

Australian Standard®

Safeguarding of machinery

Part 2: Installation and commissioning requirements for electro-sensitive systems — Optoelectronic 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 31 December 1997 and published on 5 April 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
Tractor and Machinery Association of Australia
University of Melbourne
Victorian WorkCover Authority
WorkCover N.S.W.
WorkSafe Western Australia

Additional interests participating in preparation of Standard:

Optoelectronic protective equipment manufacturers

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Australian Standard[®]

Safeguarding of machinery

Part 2: Installation and commissioning requirements for electro-sensitive systems — Optoelectronic devices

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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 work emanating from the European Community (CEN). Since many European Standards are becoming de facto international Standards, or are being adopted as International Standards by ISO, the Committee decided to use the draft European Standard as the basis for this revision.

This Standard has been developed because of the increasing use within industry of electro-sensitive protective equipment for safeguarding both cyclic and continuously running machinery, which has led to a demand for a Standard embracing a range of electro-sensitive protective equipment.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a Standard, whereas an 'informative' appendix is only for information and guidance.

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STANDARDS AUSTRALIA

Australian Standard

Safeguarding of machinery

Part 2: Installation and commissioning requirements
for electro-sensitive systems — Optoelectronic devices

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE This Standard specifies the installation and commissioning requirements for electro-sensitive protective equipment using optoelectronic devices specifically related to machinery safety.

Requirements for the manufacture and testing of electro-sensitive systems using optoelectronic devices may be found in AS 4024.3.

1.2 OBJECTIVE The objective of this Standard is to enable designers, manufacturers, suppliers, employers and users of machinery to minimize the risks to 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 optoelectronic protective devices employing radiation of wavelength within the range of 400 nm to 1500 nm.

Alternative methods of providing safety to those given may be used provided that the level of safety offered by the alternative is at least equivalent to that provided by the methods given in this Standard.

Some regulatory authorities have specific requirements relating to the forms that guarding may take and to the order in which guarding techniques may be considered. Users of this Standard should therefore make themselves aware of any specific requirements in the jurisdiction where the machinery will be used.

This Standard may still be used in these jurisdictions to identify the most appropriate level of system integrity required, and to provide guidance in other aspects of machine system safety.

1.4 REFERENCED DOCUMENT The following document is referred to in this Standard:

AS	
4024	Safeguarding of machinery
4024.1	Part 1: General principles
4024.3	Part 3: Manufacturing and testing requirements for electro-sensitive systems — Optoelectronic devices
AS/NZS	
4360	Risk management

1.5 DEFINITIONS For the purpose of this Standard the definitions given in AS 4024.1 and those below apply.

1.5.1 Actuation (of protective equipment)—physical initiation of the protective equipment when it detects the presence or intrusion of a person or a part of a person.

1.5.2 Approach

1.5.2.1 Angled approach—where the direction of approach makes an angle to the detection zone.

1.5.2.2 Normal approach—where the direction of approach makes a right angle to the detection zone.

1.5.2.3 Parallel approach—where the direction of approach is parallel to the detection zone.

1.5.3 Blanking—a facility to disable an area of the electro-sensitive protective equipment, while leaving the remaining area(s) fully active.

1.5.4 Detection capability—the sensing function parameter limit specified by the manufacturers which, when exceeded, will cause actuation of the electro-sensitive protective equipment.

1.5.5 Detection zone—the sensing field which is capable of detecting the presence or intrusion of a person or part of a person.

1.5.6 Direction of approach—the direction of movement of the body or part of the body toward the danger zone.

1.5.7 Electro-sensitive protective equipment (ESPE)—a protection trip or presence-sensing system comprising as a minimum—

- (a) a sensing function;
- (b) a system control function; and
- (c) an output signal switching device.

1.5.8 Hazardous area—any area within or around machinery which provides access to the danger zone.

1.5.9 Muting—a facility (subject to specified conditions) for automatically switching the protective equipment system into a condition where the final switching devices do not response to an interruption of the sensing unit.

1.5.10 Overall system stopping performance—the time occurring from the actuation of the sensing function to the cessation of hazardous motion, or to the removal of the risk.

