BS ISO 20283-3:2006

Mechanical vibration — Measurement of vibration on ships —

Part 3: Pre-installation vibration measurement of shipboard equipment

ICS 17.140.30; 47.020.01

British Standards

National foreword

This British Standard reproduces verbatim ISO 20283-3:2006 and implements it as the UK national standard.

The UK participation in its preparation was entrusted by Technical Committee GME/21, Mechanical vibration, shock and condition monitoring, to Subcommittee GME/21/3, Measurement and evaluation of mechanical vibration and shock, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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Summary of pages

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Mechanical vibration — Measurement of vibration on ships —

Part 3: **Pre-installation vibration measurement of shipboard equipment**

Vibrations mécaniques — Mesurage des vibrations à bord des navires —

Partie 3: Mesurage des vibrations des équipements de bord avant leur installation

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Contents

Page

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 20283-3 was prepared by Technical Committee ISO/TC 108, *Mechanical vibration and shock*, Subcommittee SC 2, *Measurement and evaluation of mechanical vibration and shock as applied to machines, vehicles and structures*.

ISO 20283 consists of the following parts, under the general title *Mechanical vibration — Measurement of vibration on ships*:

— *Part 3: Pre-installation vibration measurement of shipboard equipment*

The following parts are under preparation:

— *Part 2: Measurement of structural vibration on ships*

General guidelines and measurement and evaluation of ship propulsion machinery vibration are to form the subjects of future parts 1 and 4.

Introduction

Operating machinery and equipment aboard ships can create vibration and excessive structure-borne sound. As a result, the limits for sound pressure levels specified by contracting partners for spaces occupied by crew and passengers may be exceeded. Where it is anticipated that structure-borne sound from machinery can adversely affect occupied spaces, this part of ISO 20283 can be applied with the aim of selecting low-vibration machinery.

Measurement of the vibration of individual equipment units, conducted according to standardized procedures and compared with contractually agreed-on acceptance criteria, will provide the requisite information to the shipbuilder for the proper selection and installation of the equipment.

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Mechanical vibration — Measurement of vibration on ships —

Part 3: Pre-installation vibration measurement of shipboard equipment

1 Scope

This part of ISO 20283 gives guidelines, requirements and procedures for the measurement of vibration generated by types of shipboard equipment, and which can be transmitted into a ship structure as structure-borne sound, as part of the factory acceptance test (FAT) of the equipment unit. It specifies the measurements to be conducted for well-defined operating and mounting conditions of the unit, e.g. in the supplier's test rig.

This part of ISO 20283 is a framework for providing representative test results. It is applicable to shipboard equipment intended for passenger ships, merchant ships, yachts and high-speed craft.

This part of ISO 20283 is concerned with translational vibration, since rotational vibration is not considered to be a substantial contributor to structure-borne sound. However, it does not provide numerical limits for equipment vibration or transmitted structure-borne sound.

2 Normative references

The following referenced documents are indispensable for the application 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 31-7, *Quantities and units — Part 7: Acoustics*

ISO 1683, *Acoustics — Preferred reference quantities for acoustic levels*

ISO 2041, *Vibration and shock — Vocabulary*

ISO 5348, *Mechanical vibration and shock — Mechanical mounting of accelerometers*

ISO/TR 13298, *Ships and marine technology — Vocabulary of general terms*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 31-7, ISO 2041, ISO/TR 13298 and the following apply.

3.1
equipment
any machine, system, subsystem or part thereof which causes vibration and is intended to be installed aboard ships

EXAMPLE 1 Main propulsion plant: diesel engine, gas turbine, main reduction gear, electric propulsion motor.

EXAMPLE 2 Mechanical ventilation as well as heating, ventilation and air-conditioning (HVAC) system: air supply and exhaust fans, air-conditioning units, air-conditioning water cooling units, fresh water pumps, etc.

EXAMPLE 3 Auxiliary equipment: diesel engine or gas turbine driven generators, hydraulic plants, electric motors, etc.

NOTE Excluded are pumps directly fitted to reduction gears, diesel engines, etc., fans directly fitted to electric propulsion motors, generators, electric motors, etc., and any other auxiliary equipment attached to larger units that are subject to the pre-testing procedure.

3.2
resilient mount
device with elastic properties used to reduce transmission of structure-borne vibration

NOTE This is typically a shaped block of rubber or similar elastic material used at discrete locations at the component attachment point(s) for the purpose of supporting the component and providing vibration isolation between the component and the support foundation or structure. Use of these devices approximates a **practically free condition** (3.12) within a broad frequency range.

3.3
compound mount
double-resilient mount
three-element system consisting of an intermediate mass, the amount of which is comparable to that of the mounted equipment contained between two sets of resilient elements

NOTE Compound mounts are used to achieve greater vibration attenuation than is available with the use of simple resilient mounts. The isolated equipment is supported by the three-element system.

3.4
rigidly mounted equipment
equipment which is solidly attached to the support structure

3.5
support structure
mechanical structure of various types upon which equipment is installed

3.5.1
mounting fixture
support structure mainly intended to be used for rigidly mounted equipment with relatively light framework or structure for the purpose of vibration testing, and which is used above resilient mounts

EXAMPLE Common base frame.

NOTE The fixture can also be used for resiliently mounted equipment for the purpose of vibration testing.

3.5.2
foundation
support structure which is used below the resilient mounts and which may or may not resemble the ship structure

3.5.3
subbase
bedplate
support structure required for shipboard installation and which is necessary to hold down one or more components within alignment

3.5.4
testbed
support structure normally consisting of a massive and reinforced concrete structure to which the entire assembly of equipment, mounts and support structures is attached

3.6
test frequency range
range of one-third-octave band mid-frequencies between 10 Hz and 10 kHz

NOTE Depending on the equipment being tested, it may be reasonable to modify the frequency range, as agreed on by the purchaser and supplier.

3.7
structure-borne sound
mechanical vibration in solid structures, generated within the test frequency range by a vibratory source

NOTE 1 Main engines, auxiliary machinery can be structure-borne sound sources.

NOTE 2 In the frequency range above 16 Hz, structure-borne sound can be audible.

3.8
acceleration level
L_a
measure of vibration acceleration given by

$$L_a = 10 \lg \frac{a^2}{a_0^2} \text{ dB} \tag{1}$$

where

a is the r.m.s. value of the measured acceleration, m/s^2, and

a_0 is the acceleration reference value according to ISO 1683, where $a_0 = 10^{-6}$ m/s^2

NOTE When stating a level it is mandatory to always indicate the reference value, i.e. dB re 10^{-6} m/s^2.

