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

Part 1:

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

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

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



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Contents

Page

Foreword.....	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	2
4 Requirements	5
5 Marking	11
6 Information for use	12
7 Testing	15
Annex A (normative) Timing diagrams for devices with and without reset	28
Annex B (informative) Application notes	31
Annex C (informative) Design notes	35
Annex D (informative) Installation, commissioning and test	40
Bibliography	42

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 13856 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

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

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

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

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

Introduction

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

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

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Safety of machinery — Pressure-sensitive protective devices —

Part 1:

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

1 Scope

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

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

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

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

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

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

2 Normative references

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

EN 1070, *Safety of machinery — Terminology*

3 Terms and definitions

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

3.1

pressure-sensitive mat

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

3) To be published.

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

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

3.2

pressure-sensitive floor

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

See 3.23.5 of ISO 12100-1:—.

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

3.3

sensor

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

3.4

effective sensing area

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

See 4.2.

3.5

control unit

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

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

3.6

output signal switching device

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

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

3.7

actuating force

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

3.8

reset

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

3.9

ON state of output signal switching device(s)

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

3.10

OFF state of output signal switching device(s)

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

3.11

response time

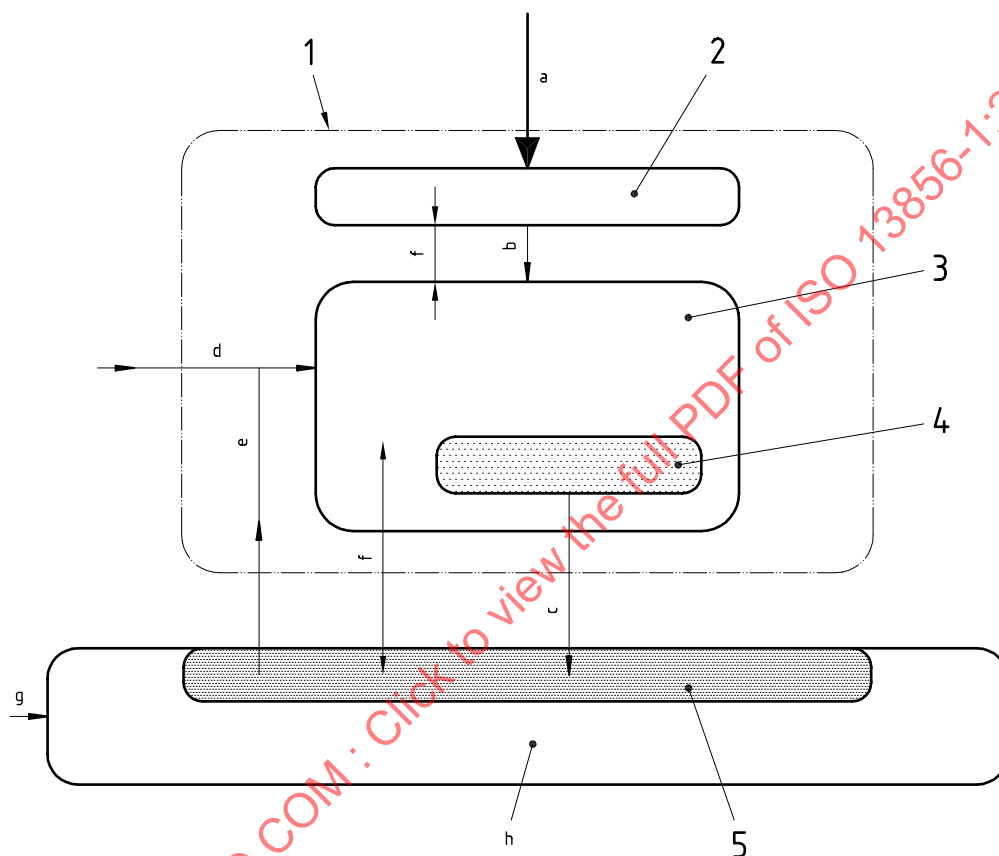
time between the start of the application of a force to the effective sensing area and the start of the OFF state of the output signal switching device

See 4.3.

3.12

dead zone

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



Key

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

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

4 Requirements

4.1 General

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

4.2 Actuating force

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

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

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

Table 1 — Actuating force

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

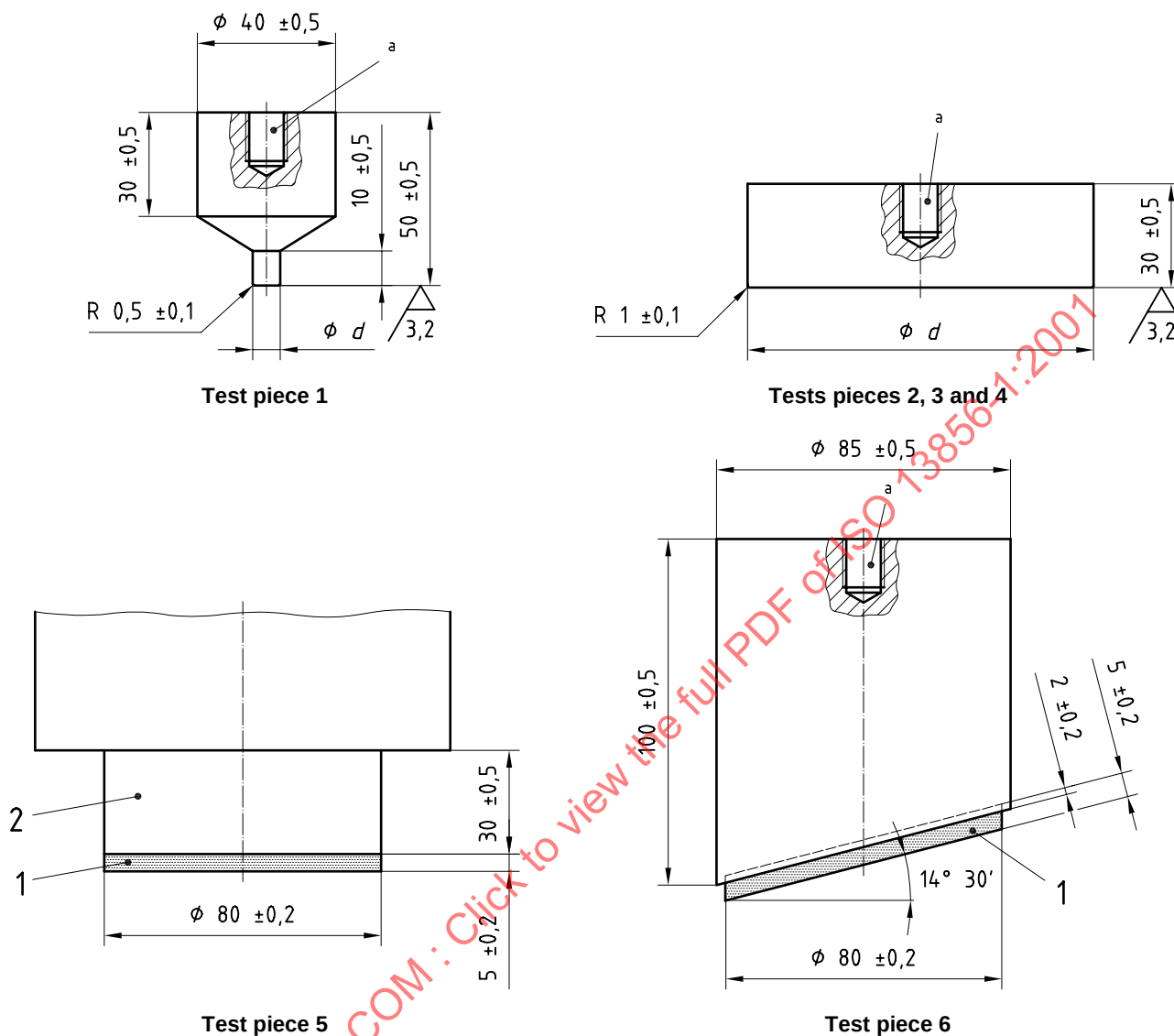
4.2.2 Combinations of sensors (see 7.4.3 and 7.4.4 for test methods)

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

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

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

Dimensions in millimetres

**Key**1 Rubber "shoe", 60 Shore A $\pm$ 5 Shore A, fixed with adhesive.

2 Steel

a Mounting proposal only

For d see Table 1.**Figure 2 — Test pieces****4.3 Response time** (see 7.5 for test method)

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

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

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

4.4 Static loading (see 7.6 for test method)

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

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

4.5 Number of operations (see 7.7 for test method)

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

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

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

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

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

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

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

4.7.1 General

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

4.7.2 Device with reset

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

The reset shall perform the following two functions.

a) Start inhibit interlock

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

b) Re-start inhibit interlock

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

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

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

4.7.3 Device without reset

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

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

4.8 Access for maintenance (see 7.10 for test method)

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

4.9 Adjustments (see 7.11 for test method)

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

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

4.10 Connections (see 7.12 for test method)

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

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

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

4.11 Environmental conditions (see 7.13 for test method)

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

4.11.1 Temperature range

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

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

4.11.2 Humidity

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

4.11.3 Electromagnetic compatibility

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

4.11.4 Vibration

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

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

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

4.12 Power supply

4.12.1 Electrical power supply (see 7.14 for test method)

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

4.12.2 Non-electrical power supply

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

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

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

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

4.13 Electrical equipment (see 7.15 for test method)

4.13.1 General

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

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

4.13.2 Protection against electric shock

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

4.13.3 Protection against overcurrent

Overcurrent protection shall be provided in accordance with 7.2.1, 7.2.3, 7.2.7, 7.2.8 and 7.2.9 of IEC 60204-1:1997.

