# INTERNATIONAL STANDARD

# ISO 13856-3

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# Safety of machinery — Pressure-sensitive protective devices —

## Part 3:
## General principles for 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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# Contents

Page

**Foreword** .... **iv**
**Introduction** .... **v**
**1 Scope** .... **1**
**2 Normative references** .... **1**
**3 Terms and definitions** .... **2**
**4 Requirements for design and testing** .... **8**
4.1 General .... 8
4.2 Basic requirements .... 8
4.3 Specific requirements for pressure-sensitive bumpers .... 15
4.4 Specific requirements for pressure-sensitive plates .... 16
4.5 Specific requirements for pressure-sensitive wires (trip wires) .... 16
**5 Marking** .... **17**
5.1 General .... 17
5.2 Labels .... 17
5.3 Marking of the control unit .... 17
5.4 Marking of the sensor .... 17
**6 Information for selection and use** .... **17**
6.1 General .... 17
6.2 Essential data for selection of suitable pressure-sensitive protective device .... 18
6.3 Information for use .... 19
**7 Verification of requirements** .... **21**
7.1 Verification of requirements applicable to all pressure-sensitive protective devices covered by this part of ISO 13856 .... 21
7.2 Verification of requirements for pressure-sensitive bumpers only .... 31
7.3 Verification of requirements for pressure-sensitive plates only .... 32
7.4 Verification of requirements for pressure-sensitive wires only .... 32
7.5 Other tests .... 33
**Annex A** (normative) **Timing diagrams for pressure-sensitive bumpers, plates, wires and similar devices with/without reset** .... **34**
**Annex B** (informative) **Device characteristics — Explanatory remarks and recommendations** .... **38**
**Annex C** (informative) **Design guidance** .... **40**
**Annex D** (informative) **Application guidance** .... **50**
**Annex E** (informative) **Commissioning and inspection** .... **54**
**Bibliography** .... **56**



# 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* and by Technical Committee CEN/TC 114, *Safety of machinery* in collaboration.

This second edition cancels and replaces the first edition (ISO 13856-3:2006), 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 should 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.

This part of 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.

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

The forces for the activation of the pressure-sensitive protection devices specified in this part of ISO 13856 are based on the information available at the time of publication. These forces will be kept under review so that the results of further research into forces that can be applied to the human body without causing significant injury can be taken into account. While these forces provide a practical means for the design and testing of the pressure-sensitive device, they cannot prevent injury in all applications. When specifying the actuating force for a specific device or application many factors should be taken into account. These include the contact area, the contact speed, the material used and the part of the body affected.

# Safety of machinery — Pressure-sensitive protective devices —

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

## 1 Scope

This part of ISO 13856 establishes general principles and specifies requirements for the design and testing of 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, and the majority of which are produced for specific applications and are not available as "off-the-shelf" items.

This part of ISO 13856 also gives specific requirements for the following pressure-sensitive protective devices:

a) pressure-sensitive bumpers;

b) pressure-sensitive plates;

c) pressure-sensitive wires (trip wires).



It deals with the design of a pressure-sensitive device with regard to safety and reliability rather than its suitability for particular applications.



NOTE 1 For the relationship between safety and reliability, see ISO 13849-1:2006, 4.2.

NOTE 2 The machinery manufacturer and/or user is responsible for installing appropriate types of protective device based on a risk assessment.

It is not applicable to

— specifying the dimensions of pressure-sensitive protective devices in relation to any particular application, or

— stopping devices according to IEC 60204-1 used for the normal operation, including emergency stopping of machinery.

NOTE 3 Specific requirements for particular applications are intended to be set forth in relevant type-C standards (see ISO 12100 and Introduction).

Additional requirements can be necessary where pressure-sensitive protective devices are used in locations accessible to elderly or disabled people or children.

NOTE 4 While requirements are given for the immunity of the device to electromagnetic disturbances, these are not intended to cover all aspects of electromagnetic compatibility (EMC).

