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Ships and marine technology — Guidelines for measurement, evaluation and reporting of vibration with regard to habitability on specific ships

Navires et technologie maritime — Lignes directrices pour le mesurage, l'évaluation et l'établissement de rapports des vibrations affectant l'habitabilité à bord des navires spéciaux

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 8, *Ships and marine technology*, Subcommittee SC 8, *Ship design*.

Introduction

Shipboard vibration that interferes with duties or reduces comfort is objectionable and often results in adverse comments from crew and passengers. To quantify this vibration, this document gives guidelines for the measurement, evaluation and reporting of habitability for all persons on board specific ships including crew.

Vibration data acquired in accordance with this document are also useful for

— comparison with ship specifications,

— comparison with other ships, and

— further development and improvement of vibration regulations.

Ships and marine technology — Guidelines for measurement, evaluation and reporting of vibration with regard to habitability on specific ships

1 Scope

This document gives guidelines for the measurement, evaluation and reporting of vibration with regard to habitability for all persons on board ships satisfying one or both of the following conditions:

a) 2-stroke cycle, long-stroke, low-speed diesel engine directly coupled to the fixed-pitch propulsion propeller is installed.

b) length of deck house (L) is limited as compared with its height (H) (i.e. deck house of around 1,0 and above in slenderness ratio of H to L). An example of length of deck house (L) and its height (H) for slenderness ratio is shown in Annex A.

Overall frequency-weighted r.m.s. vibration values in the frequency range 1 Hz to 80 Hz are given as guidance values for different spaces on ships.

This document is applicable to specific ships with intended voyages of 24 h or more.

This document specifies requirements for the instrumentation and the procedure of measurement in normally occupied spaces. It also contains analysis specifications and guidelines for the evaluation of ship vibration with respect to habitability.

This document is not applicable to machinery spaces, other than engine control rooms, where persons do not stay for prolonged periods of time.

ISO 20283-5 is generally applicable to all ships. Requirements for measurement, evaluation and reporting of vibration with regard to habitability for all persons on board passenger and merchant ships, including specific ships to which this document may also be applicable can be found in ISO 20283-5. This document is neither complementary nor additional but supplementary to ISO 20283-5. The shipbuilder can select either this document or ISO 20283-5 to apply to any specific ship upon due consideration to individual design conditions of the ship and, if any, experience in building sister or similar ships, and that particular selection is intended to be agreed on by the shipowner.

The evaluation of low-frequency ship motion which can result in motion sickness is covered by ISO 2631-1. For the evaluation of the global structural vibration of a ship, however, see ISO 20283-2.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2041, *Mechanical vibration, shock and condition monitoring — Vocabulary*

ISO 2631-1, *Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration — Part 1: General requirements*

ISO 2631-2, *Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration — Part 2: Vibration in buildings (1 Hz to 80 Hz)*

ISO 8041, *Human response to vibration — Measuring instrumentation*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2041 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
accommodation space
space intended for recreational and administration use, namely cabins including day and sleeping rooms, hospitals, mess rooms, recreation rooms

Note 1 to entry: Examples of recreation rooms are lounges, smoke rooms, cinemas, gymnasiums, libraries, hobby rooms and game rooms.

3.2
office
space or room for carrying out a ship's business

EXAMPLE Deck office, ship office, meeting rooms.

3.3
work space
space allocated predominantly for manual work, namely workshops, laundries, galleys and laboratories, but not *machinery space* (3.4)

3.4
machinery space
space which contains steam or internal-combustion machinery, pumps, air compressors, boilers, oil fuel units, major electrical machinery, oil filling stations, thrusters, refrigerating, stabilizing, steering gear, ventilation and air conditioning machinery, etc., and trunks to such spaces

3.5
duty station
work space (3.3) where crew members typically stay over prolonged periods of time (typically for a watch of 4 h) to monitor navigation or machinery

Note 1 to entry: Main duty stations are the engine control room and the wheel house excluding bridge wing areas.

3.6
open-deck recreation space
designated space on the open deck to be used for the purpose of recreation

3.7
free route
condition achieved when the ship is proceeding at a constant speed and course with helm adjustment of ±2° or less and no throttle adjustment

4 Instrumentation

4.1 General requirements

Measurements in accordance with this document may be carried out using different types of measuring and recording equipment, e.g. instruments of digital, spectral or time-based type. The measuring instrumentation shall meet the relevant requirements of ISO 8041.

It is acceptable to use instruments manufactured in accordance with ISO 8041 that have frequency indications above 80 Hz provided that the filter characteristics comply with ISO 2631-2 (for frequency

weighting, W_m, see Annex B). The compliance of the instruments with the specifications of ISO 8041 requires a calibration of at least every two years. The date of the last calibration shall be reported.