NOTE Information may need to be given to the user of the pressure-sensitive device as to the maximum rating of fuses, or setting of an overcurrent 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 6.1.2.3 of IEC 60439-1:1999.

4.13.5 Clearance, creepage distances and isolating distances

The electrical equipment shall be designed and constructed in accordance with 7.1.2 of IEC 60439-1:1999.

4.13.6 Wiring

The electrical equipment shall be wired in accordance with 7.8.3 of IEC 60439-1:1999.

4.14 Enclosure (see 7.16 for test method)

4.14.1 Sensor

The sensor enclosure shall meet a minimum standard of IP 54 (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 IP 67 (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 IP 54 (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 IP 54 (in accordance with IEC 60529), the control unit shall be to a minimum of IP 2X (in accordance with IEC 60529). The enclosure containing the output signal switching device(s) shall also meet these requirements.

4.15 Categories for safety-related parts of control systems in accordance with EN 954-1 (see 7.17 for test method)

4.15.1 Pressure-sensitive mats and pressure-sensitive floors shall meet the requirements of the category for which they are specified and marked. These categories are defined in EN 954-1.

4.15.2 The sensor, control unit and output signal switching device shall meet the requirements of category 1 as a minimum. To meet category 1, the system shall, as a minimum, meet the requirements of this part of ISO 13856 and the relevant requirements of EN 954-1.

4.15.3 Electronic control units shall meet the requirements of category 2 as a minimum.

NOTE 1 The sensor, control unit and output signal switching device may each have different categories.

NOTE 2 The fault conditions of the sensor and its connections that can be monitored should be taken into account when evaluating the category of the control unit.

NOTE 3 It is not possible at the time of writing this part of ISO 13856 for the majority of sensors to meet all the requirements specified in the categories 2, 3 and 4, in particular when considering mechanical damage and long-term deterioration.

4.16 Sensor fixings (see 7.1.2 for test method)

The sensor shall be provided with a means for fixed permanent location.

4.17 Tripping (see 7.1.2 for test method)

Where there is a danger that a person can trip on the outside edge(s) of a sensor or sensor covering, a suitable ramp shall be provided. The slope of the ramp shall not exceed 20° from the horizontal. Its existence shall be identified by contrasting colours or marking. The ramp shall not create a physical obstruction or other hazard.

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 There is at present no standard covering this subject, but ISO 14122-2 can be taken into account when the test method is agreed.

4.18 Slipperiness and softness of the sensor top surfaces (see 7.18 for test method)

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

NOTE There is at present no standard covering this subject, but ISO 14122-2 can be taken into account when the test method is agreed.

4.19 Additional coverings of top surfaces of sensor(s) (see 7.19 for test method)

The overall requirements of this part of ISO 13856 shall apply to sensor(s) which are fitted with additional or alternative coverings, e.g. protective sheets (see annex C).

4.20 Failure due to blocking or wedging (see 7.20 for test method)

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

5 Marking (see 7.1.2 for test method)

5.1 General

The pressure-sensitive mat or pressure-sensitive floor shall be marked in accordance with 5.4 of ISO 12100-2:— and 18.1 of IEC 60204-1:1997.

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 it is attached (see IEC 61310-2).

5.2 Marking of the control unit

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

- a) the category according to EN 954-1, specifying whether it applies to the control unit only or to the system as a whole;
- b) the response time;
- c) with or without reset;
- d) part number.

5.3 Marking of the sensor

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

- a) the category according to EN 954-1;
- b) if suitable for detecting persons (e.g. children) weighing more than 20 kg;
- c) the response time;
- d) the part number.

5.4 Marking of other components

Component parts 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 clause 5 of ISO 12100-2:—.

6.2 Instructions for use (see 7.1.2 for test method)

6.2.1 General

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. See annexes B and D. The instructions for use shall include the following.

6.2.2 Application

6.2.2.1 Detailed description of the device(s) and a warning

"Categories in accordance with EN 954-1 for pressure-sensitive mats and pressure-sensitive floors on machines are stated in type C standards."

Where no type C standard exists, a risk assessment shall be carried out, following the guidelines described in 5.2 of ISO 12100-1:— and in ISO 14121 which show the importance of selecting the safety device with the appropriate category in accordance with annex B of EN 954-1:1996.

6.2.2.2 Device features

- a) The category(ies) in accordance with EN 954-1;
 - 1) the limits of size and shape for individual sensors including effective sensing area;
 - 2) the limits of combination of numbers and sizes of sensor which can be used with one control unit;
 - 3) connections between components.
- b) The 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;

- 1) the fitting arrangements - how sensors can be combined;
 - 2) the fixing arrangements of the sensor and control unit;
 - 3) the mass of the sensor per square meter, and the mass of the control unit;
 - 4) the sensor additional covering details (where applicable);
 - 5) the response time;
 - 6) the power supply requirements;
 - 7) the control unit enclosure specifications in accordance with IEC 60529;
 - 8) the switching capability of the output signal switching device(s);
 - 9) the configuration(s) of the output signal switching device(s);
 - 10) the suitability for detecting walking aids e.g. walking sticks and walking frames.
- c) 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.3.3.1).
- d) The range of applications and conditions for which the device(s) is/are intended or approved including the category it complies with. Examples of unsuitable applications should also be given;
- 1) schematic representation of the safety functions and examples of machine control interface circuit diagrams;
 - 2) the rating, characteristics and location of all input/output terminals;
 - 3) guidance regarding chemical, physical and environmental resistance (e.g. resistance to solvents, permissible weight loading, operation temperature range, permissible power supply variation etc.);
 - 4) guidance regarding suitability for wheeled vehicles which may be starting, braking or turning on the surface of the sensor;
 - 5) whether the device(s) is/are designed with or without reset in accordance with 4.7.

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

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 etc.).

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 optimized during installation (including drawings where appropriate);
- e) schedule of tests to enable commissioning to be carried out after installation in order to establish that the device(s) is/are functioning;
- f) warning that the overall safety of the machine and its safety device(s) depends on the integrity of the interface between them;
- g) instruction to check that the category(ies) of the device according to EN 954-1 is/are appropriate.

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 limits of use;
- 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) tasks which require a definite 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) instructions 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 parts 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) may not be met;
- h) list of user replaceable parts specified in sufficient detail to maintain a system which complies with this part of ISO 13856;
- i) warning that only those parts approved by the manufacturer may be replaced by the user and that if non-approved spares are used or non-approved modifications are made, the device(s) may not function to the designed requirements;
- j) name and address of manufacturer and competent service organization.

6.2.7 Training requirements

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

7 Testing

7.1 General

7.1.1 The type tests 1 to 17, described in 7.4 to 7.20, shall determine whether pressure-sensitive mats or pressure-sensitive floors meet the requirements of this part of ISO 13856. The tests shall be carried out on a ready-to-use pressure-sensitive mat or pressure-sensitive floor. Unless otherwise specified, these tests shall be carried out at $23\text{ °C} \pm 5\text{ °C}$.

The following are some of the factors which can affect the performance:

- 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.

The tests described in 7.4 to 7.20 shall be carried out with the least favourable combination of factors for each test.

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

7.2 Sensor test sample

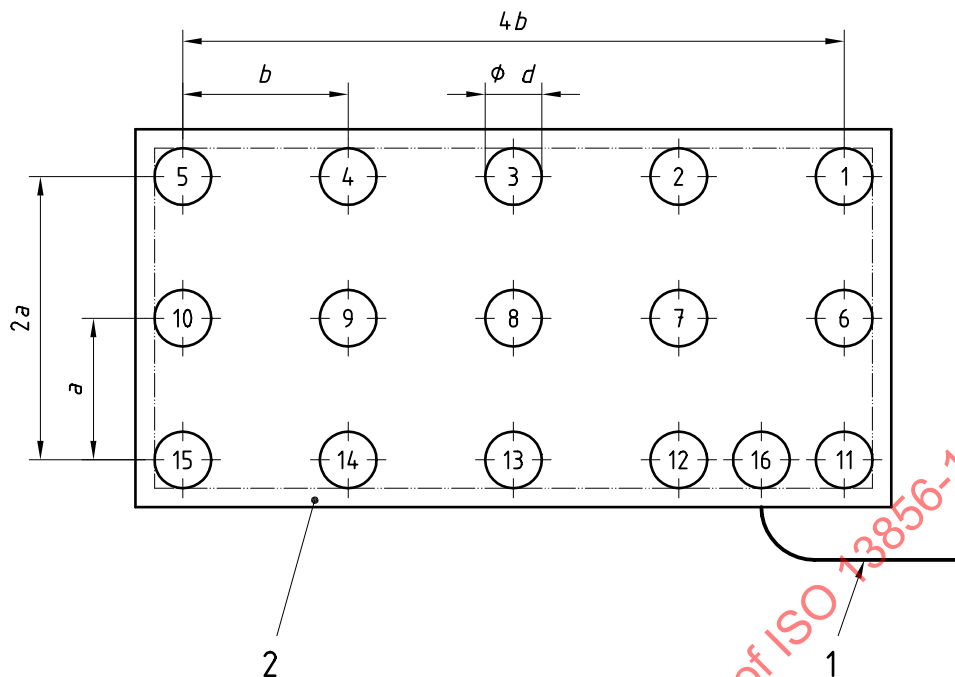
The sample(s) shall have a sensor(s) with dimensions of at least $1\text{ m} \times 0,5\text{ m}$.

