INTERNATIONAL STANDARD

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Safety of machinery — Pressure-sensitive protective devices —

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

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

Partie 3: Principes généraux de conception et d'essai des pare-chocs, plaques, câbles et dispositifs analogues sensibles à la pression

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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 13856-3 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 pressure-sensitive edges and pressure-sensitive bars*

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

Introduction

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

The safeguarding of machinery (see ISO 12100-1:2003, 3.20) can be achieved by many different means. These means include guards which prevent access to the hazard zone by means of a physical barrier (e.g. fixed guards according to ISO 14120, or interlocking guards according to ISO 14119), protective devices (e.g. electro-sensitive protective equipment according to IEC 61496) and pressure-sensitive protective devices according to this part of ISO 13856.

Type-C standards makers and designers of machinery/installations (see below for an explanation of the different types of machinery safety standards) need to 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 14121). The best solution may combine several of these different means. It is advisable, too, that the machinery/installation supplier and the user examine together carefully the existing constraints before making their decision on the choice of safeguarding means.

This part of ISO 13856 does not specify the dimensions and the configuration of the effective sensing surface of pressure-sensitive protective devices in relation to any particular application. However, there is a requirement for the manufacturer of any safety device to provide sufficient information to enable the user (i.e. the machinery manufacturer and/or the user of the machinery) to specify an adequate arrangement.

The forces specified in this part of ISO 13856 should not be considered as those which will always avoid injury or fatal accidents. This depends upon several criteria which include the sensor, the actuating speed, the contact area, the material used and the part of the body affected.

The forces specified in this part of ISO 13856 are primarily intended for the purpose of assessing the performance of the pressure-sensitive protective devices. These forces are under further investigation.

Each type of application of pressure-sensitive protective devices can present particular hazards. It is not the intention of this document to identify those hazards nor to recommend specific applications to particular equipment. Particular applications may also necessitate special requirements which are not included in this document.

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

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

— 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);

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

This part of ISO 13856 is a type-B2 standard as stated in ISO 12100-1.

When provisions of a type-C standard are different from those which are stated in type-A or -B standards, the provisions of the type-C standard take precedence over the provisions of the other standards, for machines that have been designed and built according to the provisions of the type-C standard.

ISO/TC 199 has a mandate in this area to produce type-A and type-B standards, which will allow verification of conformity with the essential safety requirements.

ISO 13856-3 is based on EN 1760-3:2004, published by the European Committee for Standardization (CEN).

Safety of machinery — Pressure-sensitive protective devices —

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

1 Scope

This part of ISO 13856 gives basic requirements for those pressure-sensitive protective devices, with or without an external reset facility, that are not specified in either ISO 13856-1 or ISO 13856-2, the majority of which are produced for specific applications and are not available as off-the-shelf items. It also gives specific requirements for the following devices:

— pressure-sensitive bumpers;

— pressure-sensitive plates;

— pressure-sensitive wires (trip wires).

Its purpose relates primarily to safety and reliability rather than suitability (for the relationship between safety and reliability, see ISO 13849-1:1999, Annex D). It does not specify the dimensions of pressure-sensitive protective devices in relation to any particular application. Specific requirements for particular applications are intended to be set forth in relevant type-C standards (see ISO 12100-1 and the Introduction).

This part of ISO 13856 does not cover stopping devices used only for the regular operation (including emergency stopping) of machinery. Nor does it apply to use in locations accessible to elderly or disabled persons or children, where special additional requirements can be necessary.

NOTE Some requirements of this part of ISO 13856 are made with respect to electromagnetic compatibility (EMC). These are intended to meet only the requirements of Council Directive 98/37/EC ("Machinery Directive") [1] and not those of Council Directive 89/336/EC ("EMC Directive") [2] of the European Union.

2 Normative references

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

ISO 4413, *Hydraulic fluid power — General rules relating to systems*

ISO 4414, *Pneumatic fluid power — General rules relating to systems*

ISO 12100-1:2003, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology*

ISO 12100-2:2003, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles*

ISO 13849-1:1999, *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 13855:2002, *Safety of machinery — Positioning of protective equipment with respect to the approach speeds of parts of the human body*

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

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

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

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

IEC 60204-1:1997, *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 60664-1:1992, *Insulation coordination for equipment within low-voltage systems — Part 1: Principles, requirements and tests*

IEC 60947-5-1, *Low-voltage switchgear and controlgear — Part 5-1: Control circuit devices and switching elements —Electromechanical control circuit devices*

IEC 60947-5-5:1997, *Low-voltage switchgear and controlgear — Part 5-5: Control circuit devices and switching elements — Electrical emergency stop device with mechanical latching function*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) — Part 4-2: Testing and measurement 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 61000-4-6, *Electromagnetic compatibility (EMC) — Part 4-6: Testing and measurement techniques — Immunity to conducted disturbances, induced by radio-frequency fields*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100-1:2003 and the following apply.