If further data analysis is required following the measurement analysis as described in this document, the measurement data should be recorded with an electronic system which produces permanent records.

4.2 Functional test

Each channel of the instruments shall be checked on board the ship prior to and after each measurement series to ensure proper functioning. The check may be made by comparing the vibration value measured at any location by the instruments with that measured at the same location by other instruments, or with that provided by a portable exciter.

5 Measurement locations and directions

5.1 Measurement locations

Measurement locations shall be selected on all decks of normally occupied spaces in sufficient quantity in order to characterize satisfactorily the vibration behaviour of the ship with respect to habitability.

In work spaces, measurement transducers shall be especially placed at main duty stations of the crew. In accommodation spaces, transducer shall be positioned in the centre of spaces or where a person stays for prolonged periods of time. In general, measurements should be made at least 1 m from a steel wall as far as practical.

Vibration transducers shall be located and attached properly to the floor surface such that the vibration at the interface between the person and the source of vibration is adequately captured. If the floor is covered with a non-rigid or resilient material, the transducer shall be suitably mounted such that the pressure distribution on the surface of the floor covering is not altered. A transducer mounted on an appropriate three-spike plate may be used. The details about the transducer installation on rigid and soft material shall be clearly stated in the measurement report.

5.2 Measurement directions

The transducer directions shall correspond to the three translational axes of the ship: longitudinal, transverse and vertical.

6 Measurement conditions

Measurement data shall be obtained, in the first instance, during the acceptance or performance trial of the ship. The collection of consistent and accurate vibration data requires the following uniform and favourable measurement conditions:

a) free-route test on a straight course;

b) constant propulsion power according to contractual normal seagoing condition;

c) propulsion rotational speed is set constant during measurements;

d) full immersion of the propeller;

e) all systems to be in normal operation mode [heating, ventilation and air conditioning (HVAC), auxiliary engines, stabilizers, etc.]; and

f) for acceptable water depth needing no shallow water correction, Beaufort scale for wind and significant wave height, refer to ISO 15016.

Any deviation from the above measurement conditions shall be mutually agreed between the interested parties and shall be stated in the test report.

7 Measurement procedure

On each deck, measurements are required in all three directions (see 5.2), i.e. covering the in-plane vibration in horizontal directions (transverse and longitudinal) in addition to out-of-plane vibration in vertical direction, at least at two meaningful locations. The results should be evaluated separately. At other locations on the same deck, measurements are required in at least vertical direction.

The frequency weighting, W_m, in accordance with ISO 2631-2 shall be applied to all measurements irrespective of their direction.

NOTE One-third-octave band values of the frequency weighting, W_m, and a graphical presentation are given in Annex B. The frequency weighting, W_m, for narrow-band analysis is given in ISO 8041.

The frequency range to be evaluated is 1 Hz to 80 Hz. The measurement duration shall be at least 1 min. If significant frequency components below 2 Hz are obvious or suspected, measurement duration of at least 2 min is recommended.

The result of each measurement shall be the overall frequency-weighted r.m.s. value as defined in ISO 2631-1. The highest value in any direction shall be used for the evaluation of habitability.

8 Evaluation

8.1 Guidance values of acceptable vibration

Vibration guidance values are given in Table 1 in terms of the overall frequency-weighted r.m.s. velocity (mm/s) and acceleration (mm/s^2) in the frequency range 1 Hz to 80 Hz.

NOTE Overall frequency-weighted r.m.s. velocity, v_W, and acceleration, a_W, are related to each other through:

$$a_W = \frac{1}{0{,}028} v_W \tag{1}$$

The guidance values stated in Table 1 are to be regarded as maximum values.

Table 1 — Guidance values of acceptable vibration

Type of occupied space	Guidance value
Accommodation space	5,0 mm/s 179 mm/s^2
Open-deck recreation space	4,5 mm/s 161 mm/s^2
Office	4,5 mm/s 161 mm/s^2
Engine control room	5,0 mm/s 179 mm/s^2
Wheel house excluding bridge wings	6,0 mm/s 214 mm/s^2
Other work spaces	6,0 mm/s 214 mm/s^2

8.2 Beating

Beating is an interference between two sinusoidal vibrations of slightly different frequencies. It is perceived as periodic variation in vibration magnitude with a frequency that is the difference between the two vibration frequencies. Beating can readily be recognized. If beating is recognized, occurrence should be reported together with at least one noticeable location.

