
**Safety of machinery — Pressure-sensitive
protective devices —**

Part 1:

**General principles for design and testing
of pressure-sensitive mats and
pressure-sensitive floors**

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*Sécurité des machines — Dispositifs de protection sensibles à la
pression —*

*Partie 1: Principes généraux de conception et d'essai des tapis et
planchers sensibles à la pression*



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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 3.

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 part of ISO 13856 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 13856-1 was prepared by Technical Committee ISO/TC 199, *Safety of machinery*.

ISO 13856 consists of the following parts, under the general title *Safety of machinery — Pressure-sensitive protective devices*:

- Part 1: *General principles for design and testing of pressure-sensitive mats and pressure-sensitive floors*
- Part 2: *General principles for the design and testing of edges and bars*
- Part 3: *General principles for the design and testing of bumpers*

Annex A forms a normative part of this part of ISO 13856. Annex B, C and D are for information only.

Introduction

Pressure-sensitive protective devices are used in a wide variety of applications with different conditions of use relating, e.g., to extremes of loading, electrical, physical and chemical environments. They are interfaced with the machine controls to ensure that the machine reverts to a safe condition if the pressure sensitive device is actuated.

Each type of application presents particular hazards. It is not the intention of this part of ISO 13856 to identify those hazards nor to recommend specific methods of application to particular machines. This is normally the function of machine specific standards.

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Safety of machinery — Pressure-sensitive protective devices —

Part 1:

General principles for design and testing of pressure-sensitive mats and pressure-sensitive floors

1 Scope

This part of ISO 13856 specifies requirements for pressure-sensitive mats and floors normally actuated by the feet, for use as safety devices to protect persons from dangerous machinery. The minimum safety requirements for the performance, marking and documentation are given.

It covers pressure-sensitive mats and floors, regardless of type of energy used, e.g. electrical, hydraulic, pneumatic or mechanical.

This part of ISO 13856 covers mats and floors designed to detect:

- a) persons weighing more than 35 kg;
- b) and persons (e.g. children) weighing more than 20 kg.

The detection of persons weighing less than 20 kg is not covered by this part of ISO 13856.

This part of ISO 13856 does not specify the dimensions or the configuration of the effective sensing area of pressure-sensitive mat(s) or floor(s) in relation to any particular application.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 13856. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 13856 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 6431:1992, *Pneumatic fluid power — Single rod cylinders, 1 000 kPa (10 bar) series, with detachable mountings, bores from 32 mm to 320 mm — Mounting dimensions*

ISO 12100-1:—¹), *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology and methodology*

ISO 12100-2:—²), *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles*

1) To be published. (Revision of ISO/TR 12100-1:1992)

2) To be published. (Revision of ISO/TR 12100-2:1992)

ISO 13856-1:2001(E)

ISO 13855:—³⁾, *Safety of machinery — Positioning of protective equipment with respect to the approach speeds of parts of the human body*

IEC 60068-2-3:1969, *Environmental testing — Part 2: Tests. Test Ca: Damp heat, steady state*

IEC 60068-2-6:1995, *Environmental testing — Part 2: Tests — Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14:1984, *Basic environmental testing procedures — Part 2: Tests. Test N: Change of temperature*

IEC 60204-1:2000, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60439-1:1999, *Low-voltage switchgear and controlgear assemblies — Part 1: Type-tested and partially type-tested assemblies*

IEC 60529, *Degrees of protection provided by enclosures (IP code)*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 2: Electrostatic discharge immunity test — Basic EMC publication*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 3: Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 4: Electrical fast transient/burst immunity test — Basic EMC publication*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) — Part 4: Testing and measurement techniques — Section 5: Surge immunity test*

IEC 61000-6-2, *Electromagnetic Compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments*

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IEC 61000-6-3, *Electromagnetic compatibility (EMC) — Part 6: Generic standards — Section 3: Emission standard for residential, commercial and light-industrial environments*

