INTERNATIONAL STANDARD

ISO 16750-3

Third edition
2012-12-15

Road vehicles — Environmental conditions and testing for electrical and electronic equipment —

Part 3: Mechanical loads

Véhicules routiers — Spécifications d'environnement et essais de l'équipement électrique et électronique —
Partie 3: Contraintes mécaniques

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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.

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 16750-3 was prepared by Technical Committee ISO/TC 22, *Road vehicle*, Subcommittee SC 3, *Electrical and electronical equipment*.

This third edition cancels and replaces the second edition (ISO 16750-3:2007), which has been technically revised.

ISO 16750 consists of the following parts, under the general title *Road vehicles — Environmental conditions and testing for electrical and electronic equipment*:

— *Part 1: General*

— *Part 2: Electrical loads*

— *Part 3: Mechanical loads*

— *Part 4: Climatic loads*

— *Part 5: Chemical loads*

Road vehicles — Environmental conditions and testing for electrical and electronic equipment —

Part 3: Mechanical loads

1 Scope

This part of ISO 16750 applies to electric and electronic systems/components for road vehicles. It describes the potential environmental stresses and specifies tests and requirements recommended for the specific mounting location on/in the vehicle.

This part of ISO 16750 describes mechanical loads.

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 16750-1, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 1: General*

IEC 60068-2, 6, *Environmental testing — Part 2-6: Testing, Test Fc: Vibration (Sinusoidal)*

IEC 60068-2, 14, *Basic environmental testing procedures — Part 2-14: Tests — Test Nb: Change of temperature*

IEC 60068-2, 64, *Environmental testing — Part 2-64: Test methods — Test Fh — Vibration, broad-band random (digital control) and guidance*

IEC 60068-2, 80, *Environmental testing — Part 2-80: Tests — Test Fi: Vibration — Mixed mode testing*

IEC 60068-2-31, *Environmental testing procedures — Part 2: Tests; Test Ec: Free fall, Clause 5.2*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16750-1 apply.

4 Tests and requirements

4.1 Vibration

4.1.1 General

The vibration test methods specified consider various levels of vibration severities applicable to on-board electrical and electronic equipment. It is recommended that the vehicle manufacturer and supplier choose the test method, the environmental temperature and vibration parameters depending on the specific mounting location.

Following the expressions in MIL-STD please notice:

When applied properly, the environmental management and engineering processes described in this part of ISO 16750 can be of enormous value in generating confidence in the environmental worthiness and overall durability. However, it is important to recognize that there are limitations inherent in laboratory testing that make it imperative to use proper caution and engineering judgement when extrapolating these laboratory results to results that may be obtained under actual service conditions. In many cases, real-world environmental stresses (singularly or in combination) cannot be duplicated practically or reliably in test laboratories. Therefore, users of this part of ISO 16750 should not assume that a system or component that passes laboratory tests of this part of ISO 16750 would also pass field/fleet verification trials.

— "The specified values are the best estimation one can get up to the moment when results from measurements in the car are received – but they do not replace a car measurement!"

The specified values apply to direct mounting in defined mounting locations. Using a bracket for mounting can result in higher or lower loads. If the device under test (DUT) is used in the vehicle with a bracket then all vibration and mechanical shock test shall be done with this bracket.

Carry out the vibration with the DUT suitably mounted on a vibration table. The mounting method(s) used shall be noted in the test report. Carry out the frequency variation by logarithmic sweeping of 0,5 octave/minute for sinusoidal tests and the sinusoidal part of sine on random tests. The scope of the recommended vibration tests is to avoid malfunctions and breakage mainly due to fatigue in the field. Testing for wear has special requirements and is not covered in this part of ISO 16750.

Loads outside of the designated test frequency ranges are to be considered separately.

NOTE Deviations from the load on the DUT can result, should vibration testing be carried out according to this part of ISO 16750 on a heavy and bulky DUT as mounting rigidity and dynamic reaction on the vibrator table excitation are different compared to the situation in the vehicle. This deviation can be minimized by applying the average control method (see Annex A).