3.1
pressure-sensitive protective device
safety device of the "mechanically actuated trip type" which can also act as an impeding device as defined in ISO 12100-1:2003, 3.27, intended to detect the touch of a person or part of a person

NOTE 1 It consists of

— a sensor(s) which generates a signal when pressure is applied to part of its outer surface, and

— a control unit, which responds to the signal from the sensor and generates an output signal(s) to the control system of a machine.

NOTE 2 Pressure-sensitive protective devices can be used as tripping devices as well as presence-sensing devices as defined in ISO 12100-1:2003, 3.26.5.

3.1.1
pressure-sensitive bumper
pressure-sensitive protective device with a sensor whose characteristics are

— a cross-section throughout the pressure-sensitive area that can be regular or irregular,

— a cross-section width usually greater than 80 mm, and

— an effective sensing surface that is deformed locally or that can move as a whole

3.1.2
pressure-sensitive plate
pressure-sensitive protective device with a sensor whose characteristics are

— an effective sensing surface that is normally, but not necessarily, flat,

— an effective sensing surface width usually greater than 80 mm, and

— an effective sensing surface that moves as a whole

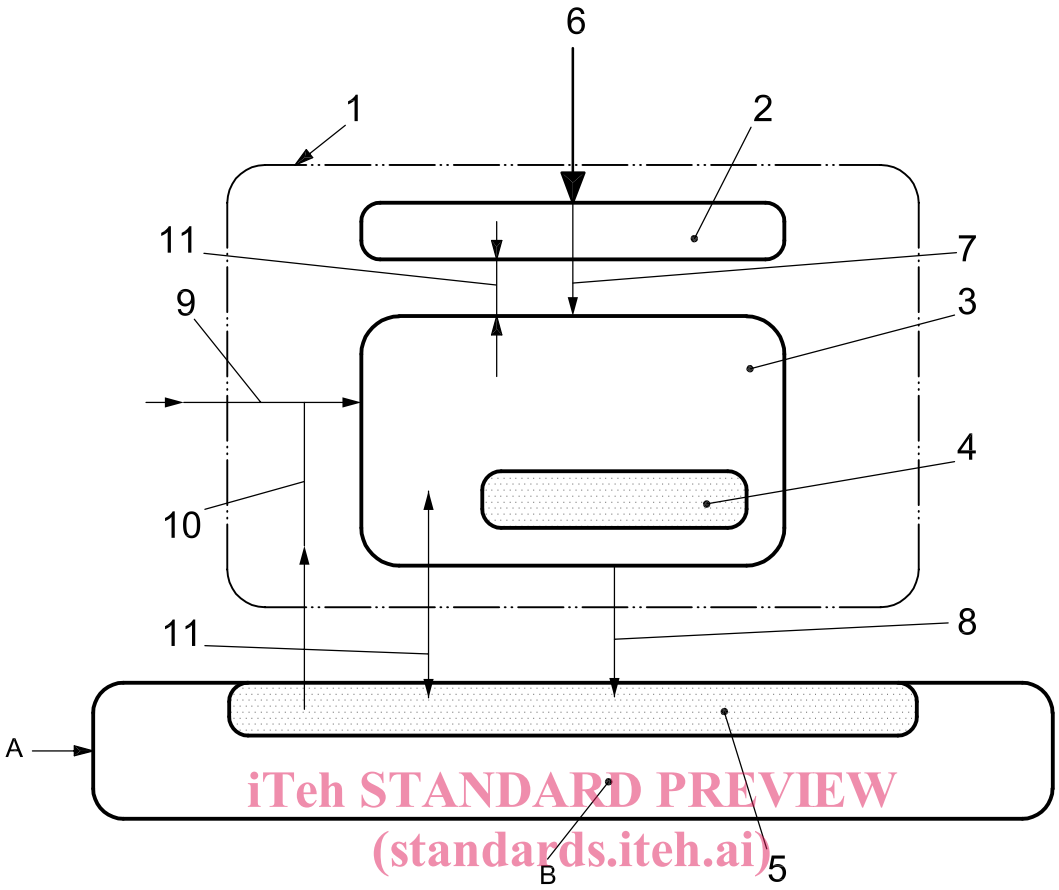
3.1.3
pressure-sensitive wire
pressure-sensitive protective device with a sensor whose characteristics are