## 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 4413, *Hydraulic fluid power — General rules and safety requirements for systems and their components*

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

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 13855:2010, *Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of the human body*

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 60068-2-27, *Environmental testing — Part 2-27: Tests — Test Ea and guidance: Shock*

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 60664-1:2007, *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 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 61000-4-6, *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*

IEC 61439-1:2009, *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 and the following apply.

**3.1**
**pressure-sensitive protective device**
sensitive protective equipment of the “mechanically activated trip” type intended to detect the touch of a person or body part of a person and which can also act as impeding device

Note 1 to entry: A pressure-sensitive protective device consists of a sensor or sensors, 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 to entry: Pressure-sensitive protective devices can be used as tripping devices as well as presence-sensing devices, as mentioned in ISO 12100:2010, Note to 3.28.5. For presence-sensing devices, see also 4.2.6.2.

Note 3 to entry: For the definitions of sensitive protective equipment and impeding device, see ISO 12100:2010, 3.28.5 and 3.29, respectively.

**3.1.1**
**pressure-sensitive bumper**
*pressure-sensitive protective device* (3.1) with a *sensor* (3.3) or sensors 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* (3.10) that is deformed locally or that can move as a whole

**3.1.2**
**pressure-sensitive plate**
*pressure-sensitive protective device* (3.1) with a *sensor* (3.3) or sensors whose characteristics are an *effective sensing surface* (3.10) 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



Note 1 to entry: See Figure C.5.



**3.1.3**
**pressure-sensitive wire**
*pressure-sensitive protective device* (3.1) with a *sensor* (3.3) or sensors 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**
**presence-sensing device**
**PSD**
sensitive protective equipment that creates a sensing field, area or plane for detecting the presence of a body part or the whole of a person

Note 1 to entry: Pressure-sensitive protective devices can be used as tripping devices as well as presence-sensing devices, as mentioned in ISO 12100:2010, Note to 3.28.5.

Note 2 to entry: See also 4.2.6.2.

**3.3**
**sensor**
part of the *pressure-sensitive protective device* (3.1) which generates a signal in response to sufficient pressure applied to part of its surface

Note 1 to entry: This definition together with that of *control unit* (3.4) covers 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**
**control unit**
part of the *pressure-sensitive protective device* (3.1) which responds to the condition of the *sensor* (3.3) and generates output signals to the machine control system

Note 1 to entry: This definition together with that of *sensor* (3.3) covers 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.

**3.5**
**output signal switching device**
part of the *control unit* (3.4) of a *pressure-sensitive protective device* (3.1) which is connected to the machine control system and transmits output signals

**3.6**
**ON state**
state in which the output circuit(s) of an *output signal switching device* (3.5) is complete and permits the flow of current or fluid

**3.7**
**OFF state**
state in which the output circuit(s) of an *output signal switching device* (3.5) is broken and interrupts the flow of current or fluid

**3.8**
**actuating force**
any force applied to the *sensor* (3.3) which causes the *output signal switching device* (3.5) to go to the *OFF state* (3.7)



**3.9**
**approach speed**
relative speed at which contact is made between the surface of the *sensor* (3.3) and a part of the body

**3.10**
**effective sensing surface**
part of the surface of the *sensor* (3.3) or a combination of sensors, as stated by the manufacturer, where the application of an *actuating force* (3.8) creates an *OFF state* (3.7) in the *output signal switching device* (3.5)

**3.11**
**effective sensing direction(s)**
direction(s) of the *actuating force* (3.8) from which the *sensor* (3.3) will be actuated

**3.12**
**dead surface**
part of the surface area of the *sensor* (3.3) outside the *effective sensing surface* (3.10)

**3.13**
**actuating travel**
distance travelled by a specified object, moving in the direction of the applied *actuating force* (3.8), and measured from the point at which this object touches the *effective sensing surface* (3.10) to the point at which the *output signal switching device* (3.5) changes to an *OFF state* (3.7) under specified conditions

Note 1 to entry: See Figure 2.

