ANSI B11.19-2010

American National Standard for Machines –

Performance Criteria for Safeguarding

Secretariat and Accredited Standards Developer:
B11 Standards, Inc.,
42293 Young Lane
Leesburg, VA 20176, USA

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American National Standards Institute

AMERICAN NATIONAL STANDARDS

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Foreword

(This forward is not part of the requirements of American National Standard B11.19-2010)

The primary objective of this standard is to establish the requirements for the design, construction, installation, operation and maintenance of the safeguarding (e.g., guards, safeguarding devices, awareness devices, safeguarding methods), complementary equipment and measures, and safe work procedures used to eliminate or control hazards to individuals associated with machines. This standard relies on other standards to determine which safeguarding is required or allowed to control identified hazards or hazardous situations, and is intended to be used in conjunction with the ANSI B11.0 standard on general safety requirements and risk assessments of machines, and the ANSI B11 "base" standard for a given machine. To accomplish this objective, this standard has established responsibilities for the safeguarding supplier (e.g., manufacturer, rebuilder, installer, integrator and modifier), the user, and individuals in the working environment. The overall goal is to achieve safe work practices and a safe work environment.

B11.19 was established as a B11 subcommittee in 1980 to bring together widely scattered information into one document. Mr. Barry Stockton (B11.19 Chairman 1980 - 2003) guided a diverse group of industry experts through the creation of the original standard in 1990, which was reaffirmed in 1997. The second revision, which was approved by ANSI in 2003, was a major rewrite that included updated Liberty Mutual anthropometric data and a new safety distance annex.

This current revision of B11.19 has incorporated new requirements and information including: Protective (safety) Stops, Perimeter Guarding, Muting, Bypass, Emergency Stop including rope/cable pulls, three-position Enabling Devices, Hold-to-run Control, Guard Interlocking Switches with guard locking, and Presence-sensing Device Initiation (PSDI).

The informative annexes have been expanded to include explanatory information on Transparent Guards using Plastic (e.g., Polycarbonate) Viewing Panels, Safe Distances for upper limbs for reaching over guards (e.g., fencing) that harmonizes with ISO 13857, an outline of Protective Measures that includes examples, and a cross reference of safety solutions in use at the time of release of this revision of B11.19.

A greater emphasis has been placed on risk assessment in an attempt to allow safety solutions other than those meeting requirements contained in clause 6.1 (control reliability). The intent is to maintain a high level of safety performance for safety related functions, but also allow safety solutions that can be reasonably justified through the process of a documented risk assessment that meets the required risk reduction.

The requirements that had been contained in ANSI B15.1 "Safety Standard for Mechanical Power Transmission Apparatus have been divided and incorporated into the ANSI B11.0-2010 and ANSI B11.19-2010 standards. The safeguarding requirements have been located in a clause of the ANSI B11.0 standard entitled "Mechanical Power Transmission Apparatus" and the specific guidelines to comply with those requirements are contained within this B11.19 standard (e.g., guards, safe-distance safeguarding and safe-location safeguarding).

Throughout its history, ANSI B11.19 has not provided the requirements for the selection of the safeguarding, but only the implementation of the safeguarding once chosen. No hierarchy, no level of risk reduction, or any relationship between safeguarding options are implied within this standard.

The words "safe" and "safety" are not absolutes. Safety begins with good design. While the goal of this standard is to eliminate injuries, this standard recognizes that risk factors cannot practically be reduced to zero in any human activity. This standard is not intended to replace good judgment and personal responsibility. Operator skill, attitude, training, job monotony, fatigue and experience are factors that affect safety and that must be considered by the user.

Other industry sectors may benefit from applying this standard. Where a machine-specific standard exists, B11.19 may be used to supplement that standard.

Safeguarding and associated equipment technologies are continuously evolving. This standard reflects the most commonly used and time-tested state of the art at the time of its approval. The inclusion or omission of language relative to any evolving technology, either in the requirements or explanatory area of this standard, in no way infers acceptance or rejection of such technologies.

Inquiries with respect to the application or the substantive requirements of this standard, and suggestions for its improvement are welcomed, and should be sent to the American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036; (212) 642-4900. Attention: B11 Secretariat.

Effective Date

The following is informative guidance only, and not a normative part of this standard. This Subcommittee recognizes that some period of time after the approval date on the title page of this document is necessary for suppliers and users to develop new designs, or modify existing designs or manufacturing processes in order to incorporate the new or revised requirements of this standard into their product development or production system.

This Subcommittee recommends that suppliers complete and implement design changes for new machines within 30 months of the approval of this standard.

For existing or modified machines, this Subcommittee recommends that users should confirm that the equipment / process has tolerable risk using generally recognized risk assessment methods within 30 months of the approval date of this standard. If the risk assessment shows that modification(s) is necessary, refer to the requirements of this standard to implement protective measures for appropriate risk reduction.

This standard was processed and submitted for ANSI approval by the B11 Accredited Standards Committee on Safety Standards for Machines. Committee approval of this standard does not necessarily imply that all committee members voted for its approval. At the time this standard was approved as an American National Standard, the ANSI B11 Accredited Standards Committee was composed of the following member organizations:

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Gary D. Kopps, Vice-Chairman
David A. Felinski, Secretary

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	Delegate	Alternate
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Aluminum Extruders Council	Melvin Mitchell	Scott J. Burkett
American Society of Safety Engineers	Bruce W. Main, PE, CSP	George Karosas, PE, CSP
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System Safety Society	John Etherton, PhD, CSP	Rod Simmons, PhD
Toyota Motor Manufacturing North America	Barry Boggs	Todd Mills
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At the time this standard was approved, the ANSI B11 ASC B11.19 Subcommittee had the following members who participated in the development of this revision:

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Standard Requirements **Explanatory Information**

American National Standard for Machines -

Performance Criteria for Safeguarding

STANDARD REQUIREMENTS

EXPLANATORY INFORMATION

(Not part of the requirements of this American National Standard for Machines —- Performance Criteria for Safeguarding ANSI B11.19–2010)

1 Scope

This standard provides performance requirements for the design, construction, installation, operation and maintenance of the safeguarding listed below when applied to machines.

a) Guards (see clause 7);
b) Safeguarding devices (see clause 8);
c) Awareness devices (see clause 9);
d) Safeguarding methods (see clause 10).

This standard also provides performance requirements for complementary equipment and measures (see clause 12), safe work procedures (see clause 11), and safety functions (see clause 6).

E1

The manufacturer or supplier referred to in this standard is the manufacturer or supplier of the safeguarding, not the manufacturer or supplier of the machine (see clause 3 definitions of manufacturer and supplier).

This standard does not provide the requirements for the selection of the safeguarding for a particular application.

See the appropriate ANSI B11 machine-specific standard or other related machinery safety standard(s) for the requirements for the selection of safeguarding based on specific applications. Selection of the safeguarding requires task and hazard identification, and the application of documented risk assessment and risk reduction of the total production system.

See ANSI B11.0 for additional information and guidance on risk assessment and risk reduction.

Any deviation in conforming to a requirement of this standard shall be carefully considered and based on a documented risk assessment to achieve acceptable risk. The reasoning and information concerning any deviation shall be included in the information for operation and maintenance of the machinery.

