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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

Vibrations mécaniques — Mesurage des vibrations à bord des navires —

Partie 5: Lignes directrices pour le mesurage, l'évaluation et l'établissement de rapports des vibrations affectant l'habitabilité à bord des navires de commerce et des paquebots

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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 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.

The committee responsible for this document is ISO/TC 108, *Mechanical vibration, shock and condition monitoring*, Subcommittee SC 2, *Measurement and evaluation of mechanical vibration and shock as applied to machines, vehicles and structures*.

This first edition of ISO 20283-5 cancels and replaces ISO 6954:2000, which has been technically revised with the following changes:

— crew and passenger spaces were clearly defined;

— measurement conditions also include dynamic positioning (DP) mode;

— guideline values were changed from pairs of lower and upper values representing the range of commonly accepted vibration magnitude to just one maximum value. This gives a clearer indication when this document is referred to in commercial contracts or similar. The actual guideline values are somewhat severer accounting for the technical progress made.

A list of parts in the ISO 20283 series can be found on the ISO website.

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, especially for the 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.

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

1 Scope

This document gives guidelines for the measurement, evaluation and reporting of vibration with regard to habitability for all persons on-board passenger and merchant ships, especially for crew. Overall frequency-weighted r.m.s. vibration values in the frequency range 1 Hz to 80 Hz are given as guideline values for different areas on ships.

This document is applicable to passenger and merchant 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.

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 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:

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

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

3.1 General

3.1.1
crew
persons on-board a ship who are responsible to keep running all functions necessary to safely navigate the ship

3.1.2
passenger
person on-board a ship not belonging to the *crew* (3.1.1)

Note 1 to entry: Passengers are also scientific personnel on research ships, temporary working crew, camera teams and similar.

3.1.3
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

3.2 Crew and passenger spaces

3.2.1
crew accommodation space
space intended for *crew* (3.1.1) recreational and administration use, namely cabins including day and sleeping rooms, hospitals, mess rooms, recreation rooms

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

3.2.2
office
area or room for carrying out a ship's business, namely deck office, ship office, meeting rooms

3.2.3
work space
area allocated for predominant manual work, namely workshops, laundries, galleys and laboratories, but except *machinery spaces* (3.2.4)

3.2.4
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

Note 1 to entry: Machinery spaces are not meant for longer stay, hence they are not considered in this document.

3.2.5
duty station
work space (3.2.3) where *crew* (3.1.1) 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 navigation bridge and the engine control room (ECR).

3.2.6
open-deck recreation space
designated area on the open decks to be used by *crew* (3.1.1) and *passengers* (3.1.2) for the purpose of recreation

3.2.7
cabin and public space
space primarily intended for *passenger* (3.1.2) use, namely passenger cabins, public spaces

Note 1 to entry: Public spaces are restaurants, lounges, reading and game rooms, gymnasiums, shops.

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 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 A).

The compliance of the instrumentation system with the specifications of ISO 8041 requires a calibration at least every 2 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 instrumentation shall be checked by mechanical excitation of the transducer prior to and after each measurement series to ensure proper functioning.

5 Measurement locations and directions

5.1 Measurement locations

The classification to be applied to the various areas of a ship according to their type, the measurement locations or any deviations from the recommendations stated in this subclause should be mutually agreed between the interested parties (e.g. shipbuilder and shipowner) prior to the measurements.

NOTE These details constitute a measurement plan.

For practical reasons, it is advised to select the locations such that a sufficient amount of sample data are collected during the measurement phase. For large spaces, it can be necessary to distribute a number of measuring positions. Navigation bridges, engine control rooms, mess rooms and lounges, which are generally larger spaces, shall be measured on a reasonable number of positions.

Measurement locations shall be selected on all decks of occupied spaces in sufficient quantity in order to characterize satisfactorily the vibration behaviour of the ship with respect to habitability. The measurement locations shall be selected in accordance with the following criteria:

a) For each type of occupied space as listed in Table 1, measurements are to be taken preferably in ship sections and areas where vibration is expected. From a walk-through of the ship or during the measurement campaign, locations with apparently elevated vibration should be added to the measurement locations.

b) At least one space of each type of occupied space as listed in Table 1 shall be measured.

c) Where multiple instances of the same type of occupied space exist on a deck, a representative sample of rooms as recommended in Table 1 should be measured.