3.9
velocity level
L_v
measure of vibration velocity given by

$$L_v = 10 \lg \frac{v^2}{v_0^2} \text{ dB} \tag{2}$$

where

v is the r.m.s. value of the measured velocity, in metres per second (m/s), and

v_0 is the velocity reference value according to ISO 1683, where $v_0 = 10^{-9}$ m/s

NOTE When stating a level it is mandatory to always indicate the reference value, i.e. dB re 10^{-9} m/s.

3.10
impedance
Z
complex ratio of the excitation force, F, to the velocity, v, taken at the same point in a mechanical system during simple harmonic motion

$$Z = F/v \tag{3}$$

NOTE 1 The unit of impedance is N·s/m. See ISO 2041 for more details on impedance.

NOTE 2 The knowledge of the impedance or **mobility** (3.11) of the foundation is necessary in the case of rigidly mounted equipment under test.

3.11
mobility
M
complex ratio of the velocity, v, to the excitation force taken at the same point in a mechanical system during simple harmonic motion

$$M = v/F \quad (4)$$

NOTE 1 The unit of mobility is m/(N·s). See ISO 2041 for more details on mobility.

NOTE 2 The knowledge of the mobility or **impedance** (3.10) of the foundation is necessary in the case of rigidly mounted equipment under test.

3.12
practically free condition
mounting configuration whereby the equipment throughout a large part of, or the entire, test frequency range can be considered to be freely suspended

NOTE 1 This is achieved by the use of very soft springs (resilient mounts) arranged between the attachment points of the equipment and the support structure. The loaded first vertical tuning frequency of the mounted equipment should not exceed about 10 Hz or be sufficiently below the lowest forcing frequency of the equipment. The loaded first vertical tuning frequency is the root of the ratio of the mount stiffness to the mass of the equipment and support structure above mounts, divided by 2π. For equipment with a mass of 100 kg or less, stiffer mounts may be used, provided the loaded first vertical tuning frequency does not exceed 15 Hz, and the local static stiffness of any foundation should be at least ten times higher than the dynamic stiffness of the mounts. The complete assembly, including equipment, support structure, resilient mounts and any foundation, should be supported on a rigid and massive testbed. Massive and rigid means that the test set-up is effectively isolated from disturbing vibration in the surroundings, i.e. above about 7 Hz.

NOTE 2 The purchaser and supplier might need to agree on alternative means and test requirements to prevent or account for interference due to limitations of the test site.

3.13
insertion loss
loss resulting from insertion of an element in a transmission system, being the ratio of the power delivered to that part of the system following the element, before the element's insertion, to the power delivered to the same part of the system after the element's insertion

4 Measurement requirements and procedures

4.1 General

The purchaser and supplier shall agree on the individual equipment to be tested; they may also agree on limits for equipment vibration or possible structure-borne sound (see Clause 5). It is necessary that both the purchaser and supplier agree on the scope of the tests (measuring positions, operating conditions, etc.) before conducting the tests to avoid misunderstanding. Unless the purchaser and supplier agree on other conditions, the measurements required by this part of ISO 20283 shall be vibration acceleration normally made during steady-state operating conditions of the equipment under test (see 4.8). For certain equipment, measurements during transient operating conditions and transient measurement techniques may be agreed on by the purchaser and supplier.

The vibration measurements on the attachment points of a machine or other equipment under practically free conditions are taken as a structure-borne sound source which the shipbuilder may then apply in conjunction with the impedances of the actual mounts (if mounts are being used in the installation) and the actual foundation aboard ship to predict the structure-borne sound from the equipment unit. The practically free condition for the test is achieved by the use of soft mounts below the attachment points (see Note in 3.2) which are instrumented for measurement. There may be occasion when the actual mounts and/or bedplate are delivered with the unit (see 4.2 and 4.7).

4.2 Measurement point locations

Measurements shall be made on the feet for both simply and compound-mounted equipment which include feet, or at the base of the equipment unit. Measurements shall be made above all mounts and isolators, i.e. on the feet or base of the unit under test, for both simply and compound-mounted equipment.

Measurement points on valves shall be on all the outlet flanges or nozzles and any other structural connections, except the inlets.

The purchaser and supplier shall agree on measurement locations for equipment which does not have well defined points of attachment (see also 4.7.1).

NOTE The purchaser and supplier could agree to refer to ISO 9611 for more detailed description of transducer locations. However, ISO 9611 contains requirements more suited for laboratory investigations, including measurements of rotational vibration, which are not considered in this part of ISO 20283 to be substantial contributors to structure-borne sound.

4.3 Transducer orientation and mounting

Measurements shall be made at the specified locations agreed on by the purchaser and supplier (see 4.2) in three orthogonal directions, one of which shall be vertical. For valves, measurements in two directions are required, perpendicular and parallel to the flow on all outlet flanges or nozzles.

NOTE The supplier's experience could be sufficient justification for reducing the number of measurements considerably, e.g. limiting to only vertical vibration. However, this needs to have the purchaser's concurrence.

Transducers shall be mounted in accordance with ISO 5348 or with the accelerometer manufacturer's instructions, preferably by screwing to an adaptor plate cemented to the equipment unit. Because the method of mounting strongly limits the upper frequency of measurement, magnetic, beeswax, adhesive tape or hand-held mounting methods shall not be used, except in instances where otherwise inaccessible or in the need of efficiency.

4.4 Measurement frequency resolution

4.4.1 General

One-third-octave band measurements in accordance with 4.4.2 shall be made at the locations specified in 4.2. Narrow-band measurements in accordance with 4.4.3 may be made, if agreed on by the purchaser and supplier, for purposes of diagnostics.

4.4.2 One-third-octave band measurements

One-third-octave band acceleration levels L_a (or velocity levels L_v depending on the agreement between the supplier and purchaser) shall be measured for the ambient (non-operating) conditions and the conditions specified in 4.8 over the test frequency range with centre frequencies of 10 Hz to 10 kHz or a range agreed on between the supplier and purchaser.

4.4.3 Narrow-band measurements

Narrow-band acceleration levels L_a may be measured with a constant-absolute or a constant-relative bandwidth analyser. The frequency range and analysis bandwidth should be selected according to the vibratory behaviour of the equipment (resonances, main working frequencies and their harmonics) and agreed on by the purchaser and supplier. The constant-absolute bandwidth should not be greater than Δf = 2,5 Hz, the constant-relative bandwidth should not be greater than 1/24 octave.

4.5 Calibration

4.5.1 Laboratory calibration

Calibration of vibration transducers may be performed by any appropriate method specified in ISO 5347 or ISO 16063 within 2 years before each use. Unless otherwise agreed on by the purchaser and supplier, calibration of each channel of the entire vibration measurement system shall be made at a minimum of two frequencies: one at the low end of the frequency range (e.g. 160 Hz); the other at the high end of the frequency range (e.g. 6,3 kHz). Calibration shall be made at voltages equal to those of the transducer output, corresponding e.g. to 90 dB, 110 dB, 130 dB and 150 dB (re 10^{-6} m/s^2) for accelerometers, to verify amplitude linearity.

