosphere at a safe distance from any hazardous area.

C 200 Power independency

201 Hoisting and derricking functions are to be independent of travelling and slewing functions.

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

D. Electrical Installations

D 100 General

101 Electrical installations are to comply with relevant and recognized codes or standards pertinent to the location of the crane.

102 Electrical installations for cranes on board ships and mobile offshore units classified by Det Norske Veritas are to meet the Society's rules for such objects.

103 Electrical motors for cranes on vessels with class notation **CRANE** are to have a certificate issued by Det Norske Veritas.

104 The design of electrical power systems for cranes is to be so arranged that possible regenerative power does not interfere with the operation of the vessel's electrical systems.

Guidance note:

The following codes and standards are recognized:

— Norwegian Standard NS 5513 — Cranes and Lifting Appliances
— Det Norske Veritas' rules for Ships Pt.4 Ch.8, «Electrical Installations»
— British Standard BS 5345 — Selection, Installation and Maintenance of Electrical Apparatus for use in Potentially Explosive Atmospheres.

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

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D 200 Plans and specifications

201 For the electrical system the following is to be submitted:

1) Drawings and specification of:
   a) switchboard
   b) distribution boards
   c) control panels.
2) Single line diagram of:
   a) power distribution
   b) lighting distribution showing full load, cable types and cross sections, make-type-rating of fuse and switchgear.
3) Schematic diagrams of:
   a) control system (with safety system)
   b) starting arrangement for engines.
4) Arrangement drawings showing:
   a) location of electrical equipment
   b) cable runs.

E. Hydraulic and Pneumatic Systems

E 100 Hydraulic systems

101 Hydraulic systems and their lay-out are to satisfy recognized codes or standards and engineering principles and shall as far as relevant or applicable comply with pertinent rules of Det Norske Veritas.

102 The fluid reservoir is to be designed with respect to:

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

103 Effective means for filtration and cooling of the fluid are to be incorporated in the system.

104 For the hydraulic system the following documentation is to be submitted:

a) System diagram of the total hydraulic system
b) Specification of hydraulic equipment
c) Functional description of the hydraulic system.

105 Flexible hoses and couplings are to be of approved type (type approval certificate issued by Det Norske Veritas is recommended).

106 Hydraulic cylinders and accumulators are to be separately approved.

E 200 Pneumatic systems

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

202 Air supply to instrumentation equipment is to be free from oil, moisture and other contaminants. The dewpoint is to be below 5°C for air in pipes located in crane engine room. In pipes outside the engine room the air is to have a dewpoint below $(T_D - 5)°$ C.

203 Components requiring extremely clean air are not to be used.

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

205 Piping and pressure vessels are to comply with relevant recognized codes and shall generally comply with Det Norske Veritas' rules.

E 300 Instrumentation

301 Components and installation shall as far as relevant comply with Det Norske Veritas' rules for Ships Pt.4 Ch.9, «Control and Monitoring Systems».

F. Safety and Safety Equipment

F 100 Operator's cabin

101 On offshore and shipboard deck cranes an operator's cabin will normally be required. This may as well 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 are to have windscreen wipers
- be adequately temperated (heated, cooled) and ventilated according to local conditions
- be of fire proof construction, have doors that can be readily opened from both inside and outside. Access/exit not to be obstructed by any boom elevation in the case of a derrick crane
- noise and vibration to remain within acceptable limits
- have a comfortable and purpose-designed seat from which all operations can easily be controlled. Foot rests to be arranged where necessary
- have crane controls marked and lit to show their respective functions.

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.

F 200 Platforms, rails and ladders

201 Safe means of access shall be provided to the cabin and any other part of a lifting appliance for the purpose of operation and required maintenance.

202 Ladders, platforms and rails shall comply with recognized standards and national regulations.

Platform shall be provided where deemed necessary for dismantling purposes and general maintenance of the lifting appliance.

F 300 Parking and precautions against wind loads

301 Lifting appliances are to 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.

F 400 Protection and precautions against fire

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

The number, capacity and location of fire extinguishers are to 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 are to be led to open air.

