RULES FOR CLASSIFICATION OF

Ships / High Speed, Light Craft and Naval Surface Craft

PART 4 CHAPTER 2

NEWBUILDINGS
MACHINERY AND SYSTEMS – MAIN CLASS

Rotating Machinery, General

JANUARY 2011

This chapter has been amended since the main revision (January 2011), most recently in July 2011.
See "Changes" on page 3.

DET NORSKE VERITAS AS

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.

The Rules lay down technical and procedural requirements related to obtaining and retaining a Class Certificate. It is used as a contractual document and includes both requirements and acceptance criteria.

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CHANGES

General

As of October 2010 all DNV service documents are primarily published electronically.

In order to ensure a practical transition from the "print" scheme to the "electronic" scheme, all rule chapters having incorporated amendments and corrections more recent than the date of the latest printed issue, have been given the date January 2011.

An overview of DNV service documents, their update status and historical "amendments and corrections" may be found through http://www.dnv.com/resources/rules_standards/.

Amendments July 2011

- **General**

— The restricted use legal clause found in Pt.1 Ch.1 Sec.5 has been added also on the front page.

Main changes

Since the previous edition (January 2006), this chapter has been amended, most recently in January 2009. All changes previously found in Pt.0 Ch.1 Sec.3 have been incorporated and a new date (January 2011) has been given as explained under "General".

In addition, the layout has been changed to one column in order to improve electronic readability.

CONTENTS

SECTION 1
INTRODUCTION

A. General

A 100 Purpose and scope

101 These rules apply to ships, high speed, light craft and naval surface craft. The requirements are also applicable for relevant class notations.

102 The classification activities include certification of products as well as assessment of the arrangement and dynamics in a machinery plant built up of various products.

103 Certification normally includes design approval, inspection and testing of components and workshop testing of the assembled product. A product certificate is issued when the certification requirements are fulfilled. However, no unit is finally accepted before the shipboard testing is successfully completed.

104 Classification activities also include approval of machinery arrangement such as foundation, alignment, etc. and all relevant dynamics such as torsional vibration, engine vibration, etc. Survey of installation and shipboard testing also forms part of classification.

A 200 Application

201 The rules in Ch.2, Ch.3, Ch.4 and Ch.5 apply to rotating machinery for functions such as:

— propulsion
— main and emergency electric power generation, see Ch.8
— steering (including thrusters)
— ballasting and cargo pumping
— and as applicable in rules for additional class notations.

202 The applicable rotating machinery in this context is:

— diesel engines, gas turbines and steam turbines as given in Ch.3
— power transmissions as gears, couplings, shafts including bearings, as given in Ch.4
— driven units as propellers, water jets, thrusters (including azimuth) and compressors, as given in Ch.5 (pumps are dealt with in Ch.6 and generators are dealt with in Ch.8).

203 System requirements such as arrangement and vibration are put into the sections for those units for which these kinds of system requirement are relevant (see Table A1).

Note that electric motors and generators are not included as products, but are considered in regard to machinery arrangement (e.g. alignment) and vibration (e.g. torsional vibration). See Ch.8 for rules for electric motors and generators.

204 For high speed and light craft the International Code of Safety for High-Speed Craft (HSC Code) applies as listed in the rules for High Speed, Light Craft and Naval Surface Craft Ch.1 Sec.1 A100.

A 300 Layout of the rules

301 Each chapter is divided into sections and each section is divided into sub-sections as follows:

A: General (describes the documentation to be submitted)
B: Design (describes the conditions for obtaining design approval, e.g. calculations, type testing, etc.)
C: Inspection and testing (describes relevant inspection and testing from steel works to finished components and sub-assemblies)
D: Workshop testing (describes inspection and testing of the assembled product)
E. Control functions, alarm and safety functions and indication (describes a summary of the requirements)
F: Arrangement (describes requirements for installation and arrangement onboard)
G: Vibration (describes requirements for system vibration relevant to the specific type of machinery. See Table A1.)
H: Installation (describes inspections and testing to be made during installation)
I: Shipboard testing (describes the testing to be made during harbour trials and sea trials)