4.5.2 Field check

The entire vibration measurement system, including the transducer(s), shall be checked at a minimum of one frequency point, using an accelerometer calibrator, at the beginning of each day and at the end of the equipment measurements. Field checks should be accurate within 2 dB.

4.6 Ambient vibration and its influence

Ambient vibration levels should be 10 dB below the vibration levels with the equipment operating, unless otherwise agreed on by the purchaser and supplier. Corrective measures may be taken to reduce the effect of ambient vibration on the equipment vibration to be measured. Measured levels of equipment vibration shall not be adjusted to account for the effects of ambient vibration.

If ambient vibration cannot be excluded, e.g. the vibration is generated by the test system or by the schedule of measurements (out of working time), a narrow-band analysis of the ambient vibration and the vibration of the equipment in operation might allow a separation of ambient vibration from equipment vibration. In these cases, the vibration level shall be corrected.

4.7 Test system

4.7.1 Mounting of equipment

Equipment is installed aboard ships in a variety of ways, the most common of which are

a) rigidly mounted to foundation,

b) rigidly mounted to a bedplate, which in turn is mounted

   — rigidly to foundation, or

   — resiliently to foundation,

c) resiliently mounted to foundation, and

d) resiliently mounted to a bedplate, which in turn is mounted

   — rigidly to foundation, or

   — resiliently to foundation.

Equipment delivered to the test site may include some or all of the mounting components to be used aboard ship.

However, the approach to characterizing the vibratory source strength of an equipment unit by measurement of its vibration requires that the equipment be supported with free boundary conditions, or as close as possible to those conditions, by the use of resilient mounts (see 3.12). In some cases, this may not be possible, e.g. when a machine is rigidly mounted to a bedplate or fixture because direct resilient mounting is not feasible. In this case, see 4.7.2.3 and 4.7.2.4.

NOTE 1 Diesel engine driven generator sets pose a special consideration. As illustrated in Annex A, there are several schemes for the mounting and connection of the generator and driver. In cases where one or both of the components are resiliently mounted to a common subbase, a flexible shaft coupling is required (see Figures A.2 and A.4). There are also sets where both units are rigidly mounted to the foundation, so that no flexible coupling is incorporated into the design (see Figures A.1 and A.3). In this case resilient mountings for the separate components cannot be used because of alignment, so that a bedplate (subbase) to which the units are rigidly mounted is necessary for the tests. In fact, this bedplate is usually part of the delivered system. The measurements are then made on the units at the points of attachment to the bedplate. Where the driver is resiliently mounted (which is part of the installed system) and the generator rigidly mounted (see Figure A.4), measurements for the driver are taken on the bedplate below the mounts, while those for the generator are taken on the generator at the attachment points.

Equipment is to be oriented in its normal shipboard-installed position and resiliently mounted, regardless of how it is mounted aboard ship. When the equipment is resiliently mounted aboard ship, the resilient mounts and, where possible, the support structure used in the test shall be the same as those used in the shipboard installation. However, gear boxes and heavy propulsion engines, e.g. two-stroke diesel engines, are in general mounted rigidly to the testbed.

NOTE 2 In special cases, resilient mounting of gear boxes and heavy propulsion engines is desirable.

When testing, the entire assembly is mounted on the testbed. Actual systems encountered in practice, whether onboard ship or in a test rig at the plant, can deviate from uniform ideal configurations. For that reason, Annex B presents typical test system configurations for meeting the requirements of this part of ISO 20283.

The test system shall be designed to ensure that vibration generated by the support does not contaminate the measurements. If contamination cannot be avoided, this effect shall be considered in the final test results. To avoid contamination, the impedance of the support structure should be similar to the shipboard foundation. If this is not the case, corrections may be made (see 4.7.3).

For equipment delivered with mounts, the purchaser and supplier may agree on having additional measurements taken at below-mount locations on the testbed or foundation, on a sufficiently stiff part of the support structure as close as possible to the attachment points. In this case, impedance measurements need to be taken at these measurement points.

4.7.2 Support structures

4.7.2.1 General

Support structures (according to 4.7.2.2 to 4.7.2.4) should have no fixed-base natural frequencies near the fundamental rotational or other primary forcing frequencies of the equipment under test to avoid resonances that can increase measured vibration levels. The local static stiffness of any foundation should be at least ten times greater than the dynamic stiffness of the mounts.

In the case where it is agreed that the equipment be mounted rigidly, the vibratory response properties of the foundation or the bedplate at the points of attachment shall be described by the impedance or mobility of the foundation or bedplate in the frequency range up to about 1 kHz.

For resiliently mounted equipment, the impedance or mobility of any support structure needs to be measured only if there is a contractual agreement for additional measurements below the elastic mounts of the equipment.

4.7.2.2 Testbed

The complete assembly, including equipment, support structure, resilient mounts and any foundation, should be supported on a rigid and massive testbed. The testbed can be rigidly or resiliently mounted with a vertical tuning frequency of up to about 5 Hz.

4.7.2.3 Subbase, bedplate

The bedplate structure shall be resiliently mounted (vertical tuning frequency of up to about 5 Hz) on the foundation only in the case that the testbed is rigidly mounted. Exception shall be made in the case of gearboxes and heavy propulsion engines that are to be rigidly mounted on the foundation (see also 4.7.1).

In the case of resiliently mounted equipment, a common subbase may consist of steel girders below the mounting of the equipment. The common subbase shall be firmly attached to the foundation or testbed. The impedance or mobility of this foundation needs to be measured only if there is a contractual agreement for additional measurements below elastic mounts of the equipment.

4.7.2.4 Mounting fixture

Equipment consisting of units with relatively light framework or structure (e.g. controllers, control cubicles, non-rotating or non-reciprocating equipment) and which are rigidly mounted aboard ship may be tested while rigidly mounted to a resiliently mounted facility, i.e. the mounting fixture. The fixture is resiliently mounted on top of the foundation instead of the subbase (see also Note 1 in 3.12). Such items shall be attached to the mounting fixture at the normal points of attachment of the equipment which are used when installed aboard ship.

4.7.3 Impedance measurements

The impedance of the support structure, consisting of bedplate, foundation or both, should be measured in order to determine whether or not the support structure is similar to the shipboard foundation, in order to obtain reference impedance data for the purpose of comparison with actual ship foundations. Impedance corrections which are based on such impedance measurements of the support structure and corresponding corrections are acceptable.

