INTERNATIONAL STANDARD

**ISO 16750-3**

First edition
2003-12-01

# 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*



Reference number
ISO 16750-3:2003(E)

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Published in Switzerland

 

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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 vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

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 describes the mechanical loads that can affect electric and electronic systems and components in respect of their mounting directly on or in road vehicles, and specifies the corresponding tests and requirements.

## 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 16750-1:2003, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 1: General*

ISO 16750-4:2003, *Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 4: Climatic loads*

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

IEC 60068-2-14, *Environmental testing — Part 2: Tests —Test N: Change of temperature*

IEC 60068-2-29, *Environmental testing — Part 2: Tests — Test Eb and guidance: Bump*

IEC 60068-2-32, *Environmental testing — Part 2: Tests — Test Ed: Free fall*

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

IEC 60068-2-80, *Environmental testing — Part 2: Tests — Test Fi: Mixed mode*[1)]

DIN 55996-1, *Paints and varnishes — Stone chip resistance test for coatings — Part 1: Multi-impact test*

## 3 Terms and definitions

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

1) To be published.

# 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.

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 electronic control unit (ECU) is used in the vehicle with a bracket, then all vibration and mechanical shock tests shall be done with this bracket.

Carry out the vibration with the device under test (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 1 octave/min for sinusoidal tests. The motion shall be applied in each of the three mutually perpendicular axes for a duration as defined for each test.

The scope of the recommended test profiles and test duration is aimed at avoiding fatigue failure. Testing for wear has special requirements and is not covered in this part of ISO 16750.

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

NOTE Deviations from the load on the DUT can result, should vibration testing be carried out according to this standard 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).

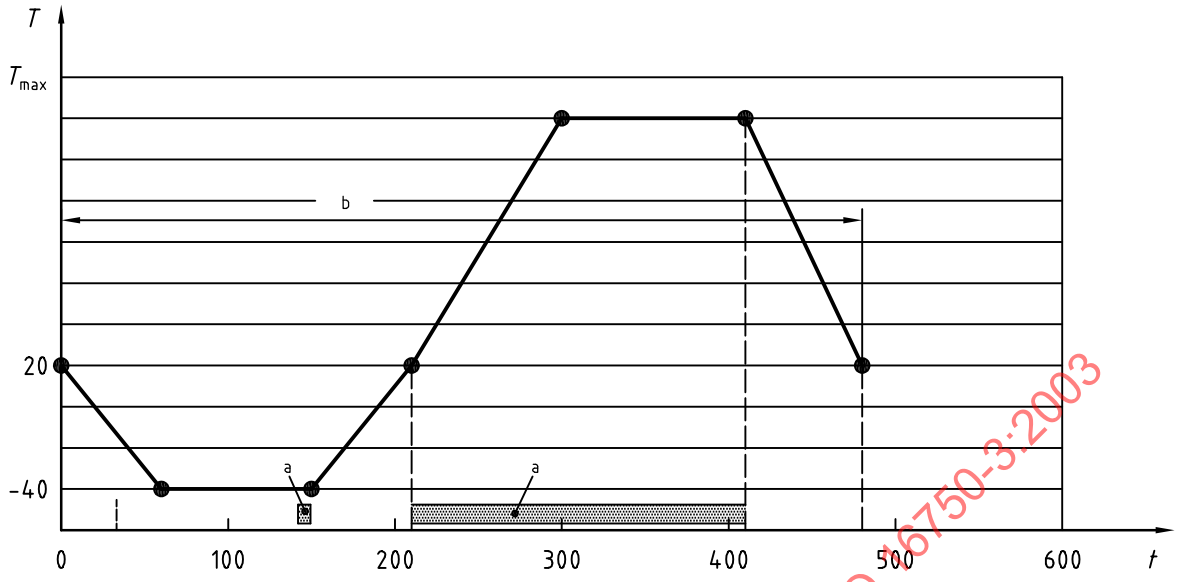
Application of the average control method according to IEC 60068-2-64 is to be agreed upon.

Subject the DUT during the vibration test to the temperature cycle according to IEC 60068-2-14, with electric operation in accordance with Figure 1. Alternatively, a test at constant temperature (RT) may be agreed upon and performed.

Operate the DUT electrically as indicated in Figure 1 at $T_{min}$, in a short functional test performed after the DUT has completely reached $T_{min}$. This functional test shall be as short as possible: long enough only such that the proper performance of the DUT can be checked. This minimizes self-heating of the ECU. Additional electrical operation of the DUT between the 210th minute and the 410th minute of the cycle (see Figure 1).

Additional drying of test chamber air is not permitted.

Owing to the fact that in the vehicle vibration stress can occur together with extremely low or high temperatures, this interaction between mechanical and temperature stress is simulated in the test, too. The 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**

$t$ time, min
$T$ temperature, °C

a Operating mode 3.2 (see ISO 16750-1:2003).
b One cycle.

**Figure 1 — Temperature profile for vibration test**

**Table 1 — Temperature vs. time for vibration test**

| Duration<br>min | Temperature<br>°C |
|---|---|
| 0 | 20 |
| 60 | –40 |
| 150 | –40 |
| 210 | 20 |
| 300 | $T_{max}$ [a] |
| 410 | $T_{max}$ [a] |
| 480 | 20 |

[a] See ISO 16750-4:2003, Table 1.



### 4.1.2 Requirements

For all vibration tests, Functional status A as defined in ISO 16750-1:2003 shall be used when in Operating mode 3.2 in accordance with ISO 16750-1:2003, Clause 5, and Functional status C shall be used during periods in other operating modes.

#### 4.1.3 Tests

##### 4.1.3.1 Test Set 1 — Equipment for passenger cars

###### 4.1.3.1.1 General

This test set (Tests I to V) is recommended mainly for testing equipment for passenger cars.

###### 4.1.3.1.2 Test I — Equipment mounted directly on the engine

###### 4.1.3.1.2.1 Purpose

The vibrations of a piston engine can be divided into two types: sinusoidal vibration resulting from the unbalanced mass forces in the cylinders, and random noise from all other vibration sources of an engine, e.g. closing of valves. Failure mode in this test is rupture owing to fatigue.

NOTE The temperature in the chamber is above room temperature at the end of the test (2,75 temperature cycles).

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

Following the forthcoming publication of IEC 60068-2-80, and the determination of the test parameters in accordance with it, this test should be performed as a combined sine and random test, also according to IEC 60068-2-80. Alternatively, these tests may be performed sequentially.