— a wire, cord, rope, or cable held in tension, and

— where a change in the tension is detected to give an output signal

3.2
sensor
that part of the pressure-sensitive protective device which generates a signal in response to sufficient pressure applied to part of its surface

NOTE This definition together with that of **control unit** (3.3) cover the functional components of a pressure-sensitive protective device. These functions can be integrated into a single assembly or contained in any number of separate assemblies (see Figure 1).



Key

A manual reset signal to the machine control system [a]
B machine control system(s)

1 pressure-sensitive protective device
2 sensor(s)
3 control unit [b]
4 output signal switching device
5 part of machine control system for pressure-sensitive protective device output signal processing
6 actuating force
7 sensor output signal
8 ON state/OFF state signal
9 manual reset signal [c]
10 reset signal from machine control system (where appropriate)
11 monitoring signals (optional)

[a] Where appropriate, this may be used as an alternative to 9.
[b] Can be located within the machine control system or as part of the machine control system, e.g. as a logic block.
[c] Where appropriate, this may be used as an alternative to A.

Figure 1 — Pressure-sensitive protective device as applied to machines

3.3
control unit
that part of the pressure-sensitive protective device which responds to the condition of the sensor and generates output signals to the machine control system

NOTE This definition together with that of **sensor** (3.2) cover the functional components of a pressure-sensitive protective device. These functions can be integrated into a single assembly or contained in any number of separate assemblies (see Figure 1).

3.4
output signal switching device
part of the control unit of a pressure-sensitive protective device which is connected into the machine control system and transmits safety output signal(s)

3.5
ON state
state of an output switching device in which the output circuit(s) is complete and permits the flow of current or fluid

3.6
OFF state
state an output switching device in which the output circuit(s) is broken and interrupts the flow of current or fluid

3.7
actuating force
any force applied to the sensor which causes the output signal switching device to go to the OFF state

3.8
approach speed
relative speed at which contact is made between the surface of the sensor and a part of the body

3.9
effective sensing surface
that part of the surface of the sensor or a combination of sensors, as stated by the manufacturer, where the application of an actuating force creates an OFF state in the output signal switching device

3.10
effective sensing direction(s)
direction(s) of the actuating force from which the sensor will be actuated

3.11
dead surface
part of the surface area of the sensor outside the effective sensing surface

3.12
actuating travel
distance travelled by a specified object, moving in the direction of the applied actuating force, and measured from the point where this object touches the effective sensing surface to the point where the output signal switching device changes to an OFF state under specified conditions

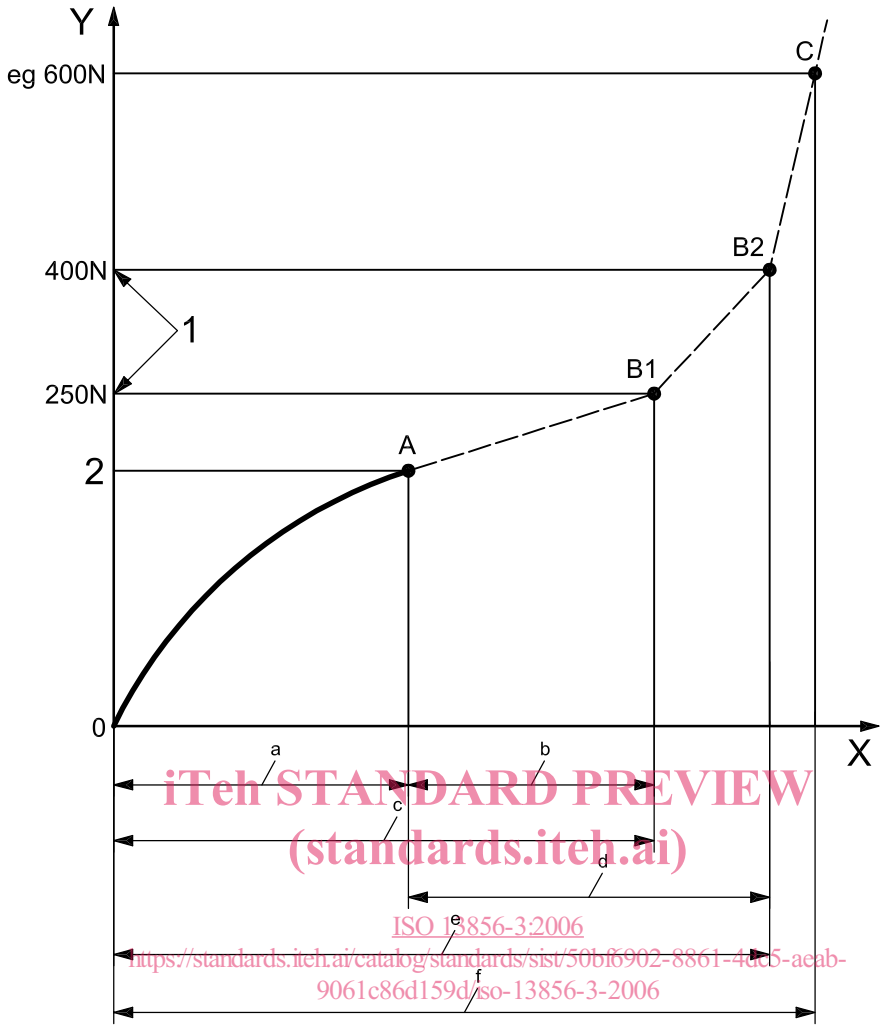
See Figure 2.