4.7.4 Corrections for non-free boundary conditions

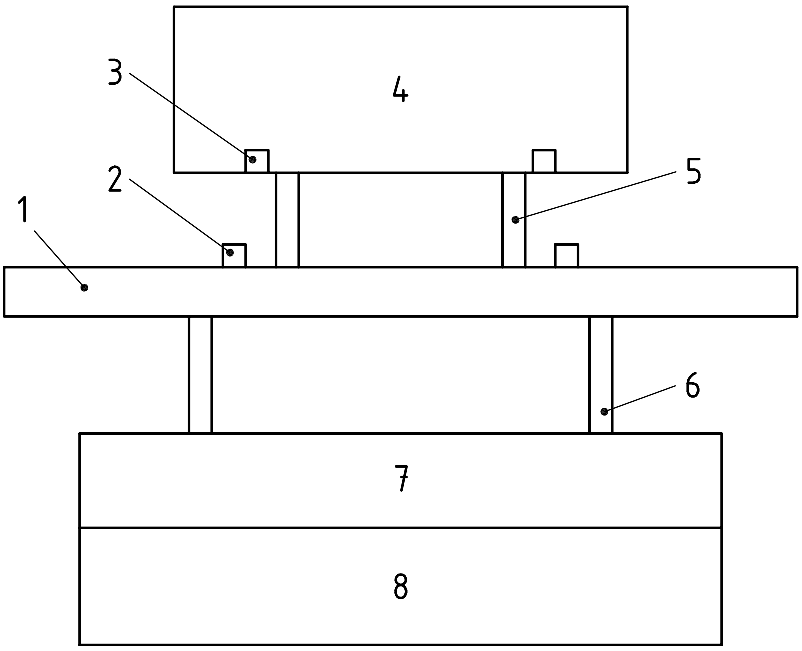
When the practically free mounting requirements cannot be met, the purchaser and supplier may exercise one or the other of the following options.

a) Replace the mounts to ensure practically free boundary conditions.

b) Retain the delivered mounts with measurements taken above the mounts and an impedance correction that should be applied to the measurements to account for the original mounts. The insertion loss of the mounts may be determined by a test method such as that illustrated in Figure 1, or by other methods if agreed on by the purchaser and supplier. This determination consists of

   — a measurement with the equipment rigidly attached to the support structure, and

   — a measurement with the equipment installed with its mounts on the support structure.



Key

1 subbase, bedplate
2 accelerometers for insertion loss measurement
3 accelerometers on equipment unit
4 equipment unit
5 vendor-supplied mounts
6 soft mounts, up to about 5 Hz
7 foundation
8 massive concrete testbed

Figure 1 — Test system and configuration for insertion loss measurement

4.8 Equipment operating conditions

The equipment under test should be operated under normal energized operating conditions. These normal energized operating conditions shall be agreed on by the purchaser and supplier. Multiple-speed equipment should be measured at each operating speed. Variable-speed equipment is to be operated and measurements taken at the maximum and minimum normal operating speeds and at an intermediate speed. The minimum speed shall not be less than 5 % of the maximum normal operating speed.

Equipment components, such as fans and pumps, shall be operating during measurements. Variable-flow equipment, such as valves for throttling service, should be operated at the maximum and minimum normal operating flow rates and at an intermediate flow rate. The minimum normal operating flow rate shall not be less than 5 % of the maximum normal operating flow rate.

Variable-speed and variable-flow equipment should be checked for any resonance or peaks of structure-borne sound by slowly varying the speed or flow from minimum to maximum rates while monitoring the vibration. Vibration levels shall be measured while the equipment is operating at speeds or flow rates where significant resonant peaking occurs.

The purchaser and supplier may agree on other operating conditions, such as starting and stopping, change of operating mode, or other specific operating cycles of the equipment.

NOTE Equipment for power transmission is normally tested at no- or low-load condition, see, for example, ISO 8579-2.

5 Data evaluation

The measured acceleration levels (or velocity levels depending on the agreement between the supplier and purchaser) for all measuring positions and measuring directions should be power-averaged to obtain representative spectra of the equipment. These test results are to be submitted to the purchaser.

The power averaging is defined by

$$L = 10 \lg \left(\frac{1}{n} \sum_{i=1}^{n} 10^{0,1 L_i} \right) \text{dB} \qquad (6)$$

where

n is the number of samples;

L_i is the level of sample i.

It is not intended that this part of ISO 20283 define or recommend numerical limits. If guidance on evaluating the equipment from the measured results is wanted, the purchaser and supplier may agree to refer to other International Standards or to limits for equipment vibration or possible structure-borne sound, agreed on by the supplier and purchaser.

6 Test report

The responsible testing party shall submit to the purchaser a written report of the measurements, including reference to this part of ISO 20283. Measurements may be provided on electronic storage media approved by the purchaser before the test. At a minimum the test report shall contain the following:

— description of the equipment tested, including identification of manufacturer, model and serial numbers and corresponding information for resilient mounts (if any);

— list of operational conditions, including driver power, speed, electrical (voltage, current and phase) and fluid (pressure, temperature and flow rate) parameters;

— testing configurations, including drawings of test fixtures;

— description of instrumentation, location and orientation of transducers;

— calibration data;

— ambient vibration levels;

— measured data as agreed on by the purchaser and supplier (power-averaged spectra, and optionally maximum envelopes, of the acceleration levels L_a or velocity levels L_v in one-third-octave and, if appropriate, narrow bands);

— results of impedance or mobility measurements of the test foundations;

— deviations from the test procedure, analyses, etc., as agreed on by the purchaser and the testing party;

— identification of the testing organization, test site, dates and personnel.

Annex A
(informative)

Typical configurations of generating sets

There are a number of possibilities for the assembly of a reciprocating internal combustion engine and a generator. Figures A.1 to A.6 show examples of typical configurations.

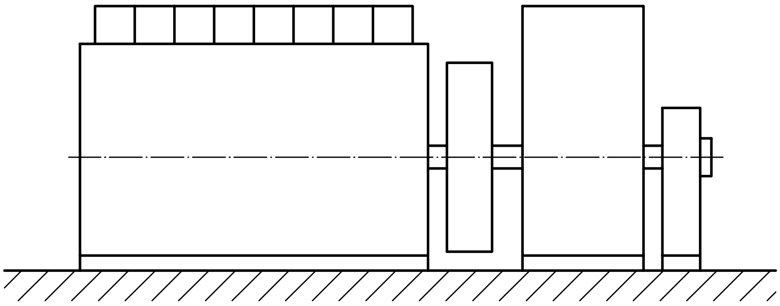


Figure A.1 — Engine and generator rigidly mounted

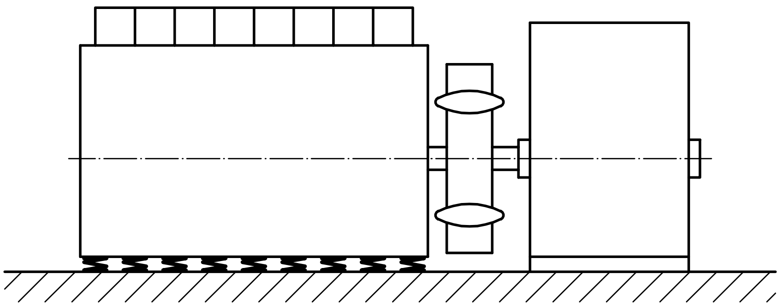


Figure A.2 — Engine resiliently mounted, generator rigidly mounted, flexible coupling