Alternate safeguarding solutions or a combination of protective measures can provide a best practical solution for a specific application. The user should evaluate the reasoning and the information concerning the deviation to ensure acceptable risk for the specific application. See ANSI B11.0.

Safeguarding and associated equipment technologies are continuously evolving. This standard reflects the most commonly used and time-tested state of the art at the time of its approval. The inclusion or omission of language relative to any evolving technology, either in the requirements or explanatory area of this standard, in no way infers acceptance or rejection of such technologies. See also, Annexes H and I.

Standard Requirements	Explanatory Information

2 References

2.1 Normative references

The standards below contain provisions that are referenced in this text. This standard is intended to be used in conjunction with these standards. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated.

ANSI B11.0 – 2010 Safety of Machinery; General Requirements and Risk Assessment

NFPA 79 – 2007 Electrical Standard for Industrial Machinery

ANSI Z535.1 – 2006 Safety Color Code

ANSI Z535.3 – 2007 Criteria for Safety Symbols

ANSI Z535.4 – 2007 Product Safety Signs and Labels

ANSI Z535.5 – 2007 Accident Prevention Tags and Labels

2.2 Informative References

The following documents in the right-hand column are not normative references, but contain information and guidance that may be helpful in the implementation of, or otherwise in conforming to the requirements of this standard. They are included for information only.

E2.2

29 CFR 1910.147: Control of hazardous energy ('lockout/tagout') (For more info, www.osha.gov)

29 CFR 1910.333 b(2): Selection and Use of Electrical Work Practices (For more info, www.osha.gov)

ANSI / NFPA 70 – 2008 The National Electrical Code

ANSI Z244.1–2003 Control of hazardous energy – Lockout/tagout and alternative methods

IEC 60204-1-– Safety of machinery – Electrical equipment of machines – Part 1: General requirements

IEC 61496-1, 2008: Safety of machinery; Electrosensitive protective equipment- Part 1: General Requirements and tests

IEC 61496-2, 2006: Safety of machinery; Electrosensitive protective equipment- Part 2: Particular Requirements for Equipment Using Active Opto-Electronic Protective Devices (AOPDs)

IEC 61496-3, 2008: Safety of machinery; Electrosensitive protective equipment- Part 3:Paricular Requirements for Active Opto-Electronic Protective devices Responsive to Diffuse Reflection (AOPDDR)

Standard Requirements	Explanatory Information
	ISO 13849-1:1999: Safety of machinery; Safety-Related Parts of Control Systems – Part 1: General Principles for Design
	EN/ISO 13849-1-2008: Safety of machinery; Safety-Related Parts of Control Systems – Part 1: General Principles for Design
	ANSI B11.1 – 2009 Safety Requirements for Mechanical Power Presses
	ANSI B11.2 – 1995 (R2005) Hydraulic Power Presses -- Safety Requirements for Construction, Care and Use
	ANSI B11.3 – 2002 (R2007) Safety Requirements for Power Press Brakes
	ANSI B11.4 – 2003 (R2008) Safety Requirements for Shears
	ANSI B11.5 – 1988 (R2008) Iron Workers -- Safety Requirements for Construction, Care and Use
	ANSI B11.6 – 2001 (R2007) Safety Requirements for Manual Turning Machines
	ANSI B11.7 – 1995 (R2010) Cold Headers and Cold Formers -- Safety Requirements for Construction, Care and Use
	ANSI B11.8 – 2001 (R2007) Safety Requirements for Manual Milling, Drilling, and Boring Machines
	ANSI B11.9 – 2010 Safety Requirements for Grinding Machines
	ANSI B11.10 – 2003 Safety Requirements for Metal Sawing Machines
	ANSI B11.11 – 2001 (R2007) Safety Requirements for Gear & Spline Cutting Machines
	ANSI B11.12 – 2005 (R2010) Safety Requirements for Roll Forming and Roll Bending Machines
	ANSI B11.13 – 1992 (R2007) Automatic Screw/Bar and Chucking Machines -- Safety Requirements for Construction, Care and Use
	ANSI B11.15 – 2001 (R2007) Safety Requirements for Pipe, Tube and Shape Bending Machines
	ANSI B11.16 (MPIF #47) – 2003 (R2009) Safety Requirements for Powder/Metal Compacting Presses
	ANSI B11.17 – 2004 (R2009) Safety Requirements for Horizontal Hydraulic Extrusion Presses

Standard Requirements	Explanatory Information
	ANSI B11.18 – 2006 Safety Requirements for Machines Processing or Slitting Coiled or Non-coiled Metal
	ANSI B11.20 – 2004 (R2009) Safety Requirements for Integrated Manufacturing Systems
	ANSI B11.21 – 2006 Safety Requirements for Machine Tools Using Lasers For Processing Materials
	ANSI B11.22 – 2002 (R2007) Safety Requirements for Numerically Controlled Turning Machines
	ANSI B11.23 – 2002 (R2007) Safety Requirements for Machining Centers
	ANSI B11.24 – 2002 (R2007) Safety Requirements for Transfer Machines
	ANSI B11.TR1 – 2004 Ergonomic Guidelines for the Design, Installation and Use of Machine Tools
	ANSI B11.TR2 – 1997 Mist Control Considerations for the Design, Installation and Use of Machine Tools Using Metalworking Fluids
	ANSI B11.TR3 – 2000 Risk Assessment and Risk Reduction – A guide to estimate, evaluate and reduce risks associated with machine tools
	ANSI B11.TR4 – 2004 Selection of Programmable Electronic Systems (PES/PLC) for Machine Tools
	ANSI B11.TR5 – 2006 Sound Level Measurement Guidelines
	ANSI B11.TR6 – 2010 Safety Control Systems for Machine Tools
	ANSI B11.TR7 – 2007 Designing and Safety for Lean Manufacturing
	ANSI Z535.6 – 2006 Product Safety Information in Product Manuals, Instructions, and other Collateral Materials

Standard Requirements	Explanatory Information
3 Definitions For the purposes of this standard, the following definitions apply. For additional definitions, see ANSI B11.0 – Safety of Machinery: General Requirements and Risk Assessment.	***E3*** In the event any of these definitions differ slightly with those found ANSI B11.0 or in the C-level (base) standard, use the latter definition in context with the C-level (base) standard. These definitions have been harmonized with ANSI B11.0, but may deviate slightly in some cases to be applicable for use in this standard. The phrase “See also” denotes not only synonyms, but also additional information and commonly confused terms.
3.1 actuating control(s): An operator control used to initiate or maintain machine motion(s) or other machine function(s).	
3.2 adjustable guard: A guard with provisions for adjustment to accommodate various jobs or tooling set-ups.	
3.3 antirepeat: The part of the control system designed to limit the machine tool to a single cycle if the actuating control is maintained in an operating position. Antirepeat requires release of all actuating controls before another cycle can be initiated.	***E3.3*** The function of antirepeat is to prevent the successive cycles that could occur if the antirepeat control did not exist.
3.4 authorized individual: Qualified personnel identified and designated by the user (employer) or supplier to perform a specified task.	
3.5 awareness device: A barrier, signal or sign that warns individuals of an impending, approaching or present hazard.	***E3.5*** Also known as *safety markings* (ANSI B15.1-2000 (R2006)).
3.5.1 awareness barrier: An awareness device that warns individuals by means of physical contact.	
3.5.2 awareness sign: An awareness device that warns individuals of a potential hazard.	
3.5.3 awareness signal: An awareness device that warns individuals by means of audible sound or visible light.	
3.6 barrier: A device or object that provides a physical boundary to a hazard.	
3.7 barrier guard: See guard.	
3.8 blanking: Bypassing a portion of the sensing field of a presence-sensing safeguarding device.	
3.9 brake monitor: See stopping performance monitor.	