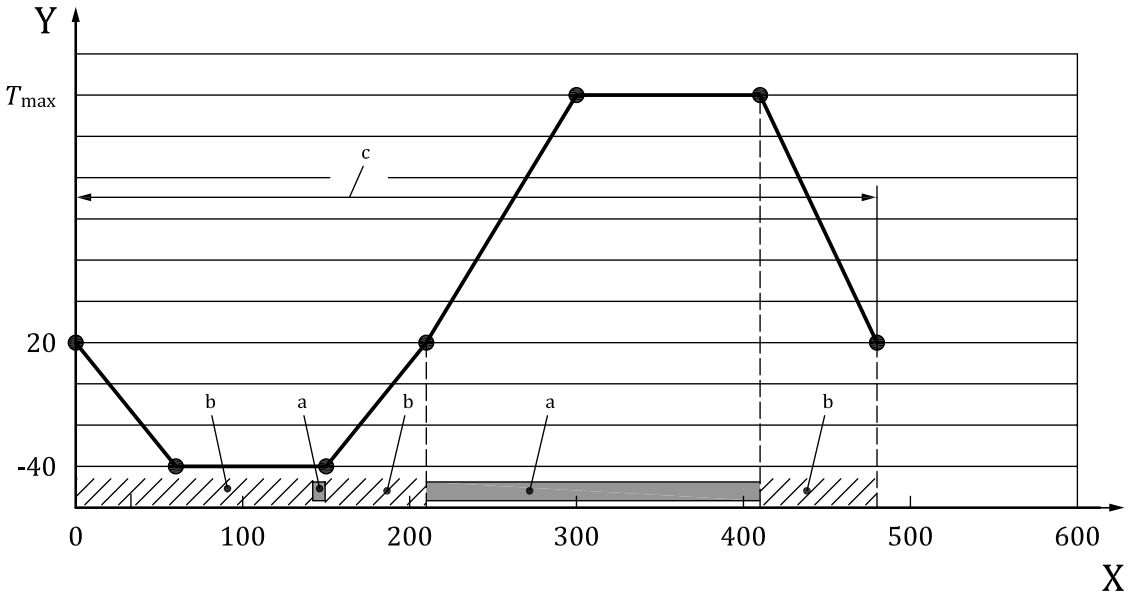
Application of the weighted average control method according to IEC 60068-2, 64 is to be agreed upon.

Subject the DUT during the vibration test to the temperature cycle according to IEC 60068-2, 14, with electric operation according to diagram 1. Alternatively, a test at constant temperature may be agreed on.

Operate the DUT electrically as indicated in Figure 1 at T_{min} (short functional test after the DUT completely reached T_{min}). This functional test shall be as short as possible — only long enough to check the proper performance of the DUT. This minimizes self-heating of the DUT. Additional electrical operation of the DUT between 210 min and 410 min of the cycle (see Figure 1).

Additional drying of test chamber air is not permitted.

In the vehicle, vibration stress can occur together with extremely low or high temperatures; for this reason, this interaction between mechanical and temperature stress is simulated in the test, too. A failure mechanism is, for example, a plastic part of a system/component, which mellows due to the high temperature and cannot withstand the acceleration under this condition.



Key

Y temperature [°C]
X time [min]

a Operating mode 3.2 according to ISO 16750-1.
b Operating mode 2.1 according to ISO 16750-1.
c One cycle.

Figure 1 — Temperature profile for the vibration test

Table 1 — Temperature versus time for the vibration test

Time min	Temperature °C
0	20
60	-40
150	-40
210	20
300	T_{max}[a]
410	T_{max}[a]
480	20

a See ISO 16750-4.

4.1.2 Tests

4.1.2.1 Test I — Passenger car, engine

4.1.2.1.1 Purpose

This test checks the DUT for malfunctions and breakage caused by vibration.

The vibrations of a piston engine can be split up into two kinds: Sinusoidal vibration which results from the unbalanced mass forces in the cylinders and random noise due to all other vibration-schemes of an engine,

e.g. closing of valves. In the lowest frequency range from 10 Hz to 100 Hz the influence of rough-road conditions is taken into account. The main failure to be identified by this test is breakage due to fatigue.

NOTE 1 Road profile usually has negligible impact on engine-mounted components. Shock inputs are effectively isolated by suspension, and engine-mounting systems.

