INTERNATIONAL STANDARD

ISO 13856-1

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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

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 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 13856-1 was prepared by Technical Committee ISO/TC 199, *Safety of machinery* and by Technical Committee CEN/TC 114, *Safety of machinery* in collaboration.

This second edition cancels and replaces the first edition (ISO 13856-1:2001) which has been technically revised.

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 design and testing of pressure-sensitive edges and pressure-sensitive bars*

— *Part 3: General principles for design and testing of pressure-sensitive bumpers, plates, wires and similar devices*

Introduction

The structure of safety standards in the field of machinery is as follows:

a) Type-A standards (basic safety standards) giving basic concepts, principles for design, and general aspects that can be applied to all machinery;

b) Type-B standards (generic safety standards) dealing with one safety aspect or one type of safeguard that can be used across a wide range of machinery:

— Type-B1 standards on particular safety aspects (e.g. safety distances, surface temperature, noise);

— Type-B2 standards on safeguards (e.g. two-hand controls, interlocking devices, pressure-sensitive devices, guards);

c) Type-C standards (machine safety standards) dealing with detailed safety requirements for a particular machine or group of machines.

This document is a type-B2 standard as stated in ISO 12100.

The requirements of this document can be supplemented or modified by a type-C standard.

For machines which are covered by the scope of a type-C standard and which have been designed and built according to the requirements of that standard, the requirements of that type-C standard take precedence.

The safeguarding of machinery (see ISO 12100:2010, 3.21) can be achieved by many different means. These means include guards which prevent access to the hazard zone by means of a physical barrier (for example, interlocking guards according to ISO 14119 or fixed guards according to ISO 14120) and protective devices (for example, electro-sensitive protective equipment according to IEC 61496-1 or pressure-sensitive protective devices according to this part of ISO 13856).

Type-C standards makers and designers of machinery/installations consider the best way to achieve the required level of safety taking into account the intended application and the results of the risk assessment (see ISO 12100).

The required solution can also be to combine several of these different means: the machinery/installation supplier and the user examine together carefully the existing hazards and constraints before making their decision on the choice of safeguarding.

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

ISO 13856 is restricted to the design of pressure-sensitive protective devices so that they can be used when the risk assessment carried out by the machine manufacturer and/or relevant type-C standard, when available, shows this to be appropriate.

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 establishes general principles and specifies requirements for the design and testing of pressure-sensitive mats and pressure-sensitive floors normally actuated by the feet for use as devices for protecting persons from hazardous machinery. The minimum safety requirements for the performance, marking and documentation are given.

This part of ISO 13856 is applicable to pressure-sensitive mats and pressure-sensitive floors, regardless of the type of energy used (e.g. electrical, hydraulic, pneumatic or mechanical), designed to detect

— persons weighing more than 35 kg, and

— persons (e.g. children) weighing more than 20 kg.

It is not applicable to the detection of persons weighing less than 20 kg.

It does not specify the following because they are application-specific:

a) dimensions or configuration of the effective sensing area of pressure-sensitive mat(s) or pressure-sensitive floor(s) in relation to any particular application;

b) when pressure-sensitive mats or floors are appropriate in a particular situation;

c) performance levels (PLs) for safety-related parts of control systems (SRP/CSs) other than providing a minimum level.

This part of ISO 13856 gives guidance to assist the user (i.e. machinery manufacturer and/or user of the machinery) in providing an adequate arrangement.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 13849-1:2006, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13849-2, *Safety of machinery — Safety-related parts of control systems — Part 2: Validation*

ISO 13855, *Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of the human body*

ISO 15552, *Pneumatic fluid power — Cylinders with detachable mountings, 1 000 kPa (10 bar) series, bores from 32 mm to 320 mm — Basic, mounting and accessories dimensions*

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

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

IEC 60068-2-78, *Environmental testing — Part 2-78: Tests — Test Cab: Damp heat, steady state*

IEC 60204-1:2005, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

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

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

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

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

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

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

IEC 61439-1:2011, *Low-voltage switchgear and controlgear assemblies — Part 1: General rules*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100, ISO 13849-1 and the following apply.

3.1
pressure-sensitive mat
sensitive protective equipment (ISO 12100:2010, 3.28.5) comprising a *sensor* (3.3) or sensors, a *control unit* (3.5) and one or more one or more *output signal switching devices* (3.6) which detects a person standing on it or who steps onto it and where the *effective sensing area* (3.4) is deformed locally when the sensor(s) is actuated

Note 1 to entry: See Figure 1 for a schematic sketch of a pressure-sensitive mat.

