

Australian Standard™

Safeguarding of machinery

Part 5: Manufacturing and testing requirements for electro-sensitive systems — Pressure-sensitive devices

This Australian Standard was prepared by Committee SF/41, General Principles for the Guarding of Machinery. It was approved on behalf of the Council of Standards Australia on 29 May 1998 and published on 5 August 1998.

The following interests are represented on Committee SF/41:

Australian Chamber of Commerce and Industry
Australian Manufacturing Workers Union
Department for Industrial Affairs, S.A.
Department of Training and Industrial Relations, Qld
Electricity Supply Association of Australia
Ergonomics Society of Australia
Federal Chamber of Automotive Industries
Metal Trades Industry Association of Australia
National Safety Council of Australia
Safety Institute of Australia
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This Standard was issued in draft form for comment as DR 97422.

Australian Standard™

Safeguarding of machinery

Part 5: Manufacturing and testing requirements for electro-sensitive systems — Pressure-sensitive devices

Originated as part of AS 4024.2(Int) — 1992.
Revised and redesignated in part as AS 4024.5 — 1998.

Published by Standards Australia
(Standards Association of Australia)
1 The Crescent, Homebush, NSW 2140

ISBN 0 7337 2056 0



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PREFACE

This Standard was prepared by the Standards Australia Committee SF/41, General Principles for the Guarding of Machinery as a revision, in part, of AS 4024.2 (Int) — 1992, *Safeguarding of machinery, Part 2: Presence sensing systems*.

During the preparation of this Standard the Committee considered two documents emanating from the European Committee for Standardization, (CEN) which have also been circulated as Committee Drafts by the International Organization for Standardization (ISO). These documents are prEN 1760.1, *Safety of machinery—Pressure sensitive protective devices Part 1: General principles for the design and testing of pressure sensing mats and floors*, and prEN 1760.2, *Safety of machinery—Pressure sensitive protective devices Part 2: General principles for the design and testing of pressure sensitive edges and pressure sensitive bars*.

The Standard was developed because of the increasing use in industry of pressure-sensitive devices as a means of safeguarding certain types of machinery. By making use of existing documents on the subject matter, the Committee is seeking to minimize the cost to industry which will use this type of protective device.

Standards Australia has a policy of adopting an International Standard where it is possible to do so. It is likely therefore, that when the above European Standards are published and adopted as International Standards, that they will be adopted as Australian Standards during a review of this Standard.

The term ‘normative’ has been used in this Standard to define the application of the appendix to which it applies. A ‘normative’ appendix is an integral part of a Standard.

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CONTENTS

	<i>Page</i>
SECTION 1 SCOPE AND GENERAL	
1.1 SCOPE	5
1.2 OBJECTIVE	5
1.3 APPLICATION	5
1.4 REFERENCED DOCUMENTS	5
1.5 DEFINITIONS	6
 SECTION 2 COMMON REQUIREMENTS FOR PRESSURE-SENSITIVE DEVICES	
2.1 GENERAL	14
2.2 ENVIRONMENTAL CONDITIONS	14
2.3 POWER SUPPLY	15
2.4 ENCLOSURES	15
2.5 ADJUSTMENT	15
2.6 RESET	15
2.7 CATEGORIES	16
2.8 CONNECTION	16
2.9 INFORMATION FOR USE	18
 SECTION 3 SPECIFIC REQUIREMENTS FOR PRESSURE-SENSITIVE MATS AND FLOORS	
3.1 SENSOR(S) — SHAPE(S), SIZE(S) AND COMBINATIONS	20
3.2 ACTUATING FORCE	20
3.3 RESPONSE TIME	22
3.4 STATIC FORCE	22
3.5 NUMBER OF OPERATIONS	24
3.6 SENSOR OUTPUT STATE	24
3.7 RESPONSE OF OUTPUT SIGNAL SWITCHING DEVICE(S) TO THE ACTUATING FORCE	24
3.8 SENSOR FIXINGS	24
3.9 TRIPPING	24
3.10 SLIPPERINESS AND SOFTNESS OF THE SENSOR TOP SURFACES	24
3.11 ADDITIONAL COVERINGS OF TOP SURFACES OF SENSOR(S)	24
3.12 MARKING	24
3.13 INFORMATION FOR USE	25
 SECTION 4 SPECIFIC REQUIREMENTS FOR PRESSURE-SENSITIVE EDGES AND BARS	
4.1 ESSENTIAL DATA FOR THE SELECTION OF A SUITABLE DEVICE(S) ..	27
4.2 EFFECTIVE SENSING FIELD	27
4.3 ACTUATING FORCE	27
4.4 ACTUATING DISTANCES	29
4.5 OVERTRAVEL DISTANCES	29
4.6 FORCE DISTANCE RELATIONSHIP(S)	29
4.7 MAXIMUM OPERATING SPEED	29
4.8 NUMBER OF OPERATIONS	29
4.9 SENSOR OUTPUT	29