The test profiles specified in the following clauses apply to loads generated by (four stroke) reciprocating engines.

NOTE 2 If the DUT is to be tested for a specific resonance effect, then a resonance dwell test according to 8.3.2 of IEC 60068-2, 6:2007 can also be applied.

4.1.2.1.2 Test

4.1.2.1.2.1 General

It is required to perform this test as a mixed mode vibration test according to IEC 60068-2, 80.

NOTE The test duration is based on A.4. The temperature in the chamber is above room temperature (RT) at the end of the test (2 3/4 temperature cycles).

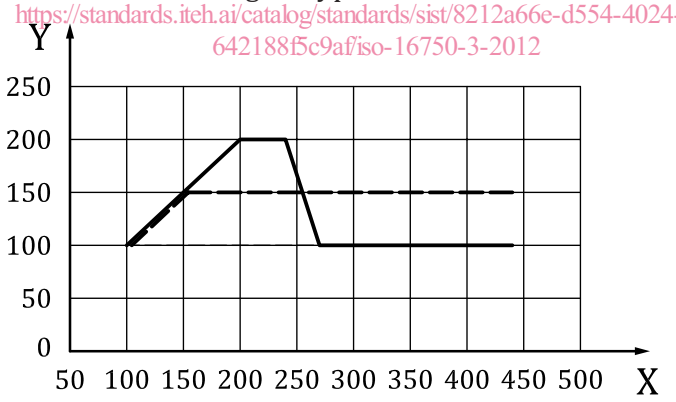
4.1.2.1.2.2 Sinusoidal vibration

Perform the test according to IEC 60068-2, 6, but using a sweep rate of ≤ 0,5 octave/minute. Use a test duration of 22 h for each plane of the DUT.

Use curve 1 in Table 2/Figure 2 for DUT intended for mounting on engines with 5 cylinders or fewer.

Use curve 2 in Table 2/Figure 2 for DUT test intended for mounting on engines with 6 cylinders or more.

Both curves may be combined to cover all engine types in one test.



Key

Y	amplitude of acceleration [m/s²]
X	frequency [Hz]
———	curve 1 (≤5 cylinders)
— —	curve 2 (>5 cylinders)

Figure 2 — Vibration severity curves

Table 2 — Values for max. acceleration versus frequency

Curve 1 (see Figure 2)	
Frequency Hz	**Amplitude of acceleration** m/s^2
100	100
200	200
240	200
270	100
440	100
Curve 2 (see Figure 2)	
Frequency Hz	**Amplitude of acceleration** m/s^2
100	100
150	150
440	150
Combination	
Frequency Hz	**Amplitude of acceleration** m/s^2
100	100
150	150
200	200
240	200
255	150
440	150

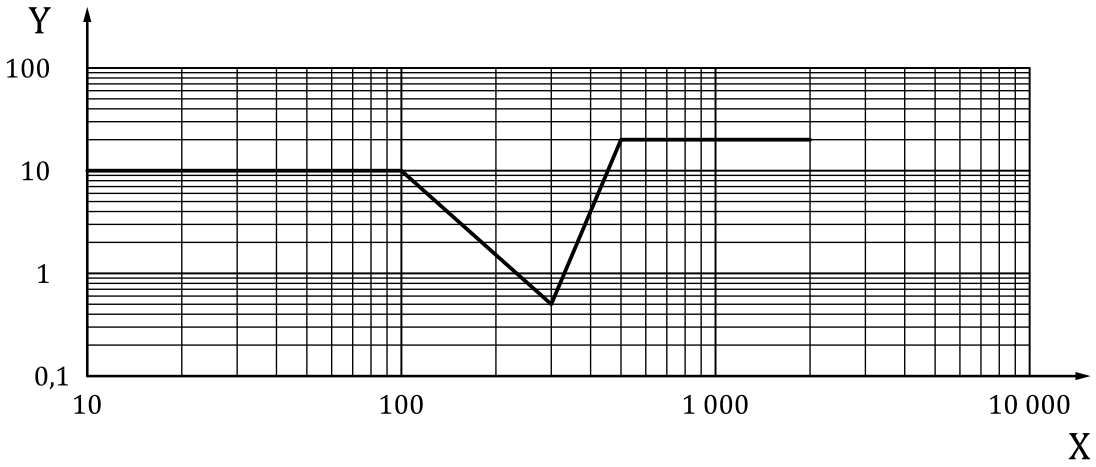
4.1.2.1.2.3 Random vibration

Perform the test according to IEC 60068-2, 64. Use a test duration of 22 h for each plane of the DUT.