If the pressure-sensitive mat or pressure-sensitive floor has only one sensor, two sensors will be required for the tests. One sensor is used to verify the requirements of 4.2, 4.3, 4.4 and 4.5.1.2 (100 000 operations at each of five locations giving 500 000 operations in total). The other sensor is used to verify the requirements of 4.5.1.1 (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 will be used to verify the requirements of 4.2 and 4.3. The sensor that is selected for the locations 1 to 16 marked on Figure 3 is used for verification of the requirement 4.4 and, together with one other sensor, the requirement of 4.5.2. One of the remaining sensors is used to verify the requirements 4.5.1 (one million operations at one location) and 4.10.

7.3 Test pieces for load tests

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



Key

- 1 Connecting cable (example)
- 2 Dead zone
- d Diameter of the respective test piece

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

7.4 Test No. 1 – Actuating force (requirements see 4.2)

7.4.1 Single sensor at ambient temperature

Test pieces and actuating forces given in Table 1 shall be applied perpendicularly to the effective sensing area in all locations shown in Figure 3 plus five points considered to be critical to meet the actuating force requirements (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 mats or pressure-sensitive floors are 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 operating temperature range (or temperature range as stated by the manufacturer)

Test pieces and actuating forces given in Table 1 shall be applied perpendicularly to the effective sensing area in locations 1, 8 and 16 shown in Figure 3, at the limits of the range, starting at the highest temperature. The sensor shall reach temperature equilibrium before it is tested.

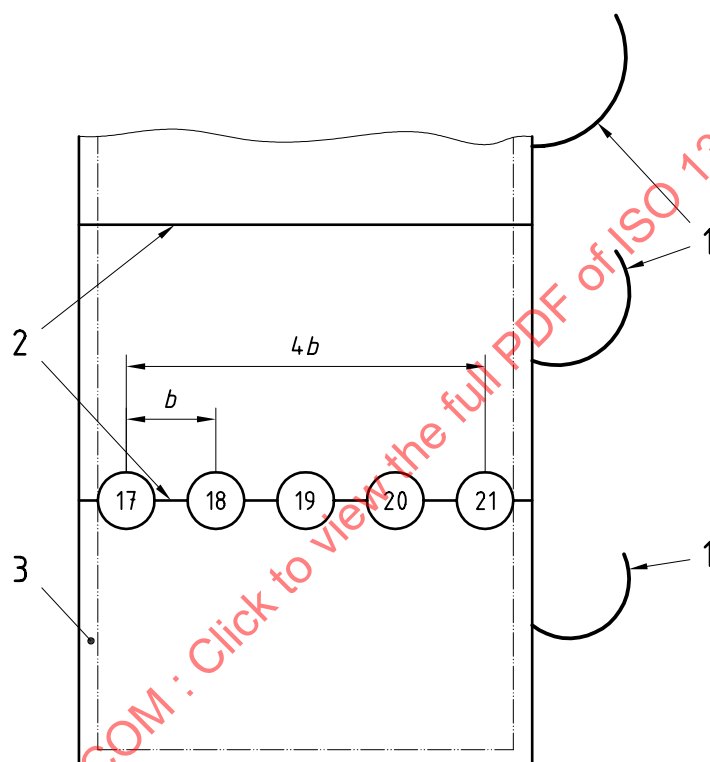
If the actuating force required to actuate the output signal switching device is, in all cases, more than 10 % below the forces shown for the relevant test piece in Table 1, the pressure-sensitive mat shall be assumed to give similar results over its whole area. If the force is not within this limit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

7.4.3 Combination of sensors at ambient temperature

7.4.3.1 Where two or more sensors are combined to constitute one effective sensing area, the same tests as 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 as shown in Figure 4 or at locations on a joint and a junction as shown in Figure 5.

7.4.3.2 For pressure-sensitive mats and pressure-sensitive floors designed to detect persons weighing more than 35 kg, use test piece 2 and actuating force as given in Table 1.

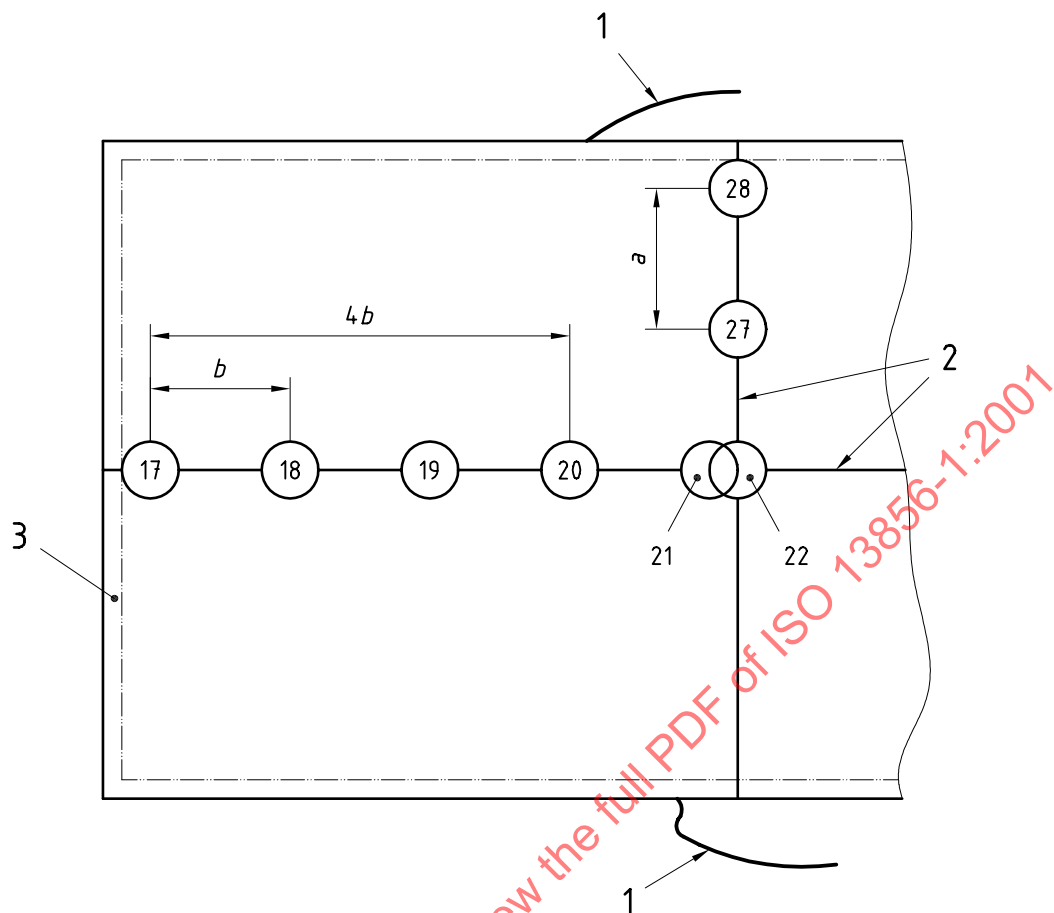
7.4.3.3 For pressure-sensitive mats and pressure-sensitive floors designed to detect persons (e.g. children) weighing more than 20 kg, use test pieces 2 and 4 and actuating forces as given in Table 1.



Key

- 1 Connecting cable (example)
- 2 Joint line
- 3 Dead zone

Figure 4 — Test locations on the joints between sensors



Key

- 1 Connecting cable
- 2 Joint line
- 3 Dead zone

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

7.4.4 Combinations of sensors at operating temperature range (or temperature range as stated by the manufacturer)

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

In addition, the following test pieces shall be applied perpendicular to the effective sensing area at locations 17, 19 and 21, as shown in Figure 4, at the temperature limits or at locations 17, 19, 22, 27 and 28 only, as shown in Figure 5, at the temperature limits. The sensors shall reach temperature equilibrium before they are tested.

7.4.4.2 For pressure-sensitive mats and pressure-sensitive floors designed to detect persons weighing more than 35 kg, use test piece 2 and actuating force as given in Table 1.

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

7.5 Test No. 2 — Response time (requirements see 4.3)

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

The response time is measured with test piece 7 (see Figure 6) of $(30^{+0,5}_{-0,0})$ kg mass and diameter d of test piece 2 of 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 with test piece 8 (see Figure 6) of $(15^{+0,5}_{-0,0})$ kg mass and a diameter d of test piece 4 of Table 1.

The test pieces (see Figure 6) are constructed so that when the lower part of the 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 to the effective sensing area perpendicularly at a velocity of $(0,25^{+0}_{-0,03})$ m/s. 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.