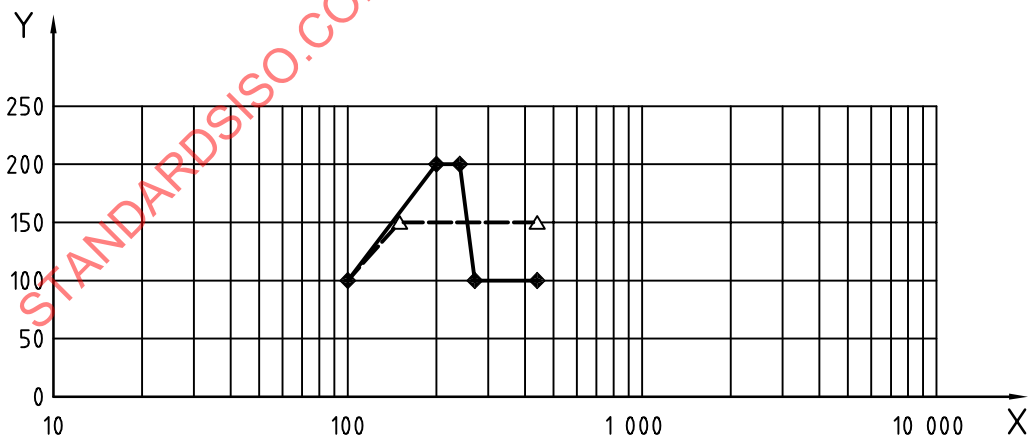
###### 4.1.3.1.2.2 Sinusoidal vibration

Perform the test according to IEC 60068-2-6. The test duration shall be 22 h for each plane of the DUT. The amplitude of acceleration and the frequency shall be in accordance with Figure 2 and Table 2, as follows:

— use Curve 1 for DUTs intended for mounting on engines with five cylinders or less;

— use Curve 2 for DUTs intended for mounting on engines with six or more cylinders.

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




**Key**

X frequency, Hz

Y amplitude of acceleration, $m/s^2$

Curve 1 (engines with 5 cylinders or less)

Curve 2 (engines with 6 or more cylinders)

**Figure 2 — Vibration severity curves**

**Table 2 — Values for frequency and acceleration**

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

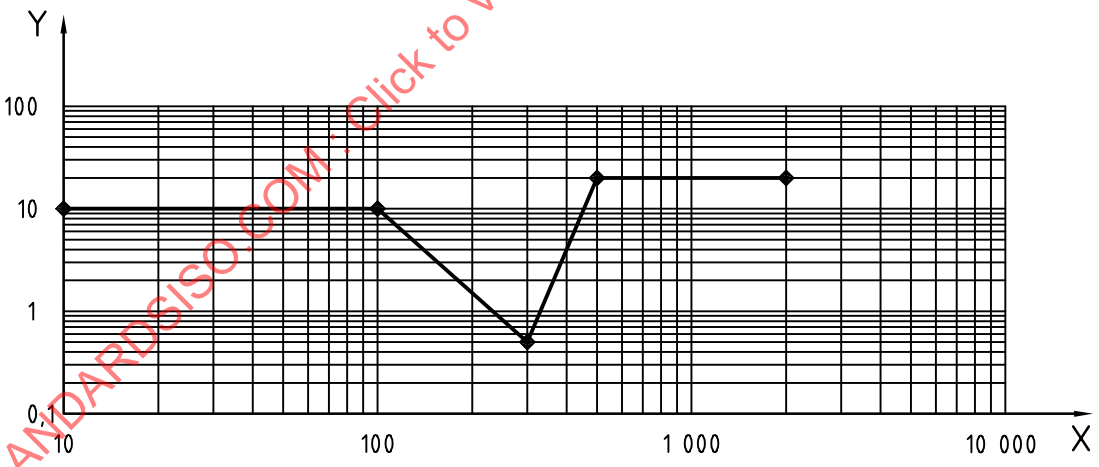
#### 4.1.3.1.2.3 Random vibration

Perform the test according to IEC 60068-2-64. The test duration shall be 22 h for each plane of the DUT.

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

See Figure 3 and Table 3.

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




**Key**

X frequency, Hz

Y power spectral density (PSD) of acceleration, $(m/s^2)^2/Hz$

**Figure 3 — PSD of acceleration vs. frequency**

**Table 3 — Values for frequency and power spectral density**

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

#### 4.1.3.1.3 Test II — Gear box mounted equipment

##### 4.1.3.1.3.1 Purpose

The vibrations of a gear box can be divided into two types, resulting partly from vibrations transmitted from the engine: sinusoidal vibration, which results from unbalanced mass forces, and random noise created by the friction of the gearwheels and other vibration sources in the engine. Failure mode in this test is rupture due to fatigue.

NOTE The temperature in the chamber is above room temperature at the end of the test (2,75 temperature cycles).

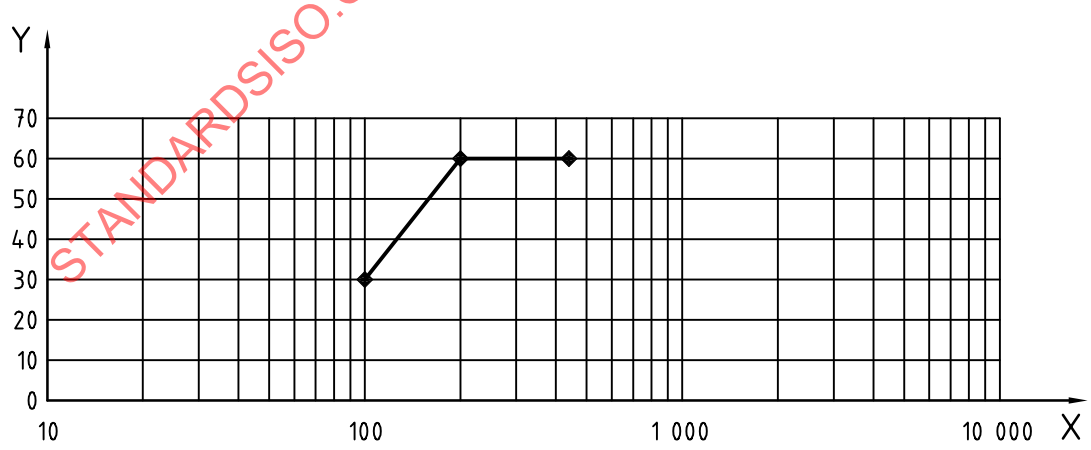
The test profiles specified in the following subclauses apply to loads generated by gear box vibrations. Changing the gears can create additional mechanical shock and shall be considered separately.

Following the forthcoming publication of IEC 60068-2-80, and the determination of the test parameters in accordance with it, this test should be performed as a combined sine and random test, also according to IEC 60068-2-80. Alternatively, these tests may be performed sequentially.

##### 4.1.3.1.3.2 Sinusoidal vibration

Perform the test according to IEC 60068-2-6. The test duration shall be 22 h for each plane of the DUT.

See Figure 4 and Table 4.




