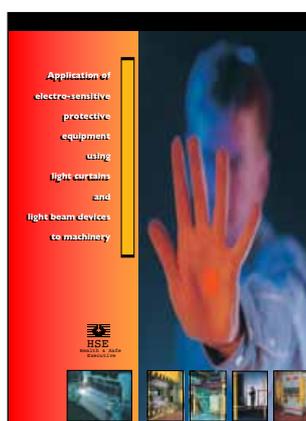


Application of electro-sensitive protective equipment using light curtains and light beam devices to machinery



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This guidance provides practical advice about electro-sensitive protective equipment (ESPE) using active opto-electronic protection devices (AOPDs) for safeguarding machinery. The guidance is only relevant to ESPEs used to protect people from hazardous parts of machinery.

The book covers installation, use and inspection of protective equipment and will enable industry advisory committees, trade associations, suppliers and others to produce an installation specification.

The guidance has been updated to take into account the current position of European (and international) standards on machinery safety.

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Contents

Introduction 5

Existing installations 6

Scope 7

ESPE functions and AOPD applications 8

Functions performed by ESPEs using AOPDs 8

Factors affecting the suitability of an installation 9

Positioning of AOPDs with respect to machinery 10

Alternative formats for AOPDs 10

AOPD positioning 10

Normal approach light curtains 10

Parallel approach light curtains 13

Angled approach light curtains 14

Fixed or rotating arm dual format light curtains 14

ESPEs used solely or in part as trip devices 15

ESPE interfacing with the machine control system 17

Brakes 17

General 17

Selection 18

Mechanical braking systems 19

Adjustment 20

Electrodynamical braking systems 20

Clutches 22

General 22

Design considerations 22

Electrical/electronic considerations 23

Electromagnetic contactors 23

Hydraulic and pneumatic considerations 24

General 24

Machinery employing an ESPE as a trip device 24

Protection against gravity fall 24

Hydraulic circuit protection 25

Pneumatic control of brakes and clutches 25

ESPE installation 26

General requirements 26

Labelling 26

Standards of performance 28

Machine control systems 28

AOPD use 31

Stopping performance monitoring 31

Muting 32

Use of an ESPE for machine initiation 33

Inspection and test 35

General 35

Initial inspection and test 36

Periodic inspection and test 37

Functional safety checks 38

Appendices 39

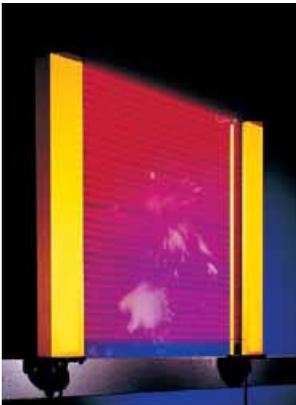
Appendix A: Commonly used terms 39

Appendix B: Schematic examples of ESPE 43

Acknowledgements 45

References 46

Introduction



Light curtain (AOPD)



Light beam device
(AOPD)

1 This guidance gives advice about electro-sensitive protective equipment (ESPE) using active opto-electronic protection devices (AOPD) for safeguarding machinery. An AOPD is a light curtain and/or light beam device and can be used alone or in combination with other safeguards depending on the application. Commonly used terms are defined in Appendix A.

2 When using ESPEs the guidance identifies:

- (a) different functions performed;
- (b) appropriate machinery application; and
- (c) interfacing with the machine control system.

For AOPDs used for safeguarding machinery the guidance covers:

- (a) application;
- (b) dimensions and disposition of light curtains or light beam devices with respect to machinery;
- (c) necessary machinery characteristics and interfacing requirements;
- (d) installation;
- (e) use; and
- (f) routine inspection and testing, and maintenance.

3 The aim of the guidance is to enable industry advisory committees, trade associations, suppliers and other persons with the appropriate technical knowledge to produce an installation specification for any appropriate application on:

- (a) new machines supplied under the Supply of Machinery (Safety) Regulations 1992 (as amended) which have not been constructed to a transposed harmonised (type C) standard; or
- (b) machines which are having their safeguards reviewed and on which ESPEs may or may not have been fitted or used.

4 The information in this guidance has been updated to take into account the current position of European (and international) standards on machinery safety, which are produced in support of relevant European Directives.

Combined horizontal and
vertical light curtains
applied to a hydraulic
press brake



Existing installations

5 This guidance is not meant to be retrospective but individual joint industry advisory committees, trade associations or users are encouraged to bring existing installation standards into line with it. Those current installations, for example using ESPEs in accordance with BS 6491: 1984 and using an installation standard derived from HSE Guidance Note PM41 *Application of photo-electric safety systems to machinery* (which is replaced by this publication), need not be modified in line with this guidance unless the risk assessment indicates otherwise.



Large press with light curtains

Scope

6 The guidance contained in this document is only relevant to ESPEs used to protect persons from dangerous parts of machinery. An ESPE is defined as a safety component in regulation 2 - Supply of Machinery (Safety) (Amending) Regulations 1994. ESPEs according to IEC 61496: 1997, Parts 1 and 2, or to an equivalent standard of performance, should be used for this purpose. IEC 61496: 1997 will be available as BS EN 61496 in the near future. This guidance does not apply to those AOPDs (eg light beam devices) used solely for sequence control of machinery processes or other production purposes.



Hydraulic press brake with horizontal light curtain

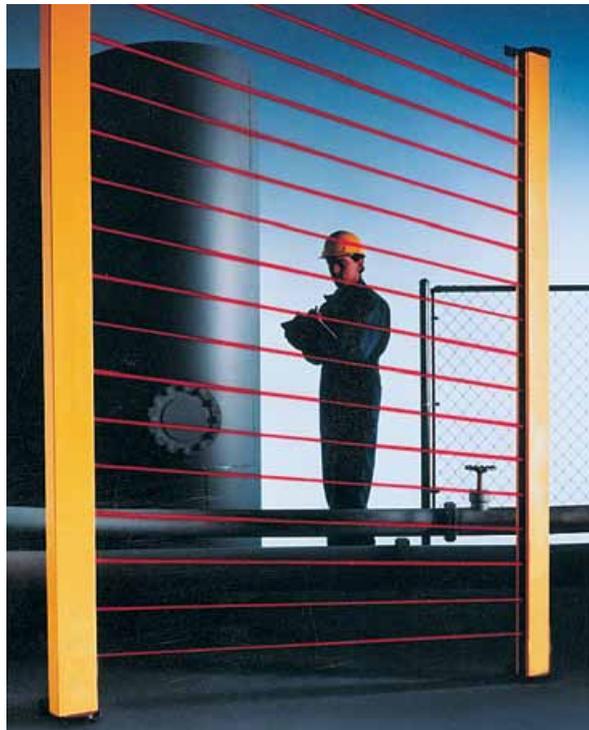
ESPE functions and AOPD applications

Functions performed by ESPEs using AOPDs

7 An AOPD may be used as:

- (a) a trip device;
- (b) a combined trip device and presence-sensing device; and
- (c) a presence-sensing device.

8 In most applications where the AOPD is used as a trip device, it will also, during certain periods, act as a presence-sensing device. For instance, on a small downstroking hydraulic press, the AOPD is designed and positioned to act as a trip device if a person approaches the downstroking ram. It will act also as a presence-sensing device when the person is in the danger zone. However, the system can be used solely as a presence-sensing device (eg for secondary guarding inside perimeter fencing with interlocked access) and the stopping performance of the machine need not be considered. AOPDs should not be regarded as a substitute for primary isolation and safe systems of work during plant maintenance and similar activities (see BS EN 1037: 1996).



Light curtain can be used as combined trip device and presence-sensing device

Factors affecting the suitability of an installation

9 Factors that might preclude the use of AOPDs include:

- (a) a tendency for the machinery to eject materials or component parts;
- (b) risk of injury from thermal or other radiation;
- (c) unacceptable noise levels; and
- (d) an environment likely to adversely affect the efficiency of the ESPE, through extraneous radiation, vibration, dust, excess water, or extremes of temperature (see IEC 61496, Part 1: 1997 for minimum levels of immunity).

10 The use of AOPDs may be appropriate if additional steps are taken to control the risks associated with the above hazards, eg local fixed guards to contain ejection.

11 Some factors make AOPDs unsuitable as trip devices. These include:

- (a) inconsistent or inadequate machine stopping performance due, for example, to:
 - (i) the reaction characteristics of the machinery control circuitry, whether electrical, hydraulic or pneumatic;
 - (ii) poor brake design; or
 - (iii) variable speed, load or inertia; and
- (b) the inability of the machine to stop part-way through a cycle due to:
 - (i) nature of the process, eg a multi-station process where stopping between stations would create a production problem;
 - (ii) the method of drive, eg positive key clutches or similar means for engaging the drive that are so arranged that once started, the machinery can only be stopped when the cycle is complete; or
 - (iii) stored energy, eg in the form of stored pressure in pneumatic reservoirs or hydraulic accumulators.



Light curtain may not be suitable in some applications

Positioning of AOPDs with respect to machinery

Alternative formats for AOPDs



Combined vertical and horizontal light curtain applied to a hydraulic press brake



Light curtain which can have its assembly rotated to alter the angle of approach

12 An AOPD consisting of one light beam device should be used only if the ESPE meets the requirements of IEC 61496: 1997 (or an equivalent standard of performance) and is installed according to the advice given in this guidance. However, to give the required level of protection most applications will require a light curtain or an AOPD consisting of more than one light beam device.

