

Therefore, the minimum safe distance for the same application would be 457.28mm based on EN 999.

Interference from Reflective Surfaces and Other Opto-Electronic Devices

When reflective surfaces (shiny/polished metals, foils, glossy painted surfaces, etc.) are in close proximity to opto-electronic devices such as light curtains, the system is susceptible to faults due to deflection of the optical beams. A situation such as this can result in the light curtain not detecting an object or personnel in the sensing field.

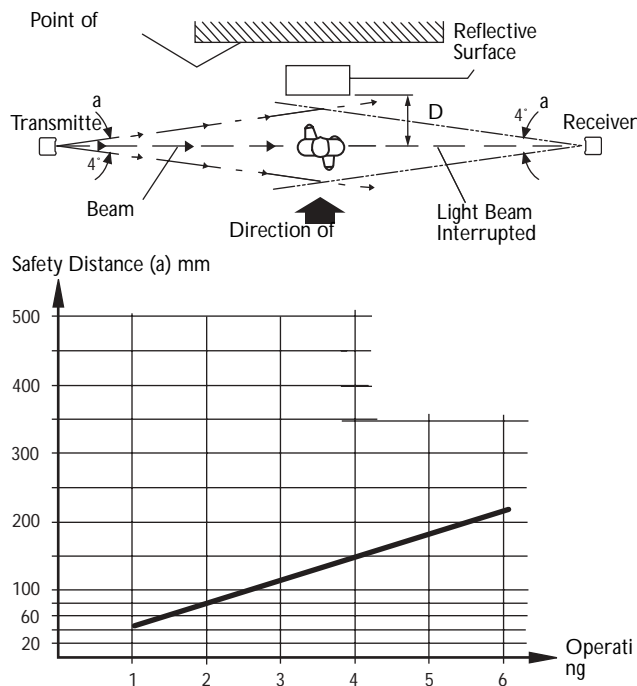


Figure 82: POC alignment/distance

When installing light curtains, the potential for interference can be calculated to determine the minimum distance that the light curtain must be mounted from the reflective surface in question. As a general rule, no reflective surfaces should be contained within the beam angle of the light curtain emitter or receiver with misalignment taken into account. Using the following formula:

$$D = R/2 (\tan 2a)$$

Where:

- D** Distance to the reflective surface (worst case)
- R** Distance between the light curtain emitter and receiver
- a** The angle of acceptable misalignment (angle of divergence) as determined from the light curtain specifications

It is also necessary to take into account other opto-electronic devices near the safety light curtain. It is quite possible for light curtains to interfere with each other or “crosstalk.”

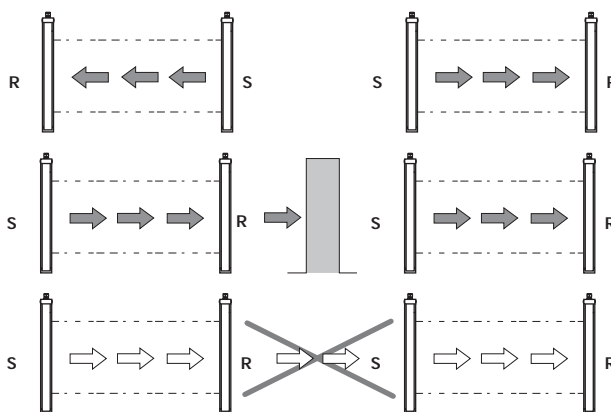


Figure 83: Multiple POC

U.S. Safety Regulations

This section introduces some of the industrial machine guarding safety regulations in the U.S. This is only a starting point; readers must further investigate the requirements for their specific applications and take measures to ensure that their designs, uses and maintenance procedures and practices meet their own needs as well as national and local codes and regulations.

There are many organizations that promote industrial safety in the United States. These include:

1. Corporations, which use established requirements as well as establish their own internal requirements;
2. The Occupational Safety and Health Administration (OSHA);
3. Industrial organizations like the National Fire Protection Association (NFPA), the Robotics Industries Association (RIA), and the Association of Manufacturing Technology (AMT); and the suppliers of safety products and solutions, like Rockwell Automation.

Occupational Safety and Health Administration

In the United States, one of the main drivers of industrial safety is the Occupational Safety and Health Administration (OSHA). OSHA was established in 1970 by an Act of the U.S. Congress. The purpose of this act is to provide safe and healthful working conditions and to preserve human resources. OSHA accomplishes this task by publishing regulations in Title 29 of the Code of Federal Regulation (29 CFR).

Standards pertaining to industrial machinery are published by OSHA in Part 1910 of 29 CFR. Table 5 is a list of those standards pertaining to specific machines.