IEC 61310-2, *Safety of machinery — Indication, marking and actuation — Part 2: Requirements for marking*

EN 954-1:1996, *Safety of machinery — Safety related parts of control systems — Part 1: General principles for design*

EN 982:1996, *Safety of machinery — Safety requirements for fluid power systems and their components — Hydraulics*

EN 983:1996, *Safety of machinery — Safety requirements for fluid power systems and their components — Pneumatics*

EN 1070, *Safety of machinery — Terminology*

3 Terms and definitions

For the purposes of this part of ISO 13856, the terms and definitions given in EN 1070 and the following apply.

3.1

pressure-sensitive mat

safety device that detects a person standing on it or who steps on to it comprising a sensor(s) that responds to the application of pressure, a control unit and one or more output signal switching device(s)

3) To be published.

See Figure 1 and 3.23.5 of ISO 12100-1:—.

NOTE In a pressure-sensitive mat the effective sensing area is deformed locally when the sensor(s) is actuated.

3.2

pressure-sensitive floor

safety device that detects a person standing on it or who steps on to it comprising a sensor(s) that responds to the application of pressure, a control unit and one or more output signal switching device(s)

See 3.23.5 of ISO 12100-1:—.

NOTE In a pressure-sensitive floor the effective sensing area is moved as a whole when the sensor(s) is actuated.

3.3

sensor

that part of the pressure-sensitive mat or pressure-sensitive floor that contains an effective sensing area on which the application of an actuating force causes the signal from the sensor to the control unit to change state

3.4

effective sensing area

that part of the top surface area of the sensor or a combination of sensors of the pressure-sensitive mat or pressure-sensitive floor within which a response to an actuating force will take place

See 4.2.

3.5

control unit

device that responds to the condition of the sensor(s) and controls the state of the output signal switching device

NOTE It may also monitor the integrity of the pressure-sensitive mat or pressure-sensitive floor (see reference to categories in EN 954-1:1996) and it may contain facilities to process a reset signal. The control unit may be integrated with the machine control system.

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3.6

output signal switching device

that part of the pressure-sensitive mat or pressure sensitive floor that, when the sensor or monitoring function means is actuated, responds by producing an OFF state

NOTE The output signal switching device may be integrated with the machine control system.

3.7

actuating force

any force that produces pressure on the effective sensing area to create an OFF state in the output signal switching device

3.8

reset

function which permits an ON state in the output signal switching devices, provided certain conditions be met

3.9

ON state of output signal switching device(s)

state in which the output circuit(s) is complete and the flow of current or fluid is possible

3.10

OFF state of output signal switching device(s)

state in which the output circuit(s) is broken and the flow of current or fluid is interrupted