Standard Requirements	Explanatory Information
3.10 break: The term "break" when used in conjunction with PSDI operations refers to one intrusion into and subsequent withdrawal from the sensing field of the presence-sensing device.	***E3.10*** Single break and double break refer to either one intrusion and withdrawal from the sensing field or two intrusions and withdrawals after which a cycle is initiated. See also, ***Presence-Sensing Device Initiation***.
3.11 bypass: To render ineffective any safety-related function of the control system or safeguarding device.	***E3.11*** Bypassing the safety device or function is done manually and typically requires additional protective measures. Not to be confused with ***muting***.
3.12 clutch: A mechanism that, when engaged, transmits torque to impart motion from a driving member to a driven member.	
3.13 complementary equipment and measures: Devices or methods used to ensure or augment the proper operation of the safeguarding.	***E3.13*** See also, clause 12.
3.14 concurrent: Acting in conjunction with another; used to describe a situation where two or more controls exist in an operated condition at the same time (but not necessarily simultaneously).	
3.15 control reliability: The capability of the [machine] control system, the safeguarding, other control components and related interfacing to achieve a safe state in the event of a failure within their safety related functions.	***E3.15*** See 6.1. See also, ***safety-related function***.
3.16 control system: Sensors, manual input and mode selection elements, interlocking and decision-making circuitry and output elements to the machine actuators, operating devices and mechanisms.	
3.17 cycle: A complete movement of a machine, from the initial start position back to the same start position, which may include feeding and removal of the material or workpiece.	
3.18 design: To develop and plan the machine or safeguarding to meet the intended purpose and function.	
3.19 device: A component, attachment or mechanism designed to serve a specific purpose or perform a specific function.	
3.20 enabling device: A manually operated control device, when continuously activated and used in conjunction with a separate actuating control, will allow the machine to function.	
3.21 ensure: To design, construct, and apply by the user or supplier or to establish, maintain, or monitor an effective program, procedure, or system to implement the safeguarding or system requirements of this standard.	***E3.21*** It should be noted that usage of this word is not meant to be an absolute and is different than common usage.
3.22 foot control: A foot-operated mechanism or device used as an actuating control.	***E3.22*** Also referred to as *foot pedal*; *foot treadle*; *foot treadle bar*; *pedal*; *switch*; or *valve*.

Standard Requirements	Explanatory Information
3.23 guard: A barrier that prevents exposure to a hazard.	***E3.23*** Sometimes referred to as *barrier guard*.
3.24 hand control: A hand-operated mechanism or device used as an actuating control.	***E3.24*** Also referred to as *actuating control*; *two-hand contro*l; or *two-hand trip*.
3.25 hand tool: Any device used for manual feeding, or for freeing a stuck workpiece or scrap.	
3.26 hazard: A potential source of harm.	
3.27 hazard area: See hazard zone.	
3.28 hazard zone: Any space within and/or around a machine in which a person can be exposed to a hazard.	***E3.28*** Also referred to as *hazard area* or *hazard space*.
3.29 hazardous situation: A circumstance in which a person is exposed to a hazard(s).	***E3.29*** A hazardous situation is also referred to as a *task/hazard pair* (*combination*).
3.30 hold-to-run control: Control device which initiates and maintains hazardous machine functions only as long as the manual control is actuated.	***E3.30*** See also, ANSI / ISO 12100.
3.31 interlock blocking device: A personal control device used to prevent energizing of interlocked guard circuit(s).	***E3.31*** This may be a padlock or other lockable device.
3.32 individual: A person, including personnel, who may or may not be under the direct control of the supplier or user. See also, **personnel**.	***E3.32*** For the purposes of this standard, a distinction between individual and personnel is drawn. The term "individual" includes personnel but encompasses persons who are not under direct or indirect control of the supplier or user (e.g., visitors, vendors, etc.). See also, personnel.
3.33 installer: An individual, partnership or corporation responsible for placement and preparation for use of a machine.	***E3.33*** Responsibility for installation of the machine usually depends on the terms of the purchase agreement. See also, ***supplier***.
3.34 integrator: An entity that designs, provides, manufactures or assembles a machine, its associated machines or equipment, the safeguarding, control interfaces, interconnections or the control system into a machine tool system.	***E3.34*** See also, ***supplier***.
3.35 interlock: Mechanical, electrical, fluid power or other type of device or means to prevent a hazardous situation(s) under specified conditions.	
3.36 interlocked guard: A barrier, or section of a barrier, interfaced with the machine control system in such a manner so as to prevent inadvertent access to the hazard.	
3.37 limiting/blocking pin: A mechanical device which limits the range of motion.	***E3.37*** A limiting/blocking pin can incorporate a locking pin function. Also known as *over-travel*; *end-stop*; or *end-of-travel stop.*
3.38 locking pin: An energy-isolating device that is engaged either manually or by the control system to prevent motion.	***E3.38*** A locking pin is used to prevent motion once the machine is stopped. The locking pin may be designed to prevent motion resulting only from gravity or prevent motion from the additional force of the drive system.

Standard Requirements	Explanatory Information
3.39 maintenance personnel: Qualified personnel trained and authorized to maintain the machine, including the safeguarding.	***E3.39*** When maintenance personnel perform installation, integration or modification activities, they are considered installers, integrators or modifiers, respectively. See also, the clause 3 definitions of these terms, and 4.1.
3.40 manufacturer: See ***supplier***.	
3.41 mode: The operation of a machine or machine system as determined by the state or condition of the control system.	***E3.41*** Modes can include automatic, continuous, jog/inch, manual, normal, run, semi-automatic. See also, ANSI B11.
3.42 modification: Change to the machine or machine system that alters its original purpose, function, capacity, operation or safeguarding requirements.	
3.43 modifier: Any entity that changes the original purpose, function or capacity of the machine or machine system by design or construction.	***E3.43*** See also, ***supplier***, ***modification***.
3.44 monitoring: The checking of system components to detect a failure of a component, subassembly or module that affects the performance of the safety-related functions.	
3.45 movable barrier device: A safeguarding device arranged to enclose the hazard zone before machine motion can be initiated.	***E3.45*** There are two types of movable barrier devices: • Type A, which encloses the hazard zone during the complete machine cycle; • Type B, which encloses the hazard zone during the hazardous portion of the machine cycle.
3.46 muting: The temporary automatic suspension of a safety-related function(s).	***E3.46*** Not to be confused with ***bypassing.***
3.47 operator: An individual who performs production work or controls a machine.	
3.48 operator controls: A pushbutton, switch, lever, hand wheel, or other device actuated by the operator that initiates, cycles, controls or stops the motion of a machine.	***E3.48*** See also, ***actuating control***.
3.49 perimeter guarding: A guard or safeguard designed to limit or detect an individual(s) entering a hazardous area after which the individual(s) is not continuously being detected.	***E3.49*** Also known as *pass through guarding* or *full body access.*
3.50 personnel: Individuals who are employed by or on behalf of the user or supplier.	***E3.50*** Personnel includes subcontractors, consultants, or other contract workers under the indirect control of the supplier or user.
3.51 point of operation: The location in the machine where the material or workpiece is positioned and work is performed.	
3.52 presence-sensing device: A device that creates a sensing field, area or plane to detect the presence of an individual or object.	***E3.52*** For the purpose of this standard, a presence-sensing device is an electro-optical, radio frequency or area scanning device. See also *safety mats* and *safety edges* for information on pressure sensitive devices.