The r.m.s. acceleration value shall be 181 m/s^2.

The PSD versus frequency are referred to in Figure 3 and Table 3

NOTE The Power Spectral Density (PSD) values (random vibration) are reduced in the frequency range of the sinusoidal vibration test.



Key

Y PSD $[(m/s^2)^2/Hz]$
X frequency [Hz]

Figure 3 — PSD of acceleration versus frequency

Table 3 — Values for frequency and PSD

Frequency Hz	PSD $(m/s^2)^2/Hz$
10	10
100	10
300	0,51
500	20
2 000	20

4.1.2.1.3 Requirement

Breakage shall not occur.

Functional status A (see ISO 16750-1) is required during operating mode 3.2 as defined in ISO 16750-1, and functional status C during periods with other operating modes.

4.1.2.2 Test II — Passenger car, gearbox

4.1.2.2.1 Purpose

This test checks the DUT for malfunctions and breakage caused by vibration.

The vibrations of a gearbox can be split up into two kinds which result partly from sinusoidal vibration from unbalanced mass forces of the engine (e.g. dominating orders) in the frequency range from 100 Hz to 440 Hz and vibration from the friction of the gear wheels and other schemes, which are tested in the random part. In the lowest frequency range from 10 Hz to 100 Hz the influence of rough-road conditions is taken into account. The main failure to be identified by this test is breakage due to fatigue.

The test profiles specified in the following subclauses apply to loads generated by gearbox vibrations. Changing the gears can create additional mechanical shock and shall be considered separately.

4.1.2.2.2 Test

4.1.2.2.2.1 General

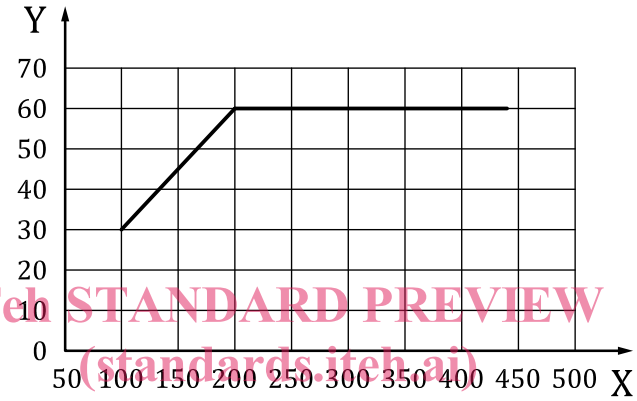
It is required to perform this test as a mixed mode vibration test according to IEC 60068-2, 80.

NOTE The test duration is based on A.4. The temperature in the chamber is above RT at the end of the test (2 3/4 temperature cycles).

4.1.2.2.2.2 Sinusoidal vibration

Perform the test according to IEC 60068-2, 6, but using a sweep rate of ≤ 0,5 octave/minute. Use a test duration of 22 h for each plane of the DUT.

The amplitude versus frequency are referred to in Figure 4 and Table 4.



Key

Y amplitude of acceleration [m/s^2]
X frequency [Hz]