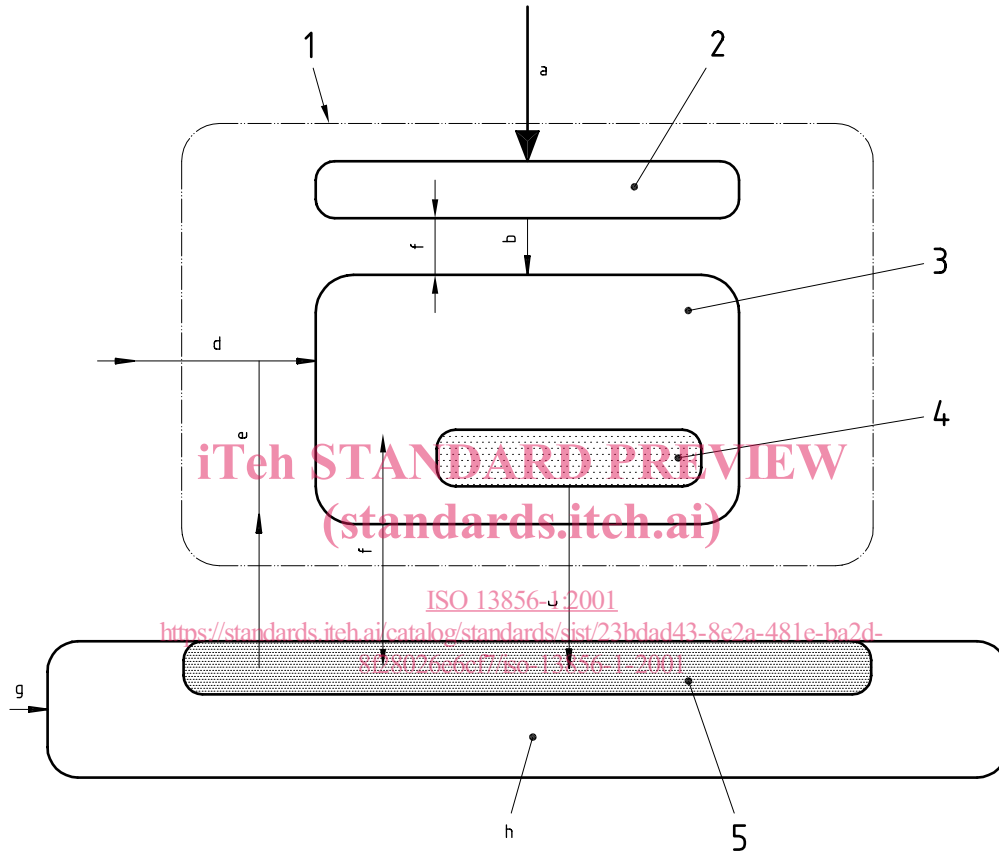
3.11 response time

time between the start of the application of a force to the effective sensing area and the start of the OFF state of the output signal switching device

See 4.3.

3.12 dead zone

that part of the top surface area of the sensor outside the effective sensing area



Key

- 1 Pressure-sensitive mat or floor output signal processing
- 2 Sensors
- 3 Control unit – may be integrated with the machine control system
- 4 Output signal switching device(s) – may be integrated with the machine control system
- 5 Part of the machine control system for pressure sensitive mat/pressure sensitive floor output signal processing
- a Actuating force
- b Sensor output
- c ON state/OFF state signal
- d Manual reset signal (where appropriate alternative to ^g)
- e Reset signal from machine control system (where appropriate)
- f Monitoring signals (optional)
- g Manual reset signal to the machine control system (where appropriate alternative to ^d)
- h Machine control system(s)

Figure 1 — Pressure-sensitive mat or pressure-sensitive floor interfaced with a machine

4 Requirements

4.1 General

Pressure-sensitive mats and pressure-sensitive floors shall be able to detect a person who is standing on, or who steps on to the effective sensing area.

4.2 Actuating force

4.2.1 Single sensor (see 7.4.1 and 7.4.2 for test method)

The pressure-sensitive mat or pressure-sensitive floor shall respond to the actuating forces stated in Table 1 when the test piece (see Figure 2) is applied over the effective sensing area at a maximum speed of 2 mm/s within the operating temperature range.

Test pieces 1, 2 and 3 apply to pressure-sensitive mats and pressure-sensitive floors designed to detect persons weighing more than 35 kg. Test piece 4 shall additionally be applied to pressure-sensitive mats and pressure-sensitive floors designed to detect persons (e.g. children) weighing more than 20 kg.

Table 1 — Actuating force

Application	Test piece		Actuating force N
	Number	<i>d</i> mm	
For pressure-sensitive mats and pressure-sensitive floors designed to detect persons weighing more than 35 kg	1	11	300
	2	80	300
	3	200	600
Additional test for pressure-sensitive mats and pressure-sensitive floors designed to detect persons (e.g. children) weighing more than 20 kg	4	40	150