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Section	Description
1910.212	General Requirements for all machines
1910.213	Woodworking machinery requirements
1910.214	Cooperage Machinery
1910.215	Abrasive Wheel Machinery
1910.216	Mills and Calendars in the rubber and plastics industry
1910.217	Mechanical Power Presses
1910.218	Forging Machines
1910.219	Mechanical Power-transmission Apparatus

Table 6

Where possible, OSHA promulgates national consensus standards or established Federal standards as safety standards. The mandatory provisions (e.g., the word shall implies mandatory) of the standards, incorporated by reference, have the same force and effects as the standards listed in Part 1910. For example, the national consensus standard NFPA 70 is listed as a reference document in Appendix A of Subpart S-Electrical of Part 1910 of 29 CFR. NFPA 70 is a standard, which was developed by the National Fire Protection Association (NFPA). NFPA 70 is also known as the National Electric Code (NEC). Therefore all the mandatory requirements in the NEC are mandatory by OSHA.

With reference to safety light curtains, standards are categorized as either application standards or construction standards. Application standards define how to apply a light curtain to machinery. Examples include ANSI B11.1, which provides information on the use of machine guarding on power presses, and ANSI/RIA R15.06, which outlines light curtain use for robot guarding. Construction standards provide details on the design and construction of Presence Sensing Devices (PSDs) in safety applications. IEC61496, "Safety of Machinery -Electrosensitive Protective Equipment" covers the requirements of light curtains, and photoelectric sensors in general, used in safety applications.

The following are selected OSHA standards and Precision Metalforming Association (PMA) interpretations related to machine guarding and safety light curtains:

OSHA 1910.217(b)(7)—Part Revolution Clutch, Controls

(7) Machines using part revolution clutches.

- (i) The clutch shall release and the brake shall be applied when the external clutch engaging means is removed, deactivated, or de-energized.
- (ii) A red colour stop control shall be provided with the clutch/brake control system. Momentary operation of the stop control shall immediately deactivate the clutch and apply the brake. The stop control shall override any other control, and re-actuation of the clutch shall require use of the operating (tripping) means which has been selected.

OSHA 1910.217(b)(13)—Control Reliability

- (13) Control reliability. When required by paragraph (c) (5) of this section, the control system shall be constructed so that a failure within the system shall not prevent the normal stopping action from being applied to the press when required, but does

prevent initiation of a successive stroke until the failure is corrected. The failure shall be detectable by a simple test, or indicated by the control system. This requirement does not apply to those elements of the control system which have no effect on the protection against point of operation injuries.

OSHA 1910.217(b)(14)—Brake System Monitoring

(14) Brake system monitoring. When required by paragraph (c)(5) of this section, the brake monitor shall meet the following requirements:

- (i) Be so constructed as to automatically prevent the activation of a successive stroke if the stopping time or braking distance deteriorates to a point where the safety distance being utilized does not meet the requirements set forth in paragraph (c)(3)(iii)(e) or (c)(3)(vii)(c) of this section. The brake monitor used with the Type B gate or movable barrier device shall be installed in a manner to detect slide top-stop overrun beyond the normal limit reasonably established by the employer.
- (ii) Be installed on a press which indicates when the performance of the braking system has deteriorated to the extent described in paragraph (b)(14)(i) of this section; and
- (iii) Be constructed and in-stalled in a manner to monitor brake system performance on each stroke.

OSHA 1910.217(c) - Safeguarding the Point of Operation

(1) General Requirements.

- (i) It shall be the responsibility of the employer to provide and insure the usage of "point of operation guards" or properly applied and adjusted point of operation devices on every operation performed on a mechanical power press (see Table 0-10).
- (ii) The requirement of subdivision (i) of this sub paragraph shall not apply when the point of operation opening is one-fourth inch or less (see Table 0-10).

Table O-10 [from OSHA 1910.217 (f)(4)]

Distance of Opening from Point of Operation Hazard (inches)	Maximum Width of Opening (inches)
1/2 to 1-1/2	1/4
1-1/2 to 2-1/2	3/8
2-1/2 to 3-1/2	1/2
3-1/2 to 5-1/2	5/8
5-1/2 to 6-1/2	3/4
6-1/2 to 7-1/2	7/8
7-1/2 to 12-1/2	1-1/4
12-1/2 to 15-1/2	1-1/2
15-1/2 to 17-1/2	1-7/8
17-1/2 to 31-1/2	2-1/8



OSHA 1910.217 (c)(3)—Point of Operation Devices

(i) Point of operation devices shall protect the operator by:

(a) Preventing and/or stopping normal stroking of the press if the operator's hands are inadvertently placed in the point of operation.