Standard Requirements	Explanatory Information
3.53 Presence–Sensing Device Initiation (PSDI): Operating mode of indirect manual initiation of a single cycle by a presence–sensing device when it senses that work motions of the operator related to feeding or removing parts are completed and all parts of the operator's body are withdrawn from the sensing field of the device.	***E3.53*** This operating mode is also known as "ESPE used as a machine reinitiation device" (IEC 61496-1) and "sensitive protective equipment when used for cycle initiation" (ISO 12100). See also, ***break***.
3.54 probe detection device: A device used to detect the presence or absence of the individual's hand by encircling all or part of the hazard zone with a two- or three-dimensional object prior to actuating the machine cycle.	
3.55 protective measure (risk reduction measure): Any action or means used to eliminate or control access to hazards hazards and/or reduce risks.	***E3.55*** Protective measures can include but are not limited to: inherently safe design; guards; safeguarding devices; complementary equipment and measures; awareness devices including warnings; safe work practices / procedures, training or other administrative controls, and personal protective equipment (PPE).
3.56 pull back (pull out) device: A device that is attached to the operator's hands and wrists and is connected to the ram, slide, upper die, or other moving portion of the machine, so that when properly adjusted, the device will prevent the operator from reaching into the hazard zone, or withdraw the operator's hands from the hazard zone during hazardous motion.	
3.57 qualified personnel: An individual who, as a result of training and experience, understands and demonstrates competence with the design, construction, operation or maintenance of the machine and the associated hazards.	
3.58 rebuilder (reconstructor): An entity who rebuilds or reconstructs a machine tool or machine tool system.	***E3.58*** See also, ***supplier***. For definition of *rebuilding*, see ANSI B11.0.
3.59 redundancy: The use of multiple means to perform the same function.	
3.60 repeat: An unintended or unexpected successive cycle of the machine.	***E3.60*** Typically results from, or in conjunction with, a malfunction.
3.61 restraint device: A safeguarding device with attachments for the operator's hands and wrists that prevents the operator from reaching into the hazard zone.	***E3.61*** Also sometimes referred to as a *hold out device*.
3.62 safe-holding (workpiece) safeguarding method: A method of safeguarding in which the operator's hands are maintained away from the hazardous portion of the machine cycle by requiring that both hands are used to hold or support the workpiece, or by requiring that one hand holds the workpiece while the other hand operates the machine.	

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3.63 safe-opening safeguarding method: A method of safeguarding that limits access to the hazard zone by the size of openings or by closing off access when the workpiece is in place in the machine.	
3.64 safe-work procedure(s): Formal written documentation developed by the user that describes steps that are to be taken to safely complete tasks where hazardous situations may be present or hazardous events are likely to occur.	
3.65 safeguarding: Protection of personnel from hazards by the use of guards, safeguarding devices, awareness devices, or safeguarding methods.	***E3.65*** See also, ***protective measure***.
3.66 safeguarding device: A device that detects or prevents inadvertent access to a hazard.	***E3.66*** For a device to be used for safeguarding purposes, it must comply with clauses 6 and 8 (at a minimum). The scope of, and the devices that are included within, the classification of "Safeguarding Device" as defined by this standard is not as broad as the classification of "Protective Device" as defined by ISO 12100. Some of the devices that are considered "Protective Devices" do not meet the B11.0 definition of "Safeguarding Device" and are considered "Complementary Equipment" by this standard (see clause 12).
3.67 safeguarding method: Safeguarding implemented to protect individuals from hazards by the physical arrangement of distance, holding, openings, or positioning of the machine or machine system to ensure that a hazard cannot be reached.	***E3.67*** The phrase "safeguarding by location" is often used to describe these methods.
3.68 safety block: A prop that is inserted between opposing tooling or machine members to prevent closing of machine members or tooling components.	***E3.68*** Also referred to as *die block*.
3.69 safety distance: The distance a safeguard is installed from a hazard such that individuals are not exposed to the hazard.	***E3.69*** See also, Annex D.
3.70 safe-distance safeguarding method: A method of safeguarding in which a minimum distance is determined and awareness to the hazard is identified so it can be avoided.	
3.71 safe-location safeguarding method: A method of safeguarding by physically locating either the hazard or the individual such that the hazard is not accessible.	
3.72 safety edge device: A device, consisting of a sensing edge and its control, that detects an individual(s) when in contact with its sensing edge.	
3.73 safety interface module: A device designed to ensure the performance of the safety-related function(s).	***E3.73*** Safety interface modules are also commonly referred to as *safety relay modules*.
3.74 safety markings: See awareness device.	

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3.75 safety mat device: A device, consisting of a sensing surface and control, which detects the presence of an individual(s) on its surface.	
3.76 safety-related function(s): That portion of the control system or safeguarding device that controls (limits) exposure to a hazardous situation or reduces risk to an acceptable level.	
3.77 sensing angle: The angle defining the sensing surface at which the individual will always be detected by the sensing edge.	
3.78 set-up: The process of changing over or adjusting the machine work holding device(s), tooling and safeguarding and ensuring proper and safe operation of the machine or machine system.	***E3.78*** Also referred to as *tryout*.
3.79 shield: A barrier used to either keep chips or coolant within the confines of the machine, or to reduce the potential of tooling parts or workpieces from being ejected from the machine.	
3.80 single control safeguarding device: A single actuating control used to initiate or maintain machine motion, located at a safe distance from the hazard.	
3.81 single cycle (stroke): One complete cycle of the machine from the initial (open) position through the closing or work performing position and a return to the initial position.	
3.82 slide lock: An energy-isolating device intended to address gravity hazards associated with a slide.	***3.82*** A slide lock is not intended to prevent motion by the drive system. A slide is also called a *ram*, *plunger*, or *platen*.
3.83 stop: Immediate or controlled cessation of machine motion or other hazardous situations. There are many terms used to describe the different kinds of stops, including user- or supplier-specific terms, the operation and function of which is determined by the individual design. Definitions of some of the more commonly used "stop" terminology include:	***3.83*** See also, NFPA 79.
3.83.1 controlled stop: The stopping of machine motion while retaining power to the machine actuators during the stopping process. Also referred to as Category 1 or 2 stop.	
3.83.2 emergency stop: The stopping of a machine, manually initiated, for emergency purposes;	
3.83.3 normal stop: The stopping of a machine, initiated by the control system, at the completion of a cycle;	
3.83.4 protective stop: The stopping of a machine initiated by safeguarding for safeguarding purposes;	***E3.83.4*** This type of stop allows the orderly cessation of motion or the hazardous situation and allows for the retention of program logic to facilitate restarting of the machine. This type of stop includes stop Categories 0, 1 and 2 as defined in NFPA 79. Also known as *safety stop*.

