INTERNATIONAL STANDARD

ISO 13856-1

Second edition
2013-04-15

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

Reference number
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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)

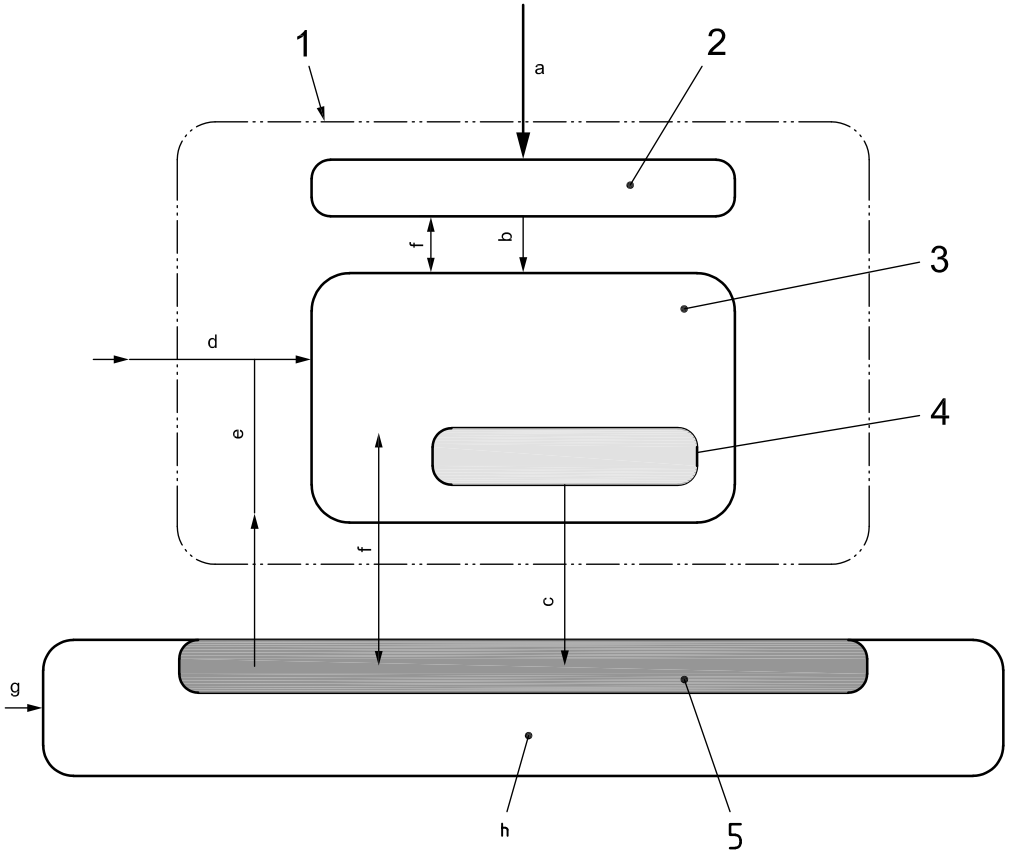
4 Requirements for design and testing

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

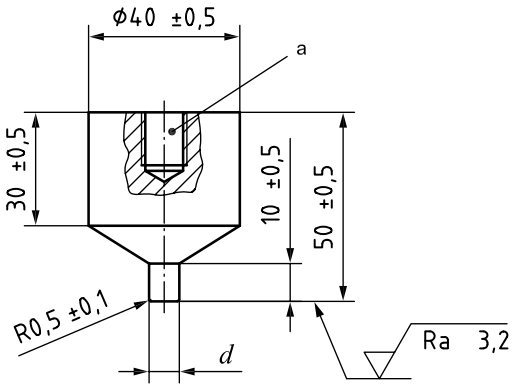
See 7.4.3 and 7.4.4 for the test method.

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.

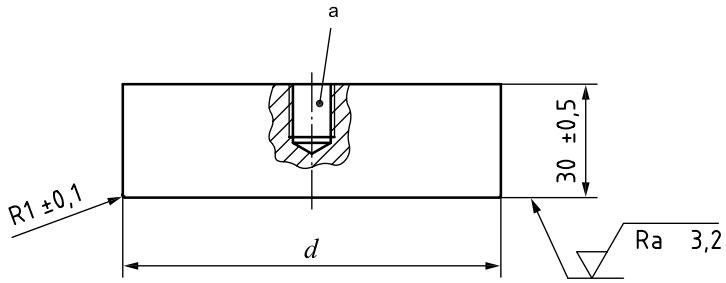
Where pressure-sensitive mats and pressure-sensitive floors are designed to detect persons (e.g. children) weighing 20 kg or more, only test pieces 2 and 4 apply.

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

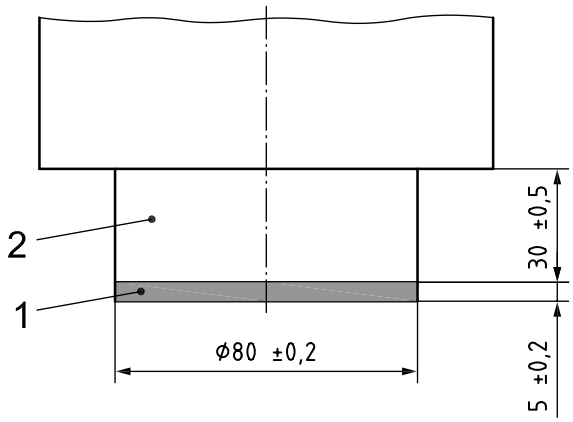
Dimensions in millimetres



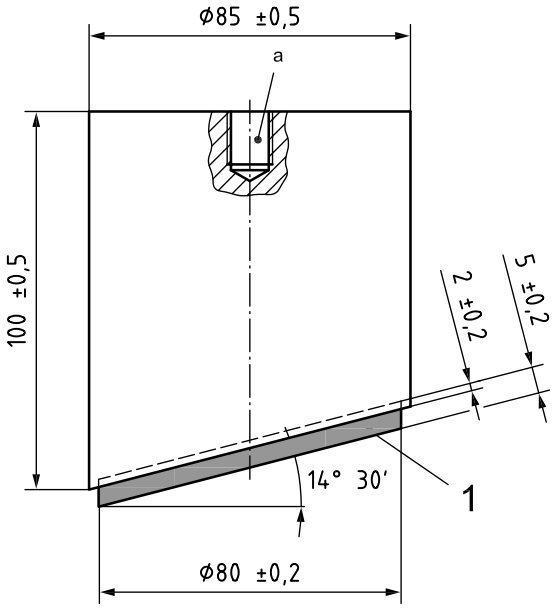
Test piece 1



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.

Where a sensor is fixed to a part of a machine, the effects of vibration should be considered. See also Annex B.

NOTE It is not practicable to give special requirements for sensors in this part of ISO 13856 because of the variation in their sizes and shapes. Sensors are normally fixed to the ground, in which case vibration is normally not critical.

4.12 Power supply

4.12.1 Electrical power supply

See 7.14 for the test method.

The pressure-sensitive mat or pressure-sensitive floor shall meet the requirements of IEC 60204-1:2005, 4.3.

4.12.2 Non-electrical power supply

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

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

Variations below the operating range shall not result in failure to danger (see also ISO 4413 and ISO 4414).

NOTE No test methods have been established for such equipment.

4.13 Electrical equipment

4.13.1 General

See 7.15 for the test method.

The electrical equipment (components) of the pressure-sensitive mat or pressure-sensitive floor shall

— conform to the appropriate existing International Standards,

— be suitable for the intended use, and

— be operated within their specified ratings.

4.13.2 Protection against electric shock

Protection against electrical shock shall be provided in accordance with IEC 60204-1:2005, 6.1, 6.2 and 6.3.

4.13.3 Protection against over-current

Protection against over-current shall be provided in accordance with IEC 60204-1:2005, 7.2.1, 7.2.3, 7.2.7, 7.2.8 and 7.2.9.

NOTE It can be necessary to give information to the user of the pressure-sensitive mat or pressure-sensitive floor as to the maximum rating of fuses or the setting of an over-current protective device for the circuit(s) connected to the output connection points of the output signal switching device(s).

4.13.4 Pollution degree

The electrical equipment shall be suitable for pollution degree 2 in accordance with IEC 61439-1:2011, 7.1.3.

4.13.5 Clearances and creepage distances

The electrical equipment shall be designed and constructed in accordance with IEC 61439-1:2011, 8.3 and 10.4.

4.13.6 Wiring

The electrical equipment shall be wired in accordance with IEC 61439-1:2011, 11.10.

4.14 Enclosure

See 7.16 for the test method.

4.14.1 Sensor

The sensor enclosure shall meet a minimum standard of IP54 in accordance with IEC 60529.

When the manufacturer specifies that the sensor can be immersed in water, the minimum enclosure level of the sensor shall be IP67 in accordance with IEC 60529.

4.14.2 Control unit and output signal switching device enclosure

The control unit enclosure shall meet a minimum standard of IP54 in accordance with IEC 60529. Where the control unit is designed for mounting in another control equipment enclosure and this enclosure is to a minimum of IP54 in accordance with IEC 60529, the control unit shall be to a minimum of IP2X in accordance with IEC 60529. The enclosure containing the output signal switching device(s) shall also meet these requirements.

4.15 Performance levels and categories for SRP/CSs in accordance with ISO 13849-1

4.15.1 For appropriate PLs for specific applications, see the corresponding type-C standards. In the absence of an appropriate type-C standard, the manufacturer of the machinery or the integrator of the machinery (see ISO 11161:2007, 3.10 for definition) should carry out a risk assessment to determine the PL required, using the guidance given in ISO 13849-1.

See 7.17 for the test method.

4.15.2 Pressure-sensitive mats and pressure-sensitive floors shall meet the requirements of the performance level (PL) and category for which they are specified and marked. The PLs and categories are specified in ISO 13849-1.

4.15.3 Pressure-sensitive mats and pressure-sensitive floors shall meet at least the requirements of PL = c according to ISO 13849-1.

NOTE Mechanical damage of the sensor surface that does not affect the safety function (e.g. scratches by swarf) are not treated as failures.

4.15.4 The mean number of cycles until 10 % of the components fail to danger (B_{10d} – values for pressure-sensitive mats and pressure-sensitive floors) shall be determined according to the test given in 7.7, but at location 8 only.

The test results shall be documented and shall, as a minimum, include the following information:

— temperature (of the environment);

— operating voltage and operating current;

— type of loading;

— switching frequency;

— test location;

— test loading;

— actuating speed;

— number of operations;

— B_{10d} values;

— types of failure;

— test person, test laboratory, date and signature.

NOTE The determination of the B_{10d} values is carried out by the manufacturer.

4.15.5 If a pressure-sensitive mat is required to comply with category 3, its architecture may deviate from the designated architecture according to ISO 13849-1:2006, 6.2, provided that the required PL is achieved.

Fault exclusions shall be listed and explained in the instructions for use. Fault exclusions which are not tolerable due to a reasonably foreseeable misuse of the pressure-sensitive mat or pressure-sensitive floor shall not be made.

If fault exclusion is used for the determination of the PL, the diagnostic coverage does not need to be calculated or included when determining the PL. Under these conditions, a high expectation of the mean time to dangerous failure ($MTTF_d$) shall be present to reach performance level d.

4.16 Sensor fittings

See 7.1.2 for the test method.

A means for securing sensors at their intended location shall be provided.

4.17 Tripping

See 7.1.2 for the test method.

For sensors provided with a ramp or for which a ramp is deliverable as an accessory, the slope of the ramp shall not exceed 20° from the horizontal. The ramp shall not create a physical obstruction or other hazard.

For sensors with a height exceeding 4 mm, under actuated or non-actuated conditions, the need for either a recessed installation or provision of a ramp complying with the requirements given above shall be stated in the instruction handbook.

Where there is a combination of sensors and/or additional coverings, provision shall be made to minimize the tripping hazard at joints and junctions between the sensors.

NOTE See ISO 14122-2 for the dimension indicated.

4.18 Slip-resistance

See 7.18 for the test method.

Provisions shall be made on the top surface of the sensor to minimize slipping under the expected operating conditions.

NOTE See also ISO 14122-2.

4.19 Additional coverings of top surfaces of sensor(s)

See 7.19 for the test method.

The requirements of Clause 4 shall also apply to sensor(s) when fitted with additional or alternative coverings, for example, protective sheets.