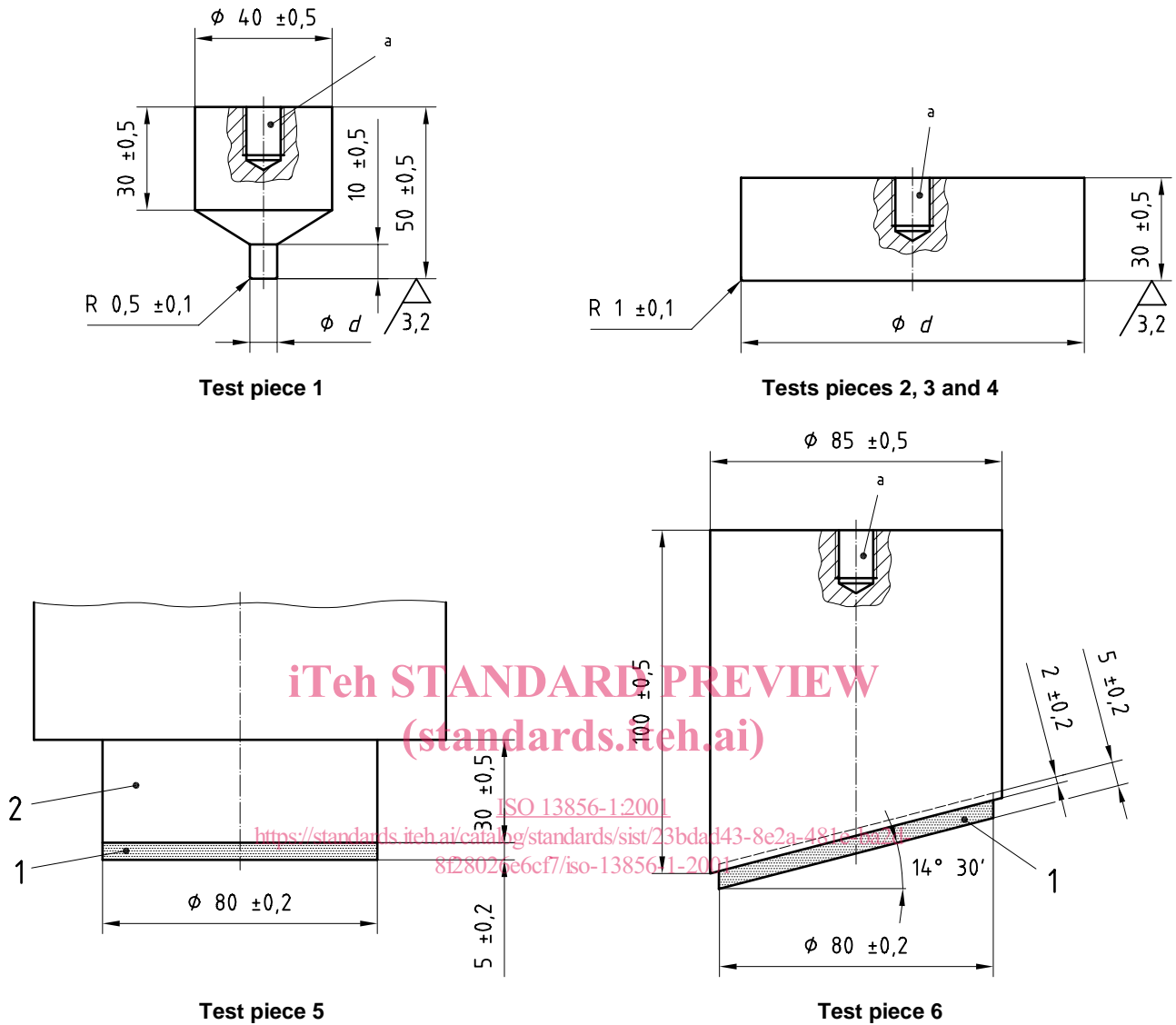
4.2.2 Combinations of sensors (see 7.4.3 and 7.4.4 for test methods)

Where an effective sensing area is built up of more than one sensor, joints and junctions shall fulfil the requirements of 4.2.1 except that only test piece 2 in Table 1 applies to pressure-sensitive mats and pressure-sensitive floors designed to detect persons weighing more than 35 kg.