NOTE Actuating travel can differ from *pre-travel*, a term relating to an edge or bar (see ISO 13856-2) and signifying travel in the direction normal to the reference axis; actuating travel is in the direction of the applied force.

3.13
working travel
distance travelled by a specified object, moving in the direction of the applied actuating force, and measured from the point where this object touches the effective sensing surface, under specified conditions, to where a specified force is exerted on the object

See Figure 2.

NOTE See also Annex B.



Key

X travel, mm

Y force, N

1 stated limit force

2 lowest actuating force

Force–travel point A is the actuating point and the point of maximum operating speed.

Force travel points B1 and B2 occur at a force of 250 N or 400 N and at an operating speed of $\leqslant$ 10 mm/s.

Force–travel point C occurs at, in this example, 600 N and at an operating speed of $\leqslant$ 10 mm/s.

NOTE Test piece 1 (see Table 1) is used to apply the forces.

a Actuating travel.

b Overtravel at 250 N.

c Working travel at 250 N.

d Overtravel at 400 N.

e Working travel at 400 N.

f Total travel.

Figure 2 — Example of force–travel diagram

3.14
overtravel
difference between the working travel and the actuating travel when both these distances are measured with the same object applied under the same conditions

See Figure 2.

3.15
force–travel relationship
relationship between the force applied and the distance travelled by a pressure-sensitive protective device in operation

See Figure 2.

3.16
reset
function which permits an ON state in the output signal switching device, provided that certain conditions are met

3.17
mounting orientations
position in space of the sensor

3.18
presence-sensing device
PSD
device that creates a sensing field, area or plane for detecting the presence of a part or the whole of a person

NOTE Pressure-sensitive protective devices can be used as tripping devices as well as presence-sensing devices as defined in ISO 12100-1:2003, 3.26.5.

3.19
total travel
movement or deformation of the effective sensing surface of a pressure-sensitive protective device, measured in the direction of the actuating force from the point of contact to the point where no further significant deformation of the effective sensing surface occurs

4 Requirements

4.1 General

The majority of devices covered by this part of ISO 13856 are made for specific applications. Where appropriate, the device manufacturer and the machine builder shall agree on the requirements in accordance with the risk assessment and specify the essential force–travel data for the application.

The device shall have dimensions and be positioned such that the sensor will detect by touch the approach of a person or part of a person to a dangerous situation or a danger zone.

In general, there are two types of application, as follows.

a) The device is used to stop the dangerous parts of machinery that are remote from the sensor. In this application, the distance between the sensor and the moving parts of the machine shall be such that the machine stops before any part of the body can reach the hazardous zone. The distance shall be calculated on the basis of the principles presented in ISO 13855. See the example given in C.3.2.

b) The sensor is mounted on the dangerous part of the machine or adjacent to it, so that the machine will stop or reverse to a safe position after the sensor is actuated and before injury can occur. See the example given in C.2.10.

The following basic requirements apply to all the devices covered by this part of ISO 13856. Additional specific requirements are given for pressure-sensitive bumpers, pressure-sensitive plates and pressure-sensitive wires. The specific requirements according to 4.3 to 4.5 take precedence over the basic requirements given in 4.2.