4.20 Failure due to blocking or wedging

See 7.20 for the test method.

There shall be no risk of failure due to solid objects or build-up of dirt or swarf under the sensor or combination of sensors or their associated connecting parts.

5 Marking

5.1 General

See 7.1.2 for the test method.

The pressure-sensitive mat or pressure-sensitive floor shall be marked in accordance with ISO 12100:2010, 6.4.4 and IEC 60204-1:2005, Clause 16.

All labels and markings shall be securely fixed and durable for the expected lifetime of the part of the pressure-sensitive mat or pressure-sensitive floor to which they are attached (see IEC 61310-2).

5.2 Marking of control unit

The control unit label(s) shall also contain the following information, or indicate where this information can be found:

— the PL and category according to ISO 13849-1 for the pressure-sensitive mat or pressure-sensitive floor;

— the response time for the pressure-sensitive mat or pressure-sensitive floor;

— with or without reset;

— means of identification, for example, serial number, type designation.

5.3 Marking of sensor

The sensor label shall also contain the following information or indicate where this information can be found:

— if suitable for detecting persons (e.g. children) weighing more than 20 kg;

— means of identification, for example, serial number, type designation.

5.4 Marking of other components

Components of the pressure-sensitive mat or pressure-sensitive floor that can be replaced in accordance with the information for use shall be identifiable.

6 Information for use

6.1 General

Information to be supplied to the user and the way it is presented shall comply with ISO 12100:2010, 6.4.

6.2 Instructions for use

6.2.1 General

See 7.1.2 for the test method.

The instructions for use (e.g. handbook) shall include all the information necessary for safe installation, use and maintenance of the device as listed in 6.2.2 to 6.2.6.

The information for use shall contain on the first page the means of identification required by 5.2 and 5.3. See also Annexes B and D.

6.2.2 Device features

a) Category or categories, PLs and average probability of a dangerous failure per hour in accordance with ISO 13849-1.

b) Limits of size and shape for individual sensors including effective sensing area.

c) Limits of combination of numbers and sizes of sensor(s) which can be used with one control unit.

d) Connections between components.

e) Limits of connection length between individual components of the pressure-sensitive mat or pressure-sensitive floor and types of connectors, e.g. Cable specification and plugs and sockets.

f) Fitting arrangements — how sensors can be combined.

g) Fixing arrangements of the sensor and control unit.

h) Mass of the sensor per square metre, and the mass of the control unit.

i) Sensor additional covering details (where applicable).

j) Response time.

k) Power supply requirements.

l) Control unit enclosure specifications in accordance with IEC 60529.

m) Switching capability of the output signal switching device(s).

n) Configuration(s) of the output signal switching device(s).

o) Suitability for detecting walking aids e.g. walking sticks and walking frames.

p) The formula for calculating the required effective sensing area in relation to the hazard location shall be provided. Typical examples of the application of the formula shall be given (see ISO 13855 and C.3.3).

q) Range of applications and conditions for which the device(s) is intended or approved, including the category and PL it complies with. Examples of unsuitable applications should also be given.

r) Schematic representation of the safety functions and examples of machine control interface circuit diagrams.

s) Rating, characteristics and location of all input/output terminals.

t) Guidance regarding chemical, physical and environmental resistance (e.g. resistance to solvents, allowable weight loading, operation temperature range, allowable power supply variation).

u) Guidance regarding suitability for wheeled vehicles which can be starting, braking or turning on the surface of the sensor.

v) Whether the device(s) is designed with or without reset in accordance with 4.7 and when the device is without a reset, the need for a reset to be provided by the machinery manufacturer or user (see ISO 13849-1:2006, 5.2).

6.2.3 Packaging, transportation, handling and storage

a) Description of packaging and methods of unpacking to prevent damage to the device(s).

b) Transportation and handling methods to prevent damage or personal injury.

c) Storage requirements (e.g. lay flat, temperature range).

6.2.4 Installation and commissioning

a) Instruction that the instruction handbook should be read in full before any installation work is attempted.

b) Requirements regarding the surface on which the sensor is to be mounted.

c) Installation method including tooling required (see Annex B for guidance).

d) Design features of the effective sensing area and the dead zones and how they should be optimised during installation (including drawing where appropriate).

e) Requirements regarding ramps in accordance with 4.17, if needed.

f) Details of any recess in the floor required to reduce the height of the sensor to prevent tripping.

g) Schedule of tests to enable commissioning to be carried out after installation to establish that the device(s) is functioning.

h) Warning that the overall safety of the machine and its safeguard(s) depends on the integrity of the interface between them.

i) Instruction to check the appropriateness of the category(ies) and PL(s) of the device according to ISO 13849-1.

j) Indication of fault exclusions (see ISO 13849-1:2006, Clause 11).

k) Explanation on how the PL was calculated with reference to the variable parameters mean operation time (in hours per day and days per year) and mean time between the beginning of two successive cycles of the component considered (cycle time).

l) Statement that the integrator shall determine the PL for his application.

6.2.5 Operating instructions

a) Purpose and method of operation of actuator(s) and indicators, e.g. starting and re-starting.

b) Information regarding use limits.

c) Instructions for fault identification.

6.2.6 Maintenance

a) Warning that the maintenance section of the handbook should be read in full before any maintenance is attempted.

b) Identification of tasks which require special technical knowledge or particular skills and hence should be carried out exclusively by suitably trained, skilled persons.

c) Specification of type and frequency of inspection and maintenance.

d) Instruction for cleaning.

e) Information, e.g. drawings and diagrams, enabling trained personnel to carry out fault-finding, servicing and repair.

f) Details of tests required after replacement of components to establish that the device(s) function(s) as designed.

g) Warning that all covers, clips, edging strips and fastenings removed during maintenance shall be refitted after maintenance and that if such parts are not correctly refitted the requirements for the device(s) can possibly not be met.

h) List of user-replaceable components specified in sufficient detail to maintain a system which complies with this part of ISO 13856.

i) Indication of those components which may be replaced by the user and a warning that only components approved by the manufacturer may be used.

j) Name and address of manufacturer and competent service organization.

6.2.7 Training requirements

The instructions for use shall give recommendations for the minimum training requirements of the user's personnel, including installers, operators and maintenance/inspection staff, to ensure that the device(s) are installed, used and maintained to comply with this part of ISO 13856.

6.2.8 Periodic tests

The instructions for use shall contain information on in-service inspections of the sensor. For this purpose, the following information is required:

a) a statement that the sensor has to be tested at periodic intervals with a static force of 300 N applied through an 80 mm diameter flat surface (corresponds to test piece 2) within the effective sensing area;

b) an indication that the test interval depends on the use of the pressure-sensitive mat or pressure-sensitive floor and that it has to be specified by the operator according to the national legislative requirements;

c) an indication of the maximum test interval, for example, a test at least every three months.

7 Testing

7.1 General

7.1.1 Type tests Nos. 1 to 17 given in 7.4 to 7.20, shall be carried out to determine whether a pressure-sensitive mat or pressure-sensitive floor meets the requirements of this part of ISO 13856. Unless otherwise specified, the type tests shall be carried out on a ready-to-use pressure-sensitive mat or pressure-sensitive floor at (23 ± 5) °C.

The following are some of the factors which can affect the performance of the pressure-sensitive mat or pressure-sensitive floor:

a) size of the sensor surface area;

b) top or additional covering material of the effective sensing area;

c) combination of sensors;

d) length of the interconnecting cables or tubes.

Consequently, each of the tests according to 7.4 to 7.20 shall be carried out with the least favourable combination of these factors.

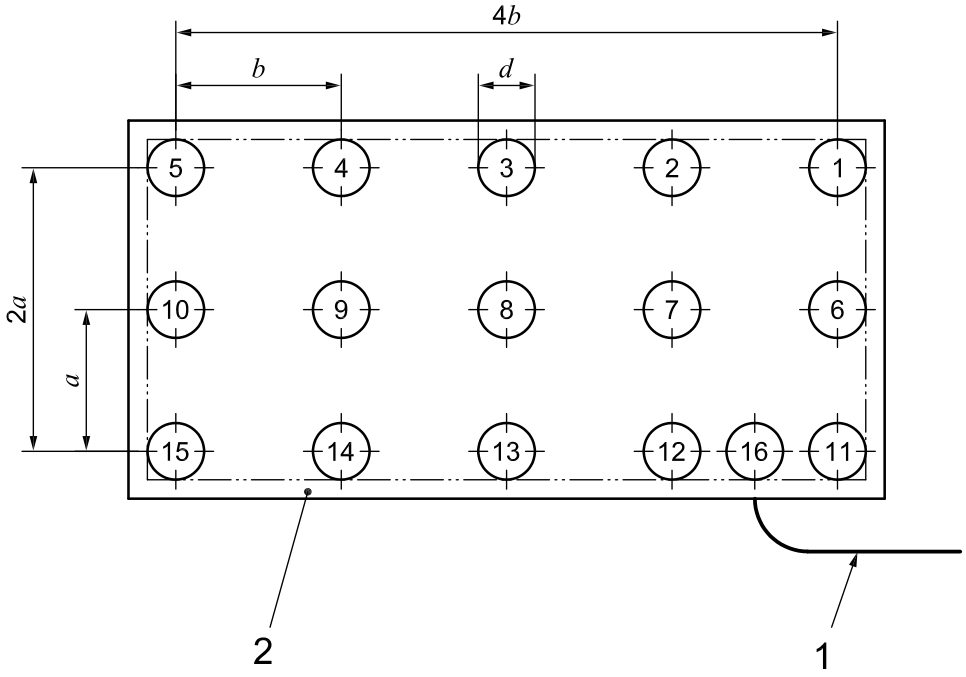
7.1.2 Where no special test methods are specified, verification shall be by means of inspection.

7.2 Sensor test sample

The test sample(s) shall have a sensor(s) with dimensions of at least 0,5 m × 1,0 m.

If the pressure-sensitive mat or pressure-sensitive floor has only one sensor, two sensors are required for the tests. One sensor shall be used to verify the requirements of 4.2, 4.3, 4.4 and 4.5.1.1 (100 000 operations at each of five locations giving 500 000 operations in total). The other sensor shall be used to verify the requirements of 4.5.1.2 (one million operations at one location) and 4.10.

If the pressure-sensitive mat or pressure-sensitive floor is designed with an effective sensing area built-up from a combination of sensors, then a number of sensors for connection with one control unit are required. The combination of sensors shall be used to verify the requirements of 4.2 and 4.3. The sensor selected for locations 1 to 16 according to Figure 3 shall be used to verify the requirement of 4.4. One of the remaining sensors shall be used to verify the requirements of 4.5.1.2 (one million operations at one location) and 4.10. After testing, the requirement of 4.5.2 shall be verified.



Key

1	connecting cable (example)
2	dead zone
a, b	distances between test locations
d	diameter of the respective test piece

Figure 3 — Test locations of effective sensing area of single sensor

7.3 Test pieces for load tests

These tests shall be carried out with the test pieces shown in Figure 2. The test pieces shall be manufactured from aluminium alloy, except where otherwise specified in Figure 2.

7.4 Test No. 1 — Actuating force

See 4.2 for the requirements.

7.4.1 Single sensor at ambient temperature

The test pieces and their corresponding actuating forces according to Table 1 shall be applied perpendicular to the effective sensing area in all locations shown in Figure 3 and at five locations considered to be critical for meeting the actuating force/response requirements of 4.2 (see Annex C). In Figures 3, 4 and 5, the diameters of the circles shown for the locations represent the diameter of the relevant test piece.

Test piece 4 shall only be applied if the pressure-sensitive mat or pressure-sensitive floor is designed to detect persons (e.g. children) weighing more than 20 kg. Additional tests shall be carried out at one random location with test piece 2 at the limits of the specified power supply variations.

7.4.2 Single sensor at designated operating temperature range

The test pieces and their corresponding actuating forces according to Table 1 shall be applied perpendicular to the effective sensing area at locations 1, 8 and 16 as shown in Figure 3, at the limits of the range and starting at the highest temperature. The sensor shall reach temperature equilibrium before being tested.