4.10	RESPONSE OF OUTPUT SIGNAL SWITCHING DEVICE TO THE ACTUATING FORCE	29
4.11	ADDITIONAL COVERINGS FOR SENSORS	29
4.12	SENSOR FIXING	29
4.13	DEFORMATION	30
4.14	SHARP CORNERS AND EXPOSED SURFACES	30
4.15	MARKING	30
4.16	INFORMATION FOR USE	31
 SECTION 5 TESTING REQUIREMENTS FOR PRESSURE-SENSITIVE MATS AND FLOORS		
5.1	GENERAL	32
5.2	SENSOR TEST SAMPLE	32
5.3	TESTPIECES FOR LOAD TESTS	32
5.4	TEST NO. 1: ACTUATING FORCE	33
5.5	TEST NO. 2: RESPONSE TIME	35
5.6	TEST NO. 3: STATIC FORCE	35
5.7	TEST NO. 4: NUMBER OF OPERATIONS	36
5.8	TEST NO. 5: OUTPUT STATE OF THE SENSOR	37
5.9	TEST NO. 6: RESPONSE OF OUTPUT SIGNAL SWITCHING DEVICE TO THE ACTUATING FORCE	37
5.10	TEST NO. 10: ENVIRONMENTAL BEHAVIOUR	41
5.11	TEST NO. 11: ELECTRICAL POWER SUPPLY	42
 SECTION 6 TESTING REQUIREMENTS FOR PRESSURE-SENSITIVE EDGES AND BARS		
6.1	GENERAL	43
6.2	TEST SAMPLES	43
6.3	TESTPIECES	44
6.4	TEST NO. 1: ESSENTIAL DATA FOR SELECTION OF A SUITABLE DEVICE(S)	44
6.5	TEST NO. 2: MOUNTING ORIENTATIONS OF SENSORS FOR TESTING	44
6.6	TEST NO. 3: ACTUATING FORCE	44
6.7	TEST NO. 4: FORCE DISTANCE RELATIONSHIP(S)	51
6.8	TEST NO. 5: NUMBER OF OPERATIONS	51
6.9	TEST NO. 6: OUTPUT STATE OF THE SENSOR AND OUTPUT SIGNAL SWITCHING DEVICE	52
6.10	TEST NO. 7: RESPONSE OF OUTPUT SIGNAL SWITCHING DEVICE . . .	52
6.11	TEST NO. 8: ENVIRONMENTAL TESTS	52
6.12	TEST NO. 9: POWER SUPPLY (ELECTRICAL)	53
6.13	TEST NO. 10: SENSOR FIXING	53
6.14	TEST NO. 11: DEFORMATION	54
APPENDIX A DESIGN AND SELECTION OF PRESSURE-SENSITIVE SYSTEMS		55

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Australian Standard

Safeguarding of machinery

Part 5: Manufacturing and testing requirements for
electro-sensitive systems — Pressure-sensitive devices

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE This Standard specifies the manufacturing and testing requirements for pressure-sensitive devices i.e. mats, floors, edges and bars, used to detect persons or parts of persons who may be exposed to contact with hazardous moving parts or may be too near a hazardous location.

Information for manufacturers relating to design of pressure-sensitive systems is given in Appendix A.

1.2 OBJECTIVE The objective of this Standard is to enable designers, manufacturers, suppliers, employers and users of machinery to minimize the risks to the health and safety of employees and others working with or otherwise near machinery.

1.3 APPLICATION This Standard is intended for use by those who design, manufacture, supply, install or use machinery-guarding or safety devices. It applies to pressure-sensitive mats and floors for general use, where persons having a mass greater than 30 kg are present. It also applies where persons having a mass not less than 15 kg may be present. It does not apply to those instances where pressure-sensitive mats and floors are used where persons having a mass of less than 15 kg are present.

It applies where pressure-sensitive edges and bars are used to either detect the presence of persons who may be exposed to contact with hazardous moving parts or who may approach too close to a danger zone.

1.4 REFERENCED DOCUMENTS The following documents are referred to in this Standard:

AS	
1099	Basic environmental testing procedures for electrotechnology
1099.2.3	Part 2.3: Tests — Test Ca — Damp heat, steady state
1543	Electrical equipment of industrial machines
1939	Degrees of protection provided by enclosures for electrical equipment (IP Code)
4024	Safeguarding of machinery
4024.1	Part 1: General principles
4024.4	Part 4: Installation and commissioning requirements for electro-sensitive systems — Pressure-sensitive devices
IEC	
60068	Basic environmental testing procedures
60068-2-6	Part 2-6: Tests — Test Fc: Vibration (sinusoidal)
60068-2-14	Part 2-14: Tests — Test N: Change in temperature
60068-2-29	Part 2-29: Tests — Test Eb and guidance: Bump

IEC	
60664	Insulation coordination for equipment within low-voltage systems
60664-1	Part 1: Principles requirements and tests
60801	Electromagnetic compatibility for industrial-process measurement and control equipment
60801-4	Part 4: Electrical fast transient/burst requirements
BS EN	
60204	Safety of machinery — Electrical equipment of machines
60204-1	Part 1: Specification for general requirements
60801	Electromagnetic compatibility for industrial-process measurement and control equipment
60801-2	Part 2: Electrostatic discharge requirements
61000	Electromagnetic compatibility (EMC)
61000-4-3	Part 4: Testing and measurement techniques — Section 4.3: Radiated, radio-frequency, electromagnetic field immunity test

1.5 DEFINITIONS For the purposes of this Standard, the definitions below apply.

1.5.1 Actuating distance — the distances travelled by an object, moving in a direction normal to the reference axis and in the axis of the applied actuating force measured from where this object touches the effective sensing field to where the output signal switching device(s) changes to an ‘off’ state under specified conditions (see Figure 1.1).

1.5.2 Actuating force — the force that produces a pressure on the effective sensing area to create an ‘off’ state in the output signal switching device when it is applied perpendicularly to the effective sensing area.

1.5.3 Control unit — the device that responds to the condition of the sensor or sensors and controls the state of the output signal switching device. It may also monitor the integrity of the pressure-sensitive device (see AS 4024.1) and it may contain facilities to process a reset signal.

1.5.4 Dead zone — that part of the top surface area of the sensor that does not respond to the actuating force.

1.5.5 Effective sensing angle — the angle around the reference axis, which limits the effective sensing field along the effective sensing length (see Figures 1.2 and 1.3).

1.5.6 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.

1.5.7 Effective sensing field — that part of the surface of the sensor or a combination of sensors of the pressure-sensitive edge or pressure-sensitive bar within the effective sensing angle and the effective sensing length where the application of an actuating force creates an ‘off’ state in the output signal switching device (see Figures 1.2 and 1.3).

1.5.8 Effective sensing length — the length of the effective sensing field.

1.5.9 Force-distance relationship — the relationship between force applied normal to the reference axis and distance travelled by a specified object normal to the reference axis under specified conditions (see Figure 1.4).