Note 2 to entry: Actuating travel can differ from *pre-travel*, a term relating to a pressure-sensitive edge or pressure-sensitive 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.

**3.14**
**working travel**
distance travelled by a specified object, moving in the direction of the applied *actuating force* (3.8), and measured from the point at which this object touches the *effective sensing surface* (3.10), under specified conditions, to where a specified force is exerted on the object

Note 1 to entry: See Figure 2 and Annex B.

**3.15**
**overtravel**
difference between the *working travel* (3.14) and the *actuating travel* (3.13) when both these distances are measured with the same object applied under the same conditions

Note 1 to entry: See Figure 2.

**3.16**
**force-travel relationship**
relationship between the force applied and the distance travelled by a *pressure-sensitive protective device* (3.1) in operation

Note 1 to entry: See Figure 2.

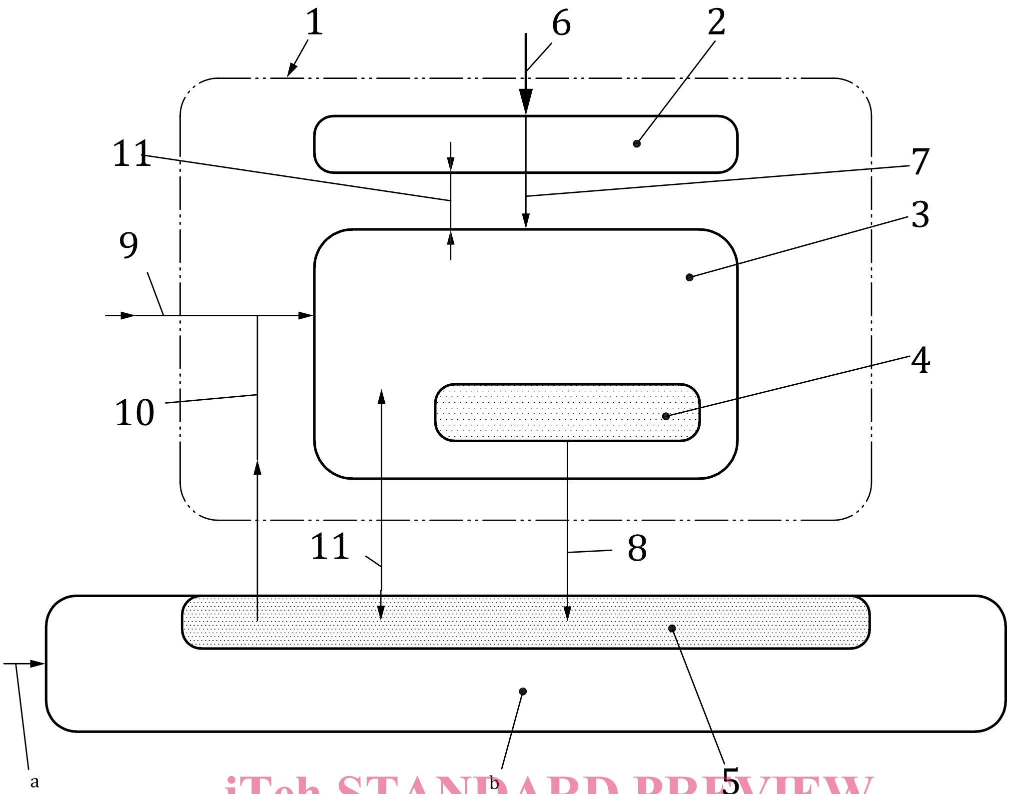
**3.17**
**reset**
function which permits an *ON state* (3.6) in the *output signal switching device* (3.5), provided that certain conditions are met