13 There are five main formats of AOPDs:

- (a) *normal approach* - where the detection zone is NORMAL to the direction of approach. This may be achieved by vertical or horizontal light curtains or arrangements of light beam devices (Figure 1a);
- (b) *parallel approach* - where the detection zone is PARALLEL to the direction of approach (Figure 1b);
- (c) *angled approach* - where the detection zone is at some other angle to the direction of approach (Figure 1c);
- (d) *combination* - where the detection zone combines two or more of the above; and
- (e) *fixed or rotating dual format* - where the detection zone can be readily converted to a position either normal or parallel to the direction of approach. If the conversion is carried out by rotation of the AOPD assembly, it should not be possible to rotate the assembly towards the dangerous parts if the minimum separation distance, calculated in accordance with paragraphs 14 to 28, cannot be maintained.

AOPD positioning

14 For the purposes of this section, the term 'light curtain' includes a light curtain as defined, or an arrangement of light beam devices having the same detection capability as the light curtain.

15 When an ESPE is used as a trip device it should ensure that it is not possible for a person to reach through the AOPD to any dangerous parts, before they have been brought to a safe condition. The position of AOPDs with respect to the danger zone need not normally be capable of adjustment. However, where adjustment of separation distance is found to be necessary, means should be provided to ensure the correct separation distance can be maintained and that the adjustment does not expose persons to risk of injury. For the purpose of calculating the separation distance, danger zone should be interpreted as nearest dangerous part (see Figures 1(a)-(c)).

Normal approach light curtains (Figure 1a)

16 For machinery with variable characteristics, a single position based on the parameters requiring the greatest separation distance will be used. Calculation of the separation distance should be based on the methodology contained in EN 999: 98 *Safety of machinery - the positioning of protective equipment in respect of approach speeds of parts of the human body*, as set out below. It should be noted that in EN 999: 98 the term 'minimum distance' is used.

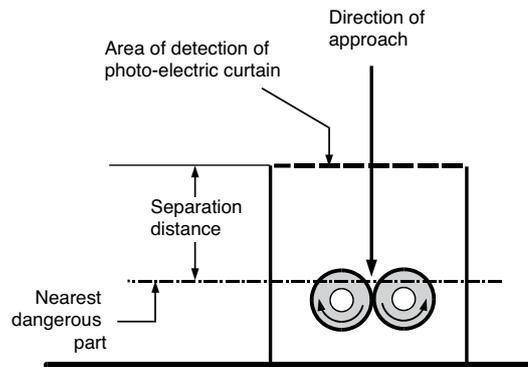
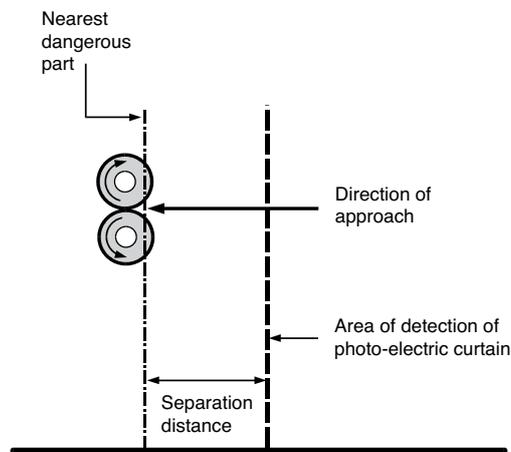
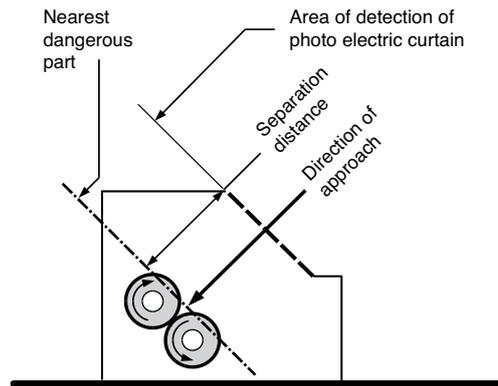


Figure 1a Normal approach curtain: three theoretical applications

17 The separation distance from the danger zone should be calculated by using the formula:

$$S = (K \times T) + C$$

where:

S is the separation distance, in millimetres, from the danger zone to the detection point, line, plane or zone;

K is a parameter, in millimetres per second, derived from data on approach speeds of the body or parts of the body;

T is the overall system stopping performance in seconds;

C is an additional distance, in millimetres, based on intrusion towards the danger zone prior to actuation of the AOPD.

18 For light curtains with a maximum object detection capability of 40 mm diameter, the separation distance (S) from the detection zone to the danger zone should not be less than that calculated by using the formula given in paragraph 17 where:

$$K = 2000 \text{ mm/s};$$

$$C = 8(d-14) \text{ but not less than } 0; \text{ and}$$

d = the detection capability of the light curtain in millimetres and subject to a minimum allowable value of S of 100 mm.

19 If S is found to be greater than 500 mm when using a value of 2000 mm/s for K, then a value of 1600 mm/s for K may be used. However, if the results of the calculation give a value less than 500 mm, the separation distance used should be 500 mm. The formula becomes:

$$S = (1600 \text{ mm/s} \times T) + 8(d-14 \text{ mm}).$$

See EN 999: 1998 for the calculation of the separation distance for AOPDs having a detection capability larger than 40 mm.

20 Access to the danger zone from any direction not protected by the light curtain needs to be prevented by fixed or interlocking guards or other equally effective means. Similar steps should be taken to prevent or detect anyone remaining between the light curtain and the danger zone. These could also include the use of light beam devices.

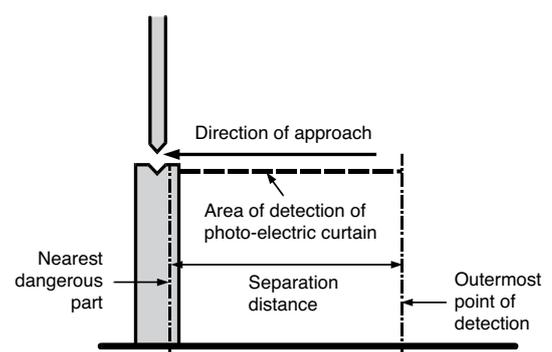


Figure 1b Parallel approach curtain

Parallel approach light curtains (Figure 1b)

21 The separation distance should be calculated by using the formula given in paragraph 17 where:

$$K = 1600 \text{ mm/s;}$$

$$C = (1200 \text{ mm} - 0.4 H), \text{ but not less than } 850 \text{ mm; and}$$

H = the height of the detection zone above the reference plane (eg floor) in millimetres.

22 Normally the height of the light curtain should be such that it is positioned just below the lowest limit of the danger zone and its object detection capability should be such that it is not possible to stand within the detection zone without actuating the light curtain. For parallel approach light curtains, H should not exceed 1000 mm.

23 For a given height of the detection zone, the corresponding detection capability 'd' can be calculated by using the formula:

$$d = \frac{H}{15} + 50 \text{ mm}$$

24 Constraints imposed by the methods of working at particular machinery will determine whether the light curtain should be positioned above or below the limits of the danger zone. Whichever position is adopted, the light curtain should be positioned as close as possible to the machine. Where necessary, additional steps should be taken to prevent access to the danger zone from above, below or around the light curtain. These steps may include the use of fixed or interlocking guards, fixed bars, extra light beam devices, or pressure-sensitive mats.

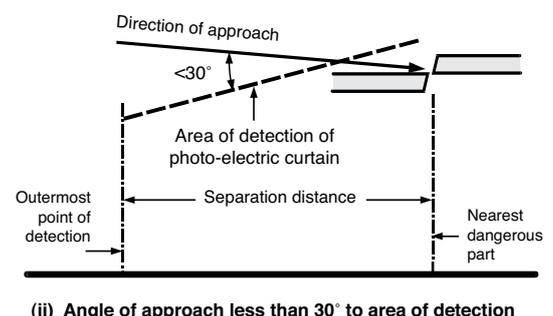
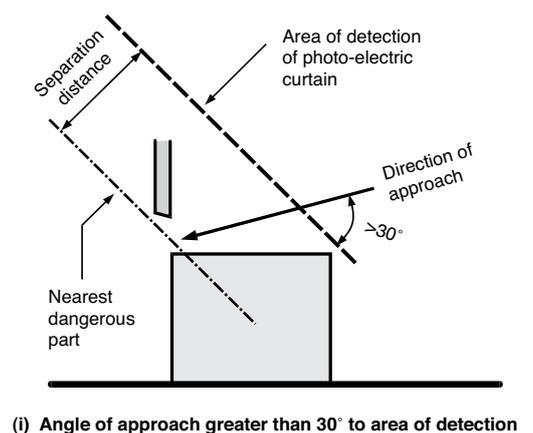


Figure 1c Angled approach curtain

Angled approach light curtains (Figure 1c)

25 It may be advantageous to position the light curtain so that approach to the dangerous parts through the light curtain is in a direction which is neither normal nor parallel to the area of detection. If the light curtain has been installed so that the angle of approach to the detection zone is within 5 degrees of their designed approach (either normal or parallel), then it need not be considered as an angled approach light curtain.

26 For detection zones which are positioned at angles greater than 5 degrees to the direction of approach the separation distance should be calculated in accordance with the most appropriate formula. Light curtains with foreseeable angles of approach greater than 30 degrees should be considered as normal approach, and light curtains with foreseeable angles of approach less than 30 degrees should be considered as parallel approach.

27 When angled approach light curtains are considered to be parallel approach, the formula used to derive the separation distance should apply to that part of the detection zone furthest away from the danger zone.