403 Cofferdams are to be arranged at fuel filling pipe.

404 Entrance doors to crane machinery spaces are to be self-closing.

405 It is to 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.

F 500 Safety devices and equipment

501 With due consideration of type and intended service, all lifting appliances for cargo handling shall be provided with safety equipment and safety systems as required in the following. Alternative arrangements/ equipment which will provide equivalent safe operation will be considered. Safety functions are not to induce damage or danger even if the movements are stopped from full speed and/or with full load. Monitoring of safety equipment is to be as required in Table Fl.

502 Lifting appliances are in general to be provided with:

- mechanical safety brakes on all movements in addition to any braking ability inherent in the driving mechanism of the crane or drums (see B300)
- overload protection (see F507 and 508)
- load indicator or load moment indicator (see F509)
- limit switches restricting the appliance, any part of it and the hooks from overtravel in any mode of operation
- safety valves on all main circuits of the hydraulic system
- emergency stop system
- boom stopper on derrick cranes
- end stoppers in the case of travelling cranes
- audible warning alarm.

503 In addition to the requirements in 502 offshore cranes are to be provided with:

- constant tension system if the hook capacity is less than 25 tonnes and the crane is intended for loading/unloading of moving objects (e.g. offshore supply vessels) or underwater load handling (see 515)
- slack wire rope detection (see 516)
- emergency release system (see 513)
- retention device (optional) on slewing bearing of enclosed, anti-frictional type (ball or roller bearings) (see Guidance, Sec.3 E300)
- auto-recording of service data (black box) (optional).

504 Cargo ramps and movable cargo decks are to be provided with:

- overload protection of hoisting system
- means to ensure that power is not disconnected before all retractable locks which are securing the ramp/deck are engaged
- means to ensure that locks, which are securing a ramp/ deck, are disengaged before 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.

505 In the case of a mobile crane, the crane is, in addition to the requirement in 502, to be provided with:

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

506 Cranes and other lifting appliances, except offshore cranes, are to be provided with an automatic overload shut-down device.

The shut-down device is to be activated if the response of the load being raised or lowered exceeds a predetermined amount which is not to 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.

The shut-down device when activated is not to prevent the load or crane to be moved to a better position (e.g. lower the load or hoist the boom).

507 Offshore cranes are to be provided with an alarm which automatically will be activated if the load exceeds the amount given in 506. The alarm shall warn all personnel within the working area of the crane including personnel onboard an attending supply vessel. See also 511.

508 *Load indicator or load moment indicator* giving continuous information is to be provided when the safe working load is 50 kN or greater except for cranes where the allowed maximum rated load is constant (i.e. independent of load radius).

509 Offshore cranes are to be provided with an audible and visual alarm system inside the operator's cabin or outside, in the case of a crane without operator's cabin. The alarm shall be activated when the load or overturning moment is 90% of the SWL respectively 90% of the permitted moment from the SWL and any dead loads.

510 Offshore cranes and gantry or similar cranes are to be provided with a horn or similar warning device that can be operated separately by the crane operator to warn or attract the attention of any person within the operational area of the crane.

In the case of travelling cranes moving at ground level a continuous audible warning shall be given within the operational area when the crane is to move/is moving along its track. Above warning signals shall be distinctly different from all other sound signals on an installation.

511 *Limit switches* are to be positively activated and be of the fail-safe type. Fail-safe in this context means that the crane shall go to a defined safe condition in case of failure such as power failure, cable defect etc.

After a limit switch has been activated, a movement in the reverse direction shall not be prevented.

Where more than one movement/operational mode will cause overtravel, all limit switches limiting such overtravel to occur shall be activated simultaneously (e.g. hoist block overtravel at boom top may be caused either by hoisting or luffing).