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

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

The tests shall be carried out at all the above indicated locations at $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$. At the limits of the specified temperature range, the tests shall be carried out only at locations 1 and 16 (as shown in Figure 3) and 17 (as shown in Figure 4) or 17, 22 and 27 (as shown in Figure 5).

Additional tests shall be carried out at one random location on a single sensor at $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ at the limits of the specified power supply variations. The longest measured time shall be equal to or shorter than the stated response time.

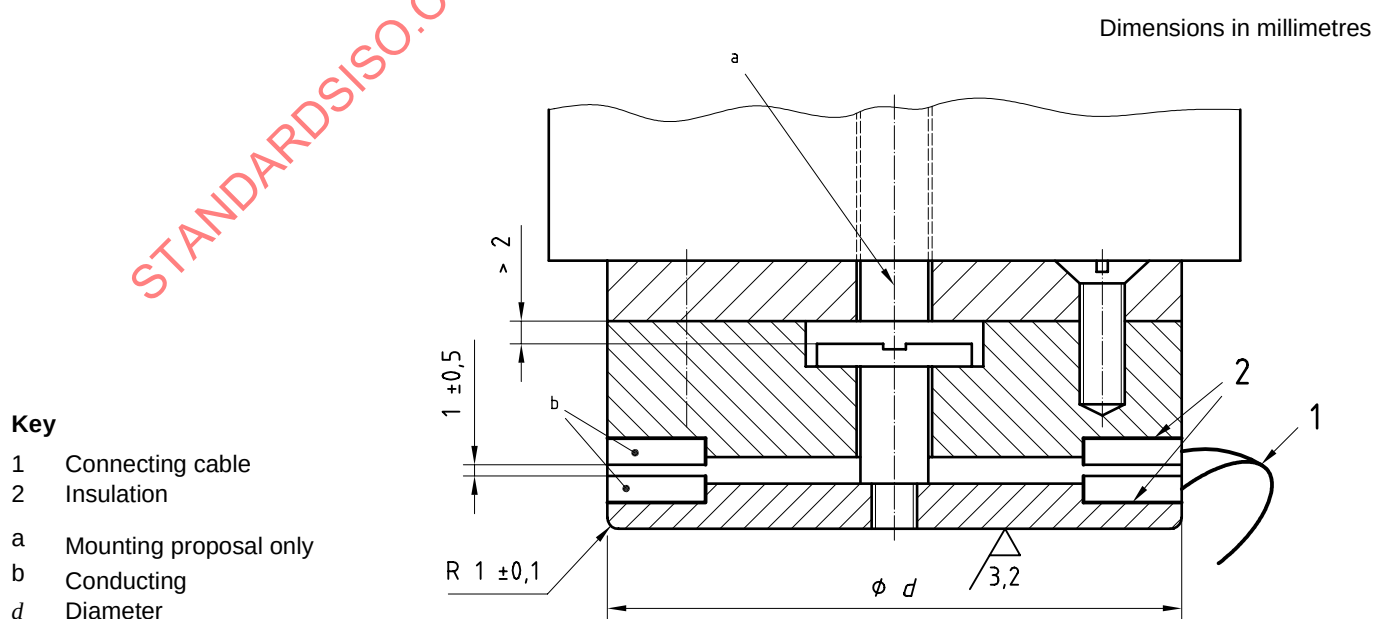


Figure 6 — Test pieces 7 and 8 to measure the response time

7.6 Test No. 3 — Static loading (requirements see 4.4)

NOTE It is possible that pressure-sensitive floors are designed to be integrated with a machine. In this case it is not possible to carry out the tests required for pressure-sensitive mats.

7.6.1 A static force of $2\,000\text{ N} \pm 50\text{ N}$ shall be applied perpendicular to the effective sensing area through test piece 2 (as shown in Figure 2) for 8 h on a sensor at a random location within 120 mm of the edges of the effective sensing area.

The output signal switching device shall change to an ON state 2 min after the force has been removed (if the system has a reset, it has to be actuated). The deformation of the effective sensing area surface through the test piece shall be measured one hour 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 $750\text{ N} \pm 20\text{ N}$ shall be applied perpendicular to the effective sensing area through test piece 1 (as shown in Figure 2) for 8 h at another location within 120 mm of the edges of the effective sensing area.

The output signal switching device shall change to an ON state 2 min after the force has been removed (if the system has a reset, it has to be actuated). The deformation of the effective sensing area surface through the test piece shall be measured one hour 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 of measuring the deformation in 7.6.1 and 7.6.2, the actuating force and response time shall be checked at the location where 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.

7.7 Test No. 4 — Number of operations (requirements see 4.5)

7.7.1 The tests of requirement 4.5.1.1 (100 000 operations at each of five locations) shall be carried out as shown on Figures 7 and 8 using test piece 6 (see Figure 2). The actuation shall be achieved by supplying a working pressure of $3,8\text{ bar} \pm 0,2\text{ bar}$ to the pneumatic cylinder in accordance with ISO 6431 with a 50 mm diameter and a 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 that is directly connected to the pneumatic cylinder or through a short air line. This line shall have a nominal diameter $\geq 10\text{ mm}$ and a length $< 200\text{ mm}$. A flow control valve shall be installed in the downstream side to achieve an impact velocity of $(0,55^{+0,05}_{-0,00})\text{ m/s}$ 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 on 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 the test piece 6 (see Figure 2) at the effective sensing area shall be in the two directions shown on 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, 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.

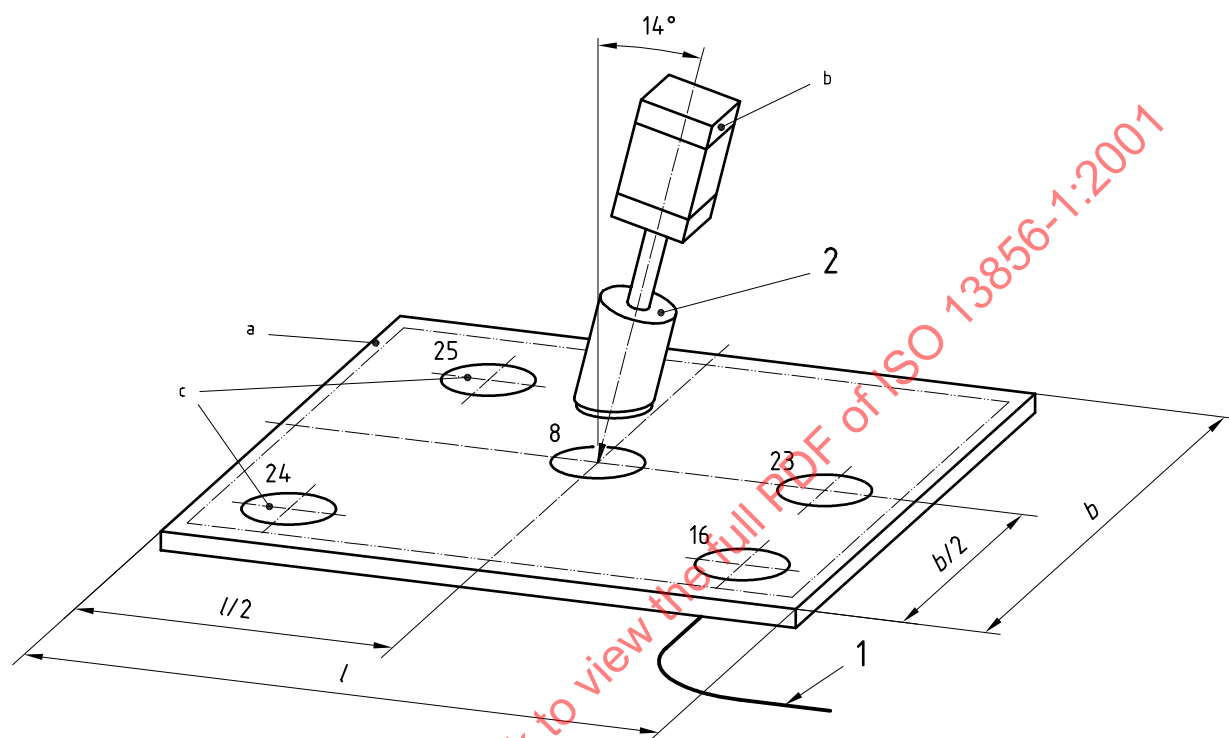
During this test, the output signal switching device is connected to the sensor(s) and the pressure-sensitive mat or pressure-sensitive floor has to be operating. The sensor(s) shall be fixed with fastening elements specified by the manufacturer in the manual.

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 with a mass of $75\text{ kg} \pm 1\text{ kg}$ (see Figure 2) at a vertical impact velocity of $(0,55^{+0,05}_{-0,00})\text{ m/s}$. 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 mm in a vertical direction while the test is in progress.