NOTE: The overall system stopping performance comprises a minimum of two phases as follows:

$$T = t_1 + t_2$$

where

T = overall system stopping performance

t_1 = the maximum time in seconds, between the actuation of the sensing function and the output signal switching devices being in the 'off' state.

t_2 = the response time of the machine, in seconds, i.e. the time required to stop the machine or remove the risk after receiving the output signal from the protective equipment.

The relationship between t_1 and t_2 is defined in Figure 1.1. It is a function of the protective equipment and the machine respectively and is determined by design.

1.5.11 Residual risk—any risk remaining after safety measures have been taken.

1.5.12 Safety distance—the minimum distance(s) from the detection zone to the danger zone that ensures that the risk of exposure to any hazard is eliminated.

1.5.13 Safety measure—a means that eliminates or minimizes a hazard or a risk.

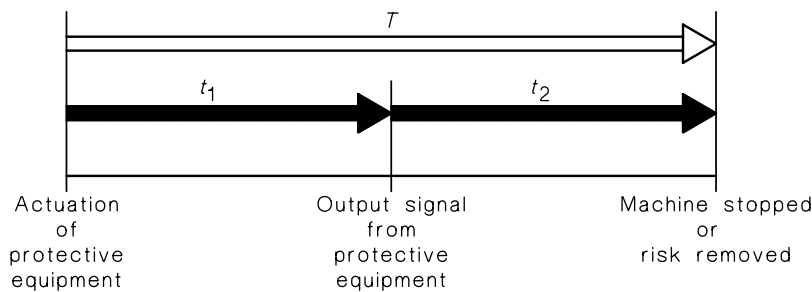


FIGURE 1.1 RELATIONSHIP BETWEEN t_1 AND t_2

1.6 GENERAL Electro-sensitive protective equipment is applied to machinery that presents a risk of personal injury. It provides protection by causing the machine to revert to a safe condition before a person can be placed in a hazardous situation.

The equipment incorporates at least one sensing device that employs one or more types of detection by means of electromagnetic radiation. This radiation can be either self-generated by the device or supplied from an external source.

Each type of machine presents its own particular hazards. The treatment of applications of the electro-sensitive protective equipment should be a matter for agreement between the equipment supplier and the machine user and in this context attention is drawn to the relevant guidance given in AS 4024.1.

Some types of electro-sensitive protective equipment fitted to certain machines have the facility of muting the equipment during certain parts of the machine cycle. There also exists an additional feature used to blank out a part of the detection zone, for example to permit strip to be fed to a press. Unlike muting, this facility is functional during the entire machine cycle, and particular care is necessary to prevent access being gained to the danger zone through the blanked section of the equipment.

Electro-sensitive protective equipment for a machine shall be selected and used in accordance with the appropriate Standard for that particular machine. If no Standard exists, a risk assessment shall be undertaken according to AS 4024.1 prior to selecting the appropriate device.

SECTION 2 RISK ASSESSMENT

2.1 GENERAL This Section describes the procedure known as risk assessment by which the knowledge and experience of the design, use, incidents, accidents and harm related to machinery is brought together in order to assess the risks during the life of the machinery (see also AS 4024.1 and AS/NZS 4360).

This Standard is not intended to provide a detailed account of methods for analysing hazards and estimating risks as this is dealt with elsewhere (e.g. textbooks and other reference documents).

2.2 RISK ASSESSMENT Risk assessment is a series of logical steps to enable the examination in a systematic way of the hazards associated with machinery. Risk assessment is followed, whenever necessary, by risk reduction as described in AS 4024.1. When this process is repeated it forms the iterative process for eliminating hazards as far as possible and implementing safety measures according to the state of the art.

Risk assessment includes (see Figure 2.1) the following:

- (a) *Risk analysis* Risk analysis consists of —
 - (i) determination of the limits of the machinery;
 - (ii) hazard identification; and
 - (iii) risk estimation.
- (b) *Risk evaluation* Risk analysis provides the information required for the risk evaluation, which in turn allows judgements to be made on the safety of machinery.