Table F1 Monitoring of safety equipment

Required monitoring (stated by an x)	*Industrial and shipboard cranes*			*Cargo decks and ramps*			*Offshore cranes*		
Event	*Indication*	*Alarm*	*Auto stop*	*Indication*	*Alarm*	*Auto stop*	*Indication*	*Alarm*	*Auto stop*
Load high; See F506, 507, 509			x				x	x	
Overturning moment high; See F506, 507, 509			x				x	x	
Hook position:									
Upper	x		x				x		x
Lower; See F513	x		x				x		x
Boom/jib position:									
Upper			x				x		x
Lower			x				x		x
Travelling motion of slewing ring:									
End stops, temporary or permanent obstructions; See F518									
Warning; See F510			x						x
		x						x	
Slack wire rope; See F516	x						x		x
Remote control				x	x				
Position of ramps:									
Upper						x			
Inclination						x			
Power failure to safety system	x	x		x	x			x	x

512 *Limit switches* may incorporate a manually operated «over-ride» system, provided positive and maintained action combined with indication and alarm is necessary to over-ride the limitation. See also A303.

513 For cranes intended for loading/unloading of moving objects (e.g. from offshore supply vessels), an *emergency release system* is to be provided to allow paying out of hoist wire rope in the event of accidental overloading of crane due to the hook or load being tangled to the supply boat. At the same time hook stop in lower position shall be cancelled. Pay out speed is only to be limited by a constant tension in the wire rope not less than 1.5 tonnes.

The release switch or handle is to be protected against inadvertent use.

514 *Constant tension system* (motion compensator) is to exert a lift capacity sufficient to keep a holding force not exceeding 1.5 tonnes.

The constant tension system is to operate under all conditions, including power failure in control system.

The constant tension switch or handle is to be effectively secured against inadvertent use. The winch is automatically to return with soft characteristic to normal hoisting, braking or holding condition when the constant tension is disengaged.

515 *Emergency stop systems* are to be arranged for all power generation or power supply to the crane. The systems are to activate the brakes to engage in a progressive and safe manner. The emergency stop switch or handle is to be protected against inadvertent use.

On electrically operated cranes the emergency stop system shall disconnect all phases of the main power supply.

516 Drums are normally to have a *slack wire rope detection device*, which will be activated automatically if the wire rope becomes slack during lowering. The device shall give an indication, and on offshore cranes, cut off the operating power to the winch. Where the crane operator will have a full view of the drums from his normal position, the slack wire rope detection device may be omitted.

517 *Crane boom stopper* is to be fitted for limiting the boom angle to the maximum allowable.

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

519 *Slewing mechanisms* are to be so designed that they 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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SECTION 6
TESTING AND TEST CERTIFICATES MARKING

A. Functional Testing of Completed Lifting Appliances

A 100 General

101 Each completed crane is to be subjected to functional testing in the presence of a surveyor to the Society.

102 The functional testing is to be carried out in accordance with a detailed programme, which is to be submitted for approval well in advance of the actual testing. The programme is to specify in detail how the respective functions are to be tested and required observations during the test. The tests specified below are to be included in the test programme.

103 A copy of the approved test programme is to be kept in the crane manual. It is to be completed with final results and endorsed by the «competent person».

104 The significant characteristics of power and braking systems and the safety equipment are to be considered. Braking systems and safety equipment are to 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 is to 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. are to be measured and recorded.

202 Automatic control, remote control and alarm systems — as far as arranged — connected with power systems shall be tested.

203 After the test, the lubricating and/or hydraulic oil filters are to 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 is to be verified that control systems function satisfactorily during normal load changes.

302 Failure conditions or boundary conditions are to be simulated as realistically as possible, preferably by letting the monitored parameters pass the alarm and safety limits.

A 400 Electrical installations

401 Insulation-resistance test is to 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 megaohm is to be obtained. This also applies to instrumentation and communication circuits with voltages above 30 V A.C. or 50 V D.C.

The insulation resistance of a motor is not to be less than:

$$\frac{3 \times \text{rated voltage}}{\text{rated kVA} + 1\,000}\ \text{megaohms}$$

the test being made on a clean and dry motor when hot.