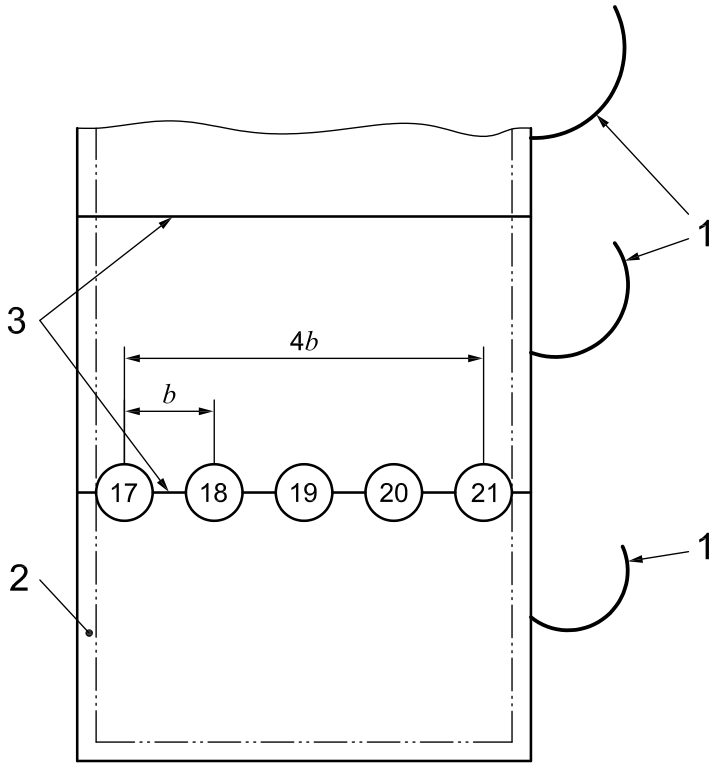
If the actuating force required to actuate the output signal switching device is in any case more than 10 % below the force specified in Table 1 for the corresponding test piece, the pressure-sensitive mat or pressure-sensitive floor shall be assumed to give similar results over its whole area. If the force is not within this limit, but is below the level given in Table 1, then the test shall be carried out at the limits of the temperature range at all the locations on the sensors shown in Figure 3, as well as on the critical points mentioned in 7.4.1.

7.4.3 Combination of sensors at ambient temperature

Where two or more sensors are combined to constitute one effective sensing area, the same tests as given in 7.4.1 shall be carried out on one sensor at the ambient temperature. In addition, the following test pieces shall be applied perpendicular to the effective sensing area at locations on joints according to Figure 4, or at locations on a joint and a junction according to Figure 5, as appropriate:

— for pressure-sensitive mats and pressure-sensor floors designed to detect persons weighing more than 35 kg: test piece 2 and its actuating force as given in Table 1;

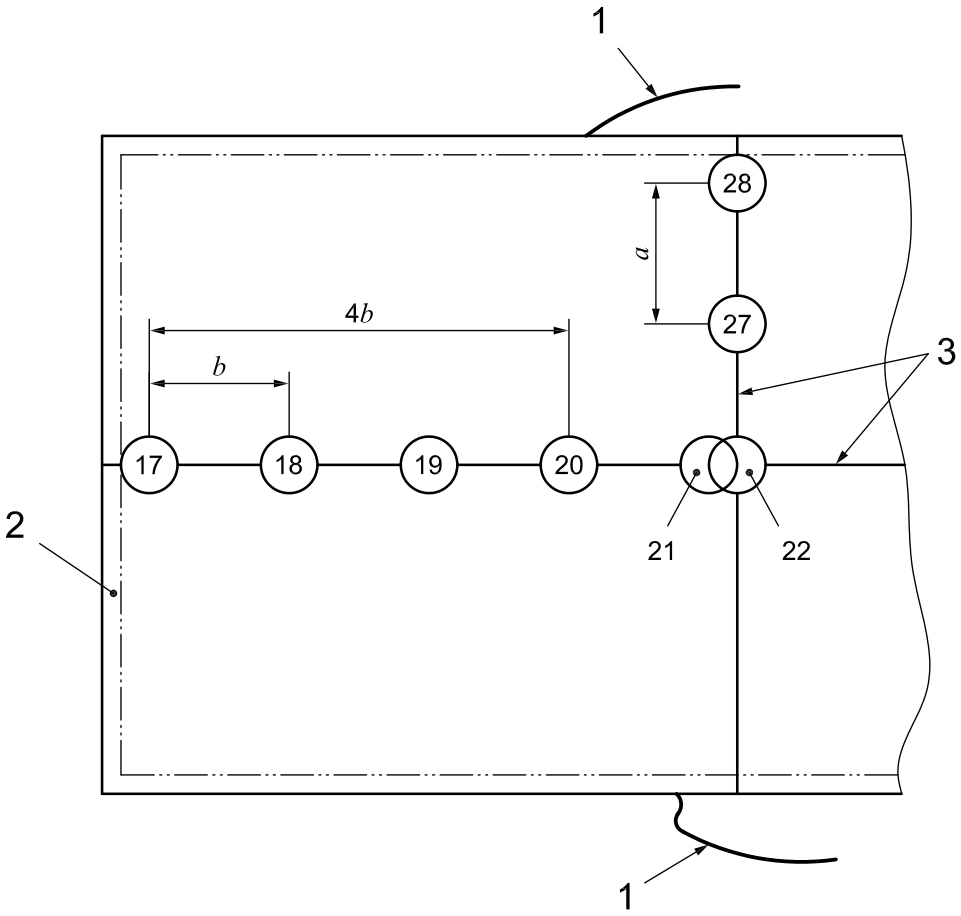
— for pressure-sensitive mats and pressure-sensitive floors designed to detect persons (e.g. children) weighing more than 20 kg: test pieces 2 and 4 and their actuating forces as given in Table 1.



Key

1 connecting cable (example)
2 dead zone
3 joint line
b distance between test locations

Figure 4 — Test locations on joints between sensors



Key

1 connecting cable (example)
2 dead zone
3 joint line
a, *b* distances between test locations

Figure 5 — Test locations on joints and on junction between sensors

7.4.4 Combinations of sensors at designated operating temperature range

Where two or more sensors are combined to constitute one effective sensing area, the same tests as given in 7.4.2 shall be carried out on one sensor at the limits of the temperature range. The sensors shall reach temperature equilibrium before being tested.

In addition, the following test pieces shall be applied perpendicular to the effective sensing area at locations 17, 19 and 21, in accordance with Figure 4, at the limits of temperature or locations 17, 19, 22, 27 and 28 only, in accordance with Figure 5, and at the temperature limits, as appropriate:

— for pressure-sensitive mats and pressure-sensor floors designed to detect persons weighing more than 35 kg: test piece 2 and its actuating force according to Table 1;

— for pressure-sensitive mats and pressure-sensitive floors designed to detect persons (e.g. children) weighing more than 20 kg: test pieces 2 and 4 and their actuating forces according to Table 1.

7.5 Test No. 2 — Response time

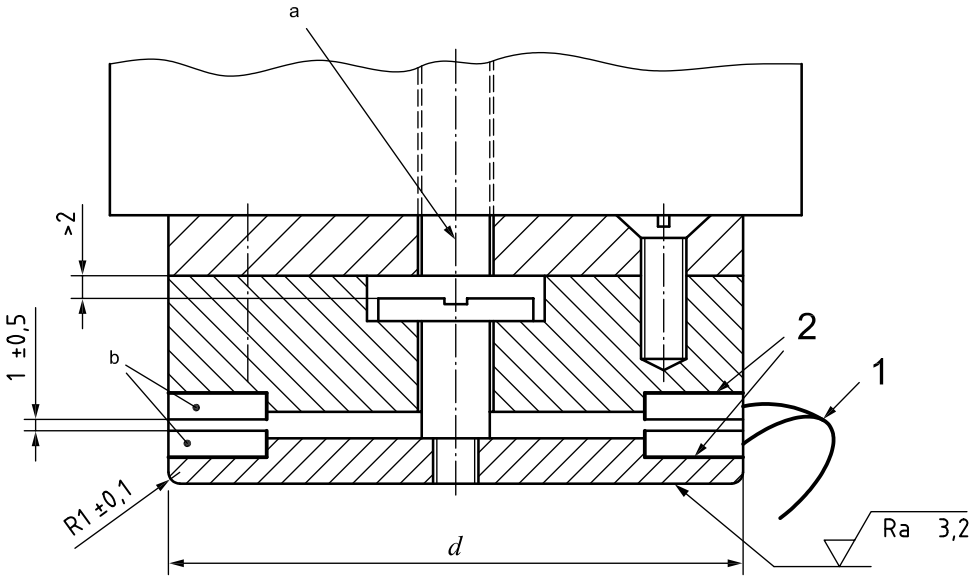
See 4.3 for the requirements.

For this test, the sensor configuration which is expected to give the longest response time shall be used.

The response time is measured using test piece 7 (see Figure 6), of $30^{+0,5}_{0}$ kg mass and diameter, *d*, of test piece 2 according to Table 1. If the pressure-sensitive mat or pressure-sensitive floor is designed to detect persons (e.g. children) weighing more than 20 kg, the test is carried out using test piece 8 (see Figure 6), of $15^{+0,5}_{0}$ kg mass and diameter, *d*, of test piece 4 according to Table 1.

The test pieces (see Figure 6) are constructed so that when the lower part of a test piece touches the effective sensing area with a force less than 10 N, an electrical signal is produced. The test pieces shall be applied perpendicularly at a speed of $0,25^{0}_{-0,03}$ $m \cdot s^{-1}$ to the effective sensing area. The time between the initiation of the electrical signal from the test piece and the start of the OFF state of the output signal switching device shall be measured. The tests shall be carried out at locations 1, 4, 8 and 16, as shown in Figure 3, and at a random location which is expected to give the longest response time.

Dimensions in millimetres



Key

1 connecting cable
2 insulation
d diameter
a Mounting proposal only.
b Conducting.

Figure 6 — Test pieces 7 and 8 — Used to measure response time

When the combination of sensors is arranged according to Figure 4, the tests shall be carried out at locations 1, 4, 8 and 16, shown in Figure 3, at the random location on the sensor expected to give the longest response time because of its location within the combination, and at locations 17 and 19, shown in Figure 4.

When the combination of sensors is arranged in accordance with Figure 5, the tests shall be carried out at locations 1, 4, 8 and 16, shown in Figure 3, at the random location on the sensor expected to give the longest response time because of its location within the combination, and at locations 17, 19, 22, 27 and 28, shown in Figure 5.

The tests shall be carried out at all the above indicated locations at (23 ± 5) °C.

At the limits of the specified temperature range, the tests shall be carried out only at locations 1 and 16, shown in Figure 3, and at location 17, shown in Figure 4, or at locations 17, 22 and 27, shown in Figure 5.

Additional tests shall be carried out at one random location on a single sensor at (23 ± 5) °C at the limits of the specified range of power supply variations. The longest measured time shall be less than or equal to the stated response time.

7.6 Test No. 3 — Static loading

See 4.4 for the requirements.

7.6.1 A static force of (2 000 ± 50) N shall be applied perpendicular to the effective sensing area through test piece 2 (see Figure 2) for 8 h on a sensor at a random location within 120 mm from the edges of the effective sensing area.

The output signal switching device shall change to an ON state within 2 min after the force has been removed; if the system has a reset, it shall be actuated. The deformation of the effective sensing area surface caused by the test piece shall be measured 1 h after removing the force. The depth of the deformation shall not exceed 2 mm, measured from the lowest part of the top surface.

7.6.2 A static force of (750 ± 20) N shall be applied perpendicular to the effective sensing area through test piece 1 (see Figure 2) for 8 h at another location within 120 mm from the edges of the effective sensing area.

The output signal switching device shall change to an ON state within 2 min after the force has been removed; if the system has a reset, it shall be actuated. The deformation of the effective sensing area surface caused by the test piece shall be measured 1 h after removing the force. The depth of the deformation shall not exceed 2 mm, measured from the lowest part of the top surface.

7.6.3 Within 30 min after measuring the deformation in 7.6.1 and 7.6.2, the actuating force and response time shall be checked at the location at which the test has been performed. For testing the actuating force and the response time, test piece 2 (see Table 1) shall be applied. Test piece 4 shall also be applied when the pressure-sensitive mats and pressure-sensitive floors are designed to detect persons (e.g. children) weighing more than 20 kg.

7.6.4 For pressure-sensitive floors which are integrated within a machine the tests given in 7.6.1 to 7.6.3 shall be performed after the floor has been installed in the machine or with conditions simulating the intended installation.