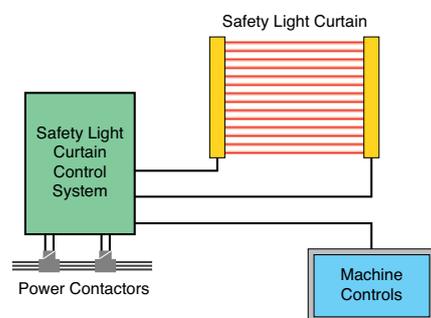
Fixed or rotating arm dual format light curtains

28 When the detection zone can readily be converted to a configuration which can be either normal or parallel to the direction of approach, then the separation distances for both directions of approach will apply.

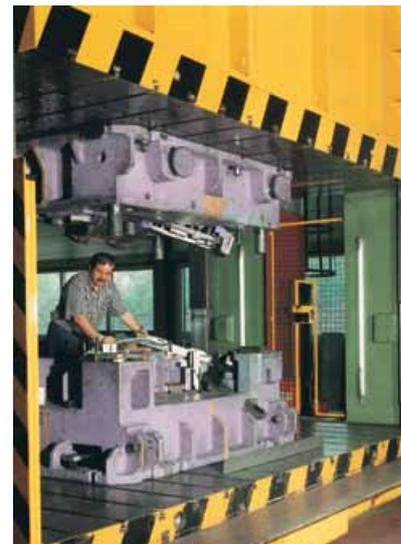
ESPEs used solely or in part as trip devices

29 Different types of machinery can present substantially different levels of risk due to different inherent hazards and different methods of working. A single standard for the installation of an ESPE to be used as a trip device and presence-sensing device will not therefore be appropriate for all applications. For this reason, IEC 61496 specifies two types of ESPE using AOPDs (type 2 and type 4). A type 2 ESPE has a means of periodic test to reveal a failure to danger, while a type 4 ESPE will not fail to danger for a single fault and is resistant to an accumulation of undetected faults (see IEC 61496-1). A fault in a type 4 ESPE is revealed by at least one of the output signal switching devices (OSSDs) going to and remaining in the OFF-state, see IEC 61496-1.

30 In cases such as cyclic machines which are hand fed, for example a friction clutch power press, and where the ESPE is provided as the primary safeguard to protect persons at risk, the results of a risk assessment (see BS EN 1050) are likely to indicate that the use of a type 4 ESPE is appropriate.



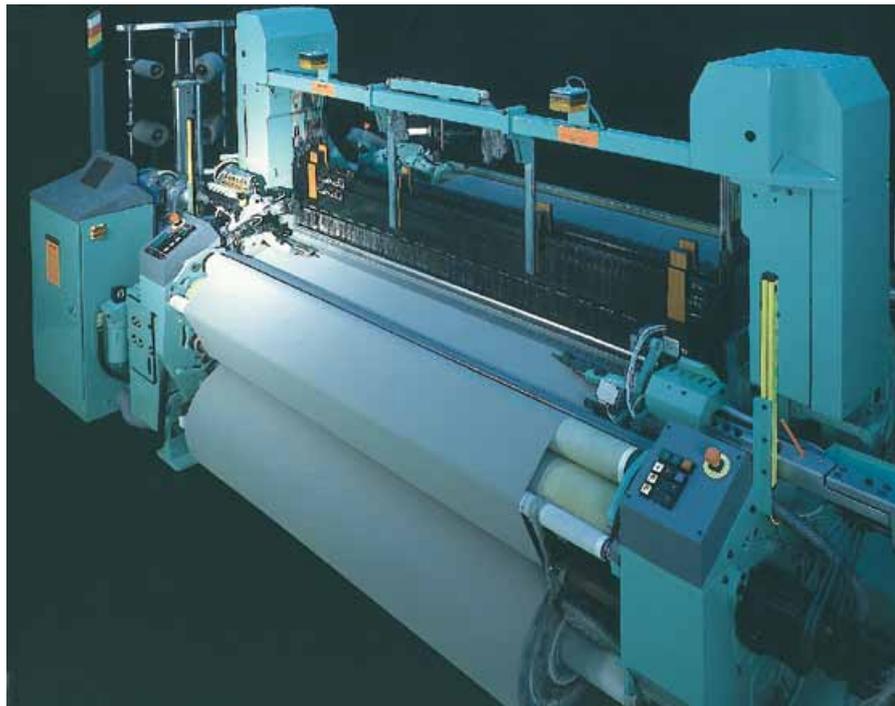
ESPE interfacing with the machine control system providing monitoring of the light curtain and power contactors



Hydraulic press, Type 4 external ESPE with internal laser scanner

31 On the other hand, with continuously operating, automatic, semi-automatic or cyclic machinery where reasons to approach the machine are few and consequent risk of injury is therefore lower, eg folder box gluers, filter presses, collating machines, the results of a risk assessment often indicate that the use of a type 2 ESPE, or a different type of safeguard, may be appropriate. Stopping time should always be one of the parameters taken into account in determining the separation distance.

32 Type 'C' (product) standards may specify the type and way in which the ESPE should be applied.



Weaving machine with light curtain

33 Where an unusual application arises, however, a suitable installation standard should be determined by applying the general principles contained in this guidance. Further advice may be obtained, where necessary, from an appropriate specialist source.

ESPE interfacing with the machine control system

Brakes

General

34 Paragraphs 14 to 28 formulate the relationship between the separation distance and the overall system stopping performance. On some machines a brake will not be necessary for this, on others an adequate brake may already be fitted to facilitate the normal operation of the machine. However, where more effective braking is required on an existing machine before an AOPD can be used as a trip device, steps should be taken to ensure that the machine is able to withstand any additional forces generated by the braking system. Where this is not possible, alternative means of safeguarding should be adopted. Where additional braking systems are fitted to provide adequate overall system stopping performance, the total braking torque must be applied whenever the machine is stopped in order to ensure that the overall system stopping performance is properly monitored.

35 Brakes may be either mechanical or electrical. Mechanical brakes include drum, band (see paragraph 36), single/multiple plate and disc types, while electrodynamic braking can be obtained by dc injection, capacitance or reverse plugging techniques. It is important that the most suitable braking system should be used on any machinery to which an ESPE is applied (see paragraphs 39 to 47).



Clutch-brake unit for large power press

Selection

36 The braking of machinery is usually part of the basic design concept and is largely dictated by the machinery's characteristics. The design of the brake should, where possible, be such that a single component failure does not result in the brake failing to danger. For this reason the use of band brakes is unacceptable.



Open-fronted power press with light curtain

37 Electrically actuated electromechanical brakes should be arranged so that de-energisation results in the brake being applied.

38 The braking capacity required to bring machinery to rest is related to the momentum of the moving parts and the frequency of application of the brake. The possibility of interposing a clutch mechanism should therefore be considered as a means of limiting the energy to be dissipated by the brake. Where this is possible, the use of a combined clutch/brake system is recommended.

Mechanical braking systems

39 Brakes for use in conjunction with AOPD trip devices should have the following design characteristics:

- (a) their capacity should enable them to perform satisfactorily under conditions of maximum sustained use;
- (b) heat should be adequately dissipated, to prevent excessive temperature rise;
- (c) failure of any one component should not stress other components so that rapid consequential failure is possible;
- (d) arrangements for housing and guiding should minimise the risk of binding;
- (e) potential for corrosion to adversely affect the brake performance should be minimised;
- (f) design and positioning should ensure that contaminants (eg oil or other potential lubricants in the case of dry clutches and brakes) are prevented from penetrating to the braking surfaces;
- (g) friction linings on brakes should be fastened in a manner that will minimise the possibility that they will loosen with wear;
- (h) accumulation of dust or debris produced from frictional surfaces should be minimised in areas where it is likely to give rise to brake drag or seizure and broken components should not be likely to cause brake failure;
- (i) failure of electric power supply, or loss of pneumatic or hydraulic pressure, should cause the immediate application of the brake and, where appropriate, disengagement of the clutch;
- (j) springs used for applying the brake should be adequately rated and be of sufficient strength to ensure prompt and effective brake application. A single spring should not be used for this duty unless equivalent safety is assured by other means. Any set of springs should be uniform in dimension, quality and rating and the failure of one spring should not significantly reduce the performance of the brake. The means for loading the springs should be such that, when correctly adjusted, the spring anchorages can be locked to prevent risk of slackening back; and
- (k) where the brake is used in combination with a clutch, the installation should be such that their correct synchronisation is ensured. To this end, the connection between the brake and clutch should be robustly constructed and as short and direct as practicable. In this respect, air-operated integral clutch-brake units can often be used. Information on brake control is given in paragraph 66.



Power press with light curtain

Adjustment

40 When appropriate, adequate instructions on setting the brake and the replacement of parts subject to wear should be available. These should include:

- (a) the free length of springs and the lengths to which springs should be compressed or the working tolerances of the gap between frictional surfaces;
- (b) the frequency of inspection; and, where appropriate,
- (c) the correct adjustment procedure for the operating mechanism.

Electrodynamic braking systems

41 At present there is no recognised published standard of either performance (stopping capability) or electrical integrity for dynamic electrical braking systems for safety applications. Several systems are available, including:

- (a) dc injection: the normal ac supply to the induction motor is removed and a dc current is injected into the stator winding for a predetermined period;
- (b) capacitor: the normal ac supply to the motor is removed and a capacitor or capacitors are connected across the stator winding;
- (c) combination of (a) and (b);
- (d) method (b) followed by the short circuiting of the stator windings during the run down period of the motor;
- (e) plugging: reversal of the connections to the induction motor. It is essential that the motor is disconnected as soon as it stops otherwise it will run up to full speed in the reverse direction. Before this system is adopted care should be taken to ensure that a proposed application is suitable and, in general, this will only be so if inadvertent reversal of motion does not create a hazardous situation; and
- (f) regeneration, see paragraphs 43 and 44. Some machines (eg power presses) utilise speed control, and speed changes are achieved through regeneration effects. This also contributes to stopping in conjunction with mechanically applied brakes.

