RULES FOR
CLASSIFICATION OF

SHIPS

NEWBUILDINGS

SPECIAL EQUIPMENT AND SYSTEMS
ADDITIONAL CLASS

PART 6 CHAPTER 15

VIBRATION CLASS

JULY 2004
This booklet includes the relevant amendments and corrections shown in the July 2009 version of Pt.0 Ch.1 Sec.3.

CONTENTS PAGE

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INTRODUCTION

General

The Board approved this new chapter in June 2004. These new rules enter into force on 1 January 2005.

This chapter is valid until superseded by a revised chapter. Supplements will not be issued except for an updated list of corrections presented in Pt.0 Ch.1 Sec.3. Pt.0 Ch.1 is normally revised in January and July each year.

Revised chapters will be forwarded to all subscribers to the rules. Buyers of reprints are advised to check the updated list of rule chapters printed in Pt.0 Ch.1 Sec.1 to ensure that the chapter is current.

Introduction

This new chapter introduces the additional voluntary class notation **VIBR**. Vessels that fulfil the requirements for vibration class notation will be assigned the class notation **VIBR**. The notation is applicable to newbuildings and ships in operation that meet specified vibration level criteria measured at pre-defined positions for machinery, components, equipment and structure.

Corrections and Clarifications

In addition to the above stated rule requirements, a number of corrections and clarifications have been made to the existing rule text.

Comments to the rules may be sent by e-mail to *rules@dnv.com*
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SECTION 1
GENERAL REQUIREMENTS

A. Classification

A 100 Objective

101 The objective of the vibration class notation is to reduce the risk of failure in machinery, components and structures onboard ships, caused by excessive vibration. This will be achieved through a proactive, systematic risk based plan for survey and measurement of main components onboard.

102 The class notation is applicable to machinery, components and equipment. It is also applicable to the structure in compartments where machinery, components and equipment are situated close to the propeller(s).

103 The vibration class notation shall not apply as the basis for class survey of items in the machinery inventory list as described in Pt.7 Ch.1 Sec.4 E.

Guidance note:

Machinery CM (Pt.7 Ch.1 Sec.8 C) is the survey arrangement for machinery items in the inventory list class based on condition monitoring

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B. Applications

B 100 General

101 The main reasons for evaluating and avoiding shipboard vibrations are:

— vibration may impair the proper functioning of essential machinery and equipment.
— vibration may cause fatigue damage to important structural elements in the ship.

102 The rules state requirements for vibration related to machinery, equipment and structure, applicable for all types of ships. Generally the requirements in this notation come in addition to the requirements to machinery component as described in the basic rules Pt.4 Ch. 3 and Pt.4 Ch. 4.

103 The influence of vibration from a comfort point of view is not included in this notation. The class notation **COMF-V** (Ref. The Rules for Classification of Ships Pt.5 Ch.12), describes comfort limitations for noise, vibration and indoor climate, onboard ships.

104 Compliance with the rules shall be verified through survey and measurements in predefined positions.

105 The rules apply to the machinery components and structure as specified in Table B1 and described in Sec.3. The table is based on a common set of positions predefined for generic ship types. An evaluation of the particular vessel is carried out prior to the measurements in order to reveal additional critical positions and complete the list for the particular vessel. The list with positions to be measured, including the corresponding vibration limits, is hereafter called the Protocol

106 Vessels that fulfil the requirements for vibration class notation will be assigned the class notation **VIBR**. The notation is applicable for both new buildings and ships in operation. The following procedure shall be followed in order to attain the **VIBR** notation:

— generation of the Protocol
— carry out measurements onboard according to the pre-defined Protocol.

When all measured positions are within the specified limits, the **VIBR** notation can be assigned.

107 For similar vessels the same Protocol may be used. However, separate measurements shall be carried out for each vessel.

108 If major modifications to the vessel, which may influence the vibration conditions onboard, are carried out, new measurements may have to be taken in order to maintain the notation. This will be decided by the Society.

109 Excessive vibration levels will normally not be accepted. However, a risk based assessment of the actual position and level will be carried out and a possible dispensation evaluated. This may require that more extensive and frequent measurements have to be carried out or some sort of monitoring has to be installed.

C. Definitions

C 100 General

101 Basic vibration quantities and units are defined in ISO 2041.

102 *Vibration level:* The specified vibration level is to be measured as r.m.s. velocity (mm/s), unless r.m.s. displacement (mm) or r.m.s. acceleration (mm/s^2) is specified.

103 *Resonance:* Coincidence between excitation frequency and natural frequency of the actual component or structural position.

104 *Structural vibration:* Vibration level measured on the vessel structure.