The location used for the application of the force shall be selected so that the largest foreseeable deformation is achieved (e.g. farthest from the supporting points or supporting surfaces of the sensor plate).

7.7 Test No. 4 — Number of operations

See 4.5 and 4.15.4 for the requirements. See also C.3.3.

7.7.1 Testing to requirement 4.5.1.1 (100 000 operations at each of five locations) shall be carried out as shown in Figures 7 and 8 using test piece 6 (see Figure 2). The actuation shall be achieved by supplying a working pressure of (3,8 ± 0,2) bar to the pneumatic cylinder according to ISO 15552 with 50 mm diameter and 125 mm stroke. This working pressure shall also exist at the valve intake (cylinder control) at the moment when the test piece impacts the effective sensing area. This can be achieved by a valve with 6 mm nominal diameter which is directly connected to the pneumatic cylinder or through a short air line. This line shall have a nominal diameter of at least 10 mm and a length less than 200 mm. A flow control valve shall be installed in the downstream side to achieve an impact velocity of $0{,}55^{+0{,}05}_{0}$ $m \cdot s^{-1}$ of the test piece.

Where the effective sensing area consists of a combination of sensors, test piece 6 shall be applied at locations 8, 16, 23, 24, and 26 as shown in Figures 9 and 10. One of these locations has to coincide with

the location where the test 7.6.1 has been performed. For this test, the operations through test piece 6 (see Figure 2) at the effective sensing area shall be in the two directions shown in Figures 7 to 10. In each direction 50 000 operations shall be performed at each location (giving 100 000 operations in total). During this test, the test piece 6 shall be applied 20 times to each location consecutively until a total of 50 000 operations has been completed at each location and in each direction.

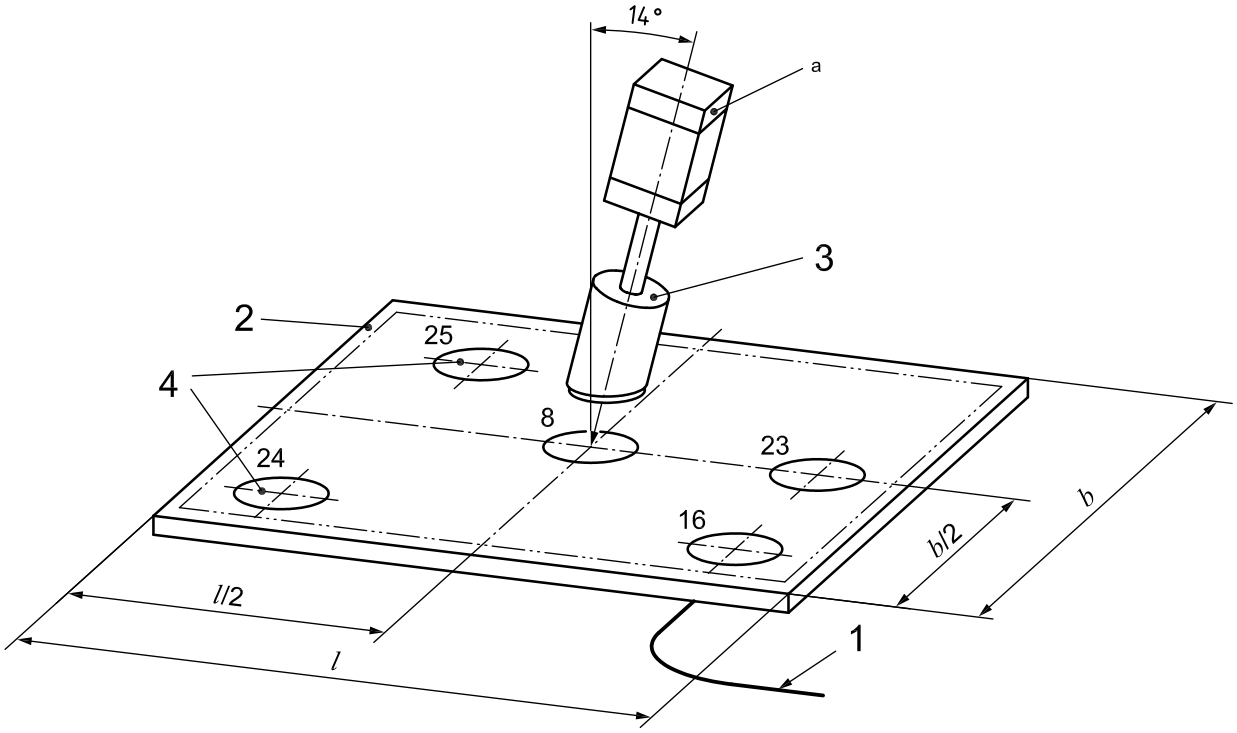
During this test the output signal switching device is connected to the sensor(s) and the pressure-sensitive mat or pressure-sensitive floor shall be operating. The sensor(s) shall be fixed with fastening elements specified by the manufacturer in the manual.

7.7.2 The test of requirement 4.5.1.2 (one million operations in one location) shall be carried out on a single sensor with the output signal switching device disconnected, by applying test piece 5 (see Figure 2) having a mass of (75 ± 1) kg and a vertical impact speed of $0{,}55^{+0{,}05}_{0}$ m·s^{-1}. The test piece shall be applied one million times at a random location on a line 120 mm inside the edges of the effective sensing area.

The test equipment surface which supports the sensor shall not move more than 1,0 mm in a vertical direction while the test is in progress.

For this test, the time of one interval of an actuation shall be $4{,}0^{+1{,}0}_{0}$ s. During each interval, test piece 5 shall touch the effective sensing area for (0,8 ± 0,2) s.

Dimensions in millimetres

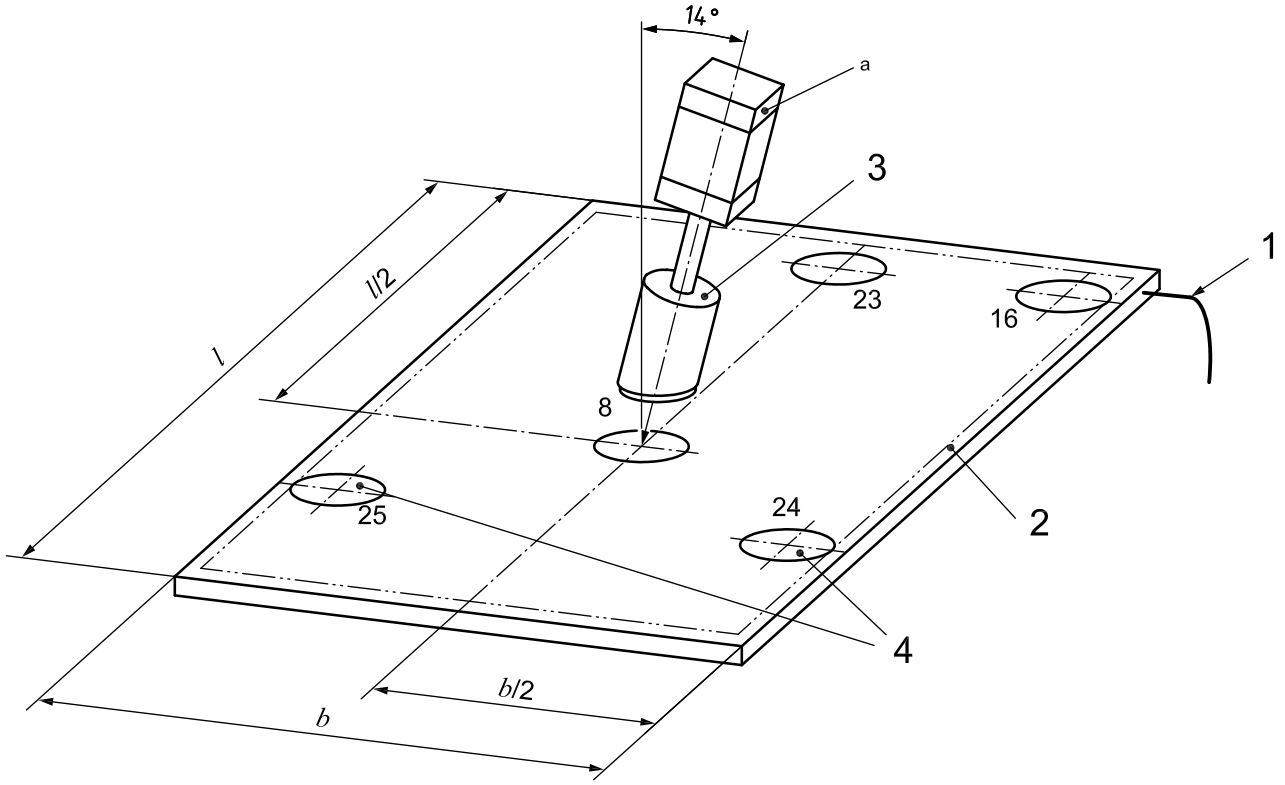


Key

1 connecting cable (example)
2 dead zone
3 test piece 6 (see Figure 2)
4 random location
l length of sensor
b width of sensor
a Inside diameter of the pneumatic cylinder, 50 mm, stroke 125 mm, according to ISO 15552.

Figure 7 — Arrangement of pneumatic cylinder and locations for "Number of operations" test, applied to single sensor (horizontal component of force acting parallel to *longest* edge of sensor)

Dimensions in millimetres

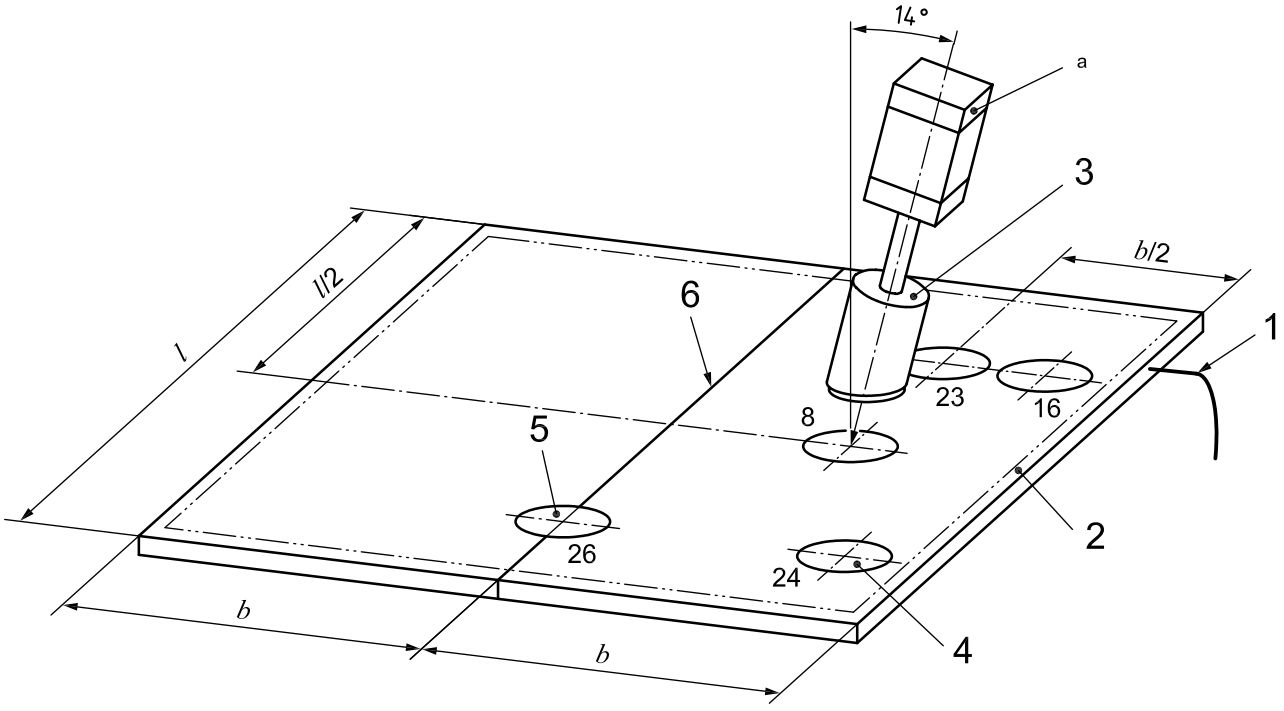


Key

1 connecting cable (example)
2 dead zone
3 test piece 6 (see Figure 2)
4 random location
l length of sensor
b width of sensor
a Inside diameter of the pneumatic cylinder, 50 mm, stroke 125 mm, according to ISO 15552.