**Key**

X frequency, Hz

Y amplitude of acceleration, $m/s^2$

**Figure 4 — Acceleration vs. frequency**

**Table 4 — Values for frequency and acceleration**

| Frequency Hz | Amplitude of acceleration $m/s^2$ |
|---|---|
| 100 | 30 |
| 200 | 60 |
| 440 | 60 |

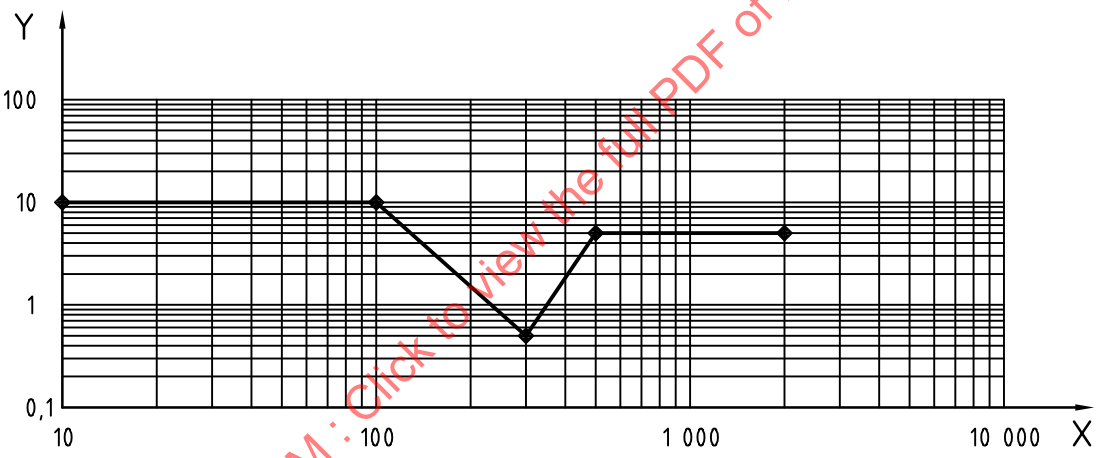
#### 4.1.3.1.3.3 Random vibration

Perform the test according to IEC 60068-2-64. The test duration shall be 22 h for each plane of the DUT.

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

See Figure 5 and Table 5.

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




**Key**

X frequency, Hz

Y power spectral density (PSD) of acceleration, $(m/s^2)^2/Hz$

**Figure 5 — PSD of acceleration vs. frequency**

**Table 5 — Values for frequency and power spectral density**

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

#### 4.1.3.1.4 Test III — Equipment mounted on flexible plenum chamber but not rigidly attached

##### 4.1.3.1.4.1 Purpose

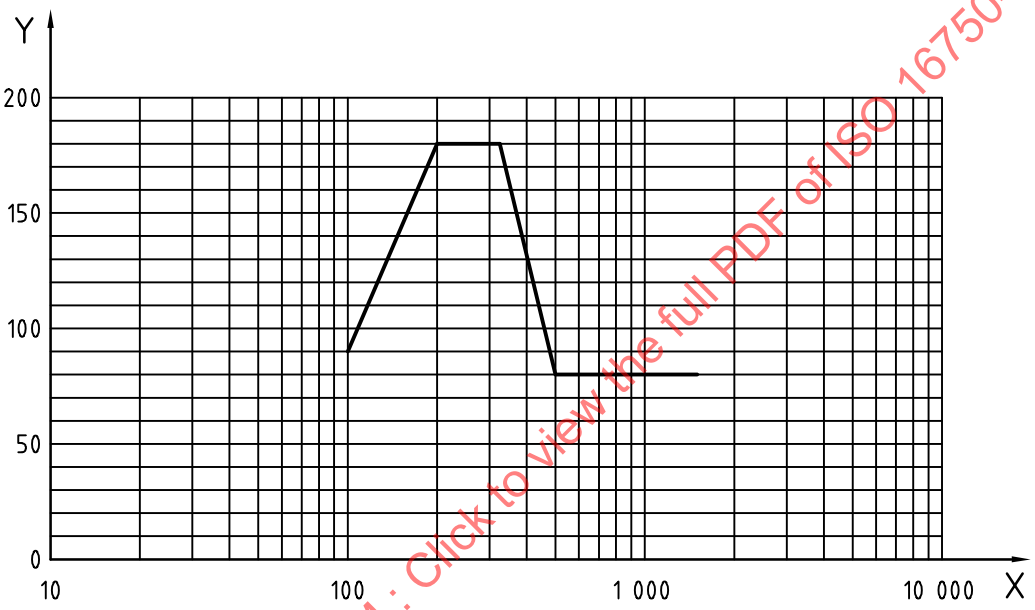
The vibrations in this mounting location are sinusoidal and are mainly induced by the pulsation of the intake air. Failure mode is rupture due to fatigue.

##### 4.1.3.1.4.2 Test

Perform the test according to IEC 60068-2-6. The test duration shall be 22 h for each plane of the DUT.

NOTE The temperature in the chamber is above room temperature at the end of the test (2,75 cycles).

See Figure 6 and Table 6.




**Key**

X frequency, Hz

Y amplitude of acceleration, $m/s^2$

**Figure 6 —Acceleration vs. frequency**

**Table 6 — Values for frequency and acceleration**

| Frequency<br>Hz | Amplitude of acceleration<br>$m/s^2$ |
|---|---|
| 100 | 90 |
| 200 | 180 |
| 325 | 180 |
| 500 | 80 |
| 1 500 | 80 |

#### 4.1.3.1.5 Test IV — Equipment mounted on sprung masses (vehicle body)

##### 4.1.3.1.5.1 Purpose

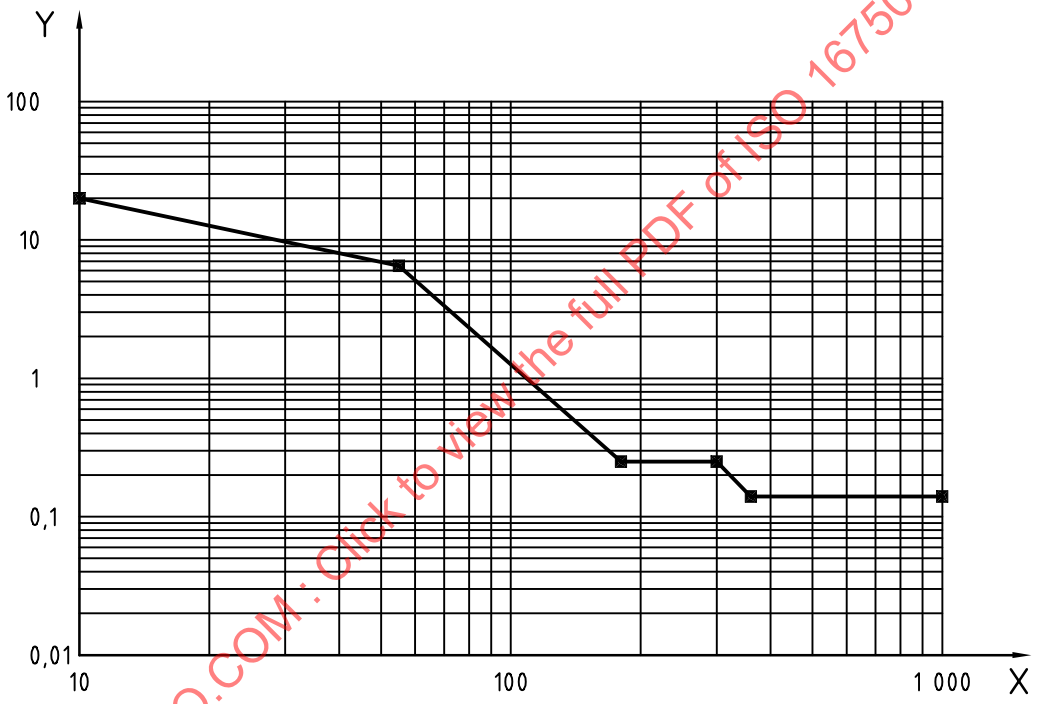
The vibration of the body is random vibration induced by rough-road-driving. Failure mode is rupture due to fatigue.