402 When found necessary by the surveyor, switchgear is to be tested on load to verify its suitability and that the operating of overcurrent 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 are to be tested with safe working load applied on crane by breaking each motion from maximum speed to full stop. In addition, each brake for the hoisting and derricking motions is to be tested for three such stops in quick succession during lowering motion. The test is also to include testing of the emergency stop system.

A 600 Safety equipment

601 Safety functions covered by Table F1 in Sec.5 shall be tested.

B. Load Testing

B 100 General

101 International and national regulations require that a lifting appliance shall be load tested:

— 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).

102 Every item of loose gear is to 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 in the case of load testing a lifting appliance the first time.

202 A mechanical or hydraulic precision dynamometer may be used:

— in the case of periodical re-testing of a lifting appliance where there is lack of movable weights
— in the case of a test following the repair or renewal of a part.

The accuracy of the dynamometer should be within ±2% 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, should 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 B1Test 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
Over 50 tonnes	10% in excess of the SWL

Guidance note:

For offshore cranes the reference SWL in the table is to be taken as the greater of:

— 0.75 · ψ · SWL
— SWL

ψ = design dynamic coefficient for the crane

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

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 be sufficient to lift the greatest possible load. In general 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)
Chain, hooks, shackles, swivels, etc.:	
SWL ≤ 25 T	2 × SWL
SWL > 25 T	(1.22 × SWL) + 20
Multi-sheave blocks: 1)	
SWL ≤ 25 T	2 × SWL
SWL > 25 T ≤ 160 T	(0.933 × SWL) + 27
SWL > 160 T	1.1 × SWL
Single-sheave blocks: 2) 3)	4 × SWL
Lifting beams, etc.: 5)	
SWL ≤ 10 T	2 × SWL
SWL > 10 T ≤ 160 T	(1.04 × SWL) + 9.6
SWL > 160 T	1.1 × SWL

1) The SWL of a multiple sheave block is equal to the suspended load.
2) For single sheave blocks with or without becket the SWL is to be taken as one half of 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.
4) For offshore cranes: 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 being fitted to the beam.

304 Built-in sheaves and other items permanently attached to the lifting appliance are not considered to be loose gear, and 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 are to 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 with the gear accessories is 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 being 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) should be issued (as far as applicable and relevant):

— Form No. CG 2: Certificate of test and thorough examination of lifting appliances
— Form No. CG 2U: Certificate of test and thorough examination of derricks used in union purchase
— Form No. CG 3: Certificate of test and thorough examination of loose gear
— Form No. CG 4: 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. CG 1 «Register of Lifting Appliances and Items of Loose Gear».

Guidance note:
The Forms Nos. 2, 3 and 4, as well as Form No. 2U when relevant, shall be attached to Form No. CG I in «filled in» order.

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

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
— in the case of a ship or other vessel, necessary precautions with respect to stability, ballasting or similar conditions have been taken
— in the case of 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
— in the case of a new installation, design approval and survey during fabrication of the lifting appliance are documented.

602 A written — and acceptable to the surveyor — test programme should preferably be available.

603 The test weights shall be lifted by the lifting machinery which is 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 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 upon. The angle at which the test was made should be stated in the test certificate. After the test load has been lifted it should be swung as far as possible in both directions.

605 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, are to be traversed and travelled over the full length of their track.

606 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.

C. Testing of Steel Wire Ropes

C 100 Cross reference

101 Steel wire ropes are to be tested as required by Sec.2 F.

C 200 Certificates

201 After testing of steel wire ropes certificates of type CG 4 are to be issued.

202 A manufacturer or supplier who has obtained a certificate for a coil of wire rope, when he resells the coil or part of it, is to issue and deliver a certificate to the buyer. The certificate is to be a copy of the original certificate additionally dated and signed by the supplier.

D. Marking and Signboards

D 100 General

101 Cranes and derrick booms and all items of fixed and loose gear and accessories are to be marked with their safe working load (SWL) in a legible and durable way. To prevent effacement of the inscriptions, they are normally to be incised, punched or marked as specified below.