Figure 8 — Arrangement of pneumatic cylinder and locations for "Number of operations" test, applied to single sensor (horizontal component of force acting parallel to *shortest* edge of sensor)

Dimensions in millimetres

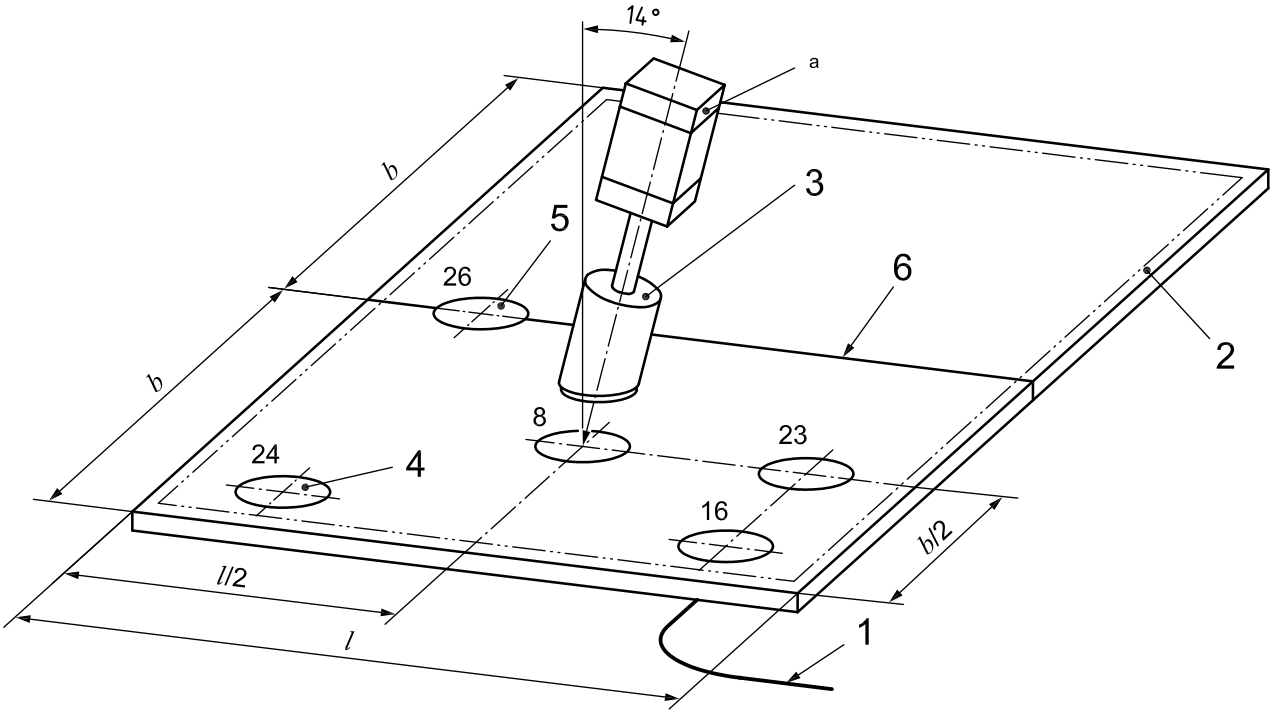


Key

1 connecting cable (example)
2 dead zone
3 test piece 6 (see Figure 2)
4 random location
5 random location on joint line
6 joint line
l length of sensor
b width of sensor
a Inside diameter of the pneumatic cylinder, 50 mm, stroke 125 mm, according to ISO 15552.

Figure 9 — Arrangement of the pneumatic for test "Number of operations", applied to combination of sensors (horizontal component of force acting parallel to *longest* edge of sensor)

Dimensions in millimetres



Key

1 connecting cable (example)
2 dead zone
3 test piece 6 according to Figure 2
4 random location
5 random location on joint line
6 joint line
l length of sensor
b width of sensor
a Inside diameter of the pneumatic cylinder, 50 mm, stroke 125 mm, according to ISO 15552.

Figure 10 — Arrangement of pneumatic cylinder and locations for "Number of operations" test, applied to combination of sensors (horizontal component of force acting parallel to *shortest* edge of sensor)

7.7.3 The functioning of the pressure-sensitive mat or pressure-sensitive floor shall be checked immediately after completion of the tests required by 7.7.1 and 7.7.2. The actuating force/response test of 7.4 shall be made using test piece 2 (see Figure 2) and the response time test specified in 7.5 shall be made using test piece 7 (see Figure 6) at the locations at which the tests of 7.7.1 and 7.7.2 have been performed. When the tests of 7.7.1 and 7.7.2 have been completed, the pressure-sensitive mat or pressure-sensitive floor shall comply with the requirements of 4.2 and 4.3.

If the pressure-sensitive mat or pressure-sensitive floor is designed to detect persons (e.g. children) weighing more than 20 kg, additional tests for the actuating force using test piece 4 (see Figure 2 and Table 1), and for the response time using test piece 8 (see Figure 6), shall be applied to the same locations as the previous tests.

7.8 Test No. 5 — Output state of sensor

See 4.6 for the requirements.

Test piece 2 (see Figure 2) with its corresponding actuating force according to Table 1 shall be applied perpendicularly to the effective sensing area, in one random location for a minimum time of 8 h, of a sensor with power ON as well as a sensor in the OFF state with power put ON after application of the force.

Where reset is provided, it shall be actuated.

The output state of the sensor shall change its state when this actuating force is applied and when power is put ON with the actuating force present.

The output state of the sensor shall remain in that state until the actuating force is removed, in accordance with Figures A.1, A.2 and A.3.

During this test, the output level of the sensor shall not change to a level which allows the output signal switching device to revert to an ON state.

7.9 Test No. 6 — Response of output signal switching device to actuating force

See 4.7 for the requirements.

The interaction of separate functions as shown in Figures A.1, A.2 and A.3 shall be tested using test piece 2 (see Figure 2) with its corresponding actuating force according to Table 1 applied perpendicularly to the effective sensing area in one random location at room temperature.

7.10 Test No. 7 — Access for maintenance

See 4.8 for the requirements.

Verification shall be by inspection.

7.11 Test No. 8 — Adjustments

See 4.9 for the requirements.

Verification shall be by inspection and by replacing the sub-assemblies authorized by the manufacturer.

7.12 Test No. 9 — Connections

See 4.10 for the requirements.

All dissimilar plug-in components that are interchangeable within the pressure-sensitive mat or pressure-sensitive floor shall be interchanged one at a time and each plug-in component shall be disconnected with power ON.

7.13 Test No. 10 — Environmental conditions

See 4.11 for the requirements.

7.13.1 Functional test

At the beginning and at the end of the tests according to 7.13.2 to 7.13.5, the function of the pressure-sensitive mat and pressure-sensitive floor shall be verified using test piece 2 (see Figure 2) with its corresponding actuating force according to Table 1, applied perpendicularly at a speed of (100 ± 5) $mm \cdot s^{-1}$ to the effective sensing area in one random location at room temperature. During this procedure, the output signal switching device shall change from an ON state to an OFF state.

7.13.2 Test No. 10.1 — Temperature

See 4.11.2 for the requirements.

The test shall be carried out according to Table 2 over the temperature range stated by the manufacturer.

Table 2 — Change of temperature

Test procedure	Remarks
IEC 60068-2-14, Test Nb	Pressure-sensitive mat or pressure-sensitive floor is connected to the power supply.

For heating and cooling, the rate of change of temperature shall be (0,8 ± 0,3) °C/min over the whole temperature range. During the test, which shall be in accordance with IEC 60068-2-14, the functional test according to 7.13.1 shall be carried out at 1 min intervals. This test may be performed using a sensor with a effective sensing area smaller than the one indicated in 7.2. The dimensions of the effective sensing area shall, however, not be less than 400 mm × 200 mm.

7.13.3 Test No. 10.2 — Humidity

See 4.11.3 for the requirements.

The requirements concerning the resistance to humidity shall be verified according to Table 3 for a period of four days.

Table 3 — Humidity

Test procedure	Remarks
IEC 60068-2-78, test Cab temperature: (40 ± 2) °C relative humidity: (93 ± 3) %	Pressure-sensitive mat or pressure-sensitive floor is not connected to the power supply.

Immediately after the test of the resistance to humidity, the insulation resistance shall be in accordance with IEC 61439-1:2011, 11.9.

7.13.4 Test No. 10.3 — Electromagnetic compatibility (immunity)

See 4.11.4 for the requirements.

Safety-related requirements shall be verified in accordance with IEC 61000-6-2.

Immunity shall be verified for the following states according to the test procedures, with the indicated characteristic values given in Table 4 and with the stated conditions given in 7.13.1:

— pressure-sensitive mat or pressure-sensitive floor with supply energy;

— pressure-sensitive mat or pressure-sensitive floor with supply energy with applied actuating force;

— pressure-sensitive mat or pressure-sensitive floor with energy supply, after removal of the actuating force and prior to the execution of the reset.

Table 4 — Electromagnetic compatibility (immunity)

Tests and characteristic values	Test procedures
Surge installation class 3	IEC 61000-4-5 power, earth and input/output lines
Electrical fast transients (burst), level 3	IEC 61000-4-4 duration of test: 2 min power, earth, and input/output lines
Electrostatic discharge, level 3	IEC 61000-4-2
Radiated, radio-frequency electro-magnetic field, level 3	IEC 61000-4-3

7.13.5 Test No. 10.4 — Vibration

See 4.11.5 for the requirements.

The requirements concerning vibration at the control unit and the output signal switching device(s) shall be verified in accordance with Table 5. A function test in accordance with 7.13.1 shall be carried out at the beginning and end of the test and at 10 s intervals during this test.

Table 5 — Vibration

Test procedure	Remarks
IEC 60068-2-6, test Fc	Pressure-sensitive mat or pressure-sensitive floor is connected to the power supply.

7.14 Test No. 11 — Electrical power supply

The requirements of 4.12.1 shall be verified in accordance with IEC 60204-1:2005, Clause 4.

7.15 Test No. 12 — Electrical equipment

It shall be verified that the electrical equipment meets the requirements of 4.13.

7.16 Test No. 13 — Enclosure

See 4.14 for the requirements.

All enclosures shall be tested in accordance with IEC 60529.

7.17 Test No. 14 — PL according to ISO 13849-1

See 4.15 for the requirements.

Safety functions and categories shall be validated according to ISO 13849-2. The PL achieved shall be compared with the PL required.

7.18 Test No. 15 — Slip-resistance

NOTE At the time of publication of this part of ISO 13856 no International Standard existed which addressed the testing of slip-resistance. General guidance is given in ISO 14122-2.

7.19 Test No. 16 — Additional coverings of top surfaces of sensor(s)

See 4.19 for the requirements.

This test shall be carried out by selecting the least favourable combination of factors for each test according to 7.1 to 7.18.

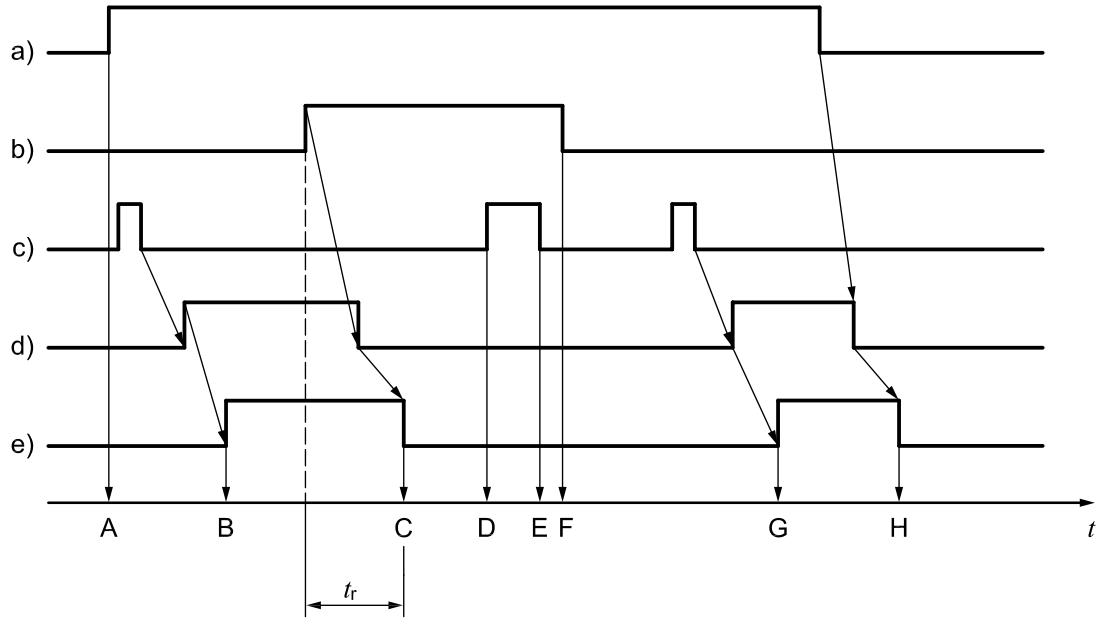
7.20 Test No. 17 — Failure due to blocking or wedging

The requirement of 4.20 shall be verified by inspection and, if any doubt remains, by a specific test.