##### 4.1.3.1.5.2 Test

Perform the test according to IEC 60068-2-64. The test duration shall be 8 h for each plane of the DUT.

The r.m.s. acceleration value shall be 27,8 $m/s^2$.

See Figure 7 and Table 7.




**Key**

X frequency, Hz

Y power spectral density (PSD) of acceleration, $(m/s^2)^2/Hz$

**Figure 7 — PSD vs. frequency**

**Table 7 — Values for frequency and power spectral density**

| Frequency<br>Hz | PSD<br>$(m/s^2)^2/Hz$ |
|---|---|
| 10 | 20 |
| 55 | 6,5 |
| 180 | 0,25 |
| 300 | 0,25 |
| 360 | 0,14 |
| 1 000 | 0,14 |

#### 4.1.3.1.6 Test V — Equipment mounted on unsprung masses (wheel, wheel suspension)

##### 4.1.3.1.6.1 Purpose

The vibration of unsprung masses is random vibration induced by rough-road-driving. Failure mode is rupture due to fatigue.

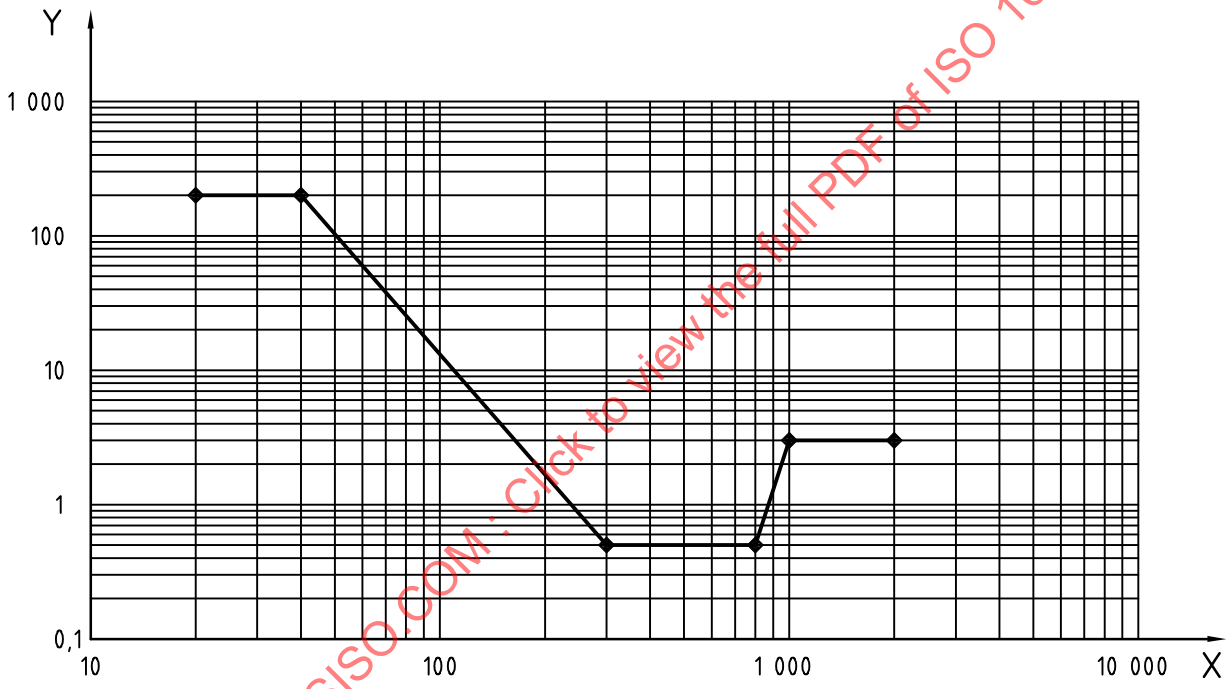
Loads with frequencies lower than 20 Hz are not covered by the test profile. In practice, high amplitudes can occur below 20 Hz; therefore, loads acting on the DUT in this frequency range shall be considered separately.

##### 4.1.3.1.6.2 Test

Perform the test according to IEC 60068-2-64. The test duration shall be 8 h for each plane of the DUT.

The r.m.s. acceleration value shall be 107,3 $m/s^2$.

See Figure 8 and Table 8.




**Key**

X frequency, Hz

Y power spectral density (PSD), $(m/s^2)^2/Hz$

**Figure 8 — PSD vs. frequency**

**Table 8 — Values for frequency and power spectral density**

| Frequency<br>Hz | PSD<br>$(m/s^2)^2/Hz$ |
|---|---|
| 20 | 200 |
| 40 | 200 |
| 300 | 0,5 |
| 800 | 0,5 |
| 1 000 | 3 |
| 2 000 | 3 |

#### 4.1.3.2 Test Set 2 — Commercial vehicles

##### 4.1.3.2.1 General

This test set (tests VI to IX) is mainly applicable to DUTs intended for mounting in commercial vehicles.

The test spectra do not consider stresses below 10 Hz. Since in practical operation large amplitudes can occur in the range below 10 Hz, stresses on the DUT in this frequency range shall be examined separately.

##### 4.1.3.2.2 Test VI — Equipment mounted on engine or gearbox

###### 4.1.3.2.2.1 Purpose

The vibrations of a piston-driven engine can be divided into two types: sinusoidal vibration that results from unbalanced mass forces, and random noise owing to all the other vibration sources of an engine, e.g. closing of valves. Because the gearbox is rigidly attached to the engine, this test can also be used for systems/components mounted at the gearbox (until now, no sufficient number of measurements on gear-box-mounted systems/components had been performed).

Failure mode in this test is rupture due to fatigue.