3.2
pressure-sensitive floor
sensitive protective equipment (ISO 12100:2010, 3.28.5) comprising a *sensor* (3.3) or sensors, a *control unit* (3.5) and one or more *output signal switching devices* (3.6) which detects a person standing on it or who steps onto it and where the *effective sensing area* (3.4) is moved as a whole when the sensor(s) is actuated

Note 1 to entry: See Figure 1 for a schematic sketch of a pressure-sensitive floor.

3.3
sensor
part of the *pressure-sensitive mat* (3.1) or *pressure-sensitive floor* (3.2) which contains an *effective sensing area* (3.4)

Note 1 to entry: The application of an actuating force to the effective sensing area causes the signal from the sensor to the control unit to change its state.

3.4
effective sensing area
part of the top surface area of the *sensor* (3.3) or a combination of sensors of the *pressure-sensitive mat* (3.1) or *pressure-sensitive floor* (3.2) within which a response to an actuating force will take place

Note 1 to entry: See 4.2 for requirements with regard to the actuating force.

3.5
control unit
device that responds to the condition of the *sensor* (3.3) and controls the state of the *output signal switching device* (3.6)

Note 1 to entry: The control unit can also monitor the integrity of the pressure-sensitive mat or pressure-sensitive floor (see reference to categories and performance levels according to ISO 13849-1) and can contain facilities for processing a reset signal. The control unit can be integrated with the machine control system.

3.6
output signal switching device
part of the *pressure-sensitive mat* (3.1) or *pressure-sensitive floor* (3.2) which responds by producing an OFF state when the *sensor* (3.3) or monitoring function means is actuated

Note 1 to entry: The output signal switching device can be integrated with the machine control system.

3.7
actuating force
any force which produces a pressure on the *effective sensing area* (3.4) to create an OFF state in the *output signal switching device* (3.6)

3.8
reset
function which permits an ON state in the *output signal switching device* (3.6), providing that certain conditions are met

3.9
ON state
state in which the output circuit(s) of an *output signal switching device* (3.6) is complete and permits the flow of current or fluid

3.10
OFF state
state in which the output circuit or circuits of an *output signal switching device* (3.6) are broken and interrupt the flow of current or fluid

3.11
response time
time between the start of the application of a force to the *effective sensing area* (3.4) and the start of the OFF state of the *output signal switching device* (3.6)

Note 1 to entry: See 4.3 for requirements with regard to the response time.

3.12
dead zone
part of the top surface area of the *sensor* (3.3) outside the *effective sensing area* (3.4)