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3.83.5 uncontrolled stop: The stopping of machine motion by removing power to the machine actuators, all brakes or other mechanical stopping devices being activated. Also referred to as a Category 0 stop.	***E3.83.5*** See also, NFPA 79.
3.84 stop command: An action to cause cessation of machine motion either automatically or through human intervention. The stop command can be immediate or normal. See also, immediate stop command, normal stop command.	
3.84.1 immediate stop [stopping] command: Initiation of a stopping command to the machine control or actuators at any point in the machine cycle.	
3.84.2 normal stop command: A command that initiates an action(s) to stop motion at the end of a machine cycle or at other points required by the machine functions.	
3.85 stop control: A control that when actuated, initiates immediate or controlled stopping action of the hazardous motion of the machine;	
3.86 stopping performance monitor: A sensor, system, or device used to monitor the stopping performance of the machine.	***E3.86*** A stopping performance monitor is sometimes referred to as a *brake monitor*.
3.87 supplier: An individual, corporation, partnership or other legal entity or form of business who provides equipment or services.	***E3.87*** A supplier can be the manufacturer, manufacturer's agent, representative or distributor, reseller, installer, modifier, rebuilder or integrator who provides equipment or services for the safeguarding associated with the machine. For the purpose of this standard, a supplier provides, or makes available for use, all or part of the safeguarding associated with the machine. When the user provides any of the above services, the user is considered the supplier.
3.88 synchronous (actuation): Concurrent actuation where the time lag between the start of one input signal and the start of the other is less than or equal to a predetermined time.	***E3.88*** For a two hand trip and control device(s) the time lag is less than or equal to 500 milliseconds.
3.89 transparent guard: a guard that enables viewing the work area / operation(s) through the guard.	***E3.89*** This is not intended to include standalone metal mesh guarding.
3.90 trip [tripping]: The initiation of a machine cycle.	***E3.90*** The initiation of a machine cycle may be by manual operator controls or by signal(s) from automation.
3.91 two-hand control device: An actuating control that requires the synchronous use of both the operator's hands to initiate a machine cycle and concurrent use during the hazardous portion of the machine cycle.	***E3.90*** Two-hand control devices are sometimes referred to as *hostage controls*.

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3.92 two-hand trip device: An actuating control that requires the synchronous use of both of the operator's hands to initiate a machine cycle.	***E3.92*** Two-hand trip devices typically cause a full machine cycle and do not issue a stop command if either or both the operator controls are released.
3.93 user: An individual, corporation, partnership other legal entity or form of business that utilizes a machine, machine production system or related equipment.	***E3.93*** The user is typically regarded as the entity that employs the operator of the machine and/or supervises the operation of the machine, including production and maintenance. Under certain circumstances (i.e., acting as a builder, modifier, integrator), the user is a supplier.
3.94 workpiece: Any piece of material placed into the machine for the purpose of having work performed upon it.	

4 Responsibility

4.1 Safeguarding supplier

4.1.1 Within the scope of its work activity, the safeguarding supplier shall ensure that safeguarding meets the design, construction, integration and installation requirements of this standard.	***E4.1.1*** See also, 3.91. If more than one entity is involved in the design, construction, integration or installation, each entity is responsible for the scope of its work activity.
4.1.2 The safeguarding supplier shall furnish documentation as required for the safeguarding, including installation requirements, operating instructions, and maintenance requirements.	***E4.1.2*** The documentation should include the following, where applicable: • performance specifications; • electrical or pneumatic schematics and diagrams; • physical environment for which the device was designed; • function and location of the operator controls, indicators, and displays; • schedules for periodic maintenance, lubrication and inspection; • signs and warnings. See also ANSI B11.0 - Annexes I and J, and ANSI Z535.6 for additional guidance.

4.2 Safeguarding user

4.2.1 The user shall be responsible for ensuring that safeguarding is provided, integrated, installed, maintained, and used in accordance with the requirements of this standard.	***E4.2.1*** The user should consider the safeguarding supplier's performance specifications, schematics, and diagrams, operating and maintenance instructions and warnings when installing, operating, and maintaining the safeguarding.
When machines are ordered/purchased without safeguards, the user shall provide safeguarding as determined by this standard, the base B11 standard and shall be based on a risk assessment. See ANSI B11.0.	When the user designs, constructs, installs, modifies or reconstructs the safeguarding, the user is considered to be the supplier. See also, 4.1.

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4.2.2 The user shall be responsible for ensuring that supervisors, operators, maintenance, and service personnel are trained in the proper installation, adjustment, operation and maintenance of the safeguarding, within the scope of their work activity.	***E4.2.2*** The user should direct operators and service personnel to immediately report to supervision, any apparent malfunction or improper operation of the safeguarding systems. The user should consider the safeguarding supplier's performance specifications, schematics and diagrams, operating and maintenance instructions, and warnings when developing installation and operation procedures or instructions.
4.2.3 The user shall ensure that when any change of the tooling, process or procedures occurs, the safeguarding continues to meet the requirements of this standard and the ANSI B11 'base' standard (the B11 standard dealing with the specific machine). See ANSI B11.0	***E4.2.3*** Changes in the production system that may affect the safeguarding include, but are not limited to: • tooling changes; • addition or removal of auxiliary equipment; • modification of the machine; • modification of machine systems; • operating method (program); • change in operating personnel; • adjustment location of safeguarding; • part configuration. Adjustments to the safeguarding or supplemental safeguarding may be necessary.
4.3 Personnel Personnel involved with the installation, operation, or maintenance of the safeguarding shall be responsible for following the training and safety procedures provided by the user in the operation and maintenance of the safeguarding.	***E4.3*** The Occupational Safety and Health Act of 1970 – Public Law 91-596, states in Section 5(b) "Each employee shall comply with occupational safety and health standards and all rules, regulations and orders issued pursuant to this Act which are applicable to his own actions and conduct." Personnel have a responsibility to avoid the hazards that are identified or known to them, and not intentionally attempt to circumvent the safeguarding.
5 Hazard control Hazards (residual risk) associated with the use of the safeguarding shall be identified and controlled as part of the overall risk reduction strategy.	***E5*** The overall hazard identification and risk reduction strategy is identified in each ANSI B11 'base' standard or in ANSI B11.0 (B11.TR3). These documents are used to select safeguarding appropriate to the reasonably foreseeable tasks and identified hazards. With the application of safeguarding, additional (new) hazards may occur that are not due to the safeguarding, but occur with the implementation. Refer to Annex B for additional information on the hazards associated with safeguarding.

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6 General safeguarding requirements

Guards, safeguarding devices, awareness devices, safeguarding methods, safe work procedures, and complementary equipment and measures shall meet the requirements of this clause and clauses 7, 8, 9, 10, 11 and 12.

6.1 Performance of the safety-related function(s)

E6.1

This subclause shall apply when referenced by other parts of this standard.

When a component, module, device or system failure occurs, such that it or a subsequent failure of another component, module, device or system would lead to the inability of the safety-related function(s) to respond to a normal stop command or an immediate stop command, the safety-related function shall:

- prevent initiation of hazardous machine motion (or situation) until the failure is corrected or until the control system is manually reset; or
- initiate an immediate stop command and prevent re-initiation of hazardous machine motion (or situation) until the failure is corrected or until the control system is manually reset; or
- prevent re-initiation of hazardous machine motion (or situation) at the next normal stop command until the failure is corrected or until the control system is manually reset.