4.2 Basic requirements

4.2.1 Actuating force

NOTE 1 See 7.1.1 and 7.1.5 for verification.

The lowest actuating force(s) necessary to cause the output signal switching device to go to an OFF state shall not exceed those specified in Table 1 when applied

— in the reference direction(s),

— over the effective sensing surface,

— at the relevant approach speed(s),

— with the sensor in the mounting orientations,

— with the relevant test piece, or

— over the temperature range,

which the manufacturer of the device has specified or have been agreed upon by the manufacturer of the device and the machine builder(s).

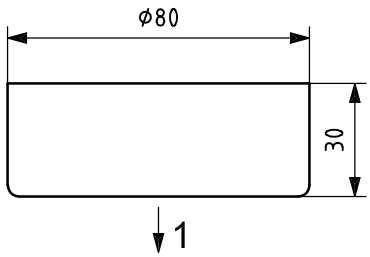
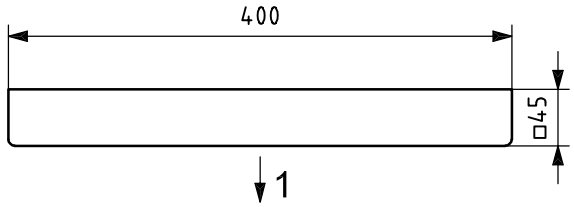
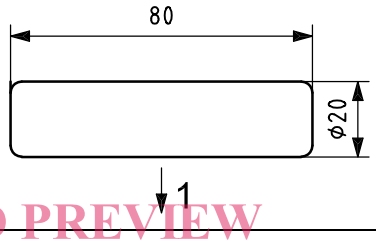
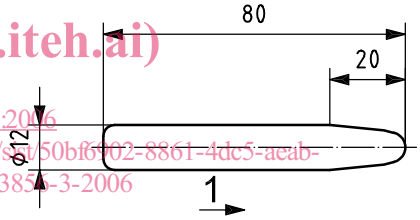
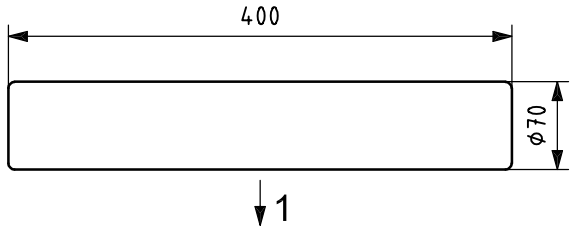
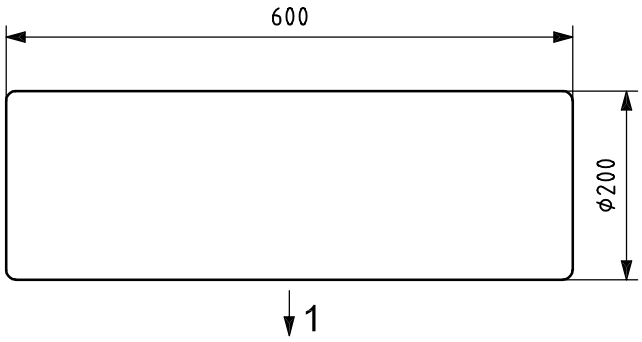
The lowest actuating force could need to be less than that stated in Table 1 for specific applications and designs of sensor. See, for example, 4.5.3 for the lowest actuating force necessary to cause the control unit for pressure-sensitive wires to go to the OFF state.

NOTE 2 The risk assessment will show which part(s) of the body are to be considered for a particular application, enabling the relevant test piece(s) to be used.

NOTE 3 The forces specified in this clause are primarily intended for the purpose of assessing the pressure-sensitive performance of the device. These forces ought not be considered as safe forces (see Annex C and ISO 14120:2002, 5.2.5.2, for guidance).

NOTE 4 Certain applications, e.g. protecting the neck, may require a higher sensitivity device, i.e. actuating forces lower than those shown in Table 1.

Table 1 — Test pieces, actuating forces and test directions

Test piece 1 Actuating force: 150 N Test piece to simulate body part: Head or hand	
Test piece 2 Actuating force: 400 N Body part: Shoulder	
Test piece 3 Actuating force: 50 N Body part: Finger (knuckle)	
Test piece 4 Actuating force: 50 N Body part: Finger (tip)	
Test piece 5 Actuating force: 250 N Body part: Arm or leg	
Test piece 6 Actuating force: 400 N Body part: Whole body	
1 test direction	