9 Test report

The test report shall, at least, contain the following information and data:

a) a reference to this document, i.e. ISO 21984;

b) place and date of the test;

c) identification of persons and organizations performing the test;

d) principal ship characteristics;

e) actual conditions of ship and environment experienced during the test, including, e.g. beating;

f) locations and orientations of the transducers;

g) recording equipment, date of last calibration and statement of functional testing; and

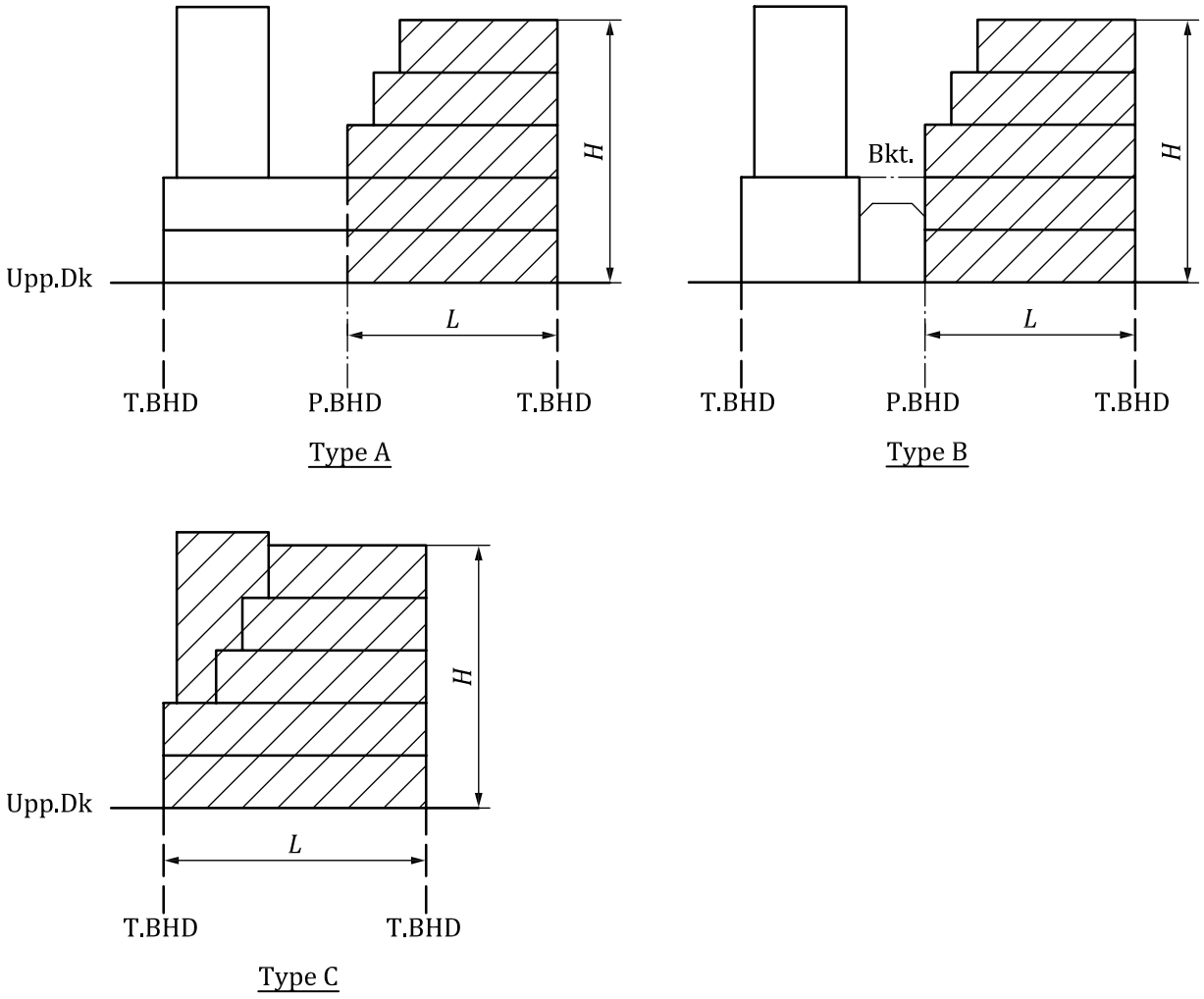
h) results of the measurements.

An example of a test report is shown in Annex C.

Annex A
(informative)

Example of length of a deck house (L) and its height (H) for slenderness ratio

Typical shapes of a deck house of specific ships are sketched in Figure A.1. Equivalent length (L) of a deck house shall be measured based on Figure A.1 considering the effectiveness of bending and shear stiffness as a cantilever. Height (H) of a deck house above the upper deck shall be measured at the centre line of the hull section.