302 Table A1 shows where the rules related to vibration and dynamics can be found for different types of application.

Table A1 Types of vibration and references to applicable rules for different machinery applications					
Type of machinery involved	*Steady state torsional vibration*	*Transient torsional vibration*	*Axial vibration*	*Whirling or lateral or rotor vibration*	*Machine and foundation vibration*
Diesel engine	Ch.3 Sec.1 A600, G300, I500	Ch.3 Sec.1 A600, G400, I600	Ch.3 Sec.1 A600, G500, I700		Ch.3 Sec.1 A600, G600, I800
Electric motor	Ch.5 Sec.3 A200, G100	Ch.5 Sec.3 A200		Ch.4 Sec.1 A400, G100 and G200	
Gas turbine	Ch.3 Sec.2 A300, G203	Ch.3 Sec.2 A300, G203		Ch.3 Sec.2 A300, G202	Ch.3 Sec.2 A300 G300
Steam turbine	Ch.3 Sec.3 A200, G100			Ch.3 Sec.3 A200, B200	
Propulsion shafting			Ch.4 Sec.1 A400, G300	Ch.4 Sec.1 A400, G100, G200	
Gearbox					Ch.4 Sec.2 G100
Clutch		Ch.4 Sec.3 A200, G100			
Piston compressor	Ch.5 Sec.4 A200, G100				
Elastic couplings	Ch.3 Sec.1 A600, G300, I500	Ch.3 Sec.1 A600, G400		Ch.4 Sec.5 G100	

SECTION 2
CERTIFICATION PRINCIPLES

A. General

A 100 Main principles

101 The Society may, upon special evaluation, accept alternative criteria and methods to those prescribed by the rules if found to represent an overall safety standard equivalent to that prescribed by the rules.

102 For type approved auxiliary machinery the product certification by the Society may, upon special evaluation and acceptance, be waived for power ratings up to 500 kW and rated torque less than 5 kNm. The condition for waiving the product certification is that this exemption is stated in the type approval certificate.

Guidance note:

In most cases this arrangement will be limited to 200 kW, as for diesel engines, but up to 500 kW may be utilised e.g. for elastic couplings when torsional vibration calculations are not required.

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B. The Certification Process

B 100 Certification schemes

101 The certification process in general is defined in Pt.1 Ch.1 Sec.4 of the Rules for Classification of Ships.

102 The certification process consists of:

Design approval, divided into:

— type approval
— case by case approval.

Survey, comprising verification of general formalities, inspection and testing.

103 Type approval is a way of certifying that the design and specification of a product is in conformity with the applicable rules. Type testing may also be required as a part of the type approval.

Type approvals are categorised as follows:

1. Product type approval

This is type approval granted to:

— fixed designs and specifications
— products that include design variations of a concept without having all details of the variants specified.

2. System type approval

Type approval may also be granted to assemblies with variation. This may be for example diesel generator sets where a specific diesel engine is combined with various elastic couplings and generators. Even complete propulsion plants may be system type approved. Each component in the system is to be type approved.

A type approval is valid for a period of 4 years and may be renewed for further periods of 4 years. A renewal is pending a satisfactory retention survey and satisfactory service experience. The purpose is to verify that the original conditions for the type approval are still valid.

Product type marking is required for all type approved products.

104 *Case by case approval* is an approval that is only valid for one specific installation. (Case by case approvals shall normally not be given for stock orders, see also Pt.1 Ch.1 Sec.4 B306 of the Rules for Classification of Ships.)

105 For definitions of NV certificate, W certificate and TR, see: Pt.1 Ch.1 Sec.4 of the Rules for Classification of Ships.

The manufacturer is to have a quality system that is suitable for the kind of certified product. The surveyor may check that the most important elements of this quality system are implemented and may carry out random inspections at any time.