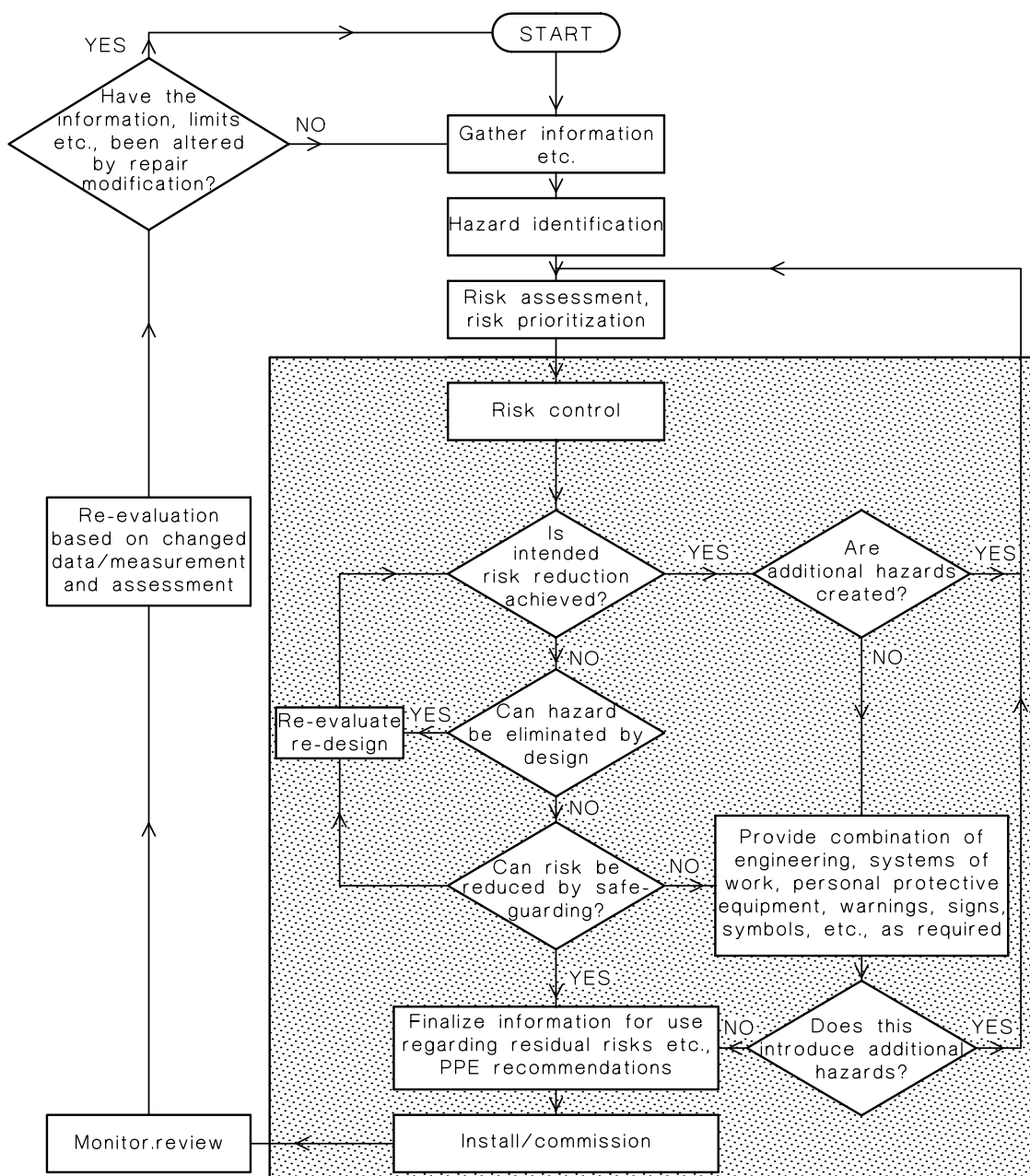
Risk assessment relies on judgemental decisions. These decisions shall be supported by qualitative methods, complemented as far as possible by quantitative methods. Quantitative methods are particularly appropriate when the foreseeable severity and extent of harm are high.

Quantitative methods are useful to assess alternative safety measures and to determine which gives better protection.

NOTE: The application of quantitative methods is restricted by the amount of useful data which are available. Therefore, in many applications only qualitative risk assessment will be possible.