1.5.10 Mounting orientations — the position in space of the sensor (see Figure 1.5).

1.5.11 ‘Off’ state of output signal switching devices — the state in which the output circuit(s) is broken and interrupts the flow of current or fluid.

1.5.12 ‘On’ state of output signal switching devices — the state in which the output circuit(s) is complete and permits the flow of current or fluid.

1.5.13 Output signal switching device — that part of the pressure-sensitive edge, bar, mat or floor which, when the sensor or monitoring function means is actuated, responds by producing an ‘off’ state.

1.5.14 Overtravel distance — the difference between the total distance and the actuating distance when both of these distances are measured with the same object applied under the same conditions (see Figure 1.4).

1.5.15 Pressure-sensitive system

1.5.15.1 Pressure-sensitive bar — safety device comprising —

- (a) a sensor(s) which generates a signal when pressure is applied to part of its outer surface, where —
 - (i) the length is greater than the width;
 - (ii) the cross-section throughout the pressure-sensitive area is constant;
 - (iii) the width of the cross-section is greater than 8 mm and generally less than 80 mm; and
 - (iv) the effective sensing field moves as a whole to actuate the sensor(s).
- (b) a control unit, which responds to the signal from the sensor and generates an output signal or signals to the control system of a machine.

NOTE: The surface of a pressure-sensitive bar can also deform locally but the deformation does not actuate the sensor(s).

1.5.15.2 Pressure-sensitive edge — Safety device comprising —

- (a) sensor(s) which generates a signal when pressure is applied to part of its outer surface, where —
 - (i) the length is greater than the width;
 - (ii) the cross-section throughout the pressure-sensitive area is constant;
 - (iii) the width of the cross-section is greater than 8 mm and generally less than 80 mm; and
 - (iv) the effective sensing field is deformed locally to actuate the sensor(s).
- (b) a control unit, which responds to the signal from the sensor and generates an output signal or signals to the control system of a machine.

1.5.15.3 Pressure-sensitive mat — a safety device comprising a sensor or sensors that responds to the application of pressure and a control unit, with or without a monitoring function depending on the category specified and with one or more output signal switching devices (see AS 4024.1 and Figure 1.1). In a pressure-sensitive mat the effective sensing area is deformed locally when a sensor is actuated.

1.5.15.4 Pressure-sensitive floor — a safety device comprising a sensor or sensors that responds to the application of pressure and a control unit, with or without a monitoring function depending on the category specified and with one or more output signal switching devices (see Figure 1.1).

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

1.5.16 Reference axis — a line in the direction of the length of the sensor, whose position in the cross-sectional view of the sensor is used to define the extent of the effective sensing field (Figures 1.2 and 1.3).

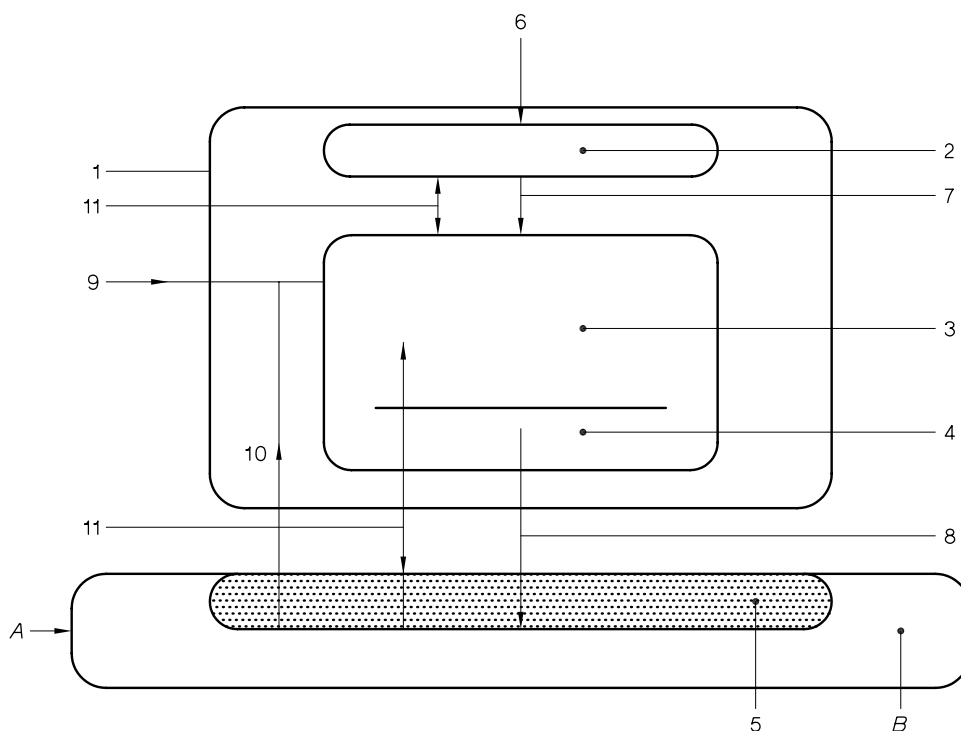
1.5.17 Reference direction — that direction of actuation, from a point on the effective sensing field towards the reference axis, which bisects the effective sensing angle and is normal to the reference axis (see Figures 1.2 and 1.3).

1.5.18 Reset—the function which permits an ‘on’ state in the output signal switching device(s) provided that certain conditions are met.

1.5.19 Response time—the 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.

1.5.20 Sensor—that part of the pressure-sensitive edge or pressure-sensitive bar that contains an effective sensing field on which the application of a pressure produced by a force equal to or greater than the actuating force causes the signal from the sensor to the control unit to change state.

1.5.21 Total distance—the distance travelled by an object, moving in a direction normal to the reference axis, from where this object touches the effective sensing field, under specified conditions, to where a force of 250 N is exerted on the object (see Figure 1.4).