Because some failures cannot be detected until the completion of a cycle or a portion of the cycle, loss of safety functions may occur for a portion of the machine cycle.

Other failures cannot be detected until a demand is made on the safety-related function. An example of such a safety-related function may be the use of a safeguard that is actuated infrequently (e.g., an interlocked guard for maintenance) that must be cycled (guard opened) to detect a failure. When a failure is detected, the safety-related function should meet the requirements of this subclause.

In the presence of a failure, the user shall be responsible to ensure that repetitive manual reset of the system or device is not used for production operation.

The intention of a manual reset is to encourage the diagnosis of a failed component, subassembly, device or module. A second failure may occur during the diagnostic or troubleshooting process, negating the safety-related function(s). Additional safeguarding should be used to protect individuals during this process.

Control reliability:

- is one of the design strategies that may be used to meet these requirements;
- cannot prevent a repeat cycle in the event of a major mechanical failure or in the presence of multiple simultaneous component failures;
- is not provided by simple redundancy. There must be monitoring to ensure that redundancy is maintained.

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	While the requirements of control reliability are not directly comparable to the requirements of ISO 13849-1 (1999) or EN/ISO 13849-1 (2008), for the purposes of this standard, complying with Category 3 or 4 and/or Performance Level “d” or “e”, at a minimum, will satisfy the requirements of control reliability. Other Categories and Performance Levels per EN/ISO 13849-1, and Safety Integrity Levels (SILs) per IEC 61508 and IEC 62061 can also satisfy the requirements of this subclause depending on the design, construction, fault exclusions, installation, and maintenance of the safety-related function and a documented risk assessment. For further information on the performance of safety-related functions, see Annex C.
6.2 Protective (Safety) Stop When required by the risk assessment, the machine shall have one or more protective stop circuits designed for the connection of interlocked guards, safeguarding (protective) devices and where applicable, complementary equipment and measures.	***E6.2*** The protective stop command can be activated either automatically (e.g., interrupting safety light curtain) or manually (e.g., opening interlocked guard). The reset of the protective stop command can be accomplished either manually or automatically. This reset is not considered starting or restarting machine operation. A protective stop is typically an immediate stop command that is initiated by the safety-related part of the control system for safeguarding purposes, which can allow an orderly cessation of the hazard or hazardous situation. This stop can retain the program logic to facilitate troubleshooting, the stop function, or to facilitate a restart. This can include but is not limited to PES/PLC and drive logic.
The cessation or reset of a protective stop command shall not initiate hazardous motion(s) or situation(s) except under specifically controlled design conditions.	Examples of a specifically controlled design condition are presence-sensing device initiation (PSDI) and Type A/B movable barrier devices. When used, these control design conditions are considered the normal machine initiation means. See 6.8 and 8.1.
Once the stop condition is removed, the use of normal machine initiation means (e.g., operator controls) to start or initiate a hazardous motion or situations shall be required.	The intent is to require a minimum of two actions to initiate a machine cycle. One action is to clear the stop command (e.g., re-arming an emergency stop device) and the second action is the normal machine initiation.
6.2.1 The protective stop circuit shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***E6.2.1*** See also, clause 5 and ANSI B11.0 (B11.TR3).

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6.2.1.1 The protective stop circuit shall control the safeguarded hazard by causing an immediate stop command of hazardous machine motion(s) or situation(s). When protective stop circuits are combined with a circuit of a lower safety performance level, the performance of the protective stop circuits shall not be reduced.	The protective stop is typically a separate function from the emergency stop function. This separation of functions allows for different safety performance levels (risk reduction) as determined by a risk assessment for the different circuits. As an example, this may allow a single channel emergency stop circuit, and a separate dual channel with monitoring circuit for a safety light curtain. This does not preclude combining emergency stop functions and protective stop functions within one circuit. The interfacing of an emergency stop command should not reduce the safety performance of safeguarding devices and their circuits. See 12.9.1.1(g). A protective stop can be a stop category 0, 1 or 2 as described by NFPA 79. If the protective stop is stop category 2, then the emergency stop cannot be combined in the same circuit. See 12.9.1.1(d).
6.2.2 The components of the protective stop circuit shall be designed, selected, constructed and interconnected in such a manner so as to withstand the anticipated operational and environmental operating conditions.	***E6.2.2*** Consideration should be given to: • frequency of operation; • need for periodic testing (especially where operation is infrequent); • vibration, shock, temperature, dust, foreign or corrosive materials, fluids, etc. As a good practice, provision should be provided for the capability of expanding or connecting additional interlocked guards, safeguarding (protective) devices, or complementary equipment.

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Table 1 – Comparison of Stop, Emergency Stop and Protective Stops

This table offers an explanatory comparison of the different functions. See NFPA 79 for stop requirements, see clause 12 for emergency stop requirements and see clause 6.2 for protective stop requirements.

	Stop	**Emergency Stop**	**Protective (Safety) Stop**
Location	Personnel have quick, unobstructed access. Stop Category 0 required on every machine (other categories may be used as determined by a risk assessment). Required on all operator stations	Personnel have quick, unobstructed access. Required on all operator stations and other locations as determined by a risk assessment	Located such that an individual cannot access the hazard. Determined by the safety distance formula
Initiation of stop signal	Manual or automatic	Manual only	Manual or automatic
Stop category**	0, 1 or 2	0 or 1 only	0, 1, or 2
Circuit performance	As determined by a documented risk assessment		
	Typically single channel (non safety rated)	Minimum single channel safety rated controls. Greater performance may be required when interfaced with a safeguarding device(s).	Typically control reliable
Circuit reset	Manual only	Manual only	Manual or automatic (hardware or software)
Bypass and mute	Allowed (for cycle completion, etc.)	Not allowed	Allowed (for muting, modes of operation, set up, etc.)
Use frequency	Variable; frequent (every cycle) to infrequent	Infrequently; only in emergency or for other immediate stop purposes	Variable; frequent (every cycle) to infrequent
Effect	De-energize the relevant circuit and override related start functions	Remove all energy sources to hazards and override all other functions and operations in all modes	Remove or control energy sources to the safeguarded hazard and override all other functions and operations in all modes associated with the safeguarded hazard
Final removal of power	Electromechanical or solid-state components	Electromechanical components or solid state output devices (drives) designed for safety related functions	Electromechanical or solid state components designed for safety related functions

**See NFPA 79 clause 9.2.2 Stop Functions. The three categories of stop functions shall be as follows:
(1) Category 0 is an uncontrolled stop by immediately removing power to the machine actuators.
(2) Category 1 is a controlled stop with power to the machine actuators available to achieve the stop then remove power when the stop is achieved.
(3) Category 2 is a controlled stop with power left available to the machine actuators.