Table 1 — Recommended measurement samples

Type of occupied space	Recommended sample ratio applicable to each deck where several occupied spaces of the same type exist
Crew spaces	
Crew accommodation and offices	≥30 % of the spaces
Work spaces	≥20 % of the spaces
Open-deck crew recreation spaces	at least 1 sample
Passenger spaces	
Cabins and public spaces	≥10 % of the spaces
Open-deck recreation spaces	at least 1 sample

5.2 Measurement position and orientation

Vibration transducers shall be preferably located at positions where work is carried out. In work spaces, on the bridge, etc. measurement transducers are to be especially placed at typical duty stations of the crew. In passenger spaces, transducer shall be positioned in the centre of cabins or where passengers stay for prolonged periods of time.

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. In general, measurements shall be made at least 1 m from a wall. 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.

The transducer orientation 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) during measurements the propulsion rotational speed is set constant;

d) sea state 3 or less;

e) full immersion of the propeller;

f) water depth not less than five times the draught of the ship;

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

In case ships are intended that they use their dynamic positioning (DP) system as a normal working condition (e.g. pipe laying, offshore operation), additional vibration measurements at DP mode shall be made in crew accommodation spaces, offices and work spaces, as well as in the navigation bridge and engine control room to ensure that the vibration guideline values in Table 2 are not exceeded.

The propulsion power to be applied during these measurements depends on the DP capacity the ship and the related components are designed for. The power to realize this DP capacity is defined as the 100 % condition; redundant installation (e.g. thrusters, propulsors) are not to be considered. For the measurements, all propulsors or groups thereof taking part in the DP operation should be operated simultaneously at about 40 % of their individual power contribution. In case the 100 % condition is not clear, 40 % of the maximum power of all propulsors or groups thereof should be applied simultaneously.

An agreement between the interested parties (e.g. shipbuilder and shipowner) on the DP measurements is strongly recommended and should consider realistic DP operations, as well as the ambient conditions and constraints of the specific sea trial.

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) at least at two meaningful locations, i.e. covering the in-plane vibration in horizontal directions (transverse and longitudinal). The results should be evaluated separately. At other locations on the same deck, measurements are only required in the 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 A. 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, a 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 Guideline values of acceptable vibration

Vibration guideline values are given in Table 2 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 1 Overall frequency-weighted r.m.s. velocity, v_w, and acceleration, a_w, are related one to each other through:

$$a_w = \frac{1}{0,028} v_w \quad (1)$$

The guideline values stated in Table 2 are to be regarded as maximum values.

NOTE 2 For crew spaces, the same vibration guideline values apply to DP, see Clause 6.

Table 2 — Guideline values of acceptable vibration

Type of occupied space	Guideline value
Crew spaces	
Crew accommodation	3,5 mm/s 125 mm/s^2
Work spaces	6,0 mm/s 214 mm/s^2
Offices	4,5 mm/s 161 mm/s^2
Navigation bridge and engine control room	5,0 mm/s 179 mm/s^2
Open-deck recreation spaces	4,5 mm/s 161 mm/s^2
Passenger spaces	
Cabins and public spaces	3,5 mm/s 125 mm/s^2
Open-deck recreation spaces	4,5 mm/s 161 mm/s^2

8.2 Excessive vibration values

The measured vibration values may exceed the guideline values of acceptable vibration at a restricted number of measurement locations as specified in Table 3.

Table 3 is applicable to a large number of measurement locations within the same type of occupied space on a deck. If only five to nine locations of the same type are measured, a maximum exceedance of 0,5 mm/s is allowed for one location only; for fewer than five locations on a deck, no exceedance is granted. No exceedance is granted in any case for navigation bridges and engine control rooms.

Table 3 — Excessive vibration values

Type of occupied space for which ten or more exist on a deck	Maximum ratio of measured spaces with exceeding vibration	Maximum allowed exceedance
Crew spaces		
Crew accommodation	10 %	1,0 mm/s 36 mm/s^2
Work spaces		
Offices		
Open-deck crew recreation spaces		
Passenger spaces		
Cabins and public spaces	10 %	1,0 mm/s 36 mm/s^2
Open-deck recreation spaces		

8.3 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 20283-5;

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;

h) results of the measurements.