Where pressure-sensitive mats and pressure-sensitive floors are designed to detect persons (e.g. children) weighing 20 kg or more only test pieces 2 and 4 shall apply.

For other parts of the effective sensing area, 4.2.1 shall apply (see Table 1).

Dimensions in millimetres



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Key

- 1 Rubber “shoe”, 60 Shore A ± 5 Shore A, fixed with adhesive.
- 2 Steel
- a Mounting proposal only

For *d* see Table 1.

Figure 2 — Test pieces

4.3 Response time (see 7.5 for test method)

The response time shall be stated by the manufacturer and shall not exceed 200 ms over the operating temperature range. The response time is the time between a) and b) where:

- a) is when a test piece vertically touches the effective sensing area at a velocity of 0,25 m/s;
- b) is the start of the OFF state of the output signal switching device (see Figures A.1, A.2 and A.3).

NOTE The 200 ms limit is specified to prevent the safety device from being defeated by the application of short stepping impulses.

4.4 Static loading (see 7.6 for test method)

4.4.1 After the application of a static force of $2\,000 \pm 50$ N within the effective sensing area through test piece 2 (see Figure 2), for a period of 8 h, the output signal switching device shall change state within 2 min of the removal of the force and the deformation shall be no more than 2 mm depth at the lowest part of the top surface after 1 h.

4.4.2 After the application of a static force of $750 \text{ N} \pm 20 \text{ N}$ within the effective sensing area at another location to that used in 4.4.1 through test piece 1 (see Figure 2) for a period of 8 h, the deformation shall be no more than 2 mm at the lowest part of the top surface after 1 h.

4.5 Number of operations (see 7.7 for test method)

4.5.1 A pressure-sensitive mat or pressure-sensitive floor shall perform its function for the typical expected number of operations.

4.5.1.1 The expected number of operations for the pressure-sensitive mat or pressure-sensitive floor is 100 000 operations in each of five locations (500 000 operations in total). If the effective sensing area consists of a combination of sensors, this requirement shall apply to the combination of sensors.

4.5.1.2 In addition, the expected number of operations for the sensor alone is a further one million operations in one other location.

4.5.2 When the requirements of 4.4 and 4.5.1 have been met, the pressure-sensitive mat or pressure-sensitive floor shall still meet the requirements of 4.2 and 4.3.

4.6 The output state of the sensor (see 7.8 for test method)

The sensor output signal shall change to a value or state which causes the output signal switching device(s) to change to the OFF state when any actuating force is applied to the effective sensing area. This value or state shall maintain the output signal switching device(s) in the OFF state until the actuating force is removed (see Figures A.1, A.2 and A.3)

4.7 Response of output signal switching device(s) to the actuating force (see 7.9 for test method)

4.7.1 General

When any actuating force is applied to the effective sensing area, the output signal switching device(s) shall change from an ON state to an OFF state. The output signal switching device shall remain in the OFF state for at least as long as the actuating force is applied.

4.7.2 Device with reset

For a pressure-sensitive mat or pressure-sensitive floor with reset, the reset signal shall be manually applied either directly to the control unit of the safety device or alternatively via the machine control system (see Figure 1).

The reset shall perform the following two functions.

a) Start inhibit interlock

At power ON the output signal switching device(s) shall remain in the OFF state until the reset signal is applied.

b) Re-start inhibit interlock

After the actuating force has been removed, the output of the output signal switching device(s) shall only change to an ON state after the application of a reset signal.

If the reset signal is applied continuously before or whilst the actuating force is applied, the output of the output signal switching device(s) shall not change to an ON state when the actuating force is removed (see Figures A.1 and A.2).

The reset signal shall control either the output of the sensor and the output signal switching device(s) (see Figure A.1) or it shall control the output of the output signal switching device(s) only (see Figure A.2).