105 *Machinery vibration:* Vibration level measured on machinery, components, equipment, pipes, etc.

106 *Protocol:* A document containing positions, requirements, test conditions and measured results. The Protocol is specifically generated for each vessel.

107 *Risk*, the combination of the frequency of occurrence and the severity of the consequence.

108 *Hazard*, a potential to threaten human life, health, property or environment.

109 *HAZID*, HAZard IDentification. A HAZID, is typically carried out as a workshop aiming at identifying the causes and effects ranged by risk of failure in machinery components and structures, performed in order to identify the positions and components which may lead to an operational interruption of the vessel. The result of this workshop is documented in the Protocol.

D. Documentation

D 100 General

101 The Protocol shall be generated to include the maximum vibration limits for actual positions and components to be measured. The Protocol shall be approved by the Society.

102 The Protocol forms the basis for the measurements to be carried out onboard. All positions described in the Protocol shall be measured and the levels documented in the tables included in the Protocol.

103 Possible additional positions detected during the survey

may be included in the Protocol.

E. References

E 100 General

101 International standards have been used as the foundation for these rules, but have not necessarily been explicitly followed. When setting the vibration limits and determining the measuring positions, due consideration has been given to technical and practical limitations inherent in the design and construction of different types of ship and localities. Unless a particular edition is referred to explicitly, the latest edition of each standard shall apply.

102 Where requirements described in the ISO standards deviate from these rules, the requirements in the rules shall take precedence.

103 Vibration standards:

— ISO 2041, "Vibration and shock — Vocabulary"
— ISO 4867, "Code for the measurement and reporting of shipboard vibration data"
— ISO 4868, "Code for the measurement and reporting of local vibration data of ship structures and equipment".
— ISO 10816-1, "Mechanical vibration-Evaluation of machine vibration by measurements on non-rotating parts, Part 1: General guidelines".

SECTION 2
VIBRATION CRITERIA

A. General

A 100 Requirements

101 Compliance with the rules shall be verified through measurements. It may, however, be advantageous to carry out a vibration assessment at an early project stage.

102 In order to be assigned the class notation **VIBR**, the requirements in Sec.1 B106 shall be met. However, in special cases small deviations from the requirements may be accepted depending upon position and measured level. This will be decided by the Society in each particular case.

103 A HAZID shall be carried out as a part of the preparation of the protocol as a tool to identify the risk level of the different positions and components. If the HAZID reveals positions or components with particularly high risk, the vibration limits may be reduced to stricter values than generally recommended.

Guidance note:

The HAZID is formally carried out as a workshop including personnel from different disciplines with experience from similar vessels.

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104 The vibration limits specified for structure aim at avoiding vibration induced fatigue cracks. For structure, used as foundation for equipment, the same limit as for the equipment shall be used. This is also applicable for mast mounted equipment, i.e. the limit specified for a radar to be mounted on a mast will be applied as the limit for the mast.

105 The vibration limits are in general given as r.m.s. vibration velocity. For some components restriction to maximum allowable r.m.s. displacement in the low frequency range and r.m.s. acceleration in the high frequency range are also specified.

B. Structural Vibration

B 100 Scope

101 Structural vibration should be limited in order to ensure structural integrity.

102 Structural vibration is a indicator of the risk of fatigue cracks in the structure. The level of vibration causing cracks will depend upon stress concentration factors, environment (corrosive medium) and workman ship of local details.

103 The class notation is applicable to structure in compartments where machinery, components and equipment is situated as well as structure close to the propeller(s). The structure in cargo areas is not included.

B 200 Criteria

201 For structural vibration, the criteria specified in Table B1 and Table B2 are not to be exceeded. Vibration levels below the criteria gives low risk for fatigue cracks.

Table B1 Steel
Velocity
4 – 200 Hz
45 mm/s

Table B2 Aluminium
Velocity
4 – 200 Hz
15 mm/s

202 For further evaluation, structural vibration may be assessed by dynamic strain measurements in conjunction with relevant material fatigue data.

203 For structural details with known global stresses, the standard vibration limits may be changed.

C. Vibration in Machinery and Components

C 100 Scope

101 Machinery vibration levels will be indicators of sound mounting, balancing and alignment for new installations as well as indicators of working performance for machinery in operation.

102 The criteria shall apply to all permissible operating speeds and loads at stable running conditions. Possible restricted operating ranges shall be clearly defined.

C 200 Criteria

201 The criteria shown in Tables C1 to C14 is not to be exceeded for the relevant machinery. The criteria shall apply for internally and externally excited vibration unless otherwise noted.