OSHA 1910.217 (c)(3)(iii)—Presence Sensing Device

(iii) A presence sensing point of operation device shall protect the operator as provided in paragraph (c)(3)(i)(a) of this section, and shall be interlocked into the control circuit to prevent or stop slide motion if the operation's hand or other part of his body is within the sensing field of the device during the down stroke of the press slide.

(a) The device may not be used on machines using full revolution clutches.

(b) The device may not be used as a tripping means to initiate slide motion except when used in total conformance with paragraph (h) of this section.

(c) The device shall not be constructed so that a failure within the system does not prevent the normal stopping action from being applied to the press when required, but does prevent the initiation of a successive stroke until the failure is corrected. The failure shall be indicated by the system.

(d) Muting (bypassing of the protective function) of such device, during the up stroke of the press slide, is permitted for the purpose of parts ejection, circuit checking, and feeding.

(e) The safety distance (D(s)) from the sensing field to the point of operation shall be greater than the distance determined by the following formula:

$$D(s) = 63 \text{ inches/second} \times T(s)$$

Where:

D_s = minimum safety distance (inches);

63 inches/second = hand speed constant; and

T_s = stopping time of the press measured at approximately 90° position of crankshaft rotation (seconds).

(f) Guards shall be used to protect all areas of entry to the point of operation not protected by the presence sensing device.

OSHA 1910.217 (c)(5) Additional Requirements for Safeguarding

Where the operator feeds or removes parts by placing one or both hands in the point of operation, and a two hand control, presence sensing device of Type B gate or movable barrier (on a part revolution clutch) is used for safeguarding.

(i) the employer shall use a control system and a brake monitor which comply with paragraphs (b) (13) and (14) of this section. This requirement shall be complied with by November 1, 1975.

(ii) the exception in paragraph (b)(7)(v)(d) of this section for two hand controls manufactured and installed before August 31, 1971, is not applicable under this paragraph (c)(5);

(iii) the control of air clutch machines shall be designed to prevent a significant increase in the normal stopping time due to a failure within the operating valve mechanism, and to inhibit further operation if such failure does occur, where a part revolution clutch is employed. The exception is paragraph (b)(7)(xi) of this section for controls manufactured and installed before August 31, 1971, is not applicable under this paragraph (c)(5).

OSHA 1910.217(e) Inspection, Maintenance, and Modification of Presses

(1) Inspection and maintenance records.

(i) It shall be the responsibility of the employer to establish and follow a program of periodic and regular inspections of his power presses to insure that all their parts, auxiliary equipment, and safeguardings are in a safe operating condition and adjustment. The employer shall maintain records of these inspections which includes the date of inspection, the signature of the person who performed the inspection, and the serial number, or other identifier of the power press that was inspected.

(ii) Each press shall be inspected and tested no less than weekly to determine the condition of the clutch/brake mechanism, antirepeat feature and single stroke mechanism. Necessary maintenance or repair or both shall be performed and completed before the press is operated. The employer shall maintain records of these inspections and the maintenance work performed. These requirements do not apply to those presses which comply with paragraphs (b)(13) and (14) of this section. The employer shall maintain a certification record of inspections, test, and maintenance work which includes the date of inspection, the signature of the person who performed the inspection, test or maintenance; and the serial number or other identifier of the press that was inspected, tested or maintained.

(2) Modification. It shall be the responsibility of any person modifying a power press to furnish instructions with the modification to establish new or changed guidelines for use and care of the power press so modified.

(3) Training of maintenance personnel. It shall be the responsibility of the employer to insure the original and continuing competence of personnel caring for, inspecting, and maintaining power presses.

OSHA 1910.217(f) Operation of Power Presses

(2) Instructions to operators. The employer shall train and instruct the operator in the safe method of work before starting work on any operation covered by this section. The employer shall insure by adequate supervision that correct operating procedures are being followed.

(3) Work area. The employer shall provide clearance between machines so that movement of one operator will not interfere with the work of another. Ample room for cleaning machines, handling material, work pieces, and scrap shall also be provided. All surrounding floors shall be kept in good condition and free from obstructions, grease, oil, and water.



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(4) Overloading. The employer shall operate his presses within the tonnage and attachment weight ratings specified by the manufacturer.

National Fire Protection Association

The National Fire Protection Association (NFPA) was organized in 1896. Its mission is to reduce the burden of fire on the quality of life by advocating scientifically based consensus codes and standards, research and education for fire and related safety issues. The NFPA sponsors many standards to help accomplish its mission. Two very important standards related to industrial safety and safe-guarding are the National Electric Code and Electrical Standard for Industrial Machinery.