LEGEND:

- 1 = Pressure-sensitive edges, bar, mat or floor
- 2 = Sensor(s)
- 3 = Control unit (may be located within the machine control system or be part of the machine control system)
- 4 = Output signal switching device(s)
- 5 = Part of the machine control system for pressure sensitive edge/pressure-sensitive bar output signal processing
- 6 = Actuating force
- 7 = Sensor output signal
- 8 = ON state/OFF state signal
- 9 = Manual reset signal (where appropriate alternative to A)
- 10 = Reset signal from machine control system (where appropriate)
- 11 = Monitoring signals (optional)
- A = Manual reset signal to the machine control system (where appropriate)
- B = Machine control system(s)

FIGURE 1.1 PRESSURE-SENSITIVE SYSTEM APPLIED TO A MACHINE

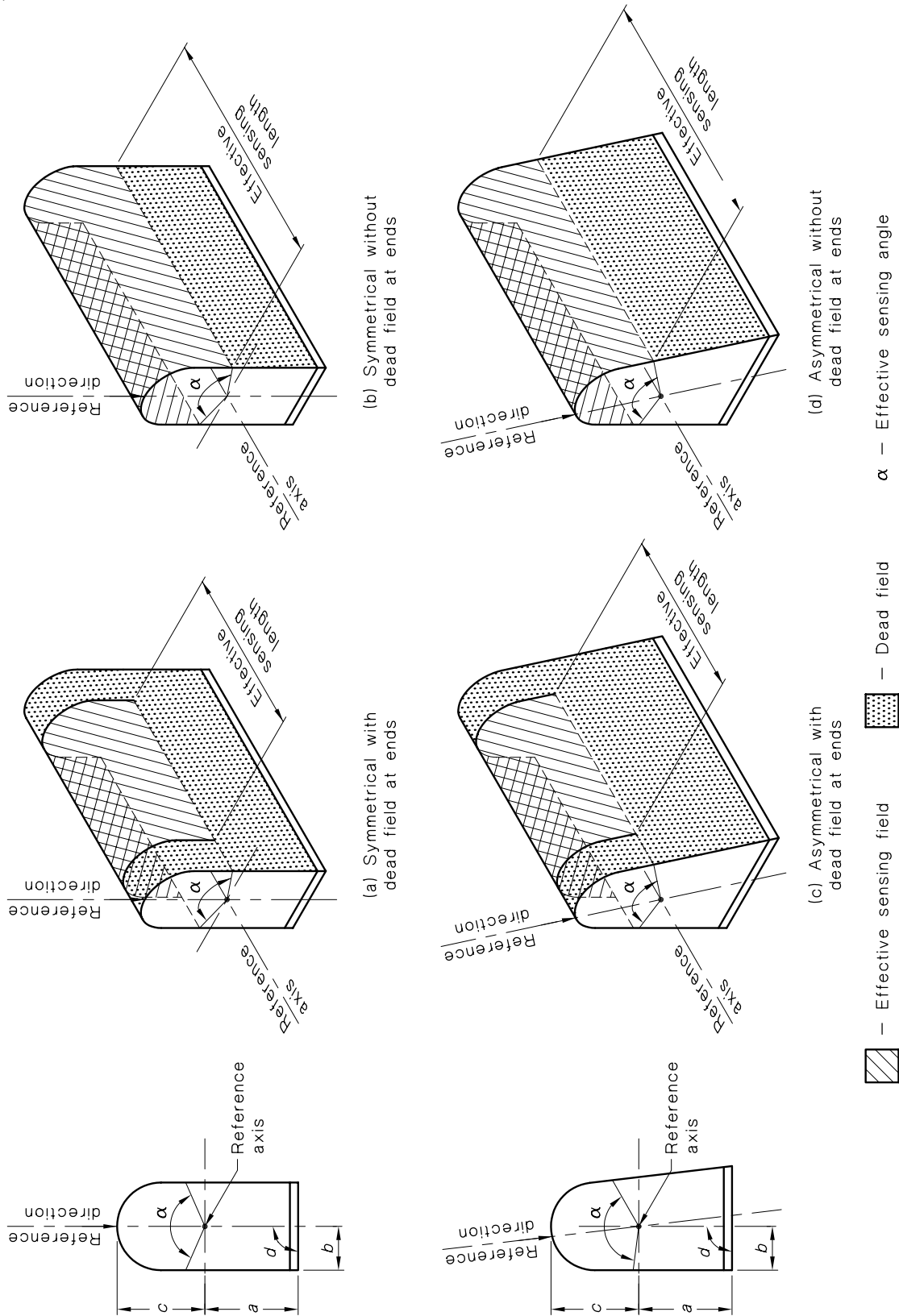


FIGURE 1.3 EFFECTIVE SENSING FIELD OF PRESSURE-SENSITIVE BARS

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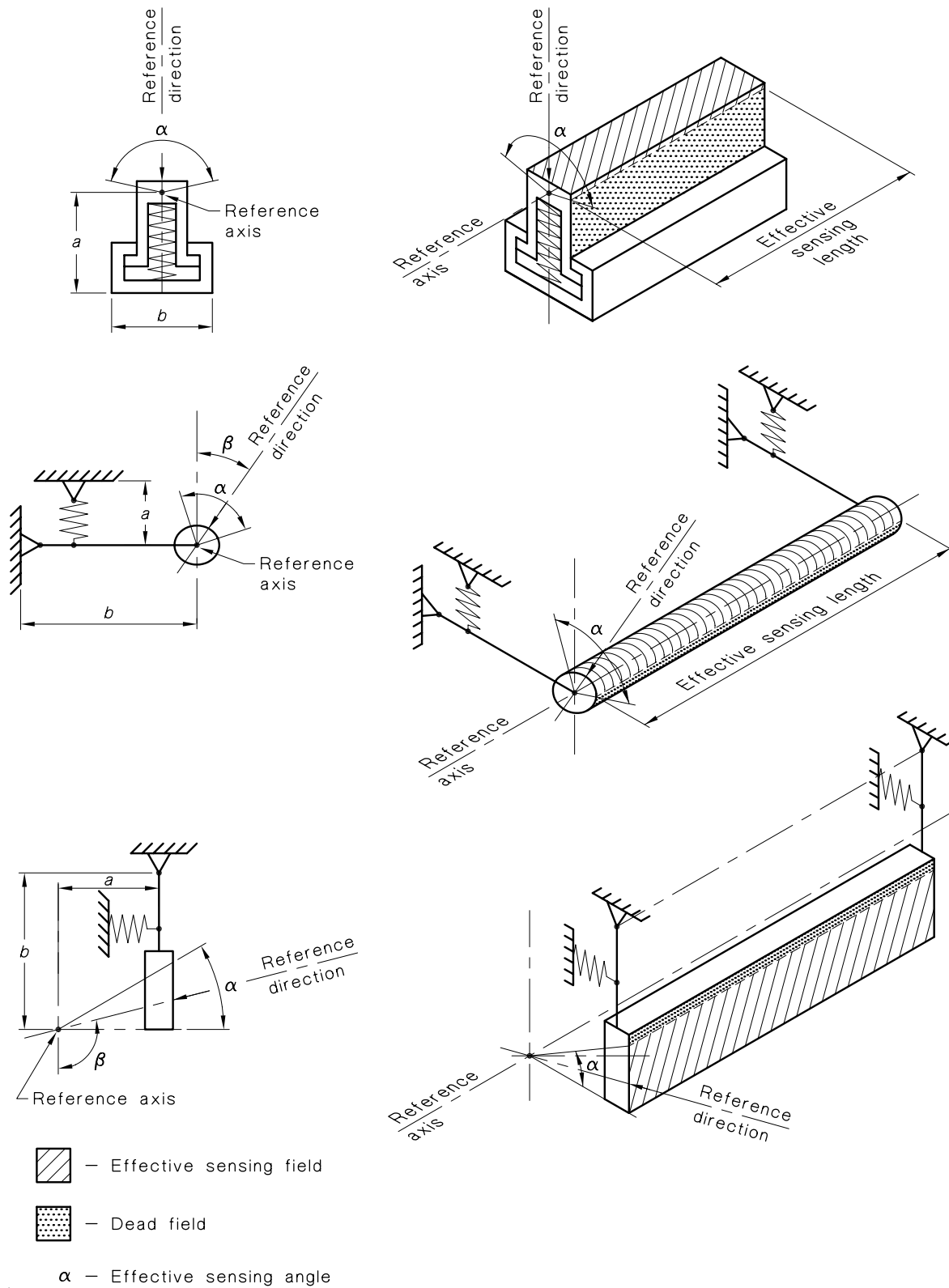