Key

T.BHD	transverse bulkhead
P.BHD	partial bulkhead or transverse frame
Bkt.	bracket to connect engine casing and deck house

Figure A.1 — Typical shapes of a deck house of specific ships

Annex B
(informative)

Frequency weighting, W_m

The frequency weighting used, W_m, is defined in ISO 2631-2. It is given in Table B.1 and shown schematically in Figure B.1 for information.

Table B.1 — Frequency weighting, W_m, defined from 1 Hz to 80 Hz, in one-third-octave bands (calculated using the true mid-frequencies, band limitation included)

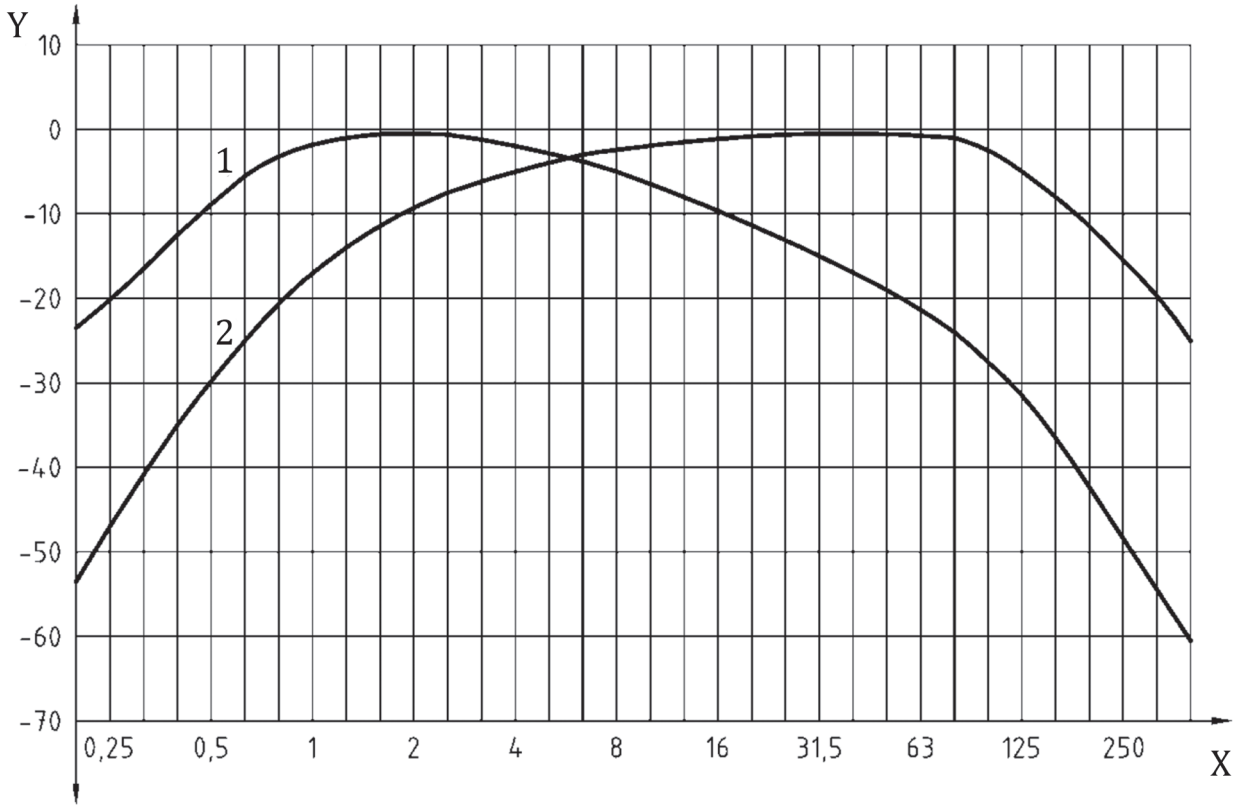
Frequency band number[a]	Frequency Hz		Acceleration as input quantity		Velocity as input quantity	
x	Nominal	True	Factor W_a	dB	Factor W_v	dB
–7	0,2	0,199 5	0,062 9	–24,02	0,002 21	–53,12
–6	0,25	0,251 2	0,099 4	–20,05	0,004 39	–47,14
–5	0,315	0,316 2	0,156	–16,12	0,008 70	–41,21
–4	0,4	0,398 1	0,243	–12,29	0,017 0	–35,38
–3	0,5	0,501 2	0,368	–8,67	0,032 5	–29,77
–2	0,63	0,631 0	0,530	–5,51	0,058 9	–24,60
–1	0,8	0,794 3	0,700	–3,09	0,097 9	–20,19
0	1	1,000	0,833	–1,59	0,147	–16,68
1	1,25	1,259	0,907	–0,85	0,201	–13,94
2	1,6	1,585	0,934	–0,59	0,260	–11,68
3	2	1,995	0,932	–0,61	0,327	–9,71
4	2,5	2,512	0,910	–0,82	0,402	–7,91
5	3,15	3,162	0,872	–1,19	0,485	–6,28
6	4	3,981	0,818	–1,74	0,573	–4,83
7	5	5,012	0,750	–2,50	0,661	–3,59
8	6,3	6,310	0,669	–3,49	0,743	–2,58
9	8	7,943	0,582	–4,70	0,813	–1,80
10	10	10,00	0,494	–6,12	0,869	–1,22
11	12,5	12,59	0,411	–7,71	0,911	–0,81
12	16	15,85	0,337	–9,44	0,941	–0,53
13	20	19,95	0,274	–11,25	0,961	–0,35
14	25	25,12	0,220	–13,14	0,973	–0,23
15	31,5	31,62	0,176	–15,09	0,979	–0,18
16	40	39,81	0,140	–17,10	0,978	–0,20
17	50	50,12	0,109	–19,23	0,964	–0,32
18	63	63,10	0,0834	–21,58	0,925	–0,67
19	80	79,43	0,060 4	–24,38	0,844	–1,48
20	100	100,0	0,040 1	–27,93	0,706	–3,02
21	125	125,9	0,024 1	–32,37	0,533	–5,46
22	160	158,5	0,013 3	–37,55	0,370	–8,64