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

Following the forthcoming publication of IEC 60068-2-80, and the determination of the test parameters in accordance with it, this test should be performed as a combined sine and random test, also according to IEC 60068-2-80. Alternatively, these tests may be performed sequentially.

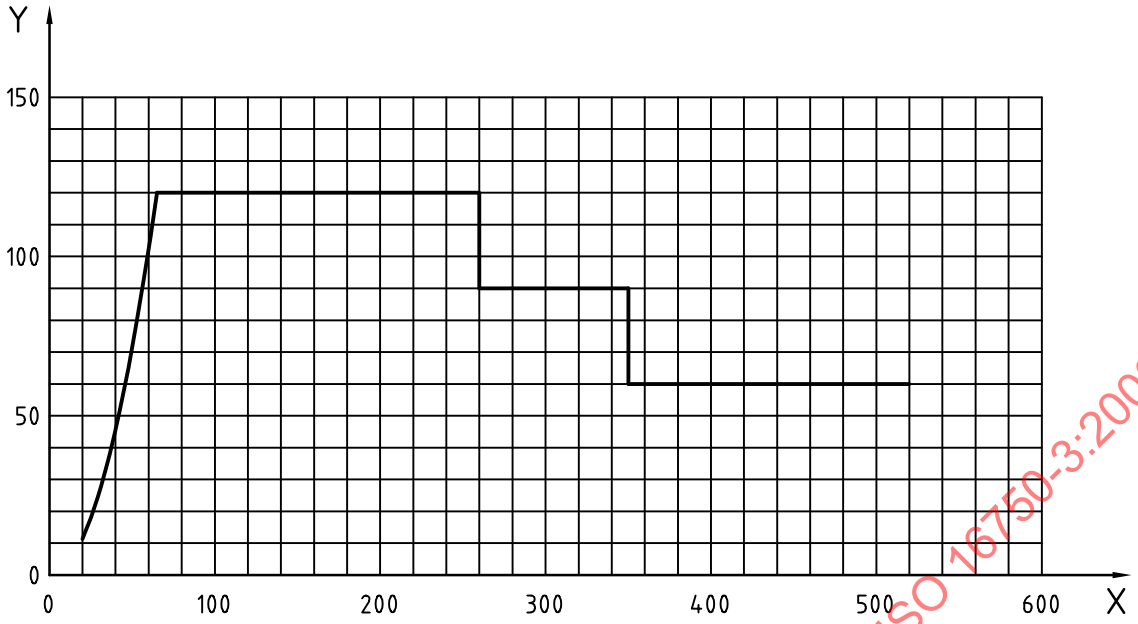
If the DUT has natural frequencies below 30 Hz, an additional test shall be carried out with a duration of 32 h in all critical planes of the DUT.

###### 4.1.3.2.2.2 Sinusoidal vibration

Perform the test according to IEC 60068-2-6. The test duration shall be 94 h for each plane of the DUT (equivalent to approx. 20 h per octave).

NOTE The temperature in the chamber is above room temperature at the end of the test (11,75 cycles).

See Figure 9 and Table 9.




**Key**

X frequency, Hz

Y amplitude of acceleration, $m/s^2$

**Figure 9 — Acceleration vs. frequency**

**Table 9 — Values for frequency and acceleration**

| Frequency<br>Hz | Amplitude of displacement<br>mm | Amplitude of acceleration<br>$m/s^2$ |
|---|---|---|
| 20 | 0,72 | (11,4) |
| 65 | 0,72 | 120 |
| 260 | | 120 |
| 260 | | 90 |
| 350 | | 90 |
| 350 | | 60 |
| 520 | | 60 |

#### 4.1.3.2.2.3 Random vibration

Perform the test according to IEC 60068-2-64.

The test duration shall be

— 94 h for each plane of the DUT (standard profile, see Table 10), and

— 32 h additionally for each critical plane of a DUT whose natural frequencies are < 30 Hz (see Table 11).

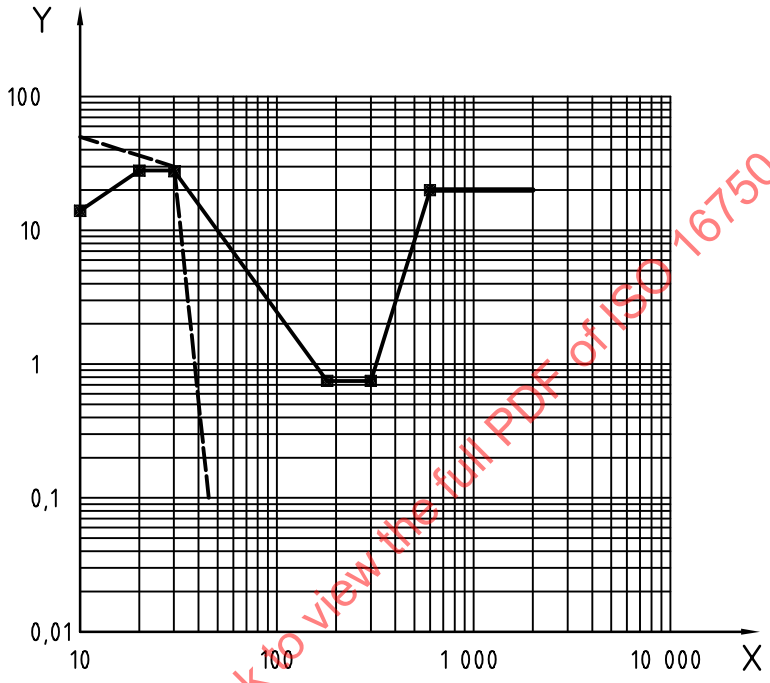
The r.m.s. acceleration values shall be

— 177 m/s$^2$ for the standard profile, and

— 28,6 m/s$^2$ in the case of DUT natural frequencies < 30 Hz.

See Figure 10 and Tables 10 and 11.

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




**Key**

X frequency, Hz

Y power spectral density (PSD) of acceleration, $(m/s^2)^2/Hz$

standard random test profile

additional profile for < 30 Hz

**Figure 10 — PSD vs. frequency**

**Table 10 — Values for frequency and power spectral density — Standard profile**

| **Frequency** Hz | **PSD** $(m/s^2)^2/Hz$ |
|---|---|
| 10 | 14 |
| 20 | 28 |
| 30 | 28 |
| 180 | 0,75 |
| 300 | 0,75 |
| 600 | 20 |
| 2 000 | 20 |

**Table 11 — Values for frequency and power spectral density — Additional profile for < 30 Hz**

| Frequency<br>Hz | PSD<br>$(m/s^2)^2/Hz$ |
|---|---|
| 10 | 50 |
| 30 | 30 |
| 45 | 0,1 |

#### 4.1.3.2.3 Test VII — Equipment mounted on sprung masses (vehicle body)

##### 4.1.3.2.3.1 Purpose

The vibration on sprung masses is random vibration induced by rough-road-driving. Failure mode is rupture due to fatigue.