FIGURE 1.3 EFFECTIVE SENSING FIELD OF PRESSURE-SENSITIVE BARS

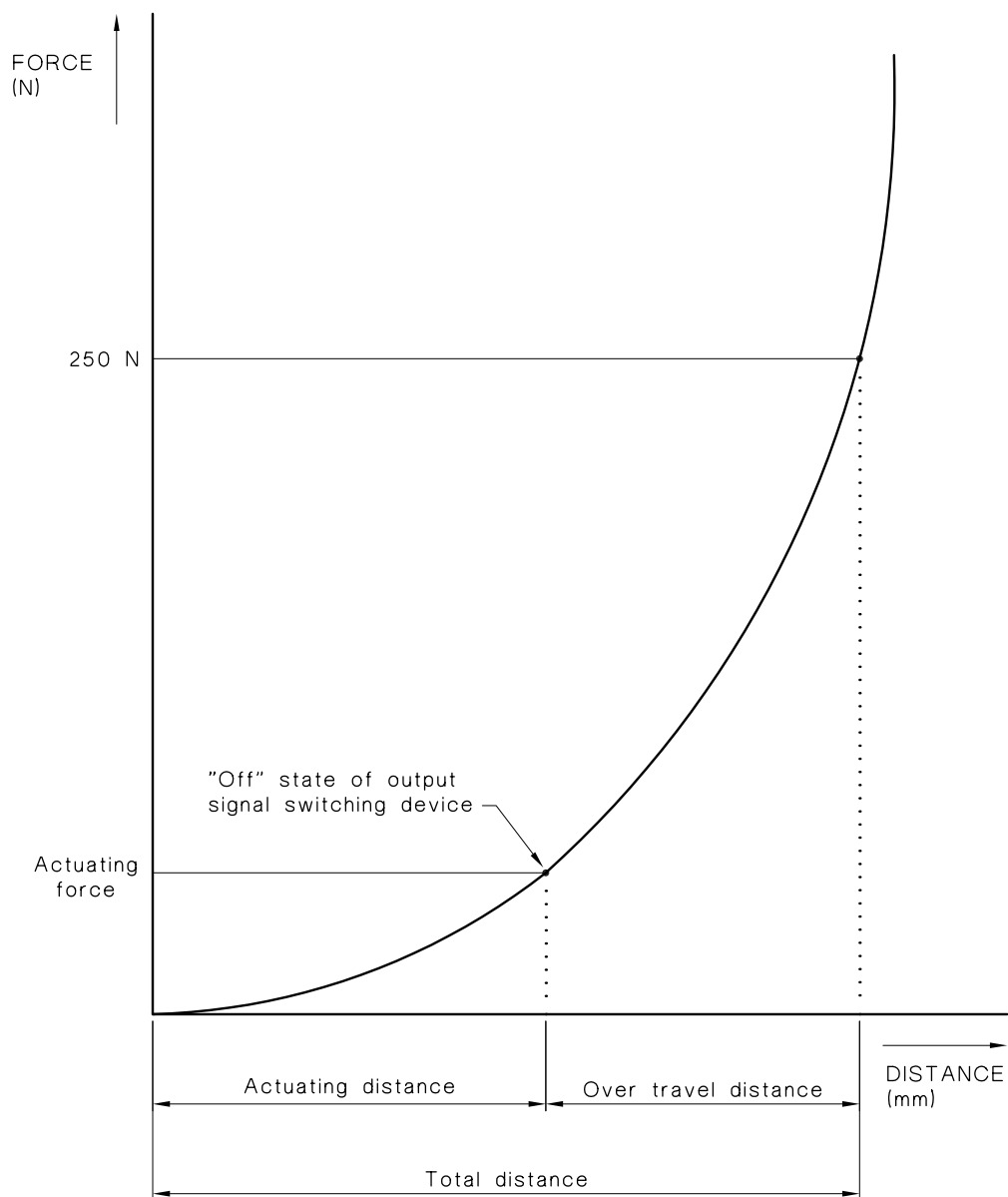
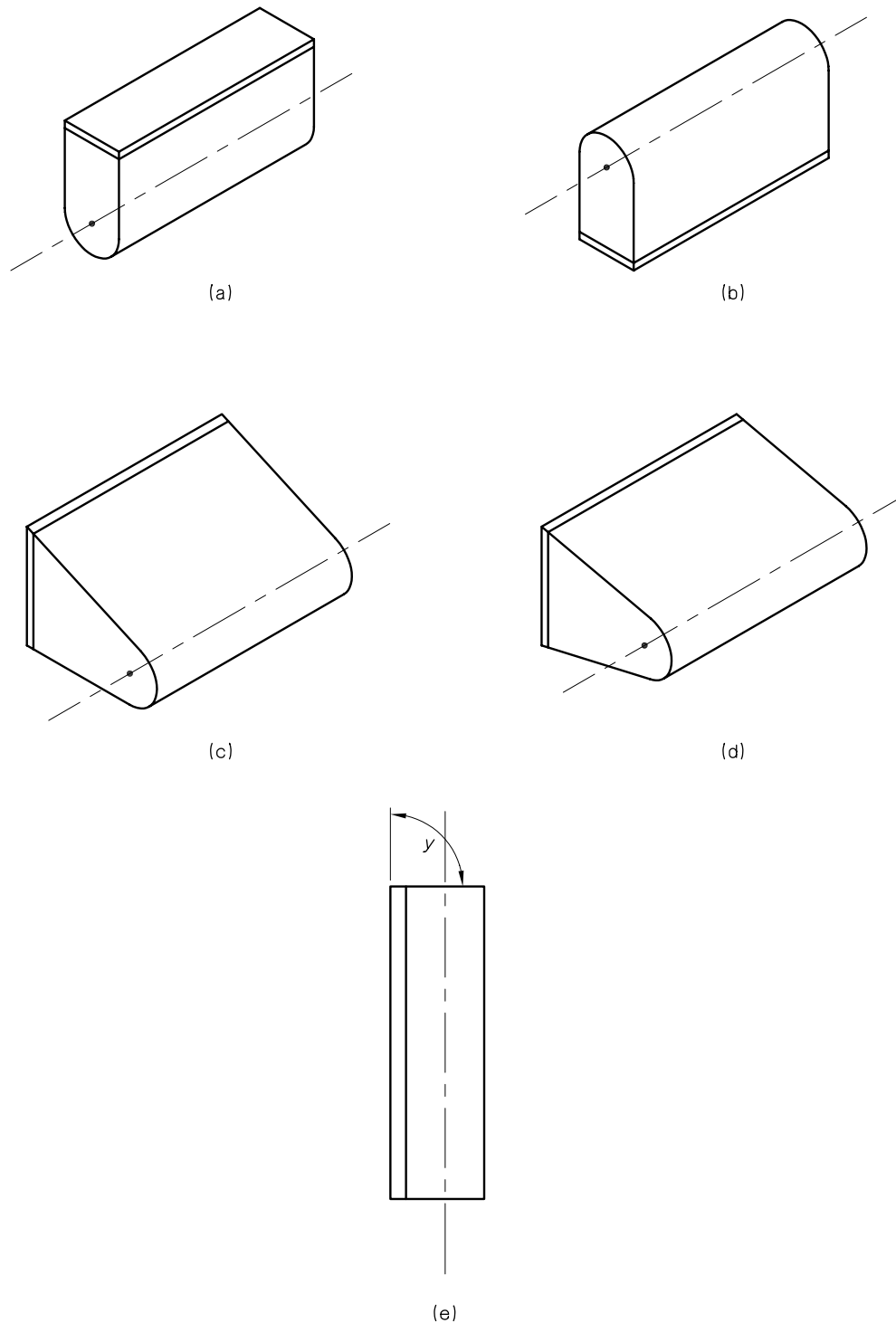


FIGURE 1.4 EXAMPLE OF A FORCE-DISTANCE DIAGRAM



Reference axis — — — — —

FIGURE 1.5 SENSOR MOUNTING ORIENTATIONS A TO E

SECTION 2 COMMON REQUIREMENTS FOR PRESSURE - SENSITIVE DEVICES

2.1 GENERAL Electrical equipment shall comply with the requirements of AS 1543.

2.2 ENVIRONMENTAL CONDITIONS

2.2.1 General The pressure-sensitive edge or pressure-sensitive bar shall continue to operate in the environmental conditions stated by the manufacturer. The minimum requirements are stated in Clauses 2.2.2, 2.2.3, 2.2.4 and 2.2.5.

2.2.2 Climatic conditions The pressure-sensitive device shall continue to comply with the requirements for actuating forces except that Testpiece 1 only is applied under the following climatic conditions:

- (a) The standard temperature range shall be 0°C to +50°C. If the manufacturer states that the pressure-sensitive device is suitable for a wider temperature range then it shall meet this requirement over the stated temperature range. For example, non-standard ranges can be –25°C to +40°C and +5°C to +70°C.
- (b) The requirements for humidity shall be in accordance with AS 1099.2.3 test Ca for a period of four days.