[a] Index *x* is the frequency band number according to IEC 61260-1.

Table B.1 *(continued)*

Frequency band number[a]	Frequency Hz		Acceleration as input quantity		Velocity as input quantity	
x	Nominal	True	Factor W_a	dB	Factor W_v	dB
23	200	199,5	0,006 94	–43,18	0,244	–12,27
24	250	251,5	0,003 54	–49,02	0,156	–16,11
25	315	316,2	0,001 79	–54,95	0,099 5	–20,04
26	400	398,1	0,000 899	–60,92	0,063 0	–24,02

[a] Index *x* is the frequency band number according to IEC 61260-1.



Key

1 based on acceleration as input quantity
2 based on velocity as input quantity
X frequency, Hz
Y frequency weighting, dB

Figure B.1 — Frequency weighting curve, W_m, band limitation included (schematic)

The frequency weighting based on acceleration as input quantity, W_a, and the frequency weighting based on velocity as input quantity, W_v, are related one to each other as shown in Formula (B.1):

$$W_a(f) = \frac{1}{0,028}\frac{1}{2\pi f}W_v(f) \tag{B.1}$$

where f is the frequency.

Annex C
(informative)

Example of report for evaluation of habitability on board ships in accordance with this document

Place of test:			Date:
Name of organization responsible for the test:			
Name of person performing the test:			
Name of ship:		Yard (shipbuilder) and yard number:	
Type of ship:		Date built:	

Hull particulars | **Main engine particulars**

Length between perpendiculars, m:		Type:	Number of cylinders:
Breadth moulded, m:	Draught, m:	Number:	Power, kW:
Remarks:		Speed, r/min:	

Propulsion particulars | **Measurement conditions**

Number and type:	Number of blades:	Sea state:	Beaufort scale for wind:
		Significant wave height, m:	Wind speed, m/s:
		Depth of water, m:	Wind direction:
Speed, r/min:		Draught forward, m:	Draught aft, m:
Remarks:		Remarks:	

Type and characteristics of measuring instrumentation

Measuring equipment particulars:
Functional test:

Measurement results

Transducer location	Direction	Overall frequency-weighted r.m.s. values	
		Acceleration mm/s^2	Velocity mm/s
1.			
2.			
3.			
….			

Bibliography

[1] ISO 15016, *Ships and marine technology — Guidelines for the assessment of speed and power performance by analysis of speed trial data*

[2] ISO 20283-2, *Mechanical vibration — Measurement of vibration on ships — Part 2: Measurement of structural vibration*

[3] ISO 20283-5, *Mechanical vibration — Measurement of vibration on ships — Part 5: Guidelines for measurement, evaluation and reporting of vibration with regard to habitability on passenger and merchant ships*

[3] IEC 61260-1, *Electroacoustics — Octave-band and fractional-octave-band filters — Part 1: Specifications*

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