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

Dimensions in millimetres

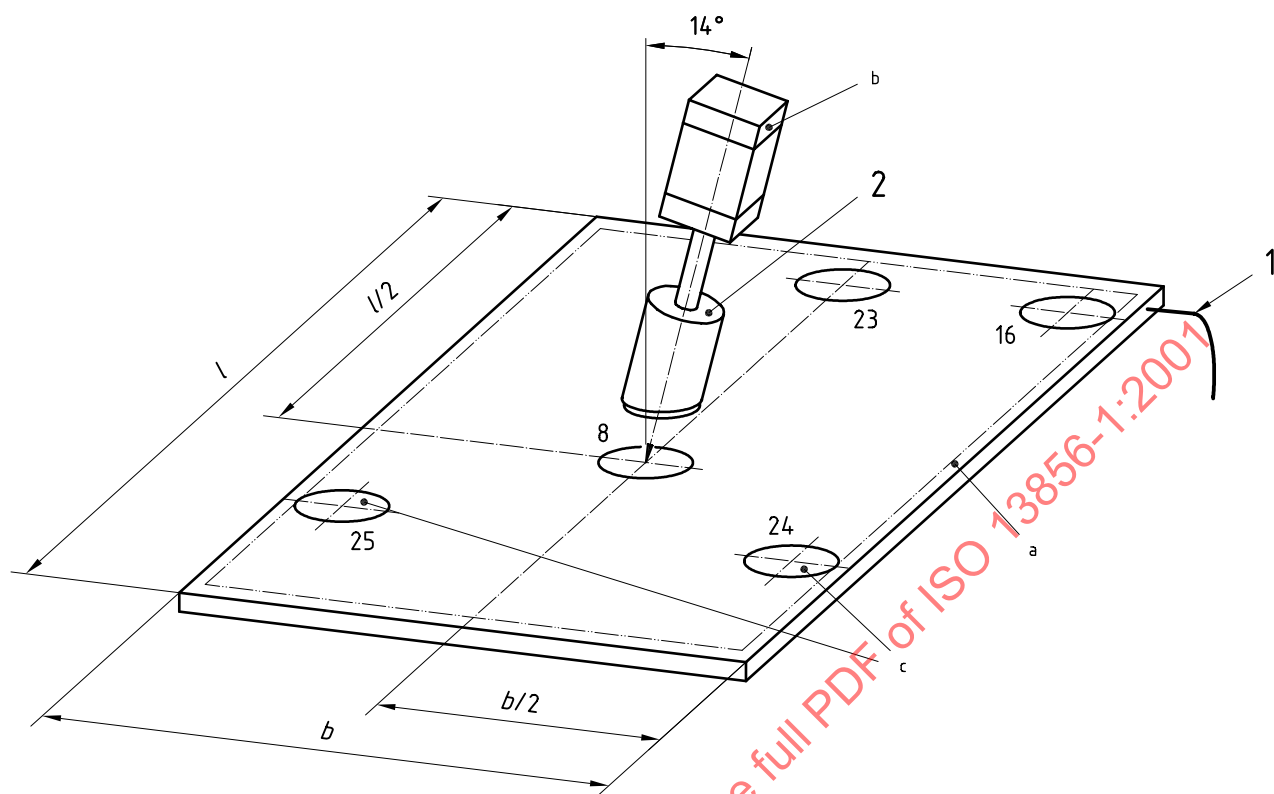


Key

- 1 Connecting cable (example)
- 2 Test piece 6 (see Figure 2)
- a Dead zone
- b Inside diameter of the pneumatic cylinder 50 mm, stroke 125 mm in accordance with ISO 6431
- c Random location
- l Length of sensor
- b Width of sensor

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

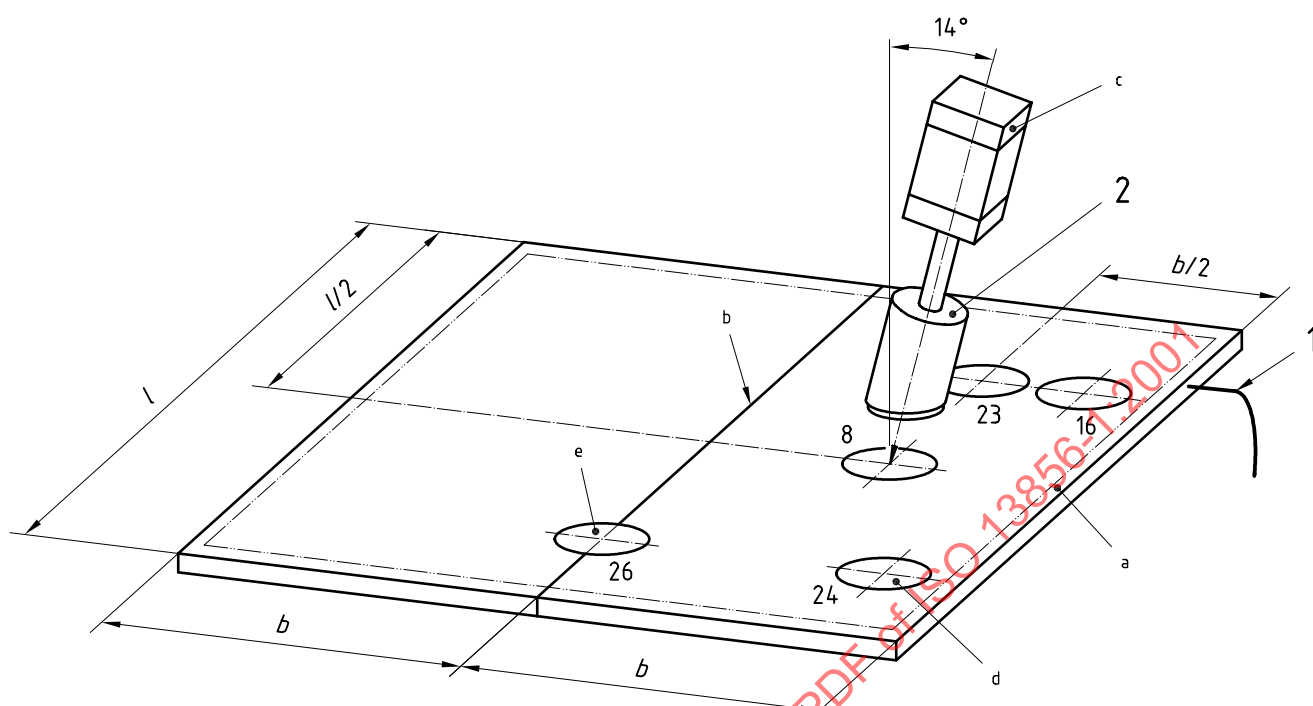
Dimensions in millimetres

**Key**

- 1 Connecting cable (example)
- 2 Test piece 6 (see Figure 2)
- a Dead zone
- b Inside diameter of the pneumatic cylinder 50 mm, stroke 125 mm in accordance with ISO 6431
- c Random location
- l Length of sensor
- b Width of sensor

Figure 8 — Arrangement of the pneumatic cylinder and locations for the test “Number of operations” applied to a single sensor (horizontal component of the force acting parallel to the shortest edge of the sensor)

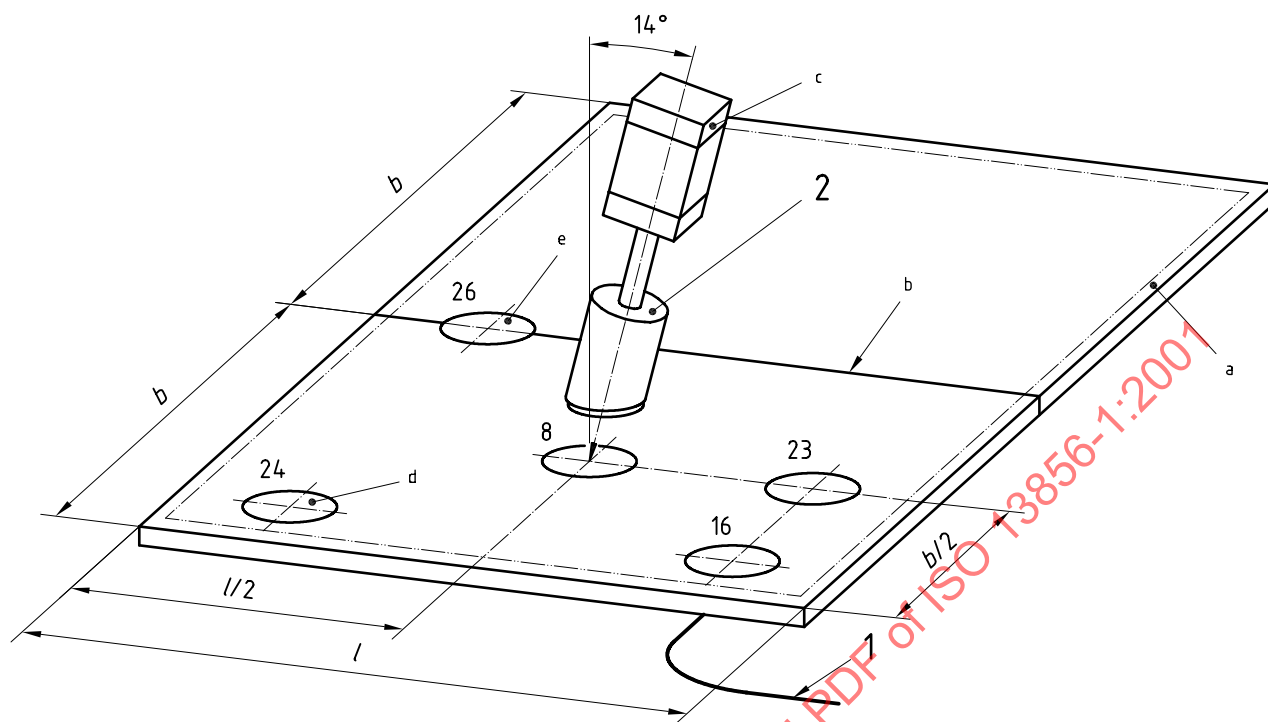
Dimensions in millimetres



Key

- 1 Connecting cable (example)
2 Test piece 6 (see Figure 2)
a Dead zone
b Joint line
c Inside diameter of pneumatic cylinder 50 mm; stroke 125 mm in accordance with ISO 6431
d Random location
e Random location on joint line
l Length of sensor
b Width of sensor