106 In Ch.3, Ch.4 and Ch.5 the terms TR, W and NV are used for product certificates as well as for documentation of single inspections such as crack detection, dimensional check, etc. If agreed to by the surveyor, the documentation of single tests may also be arranged by filling in results on a control sheet

following the component through the production. In this context TR means random checking on parallel production, W means checking on the actual component, and NV means checking by or in the presence of a surveyor.

107 If the quality of components documented by work certificates (W) or test reports (TR) is found not to fulfil the specifications, the surveyor may require the components to be documented by DNV certificates (NV).

C. Alternative Survey Arrangements

C 100 Manufacturing survey arrangements

101 Manufacturing survey arrangement (MSA) is defined in Pt.1 Ch.1 Sec.4 of the Rules for Classification of Ships. MSA is an arrangement in form of a signed document stating the roles and conditions of the Society and the manufacturer regarding inspection, testing and certification.

102 A manufacturing survey arrangement can be used to clarify:

— the extent of the required inspection and testing
— to which extent and under which conditions the manufacturer may perform all or parts of the required inspection and testing without the presence of a surveyor from the Society.

103 The MSA can be anything between a normal survey where a surveyor is present at all required inspection and testing according to the rules, and the other extreme where the manufacturer is given the permission to carry out all inspection and testing without the presence of a surveyor. The conditions for the manufacturer to be granted the permission to carry out inspection and testing without presence of a surveyor is that:

— for conditions with respect to manufacturer's quality systems, in Pt.1 Ch.1 Sec.4 B500 of the Rules for Classification of Ships are fulfilled
— the inspection and testing required by the rules are either standard procedures in the quality system or specified in detail in the manufacturing survey arrangement
— the Society carries out regular product audits to verify that all conditions in the MSA are fulfilled.

104 An MSA that permits the manufacturer to carry out all inspection and testing without the presence of a surveyor can be arranged in two versions with regard to traceability:

a) The MSA describes inspection and testing additional to the manufacturer's standard quality control in order to meet the rules. The components are to be stamped NV with a special stamp supplied by the Society.
b) The manufacturer has a standard quality control that covers all inspection and testing required by the rules. Traceability beyond the manufacturer's standard as accepted by the Society is not required. Extent of documentation of components or products (type of certificate) will be defined in the MSA.

It is a condition for both a) and b) that the MSA contains item A102 in Sec.3, and that this item is implemented in the manufacturer's quality system. Verification shall be carried out by the surveyor.

SECTION 3
DESIGN AND DOCUMENTATION

A. General

A 100 Design principles

101 All machinery is to be designed so that expected deviations of influence parameters do not result in unacceptable reduction of the reliability or safety. Influence parameters can be for example:

— power and speed *
— number of passing through a barred speed range
— machining notches in inaccessible areas
— diesel engine misfiring
— variation of elastic coupling characteristics
— variation of damper characteristics.
— normal tear and wear.
— deviation between actual material properties of the component and the minimum specified properties (as verified by test specimen.

* Where requirements for dimensions in Ch.2, Ch.3, Ch.4 and Ch.5 are based on power and revolutions per minute, denoted by P and n_0, the values applied are maximum continuous power (kW) measured on engine output shaft and corresponding revolutions per minute.

However, for plants where overload is used frequently (intermittent load), the scantling criteria may have to be based on the overload, due to accumulated fatigue.

102 The manufacturer (and designer, if producing under license) is committed to involve the Society in corrective actions whenever failures occur to products certified by the Society and addressed in these rules, including parts for which documents are submitted for information. The corrective actions include changes to design and or quality control. Failing to involve the Society, or to carry out proper corrective actions, may result in withdrawal of the type approval as well as restrictions of future approvals and or certification.

103 When the rules refer to or contain certain calculation methods, these may be replaced by equivalent or better methods. The objective is to document equivalent reliability. Rule methods normally aim at certain minimum safety factors. When such methods are replaced by more refined methods, it may be necessary to reconsider the required safety factors.