Annex A
(normative)

Timing diagrams for pressure-sensitive mats/floors with/ without reset

Figures A.1 to A.3 show the response of output signal switching device(s) to actuating force (see 4.7).



Key

a) power to pressure-sensitive mat/pressure-sensitive floor
b) actuating force
c) reset signal
d) sensor output
e) output of output signal switching device(s)
t time
t_r response time

A power to pressure-sensitive mat or pressure-sensitive floor ON: output of the output signal switching device remains in OFF state because the pressure-sensitive mat or floor not reset

B reset achieved: output of output signal switching device turns to ON state because sensor output turned ON due to operation of reset button without actuating force on sensor

C output of output signal switching device turns to OFF state because sensor output turned OFF due to actuating force on sensor

D starting point of reset signal: operation of reset button has no effect on output of output signal switching device because signal not yet terminated and actuating force still present

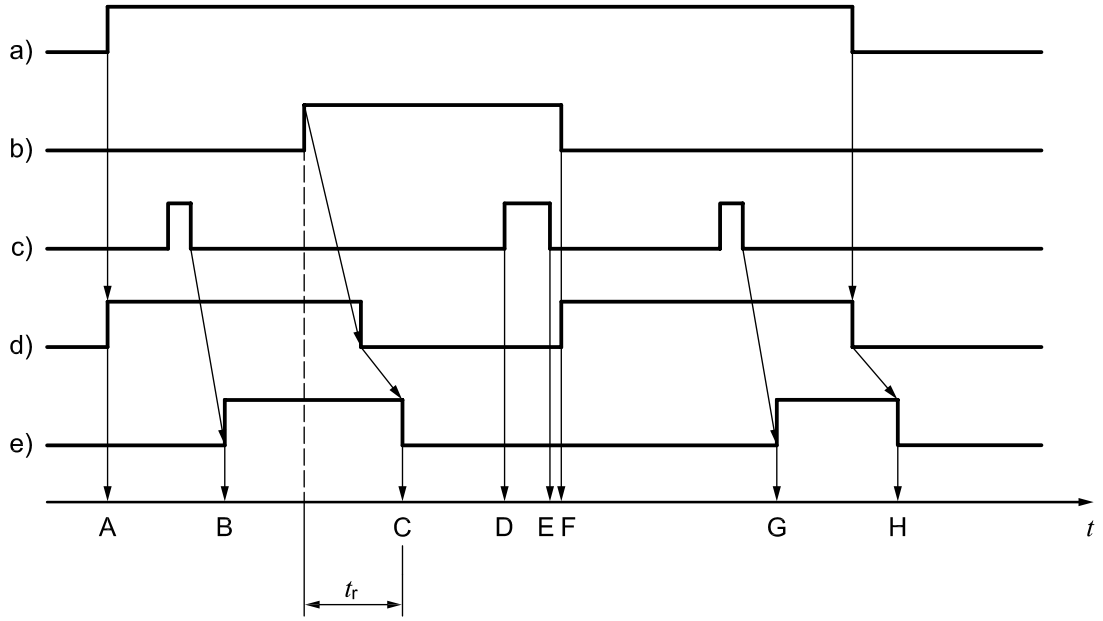
E reset signal has been present: cessation of reset signal has no effect on output of output signal switching device as long as force present on sensor; output of output signal switching device remains in OFF state

F actuating force removed from sensor: output of output signal switching device remains in OFF state because reset not applied

G reset achieved: output of output signal switching device turns to ON state because sensor output turned ON due to operation of reset button without actuating force on sensor

H power to pressure-sensitive mat or pressure-sensitive floor OFF: output of output signal switching device turns to OFF state because sensor output turned OFF

Figure A.1 — Relationship between actuating force, reset signal, sensor output and output of output signal switching device(s) (sensor output initiated by reset)



Key

a) power to pressure-sensitive mat/pressure-sensitive floor

b) actuating force

c) reset signal

d) sensor output

e) output of the output signal switching device(s)

t time

t_r response time

A power to pressure-sensitive mat or pressure-sensitive floor ON: output of output signal switching device remains in OFF state because pressure-sensitive mat or floor not reset; sensor output turned ON when power turned ON.

B reset achieved without actuating force on sensor: output of output signal switching device turns to ON state due to operation of reset button while sensor output turned ON

C actuating force on sensor: sensor output turned OFF, turning output of output signal switching device to OFF state

D starting point of reset signal: operation of reset button has no effect on output of output signal switching device because signal not yet terminated and actuating force still present

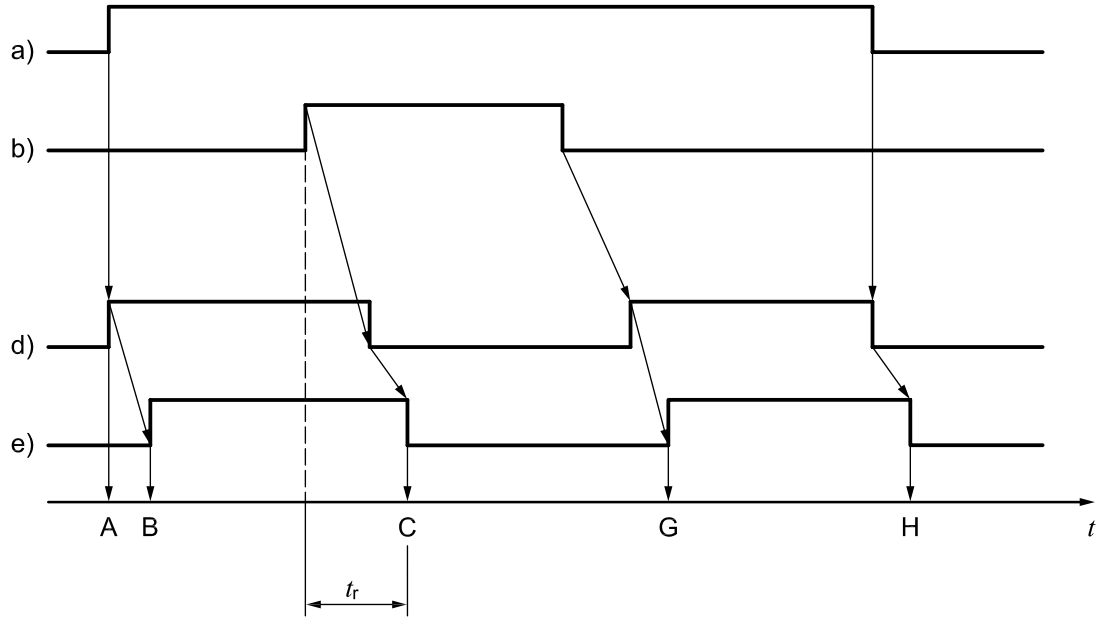
E reset signal has been present: cessation of reset signal has no effect on output of output signal switching device as long as force present on sensor; output of output signal switching device remains in OFF state

F actuating force removed from sensor: sensor output turns ON but output of output signal switching device remains in OFF state because reset not applied after removal of force

G reset achieved without actuating force on sensor: output of output signal switching device turns to ON state due to operation of reset button while sensor output turned ON.

H power to pressure-sensitive mat or pressure-sensitive floor OFF: output of output signal switching device turns to OFF state because sensor output turned OFF

Figure A.2 — Relationship between actuating force, reset signal, sensor output and output of output signal switching device(s) (sensor output independent of reset)



Key

a) power to pressure-sensitive mat/pressure-sensitive floor

b) actuating force

d) sensor output

e) output of the output signal switching device(s)

t time

t_r response time

A power to pressure-sensitive mat or pressure-sensitive floor ON: sensor output turned ON when power turned ON

B output of output signal switching device turns to ON state because no actuating force on sensor

C actuating force on sensor: sensor output is turned OFF, turning output of output signal switching device to OFF state

G output of output signal switching device turns to ON state because sensor output turned ON due to actuating force being removed from sensor

H power to pressure-sensitive mat or pressure-sensitive floor OFF: output of output signal switching device turns to OFF state because sensor output turned OFF

NOTE Reset is provided by the control system of the machine, see Figure 1 and 4.7.2.

Figure A.3 — Relationship between actuating force, sensor output and output of output signal switching device(s) (without reset)

Annex B
(informative)

Application notes

B.1 General

These application notes are presented as recommendations to manufacturers for inclusion in the instruction handbook. When selecting pressure-sensitive mats or pressure-sensitive floors, a plan should be prepared which contains, amongst other information, the recommendations given in B.2 to B.5.

B.2 Mounting surface (location)

The surface quality should meet the requirements stated by the manufacturer.

EXAMPLE 1 Irregularities can impair the function of the sensor of pressure-sensitive mat or pressure-sensitive floor and should therefore be reduced to an acceptable minimum.

Cable entry points to sensors should be considered, in order to ensure

— controls are situated in appropriate positions,

— no tripping hazards are created due to connecting cables, and

— no dead zones are created in areas to be protected.

EXAMPLE 2 Sensors can have a dead zone adjacent to the entry point of connecting cables.

B.3 Size of the sensor

When considering the sensor dimensions, the minimum distance to the hazard zone according to ISO 13855 should be taken into account.

B.4 Selection criteria

The following are some features which should be considered when selecting the system:

a) whether the pressure-sensitive mat or pressure-sensitive floor is suitable or whether additional measures (e.g. guards) are required;

b) determination of the required category and PL for the safety related parts of the control system of the pressure-sensitive mat or pressure-sensitive floor in accordance with ISO 13849-1 and/or a relevant type C standard;

c) use as a single device, or in combination with other devices;

d) ability to combine sensors;

e) avoidance of dead zones;

f) frequency of operating cycles and lifetime of the system;

g) output signal switching device switching capacity;

h) static loading, such as parts of machinery resting on the surface;

i) loading by wheeled traffic, e.g. driving, braking and turning;

j) temperature and humidity;

k) rapid variations in temperature and humidity;

l) effects of chemicals, such as oils, solvents, cutting fluids and combinations of these fluids;

m) effects of flooding, e.g. when cleaning and in case of leakages;

n) effect of foreign bodies such as swarf, dust and sand;

o) additional covering for the sensor;

p) stress due to vibration, shocks, etc.;

q) high electro-magnetic interference, such as can be found on certain types of welding equipment and radio transceivers;

r) supply voltage fluctuations outside the specification given in IEC 60204-1, which may be caused by the switching of large loads;

s) sensitivity levels which can differ from the requirements of this part of ISO 13856;