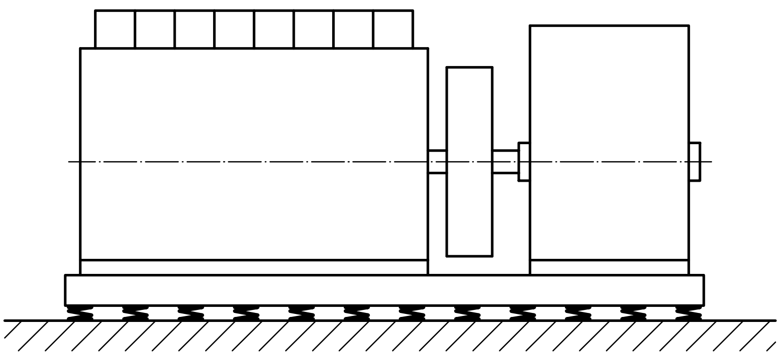


Figure A.3 — Engine and generator rigidly mounted on resiliently mounted base frame

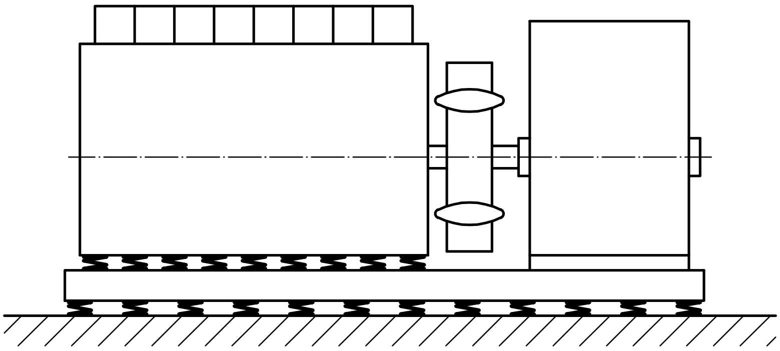


Figure A.4 — Engine resiliently mounted, generator rigidly mounted on resiliently mounted base frame, flexible coupling

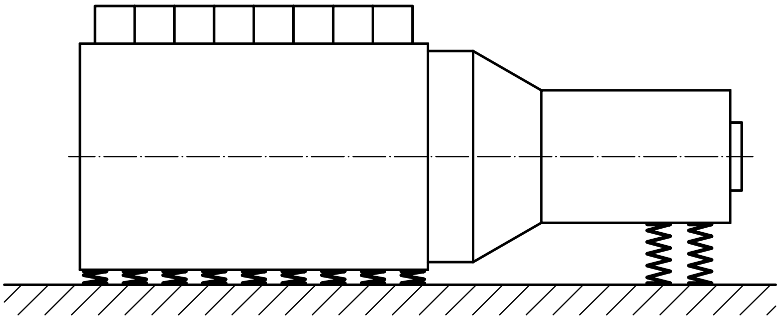


Figure A.5 — Assembly with flange housing and resilient mounting on the engine and generator

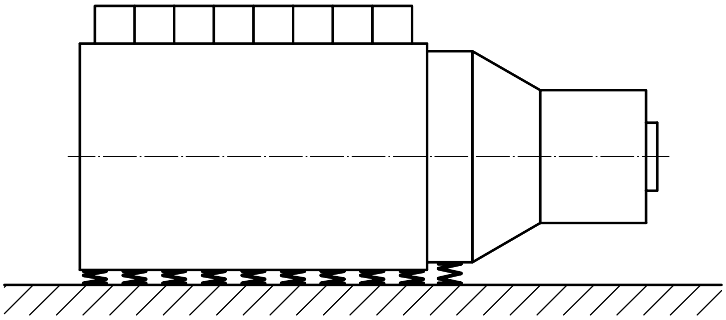
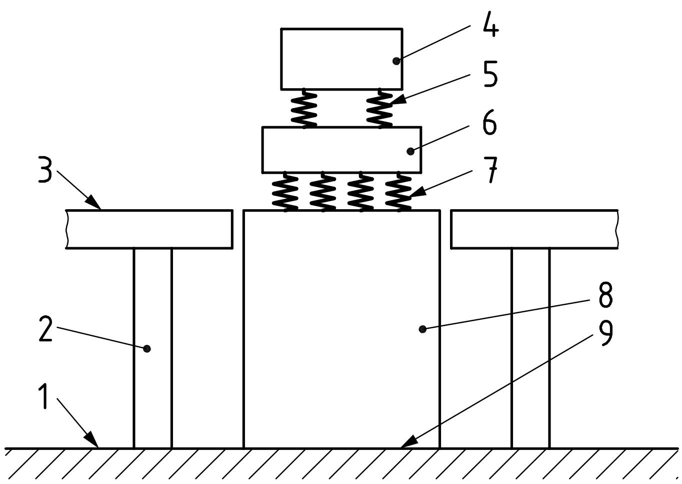


Figure A.6 — Assembly with flange housing and resilient mounting of the engine

Annex B
(informative)

Typical configurations of test systems

This annex presents typical test system configurations for meeting the requirements of this part of ISO 20283. Figures B.1 to B.4 show various support structures for resiliently mounted equipment, Figures B.5 to B.8 show support structures for equipment with mounting fixture and Figures B.9 to B.12 show support structures for gearboxes and heavy propulsion engines.



Key

1 ground
2 pillars, wall
3 workshop floor
4 shipboard equipment under test
5 resilient mounts of the shipboard equipment under test [a]
6 support structure or common subbase [b]
7 resilient mounts of support structure or common subbase [c]
8 rigid and massive testbed [d]
9 rigid mounting of testbed on ground

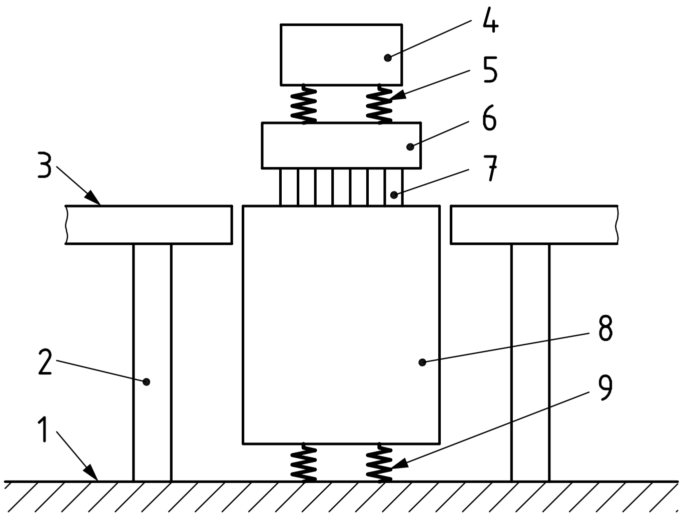
[a] The resilient mounts of the shipboard equipment under test should be chosen in such a way that a practically free condition can be achieved (see 3.12). If the practically free condition cannot be realized, see 4.7.4.