The risk assessment procedure shall be conducted in such a manner that it is possible to document —

- (i) the intended use of the machinery for which the assessment has been made, (e.g. specifications or limits);
- (ii) the hazards, hazardous situations and hazardous events identified;
- (iii) pertinent information used (e.g. accident histories and experience gained from risk reduction applied to similar machines);
- (iv) the objectives to be achieved by the risk control measures;
- (v) the safety measures implemented to eliminate identified hazards or reduce risks; and
- (vi) the residual risk to the individual hazards by specifying any relevant assumptions that have been made (loads and safety factors).



NOTE: Risk reduction and selection of appropriate risk control measures are not part of the risk assessment process.

FIGURE 2.1 THE ITERATIVE PROCESS TO ACHIEVE SAFETY

2.3 DOCUMENTATION Documenting the risk assessment is a means of describing the hazards identified and the safety measures implemented. The documentation should contain information on —

- (a) the information on which risk assessment was based;
- (b) the machinery for which the assessment has been made (specifications or limits);
- (c) any relevant assumptions which have been made, such as loads, strengths, or safety factors;
- (d) the hazard identified;
- (e) the hazardous situations identified;
- (f) the hazardous events considered in the assessment;
- (g) the data used and the sources;
- (h) any uncertainty associated with the data used and the impact on the risk assessment;
- (i) the objectives to be achieved by the risk control method;
- (j) any requirements implemented (e.g. Standards or other specifications used);
- (k) the information regarding residual risks; and
- (l) the results of the final risk evaluation.

SECTION 3 SAFETY DISTANCES

3.1 GENERAL The effectiveness of this type of protective equipment in minimizing risk relies, in part, on the relevant parts of the equipment being correctly positioned in relation to the hazardous area. In deciding on the positions a number of aspects will need to be taken into account including —

- (a) a need for the identification of hazards and an assessment of all the risks;
- (b) existing Standards;
- (c) possible future technical developments;
- (d) the type of equipment to be used;
- (e) the response times of protective equipment used;
- (f) the time taken to ensure the safe condition of the machine following operation of the protective equipment, e.g. to stop the machine;
- (g) biomechanical and anthropometric data for body parts;
- (h) the path taken by a body part when moving from the sensing or actuating means towards the hazardous area;
- (i) the possible presence of a person between the device and the hazardous area; and
- (j) the possibility of undetected access to the danger zone.

Parameters are provided and are based on values for hand/arm and approach speeds. The methodology to determine the minimum distances from specific sensing or actuating devices of protective equipment to a hazardous area are also provided.

The specific devices are trip devices (see AS 4024.1), specifically electro-sensitive protective equipment, including those trip devices used additionally to initiate operation.

Guidance is based on the assumption that the correct device has been chosen by carrying out a risk assessment in accordance with AS 4024.1.

The calculated distances, when implemented, will provide sufficient protection for persons against the risks caused by approaching a hazardous area which generates potential risks such as crushing, shearing, cutting or severing, entanglement, drawing-in or trapping, friction or abrasion, stabbing or puncture and impact.

Protection against the risks from mechanical hazards arising from the ejection of solid or fluid materials and non-mechanical hazards such as toxic emissions, electricity or radiation, are not covered by the Standard.

The distances are derived from data that take into account population groups likely to be found in European countries. Users should take into account the population to be found within their workplace.

NOTES:

- 1 If this Standard is to be used for non-industrial purposes then the designer should take into account the fact that this data is based on industrial experience.
- 2 Until specific data is available for approach speeds for children this Standard uses adult speeds and lower detection factors where relevant should be used to calculate the distances that could be within the reach of children in those areas where it is foreseen that children may be present.

3.2 SAFETY DISTANCE The safety distance between the detection zone and the danger zone shall ensure that a risk of exposure to any hazard does not occur.

In each instance, the worst case should be taken as the basis for determining the safety distance, using the stopping time of the power driven machinery.

There should be no risk of injury if the maximum value of the stopping time is consistently maintained. When calculating the safety distance, the maximum value of hand approach speed should be used.

The safety distance and the maximum value of the stopping time should be clearly marked and permanently indicated on a label near the detection zone. This does not apply to area guarding.

If the position of the detection zone is adjustable, it should be provided with means for locking in any position.