4.7.3 Device without reset

For a pressure-sensitive mat or pressure-sensitive floor without reset, the output signal of the output signal switching device(s) shall change to an ON state at power ON after the actuating force has been removed (see Figure A.3).

NOTE If a device without reset is used, then the reset function should be provided in the machine control system (see 5.4 of EN 954-1:1996).

4.8 Access for maintenance (see 7.10 for test method)

Where access is required to the interior of any part of the pressure-sensitive mat or pressure-sensitive floor, it shall be possible only by means of a key or tool. Any means of securing an enclosure shall be captive.

4.9 Adjustments (see 7.11 for test method)

There shall be no method of adjustment by the user to actuating force and response time.

Where the supplier states that sub-assemblies of the pressure-sensitive mat or pressure-sensitive floor can be individually replaced, this shall be possible without reducing the overall performance of the pressure-sensitive mat or pressure-sensitive floor and without the need for adjustment.

4.10 Connections (see 7.12 for test method)

The correct alignment of plugs/sockets shall be made clear by either type, shape, marking or designation (or a combination of these).

Where components of different configurations existing within the pressure-sensitive mat or pressure-sensitive floor are interchangeable, incorrect placement or exchange of these components shall not cause a failure to danger.

If a sensor or subsystem is connected by a plug and socket, removal or disconnection of the sensor or subsystem at the plug and socket from or within the control unit shall cause the output signal switching device(s) to go to an OFF state.

4.11 Environmental conditions (see 7.13 for test method)

The pressure-sensitive mat or pressure-sensitive floor shall continue to operate in the environmental conditions given below or in any wider range stated by the manufacturers.

4.11.1 Temperature range

The pressure-sensitive mat or pressure-sensitive floor shall comply with the requirements of 4.2.1 and 4.3 over a temperature range of + 5 °C to + 40 °C.

NOTE Extended environmental temperature ranges can be – 25 °C to + 40 °C and + 5 °C to + 70 °C.

4.11.2 Humidity

The requirements for humidity shall be in accordance with test Ca of IEC 60068-2-3:1969, for a period of four days.

4.11.3 Electromagnetic compatibility

The pressure-sensitive mat or pressure-sensitive floor shall continue in normal operation when subjected to level/class 3 in accordance with Table 4 (see 7.13.4)

4.11.4 Vibration

The requirements for vibration shall apply to the control unit and the output signal switching device(s) only and shall be in accordance with IEC 60068-2-6:

- frequency range 10 Hz to 55 Hz;
- displacement 0,15 mm;
- 10 cycles per axis;
- sweep rate one octave per minute.

NOTE Special requirements for the sensor are not practicable because of the variation in sizes and shapes of sensors. Sensors are normally fixed to the ground in which case vibration is not normally critical. Where a sensor is fixed to a part of a machine, the effects of vibration should be considered. See annex B.

4.12 Power supply

4.12.1 Electrical power supply (see 7.14 for test method)

The pressure-sensitive mat or pressure-sensitive floor shall meet the requirements of 4.3 of IEC 60204-1:1997.

4.12.2 Non-electrical power supply

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For non-electrical power supplies, the manufacturer shall state the nominal supply level and the permissible range of tolerance within which normal operation will be maintained.

Where over-pressure protective devices are not provided, over-pressure variations outside the nominal range shall not result in a failure to danger.

Variations below the operating range shall not result in a failure to danger (see also EN 982 and EN 983).

NOTE No methods of test have been established for such equipment.

4.13 Electrical equipment (see 7.15 for test method)

4.13.1 General

The electrical equipment (components) of the pressure-sensitive device shall:

- conform to International Standards where they exist;
- be suitable for the intended use;
- be operated within their specified ratings.

4.13.2 Protection against electric shock

Protection against electric shock shall be provided in accordance with 6.1, 6.2 and 6.3 of IEC 60204-1:1997.