Figure 9 — Arrangement of the pneumatic cylinder and locations for the test “Number of operations” applied to a combination of sensors
(horizontal component of the force acting parallel to the longest edge of the sensor)

**Key**

- 1 Connecting cable (example)
- 2 Test piece 6 (see Figure 2)
- a Dead zone
- b Joint line
- c Inside diameter of pneumatic cylinder 50 mm, stroke 125 mm in accordance with ISO 6431
- d Random location
- e Random location on joint line
- l Length of sensor
- b Width of sensor

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

7.7.3 The function of the pressure-sensitive mat or pressure-sensitive floor shall be checked by testing the actuating force using test piece 2 (see Figure 2) and the response time using test piece 7 (see Figure 6) at the locations where the tests of 7.7.1 and 7.7.2 have been performed.

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 the sensor (requirements see 4.6)

Test piece 2 (see Figure 2) applying the actuating force as given in Table 1 shall be applied perpendicular to the effective sensing area in one random location for a minimum time of 8 h. The output state of the sensor shall change state when this actuating force is applied to it and remain in that state until the actuating force is removed as shown in 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 the actuating force (requirements see 4.7)

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) and the actuating force as given in Table 1 applied perpendicular to the effective sensing area in one random location at room temperature.

7.10 Test No. 7 — Access for maintenance (requirements see 4.8)

Testing shall be by inspection.

7.11 Test No. 8 — Adjustments (requirements see 4.9)

Testing shall be by inspection and by replacing the sub-assemblies which are authorized by the manufacturer.

7.12 Test No. 9 — Connections (requirements see 4.10)

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 (requirements see 4.11)

7.13.1 Functional test

At the beginning and at the end of the following tests, the function of the pressure-sensitive mat and pressure-sensitive floor shall be verified using test piece 2 (see Figure 2) and the actuating force as given in Table 1, applied perpendicularly at a speed of $100 \text{ mm/s} \pm 5 \text{ mm/s}$ 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 range (requirements see 4.11.1)

The test, in accordance with Table 2, shall be carried out over the temperature range stated by the manufacturer.

Table 2 — Temperature range

Test procedure	Remarks
IEC 60068-2-14:1994 Test N	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 $0,8 \text{ }^{\circ}\text{C} \pm 0,3 \text{ }^{\circ}\text{C}$ per min over the whole temperature range. During the test, 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 can be carried out using a sensor with a smaller effective sensing area than that indicated in 7.2. The dimensions of the effective sensing area shall, however, not be less than $400 \text{ mm} \times 200 \text{ mm}$.

7.13.3 Test No. 10.2— Humidity (requirement see 4.11.2)

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

Table 3 — Humidity

Test procedure	Remarks
IEC 60068-2-3:1969 Test Ca	Pressure-sensitive mat or pressure-sensitive floor is not connected to the power supply

After the test of the resistance to humidity, the insulation resistance in accordance with 8.2.2.6 of IEC 60439-1:1999 has to be verified.

7.13.4 Test No. 10.3 — Electromagnetic compatibility (immunity) (requirements see 4.11.3)

Safety-related requirements shall be verified by reference to IEC 61000-6-3 and IEC 61000-6-2 only. Immunity shall be verified for the following three switching states according to the test procedures given in Table 4 and with the indicated characteristic values given in the specifications 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 supply energy, after removal of the actuating force and prior to the execution of the reset.

Table 4 — Electromagnetic compatibility

Kind of testing 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 electromagnetic field Level 3	IEC 61000-4-3

7.13.5 Test No. 10.4 — Vibration (requirements see 4.11.4)

The requirements concerning vibration at the control unit and the output signal switching device only shall be verified in accordance with Table 5. At 10 s intervals during this test, there will be a function test in accordance with, 7.13.1 as at the beginning and end of the test.

Table 5 — Vibration

Test Procedure	Remarks
IEC 60068-2-6	Pressure-sensitive mat or pressure-sensitive floor is connected to the power supply

7.14 Test No. 11 — Electrical power supply (requirements see 4.12.1)

The requirements of 4.12.1 shall be verified in accordance with the requirements of clause 4 of IEC 60204-1:1997

7.15 Test No. 12 — Electrical equipment (requirements see 4.13)

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

7.16 Test No. 13 — Enclosure (requirements see 4.14)

All enclosures shall be tested in accordance with the requirements of IEC 60529.

7.17 Test No. 14 — Categories for safety-related parts of control systems in accordance with EN 954-1 (requirements see 4.15)

An assessment shall be carried out to confirm that the category claimed for the equipment is in accordance with EN 954-1.

7.18 Test No. 15 — Slipperiness and softness of the sensor top surfaces (requirements see 4.18)

This requirement shall be tested by inspection until special tests are available, but ISO 14122-2 can be taken into account when test method is agreed.

7.19 Test No. 16 — Additional coverings of top surfaces of sensor(s) (requirements see 4.19)

This test shall be carried out by selecting the least favourable combination of factors for each test in accordance with 7.1 to 7.18

7.20 Test No 17 — Failure due to blocking or wedging (requirements see 4.20)

This requirement shall be verified by inspection and if in doubt by a specific test.

Annex A (normative)

Timing diagrams for devices with and without reset

The following figures illustrate the response of the output signal switching device to the actuating force (see 4.7).

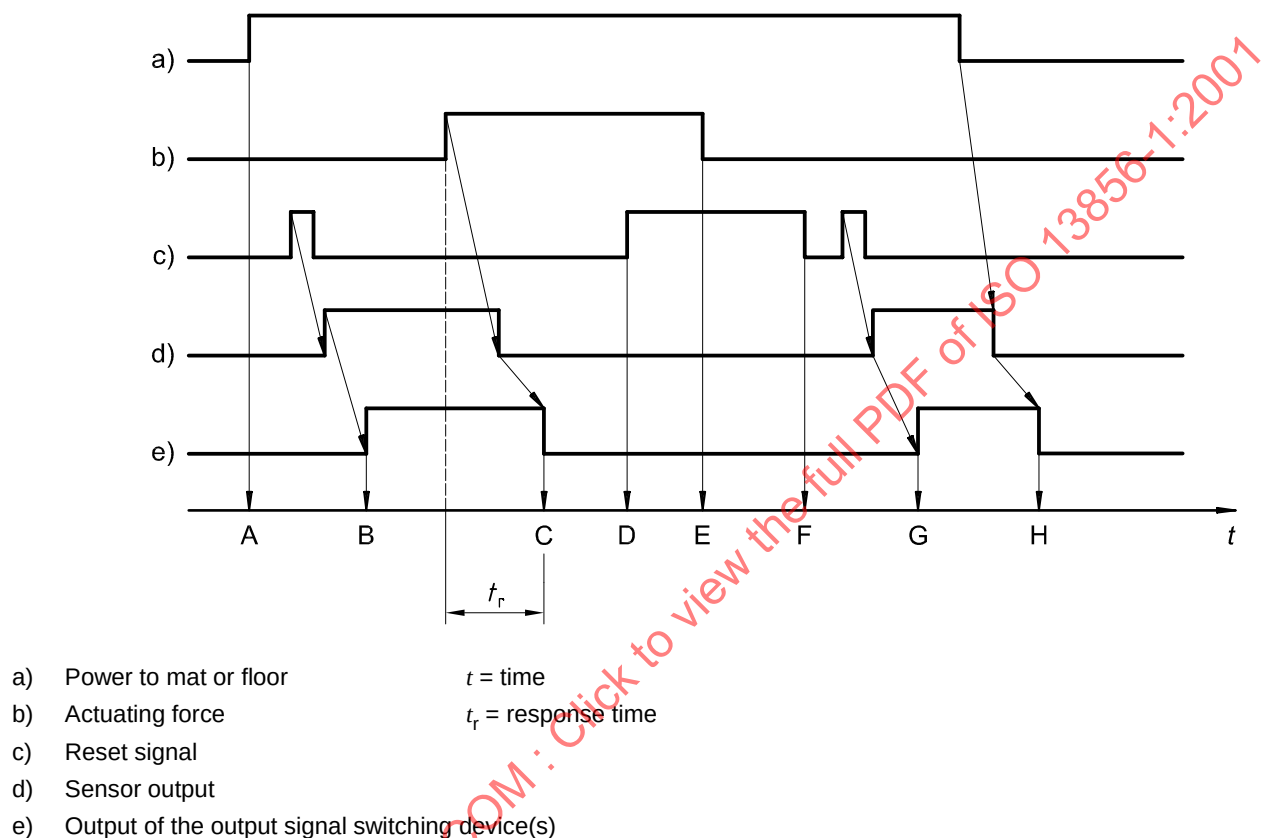
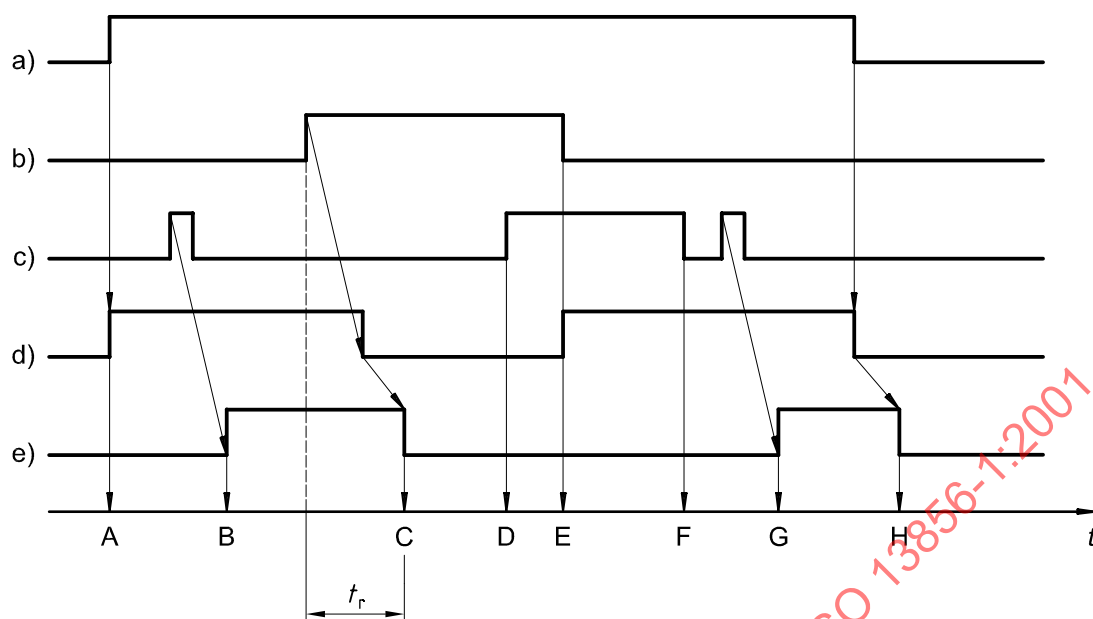