2.2.3 Electromagnetic compatibility Electromagnetic compatibility shall be in accordance with BS EN 60801-2, BS EN 61000-4-3 or IEC 60801-4.

The pressure-sensitive device shall continue in normal operation when subjected to level 2 or 3 according to Table 5 of each of the above Standards.

The manufacturer may state a higher level than that specified above. The pressure-sensitive device shall continue in normal operation when subjected to the higher level.

2.2.4 Vibration The requirements for vibration shall apply to the control unit and the output signal switching device only and shall be in accordance with IEC 60068-2-6 for the following parameters:

- (a) Frequency range, 10 Hz to 55 Hz.
- (b) Displacement, 0.15 mm.
- (c) 10 cycles per axis.
- (d) Sweep rate, 1 octave per minute.

2.2.5 Bump The requirements shall apply to the sensor of bars in the reference direction and opposite direction only and shall be in accordance with IEC 60068-2-29 for the following parameters.

- (a) Peak acceleration, 100 m/s².
- (b) Duration of the pulse, 16 ms.
- (c) Form of the pulse; half sine.
- (d) Number of pulses per direction, 1000.
- (e) Frequency approximately 1 Hz.

After this test, the pressure-sensitive bar shall continue to comply with the actuating force requirements applied through Testpiece 1.

2.3 POWER SUPPLY

2.3.1 Electrical power supply (see Clause 6.12 for test method) The pressure-sensitive edge or pressure-sensitive bar shall continue to operate under the conditions given in AS 1543.

2.3.2 Non-electrical power supply For non-electrical power supplies, e.g. hydraulic or pneumatic, the manufacturer shall state the nominal supply level and the allowable range of tolerance within which normal operation will be maintained.

Where overpressure protective devices are not provided, overpressure variations outside the operating range shall not result in a failure to danger.

Variations below the operating range shall not result in a failure to danger.

2.4 ENCLOSURES

2.4.1 Sensor The manufacturer shall specify the suitability of the sensor enclosure for particular environment, e.g. wet or dusty conditions. This specification shall be defined as an index of protection, e.g. IP44. Those parts of the sensor enclosure which contain electrical components shall meet the requirements of IP54 as a minimum. (See AS 1939.)

If the manufacturer specifies that the sensor may be immersed in water, the sensor enclosure shall meet the requirements of IP68 as a minimum. The manufacturer shall state the time and depth of immersion.

2.4.2 Control unit and output signal switching device The control unit and any external output signal switching device enclosure shall meet the requirements of IP54 as a minimum.

Where the control unit is designed for mounting in another control equipment enclosure, this enclosure shall meet the requirements of IP54 as a minimum and the control unit shall meet the requirements of IP2X as a minimum. (See AS 1939.)

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

2.5 ADJUSTMENT Pressure-sensitive devices should have no means of adjustment. If it is necessary to make adjustments, the manufacturer shall supply instructions to enable the adjustments to be made so that the requirements of the Standard can be met. There shall be arrangements for checking that such adjustments are made correctly. The adjustable elements shall only be accessible by means of a key or tool.

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 device without the need for adjustment.

2.6 RESET

2.6.1 Device with reset For a pressure-sensitive device with reset, the reset signal shall be manually initiated and shall be applied either directly to the control unit of the safety device or via the machine control system (see Figure 1.1).

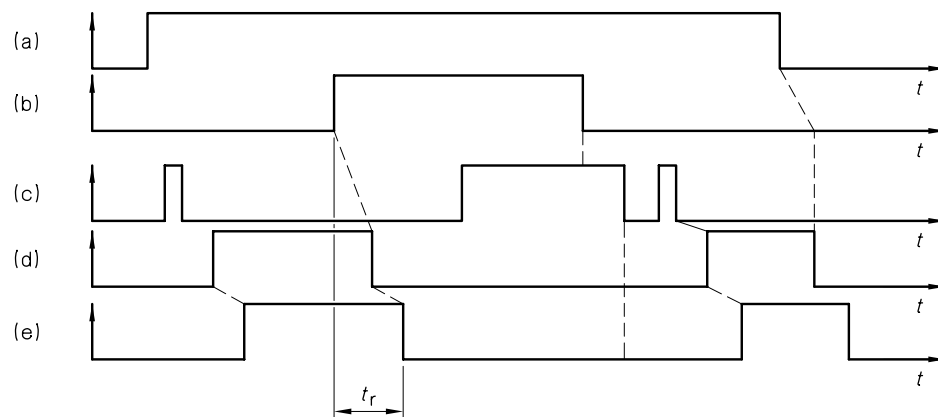
The reset shall perform two functions:

- (a) *Start interlock* At power 'on' the output signal switching device shall remain in the 'off' state until the reset signal is applied.
- (b) *Restart interlock* After the actuating force has been removed, the output of the output signal switching device shall only change to an 'on' state after the application of a reset signal.

If the reset signal is applied continuously while the minimum actuating force is applied, normal to the reference axis, the output of the output signal switching device shall not change to an 'on' state when the actuating force is removed (see Figures 2.1 and 2.2).

2.6.2 Device without reset For a pressure-sensitive device without reset the output signal of the output signal switching device shall change to an 'on' state at power on and after the actuating force has been removed (see Figure 2.3).

2.7 CATEGORIES Pressure-sensitive mats and pressure-sensitive floors shall meet the requirements of the category for which they are specified, marked and, where required, certified. These categories are set out in AS 4024.1.