42 The suitability of each of these systems will depend upon the particular application and the supplier(s) should therefore be acquainted with full details of the proposed application.

43 It is important to realise that such systems may not be suitable when certain types of motor speed control are incorporated, eg rotor resistance or solid state control. It is recommended that the system user requests a written assurance from the supplier that the system is designed for safety applications and not solely as an aid to production. Assurance should also be sought that the rating of the overall system (ie motor, transmission, machine and brake unit) is adequate for the maximum demand that could reasonably be expected, having regard to the application.

44 Electrodynamic braking systems inherently fail to danger in that, for successful operation, current is required to flow in the motor. Open circuits, loss of supply, tampering with or failure of timing systems may therefore reduce braking torque significantly or remove it altogether. The risk assessment should determine whether or not electrodynamic braking is suitable as the sole means of stopping the machine.

45 However, for those machinery applications where the operator is rarely in a potentially hazardous position immediately after there is a demand for the machine to stop, a single failure of the braking system is not so critical and, subject to the following provisions, electrodynamic braking may be acceptable:

- (a) dc injection supplies should be monitored and loss of dc supply should stop the machine and prevent further operation;
- (b) capacitors should be monitored at start-up and detection of failure should prevent further operation. As an alternative, the overall system response time should be monitored;
- (c) loss of supply to the braking control unit should prevent starting or, if the machine is in operation, should result in its stopping; and
- (d) the means of any adjustment should be in a lockable enclosure and all tools and keys giving access should only be accessible to a competent person.

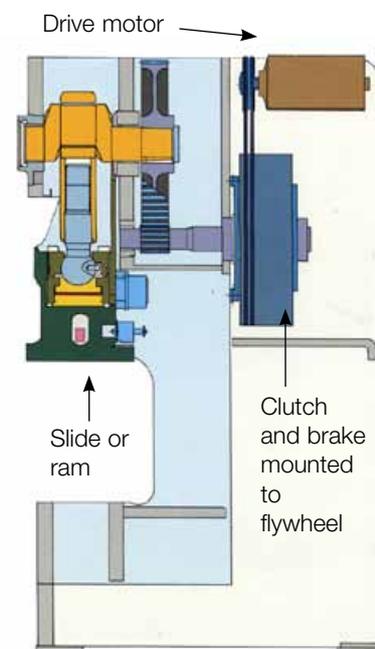
46 For some applications it may be appropriate to consider the use of an electrodynamic braking system used in conjunction with a mechanical brake to reduce the loading and increase the reliability of the mechanical brake. In such cases it is recommended that stopping performance monitoring should always be incorporated to detect deterioration or failure of the combined braking arrangement.

47 Before adopting an electrodynamic braking system for any application a thorough feasibility study should be made to ensure that the machinery is mechanically compatible with such a braking system. Aspects which should be taken into account include:

- (a) the effect of braking torque on the transmission system and driven equipment. Some electrodynamic braking systems produce torque in excess of the maximum starting torque;
- (b) the effect on the braking when either the speed or inertia of the machine is changed;
- (c) the possible additional heating effect on the motor; and
- (d) the rating of the braking unit regarding the normal operation and also any setting up procedures (eg inching).



Typical power press with light curtain



Cross section of a typical power press

Clutches

General

48 When machinery is to be safeguarded with an ESPE, it is necessary to ensure that the safety of persons working at or near that machinery is not compromised by the use of a clutch of inferior or unsuitable design.

49 When the required overall system stopping performance can be achieved, whether it is engaged or disengaged, the characteristics of the clutch are not important. When, on the other hand, safety relies on the clutch being disengaged on actuation of the AOPD, design considerations similar to those for brakes should be taken into account. In addition, the clutch design should be such that it can be disengaged at any time during the machine cycle and therefore positive key-type clutches, such as those found on some power presses, are not suitable.

50 Synchronised operation of a clutch and brake is desirable for maximum effectiveness and therefore combined clutch-brake units can often be used.

Design considerations

51 Clutches that perform a safety-related function should have the following characteristics:

- (a) their capacity should be such that operation is not adversely affected under conditions of maximum sustained use;
- (b) heat should be adequately dissipated, to prevent excessive temperature rise;
- (c) failure of any one component should not stress other components so that rapid consequential failure is possible;
- (d) potential for corrosion to adversely affect the ability of the clutch to disengage should be minimised;
- (e) any necessary working clearances should be sufficient to ensure that, under the severest conditions of operation, friction drag leading to undesired movement of the hazardous machine parts does not take place;
- (f) any friction linings should be fastened in a manner that will minimise the possibility that they will become detached during use;
- (g) accumulation of dust or debris produced from frictional surfaces should be minimised in areas where it is likely to give rise to clutch drag or seizure and broken components should not be likely to cause clutch failure;
- (h) failure of a power supply, whether pneumatic, hydraulic or electrical, should cause the immediate disengagement of the clutch where failure to do so could adversely affect the integrity of the ESPE safeguarding system;
- (i) springs used for disengaging the clutch should be of the compression type and should not be overstressed. A single spring should not be used for this duty unless equivalent safety is assured by other means. Any set of springs should be uniform in dimension, quality and rating, and the failure of one spring should not affect the ability of the clutch to disengage upon release of the engaging force. The means for loading the springs should be such that, when correctly adjusted, the spring anchorages can be locked to prevent slackening back. The arrangements for spring housing and guiding, and of guide pins, should minimise the risk of binding;
- (j) where the clutch is used in combination with a brake, the installations should be such that their correct synchronisation is ensured. To this end, the connection between clutch and brake should be robustly constructed and be as short and direct as practicable; and
- (k) if diaphragms are used they should be designed and installed so as to minimise the possibility of failure, eg through overstressing or fatigue, and care should be taken to avoid damage from sharp edges.



Robot load bay with Type 4 ESPE

52 Information on the control of clutches is given in paragraph 66.

Electrical/electronic considerations

53 Machine electrical control systems should be designed and installed with due regard to BS EN 60204-1, Part 1: 1998 and BS EN 954-1: 1997.

54 Loss of electrical supply to any part of the overall safeguarding system should not result in a failure to danger. This system should retain its integrity at least to the same levels of immunity for the ESPE as specified in IEC 61496. It is important to ensure that the ratings of the output signal switching device(s), any final switching device(s) and, if provided, the secondary switching device are adequate for their duties, ie the switching of machine primary and secondary control elements respectively.

Electromagnetic contactors

55 When the machine primary and secondary control elements are contactors these should be selected with due regard to the recommendation contained in BS EN 60947-4-1 Specification for low-voltage switchgear and controlgear Part 4-1 (1992) and Electromechanical contactors and motor starters (IEC 947-4-1: 1990). There should be co-ordination between contactors and their short circuit protection devices and general recommendations on this aspect of application are contained in BS EN 60947-4-1 and BS EN 60204-1. BS EN 60947-4-1 accepts the risk of welded contacts. When contactors are used as machine primary and secondary control elements suitable overcurrent (eg short circuit) protective devices, agreed between contactor manufacturer and user/installer, should be used to reduce the risk of contact welding. See also 7.2.10 of BS EN 60204-1.

56 A contactor used as a machine primary control element should incorporate suitable means to monitor the 'on/off' positions of the main contacts. This can sometimes be achieved by using an auxiliary contact on the same former as the main power contacts.

57 The use of solid state switching devices or contactors cannot meet the requirements for isolation and is not recommended because of the difficulties in providing adequate monitoring facilities and the precautions necessary to reduce

the possibility of common cause failures due, for example, to voltage transients or other electrical disturbances.

Hydraulic and pneumatic considerations

General

58 If the AOPD is actuated while a hazardous part of machinery is in operation, the hydraulic or pneumatic control valves should operate and promptly arrest or, where appropriate, cause the hazardous parts to adopt an otherwise non-hazardous condition before it is possible to reach the danger zone.

59 Loss of electrical power to any solenoids or loss of hydraulic or pneumatic pressure should not result in a dangerous situation.

Machinery employing an ESPE as a trip device

60 Two control valves should be provided, so arranged that if one valve fails when called upon to stop the machine the second valve will stop it or, where appropriate, will cause the hazardous parts to adopt an otherwise non-hazardous condition. The two control valves should be electrically operated or depend entirely on pilot pressure from electrically operated valves to prevent the ESPE control from being compromised. It should not be possible to initiate a further cycle or restart upon failure of either of these two valves.

61 A monitoring system (eg EDM) should be incorporated to detect the failure of either valve. Upon detection of such failure the ESPE or the machine control system should prevent further operation of the machine until any faults in either valve have been correctly diagnosed and remedied. On those machines having only one valve, eg those having category 1 or category 2 control systems to BS EN 954-1, see also paragraph 92.

62 The monitoring system should detect and register the positions of the valve pistons or spools. However, if the hydraulic or pneumatic circuit is such that failure of either valve is self-revealing, ie if the machine can no longer be operated, the recommendation for monitoring is waived. Monitoring the electrical supply to the solenoid or the position of the piston or spool actuating mechanism is unlikely to give an adequate level of integrity to the system.