**3.18**
**mounting orientation**
orientation in space of the *sensor* (3.3)



**3.19**
**total travel**
movement or deformation of the *effective sensing surface* (3.10) of a *pressure-sensitive protective device* (3.1), measured in the direction of the *actuating force* (3.8) from the point of contact to the point at which no further significant deformation of the effective sensing surface occurs






**Key**

1 pressure-sensitive protective device

2 sensor(s)

3 control unit*

4 output signal switching device

5 part of the machine control system for pressure-sensitive protective device output signal processing

6 actuating force

7 sensor output

8 ON state/OFF state signal

9 manual reset signal**

10 reset signal from machine control system (where appropriate)

11 monitoring signals (optional)

a manual reset signal to the machine control system***

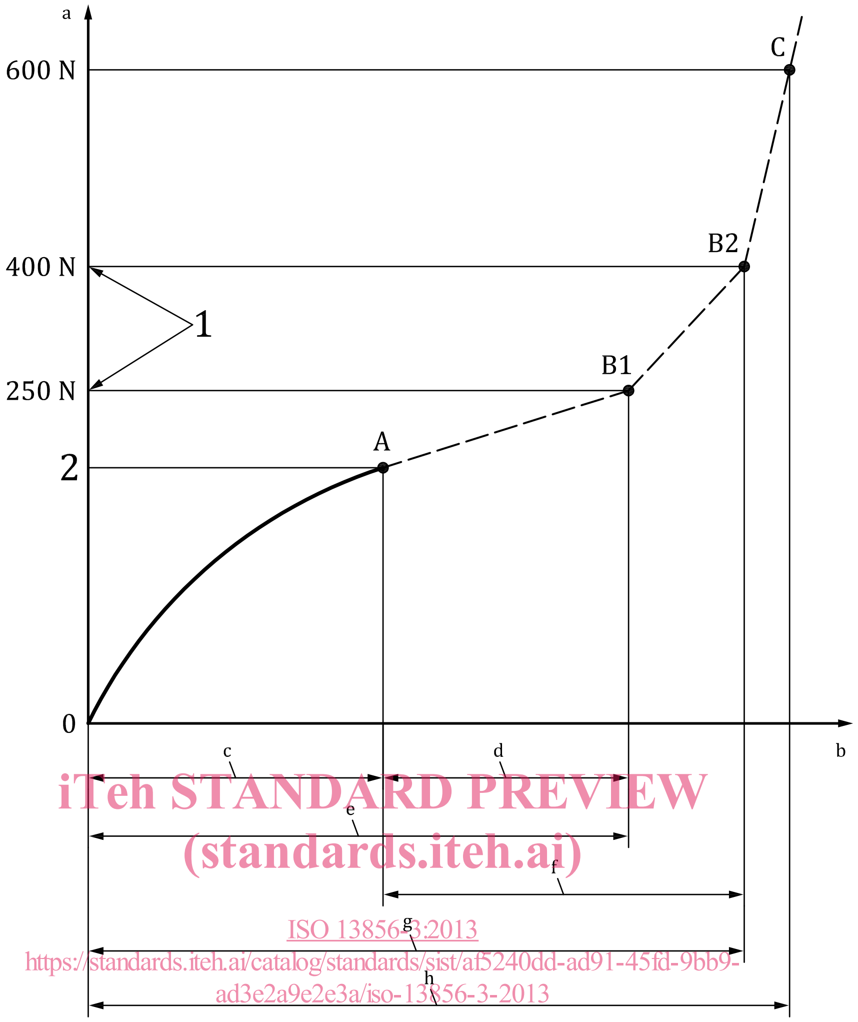
b machine control system(s)

* Can be located within the machine control system or as part of the machine control system, e.g. as a logic block.