The National Fire Protection Association has acted as sponsor of the National Electrical Code since 1911. The original code document was developed in 1897 as a result of the united efforts of various insurance, electrical, architectural, and allied interests. The NEC has since been updated numerous times; it is revised about every three years. Article 670 of the NEC covers some details on industrial machinery and refers the reader to the Electrical Standard for Industrial Machinery, NFPA 79.

NFPA 79 applies to electrical/electronic equipment, apparatus, or systems of industrial machines operating from a nominal voltage of 600 volts or less. The purpose of NFPA 79 is to provide detailed information for the application of electrical/electronic equipment, apparatus, or systems supplied as part of industrial machines that will promote safety to life and property. NFPA 79, which was officially adopted in 1962, is very similar in content to the International Electro-technical Committee standard IEC 60204-1.

Machines, which are not covered by specific OSHA standards, are required to be free of recognized hazards which may cause death or serious injuries. These machines must be designed and maintained to meet or exceed the requirements of applicable industry standards. NFPA 79 is a standard that would apply to machines not specifically covered by OSHA standards.

U.S. National Standards

The American National Standards Institute (ANSI) serves as the administrator and coordinator of the United States private sector voluntary standardization system. It is a private, non profit, membership organization supported by a diverse constituency of private and public sector organizations.

ANSI, itself, does not develop standards; it facilitates the development of standards by establishing consensus among qualified groups. ANSI also ensures that the guiding principles of consensus, due process and openness are followed by the qualified groups. Below is a partial list of industrial safety standards that can be obtained by contacting ANSI.

ANSI B11.1 *Machine Tools - Mechanical Power Presses - Safety Requirements for Construction, Care, and Use*

ANSI B11.2 *Machine Tools - Hydraulic Power Presses, Safety Requirements for Construction, Care, and Use*

ANSI B11.3 *Power Press Brakes, Safety Requirements for the Construction, Care, and Use of*

ANSI B11.4 *Machine Tools - Shears - Safety Requirements for Construction, Care, and Use*

ANSI B11.5 *Machine Tools - Iron Workers - Safety Requirements for Construction, Care, and Use*

ANSI B11.6 *Lathes, Safety Requirements for the Construction, Care, and Use of*

ANSI B11.7 *Machine Tools - Cold Headers and Cold Formers, Safety Requirements for Construction, Care, and Use*

ANSI B11.8 *Drilling, Milling, and Boring Machines, Safety Requirements for the Construction, Care, and Use of*

ANSI B11.9 *Grinding Machines, Safety Requirements for the Construction, Care, and Use of*

ANSI B11.10 *Metal Sawing Machines, Safety Requirements for Construction, Care, and Use of*

ANSI B11.11 *Gear Cutting Machines, Safety Requirements for the Construction, Care, and Use of*

ANSI B11.12 *Machine Tools - Roll-Forming and Roll-Bending Machines - Safety Requirements for the Construction, Care, and Use*

ANSI B11.13 *Machine Tools - Single- and Multiple-Spindle Automatic Bar and Chucking Machines - Safety Requirements for Construction, Care and Use*

ANSI B11.14 *Machine Tools - Coil-Slitting Machines Safety Requirements for Construction, Care, and Use*

ANSI B11.15 *Pipe, Tube, and Shape Bending Machines, Safety Requirements for Construction, Care, and Use*

ANSI B11.16 *Metal Powder Compacting Presses, Safety Requirements for Construction, Care, and Use*

ANSI B11.17 *Machine Tools - Horizontal Hydraulic Extrusion Presses - Safety Requirements for Construction, Care, and Use*

ANSI B11.18 *Machine Tools - Machines and Machinery Systems for Processing Strip, Sheet, or Plate from Coiled Configuration - Safety Requirements for Construction, Care, and Use*

ANSI B11.19 *Machine Tools - Safeguarding When Referenced by Other B11 Machine Tool Safety Standards-Performance Criteria for the Design, Construction, Care and Operation*

ANSI B11.20 *Machine Tools - Manufacturing Systems/Cells - Safety Requirements for Construction, Care, and Use*

ANSI B11.21 *Machine Tools - Machine Tools Using Lasers for Processing Materials - Safety Requirements for Design, Construction, Care, and Use*

ANSI B151.1 *Horizontal Injection Moulding Machines - Safety Requirements for Manufacture, Care and Use*

ANSI B151.15 *Extrusion Blow Moulding Machines - Safety Requirements*

ANSI B151.21 *Injection Blow Moulding Machines - Safety Requirements*

ANSI B151.26 *Plastics Machinery - Dynamic Reaction - Injection Moulding Machines - Safety Requirements for the Manufacture, Care and Use*