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

Annex A
(informative)

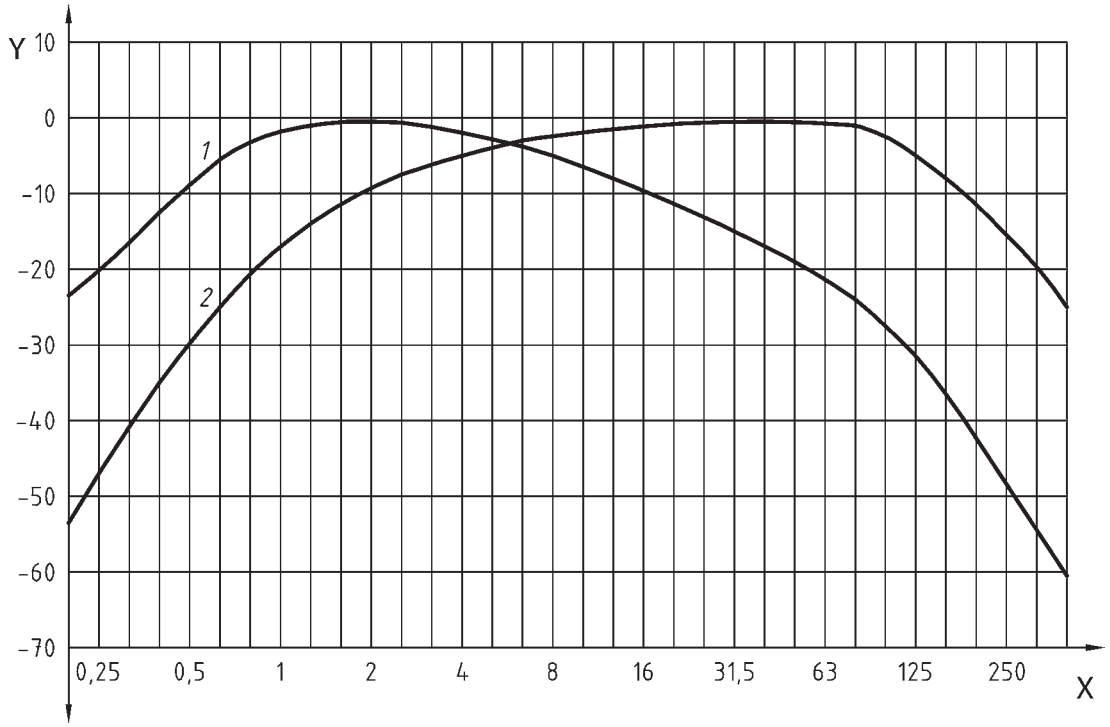
Frequency weighting, W_m

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

Table A.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	−47,15
−5	0,315	0,316 2	0,156	−16,12	0,008 68	−41,23
−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 4	−29,78
−2	0,63	0,631 0	0,530	−5,51	0,058 8	−24,61
−1	0,8	0,794 3	0,700	−3,09	0,097 8	−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	−11,69
3	2	1,995	0,932	−0,61	0,327	−9,70
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	−4,84
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	−1,79
10	10	10,00	0,494	−6,12	0,869	−1,22
11	12,5	12,59	0,411	−7,71	0,910	−0,82
12	16	15,85	0,337	−9,44	0,940	−0,54
13	20	19,95	0,274	−11,25	0,962	−0,34
14	25	25,12	0,220	−13,14	0,972	−0,24
15	31,5	31,62	0,176	−15,09	0,979	−0,18
16	40	39,81	0,140	−17,10	0,981	−0,17
17	50	50,12	0,109	−19,23	0,961	−0,34
18	63	63,10	0,083 4	−21,58	0,926	−0,67
19	80	79,43	0,060 4	−24,38	0,844	−1,47
20	100	100,0	0,040 1	−27,93	0,705	−3,03
21	125	125,9	0,024 1	−32,37	0,534	−5,45
22	160	158,5	0,013 3	−37,55	0,371	−8,62
23	200	199,5	0,006 94	−43,18	0,244	−12,27
24	250	251,2	0,003 54	−49,02	0,156	−16,11
25	315	316,2	0,001 79	−54,95	0,099 6	−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 A.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 (A.1):

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

where f is the frequency.

Annex B
(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:	Wind speed and direction:
		Depth of water, m:	
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 2041, *Mechanical vibration, shock and condition monitoring — Vocabulary*

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

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

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