[b] The local static stiffness of the support structure or common subbase should be at least ten times higher than the dynamic stiffness of the mounts of the shipboard equipment under test and the mounts of the support structure or common subbase (see 3.12 and 4.7.2.1).

[c] The resilient mounts of the support structure or common subbase should be chosen in such a way that a vertical tuning frequency of up to about 5 Hz can be achieved (see 4.7.2.3).

[d] The local static stiffness of this foundation should be at least ten times higher than the dynamic stiffness of the resilient mounts of the support structure (see 4.7.2.1 and 4.7.2.3).

Figure B.1 — Support structure with rigidly mounted testbed



Key

1 ground

2 pillars, wall

3 workshop floor

4 shipboard equipment under test

5 resilient mounts of the shipboard equipment under test [a]

6 support structure or common subbase [b]

7 rigid fitting of support structure/common subbase to testbed (see 4.7.2.3)

8 rigid and massive testbed [c]

9 resilient mounting of testbed on ground [d]

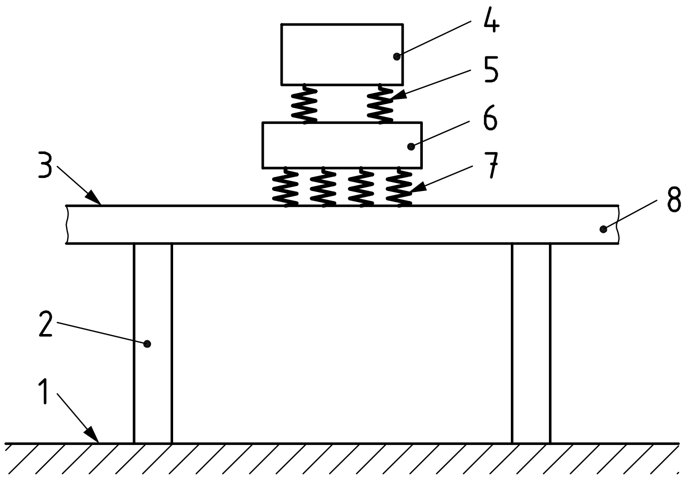
[a] The resilient mounts of the shipboard equipment under test should be chosen in such a way that a practically free condition can be achieved (see 3.12). If the practically free condition cannot be realized, see 4.7.4.

[b] The local static stiffness of the support structure or common subbase should be at least ten times higher than the dynamic stiffness of the mounts of the shipboard equipment under test (see 3.12 and 4.7.2.1).

[c] The local static stiffness of this foundation should be at least ten times higher than the dynamic stiffness of the resilient mounts of the foundation (see 3.12 and 4.7.2.1).

[d] The resilient mounts of the testbed should be chosen in such a way that a vertical tuning frequency of up to about 5 Hz can be achieved (see 4.7.2.2).

Figure B.2 — Support structure with resiliently mounted testbed



Key

1 ground

2 pillars, wall

3 workshop floor

4 shipboard equipment under test

5 resilient mounts of shipboard equipment under test [a]

6 support structure or common subbase [b]

7 resilient mounts of support structure/common subbase [c]

8 foundation [d]

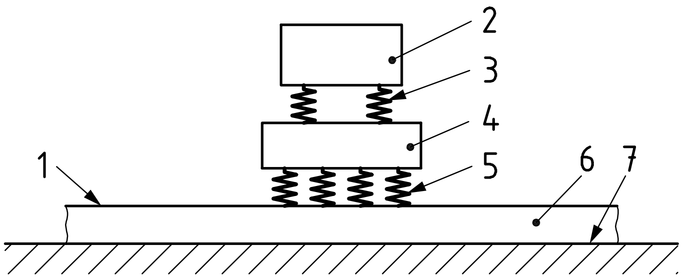
[a] The resilient mounts of the shipboard equipment under test should be chosen in such a way that a practically free condition can be achieved (see 3.12). If the practically free condition cannot be realized, see 4.7.4.

[b] The local static stiffness of the support structure or common subbase should be at least ten times higher than the dynamic stiffness of the mounts of the shipboard equipment under test (see 3.12 and 4.7.2.1).

[c] The resilient mounts of the support structure or common subbase should be chosen in such a way that a vertical tuning frequency of up to about 5 Hz can be achieved (see 4.7.2.3).

[d] The foundation consists of a heavy concrete workshop floor. The local static stiffness of the workshop floor should be at least ten times higher than the dynamic stiffness of the resilient mounts of the support structure (see 4.7.2.3). The lowest natural frequencies of the workshop floor should be well known. Resonant phenomena should be avoided with regard to the lowest forcing frequency of the shipboard equipment under test (see 4.7.2.1).

Figure B.3 — Support structure consisting of heavy concrete workshop floor on pillars



Key

1 workshop floor

2 shipboard equipment under test

3 resilient mounts of shipboard equipment under test [a]

4 support structure or common subbase [b]

5 resilient mounts of support structure/common subbase [c]

6 foundation [d]

7 ground of workshop

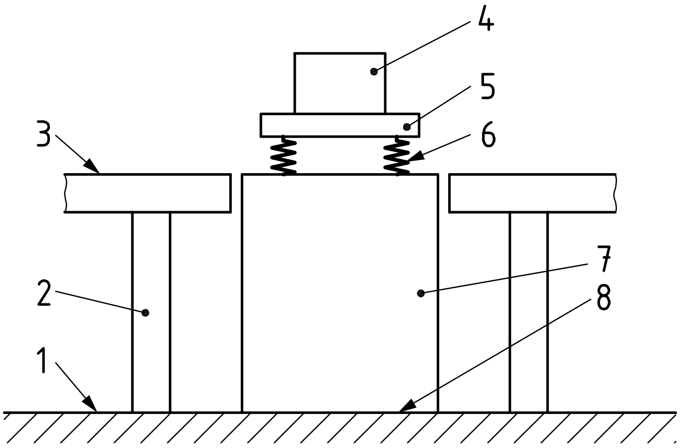
[a] The resilient mounts of the shipboard equipment under test should be chosen in such a way that a practically free condition can be achieved (see 3.12). If the practically free condition cannot be realized, see 4.7.4.