Table C1 Shaft line bearings
Velocity
1 – 200 Hz
5 mm/s
To be measured horizontally or vertically with the shaft centre. Shaft line vibration is specified in Pt.4 Ch.4 Sec.1. Frequency spectra to be presented to identify low frequency components.

Table C2 Diesel engines < 200 rpm		
	1 – 200 Hz	
	Displacement	*Velocity*
Vertical	1 mm	10 mm/s
Longitudinal	1 mm	10 mm/s
Transverse	1.5 mm	25 mm/s
To be measured at the top of the A – frame at engine ends. Frequency spectra to be presented to identify low frequency components.		

Table C3 Diesel engines > 200 rpm	
Velocity	
4 – 200 Hz	
Firmly mounted	Resiliently mounted
15 mm/s	25 mm/s
To be measured on the engine block top and bottom. 20% overshoot of the above criteria allowed for non continuous running in the operating speed range.	

Table C4 Turbochargers		
4 – 200 Hz		
Total combined power from cylinder group serving one turbocharger	*Velocity*	*Acceleration*
Below 5 MW	45 mm/s	2.5 g
5 - 10 MW	50 mm/s	2.0 g
Above 10 MW	55 mm/s	1.5 g
To be measured at the top of compressor casing. 20% overshoot of the above criteria allowed for non continuous running in the operating speed range.		

Table C5 Diesel driven generators and electrical motors on thrusters
Velocity
4 – 200 Hz
18 mm/s
To be measured in any direction on the bearings. Applies to both fixed and resilient mounted. 1st order vibration above 7 mm/s should be investigated.

Table C6 Turbines
Velocity
4 – 1000 Hz
7 mm/s
To be measured in any direction on the bearings. Applies to both fixed and resilient mounted.

Table C7 Turbine driven generators
Velocity
4 – 1000 Hz
7 mm/s
To be measured in any direction on the bearings. Applies to both fixed and resilient mounted.

Table C8 Gears
Velocity
4 – 1000 Hz
7 mm/s
To be measured in any direction on the foundation and on the input shaft bearing

Table C9 Electric motors, separators, motor driven hydraulic pumps, fans not installed on reciprocating engines	
	Velocity
	4.0 – 200 Hz 1)
Internal excited	7 mm/s 2)
External excited	12 mm/s
To be measured in any direction on the bearings.	
1) The upper frequency limit shall be at least 200 Hz and above 2 x rpm	
2) For vertically mounted motors the vibration level may be increased by 50% for the top of the motor.	

Table C10 Compressors (screw or centrifugal)	
	Velocity
	4 – 200 Hz 1)
Elastically mounted	10 mm/s
Fixed mounted	7 mm/s
To be measured in any direction on the bearings.	
1) The upper frequency limit shall be at least 200 Hz and above 2x rpm	

Table C11 Reciprocating compressors
Velocity
4 – 200 Hz
30 mm/s
To be measured in any direction on the bearings. Applies for both resilient and fixed mounted.

Table C12 Boilers
Velocity
4 – 200 Hz
45 mm/s
To be measured on stiff parts, e.g. lugs, flanges etc.

Table C13 Pipes
Velocity
4 – 200 Hz
45 mm/s

Table C14 Electronic instruments and equipment	
	Velocity
	4 – 200 Hz
Mounted on bulkheads	12 mm/s
Mounted on masts	20 mm/s
Mounted on machinery	25 mm/s
To be measured on the foundation of the actual equipment	

SECTION 3
MEASUREMENTS

A. General

A 100 Scope

101 Vibration of structure and components shall be measured in order to ensure that the actual vibration levels onboard do not exceed the limits as defined in Sec.2, before the **VIBR** notation can be assigned.

A 200 Requirements

201 The criteria for all relevant machinery are defined in Sec.2. With regard to the actual measurement positions at each component, reference is made to ISO 10816-1

202 The items to be fulfilled shall be listed in the Protocol.

Guidance note:

An example of the Protocol is shown in Table B1.

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203 Information about running machinery and the actual operational conditions, i.e. power, rpm, etc. has to be noted in the Protocol before the measurements can start.

204 The measurements shall be carried out at a pre-defined steady state operating condition representative for future in-service operation. (see also B102 and C104).

205 r.m.s. value corresponding to the defined frequency range shall be measured.

206 The measured vibration levels shall be analysed applying FFT technique. For positions where the measured level exceeds the level tabulated in the Protocol, frequency spectra shall be included.