3.3 LOCATION OF ELECTRO-SENSITIVE PROTECTIVE EQUIPMENT Electro-sensitive protective equipment shall be fitted so that —

- (a) the danger zone can be reached only through the detection zone; and
- (b) it is impossible for the operator to stand between the detection zone and the danger zone.

This includes walking through the detection zone into a hazardous area.

Where reaching over, reaching under or reaching round the electro-sensitive protective equipment is possible, additional safeguarding measures shall be provided.

If certain parts of the detection zone can be rendered ineffective by special means e.g. muting or blanking, the parts no longer protected by the electro-sensitive protective equipment shall be safeguarded by other protective devices.

The detection zone shall be adjustable only to such an extent that the additional safety devices are effective, and the safety distance is maintained.

3.4 METHODOLOGY Figure 3.1 provides a schematic representation of the methodology for determining the correct position of sensing or actuating devices of protective equipment using this Standard, which is as follows:

- (a) Identify the hazards and assess the risks. (See AS 4024.1.)
- (b) If a machine-specific Standard exists for the machine, select one of the specified types of protective equipment from that machine-specific Standard, and then use the distance specified by that Standard.
- (c) If there is no machine-specific Standard or if the Standard does not specify any minimum distances, then use the equations in this Standard to calculate the minimum distance for the protective equipment selected. The selection of the appropriate type of protective equipment should be made in accordance with the requirements of AS 4024.1.
- (d) Incorporate the distance in the machine design.
- (e) Check if the determined position will allow persons to be between the sensing devices of the protective equipment and the hazardous area without being detected. In this case supplementary measures may be required, depending on the risk.
- (f) Ensure the device has been installed in such a manner that access to the hazardous area will not be possible without detection by the device.