##### 4.1.3.2.3.2 Test

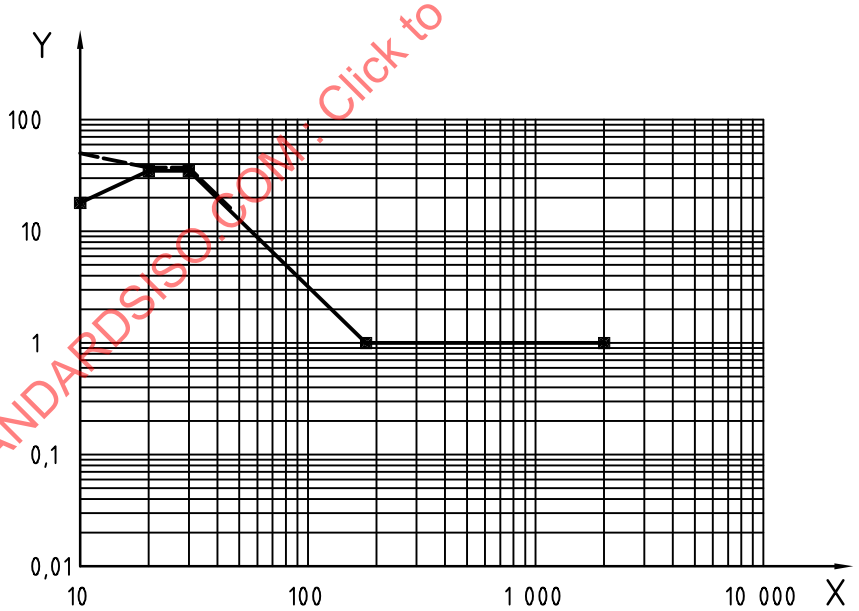
Perform the test according to IEC 60068-2-64. The test duration shall be 32 h for each plane of the DUT.

The r.m.s. acceleration values shall be

— 57,9 $m/s^2$ for the standard profile, and

— 33,7 $m/s^2$ in the case of DUT natural frequencies < 30 Hz.

See Figure 11 and Tables 12 and 13.




**Key**

X frequency, Hz

Y power spectral density (PSD) of acceleration, $(m/s^2)^2/Hz$

standard random test profile

additional profile for < 30 Hz

**Figure 11 — PSD vs. frequency**

**Table 12 — Values for frequency and power spectral density — Standard profile**

| Frequency<br>Hz | PSD<br>$(m/s^2)^2/Hz$ |
|---|---|
| 10 | 18 |
| 20 | 36 |
| 30 | 36 |
| 180 | 1 |
| 2 000 | 1 |

**Table 13 — Values for frequency and power spectral density — Additional profile for < 30 Hz**

| Frequency<br>Hz | PSD<br>$(m/s^2)^2/Hz$ |
|---|---|
| 10 | 50 |
| 20 | 36 |
| 30 | 36 |
| 45 | 16 |



#### 4.1.3.2.4 Test VIII — Equipment mounted on decoupled commercial vehicle cab

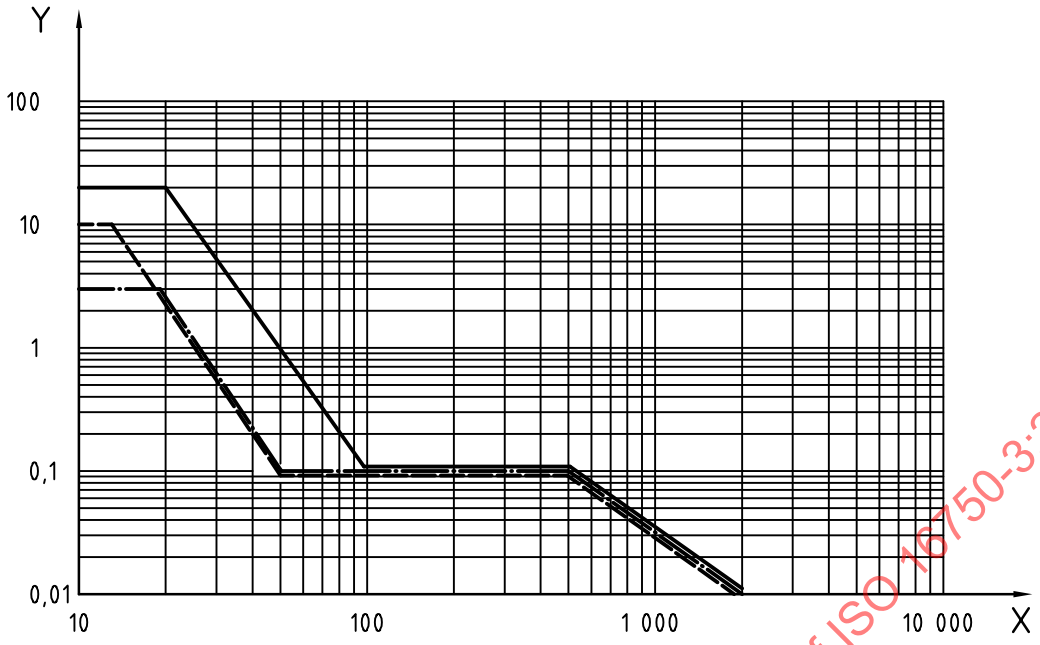
##### 4.1.3.2.4.1 Purpose

The vibration on a decoupled commercial vehicle cab is random vibration induced by rough-road-driving. Failure mode is rupture due to fatigue.

##### 4.1.3.2.4.2 Test

Perform the test according to IEC 60068-2-64. The test duration shall be 32 h for each plane of the DUT.

See Figure 12 and Table 14. The r.m.s. acceleration values shall be in accordance with Table 14.




**Key**

| | |
|---|---|
| X | frequency, Hz |
| Y | power spectral density (PSD) of acceleration, $(m/s^2)^2/Hz$ |
| ——— | vertical |
| ——·——— | longitudinal |
| — — — | lateral |

**Figure 12 — PSD vs. frequency**

**Table 14 — Values for frequency and power spectral density**

| Frequency Hz | PSD $(m/s^2)^2/Hz$ | | |
|---|---|---|---|
| | Vertical[a] | Longitudinal[b] | Lateral[c] |
| 10 | 20 | 3 | 10 |
| 13 | | | 10 |
| 19 | | 3 | |
| 20 | 20 | | |
| 50 | | 0,1 | 0,1 |
| 100 | 0,1 | | |
| 500 | 0,1 | 0,1 | 0,1 |
| 2 000 | 0,01 | 0,01 | 0,01 |

[a] r.m.s. acceleration value: 21,3 $m/s^2$.

[b] r.m.s. acceleration value: 11,8 $m/s^2$.

[c] r.m.s. acceleration value: 13,1 $m/s^2$.