Figure 4 — Acceleration versus frequency

Table 4 — Values for frequency and acceleration

Frequency Hz	**PSD** m/s^2
100	30
200	60
440	60

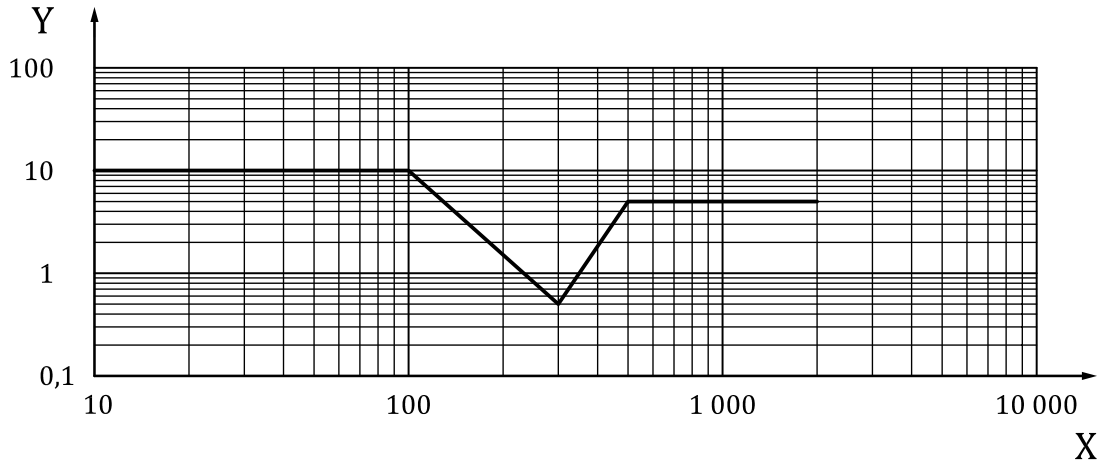
4.1.2.2.2.3 Random vibration

Perform the test according to IEC 60068-2, 64. Use a test duration of 22 h for each plane of the DUT.

The r.m.s. acceleration value shall be 96,6 m/s^2.

NOTE The PSD values (random vibration) are reduced in the frequency range of the sinusoidal vibration test.

The PSD versus frequency are referred to in Figure 5 and Table 5.



Key
Y PSD $[(m/s^2)^2/Hz]$
X frequency [Hz]

Figure 5 — PSD of acceleration versus frequency

Table 5 — Values for frequency and PSD

Frequency Hz	PSD $[(m/s^2)^2/Hz]$
10	10
100	10
300	0,51
500	5
2 000	5

4.1.2.2.3 Requirement

Breakage shall not occur.

Functional status A (see ISO 16750-1) is required during operating mode 3.2 as defined in ISO 16750-1, and functional status C during periods with other operating modes.

4.1.2.3 Test III — Passenger car, flexible plenum chamber

4.1.2.3.1 Purpose

This test checks the DUT for malfunctions and breakage caused by vibration.

This test is applicable to equipment to be mounted on flexible plenum chamber and/or connected to a source of air pulsations (e.g. intake manifold could be a source of air pulsations).

The vibrations are sinusoidal and mainly induced by the pulsation of the intake air.

NOTE This means even in case the DUT is mounted in another area (e.g. car body), connecting the DUT with a tube to the intake manifold leads to vibration load resulting out of air pulsation.

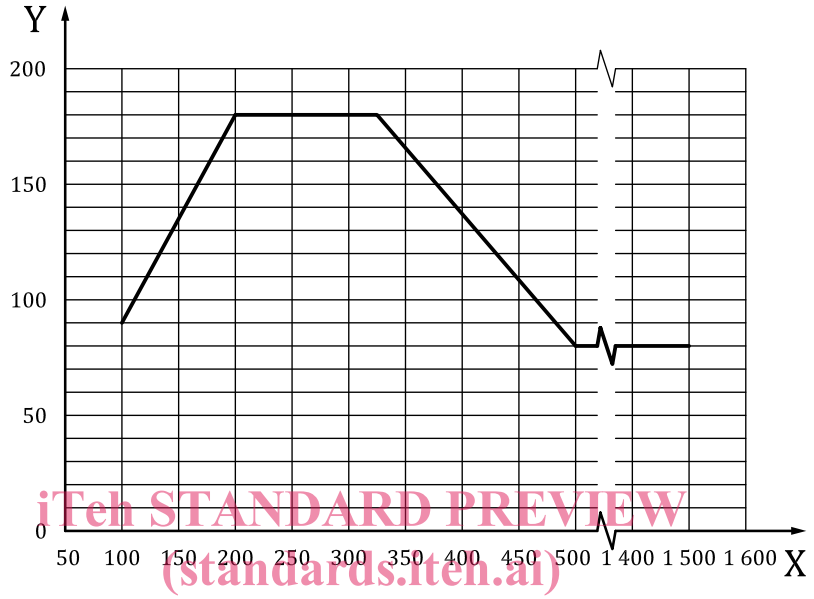
The main failure to be identified by this test is breakage due to fatigue.