Protection against gravity fall

63 Protection against gravity fall should be provided.

- (a) A pilot-operated check valve (seated valve) in association with a counterbalance valve may be used. Additionally, all the oil from the return area of the cylinder(s) should be passed through the main control valve or, if this is not possible, through an auxiliary valve which is totally dependent for its operation upon the supply of pilot oil from the main control valve. Check valves providing protection against gravity fall should be mounted directly on to the hold-up cylinder(s).
- (b) Where gravity fall would present a hazard, the pneumatic control circuit should be so designed that the air supply is maintained to the hold-up side of cylinder(s) until movement of the dangerous part of machinery is required. In the event of an air supply failure, a mechanical restraint arrangement should operate to hold the dangerous parts of machinery at the top of the stroke.

Hydraulic circuit protection

64 Hydraulic circuit protection should be provided to prevent overpressurisation caused by either malfunction of any control valve or intensification effects within the actuator.

65 Regular maintenance and inspection of the valve should be carried out to minimise the possibility of valve failure. The nature and frequency of such maintenance and inspection should be based on the supplier's recommendations and user experience.

Pneumatic control of brakes and clutches

66 Where a pneumatic supply is used to control brake disengagement and/or clutch engagement, the following additional principles should be incorporated:

- (a) all pilot and control valves should be designed and connected to ensure that any air leakage across seals or seatings in the valves can escape to atmosphere sufficiently freely to prevent pressure build-up in the operating cylinders of the brake or clutch, thereby reducing their efficiency;
- (b) exhaust ports and piping between clutch or brake operating cylinders and valves should be of sufficient capacity to ensure prompt release of air; exhaust silencers should be fitted but should be of adequate size to prevent excessive back pressure through the valve exhaust port, and freezing or clogging of this port; and
- (c) flexible pipes carrying compressed air for clutch and brake operation should be mounted and protected to avoid kinking. Such kinking can cause traps which prevent or delay the air from exhausting, thereby reducing the efficiency of the clutch and brake.

67 When pneumatic machines are equipped with two machine primary control elements, eg those having category 3 or category 4 control systems to BS EN 954-1, a double-bodied solenoid operated monitored valve or equivalent should be fitted which should directly control the pneumatic supply to any air-operated clutches.

68 Further advice on hydraulic and pneumatic systems is contained in BS EN 982: 1996 *Safety of machinery - safety requirements for fluid power systems and their components - hydraulics and pneumatics*.

ESPE installation

General requirements

69 Everyone concerned with the design, manufacture, supply and use of ESPEs and machinery to which they are applied should exchange all necessary information, including circuit diagrams, to ensure that the total installation satisfies the requirements of the Provision and Use of Work Equipment Regulations, and the Supply of Machinery (Safety) Regulations in the case of new machinery. Compliance with the recommendation of this guidance, EN 999 and IEC 61496 assists in meeting the relevant legal requirements.

70 This advice for the exchange of information is intended to reduce the possibility of the integrity of the overall protective system being adversely affected if the installer, having failed to appreciate the significance of safety-related control circuitry, unilaterally alters the circuit without reference to the suppliers of the ESPE, the associated machine safety-related control circuit and/or the machine.

71 IEC 61496-1 in Clause 7 accompanying documents, requires the ESPE supplier to provide comprehensive documentation as to the capabilities and limitations of their equipment. Similar information should be available from the machine supplier regarding the machine, whether the proposal is to fit the ESPE to an existing or new machine. In the case of existing machines where the manufacturer's information is unavailable, the person installing the ESPE should take steps to ensure that the overall safeguarding system is not thereby adversely affected.

72 Where the user is aware of any adverse environmental conditions, such as vibration, humidity, temperature, or electrical interference, they should draw them to the attention of the equipment suppliers at the contract stage so that correct and suitable equipment can be supplied and installed.



Three corner Type 2 testing fixture. Additional screens and guards may be required for safe operation in some AOPD applications

73 Adequate written instructions should be given by the supplier to the user to ensure that the user's management and the operator(s) of the machine are fully aware of how the overall safeguarding system operates and the steps that must be taken if the machine fails to operate correctly.

74 It should be ensured that appropriate steps are taken to prevent access to the danger zone from any direction not protected by the AOPD. Depending on the risk assessment and the application, such steps could include fixed or interlocking guards or screens, extra light beam devices or pressure-sensitive mats.

75 Similar steps should be taken to prevent or detect anyone remaining between the light curtain and the danger zone.

76 The user should be provided with adequate instruction on how to recognise malfunctions (eg inability of the ESPE to mute when selected, failure of the machine to stop at its normal position).

77 Components of the overall safeguarding system should only be replaced by those known to be compatible with the remainder of the system; Clause 7(r) of IEC 61496-1 gives specific requirements for the ESPE.

78 The user may need to take additional measures, eg barriers, to ensure that the installation is adequately protected against physical damage by general factory activities, eg vehicles or lifting equipment.



Power press has label with relevant information

Labelling

79 IEC 61496 requires the ESPE supplier to give relevant information which should be marked on a label or plate on the outside of the equipment, as follows:

- (a) name and address of supplier;
- (b) model, series or type;
- (c) serial number;
- (d) year of manufacture;
- (e) supply voltage and frequency;
- (f) where appropriate, the standard(s) to which the equipment was constructed and tested; and
- (g) the detection capability(s) of the AOPD in millimetres.

80 In addition to the above, the following information should be determined and made available to the user. It is recommended that this information be recorded on a label fixed to the machine:

- (a) the minimum separation distance in millimetres;
- (b) stopping performance if appropriate; and
- (c) the overall system stopping performance in milliseconds if appropriate.



Minimum separation distance must be calculated to allow safe application of the light curtain

81 The minimum separation distance for the AOPD should have been specified in accordance with the guidelines given in paragraphs 14 to 28. The position of the AOPD relative to the danger zone should be adequately secured to prevent inadvertent alteration outside this specification.

Standards of performance

82 It should not be possible for parts of machinery to be set in hazardous operation while any part of a person is in a position that would actuate the AOPD.

83 When an ESPE is used as a trip device, its actuation should result in all parts of machinery which are in hazardous operation being brought to rest or to an otherwise safe condition before the maximum overall system stopping performance specified for the particular machine has been exceeded.

84 The requirements of the previous two paragraphs need not necessarily preclude operation at reduced torque or speed, operation initiated by limited movement devices or operation at reduced pressure (see also BS EN 60204-1, 9.2.4 Suspension of safeguards) if one or more of these methods or techniques of working provide an acceptable standard of safety

85 When the AOPD is actuated during hazardous operation it should not be possible to restart the machine until the ESPE has been completely restored to its normal condition and the machine controls have been manually reoperated (restart interlock, see A6 of IEC 61496-1). In certain applications where AOPDs are applied, eg to lift doors or automatic pedestrian doors, a restart interlock is not normally provided with the ESPE.

Machine control systems

86 An operator working at machinery equipped with an ESPE relies for safety not only on the efficiency of the equipment but also on the ability of the machinery to respond correctly and effectively to its output signals. Standards for construction and performance of the ESPE are set by IEC 61496. Unless the safety-related parts of the control system of the machine are constructed and perform to a similar standard, the overall level of safeguarding might be lowered.

87 Paragraphs 69 to 78 emphasise the need for full consultation between all those concerned with the supply, installation and use of an ESPE on a machine to ensure that the installation as a whole performs as intended. Although each installation needs to be considered separately, various aspects of machinery control systems merit careful consideration. These include:

- (a) interfacing the ESPE with the machine;
- (b) brakes;
- (c) clutches;
- (d) electrical/electronic considerations;
- (e) hydraulic considerations; and
- (f) pneumatic considerations.

88 The performance of the overall safeguarding system can be compromised if due care is not given to the interfacing arrangement between the ESPE and the machine. ESPEs provide for several input/output channels (see Figures B.1 and B.2 in Appendix B), as follows:

- (a) separate outputs from each of one or more output signal switching devices (OSSDs). These are provided to interrupt circuits to the final switching devices or to the machine primary control elements;
- (b) inputs to the external device monitoring (EDM) means, when provided, of the ESPE from the machine primary control elements, for example (see A.2 of IEC 61496-1). These incoming signals give an indication of the state (eg 'on' or 'off') of the devices being monitored;

- (c) an output from the secondary switching device when provided. See A.4 of IEC 61496-1;
- (d) inputs from the stopping performance monitor (when provided) of the machine. The stopping performance monitor will generate signals depending upon the time taken, or the amount of travel before the dangerous parts of the machine come to rest or revert to a safe condition after actuation of the AOPD, or from the change of state of the OSSD(s). See also A.3 of IEC 61496-1; and
- (e) inputs from the machine which indicate that the machine is in a position at which the ESPE may be muted when a mute facility is provided. See also A.7 of IEC 61496-1.

89 In addition to the above, there may be other inputs and outputs to provide for mutual exchange of information on the state of the machine and ESPE. For example:

- (a) a computer controlled machine will normally need an output from the ESPE indicating the actuation of the OSSD(s) to be fed to the computer control system to ensure that the machine and program remain synchronised; and
- (b) where the AOPD is used as a machine reinitiation device. See also A.8 of IEC 61496-1.

90 The circuits should be arranged so that the final switching devices (or the OSSDs where final switching devices are not provided) directly control the machine primary control elements. When either final switching device and/or OSSD is in the open circuit state, the corresponding machine primary control element should be switched to the OFF- or SAFE-state irrespective of any other signals in the control system.