** Where appropriate, this may be used as an alternative to a.

*** Where appropriate, this may be used as an alternative to 9.

**Figure 1 — Systematic sketch of pressure-sensitive protective device as applied to machine**






**Key**

A actuating point and actuating force at maximum operating speed

B force-travel points occurring at force of 250 N (B1) or 400 N (B2) at operating speed of ≤ 10 mm · s−1

C force-travel point occurring, for example, at a force of 600 N at an operating speed of ≤ 10 mm · s−1

1 reference force

2 lowest actuating force

a force, N

b travel, mm

c actuating travel

d overtravel at 250 N

e working travel at 250 N

f overtravel at 400 N

g working travel at 400 N

h total travel

**Figure 2 — Diagram of force-travel relationship — Example**

# 4 Requirements for design and testing

## 4.1 General

The majority of pressure-sensitive protective 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 application specific requirements in accordance with a risk assessment and specify the essential force-travel data for the application.

The pressure-sensitive protective 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 hazardous situation or a hazard zone.

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

a) The device is used to stop the hazardous 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.4.2.

b) The sensor is mounted on the hazardous 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.3.10.

The following basic requirements apply to all the pressure-sensitive protective devices covered by this part of ISO 13856. Additional specific requirements are given for pressure-sensitive bumpers, pressure-sensitive plates and pressure-sensitive wires. These 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

For the test method, see 7.1.1 and 7.1.5.

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 2, 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, and

— over the temperature range,

which the manufacturer of the pressure-sensitive protective device has specified or which have been agreed by the manufacturer of the pressure-sensitive protective device and the machine builder(s).

The lowest actuating force could need to be less than that stated in Table 2 for specific applications and designs of sensor. See 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 1 A suitable risk assessment will show which body part(s) are to be considered for a particular application, enabling the relevant test piece(s) to be used.

NOTE 2 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 to be considered as safe forces for all applications (see Introduction and Annex C for guidance).

NOTE 3 Certain applications — for example, protecting the neck — can require a device with a higher sensitivity, i.e. actuating forces lower than those shown in Table 2.

### 4.2.2 Actuating travel

For the test method, see 7.1.1 and 7.1.6.

The actuating travel shall be not more than that stated by the manufacturer of the pressure-sensitive protective device. For devices manufactured for a specific application, the actuating travel shall be appropriate for the application (see Annex B for advice on the force-travel relationship of specific devices).

### 4.2.3 Overtravel

For the test method, see 7.1.1 and 7.1.7.

The overtravel shall be not less than that stated by the manufacturer of the pressure-sensitive protective device. For devices manufactured for a specific application, the overtravel shall be appropriate for the application (see Annex B for advice on the force-travel relationship of specific devices).

### 4.2.4 Approach speed

For the test methods, see 7.1.1, 7.1.5, 7.1.6 and 7.1.7.



The sensor shall be able to cause an OFF state in the output signal switching device when actuated with the foreseeable approach speed(s) as stated by the manufacturer of the pressure-sensitive protective device. For devices manufactured for a specific application, the approach speed shall be appropriate for the application.



### 4.2.5 Number of operations

For the test method, see 7.1.1 and 7.1.8.

The pressure-sensitive protective device shall continue in normal operation and the sensor shall have no visible signs of damage after the number of operations stated by the manufacturer of the device. For devices manufactured for a specific application, the number of operations shall be appropriate for that application.

### 4.2.6 Response of output signal switching device to actuating force

#### 4.2.6.1 Systems where sensor output remains in changed state as long as actuating force is applied

For the test method, see 7.1.1 and 7.1.9.

When the actuating force has been applied to the sensing surface of the sensor, the sensor output shall change state, causing the output signal switching device to change from an ON state to an OFF state. The change in state of the sensor output is a direct function of the applied force and this new state of the sensor output shall remain for as long as the actuating force is applied.

The output signal switching device shall only revert to the ON state when

— for systems with reset, the actuating force is removed and a reset signal is applied (see Figures A.1 and A.2), or

— for systems without reset, the actuating force is removed (see Figure A.3).