#### 4.1.3.2.5 Test IX — Equipment mounted on unsprung masses (wheel, wheel suspension)

##### 4.1.3.2.5.1 Purpose

The vibration on unsprung masses is vibration induced by rough-road-driving. Failure mode is rupture due to fatigue.

##### 4.1.3.2.5.2 Tests

Perform the random vibration Test VII in accordance with 4.1.3.2.3.2 and, in addition, a sinusoidal vibration test as follows.

Carry out the sinusoidal vibration test at room temperature.

The sinusoidal vibration test, which shall be carried out in accordance with Table 15, describes the maximum amplitudes of acceleration on wheels and wheel suspension and the respective frequencies. If natural frequencies of the DUT below 40 Hz can be ruled out, the test may be carried out in accordance with Table 16 with a test frequency of 35 Hz and on an electro-mechanical test stand.

**Table 15 — Values for frequency and acceleration — Lowest natural frequency of DUT < 40 Hz**

| Plane according to plane in vehicle | Frequency<br>Hz | Amplitude of acceleration<br>$m/s^2$ | Duration<br>min | No. of cycles (approx.) |
|---|---|---|---|---|
| Longitudinal/lateral | 8 to 6 | 150 | 4 | 2 800 |
| | 8 to 16 | 120 | 10 | 7 000 |
| | 8 to 32 | 100 | 20 | 21 000 |
| Vertical | 8 to 16 | 300 | 4 | 2 800 |
| | 8 to 16 | 250 | 10 | 7 000 |
| | 8 to 32 | 200 | 20 | 21 000 |

**Table 16 — Values for frequency and acceleration — Lowest natural frequency of DUT ⩾ 40 Hz**

| Plane according to plane in vehicle | Frequency<br>Hz | Amplitude of acceleration<br>$m/s^2$ | No. of cycles (approx.) |
|---|---|---|---|
| longitudinal, lateral | 35 | 150 | 2 800 |
| | 35 | 120 | 7 000 |
| | 35 | 100 | 21 000 |
| vertical | 35 | 300 | 2 800 |
| | 35 | 250 | 7 000 |
| | 35 | 200 | 21 000 |

## 4.2 Mechanical shock

### 4.2.1 Endurance shock test for components in or on doors and flaps

#### 4.2.1.1 Purpose

This test is applicable to DUTs intended for mounting on or in doors and flaps.

The load occurs on closures slammed shut. Failure mode is mechanical damage (e.g. a detached capacitor inside the housing of electronic control module due to the high accelerations caused by door slamming).

#### 4.2.1.2 Test

Perform the test according to IEC 60068-2-29. See Tables 17 and 18.

The DUT shall be fixed on the shaker in a direction to generate the effect of acceleration in the same direction as it occurs in vehicle use. Acceleration resulting from the shock in the test shall be in the same direction as the acceleration of the shock that occurs in the vehicle.

**Table 17 — Endurance shock test for components in or on doors and flaps — Parameters**

| | |
|---|---|
| **Operating mode of DUT** (see ISO 16750-1:2003) | 1.2 |
| **Shock form (pulse shapes)** | Half-sinusoidal |
| **Acceleration** | |
| — normal requirements | 300 m/s$^2$ |
| — increased requirements | 500 m/s$^2$ |
| **Duration** | |
| — normal requirements | 6 ms |
| — increased requirements | 11 ms |
| **Temperature** | Room temperature |

**Table 18 — Endurance shock test for components in or on doors and flaps — No. of shocks**

| DUT Mounting | Number of shocks | |
|---|---|---|
| | Severity 1 | Severity 2 |
| Driver's door, cargo door | 13 000 | 100 000 |
| Passenger doors | 6 000 | 50 000 |
| Trunk lid, tailgate | 2 400 | 30 000 |
| Engine hood | 720 | 3 000 |



#### 4.2.1.3 Requirement

Functional status shall be Class C as defined in ISO 16750-1:2003.

### 4.2.2 Mechanical shock test for components on rigid points on the body and on the frame

#### 4.2.2.1 Purpose

This test is applicable to DUTs intended for mounting on rigid points on the body and on the frame.

The load occurs, for example, when driving over a curbstone at high speed. Failure mode is mechanical damage (e.g. a detached capacitor inside the housing of an electronic control module due to the resulting high accelerations).

#### 4.2.2.2 Test

Perform the test according to IEC 60068-2-29. See Table 19.

Acceleration resulting from the shock in the test shall be applied in the same direction as the acceleration of the shock that occurs in the vehicle. If the direction of the effect is not known, the DUT shall be tested in all six spatial directions.

**Table 19 — Mechanical shock test for components on rigid points on the body and on the frame — Parameters**

| | |
|---|---|
| **Operating mode of DUT** (see ISO 16750-1:2003) | 3.2 |
| **Pulse shape** | half-sinusoidal |
| **Acceleration** | 500 m/s$^2$ |
| **Duration** | 6 ms |
| **Temperature** | Room temperature |
| **Number of shocks** | 10 per test direction |

#### 4.2.2.3 Requirement

Functional status shall be Class A as defined in ISO 16750-1:2003.

### 4.2.3 Mechanical shock test for components in or on gear-box

#### 4.2.3.1 Purpose

This test is applicable to devices under test intended for mounting in or on the gearbox.

The loads occur during pneumatic powered gear-shifting operations. Failure mode is mechanical damage (e.g. a detached capacitor inside the housing of an electronic control module due to the high accelerations caused by pneumatically powered gear-shifting operations).

#### 4.2.3.2 Test

Perform the test according to IEC 60068-2-29. See Table 20.

**Table 20 — Mechanical shock test for components in or on the gear-box — Parameters**

| | |
|---|---|
| **Operating mode of DUT** (see ISO 16750-1:2003) | 3.2 |
| **Pulse shape** | half-sinusoidal |
| **Typical max. acceleration**<br>— commercial vehicles<br>— passenger cars | 3 000 to 50 000 m/s$^2$<br>To be decided |
| **Typical duration** | < 1 ms |
| **Temperature** | To be decided |
| **Number of shocks** | To be decided |

The aforementioned values for commercial vehicles occur primarily during pneumatically supported gear-shifting operations (150 000 gear-shifting operations are typical if a range-change system is fitted).

The actual shock stresses depend both on the installation position of the gearbox and also on the design features of the gearbox and shall in individual cases be ascertained by means of suitable measurements (recommended sampling frequency is at least 25 kHz). A test shall be arranged between the manufacturer and the user.

Acceleration resulting from the shock in the test shall be applied in the same direction as the acceleration of the shock in the vehicle. If the direction of the effect is not known, the DUT shall be tested in all six spatial directions.

#### 4.2.3.3 Requirement

Functional status shall be Class A as defined in ISO 16750-1:2003.