[b] The local static stiffness of the support structure or common subbase should be at least ten times higher than the dynamic stiffness of the mounts of the shipboard equipment under test (see 3.12 and 4.7.2.1).

[c] The resilient mounts of the support structure or common subbase should be chosen in such a way that a vertical tuning frequency of up to about 5 Hz can be achieved (see 4.7.2.3).

[d] The foundation consists of a heavy concrete workshop floor. The local static stiffness of the workshop floor should be at least ten times higher than the dynamic stiffness of the resilient mounts of the support structure (see 4.7.2.1 and 4.7.2.3).

Figure B.4 — Support structure consisting of a heavy concrete workshop floor on ground



Key

1 ground
2 pillars, wall
3 workshop floor
4 shipboard equipment under test [a]
5 mounting fixture [b]
6 resilient mounts of mounting fixture [c]
7 rigid and massive testbed [d]
8 rigid mounting of testbed on ground

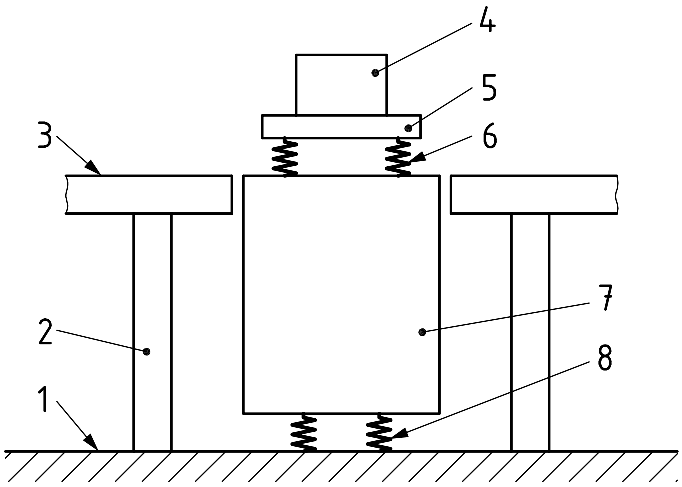
[a] See 4.7.2.4.

[b] The local static stiffness of the mounting fixture should be at least ten times higher than the dynamic stiffness of the mounts of the fixture (see 3.12 and 4.7.2.1).

[c] The resilient mounts of the mounting fixture should be chosen in such a way that a vertical tuning frequency of up to about 10 Hz can be achieved (practically free condition, see 3.12).

[d] The local static stiffness of this foundation should be at least ten times higher than the dynamic stiffness of the resilient mounts of the mounting fixture (see 3.12 and 4.7.2.1).

Figure B.5 — Mounting fixture on a rigidly mounted testbed



Key

1 ground

2 pillars, wall

3 workshop floor

4 shipboard equipment under test (see 4.7.2.4)

5 mounting fixture [a]

6 resilient mounts of mounting fixture (practically free condition) [b]

7 rigid and massive testbed [c]

8 resilient mounting of testbed on ground [d]

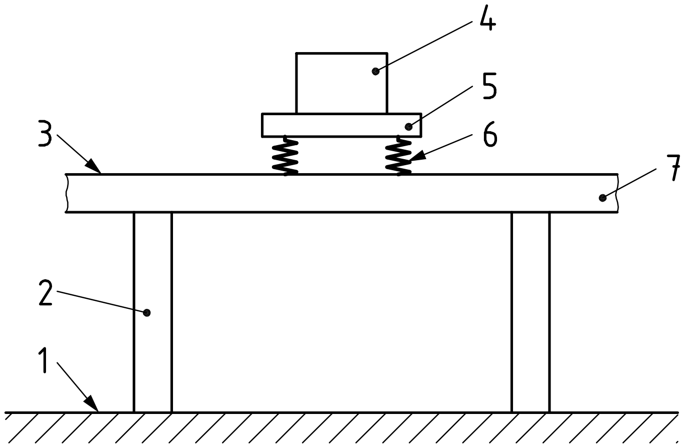
[a] The local static stiffness of the mounting fixture should be at least ten times higher than the dynamic stiffness of the mounts of the shipboard equipment under test (see 3.12 and 4.7.2.1).

[b] The resilient mounts of the mounting fixture should be chosen in such a way that a vertical tuning frequency of up to about 10 Hz can be achieved (practically free condition, see 3.12).

[c] The local static stiffness of this foundation should be at least ten times higher than the dynamic stiffness of the resilient mounts of the mounting fixture and the resilient mounts of the foundation (see 3.12 and 4.7.2.1).

[d] The resilient mounts of the testbed should be chosen in such a way that a vertical tuning frequency of up to about 5 Hz can be achieved (see 4.7.2.2).

Figure B.6 — Mounting fixture on a resiliently mounted testbed



Key

1 ground
2 pillars, wall
3 workshop floor
4 shipboard equipment under test [a]
5 mounting fixture [b]
6 resilient mounts of mounting fixture (practically free condition) [c]
7 foundation [d]

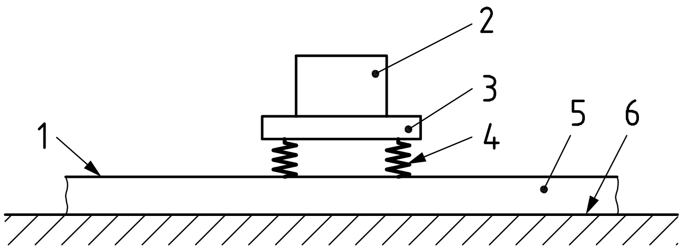
[a] See 4.7.2.4.

[b] The local static stiffness of the mounting fixture should be at least ten times higher than the dynamic stiffness of the resilient mounts of the mounting fixture (see 3.12 and 4.7.2.1).

[c] The resilient mounts of the mounting fixture should be chosen in such a way that a vertical tuning frequency of up to about 10 Hz can be achieved (practically free condition, see 3.12).

[d] The foundation consists of a heavy concrete workshop floor. The local static stiffness of the workshop floor should be at least ten times higher than the dynamic stiffness of the resilient mounts of the mounting fixture (see 3.12 and 4.7.2.1). The lowest natural frequencies of the workshop floor should be well known. Resonant phenomena should be avoided with regard to the first vertical tuning frequency of the resiliently mounted fixture.