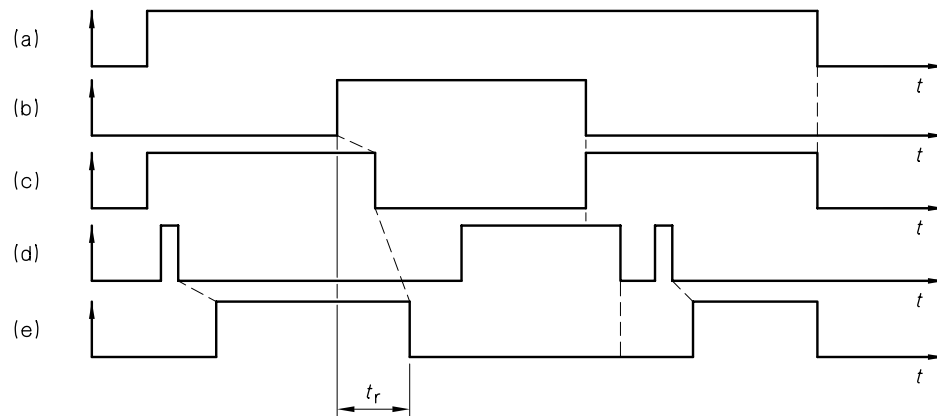
LEGEND:

- t = Time
- t_r = Response time
- (a) = Power to edge or bar
- (b) = Actuating force
- (c) = Reset signal
- (d) = Sensor output
- (e) = Output of output signal switching device(s)

FIGURE 2.1 RELATIONSHIP BETWEEN FORCE AND OUTPUT FOR DEVICE WITH RESET (SENSOR OUTPUT INITIATED BY RESET FUNCTION)

2.8 CONNECTION Where components of different configurations within the pressure-sensitive bar or pressure-sensitive edge are interchangeable by means of plug and socket connections, incorrect placement or exchange of these components shall not cause a failure to danger. (See also AS 4024.1.)

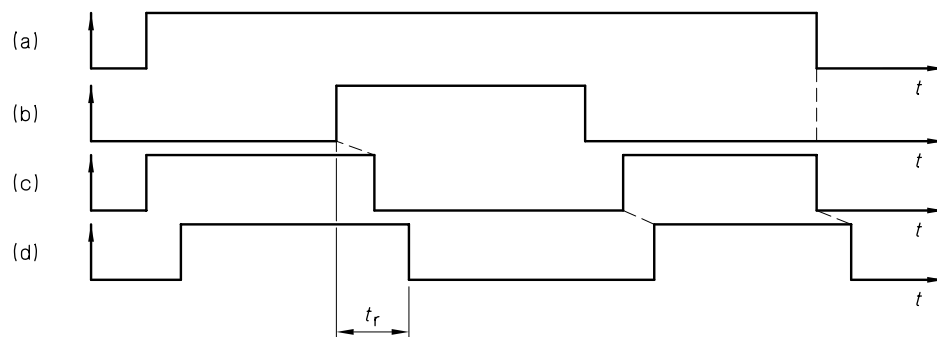
If a sensor is connected by a plug and socket, removal or disconnection of the sensor at the plug and socket from the control unit shall cause the output signal switching device to go to an 'off' state.



LEGEND:

- t = Time
- t_r = Response time
- (a) = Power to edge or bar
- (b) = Actuating force
- (c) = Reset signal
- (d) = Sensor output
- (e) = Output of output signal switching device(s)

FIGURE 2.2 RELATIONSHIP BETWEEN FORCE AND OUTPUT FOR DEVICE WITH RESET (SENSOR OUTPUT INDEPENDENT OF RESET FUNCTION)



LEGEND:

- t = Time
- t_r = Response time
- (a) = Power to edge or bar
- (b) = Actuating force
- (c) = Sensor output
- (d) = Output of output signal switching device(s)

FIGURE 2.3 RELATIONSHIP BETWEEN FORCE AND OUTPUT FOR DEVICE WITHOUT RESET FUNCTION (SENSOR OUTPUT INITIATED BY REMOVAL OF FORCE)

2.9 INFORMATION FOR USE The manufacturer or supplier of the pressure-sensitive device shall provide information for use which shall include at least the following:

- (a) Information relating to packaging, transportation, handling and storage of the device(s) including —
 - (i) dimensions;
 - (ii) mass (i.e. kilograms per metre length for edges or bars, or kilograms per square metre for mats and floors);
 - (iii) description of packaging and methods of unpacking to prevent damage to the device(s);
 - (iv) transportation and handling methods to prevent damage or personal injury; and
 - (v) storage requirements, e.g. lay flat, straight or in coils and temperature range.
- (b) Information relating to the installation and commissioning of the device(s) (see also AS 4024.4) including —
 - (i) a warning that the instructions should be read in full before any installation work is attempted;
 - (ii) requirements regarding the surface on which the sensor will be mounted;
 - (iii) information shall be provided regarding methods of installation including tooling required;
 - (iv) design features of the effective sensing fields and the effects of dead fields or zones can be minimized by installation (including drawings, where appropriate);
 - (v) schedule of tests to be carried out after installation to establish that the device(s) is functioning and has been fitted correctly;
 - (vi) warning that the overall safety of the machine and its safety device(s) depends on the integrity of the interface between them;
 - (vii) the category required for the pressure-sensitive protection device shall comply with the category established by the risk assessment; and
 - (viii) a record sheet which shall be completed by the installer showing which control unit and sensor(s) are installed.
- (c) Information relating to the use of the device(s) including —
 - (i) purpose and method of operation of the control unit and indicators;
 - (ii) information regarding limits of use; and
 - (iii) instructions for fault identification and for restarting after an intervention.
- (d) Instruction for maintenance including —
 - (i) a warning that the maintenance instructions should be read before any maintenance is attempted;
 - (ii) nature and frequency of checking, inspection and maintenance;
 - (iii) instruction for allowable setting, adjustment and cleaning;
 - (iv) actions which require a definite technical knowledge or particular skills or both and hence should be carried out exclusively by skilled persons suitably trained;
 - (v) information, for example, drawings and diagrams, enabling trained personnel to carry out fault finding tasks;