102 All blocks and all items of loose gear and accessories are to be marked with an identification mark to enable them to be readily related to their appropriate test certificates, and with the stamp of the institution, society, body or manufacturer who carried out the load test.

103 Derrick booms as well as cranes on board vessels are to be marked with a reference number to enable them to be related to their location onboard.

D 200 Derrick booms

201 On derrick booms the markings of reference number, SWL and allowed angles are to be located near the seating (gudgeon pin) by painted letters and numbers in a frame of indentations or welding spots, incised on a brass plate or inscribed on other material sufficiently resistant to defacement, such as plastic of sandwich construction.

The identification numbers and stamp of the surveyor are to be punched or incised.

202 Booms are to be marked with SWL with single reeved cargo runner and for 15° boom angle, or for the lowest angle exceeding 15° to which the arrangements on board allows the booms to be lowered to. Example No. 3 SWL 5 T 15°.

Booms with alternative rigging are to be marked accordingly. Example No. 4 SWL 5/10 T 15°.

203 Heavy lift booms are to be marked with the minimum angle and the maximum load for which boom, gear and accessories are calculated. Example SWL 60 T 30°.

204 The maximum allowed boom angles are to be marked for booms which can be subjected to stalling. Example No. 3 SWL 15 T 15 – 60°.

205 Where booms may be used in union purchase the markings are to be made on separate plates which are to be fitted at a convenient location approximately in the middle between the booms. Example No. 3 + 4 SWL(U) 2 T.

206 Reference number and SWL are to be marked in letters and figures of at least 80 mm height and the angle in figures of at least 60 mm height.

D 300 Cranes

301 The markings of SWL and allowed radii (and the reference number in case of shipboard cranes) are to be painted in a conspicuous place on the crane.

The identification numbers and stamp of the surveyor are to be punched or incised.

302 Cranes with constant SWL for all radii are to 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.

303 Cranes with SWL depending on the jib radius are to be marked with possible crane reference number and with maximum and minimum SWL and corresponding radii. Example No. 5 SWL 15 T 5 M, SWL 5 T 15 M.

304 Reference numbers and SWL are to 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.

D 400 Blocks

401 The SWL of blocks together with the identification numbers and the surveyor's/Manufacturer's stamp are to 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 to be marked with SWL, identification number and the certifying authorities' stamp on a legibly and durably fitted ring or plate.

502 Where wire rope slings are fitted with pressure locks the markings are to be located on the locks.

503 For wire rope slings the SWL by 0° is to 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.

504 Instead of marking of slings as stated in 503 displayed information on use of the slings may be accepted. The display is to be easily seen and the slings are to be easily identified in accordance with the display.

505 Lifting beams and lifting frames shall be marked with SWL, own weight, identification number and the certifying authorities stamp.

APPENDIX A
WIND LOADS ON CRANES

A. Wind Load Calculation

A 100 General

101 In the following a simplified method of wind load calculation is given. This 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 made is that wind pressure and suction act normal to surfaces. A consequence of this is that 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:

$$P = A\ q\ \sin\alpha$$

where:

P = wind force in da N
A = exposed area in m^2
q = air velocity pressure = $\rho v^2 / 2 = v^2 / 16$. 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/m^3)
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 Al.

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:

$$P_1 = A_1\ q\ C_1\ \sin\alpha_1$$

$$P = A_2\ q\ C_2\ \sin\alpha_2$$

Referring to Fig.1, P_1 is the total force acting normal to the flanges (resulting from pressure and suction on both flanges) and P_2 is the total force acting normal to the web. Further $A_1 = l\ h_1$ and $A_2 = l\ h_2$.

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 Al. Note that C is used as a common symbol for «pressure coefficient» (pressure or suction) and «force coefficient» (sum of pressure and suction).