## 4.3 Free fall

### 4.3.1 Purpose

A system/component could drop to the floor during handling (e.g. at the manufacturing line of the car manufacturer). If a system/component is visibly damaged after a fall, it will be replaced. But if it is not visibly damaged, it will be installed in the car and then must work correctly. Failure mode is mechanical damage (e.g. a detached capacitor inside the housing of an electronic control module due to the high accelerations when the DUT hits the ground).

### 4.3.2 Test

Parts that will obviously be damaged by the fall shall not be checked (e.g. headlights).

Parts that could withstand a fall without visible damage shall be checked as follows.

Perform the test according to IEC 60068-2-32, using the test parameters given in Table 21.

Visually examine the devices under test after the falls.

**Table 21 — Free fall — Parameters**

| | |
|---|---|
| **Number of devices under test** | 3 |
| **Falls per DUT** | 2 |
| **Drop height** | 1 m free fall or the height of handling according to agreement |
| **Impact surface** | Concrete ground or steel plate |
| **Orientation of the sample** | For the first fall of each DUT a different dimensional axis shall be chosen. The second fall shall be performed on the given DUT with the same dimensional axis but on the opposite side of the housing. |
| **Operating mode of the DUT** (see ISO 16750-1:2003) | 1.1 |
| **Temperature** | To be decided |

### 4.3.3 Requirement

Hidden damage is not permitted. Minor damage of the housing is permitted as long as this does not affect the performance of the DUT. Proper performance shall be proven following the test.

Functional status shall be Class C as defined in ISO 16750-1:2003.

### 4.4 Surface strength/scratch and abrasion resistance

Tests and requirements shall be agreed upon between manufacturer and customer. For example, marking and labelling on control elements and keys shall remain visible.

### 4.5 Gravel bombardment

This test checks the resistance against gravel bombardment (in exposed mounting locations, e.g. front end). See DIN 55996-1[2)].

## 5 Code letters for mechanical loads

See Annex B.

## 6 Documentation

For documentation purposes, the designations given in ISO 16750-1 shall be used. See Table 22.



2) An ISO equivalent is planned.

**Table 22 — Tests and test codes**

| Test | | Series 1 vibration tests; passenger cars | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Test I, sinusoidal vibration** (see 4.1.3.1.2.2) | **Test I, random vibration** (see 4.1.3.1.2.3) | **Test II** (see 4.1.3.1.3) | **Test III** (see 4.1.3.1.4) | **Test IV** (see 4.1.3.1.5) | **Test V** (see 4.1.3.1.6) |
| **DUT mounting** | | **Engine mounted** | **Engine mounted** | **Gearbox mounted** | **Flexible plenum chamber** | **Body- mounted sprung masses** | **Unsprung masses** |
| **Test Code letter** | AA | Curve 1 | yes | — | — | — | — |
| | BA | Curve 2 | yes | — | — | — | — |
| | CA | Combined | yes | — | — | — | — |
| | DA | — | — | | yes | — | — |
| | EA | — | — | — | — | yes | — |
| | FA | — | — | — | — | yes | — |
| | GA | — | — | — | — | yes | — |
| | HA | — | — | — | — | yes | — |
| | IA | — | — | — | — | yes | — |
| | JA | — | — | — | — | yes | — |
| | KA | — | — | — | — | — | yes |
| | LA | — | — | — | — | — | yes |
| | MA | — | — | — | — | — | — |
| | NA | — | — | — | — | — | — |
| | OA | — | — | — | — | — | — |
| | PA | — | — | — | — | — | — |
| | QA | — | — | — | — | — | — |
| | RA | — | — | — | — | — | — |
| | SA | — | — | — | — | — | — |
| | TA | — | — | — | — | — | — |
| | UA | — | — | — | — | — | — |
| | VA | — | — | — | — | — | — |
| | WA | — | — | — | — | — | — |
| | XA | — | — | — | — | — | — |
| | YA | — | — | — | — | — | — |
| | AB | — | — | — | — | — | — |
| | BB | — | — | — | — | — | — |
| | CB | — | — | yes | — | — | — |
| | Z | Upon agreement | | | | | |

**Table 22** (*continued*)

| Test | | Series 2 vibration tests: commercial vehicles | | | | Mechanical shock tests | | | | | Free fall |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Test VI (see 4.1.3.2.2) | Test VII (see 4.1.3.2.3) | Test VIII (see 4.1.3.2.4) | Test IX (see 4.1.3.2.5) | Severity 1 (see 4.2.1.2) | | Severity 2 (see 4.2.1.2) | | (see 4.2.2) | (see 4.3) |
| | | | | | | 300 m/s$^2$ 6 ms | 500 m/s$^2$ 11 ms | 300 m/s$^2$ 6 ms | 500 m/s$^2$ 11 ms | | |
| DUT mounting | | Engine- or gearbox-mounted | Body mounted sprung masses | Decoupled vehicle cab | Unsprung masses | Doors and flaps | Doors and flaps | Doors and flaps | Doors and flaps | Rigid points | — |
| Test Code letter | AA | — | — | — | — | — | — | — | — | — | yes |
| | BA | — | — | — | — | — | — | — | — | — | yes |
| | CA | — | — | — | — | — | — | — | — | — | yes |
| | DA | — | — | — | — | — | — | — | — | — | yes |
| | EA | — | — | — | — | — | — | — | — | — | yes |
| | FA | — | — | — | — | — | — | — | — | yes | yes |
| | GA | — | — | — | — | yes | — | — | — | — | yes |
| | HA | — | — | — | — | — | yes | — | — | — | yes |
| | IA | — | — | — | — | — | — | yes | — | — | yes |
| | JA | — | — | — | — | — | — | | yes | — | yes |
| | KA | — | — | — | — | — | — | — | — | — | yes |
| | LA | — | — | — | — | — | — | — | — | yes | yes |
| | MA | yes | — | — | — | — | — | — | — | — | yes |
| | NA | — | yes | — | — | — | — | — | — | — | yes |
| | OA | — | yes | — | — | — | — | — | — | yes | yes |
| | PA | — | yes | — | — | yes | — | — | — | — | yes |
| | QA | — | yes | — | — | — | yes | — | — | — | yes |
| | RA | — | yes | — | — | — | — | yes | — | — | yes |
| | SA | — | yes | — | — | — | — | — | yes | — | yes |
| | TA | — | — | — | yes | — | — | — | — | — | yes |
| | UA | — | — | yes | — | — | — | — | — | — | yes |
| | VA | — | — | yes | — | — | — | — | — | yes | yes |
| | WA | — | — | yes | — | yes | — | — | — | — | yes |
| | XA | — | — | yes | — | — | yes | — | — | — | yes |
| | YA | — | — | yes | — | — | — | yes | — | — | yes |
| | AB | — | — | yes | — | — | — | — | yes | — | yes |
| | BB | — | — | — | yes | — | — | — | — | yes | yes |
| | CB | — | — | — | — | — | — | — | — | — | yes |
| | Z | Upon agreement | | | | | | | | | |