Guidance note:

Machinery may exhibit stochastic vibration which will not be correctly represented in an FFT analyses. This will be most pronounced for elastically mounted machinery/equipment and mainly for the low frequency content of the vibration. The criteria are therefore mainly related to frequencies above 4 Hz where stochastic vibration is of minor importance.

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207 For positions not predefined in the Protocol, which are found during the survey to have high vibration levels, shall be included in the measurements.

Guidance note:

Typical examples are pipes vital for the operation of the vessel. It is difficult to predefine all position to be measured, because the clamping carried out during installation will determine the effective length of the different sections and consequently the natural frequency. In these cases, it is up to the surveyor to inspect the pipes and sense if any magnification of the vibration is present due to resonance.

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B. Test Procedure

B 100 Measurements

101 The Protocol shall be approved by the Society prior to measurements being taken.

Guidance note:

The selection of components and positions to be measured includes a risk evaluation, HAZID, of the different components. The basis for the requirements is the vibration limits as defined in Sec.2. The result of this work is the Protocol, as shown as an example in Table B1, to be filled in during the measurements onboard.

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102 The measurements shall be carried out by a qualified vibration expert under supervision of a DNV surveyor.

103 The measuring positions shall be selected such as to give a representative description of the vibration situation on board the ship.

104 The measurements shall be analysed using FFT techniques, and presented in the frequency domain (frequency spectra).

105 Analysis parameters:

- frequency range 1–200 Hz (unless noted for special components)
- at least 400 spectral-lines
- window function which gives an accurate estimate of the amplitude value of the single components in the frequency spectra (for instance flat top window)
- the vibration recordings shall be averaged over a time period necessary to achieve a stable reading, minimum 30 s.

106 The velocity levels shall be presented as r.m.s. values. For measured levels close to or exceeding the limits, plot showing the vibration spectra for the actual positions shall be included.

107 Calibration of instruments shall be carried out minimum every second year or according to standards.

B 200 Protocol

201 Table B1 shows an example of the Vibration Analyses Protocol.

Table B1 Vibration Analyses Protocol for: (insert name of vessel)

System	*Position*	*Checked*	*Limit [mm/s]*	*Measured [mm/s]*	*Max. Ampl./Freq.* mm/s / [Hz]*	*Comment*

* Only to be given when the vibration criterion is exceeded.

System	is the main machinery group
Position	is the actual measuring position
Checked	some position may only be checked without further measurements
Limit	is the predefined limit for the actual position
Measured	is the r.m.s. vibration level measured at the actual position
Max. Ampl./Freq.	is the maximum vibration component and the corresponding frequency
Frequency	is the frequency corresponding to a specific vibration component

C. Test Conditions

C 100 General

101 Generally the power output on the propeller shaft(s) shall correspond to contractual normal seagoing condition, or at least 85% of maximum continuous power available on the propeller shaft(s), unless stated differently in the Protocol. All other machinery shall be run under normal operating conditions during the tests. However, if the HAZID should reveal other operational conditions as critical, these conditions will be included in the protocol and the measurements

102 For engines and components operated at different RPM, a run-up may be required.

103 For ships normally operated in deep waters, the test should be conducted in a depth of water not less than four times the draught of the ship. For ships to be operated continuously in shallow waters, the tests shall be performed at the relevant depth of water.

104 The tests should be conducted in a sea state that does not significantly influence the measurement results.

105 The loading condition(s) of the ship shall be as close as possible to normal operating condition(s). For ships with larger variation than 25% in relevant displacements, the measurements shall normally be taken at two loading conditions close to the relevant heavy and light condition. Where this is not possible from a practical point of view, a light and heavy ballast condition are to be applied. The loading condition(s) used shall be approved by the Society, prior to testing.

106 The ship should sail on a straight course with minimum rudder deflection.

107 Any divergence from the above mentioned conditions shall be clearly stated in the report.

108 Special equipment and components, which are operated for limited periods, shall be included.

109 Information about running machinery and the actual ship operating conditions shall be noted in the Protocol.

D. Reporting

D 100 General

101 Prior to the measurements a plan with the following information shall be issued:

— specification of measuring positions and corresponding limits, the Protocol
— required loading conditions
— required operating conditions for machinery
— instrumentation to be used.

102 After the measurements have been carried out, a report shall be issued. The report shall contain the following information:

— ship and machinery particulars
— condition during the measurements such as power output, propeller and or engine speed, draught, water depth, wind and sea state
— sketches or pictures showing the location of the measuring positions and their direction of measurements
— tables of the measured vibration levels as defined in the Protocol. The required frequency spectra for the different positions shall be included
— instrumentation that has been used, including type of analyzer, window function that has been applied, averaging time and resolution
— description of possible excessive vibration levels.