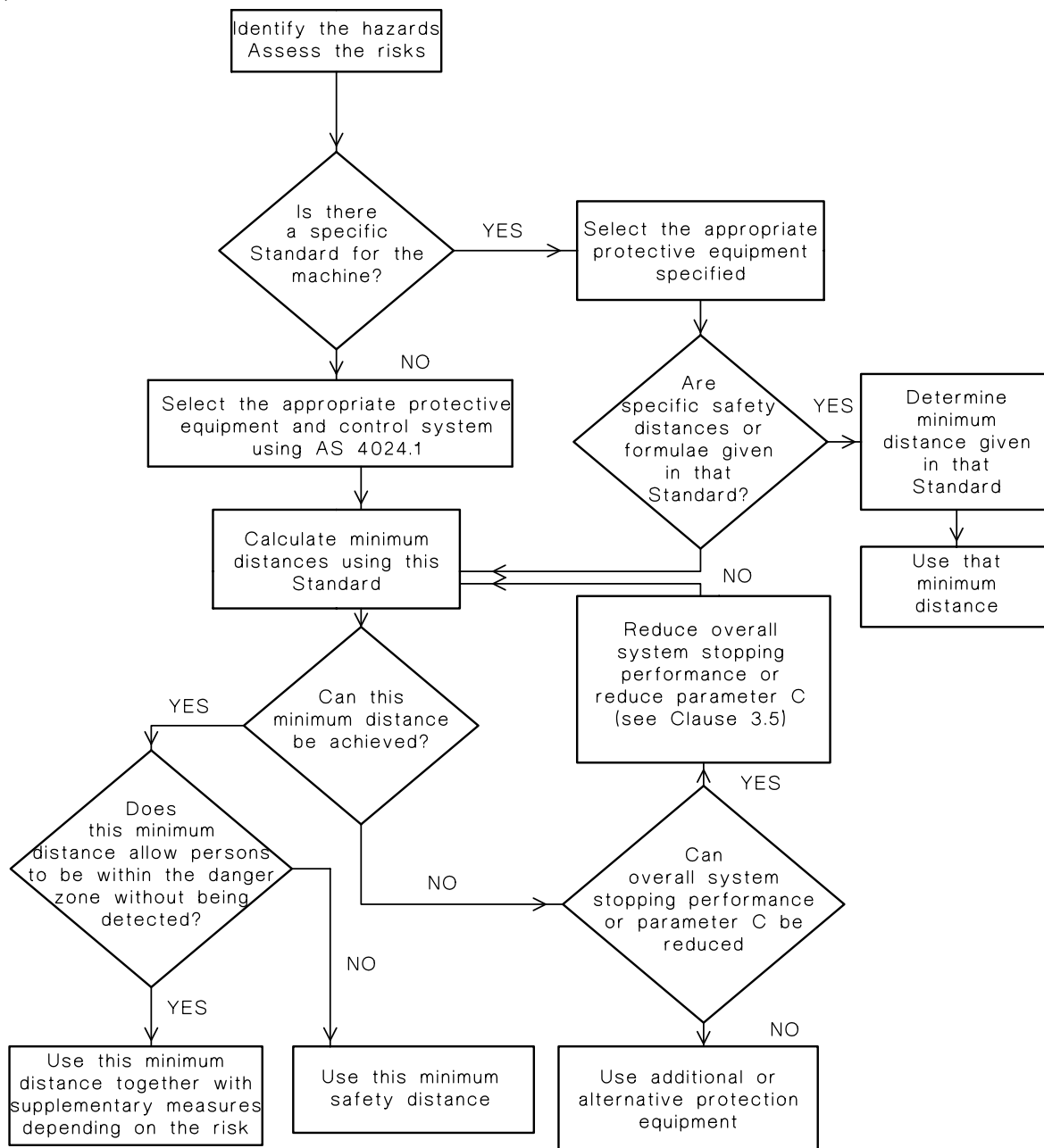


FIGURE 3.1 SCHEMATIC OF METHODOLOGY

3.5 GENERAL EQUATION FOR CALCULATING MINIMUM DISTANCES The minimum distance from the danger zone shall be calculated by using the following general Equation 3(1):

$$S = (K \times T) + C \quad \dots 3(1)$$

where

S = the minimum distance from the danger zone to the detection zone, in millimetres

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

T = the overall system stopping performance, in seconds

C = the intrusion distance of the body or part of the body towards the danger zone before actuation of the protective equipment, in millimetres.

NOTE: For worked examples see Appendix A.

3.6 CALCULATING MINIMUM DISTANCES FOR ELECTRO-SENSITIVE PROTECTIVE EQUIPMENT EMPLOYING ACTIVE OPTOELECTRONIC PROTECTIVE DEVICES

3.6.1 General This Clause considers three main applications based on the direction of approach to the detection zone, which are —

- (a) normal approach (at right angles) to the detection zone;
- (b) parallel approach to the detection zone; and
- (c) angled approach to the detection zone.

Where it is foreseeable that any gaps adjacent to or within the detection zone of the electro-sensitive protective equipment will allow access to the hazardous area then this shall be taken into account in the correct positioning of the protective equipment and additional safeguards shall be considered. See AS 4024.1 for guidance on safety distances for non-electro-sensitive systems.

3.6.2 Direction of approach normal to the detection zone (See also Figure 3.2)

3.6.2.1 *Electro-sensitive protective equipment with a maximum detection capability of 40 mm diameter* The minimum distance from the detection zone to the danger zone shall be not less than that calculated using the following equation:

$$S = (K \times T) + C \quad \dots 3(1)$$

where

S = the minimum distance from the danger zone to the detection zone, in millimetres

K = approach speed of the body or part of the body, in millimetres per second
= 2000 mm/s

T = the overall system stopping performance, in seconds

C = the intrusion distance of the body or part of the body towards the danger zone before actuations of the particular equipment, in millimetres

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

d is the detection capability of the device in millimetres

then

$$S = (2000 \text{ mm/s} \times T) + 8(d - 14 \text{ mm}) \quad \dots 3(2)$$

This equation applies for all minimum distances of S up to and including 500 mm. The minimum value of S shall be not less than 100 mm.

If S is found to be greater than 500 mm the following equation may be used:

$$S = (K \times T) + C \quad \dots 3(1)$$

where

S = the minimum distance from the danger zone to the detection zone, in millimetres

K = approach speed of the body or part of the body, in millimetres per second
= 1600 mm/s

T = the overall system stopping performance, in seconds

C = the intrusion distance of the body or part of the body towards the danger zone before actuation of the particular equipment, in millimetres
= $8(d - 14 \text{ mm})$ but not less than 0

then

$$S = (1600 \text{ mm/s} \times T) + 8(d - 14 \text{ mm}) \quad \dots 3(3)$$

The value of S shall be not less than 500 mm.