104 When the rules require calculations and or analyses, this is to contain objectives, premises, assumptions and the conclusions.

105 The reliability and safety of components and complete units may also be documented by means of approved tests or service experience. The latter will only be considered if a relevant load history can be documented. Acceptance of load history will be decided from case-to-case by the society. Relevant load history means a suitable operation period (e.g. more than 2 500 hours for propulsion) under running conditions similar to the expected running conditions for the product to be approved.

106 Ch.2, Ch.3, Ch.4 and Ch.5 contain basic requirements for design, manufacturing, testing and documentation. Some of these requirements will be verified and followed up by the Society during design approval or survey, while others are given mainly as general information for the designer, manufacturer or yard, and as basis for their own construction and follow-up. It is to be noted, however, that the absence of verification by the Society for such requirements during approval or survey phases will not relieve the designer, manufacturer or yard from their obligation to fulfil the said rule requirements.

A 200 Material and testing specifications

201 A material specification is as a minimum to contain the following:

— type of material
— chemical composition
— production method (cast, hot rolled, separately forged, blank cut out of a forged bar of specified size, etc.)
— type of heat treatment
— minimum mechanical properties (which normally includes impact energy Charpy-V for quenched and tempered steels)
— an NDT specification containing:
  — method of NDT
  — extent
  — acceptance criteria

High stress areas, and in particular, zones with stress risers, such as:

— keyways
— holes
— splines
— teeth

and

— shrinkage surfaces,

shall be included in the NDT specification.

For surfaces with specified hardness exceeding 400 HV, the extent of NDT shall be 100%.

All NDT work shall be performed according to a written procedure. The procedure shall be in compliance with Classification Notes 7, or other recognised standards. The surveyor may require that the procedure is approved or qualified for the work.

Unless otherwise specified in these rules or approved manufacturer's specification, acceptance criteria from the following documents can be used for NDT of machinery components:

For forged components:
IACS Recommendation no.68, Inspection zone 1

For cast components:
IACS Recommendation no.69, Quality level 1

For welds: ISO 5817 Level B.

The extent of material testing and documentation thereof is specified for the various components dealt with in Ch.3 to Ch.5.

Guidance note:

The objective and scope of quality control for materials, material testing and documentation thereof is to verify that the relevant properties as specified by the designer and accepted by the Society are obtained.

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202 Material specifications including material testing and documentation may refer to any of the following:

— Pt.2 Ch.2 *)
— any national standard
— works internal standards (provided implemented in the quality system).

If reference is made to standards that are not considered as "well known", then full details of these standards shall be submitted for approval.

Whenever a material standard deviates from Pt.2 Ch.2, then it may be required that the deviation is justified by use of the principle of equivalency.

The principles given in Pt.2 Ch.1 apply also when national or work internal standards are referred to.

*) The surface defect acceptance in Pt.2 Ch.2 Sec.5 A900 (linear indication of 1.5 mm) is not permitted in areas of high dynamic stresses such as e.g. crankshaft fillets and oil holes, gear teeth, shaft details in direct coupled diesel plants.

*) The use of carbon or carbon-manganese steels for large components is limited to a specified tensile strength of 600 MPa.

203 Testing of material properties of forged and rolled steel is normally made on samples taken from representative sections of the actual components. This is necessary for highly loaded (relative to the ability of the material) components.

Guidance note:

For moderately loaded components, testing of small, separately forged specimens may be accepted, if the material properties of the small specimens are correlated (by the designer) to the actual size of the components.

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204 For cast materials the designer shall consider the correlation between the specified material properties as documented from integrally cast test pieces or separately cast test blocks and the expected properties of the actual component.

Documentation of such correlation may be required.

205 Blanks for gears and short shafts may be cut from forged bars without further forging.

Such blanks are considered equivalent (regarding fatigue strength) to separate forgings (close to shape)

provided that the forging process has been approved by DNV.

Without this qualification the fatigue properties will be assessed 20% below those of separate forgings.