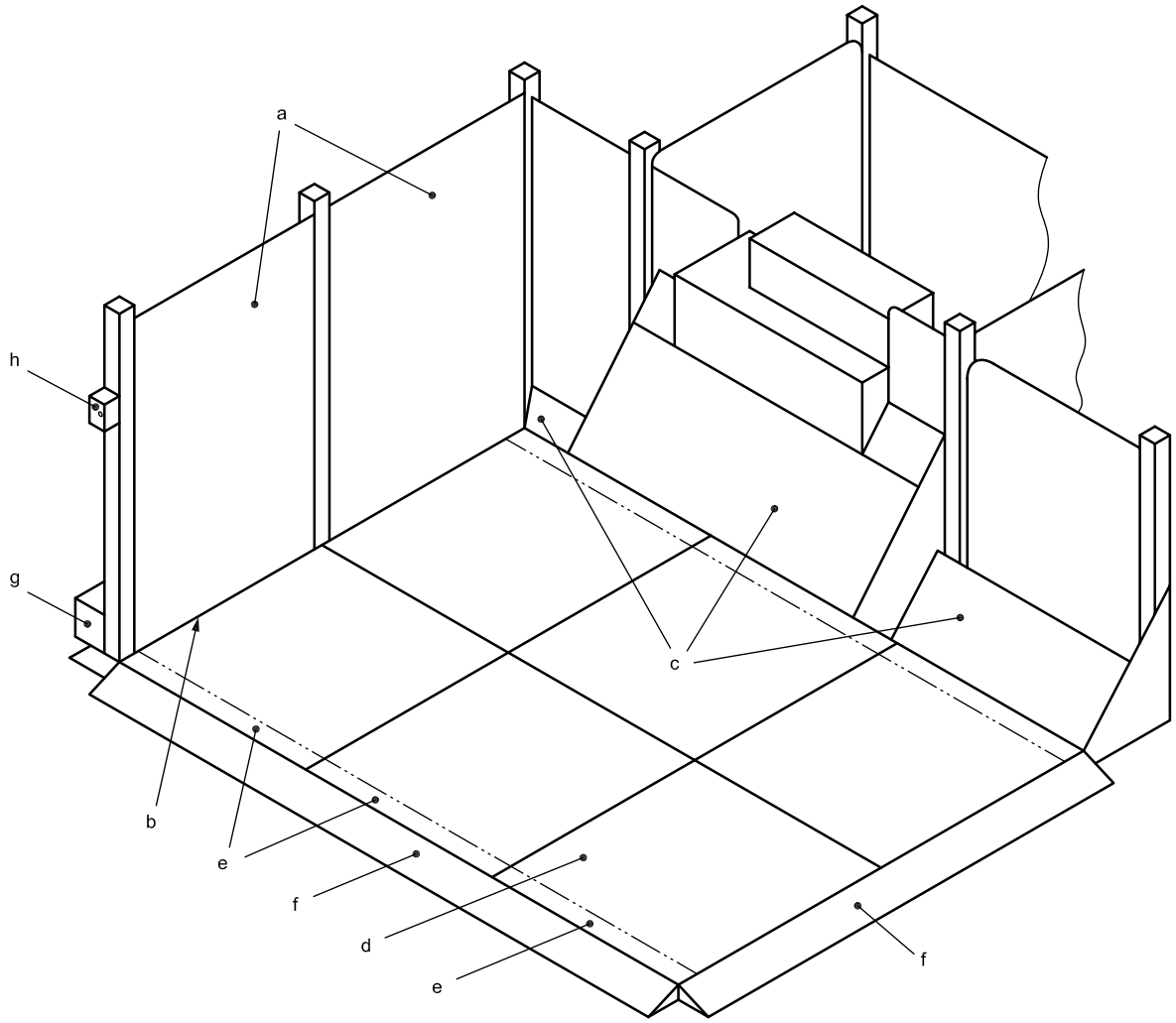
t) need for reset and the location of the reset button;

u) need for special wording, signs and marking;

v) sensor fixing.

B.5 Comparison between well-designed and poorly-designed installation

See Figures B.1 and B.2.



a Additional fixed guards are fitted which prevent access to the hazard zone of the machinery.

b The fixed guard is arranged and designed so that there is no access to the hazard zone between the fixed guard and the sensors. The fixed guard permits access to the hazard zone through the sensors only.

c A sloping cover plate prevents the operator standing at the side of the effective sensing field and in the hazard zone.

d Sensors are properly installed.

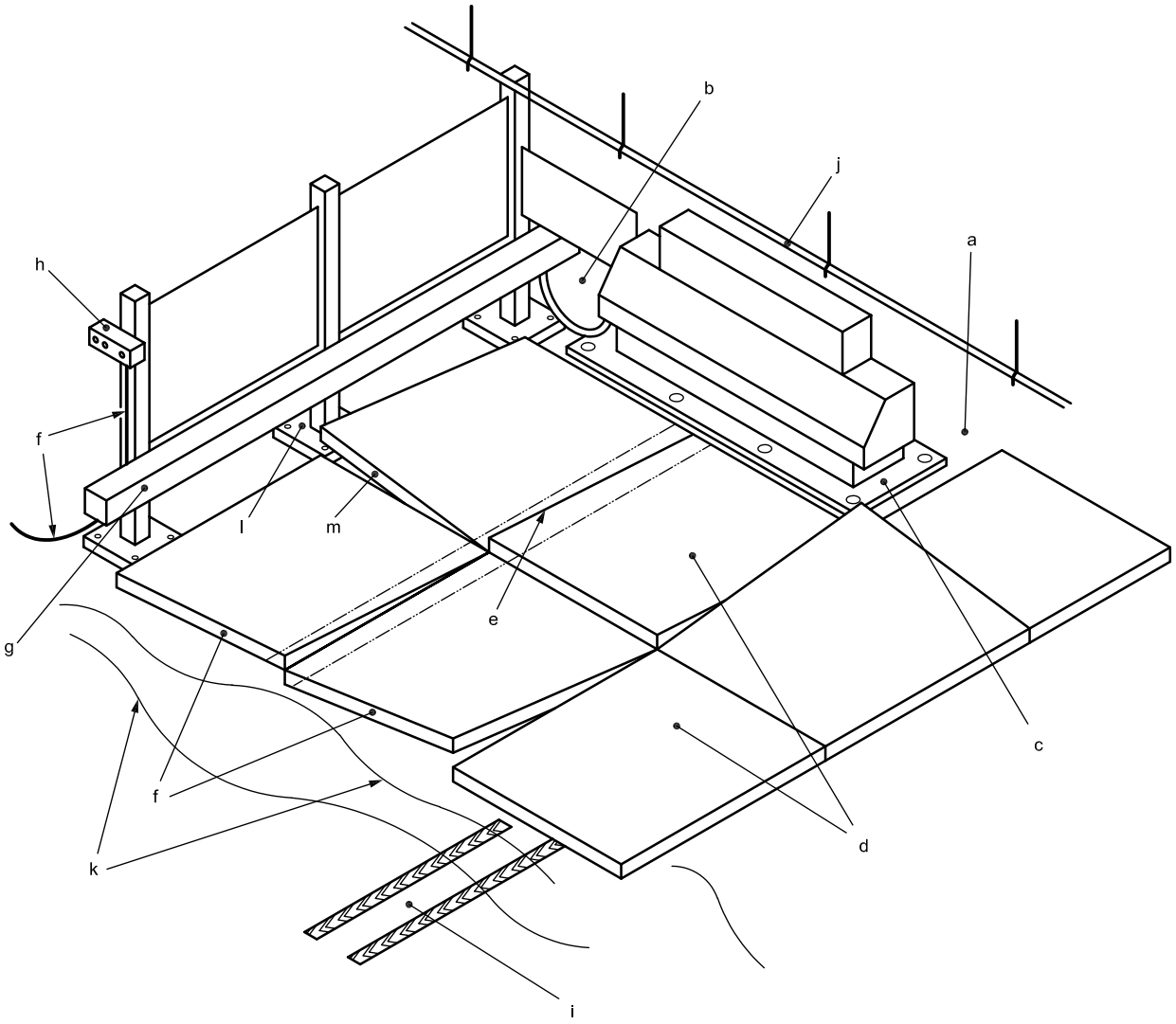
e The dead zones of the sensors are located such that the protective function will not be impaired.

f The tripping hazard at the sensor edge is reduced by a ramp at the point of access. The ramp can also protect connecting cables.

g The cable trunking is installed at the outside of the fixed guard.

h Reset button is located in a well protected location from where the hazard zone is fully visible.

Figure B.1 — Well-designed installation



a Fixed guards for the hazard zone are not sufficient.

b Hazard zone not protected from rear and accessible by reaching over and under fixed guard, which is too small.

c The operator can stand on the machinery baseplate in the hazard zone.

d The sensors are not properly fixed.

e The dead zones of the sensors are so located that the operator is able to reach the hazard zone.

f Tripping hazards from exposed edges of sensors and trailing cables not protected against mechanical damage.

g Cable trunking installed on inside of fixed guard and can be misused to provide access to hazard zone.

h Control unit installed in vulnerable position and can be subject to mechanical damage from passing traffic.

i Sensors should not be installed on traffic routes.

j Service pipe installed above sensors can be misused to swing over sensors into hazard zone.

k Function and expected service life of the sensors will be reduced due to ground irregularities.

l Access to the hazard zone is provided by the baseplates of the fixed guard.

m Sensor not fastened down and presenting a tripping hazard.

Figure B.2 — Poorly-designed installation

Annex C
(informative)

Design notes

C.1 General

These design notes are presented as a guide to manufacturers, users and testing authorities. Failure to meet these recommendations does not necessarily mean that a product is unsafe. It is possible, for example, that a particular design problem has been overcome in an alternative way.

C.2 Conditions

C.2.1 Frequent actuation

When designing pressure-sensitive mats and pressure-sensitive floors, consideration should be given to the fact that they are also used in applications where they are frequently actuated. In the case of use on production machinery, e.g. when loading a device, more than three million operations in the same place can be expected in one year. In the case of pressure-sensitive mats, this can result in a change in sensitivity at the point where the foot is applied.

C.2.2 Infrequent actuation

When designing pressure-sensitive mats and pressure-sensitive floors, consideration should be given to the fact that they are also used in applications where they are only actuated occasionally, at which time they should give reliable operation.

C.2.3 Sensor cables

Where two wires in and two wires out are used to detect cable damage, the wires should be connected at opposite ends of the contact element to ensure integrity through the contact element. If wires are connected close together and there is an open circuit joint onto the contact element, an unsafe situation can arise.

C.2.4 Exceptionally heavy loads

In some situations, heavy loads, such as fork lift trucks, can be applied to the sensor during servicing or tool changing. If this is required, the user should clearly identify the need to the manufacturer/supplier.

C.3 Pressure-sensitive mats

C.3.1 General

The sensor of a pressure-sensitive mat is normally in the form of a sandwich consisting of a top surface, a sensing element and a base.

C.3.2 Sensor surface

The sensor top surface should be of a material which will withstand the operating duty to be expected. In addition, applied forces should not lead to permanent deformation that can form “bridges” over part of the effective sensing field.

The sensor top surface should be of a non-slip design for its lifetime.

Consideration should be given to the effects of liquids which the sensor top surface can be expected to encounter in the application. For example, some liquids can cause long-term degradation or swelling which will cause an unsafe condition.

C.3.3 Sensor performance

Sensors can have certain areas which are less sensitive than others and also areas which are more prone to damage than others. Sensitivity is often reduced around the edges of a sensor, near the connection point with incoming cables, tubes, fibres or leads and at points where sensing plates are held apart. The specified actuating forces should be taken into account.

Life tests should be carried out in areas which are more susceptible to damage and early failure. These include cable entries, joints between the incoming cable and the sensor and soldered or other connections within the sensor.

C.3.4 Internal air gap

Any gap within the sensor of the pressure-sensitive mat should be kept to a minimum. Ingress of material, either as small or large particles, or vermin or fluid which can be present in the area where the pressure-sensitive mat is to be used, can cause the sensor to corrode or to lose its sensitivity.

It is not always possible to detect a very small hole in the surface of the pressure-sensitive mat during regular inspection. However, it can be sufficiently large to allow foreign bodies or fluid into the interior of the pressure-sensitive mat. The larger the air gap, the more foreign bodies, fluid or dirt is likely to enter the gap and form a barrier which prevents the sensor being actuated.

C.3.5 Pressure-sensitive mats with electric sensors

On some designs, electric contact plates are used. The contact plates are normally separated by an air gap which is closed when a force is applied to the surface. Springs, insulating pads or a resilient foam separate the contact plates so that the air gap is created. Consideration should be given to the effects of failure of the springs, insulating pads, the resilient foam and the contact plates. Sensor connections should also be considered.

On other types of electric sensor design, the sensor output will vary in a linear manner dependent on applied force. This can be in the form of a variable resistance, capacitance or other effect.

Consideration should be given to the long-term stability of variable parts under operating conditions and the effects of ingress of water or other chemicals.

C.3.6 Pressure-sensitive mats with pneumatic sensors

If a force is applied on the effective sensing field of a pneumatic sensor it creates a pressure change as a signal. The time between the application of the force and the signal output depends on the location of the applied force. The longest period of time should be considered.