The relationship between safety distance and overall response time is depicted in Figure 3.3.

Access to the danger zone by reaching over or around the electro-sensitive protective equipment (and any other protective equipment) shall be prevented using the values of safety distances given in the table of guard distance within AS 4024.1 where applicable. The minimum height of the electrosensitive protective equipment shall be not less than 300 mm.

Where it is foreseeable that electro-sensitive protective equipment will be used in non-industrial applications (e.g in the presence of children), the minimum distance S calculated using Equation 3(2) shall be increased by at least 75 mm. In such cases, Equation 3(3) is not applicable.

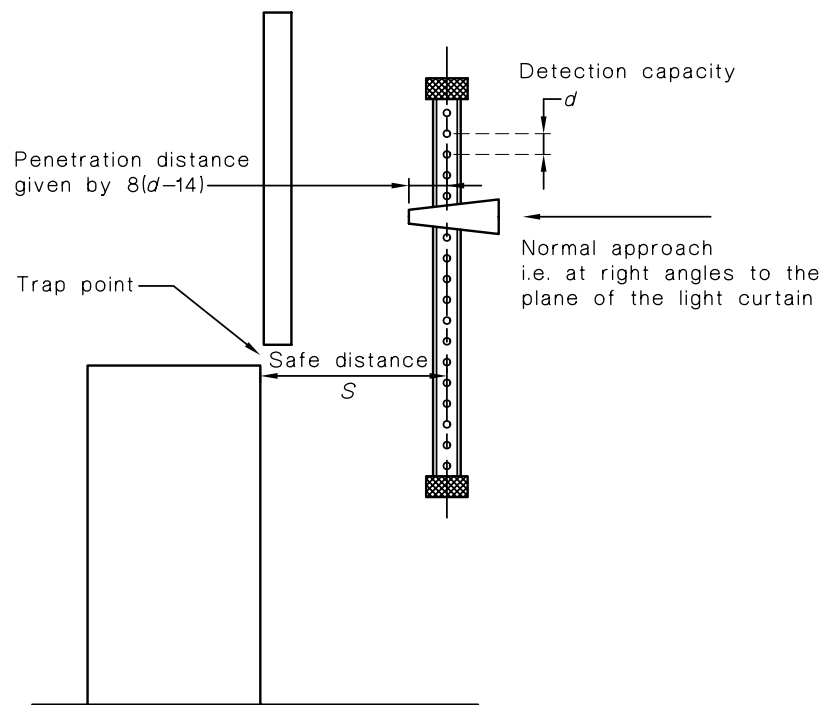


FIGURE 3.2 APPROACH NORMAL TO THE LIGHT CURTAIN

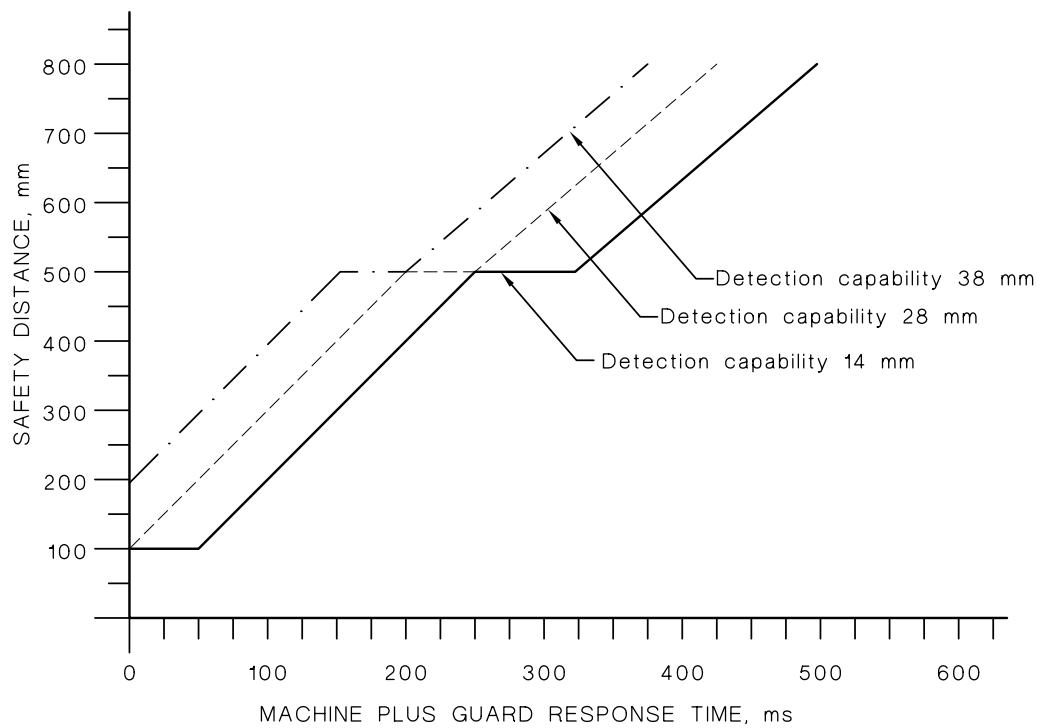


FIGURE 3.3 SAFETY DISTANCE Vs RESPONSE TIME FOR NORMAL APPROACH

3.6.2.2 Electro-sensitive protective equipment used for the initiation of machine operation Electro-sensitive protective equipment used for the initiation of machine operation shall have a detection capability equal to or less than 30 mm. In this case Equation 3(1) shall apply and the minimum distance S shall be greater than 150 mm. The relationship between safety distance and response time for this application is depicted in Figure 3.4.