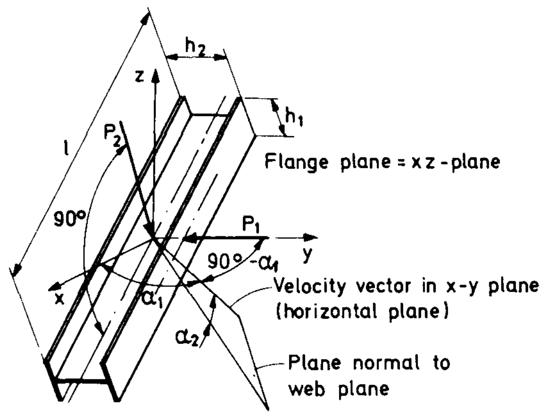

Fig. 1 Wind force on H-shaped members.

Table A1 Coefficient C

Type of member	*Coefficient C*		
	Pressure	*Suction*	*Total*
Flat side sections			2.0
Tubular members diameter < 0.3 m diameter ≥ 0.3 m			 1.2 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, counter-weights shapes Other shapes	Max: 1.0 Average: 0.7	Max: 1.0 Average: 0.5	1.2
Working load: Containers and similar shapes Other shapes	(0.7)	(0.5)	1.2 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 = *l* d, 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 Al.

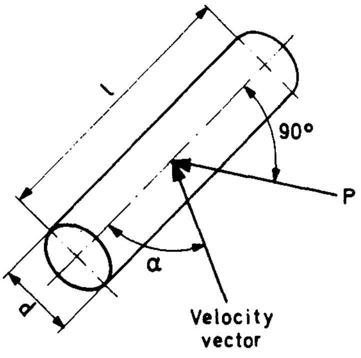

Fig. 2 Wind force on tubular members.

A 500 Air velocity pressure

501 The velocity pressure q to be used as design parameter is to 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:

$$q = q_{10} (0.9 + 0.01 H)$$

where:

q_{10} = 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 pressure in da N/m^2

Location	*Crane condition*	v_{10}	q_{10}
Inland and sheltered locations	"Working"	~20	25
Ship in harbour	"Out of service"	~36	80
Offshore and open areas	"Working"	~24	36
Ship at sea	"Out of service"	~44	120

APPENDIX B
CERTIFICATES

A. General

A 100 Forms overview

101 The following is a list of Cargo Gear Forms used by DNV (July 2006):

CG10 Record of thorough examination of lifting gear
CG11 Examination of lifting appliances or lifting gears
CG2 Certificate of test and thorough examination of lifting appliances.
CG2U Certificate of test and thorough examination of derricks used in union purchases
CG3 Certificate of test and thorough examination of loose gear
CG4 Certificate of test and thorough examination of wire rope

DET NORSKE VERITAS

DNV Id. No.: ....

RECORD OF THOROUGH EXAMINATION OF LIFTING APPLIANCE OR LIFTING GEAR

U.K. OFFSHORE INSTALLATIONS

Name and address of installation owner			
Name or designation of offshore installation			
1. Description and distinguishing mark or number of lifting appliance or lifting gear and where located			
2. Maker and date of make			
3. Date of last record of examination (if seen) Name of person who conducted last examination, and of his employer		4. Date first put into use (if known)	
5. Parts not accessible for thorough examination			
6. Parts that require opening up at the next examination			
7. Particulars of defects and remedy: particulars of any defect found in the lifting appliance or lifting gear which affects the safety of the appliance and the repairs (if any) required, either: (i) immediately, or (ii) within a specified time (which must be stated), to enable the lifting appliance or lifting gear to continue to be used with safety (if no such repairs are required, the word NONE is to be entered)			
8. Safe Working Load subject to the repairs, renewals and alterations (if any) specified above. In the case of a crane with a variable operating radius, including a crane with derricking jib, the safe working load at various radii of the jib, trolley, or crab is to be stated	Load Radius	Safe Working Load Main Hoist	Safe Working Load Whip Hoist
8. Boom Length			

I hereby certify that on .... (date) the item described in this report was thoroughly examined, so far as accessible, and the above particulars are correct.