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6.3 Safety distance When required by this standard, the guard or safeguarding device shall be located at a distance from its associated hazard such that individuals cannot reach the hazard before cessation of hazardous motion (or situation).	***E6.3*** See Annex D for further explanation and an example method to calculate the safety distance. Additional methods might be used as determined by the supporting risk assessment documentation.
6.4 Stopping performance monitor When the stopping time of the machine can increase to a value where the calculated safety distance used in locating the safeguarding is no longer met, a stopping performance monitor shall be provided in accordance with 12.4 of this standard.	***E6.4*** A stopping performance monitor is used to detect when stopping time increases to a value that the safety distance calculated as required by 6.3 no longer protects the safeguarded individual(s).
See the 'base' B11 machine safety standard for specific requirements.	Driven machines having no clutch in their power-trains and use of servo drives, ac or dc drives, or variable speed drives having closed loop control may not require a stopping performance monitor. Failure of these drives is usually catastrophic. The operating mechanisms (cylinders, valves, hydraulic/pneumatic motors) of hydraulic and pneumatic operated machines may become sticky, sluggish or may wear, affecting the stopping distance. The use of a stopping performance monitor should be evaluated based on the risk assessment.
6.5 Perimeter safeguarding **6.5.1 Perimeter-guarding** Perimeter-guarding is utilized where areas containing single or multiple hazards are not individually safeguarded.	***E 6.5.1*** Perimeter-guarding applications are designed to detect an individual entering a hazardous area (e.g., interlocked gate or door on fencing, electro-optical presence-sensing safeguarding devices, electro-mechanical switches, etc.). This is not intended to replace lockout/tagout or alternatives to safe energy control (see also, ANSI Z 244.1)
6.5.1.1 Perimeter-guarding applications shall be designed to stop hazardous motion and prevent the initiation of hazardous motion while an individual is in the safeguarded area.	***E6.5.1.1*** This type of situation is often referred to as a *pass-through*. A pass-through hazard occurs when an individual crosses the safeguard, which issues a stop command to remove the hazard. Subsequently, the individual may cross into the hazardous area but their presence is no longer detected. A hazard arises if the machine motion resumes while personnel are within the safeguarded area.
6.5.2 When an individual(s) can pass through the safeguard into the safeguarded area and is no longer detected by the safeguard or other supplemental safeguarding:	***E6.5.2***

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a) additional protective measures shall be used in conjunction with the perimeter guarding to prevent the individual from exposure to the hazard; or	
b) the perimeter guarding system shall require manual reset before hazardous motion can occur. The sole action of closing a guard or clearing the sensing field of a presence-sensing device shall not reset the perimeter safeguarding circuit or function.	b) in perimeter guarding applications, the individual is not continuously being detected (e.g., continuously interrupting the sensing field of a presence-sensing device).
6.5.3 When used or required by 6.5.2 (b), the manual reset device shall be located outside of the safeguarded area such that the perimeter guarding cannot be reset from within the hazardous area.	***E6.5.3*** Means of manual reset can include but are not limited to: • pushbuttons; • slide bolts; • trapped key systems; • manually actuated safety switches, or • other means of providing additional intentional action(s) to reset the perimeter guarding. An additional means can be a key-actuated switch that can provide some operator supervisory control, as the key can be removed from the switch and kept in the possession of an individual. This does not prevent unauthorized or inadvertent resets due to spare keys in the possession of others, or additional personnel entering the guarded area unnoticed.
6.5.4 Reset of the perimeter safeguarding shall only be performed after the hazard zone is clear of all individuals.	***E6.5.4*** One means of meeting the requirements of this subclause when multiple individuals are in the hazard zone is to provide each individual with their own means of control.
6.5.4.1 If the entire safeguarded area is not visible from the single reset device location, then a method for detecting personnel or by providing an "inhibit" to the reset function at the non-observable location(s) shall be used.	***E6.5.4.1*** Means for inhibiting the reset function may be a detented operator (e.g., emergency stop device) located in the non-observable location(s).
If a means or method for detecting personnel is not reasonably practicable, the following requirements shall apply:	
a) visual or audible warning device(s) shall be used;	a) color blindness and background noise should be considered. See clause 9.
b) operation of the reset function shall immediately activate the warning device;	
c) the warning device shall be continuously activated until the predetermined warning period has elapsed;	c) the safeguarding circuit(s) should not be reset until the warning period has elapsed.
d) the restart function shall be inhibited during the warning period;	
e) the restart shall require the use of the normal initiating means;	

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f) if the restart of the machine or other hazard(s) can occur unexpectedly or unintentionally, the safeguarded circuit shall not be capable of being reset until the warning period has elapsed; and	f) unexpected or unintended machine motion or other hazard(s) can occur such as: • if the restart function fails such that the machine cycle occurs as soon as the safeguard is reset; or • if fluid power system contains trapped energy that can cause hazardous motion.
g) a means of preventing reset or restart shall be provided inside the safeguarded area. Operation of this means shall override all safeguarding device resets and start/restart functions.	g) a method of accomplishing this function is through use of an easily accessible control to issue an immediate stop command (e.g., emergency stop device or rope/cable pull) inside the safeguarded area.
6.5.5 Reset of the perimeter safeguarding system shall not, in or of itself: • restart the machine or equipment; • cause a hazardous situation.	***E6.5.5*** The user should evaluate the installation and perform a risk assessment to determine the appropriate elements needed for an effective reset procedure. These elements may include pre-determined time, sequence, location, or position. When a specific reset sequence is required, the control circuitry should force this reset sequence and the control system should have the ability to prompt for it.
6.5.6 The reset function and its interface shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***E6.5.6*** One method of complying with this clause is to require an open-closed-open action within a specific time frame for a valid reset. This prevents a shorted or failed ON switch from creating an automatic reset of the safeguarding system. See also, clause 5 and ANSI B11.0 (B11.TR3).
6.6 Bypassing **6.6.1** Bypassing of the interlocked guard or a safeguarding device shall be permitted in accordance with clauses 7 and 8.	***E6.6.1*** Bypassing renders ineffective one or more safety-related function(s) of the control system or safeguarding device(s). Bypassing is typically a manually actuated or selected function. This function is sometimes known as overriding.
6.6.2 When the safety-related function is bypassed, other protective measures shall be provided and used.	***E6.6.2*** Other protective measures include, but are not limited to, the following measures: Alternate or supplemental safeguarding devices (clause 8); • Initiation of motion by a hold-to-run or other control device; • A portable control station (e.g., pendant) with an emergency stop device, and where used, an enabling device. Where a portable station is used, motion shall only be initiated from that station; • Limiting the speed or the power of motion; • Limiting the range of motion.

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6.6.3 Emergency stop functions shall remain active at all times.	***E6.6.3*** As an example, if the safeguarding device to be bypassed is a two-hand control operator station with an emergency stop device, bypassing the safety-related (two-hand control) function cannot render the emergency stop function ineffective. If the operator station can be disconnected or is cableless, see NFPA 79.
6.6.4 The bypassing function, including its components, shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment but at a minimum shall be equal to that required of the safety function being bypassed. When conforming to the requirements of 6.1, a single failure shall not cause or extend a bypassed condition such that individual(s) are exposed to a hazard.	***E6.6.4*** As an example, a simple key-operated switch wired in parallel with the device's output is inadequate, as its failure can remain undetected. See Annex C for further information. See also, clause 5 and ANSI B11.0 (B11.TR3).
6.6.5 The means of selecting or enabling bypassing shall be capable of being supervised.	***E6.6.5*** Methods of meeting this requirement include, but are not limited to, the use of key operated controls, controls located under lockable covers, or controls that requires a tool or password to access. Adjustment or configuration should only be performed by authorized individuals.
6.6.6 It shall not be possible for common cause failures or environmental conditions to initiate a bypassed condition.	***E6.6.6*** Common cause failures are dependent on the sensing technology of the devices or the means to initiate a bypass. Examples include, but are not limited to: • power supply failures; • airborne contamination (e.g., dust); • weld flash/slag; • humidity. Diverse technologies can eliminate or greatly reduce the possibility of common cause failures, such as complementary signals (one ON and one OFF, or one PNP and one NPN). Interruption of power to the means of bypassing should not allow a bypass condition to be initiated or be continued. The risk assessment should address the issue of interruption and restoration of power to the system.