4.1.2.3.2 Test

Perform the test according to IEC 60068-2, 6 sinusoidal vibration, but a sweep rate of ≤ 0,5 octave/minute shall be used. Use a test duration of 22 h for each plane of the DUT.

NOTE The test duration is based on A.4. The temperature in the chamber is above RT at the end of the test (2 3/4 temperature cycles).

The amplitude versus frequency are referred to in Figure 6 and Table 6.



Key

Y PSD [$(m/s^2)^2$/Hz]
X frequency [Hz]

Figure 6 — Max. acceleration versus frequency

Table 6 — Values for acceleration and frequency

Frequency Hz	**Amplitude of acceleration** (m/s^2)
100	90
200	180
325	180
500	80
1 500	80

4.1.2.3.3 Requirement

Breakage shall not occur.

Functional status A (see ISO 16750-1) is required during operating mode 3.2 as defined in ISO 16750-1, and functional status C during periods with other operating modes

4.1.2.4 Test IV — Passenger car, sprung masses (vehicle body)

4.1.2.4.1 Purpose

This test checks the DUT for malfunctions and breakage caused by vibration.

Vibration of the body is random vibration induced by rough-road driving. The main failure to be identified by this test is breakage due to fatigue.

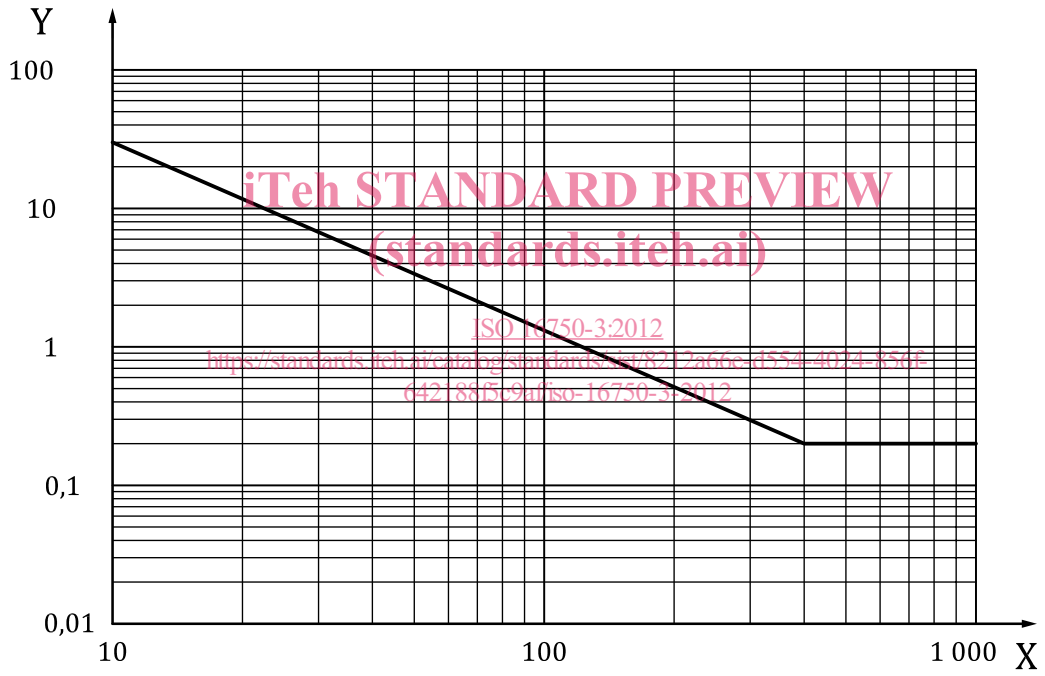
4.1.2.4.2 Test

Perform the test according to IEC 60068-2, 64 random vibration. Use a test duration of 8 h for each plane of the DUT.

The r.m.s. acceleration value shall be 27,1 m/s^2.

The PSD versus frequency are referred to in Figure 7 and Table 7.

NOTE The test duration is based on A.5.