91 When machines are equipped with two machine primary control elements, each of those elements should, irrespective of the state of the other, be capable of stopping the machine. These two channels of control need not be identical. For example, one channel may control a solenoid operated valve, the other may control the contactor in a hydraulic pump motor starter. In such cases the overall system stopping performance should take account of the response time of the slower of the two channels.

92 On machines where the risk assessment indicates that dual machine primary control elements are not justified, it is recommended that the outputs from the OSSDs are connected so that each OSSD is capable of switching the machine primary control element (MPCE) to the OFF-state. Duplication of the machine primary control element (MPCE) monitoring signal facility may be required in order to satisfy the monitoring capability of a type 4 ESPE. The circuits between final switching devices (and/or OSSDs) and their corresponding machine primary control elements should be arranged so that a single fault or earth fault does not result in both control channels failing to a potentially hazardous state.



Test rig with combination of protective measures including light curtain

AOPD use

Stopping performance monitoring

93 On cyclic hand-fed machines where the AOPD is used as a trip device consistent braking performance is vital. Unless a stopping performance monitor (SPM) is provided, any gradual deterioration in overall system stopping performance will not be detected. Stopping performance monitoring is therefore considered essential wherever the means of arresting motion are inherently subject to deterioration.

94 Other machines should also have their overall system stopping performance monitored unless it has been established over an extended period that their stopping performance is consistent and not subject to deterioration. As a guide, unless it can be shown that the overall system stopping performance will not deteriorate by more than 10% over the period between inspections by a competent person (see paragraphs 124 to 126), stopping performance monitoring should be provided.

95 The provision of stopping performance monitoring may not be necessary when there is:

- (a) a low frequency of demand on the braking system;
- (b) no risk of serious injury even if the overall system stopping performance deteriorated;

providing the design and rating of the braking system are adequate and an effective maintenance regime is implemented.

96 An arrangement whereby the overall system stopping performance can be 'assessed' by the operator should be provided where it is reasonable to do so. Examples of such arrangements are:

- (a) direct 'read-out' of overall system stopping performance (in milliseconds);
- (b) discs with coloured sectors on shafts;
- (c) stroke position indicator; and
- (d) a test cam switch which initiates stopping at a predetermined position in the cycle. The actual stopping position can then be compared with a marked datum.

97 These methods will provide the operator with a simple indication of deterioration in overall system stopping performance.

98 It should be recognised that stopping performance monitoring only gives protection against the gradual deterioration of stopping systems: a catastrophic brake or clutch failure, for example, is likely to result in at least one potentially hazardous operation. For this reason the design and construction of brakes and other stopping devices should minimise the possibility of catastrophic failure.

99 Where possible, all systems of stopping performance monitoring should be arranged so that the braking conditions being monitored are comparable with actual braking conditions when the light curtain is interrupted during hazardous motion (eg similar inertia, speed, friction, direction, load).

100 In the case of continuously operating machinery, stopping performance

monitoring, when incorporated, should take place each time the machinery is called upon to stop whether by actuation of the AOPD or of the machinery controls.

101 When provided as part of the ESPE, the stopping performance monitor should be in accordance with A.3 of IEC 61496-1.

102 All stopping performance monitors will have an inherent accuracy/resolution which needs to be taken into account when they are set.

103 The stopping performance monitor should be set so that the system will go to lock-out condition if the overall system stopping performance marked on the label, and used for the calculation of separation distance (see paragraphs 14 to 28), is exceeded.

Muting

104 A muting facility should be used if it is essential to the process currently being undertaken on the machine. When muting is not required on a particular machine, the facility should not be available.

105 When provided as part of the ESPE, the muting facility should be in accordance with A.7 of IEC 61496-1.

106 Situations requiring a mute condition may include:

- (a) where material being processed would actuate the AOPD during part of the cycle of operations, and where arrangements for differentiating between the material and the operator are impracticable;
- (b) where close observation of the process requires the operator to stand in a position which would actuate the AOPD.



Entry-exit system. Four beam muting, three beam guard

107 Muting is acceptable provided that it occurs only during the time in the operating cycle or sequence when safety is maintained by alternative means. The position at which muting occurs should be independent of the overall response time and also of operator intervention (except in so far as the mute may be adjusted automatically when the operator adjusts other machine operating parameters, eg to accommodate different material thicknesses). If the position at which muting occurs can be adjusted, the means of adjustment should be provided with a locking facility so that adjustment can be restricted to suitably trained persons.

108 Where provided, selection of the muting facility should be possible only by means of a key operated switch or other secure means. This enables the selection of mute to be under the control of a suitably trained person.

Use of an ESPE for machine initiation

109 On some machines, in addition to its function as a protective device, the ESPE may be used to initiate machine operation. Two modes of operation may be provided as follows:

- (a) single break, where an actuation and de-actuation of the AOPD (light curtain) initiates machine operation;
- (b) double break, where two consecutive actuations and de-actuations of the light curtain initiates machine operation.

When either of these modes is used, paragraph 85 still applies. When provided as part of the ESPE, this facility should be in accordance with A.8 of IEC 61496-1.

110 This mode of operation should be used only on high frequency/short cycle time operations. Often in such applications, safeguarding may instead be achieved by automating the material feed and/or product removal.

111 Whether these modes of operation are appropriate in any specific application will depend on the type of machine and details of the particular installation. Advice for the positioning of the light curtain with respect to the danger zone for these modes of operation is contained in BS EN 999.

112 Where these methods are used they should not be the only method of initiating machine operation but should be selectable alternatives to a conventional control (eg push button, treadle, etc) where the ESPE performs the single function of a guard only. Furthermore, a start interlock (see A.5 of IEC 61496-1) and a restart interlock (see A.6 of IEC 61496-1) should be provided.

113 In guard-only, single-break or double-break modes, interruption of the light curtain during hazardous motion should stop the machine or bring the dangerous parts to an otherwise safe condition.

114 Setting, maintenance and similar non-production operations should be carried out with the ESPE selected in the guard-only mode.

115 When a machine can be operated in either single- or double-break modes, it is essential that the following conditions are fulfilled:

- (a) effective provision needs to be made and maintained to ensure that it is impossible for persons to pass completely through the light curtain towards the danger zone and so allow the light curtain to clear behind them. See also paragraph 74;

- (b) the ESPE safety-related function needs to be effective at all times during the hazardous operation of the machinery;
- (c) the automatic machine initiation system and resetting of similar facility should not reduce the safety integrity of the ESPE and the associated machine safety-related control system (see paragraphs 86 to 92);
- (d) the facility for the initiation of machinery operation upon deactuation (clearing) of the light curtain should be limited to a period commensurate with the normal cycle time. Normal means of initiating machinery operation is therefore required for occasions when machinery operation is not initiated within that limited period; and
- (e) if the light curtain is actuated during hazardous operation, it should not be possible for operation to be reinitiated until the ESPE has been completely restored to its normal condition and the machine controls have been manually reoperated (see paragraph 87).

Inspection and test

General

116 This section is concerned with the inspection and test of the total installation, ie the machine and its associated ESPE. Regulation 6 of the Provision and Use of Work Equipment Regulations 1998 (PUWER) requires that:

- (1) *Every employer shall ensure that, where the safety of work equipment depends on the installation conditions, it is inspected -*
 - (a) *after installation and before being put into service for the first time; or*
 - (b) *after assembly at a new site or in a new location,*

to ensure that it has been installed correctly and is safe to operate.

- (2) *Every employer shall ensure that work equipment exposed to conditions causing deterioration which is liable to result in dangerous situations is inspected -*
 - (a) *at suitable intervals; and*
 - (b) *each time that exceptional circumstances which are liable to jeopardise the safety of the work equipment have occurred,*

to ensure that health and safety conditions are maintained and that any deterioration can be detected and remedied in good time.

117 However, regulation 6 does not apply to power presses, for which there are separate statutory requirements in Part IV of PUWER 1998. These cover thorough examination, inspection and test of power press guards and protection devices, which include ESPE (see *Safe use of power presses* L112). The statutory requirements are:

- (a) regulation 32(1) and 32(2) for initial thorough examination and testing requirements;
- (b) regulation 32(4) for periodic thorough examination requirements; and
- (c) regulation 33(1) for inspection and test requirements after setting, resetting or adjustment of power press tools, and before the expiration of the fourth hour of any working period.

118 Inspection and (where necessary) testing is only required under regulation 6 where the safe operation is: critically dependent on work equipment being properly installed or reinstalled and failure to carry this out would lead to a significant risk, ie one which could foreseeably result in a major injury or worse; and where the safe operation is critically dependent on its condition in use and deterioration would lead to a significant risk to the operator or other worker. If this is the case in either or both these situations, then the following procedures should be used to ascertain that the machine and ESPE are operating safely:

- (a) initial inspection and test: when the installation is first commissioned the total 'package' of machine and ESPE should be inspected and tested (paragraphs 120 to 123); the same procedure is recommended following repair or modification which may affect the safe operation of the ESPE; and
- (b) periodic inspection and test: installations using ESPEs (see IEC 61496) should be inspected at suitable intervals (see paragraphs 124 to 126).



**Type 4 ESPE Assembly
fixture**

Additionally, though not required under regulation 6, there are functional safety checks: namely checks that can be carried out to ascertain that the machine and ESPE continue to operate safely between necessary periodic inspection and test (paragraphs 127 and 128).

119 The machine supplier and the ESPE supplier should ensure that information on the routine maintenance and inspection requirements for their equipment is available, including, where necessary, routine replacement of electrical or mechanical parts. Users should also be informed of routine functional safety checks to ascertain that the machine and ESPE are operating safely.