Person conducting examination: Name: .... Sign: ....

Date: ....

Employer: Det Norske Veritas Counter-signature on behalf of employer: ....

Date: ....

Supplementary remarks (please number items as above)

Details of component test certificates seen by person conducting examination

DET NORSKE VERITAS   Report No.: ....

EXAMINATION OF LIFTING APPLIANCE OR LIFTING GEAR
CG11

ACCORDING TO	Rules/Regulations		
CUSTOMER INFORMATION	Name and address of installation owner		
	Examination requested by		Customer's ref.
LIFTING APPLIANCE	Location (Name of Ship, Platform etc.)		Id. No.
	Manufacturer		
	Model	Serial No.	Running hours (h)
	Type		

CAPACITIES		MAIN HOIST		AUX. HOIST		Description/additional information
Condition	Angle (deg)	Radius (m)	SWL (tonnes)	Radius (m)	SWL (tonnes)	
Max moment						Initial Cert.No./date
Max outreach						

EXAMINATION AND TESTING SUMMARY			
Examination type ☐ Annual	☐ 5-yearly	☐ Initial	☐ Form 68.43a checked
Latest test Certificate (CG 2)	Date		Issued by

STRUCTURE				MACHINERY				SYSTEMS			
Component	Remark No.	Accepted Yes	No	Component	Remark No.	Accepted Yes	No	Component	Remark No.	Accepted Yes	No
Rev. frame/ A-frame/ Pedestal		☐	☐	Main hoist *		☐	☐	Safety equipment		☐	☐
Cabin		☐	☐	Aux. hoist *		☐	☐	Hydraulic/ pneumatic systems		☐	☐
Boom incl. bolts & pins		☐	☐	Boom hoist *		☐	☐	Electric/ inst. systems		☐	☐
Gangways, platforms and ladders		☐	☐	Telescope		☐	☐	Fire extinguisher		☐	☐
Slewing bearing/ bolts		☐	☐	Slewing		☐	☐	Communi- cation		☐	☐
Gantry/ traverse		☐	☐	Travelling		☐	☐	Document- ation and instructions		☐	☐
Trolley		☐	☐			☐	☐	Load charts		☐	☐
Support structure		☐	☐			☐	☐	Certificates/ CG-forms		☐	☐
				* Incl. wire ropes, sheaves, blocks, hooks, etc.							

DET NORSKE VERITAS, VERITASVEIEN 1, NO-1322 HØVIK, NORWAY, TEL INT: +47 67 57 99 00, TELEFAX: +47 67 57 99 11
Form No.: CG11   Issue: January 2005   Page 1 of 2
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Remarks (with reference numbers, where applicable)

For further comments use form No. 40.9a as appendix

Details of components test certificates

For further comments use form No. 40.9a as appendix

I hereby certify that the above items of loose gear were tested and thoroughly examined and no defects affecting their SWL were found.

Place: .... Signature: ....

Date:

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)

Reason for issuing the certificate: ☐ Initial certification ☐ Recertification ☐ Repair

☐ 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: .... Signature: ....

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.

☐ Tick off here if an appendix is issued

DET NORSKE VERITAS, VERITASVEIEN 1, NO-1322 HØVIK, NORWAY, TEL INT: +47 67 57 99 00, TELEFAX: +47 67 57 99 11
Form No.: CG2 Issue: July 1999 Page 1 of 2
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Certificate No.:

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'.

DNV

DET NORSKE VERITAS

Certificate No. ....

CERTIFICATE OF TEST AND THOROUGH EXAMINATION OF DERRICKS USED IN UNION PURCHASE CG2(U)

Location (name of ship, platform etc.)	Call sign
	DNV ID. No.