A 300 Welding specification

301 For welded connections in components dealt with in Ch.3 - Ch.5 the specification shall at least contain:

— welding procedure specification, see Pt.2 Ch.3 Sec.5 B101
— NDT specification containing:
  - method of NDT
  - extent
  - acceptance criteria.

B. Special Materials and Processes

B 100 General

101 For materials which have higher fatigue properties than ordinary materials for example due to high cleanliness (see Pt.2 Ch.2 Sec.5 A), and for processes which lead to improved fatigue properties such as continuous grain flow forging, shot peening, cold rolling etc., special approval may be given.

102 A special process approval shall always be combined with an MSA, when an NV certificate is required.

B 200 Approval

201 Such special process approvals are usually based on fatigue tests. These tests can be full size tests or tests of specimens taken out of a component. This is not applicable for materials and processes where sufficient previous experience is available.

202 The specifications laid down in the special approval shall be consistent with the material or process which was used for documentation of the elevated fatigue properties.

Guidance note:

For example, if a special process approval is given based on results achieved due to high material cleanliness, the cleanliness specification should be in the same range.

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SECTION 4
ELECTRIC POWER GENERATION

A. General

A 100 Speed governing of generating sets

101 Prime movers for driving generators of the main and emergency sources of electrical power shall be fitted with a speed governor which will prevent transient frequency variations in the electrical network in excess of ±10% of the rated frequency with a recovery time to steady state conditions not exceeding 5 seconds, when the maximum electrical step load is switched on or off.

In the case when a step load equivalent to the rated output of a generator is switched off, a transient speed variation in excess of 10% of the rated speed may be acceptable, provided this does not cause the intervention of the overspeed device as required by Ch.3 Sec.1 E300.

(IACS UR M3.2.1)

102 At all loads between no load and rated power the permanent speed variation shall not deviate to a value that may be detrimental to the reliability of any electric consumer.

Guidance note:

±5% of the rated speed is considered as a safe value.

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103 Prime movers shall be selected in such a way that they will meet the load demand within the ship's mains.

Application of electrical load shall be possible with three load steps and shall be such that prime movers – running at no load – can suddenly be loaded to 1/3 of the rated power of the generator followed by the next 1/3 after an interval sufficient to restore the speed to a steady state condition. Finally, the sudden load step from 2/3 to full load applies. Additionally, the prime mover shall be able to take a sudden application of not less than 1/3 of full load when running at any part load below 2/3 of full power. Steady state conditions shall be achieved in not more than 5 seconds.

Steady state conditions are those at which the envelope of speed variation does not exceed ±1% of the declared speed at the new power.

104 Prime movers, which cannot fulfil the requirement in 103, are only accepted when the system is so designed that all electrical power demand is served with the rate of load applications applicable for the specific prime mover installation.

105 When generator sets are running in parallel, it shall be ensured that, in case of loss of any of these generating sets, the remaining ones are kept in operation to permit propulsion and steering and to ensure safety.

106 Emergency generator sets must satisfy the governor conditions as per 101 and 102, even when:

a) their total consumer load is applied suddenly, or

b) their total consumer load is applied in steps, subject to:

- the total load is supplied within 45 s since power failure on the main switchboard
- the maximum step load is declared and demonstrated
- the power distribution system is designed such that the declared maximum step loading is not exceeded
- the compliance of time delays and loading sequence with the above shall be demonstrated at ship's trials.

(IACS UR M3.2.4)

107 For A.C. generating sets operating in parallel, the governing characteristics of the prime movers shall be such that within the limits of 20% and 100% total load the load on any generating set will not normally differ from its proportionate share of the total load by more than 15% of the rated power of the largest machine or 25% of the rated power of the individual machine in question, whichever is the less.

For an A.C. generating set intended to operate in parallel, facilities shall be provided to adjust the governor sufficiently fine to permit an adjustment of load not exceeding 5% of the rated load at normal frequency.

(IACS UR M3.2.6)