Initial inspection and test

120 The initial inspection and test should be carried out by competent persons with the necessary knowledge and experience, who possess, or have access to, all the information the machine and ESPE supplier should have provided. The competent person could be, for example, an in-house inspector or, more likely, a representative of the installer or supplier, or an independent inspecting engineering surveyor.

121 The results of the initial inspection and test should be recorded, and copies of this record kept by the user. The results of inspection and test following repair or modification which may affect the safe operation of the ESPE should also be recorded and copies kept by the user.

122 The person carrying out the inspection and test should ensure that the following general standard of performance is achieved:

- (a) it should not be possible for the dangerous parts of the machine to be set in operation while any part of a person is in such a position as to actuate the AOPD; and
- (b) actuation of the AOPD during a phase of the operating cycle when there is or may be a risk should result in the dangerous parts being arrested or, where appropriate, assuming an otherwise non-hazardous condition before any part of any person can reach them. It should not be possible for the hazardous parts to be put into operation again until the protective equipment has been completely restored to its normal condition and the machine controls reoperated.

123 The persons carrying out the inspection and test should also:

- (a) inspect the position of the AOPD (eg light curtain) to ensure that it is set at the correct separation distance from the danger zone as recorded on the machine and/or ESPE information label or plate;
- (b) ensure that additional safeguards have been provided where necessary to prevent access to the danger zone from any direction not protected by the AOPD;
- (c) test the overall response time using a timing instrument designed for that purpose and ensure that it is the same as or less than the overall response time recorded on the information label or plate;
- (d) test that it is not possible for a person to stand between the AOPD and the danger zone;
- (e) test the AOPD detection capability according to the supplier's recommendations;
- (f) inspect the machine controls and connections to the ESPE to ensure that the machine and ESPE designer's requirements are met;
- (g) inspect the stopping performance monitor (if fitted) to ensure that it is correctly

positioned and fitted, test that the monitor is working satisfactorily to the supplier's recommendations, and ensure that the means by which the overall system stopping performance can be assessed by the operator (see paragraph 96) is indicating correctly;

- (h) test the muting arrangements (if fitted); and
- (i) inspect any brakes or clutches (if fitted) to the supplier's recommendations.

Periodic inspection and test



Stretch wrapper with
lifting table (light curtain
protected by IP67
polycarbonate tubes)

124 The user should ensure that only competent persons carry out the periodic inspections and tests. Such persons could be independent inspecting engineering surveyors, machinery suppliers, ESPE suppliers, or from within the user's organisation. The recommended maximum period between each periodic inspection and test is six months for type 4 ESPE and 12 months for type 2 ESPE, but this will depend on the equipment it is fitted to and the risk as a whole.

125 The results of the inspection and test should be recorded and a copy of this record kept by the user.

126 The person carrying out the inspection and test should ensure that the same general standards of performance are achieved as in paragraph 122 and should:

- (a) carry out the inspection and tests set out in paragraph 123, except for paragraph 123(f). In the case of paragraph 123(c) alternative, equally effective means for determining that the overall response time, recorded on the information plate, has not been exceeded are permissible;
- (b) inspect and test the machine primary control elements (MPCE) to ensure that they are functioning correctly and are not in need of maintenance and/or replacement;
- (c) inspect the machine to ensure that there are no other mechanical or structural aspects that would prevent the machine from stopping or assuming an otherwise safe condition when called upon by the ESPE to do so; and
- (d) inspect the machine controls and connections to the ESPE to ensure that no modifications have been made which adversely affect the system.



Frequent functional safety checks may be required

Functional safety checks

127 While functional safety checks are not required by regulation 6, they are good practice and may be carried out on a frequent (eg daily) basis, dependent on the risk. The checks may be selected from those given in paragraph 128 as appropriate. These checks could be carried out by a suitably trained operator.

128 The person undertaking these checks should:

- (a) check that access to the dangerous parts of machinery is not possible from any direction not protected by the AOPD, and that side and rear guards are in order;
- (b) check that the separation distance from the danger zone to the AOPD is not less than the distance stated on the machine and/or ESPE information plate;
- (c) check that it is not possible for a person to stand between the AOPD (eg light curtain) and the danger zone;
- (d) test the effectiveness of the ESPE with power on but with the machine at rest as follows:
 - (i) first establish that the AOPD is functioning by checking the state of the appropriate indicators, and ensure that the ESPE is not muted;
 - (ii) insert the appropriate diameter test piece into the AOPD (eg light curtain). The test piece should be passed very slowly down the light curtain in three separate places: close to one transmitter/receiver column, close to the other transmitter/receiver column, and in the middle of the light curtain. The indicator light which indicates actuation (interruption) of the AOPD (light curtain) should change state whenever the test piece enters and leaves the AOPD (light curtain) and should not change state for the whole time the test piece is in the detection zone;
 - (iii) initiate machine operation and insert the test piece into the AOPD (light curtain). The axis of the test piece should be at right angles to the detection zone so as to interrupt the minimum area. Under no circumstances should an attempt be made to insert the test piece into the danger zone. Upon insertion of the test piece during hazardous operation, the dangerous parts of the machine should come to rest, or to an otherwise safe condition, without apparent delay;
- (e) test that when the mute mode is operative, ie the ESPE is muted, the machinery operation is no longer hazardous. For example, the gap between the top and bottom tools at muting on a press brake should be just greater than the material thickness. Check that the mute indicator (when provided) is illuminated when the ESPE has been muted;
- (f) check that the stopping performance monitor (where provided) is in use and is set up and functioning in the manner recommended by the supplier;
- (g) check that the cabinets housing the electrical/electronic equipment are closed and locked and that the key is removed for retention by a suitable person; and
- (h) check for external signs of damage to equipment or to electrical wiring. Any damage found should be reported to line management.



Insert the appropriate diameter test piece into the light curtain



Examples of test pieces for a light curtain

Appendix A:

Commonly used terms

For the purposes of this guidance the following definitions apply (*derived from IEC 61496).

Detection capability

In an active opto-electronic protective device (AOPD), the dimension representing the diameter of the opaque cylinder which:

- (a) for a light curtain, will actuate the sensing device when placed in the detection zone; and
- (b) for a light beam device, will actuate the sensing device when placed in the beam on the axis of the beam.

See 3.202 of IEC 61496-2.

*Control/monitoring device**

The part of electro-sensitive protective equipment (ESPE) that:

- (a) receives and processes information from the sensing device and provides signals to the output signal switching devices (OSSDs); and
- (b) monitors the sensing device and the OSSDs.

*Detection zone**

The zone within which a specified test piece will be detected by the electro-sensitive protective equipment (ESPE).

Danger zone (hazard zone)

Any zone within and/or around machinery in which a person is exposed to a risk of injury or damage to health.

The hazard generating the risk envisaged in this definition:

- (a) either is permanently present during the intended use of the machine (motion of hazardous moving elements, electric arc during a welding phase); and
- (b) or may appear unexpectedly (unintended/unexpected start-up).

(See 3.10 of BS EN 292:1991, Part 1)

Competent person

Any person designated by the occupier or employer to be responsible for the initial or periodic inspection including testing of the electro-sensitive protective equipment (ESPE) and the machine to which it is applied.

For power presses cases there are specific legal requirements concerning the appointment of persons to carry out such inspection and tests, in particular Part IV of the Provision and Use of Work Equipment Regulations 1998 applies (see paragraph 116).

Definition of meeting from 3.16 (IEC61496. Part1).

Electrodynamic braking system

An arrangement by which electromagnetic forces are used directly to bring the moving part(s) to rest.

*Electro-sensitive protective equipment (ESPE)**

An assembly of devices and/or components working together for protective tripping or presence-sensing and comprising as a minimum:

- (a) a sensing device;
- (b) control/monitoring devices; and
- (c) output signal switching devices.

The safety-related control system associated with the ESPE, or the ESPE itself, may include a secondary switching device, muting functions, stopping performance monitor etc (see Appendix B). In order to assist in the understanding of the inter-relationship of the various major elements of the ESPE and the associated safety-related control systems, block schematic diagrams are included as Figures A.1 and A.2 in Appendix B.

*External device monitoring (EDM)**

A means by which the electro-sensitive protective equipment (ESPE) monitors the state of control devices which are external to the ESPE.

*Final switching device (FSD)**

The component of the machine's safety-related control system that interrupts the circuit to the machine primary control element (MPCE) when the output signal switching device (OSSD) goes to the OFF-state (see Figures A.1 and A.2 in Appendix B).

Hazard

A potential source of harm. The term hazard is generally qualified in order to define its origin or the nature of the expected harm (eg electric shock hazard, crushing hazard, shearing hazard, toxic hazard, fire hazard or drowning hazard). (3.5 of BS EN 292: 1991, Part 1.)

Hazardous situation

A circumstance in which a person is exposed to a hazard or hazards.

Interface

The configuration of all the points of electrical interaction between the machine, its safety-related control system and the ESPE.

*Light beam device**

An active opto-electronic protective device (AOPD) comprising one emitting element and one receiving element, where a detection zone is not specified by the supplier. An AOPD can comprise an arrangement of more than one light beam device.

*Light curtain**

An active opto-electronic protective device (AOPD) comprising an integrated assembly of one or more emitting element(s) and one or more receiving element(s) forming a detection zone with a detection capability, both specified by the supplier.

*Lock-out condition**

A condition, initiated by a fault, preventing normal operation of the electro-sensitive protective equipment (ESPE) which is automatically attained when all output signal switching devices (OSSDs) and, where applicable, all final switching devices (FSDs) and secondary switching devices (SSDs) are signalled to go to the OFF-state.