Owners	Port of registry

(1) Situation and description of derricks used in union purchase (with distinguishing numbers or marks,) which have been tested and thoroughly examined	(2) Maximum height of triangle plate above hatch coaming (m) or maximum angle between runners	(3) Test load (tonnes)	(4) Safe working load, (SWL) (U) when operating in union purchase (tonnes)

Position of outboard preventer guy attachments:		Position of inboard preventer guy attachments:	
(a) forward/aft * of mast	(m)	(a) forward/aft * of mast	(m)
(b) from ship's centre line	(m)	(b) from ship's centre line	(m)
(c) above/below the boom's goosenecks	(m)	(c) above/below the boom's goosenecks	(m)

Reason for issuing the certificate: ☐ Initial certification ☐ Re certification ☐ Repair

☐ 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: .... Signature: ....

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.

*Delete as appropriate

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.

DET NORSKE VERITAS, VERITASVEIEN 1, NO-1322 HØVIK, NORWAY, TEL INT: +47 67 57 99 00, TELEFAX: +47 67 57 99 11

Form No.: CG2U Issue: October 2000 Page 1 of 2

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INSTRUCTIONS

1. Before being taken into use, the derricks rigged in union purchase shall be tested with a test load which shall exceed the safe working load (SWL (U)) 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. Tests are to be carried out at the approved maximum height of the triangle plate above the hatch coaming or at the angle between the cargo runners and with the derrick booms in their working positions, to prove the strength of deck eye plates and the union purchase system. These heights or angles must not exceed the values shown on the rigging plan.

3. Test should be carried out using test loads.

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'.

DET NORSKE VERITAS   Certificate No. ....

CERTIFICATE OF TEST AND THOROUGH EXAMINATION OF LOOSE GEAR (CG3)

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: ☐ Initial certification ☐ Recertification ☐ Repair
☐ 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: .... Signature: ....

Date: --

Note:
This Certificate is the standard international form as recommended by the International Labour Office in accordance with ILO Convention No. 152.

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INSTRUCTIONS Certificate No.

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:

Item	Test load (tonnes)
Single sheave blocks (see Note 1)	4 × SWL
Multi sheave blocks (see Note 2): SWL ≤ 25 tonnes 25 tonnes < SWL ≤ 160 tonnes SWL > 160 tonnes	 2 × SWL (0.933 × SWL) + 27 1.1 × SWL
Chains, hooks, rings, shackles, swivels etc.: SWL ≤ 25 tonnes SWL > 25 tonnes	 2 × SWL (1.22 × SWL) + 20
Lifting beams, spreaders, frames, and similar devices: SWL ≤ 10 tonnes 10 tonnes < SWL ≤ 160 tonnes SWL > 160 tonnes	 2 × SWL (1.04 × SWL) + 9.6 1.1 × SWL
1. The SWL for a single sheave block, including single sheave blocks with beckets, is to be taken as one half of the resultant load on the head fitting. 2. The SWL of a multi sheave block is to be taken as the resultant load on the head fitting.	

2. This form may also be used for the certification of interchangeable components of lifting appliances.

3. The expression 'tonne' shall mean a tonne of 1000 kg.

4. 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'.

DET NORSKE VERITAS

Certificate No.

CERTIFICATE OF TEST AND THOROUGH EXAMINATION OF WIRE ROPE
CG4

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/mm²)
Date of test of sample		
Load at which sample broke (tonnes)	Safe working load of rope (tonnes)	
Intended use		
Remarks		

DNV station employing the competent person: --

I certify that the above particulars are correct, and that the rope was tested and examined and no defects affecting its SWL were found.

Place: .... Signature: ....

Date: --

Note:
This Certificate is the standard international form as recommended by the International Labour Office in accordance with ILO Convention No. 152.

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:

Item	Coefficient
Wire rope forming part of a sling:	
SWL of the sling	
SWL $\leq$ 10 tonnes	5
10 tonnes < SWL $\leq$ 160 tonnes	$\frac{10^4}{(8.85 \times SWL) + 1910}$
SWL > 160 tonnes	3
Wire rope as integral part of a lifting appliance: SWL of the lifting appliance	
SWL $\leq$ 160 tonnes	$\frac{10^4}{(8.85 \times SWL) + 1910}$
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'.