The integrity of the pneumatic sensor (and pneumatic system) is lost, for example, when there are holes or cuts on the sensor or when the tube between the sensor and the switch is broken. In such cases, the pneumatic signal is not transmitted to the control system and the pressure-sensitive mats fail to danger (i. e the person stepping on the mat is not detected).

The pneumatic sensor does not detect a person who is already present on the sensor, when power is put ON.

For these reasons, pneumatic sensors may be used exclusively for in applications where only low risk reduction is needed.

C.3.7 Pressure-sensitive mats with fibre-optic sensors

When a force is applied to the effective sensing field of a fibre-optic sensor there is a change in the light passing through an optical fibre. Consideration should be given to the long-term changes that can occur in the light emitters and detectors and in the optical fibre.

At the design stage, care should be taken that no light can go directly from the emitter to the detector without going through the optical fibre.

C.3.8 Connecting cables

In practice, it is foreseeable that sensors can be dragged around by their connecting cables. Consequently, the joint between the connecting cable and the sensor is important. It should withstand both sharp and steady pulls and continuous flexing. Alternatively, a simple means by which the cable becomes disconnected without damage and leaves a safe situation can be used.

C.3.9 Tripping hazard

A tripping hazard exists when the difference in height of adjacent horizontal surfaces amounts to at least 4 mm. Measures should be provided that eliminate the tripping hazard at the surrounding sensor edge. A suitable solution is a ground-flush installation of the sensor, or a ramp with a 20° slope. Sensors that can be combined should be designed such that they do not create a tripping hazard in the combined condition. Lifetime deterioration in hostile conditions should be considered.

C.4 Pressure-sensitive floors

C.4.1 General

Pressure-sensitive floors have a sensor with a rigid effective sensing field such as fabricated steel plates.

C.4.2 Sensor surfaces

The sensor top surface should be of a material which will withstand the operating duty to be expected. In addition, applied forces should not lead to permanent deformation that can form “bridges” over part of the effective sensing area.

The sensor top surface should be of a non-slip design for its lifetime.

Consideration should be given to the effects of liquids which can be expected to be encountered in the application. For example, some liquids can cause long term degradation or swelling into an unsafe condition.

C.4.3 Blocking of contact travel of sensor surface

It is possible that the movement of the rigid sensor surface can be blocked due to the following reasons:

— wedging of sensor surface;

— build-up of foreign bodies such as e.g. swarf, dust and sand under the sensor surface;

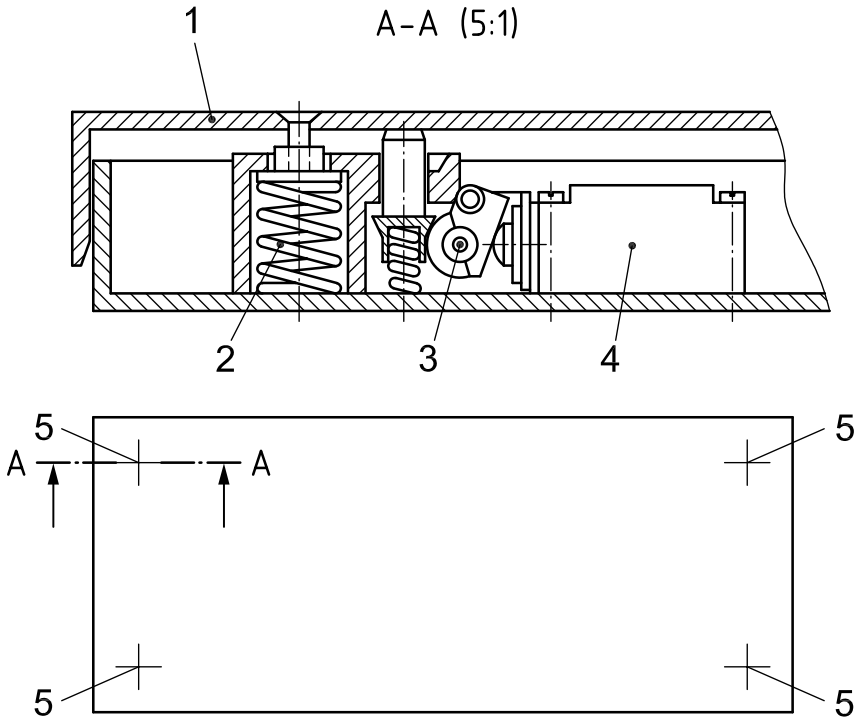
— warping of sensor surface;

— seizing of guide pins of sensor surface due to corrosion or icing.

The blocking of the movement of the rigid sensor surface should be taken into account in the risk assessment. As a general rule pressure-sensitive floors can be used only on applications where only low risk reduction is needed.

C.4.4 Use of position switches

C.4.4.1 Where position switches are used in pressure-sensitive floors, they should be selected, positioned and integrated into the control system such that they cannot fail to danger (see Figure C.1). For further information see also ISO 14119.



Key

1 moving rigid sensor surface
2 spring pushing the sensor surface back after stepping off the plate
3 position switch (position sensor) with direct mechanical actuation
4 cam transferring the movement of the sensor surface to the position switch
5 position switch (position sensor)

Figure C.1 — Use of position switches

C.4.4.2 Failures of position switches used in pressure-sensitive floors can be caused by:

— corrosion of position switches due to the effects of chemicals;

— blocking of position switches due to infrequent use;

— on-cam operated systems: excessive wear or misalignment of cams;

— position switches loose on brackets causing misalignment.

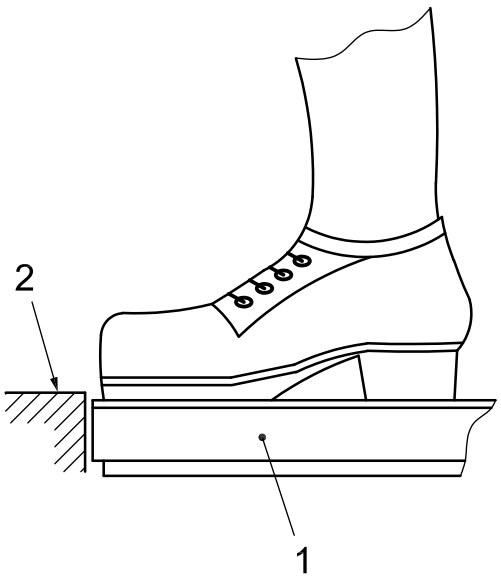
The failures of position switches should be taken into account in the risk assessment. As a general rule pressure-sensitive floors can be used only on applications where only low risk reduction is needed.

C.4.5 Connecting cables

Connecting cables should be installed in such a way that they do not create tripping hazards or dead zones and cannot be damaged.

C.4.6 Tripping hazard

A tripping hazard exists when the difference in height of adjacent horizontal surfaces amounts to at least 4 mm. Measures should be provided that eliminate the tripping hazard at the surrounding sensor edge. A suitable solution is a ground-flush installation of the sensor, or a ramp with a 20° slope. Sensors that can be combined should be so designed that they do not create a tripping hazard in the combined condition. Lifetime deterioration in hostile conditions should be considered. The movement of the sensor surface should not be so large as to cause a tripping hazard between it and the surrounding fixed surfaces (see Figure C.2).



Key

1 sensor surface

2 adjacent horizontal surface

Figure C.2 — Tripping

C.4.7 Removal of sensor surface

The pressure-sensitive floor should be so designed that it does not fail to danger when the sensor surface is removed.

An additional device is needed to detect the removal of the sensor surface (not shown in Figure C.1).

Annex D
(informative)

Installation, commissioning and testing

D.1 General

These notes are presented as recommendations to manufacturers and users on installation, commissioning, testing after installation and regular tests.

All information for installation, maintenance and testing of pressure-sensitive mats and pressure-sensitive floors should be supplied to the user. Recommendations should be given including fixing, lubrication, regular tests and replacement of mechanical and electrical parts. Users should also be provided with appropriate test procedures or systems for checking that the pressure-sensitive mat or pressure-sensitive floor is operating within its specification.

D.2 Installation

D.2.1 For correct installation, information about mechanical and electrical requirements for the application and, where necessary, installation drawings should be provided.

D.2.2 The manufacturer should specify the technical knowledge and particular skills that are required to install the pressure-sensitive mat or pressure-sensitive floor.

D.2.3 Test methods and inspection methods for testing after installation should be described.

D.3 Commissioning

D.3.1 Commissioning should include examination and tests carried out by trained and competent persons.

D.3.2 The results of the examination and tests should be recorded, and copies of these records should be kept by the user.

D.3.3 During commissioning, the following checks in particular should be carried out:

a) ascertain that the mounting surface and environmental conditions are suitable for the pressure-sensitive mat or pressure-sensitive floor in use;

b) confirm that the minimum distance is in accordance with the requirements of ISO 13855;

c) check that the sensor is fastened securely in place and does not provide a tripping hazard;

d) ensure that there are no dead zones that provide an access path to the hazard zone;

e) ensure that the removal of the power supply from the pressure-sensitive mat or pressure-sensitive floor prevents further operation of the machine, which should not be capable of being reactivated until power has been restored and the reset operated;

f) check that a hazardous movement is prevented while an actuating force is applied to the effective sensing area;

g) ensure that additional safeguards have been provided, where necessary, to prevent access to the hazardous parts of machinery from any direction not protected by the pressure-sensitive mat or pressure-sensitive floor;

h) ascertain that the presence of a person between the hazard zone and the sensor is prevented or, if this is not possible, ensure that further protective measures are taken.

i) check that all indicator lamps are functioning correctly;

j) verify the sensitivity of the pressure-sensitive mat or pressure-sensitive floor over the whole effective sensing area;

k) As the adequate safety required for a machine is dependent on the safety integrity of the interface between the machine and its protective device(s), ensure that the category and/or PL is in accordance with those given, in accordance with ISO 13849-1, by a type-C standard or a risk assessment — thereby ensuring that the machine control circuits and connections to the safeguard(s) are in accordance with the interface connections agreed between the machine control manufacturer and the manufacturer of the pressure-sensitive protective device;

l) where muting is provided, ensure that it occurs only during the intended part of the machine's operation, e.g. during the cycle where no hazard exists (see ISO 13849-1 and, for the design of the muting function, see also IEC/TS 62046).

D.4 Regular inspection and testing

D.4.1 It is recommended that regular examination, inspection and test procedures be carried out by qualified and competent persons. The manufacturer of the pressure-sensitive mat or pressure-sensitive floor should indicate the frequency of inspections based on experience in use.

D.4.2 The examination set out in D.3.3 should be repeated.

D.4.3 During regular inspections, check that no modifications have been made to the system and no changes (such as wear to brake pads) have occurred which affect the overall safety of the system.

D.4.4 Check that all control unit enclosures are closed and in good condition and can only be opened by a key or tool. Check that key(s) are removed for retention by designated personnel.

If the pressure-sensitive mat or pressure-sensitive floor fails any of the above tests, it should be isolated and the condition reported and recorded. The pressure-sensitive mat or pressure-sensitive floor should only be re-commissioned after all faults have been rectified.

D.5 Tests after maintenance

After maintenance has been undertaken, a full check of the system as specified in D.4 should be carried out. Special attention should be given to the function of those parts that have been replaced or repaired.

Bibliography

[1] ISO 4413, *Hydraulic fluid power — General rules and safety requirements for systems and their components*

[2] ISO 4414, *Pneumatic fluid power — General rules and safety requirements for systems and their components*

[3] ISO 7250 (all parts), *Basic human body measurements for technological design*

[4] ISO 11161:2007, *Safety of machinery — Integrated manufacturing systems — Basic requirements*

[5] ISO 11429, *Ergonomics — System of auditory and visual danger and information signals*

[6] ISO 13854, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*

[7] ISO 13857, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs*

[8] ISO 14119, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*

[9] ISO 14120, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

[10] ISO 14122-2:2001, *Safety of machinery — Permanent means of access to machinery — Part 2: Working platforms and walkways*

[11] IEC 60073, *Basic and safety principles for man-machine interface, marking and identification — Coding principles for indication devices and actuators*

[12] IEC 61310-1, *Safety of machinery — Indication, marking and actuation — Part 1: Requirements for visual, acoustic and tactile signals*

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

[14] IEC 61496-1, *Safety of machinery — Electro-sensitive protective equipment — Part 1: General requirements and tests*

[15] IEC/TS 62046, *Safety of machinery — Application of protective equipment to detect the presence of persons*

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