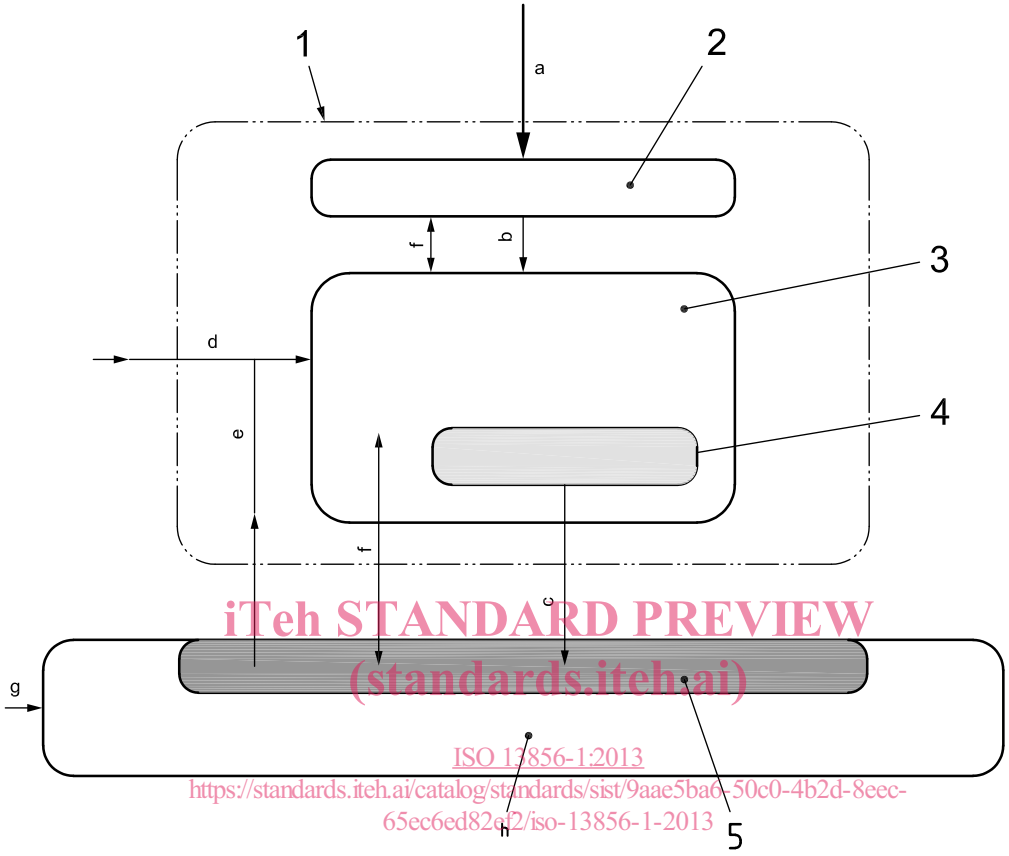
4 Requirements for design and testing

4.1 General

The following requirements are based on the assumption that the user (e.g. machine manufacturer or user of the machinery) determines the suitability of a pressure-sensitive mat or pressure-sensitive floor,

the required PL and the dimensions and orientation. It is also assumed that this information is given to the manufacturer of the pressure-sensitive protective device.

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



Key

1 pressure-sensitive mat or pressure-sensitive floor
2 sensor(s)
3 control unit*
4 output signal switching device(s)*
5 part of machine control system for pressure-sensitive mat or pressure-sensitive floor output signal processing
a actuating force
b sensor output
c ON state/OFF state signal
d manual reset signal**
e reset signal from machine control system (where appropriate)
f monitoring signals (optional)
g manual reset signal to the machine control system***
h machine control system(s)
* Can be located within the machine control system or as part of the machine control system.
** Where appropriate, this may be used as an alternative to g.
*** Where appropriate, this may be used as an alternative to d.

Figure 1 — Systematic sketch of pressure-sensitive mat/pressure-sensitive floor applied to machine

4.2 Actuating force

4.2.1 Single sensor

See 7.4.1 and 7.4.2 for the test method.

The pressure-sensitive mat or pressure-sensitive floor shall respond to the actuating force in accordance with Table 1 when the corresponding test piece (see Figure 2) is applied over the effective sensing area at a maximum speed of 2 mm·s^{-1} 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 forces

Application	Test piece		Actuating force
	No.	*d* mm	N
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

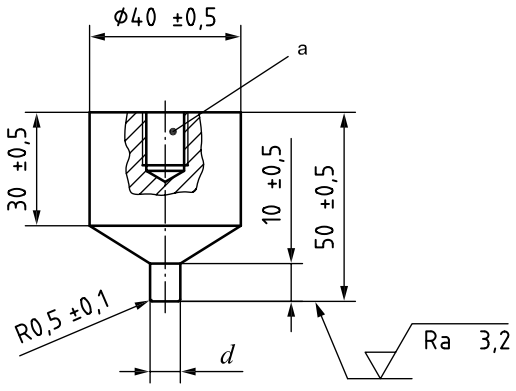
See 7.4.3 and 7.4.4 for the test method.

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, according to Table 1, applies to pressure-sensitive mats and pressure-sensitive floors designed to detect persons weighing more than 35 kg.

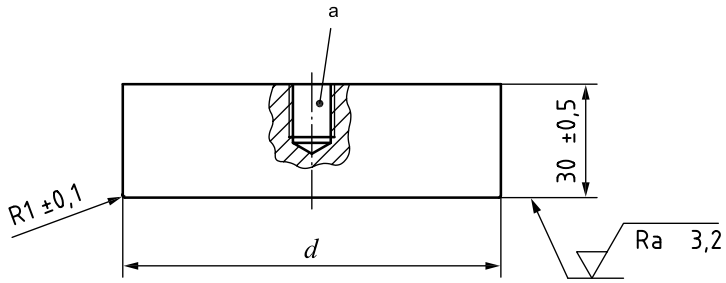
Where pressure-sensitive mats and pressure-sensitive floors are designed to detect persons (e.g. children) weighing 20 kg or more, only test pieces 2 and 4 apply.

For other parts of the effective sensing area, 4.2.1 applies.