Figure B.7 — Mounting fixture on a heavy concrete workshop floor on pillars



Key

1 workshop floor
2 shipboard equipment under test [a]
3 mounting fixture [b]
4 resilient mounts of mounting fixture (practically free condition) [c]
5 foundation [d]
6 ground of workshop

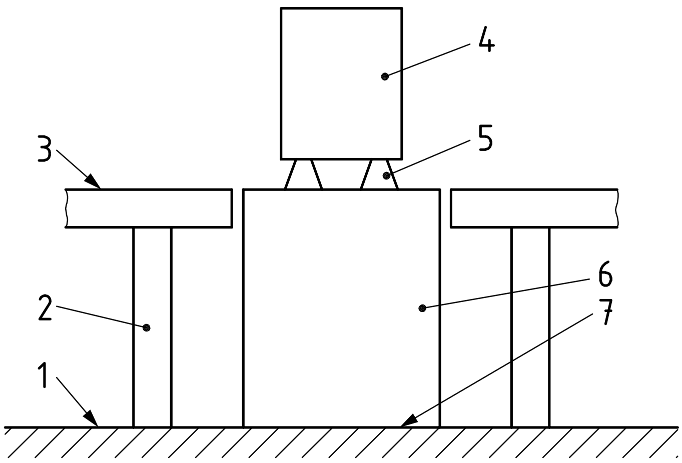
[a] See 4.7.2.4.

[b] The local static stiffness of the mounting fixture should be at least ten times higher than the dynamic stiffness of the mounts of the mounting feature (see 3.12 and 4.7.2.1).

[c] The resilient mounts of the mounting fixture should be chosen in such a way that a vertical tuning frequency of up to about 10 Hz can be achieved (practically free condition, see 3.12).

[d] The foundation consists of a heavy concrete workshop floor. The local static stiffness of the workshop floor should be at least ten times higher than the dynamic stiffness of the resilient mounts of the mounting fixture (see 3.12 and 4.7.2.1).

Figure B.8 — Mounting fixture on heavy concrete workshop floor on ground

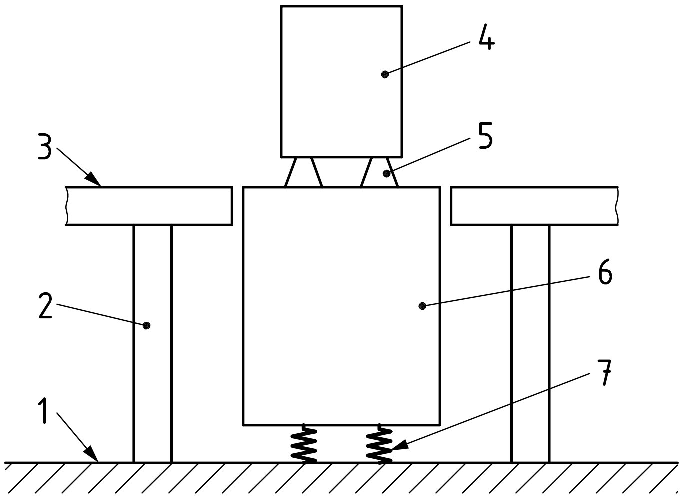


Key

1 ground
2 pillars, wall
3 workshop floor
4 heavy shipboard equipment under test [a]
5 rigid mounting of heavy shipboard equipment under test on foundation (see 4.7.2.3)
6 rigid and massive testbed (see 4.7.2.1)
7 rigid mounting of testbed on ground

[a] See 4.7.1 and 4.7.2.3.

Figure B.9 — Gearboxes and heavy propulsion engines on rigidly mounted testbed



Key

1 ground

2 pillars, wall

3 workshop floor

4 heavy shipboard equipment under test [a]

5 rigid mounting of heavy shipboard equipment under test on foundation [b]

6 rigid and massive testbed [c]

7 resilient mounts of testbed [d]

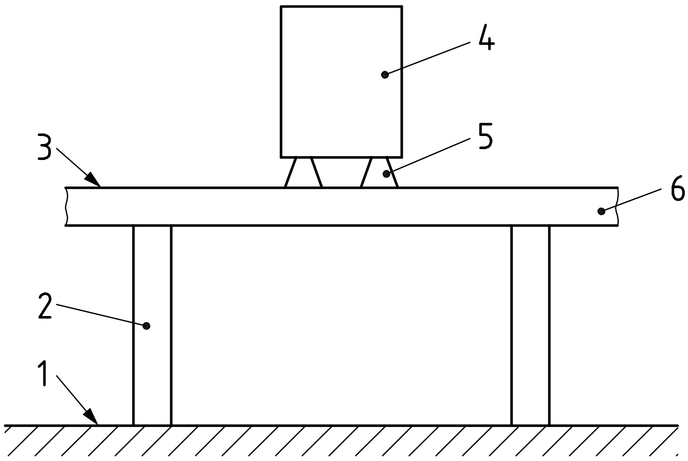
[a] See 4.7.1 and 4.7.2.3.

[b] See 4.7.2.3.

[c] The local static stiffness of this foundation should be at least ten times higher than the dynamic stiffness of the resilient mounts of the foundation (see 3.12 and 4.7.2.1).

[d] The testbed is resiliently mounted on the ground. These mounts should be chosen such that a vertical tuning frequency of up to about 5 Hz can be achieved (see 4.7.2.2).

Figure B.10 — Gearboxes and heavy propulsion engines on resiliently mounted testbed



Key

1 ground

2 pillars, wall

3 workshop floor

4 heavy shipboard equipment under test [a]

5 rigid mounting of heavy shipboard equipment under test on foundation [b]

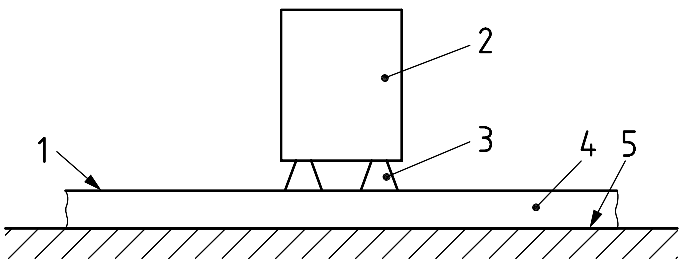
6 foundation [c]

[a] See 4.7.1 and 4.7.2.3.

[b] See 4.7.2.3.

[c] The foundation consists of a heavy concrete workshop floor. The lowest natural frequencies of the workshop floor should be well known. Resonant phenomena should be avoided with regard to the lowest forcing frequency of the heavy shipboard equipment under test (see 4.7.2.1).

Figure B.11 — Gearboxes and heavy propulsion engines on a heavy concrete workshop floor on pillars



Key

1 workshop floor

2 heavy shipboard equipment under test [a]

3 rigid mounting of heavy shipboard equipment under test on foundation (see 4.7.2.3)

4 foundation [b]

5 ground of the workshop

[a] See 4.7.1 and 4.7.2.3.

[b] The foundation consists of a heavy concrete workshop floor (see 4.7.2.1).

Figure B.12 — Gearboxes and heavy propulsion engines on a heavy concrete workshop floor on ground

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1) 4 Albert Embankment, London SE1 7SR, www.imo.org

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