Where the electro-sensitive protective equipment is intended to detect fingers or hands, machine initiation is allowed only when the detection capability of the electro-sensitive protective equipment does not exceed 14 mm.

Where it is foreseeable that the work will consist of rapid repetitive operations, e.g. where the operator is sitting close to the machine during work, the workpieces are small, of low weight, easy to grip and handle with one hand and the cycle time is short, then the minimum distance shall be calculated using the following equation:

$$S = (K \times T) + C \quad \dots 3(1)$$

where

S = the minimum distance from the danger zone to the detection zone, in millimetres

K = the approach speed of the body or part of the body, in millimetres per second
= 2500 mm/s

T = the overall system stopping performance, in seconds

C = the intrusion distance of the body or part of the body towards the danger zone before actuation of the particular equipment, in millimetres
= $8(d - 14 \text{ mm})$ but not less than 0

then

$$S = (2500 \text{ mm/s} \times T) + 8(d - 14 \text{ mm}) \quad \dots 3(4)$$

The minimum distance S shall be greater than 150 mm and the detection capability of d shall be less than 30 mm.

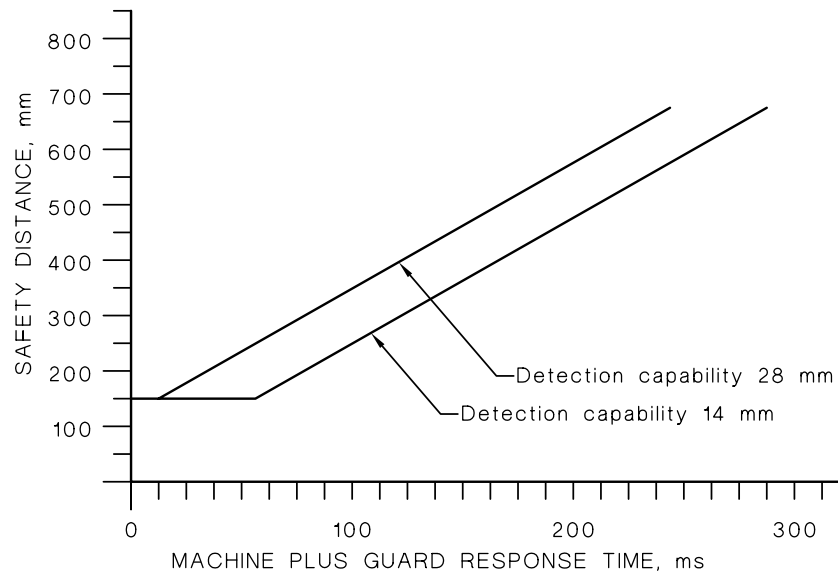


FIGURE 3.4 MINIMUM DISTANCE Vs OVERALL RESPONSE TIME FOR DEVICES USED FOR MACHINE INITIATION