*Machine primary control element (MPCE)**

The electrically powered element that directly controls the normal operation of a machine in such a way that it is the last element (in time) to function when machine operation is to be initiated or arrested. This element can be, for example, a mains contactor, a magnetic clutch or an electrically operated hydraulic valve.

*Machine secondary control element (MSCE)**

A machine control element, independent of the machine primary control element(s), that is capable of removing the source of power from the prime mover of the relevant hazardous parts. When fitted, the MSCE is normally controlled by the secondary switching device. This element can be, for example, a mains contactor, a magnetic clutch or an electrically-operated hydraulic valve.

*Muting**

A temporary automatic suspension of a safety function or functions by safety-related parts of the control system. (3.16 of IEC 61496, Part 1.)

NOTE - For ESPE-muting see A.7.

*Output signal switching device (OSSD)**

The component of the electro-sensitive protective equipment (ESPE) connected to the machine control system which, when the sensing device is actuated during normal operation, responds by going to the OFF-state. (3.19 of IEC 61496, Part 1.)

Overall safeguarding system

The combination of the ESPE, final switching device(s) and machine primary control element(s) with the machine secondary control element and any machine clutch or braking system or other arrangements by which the dangerous parts of a machine are brought to a safe state when the light curtain or light beam device is interrupted.

*Overall system stopping performance**

The time interval resulting from the sum of the electro-sensitive protective equipment (ESPE) response time and the time to the cessation of hazardous machine operation.

Presence-sensing device

A device which detects the presence of a person, or a part of a person, in a danger zone and prevents hazardous operation of the machine while anyone is in that area. This device can be a pressure-sensitive mat, for example.

*Response time**

The maximum time between the occurrence of the event leading to the actuation of the sensing device and the output signal switching devices (OSSDs) achieving the OFF-state.

*Secondary switching device (SSD)**

A device which, in a lock-out condition, performs a back-up safety function by going to the OFF-state and initiating an appropriate machine control action, eg de-energising the machine secondary control element (MSCE).

Separation distance

The distance, along the direction of approach, between the outermost position at which the appropriate test piece will just be detected and the nearest dangerous part.

*Stopping performance monitor (SPM)**

A monitoring means to determine whether or not the overall system stopping performance is within the preset limit(s).

Supplier (derived from BS EN 60204-1)

Entity (eg manufacturer, contractor, installer, integrator) who provides equipment or services associated with the machine. Users may also act in the capacity of suppliers to themselves.

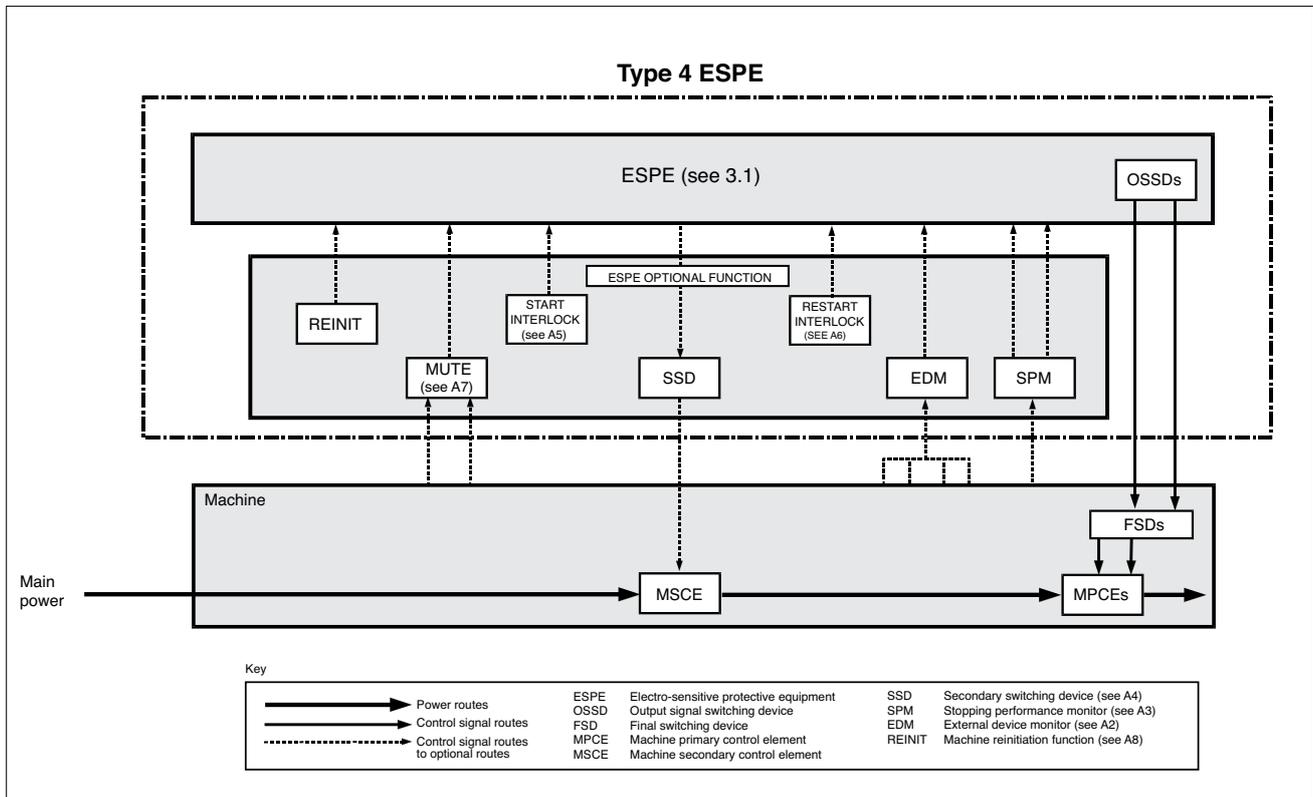
*Test piece**

An opaque cylindrical element used to verify the detection capability of the active opto-electronic protective device (AOPD).

*Trip device**

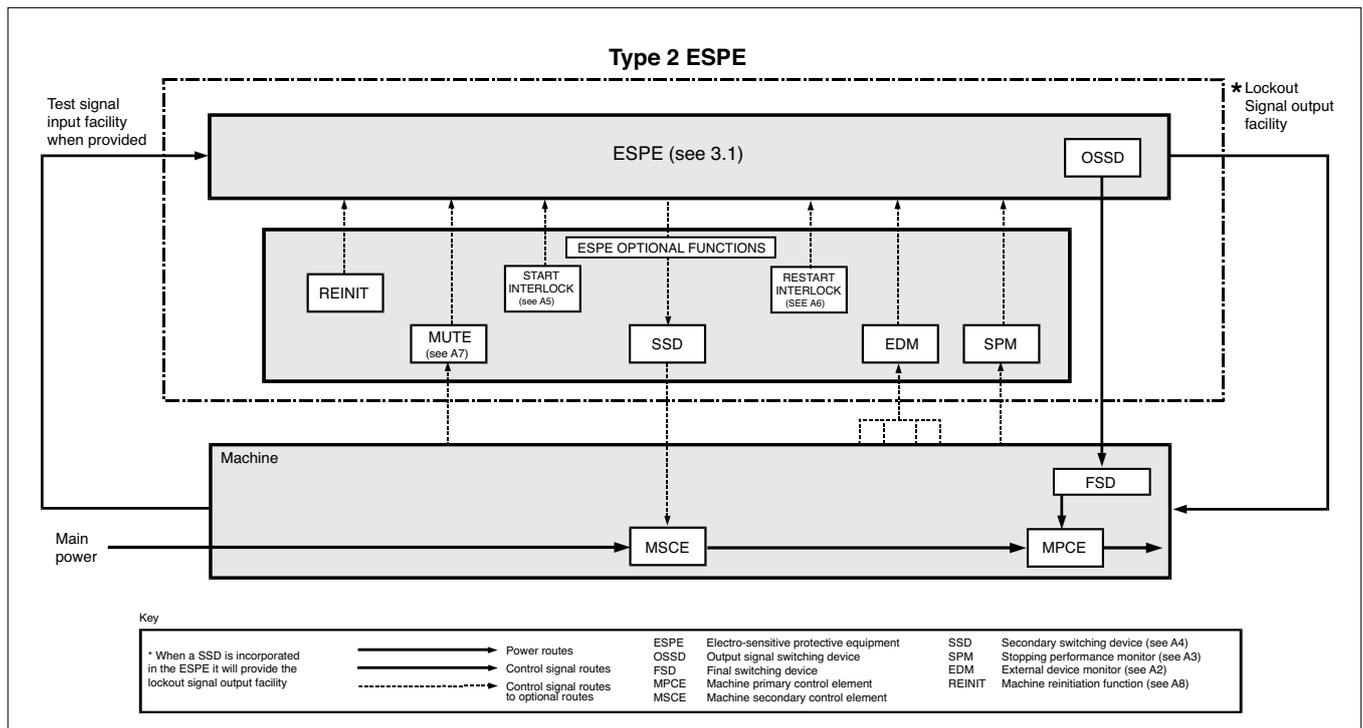
A device which causes a machine or machine elements to stop (or ensures an otherwise non-hazardous condition) when a person or a part of a person is detected by the sensing device.

Appendix B: Schematic examples of ESPE



Schematic example for the interfacing of a Type 4 ESPE to the machine

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Schematic example for the interfacing of a Type 2 ESPE to the machine

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