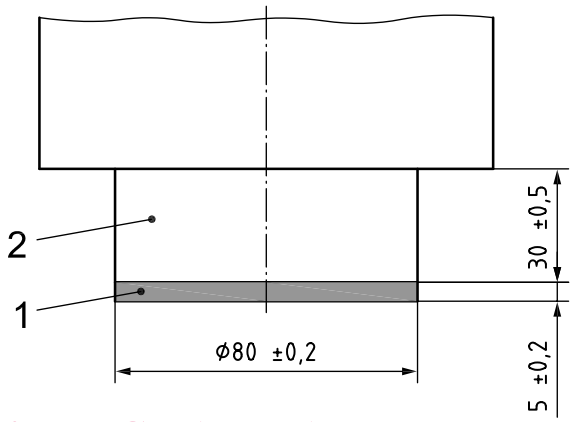
Dimensions in millimetres



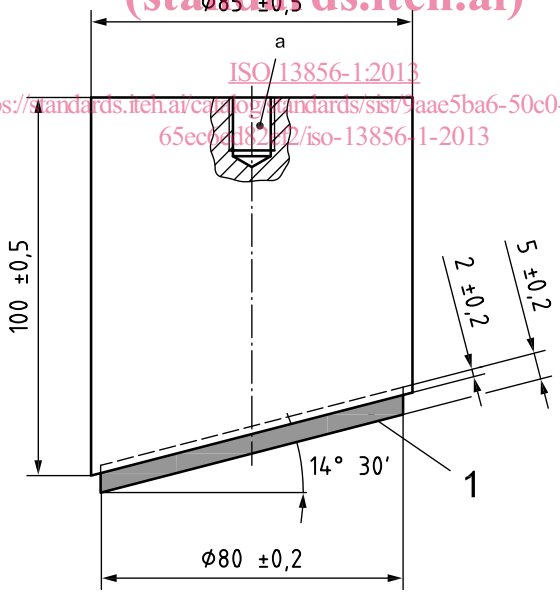
Test piece 1



Test pieces 2, 3 and 4



Test piece 5



Test piece 6

Key

1 rubber “shoe”, (60 ± 5) Shore A, fixed with adhesive

2 steel

d see Table 1

a Mounting proposal only.

Figure 2 — Test pieces 1 to 6

4.3 Response time

See 7.5 for the 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 touches vertically the effective sensing area at a speed of 0,25 $m \cdot s^{-1}$, and

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 safeguard from being defeated by the application of short stepping impulses.

4.4 Static loading

See 7.6 for the test method.

4.4.1 After the application of a static force of (2 000 ± 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 its state within 2 min after the removal of the force. For pressure-sensitive mats, after 1 h the deformation shall not be more than 2 mm in depth at the lowest part of the top surface; for pressure-sensitive floors, there shall not be any permanent deformation.

4.4.2 After the application of a static force of (750 ± 20) N within the effective sensing area through test piece 1 (see Figure 2) at another location to that used in 4.4.1 for a period of 8 h, the output signal switching device shall change its state within 2 min after the removal of the force. For pressure-sensitive mats, after 1 h the deformation shall not be more than 2 mm in depth at the lowest part of the top surface; for pressure-sensitive floors, there shall not be any permanent deformation.

4.5 Number of operations

See 7.7 for the test method.

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

4.5.1.1 The expected number of operations for the pressure-sensitive mat or pressure-sensitive floor shall be not less than 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 Output state of sensor

See 7.8 for the test method.

When an actuating force is applied to the effective sensing area or is present on the effective sensing area at power on, 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. This value or state shall maintain the output signal switching device(s) in the OFF state at least until the actuating force is removed (see Figures A.1, A.2 and A.3).

When the pressure-sensitive mat or pressure-sensitive floor is provided with a reset, the output signal switching device shall change its state only after the reset signal has been applied following the removal of the actuating force.

4.7 Response of output signal switching device(s) to actuating force

4.7.1 General

See 7.9 for the test method.

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. Similarly, the OFF state shall also be generated when an actuating force is already present on the effective sensing area when power is put ON.

The output signal switching device shall remain in the OFF state for at least as long as the actuating force is present on the effective sensing area.

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 safeguard or, alternatively, via the machine control system (see Figure 1).

The reset shall perform 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 change to an ON state only after the application of a reset signal.

If the reset signal is applied continuously before or while 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 without the application of an additional reset signal (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 and after the actuating force has been removed (see Figure A.3).

If a device without reset is used, then the reset function should be provided in the machine control system (see ISO 13849-1:2006, 5.4).

4.8 Access for maintenance

See 7.10 for the 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, excluding the key or tool for opening, shall be captive.

4.9 Adjustments

See 7.11 for the test method.

There shall be no means of adjustment by the user of the actuating force or 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 the test method.

The correct alignment of plug/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 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

4.11.1 General

See 7.13 for the test method.

The pressure-sensitive mat or pressure-sensitive floor shall continue to operate in accordance with this part of ISO 13856 in the environmental conditions given in 4.11.2 to 4.11.5 or in any wider range stated by the manufacturers.

4.11.2 Temperature

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

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

4.11.3 Humidity

The requirements for the resistance to humidity shall be in accordance with IEC 60068-2-78, for a period of four days.

4.11.4 Electromagnetic compatibility (immunity)

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).

4.11.5 Vibration

The requirements concerning 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. The following shall apply:

— frequency range, 10 Hz to 55 Hz;

— displacement, 0,15 mm;

— 10 cycles per axis;

— sweep rate, one octave per minute.