Key

Y PSD $[(m/s^2)^2/Hz]$
X frequency [Hz]

Figure 7 — PSD of acceleration versus frequency

Table 7 — Values for PSD and frequency

Frequency Hz	**PSD** $[(m/s^2)^2/Hz]$
10	30
400	0,2
1 000	0,2

4.1.2.4.3 Requirement

Breakage shall not occur.

Functional status A (see ISO 16750-1) is required during operating mode 3.2 as defined in ISO 16750-1, and functional status C during periods with other operating modes.

4.1.2.5 Test V — Passenger car, unsprung masses (wheel, wheel suspension)

4.1.2.5.1 Purpose

This test checks the DUT for malfunctions and breakage caused by vibration.

Vibration of unsprung masses is random vibration induced by rough-road driving. The main failure to be identified by this test is breakage due to fatigue.

Loads with frequencies lower than 20 Hz are not covered by the test profile specified here. In practice high amplitudes can occur below 20 Hz; therefore, loads acting on the DUT in this frequency range shall be considered separately.

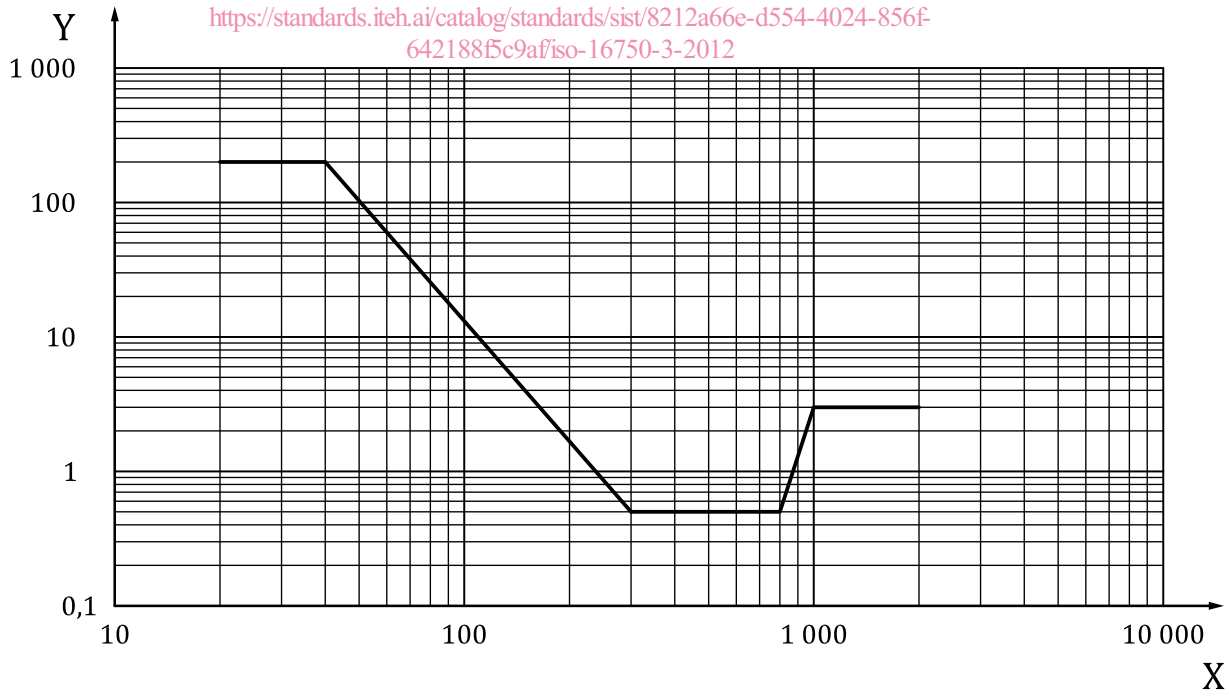
4.1.2.5.2 Test

Perform the test according to IEC 60068-2, 64 random vibration. Use a test duration of 8 h for each plane of the DUT.

The r.m.s. acceleration is 107,3 m/s^2.

The PSD versus frequency are referred to in Figure 8 and Table 8.

NOTE The test duration is based on A.5.



Key

Y PSD [(m/s^2)^2/Hz]
X frequency [Hz]

Figure 8 — PSD of acceleration versus frequency