Figure A.1 — Relationship between actuating force, reset signal, and output
(sensor output initiated by reset function)

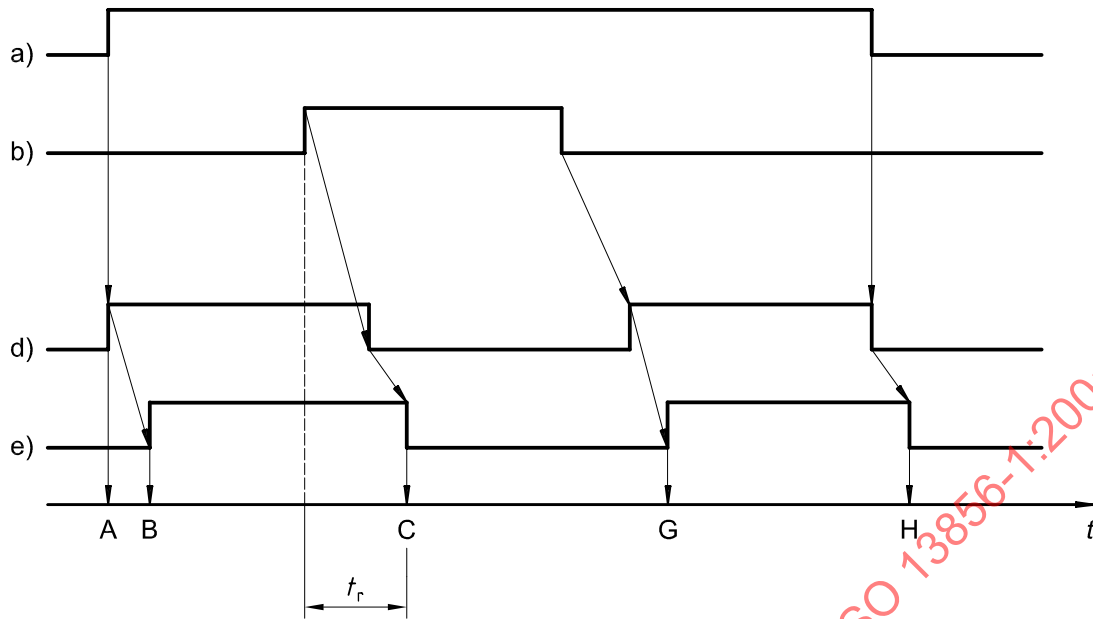
- A Power to the device is ON; output remains OFF because the device has not been reset
- B Reset signal present. Output of the device is turned ON because sensor is turned ON due to operation of reset button without actuating force on the pressure-sensitive mat or pressure-sensitive floor
- C Output of the device is OFF because sensor is turned OFF due to actuating force on the sensor
- D Reset signal present. Operation of reset button has no effect on output of the device as long as a force is present on the sensor; device remains OFF
- E Actuating force removed from the sensor; the output of the device remains OFF even though the reset signal is still present
- F Reset signal removed. Release of reset button has no effect on output of the device even when the force has been removed from the sensor
- G Reset signal present. Output of the device is turned ON because sensor is turned ON due to operation of reset button without actuating force on the sensor
- H Power to the device is OFF; sensor output and device output are turned OFF



- a) Power to mat or floor $t = \text{time}$
 b) Actuating force $t_r = \text{response time}$
 c) Reset signal
 d) Sensor output
 e) Output of the output signal switching device(s)

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

- A Power to the device is ON; output remains OFF because the device has not been reset. Sensor is turned ON when the power is turned ON
- B Reset signal present without actuating force on sensor. Output of the device is turned ON due to operation of reset button as long as the sensor is turned ON
- C Actuating force on sensor. Output of the sensor is turned OFF which also turns the device OFF
- D Reset signal present. Operation of reset button has no effect on output of the device as long as a force is present on the mat or floor sensor; device remains OFF
- E Actuating force removed from sensor; the output of the sensor is turned ON but the device remains OFF even though the reset signal is still present
- F Reset signal removed. Release of reset button has no effect on the output of the sensor which remains ON. The device remains OFF
- G Reset signal present without actuating force on sensor. Output of the device is turned ON due to operation of reset button as long as the sensor is turned ON
- H Power to the device is OFF; sensor output and device output are turned OFF



- a) Power to mat or floor $t = \text{time}$
- b) Actuating force $t_r = \text{response time}$
- d) Sensor output
- e) Output of the output signal switching device(s)

Figure A.3 — Relationship between actuating force and output for devices without reset

- A Power to the device is ON; sensor is turned ON
- B Output of the device is turned ON because there is no actuating force on the sensor
- C Output of the device is OFF because sensor is OFF due to actuating force on the sensor
- G Output of the device is turned ON because sensor is ON due to actuating force being removed from the sensor
- H Power to the device is OFF; sensor and device output are turned OFF

Annex B

(informative)

Application notes

B.1 General

These notes should be regarded 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 following recommendations.

B.2 Mounting surface (location)

The surface quality should meet the requirements stated by the manufacturer, e.g. irregularities may impair the function of the sensor of pressure-sensitive mats and pressure-sensitive floors and therefore should be reduced to an acceptable minimum.

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

- that controls are situated in appropriate positions;
- that no tripping hazards are created due to connecting cables;
- that no dead zones are created in areas to be protected, e.g. sensors may 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 should be taken into account according to the requirements of ISO 13855.

B.4 Selection criteria

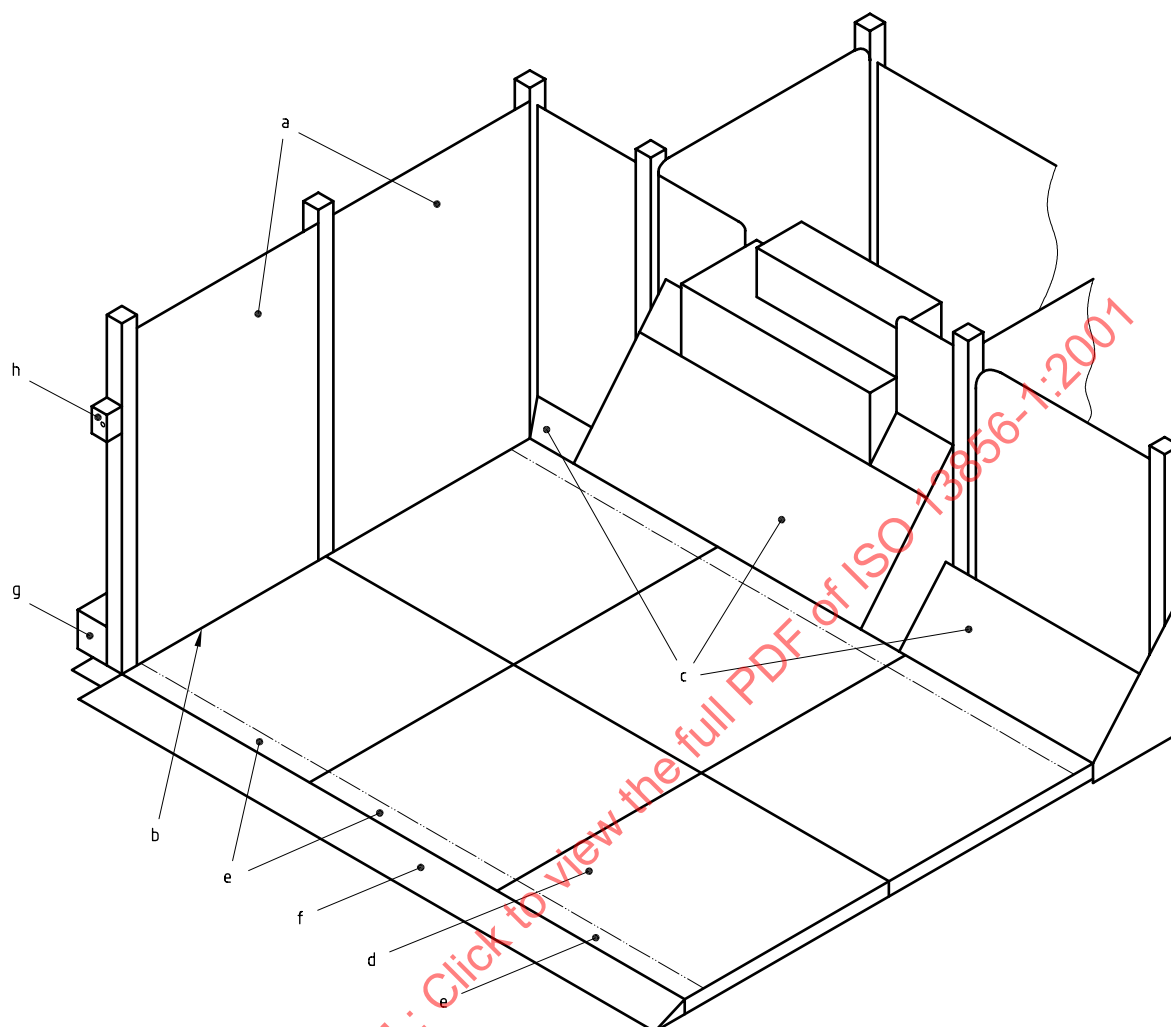
The following list contains some features which should be considered when selecting the system:

- a) use as a single device, or in combination with other devices;
- b) ability to combine sensors;
- c) avoidance of dead zones;
- d) frequency of operating cycles and lifetime of the system;
- e) output signal switching device switching capacity;
- f) static loading, such as parts of machinery resting on the surface;
- g) loading by wheeled traffic, e.g. driving, braking and turning;
- h) temperature and humidity;

- i) rapid variations in temperature and humidity;
- j) effects of chemicals such as oils, solvents, cutting fluids and combinations of these fluids;
- k) effects of flooding, e.g. when cleaning and in case of leakages;
- l) effect of foreign bodies such as swarf, dust and sand;
- m) additional covering for the sensor;
- n) stress due to vibration, shocks, etc.;
- o) high electro-magnetic interference, such as can be found on certain types of welding equipment and radio transceivers;
- p) supply voltage fluctuations outside the specification in accordance with IEC 60204-1, which may be caused by the switching of large loads;
- q) sensitivity levels which can differ from the requirements of this part of ISO 13856;
- r) the need for reset and the location of the reset button;
- s) required control category of pressure-sensitive mat or pressure-sensitive floor in accordance with EN 954-1;
- t) need for special wording, signs and marking;
- u) sensor fixing.

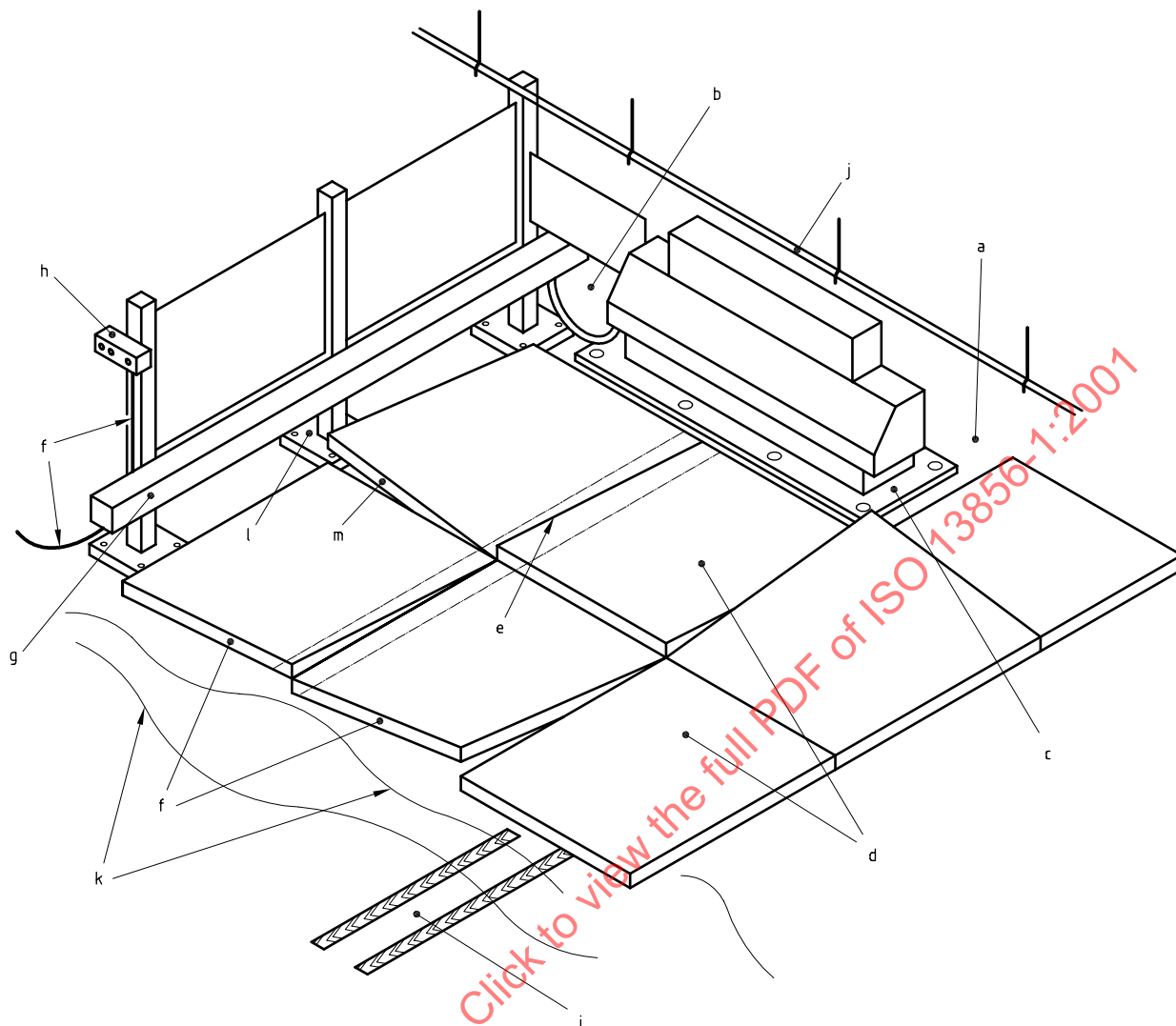
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B.5 Comparison between good and poor installation design



- a Additional fixed guards are fitted, which prevent access to the danger zone of the machinery.
- b The fixed guard is arranged and designed in such a way that there is no access to the danger zone between the fixed guard and the sensors. The fixed guard permits access to the danger 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 danger zone.
- d Sensors are properly installed.
- e The dead zones of the sensors are located in such a way 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 may 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 danger zone is fully visible.

Figure B.1 — Well-designed installation



- a Fixed guards to the danger zone are not sufficient.
- b The danger zone is not protected from the rear and is accessible by reaching over and under the fixed guard, which is too small.
- c The operator can stand on the machinery baseplate in the danger zone.
- d The sensors are not properly fixed.
- e The dead zones of the sensors are located in such a way that the operator can reach the danger zone.
- f Tripping hazards presented by exposed edges of sensors and trailing cables: trailing cables are not protected against mechanical damage.
- g Cable trunking is installed on the inside of the fixed guard and can be misused to provide access to the danger zone.
- h The control unit is installed in a vulnerable position and can be subject to mechanical damage from passing traffic.
- i Sensors should not be installed on traffic routes.
- j A service pipe installed above the sensors may be misused and consequently swung over the sensors into the danger zone.
- k The function and expected service life of the sensors will be reduced due to ground irregularities.
- l Access to the danger zone is provided by the baseplates of the fixed guard.
- m Sensor not fastened down and presenting a tripping hazard