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6.6.7 Indication that the bypass is active shall be provided and shall be readily observable by individuals protected by the safeguarding device or the safety-related function.	***E6.6.7*** This indication warns that the protective function is suspended. An amber indicator lamp or other means may be used to meet this requirement. Due to the prevalence of color blindness (10% in males for red/green), methods such as unambiguous positioning, patterning, labeling or flashing of the indicators may be effective in providing the indication required. Care should be taken to ensure that the operators and other individuals are aware that the device has been bypassed so that individuals do not assume that the device is active and that they are safeguarded when in fact, the device is bypassed. This indication is to be readily observable from the location of the bypassed safeguard. Operation of the indication should be verified at suitable intervals.
6.7 Muting **6.7.1** Muting of the interlocked guard or a safeguarding device shall be permitted in accordance with clause 7 and 8, and when: • individuals are not exposed to the hazard, or during the non-hazardous portion of the machine cycle; • the hazard cannot be accessed or is otherwise safeguarded.	***E6.7.1*** Muting is the temporary, automatic suspension of the safeguarding function during a non-hazardous portion of the machine cycle without human interaction. This allows for material to be fed into a machine or process without issuing a stop command. Examples include but are not limited to: • loading of a part; • unloading of a part; • material movement during the process; • repositioning the workpiece or part. The muting function typically is provided by either the machine control, the means that monitors the interlocked guard, the safeguarding device itself, or other safety related logic device. Muting should not be confused with “bypassing” or “overriding,” which is initiated by an individual manually suspending the normal function of a safeguard. Another term commonly confused with muting is “blanking,” which desensitizes or disables a portion of the sensing field of a Presence-sensing Safeguarding Device such that a specific interruption is ignored.

Standard Requirements	Explanatory Information
	To mute a safeguard appropriately, the design of a muting system should include, but is not limited to: • the ability to identify the non-hazardous portion of the machine cycle, • the selection of the proper means (e.g., devices) that signal a mute cycle for the expected environmental and application conditions, • proper mounting and installation of the muting means (e.g., devices).
6.7.1.1 Emergency Stop functions shall remain active at all times.	
6.7.2 Muting shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment but at a minimum shall be equal to that required of the safety function being muted.	***E6.7.2*** As an example, a single unmonitored cam-operated limit switch wired in parallel with the device's output is inadequate, as its failure can remain undetected. A single failure should not extend a muted condition such that individual(s) are exposed to a hazard. See Annex C for further information. See also, clause 5 and ANSI B11.0 (B11.TR3).
6.7.2.1 When complying with the requirements of 6.1: • a single source that initiates or continues a muted condition shall comply with the requirements of 6.1, or	***E6.7.2.1*** A safeguarding device that complies with clause 8 can be used as a source. A source can also be a device or system that is tested, verified or monitored for proper operation that meets the requirements of 6.1. Typically monitored single source devices are used in short machine cycles where the monitoring is performed at a minimum of once a cycle. It is not acceptable to use a single standalone switch, device, or relay for the mute source that is not monitored. This single device may fail so that a mute condition occurs at an inappropriate time.
• the mute condition shall be initiated and continued by a minimum of two independent sources that function with a concurrent action.	These signal sources are typically hardwired and function within prescribed time of each other. Two dissimilar devices such as encoders and resolvers may also be used. Only one of these sources should pass through, or be affected by, a non safety rated programmable logic controller or similar device (e.g., PES). Annex A.7 of IEC 61496-1 requires at least two independent hard-wired muting signal sources to initiate the function.

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	If the two sources disagree or conflict, the mute condition ends or does not occur. Incorrect signals, sequence, or timing of the muting sensors or signals do not allow a mute condition. This is to ensure that a single fault cannot cause (start) a muted condition.
6.7.3 If the muting function is capable of adjustment or configuration, the means shall be capable of being supervised.	***E6.7.3*** Methods of meeting this requirement include, but are not limited to, the use of key operated controls, controls located under lockable covers, or controls that requires a tool or password to access. Adjustment or configuration should only be performed by authorized individuals.
6.7.4 If the machine has reversing capability or alternate motion paths where a hazard is possible, the control system shall include an automatic means so muting is only permitted in the non-hazardous direction or path.	***E6.7.4*** As an example, one method of meeting this requirement is by the use of a control circuit interlock on the drive motor starter (forward direction contact) to allow "muting" only in the forward direction, when the starter is energized. Another method is to incorporate a Mute Enable function such that a mute condition cannot begin if the Mute Enable signal is not present.
6.7.5 It shall not be possible to initiate the mute condition when the interlocked guard or safeguarding device: • safety outputs are in the open state, the OFF-state, or the non-conducting state; or • is in the lock-out condition.	
6.7.6 Muting shall not be used if an individual can enter the hazard zone by passing through the safeguard sensing field unless: • detected by supplemental safeguarding that would initiate an immediate stop command or otherwise prevent access to the hazard; or • a manual reset of the safeguard is required. See 6.5.	***E6.7.6*** A hazardous situation can occur if devices that are safeguarding multiple areas, such as safety light curtains using mirrors or that have multiple sensing fields, are muted and an individual can enter the hazard zone without being detected. This requirement is not intended to detect deliberate acts to bypass or circumvent safeguards such as riding within material in order to avoid detection. See 4.3 on circumvention of safeguards.
6.7.7 The risk assessment shall identify the need for consideration if an individual can enter the hazard zone by passing through the safeguard sensing field with the material.	***E6.7.7*** Consideration includes but is not limited to: • distinguishing a person from the material that is allowed to pass through the sensing field; • detecting the load being conveyed, but not the pallet or transport; • reducing the possibility of personnel entering the hazard zone immediately preceding or following the material or alongside; • reducing the possibility of entrapment by the material, the pallet or the transport.
6.7.8 It shall not be possible for common cause failures or environmental conditions to initiate a mute condition.	***E6.7.8*** Common cause failures are dependent on the sensing technology of the devices or the means to initiate a mute.

Standard Requirements	Explanatory Information
	Examples include, but are not limited to: • power supply failures; • airborne contamination (e.g., dust); • weld flash/slag; • humidity. Diverse technologies can eliminate or greatly reduce the possibility of common cause failures, such as: • one photoelectric sensor and one inductive proximity sensor; • complementary signals (one ON and one OFF, or one PNP and one NPN); • different sensing means (one diffuse and one through-beam photoelectric sensor). Interruption of power to the means of muting should not allow a mute condition to be initiated or be continued. The restoration of the power to the means of muting may not initiate muting unless: • the safety outputs are in the closed state, the ON-state, or the conducting state before the mute is initiated; • the muting means or devices are signaling a mute condition; • the Mute Enable command, when used, is active. The risk assessment should address the issue of interruption and restoration of power to the system.
6.7.8.1 The mute means or devices shall be installed to prevent maladjustment or misalignment that results in an unintended or inappropriate mute condition, or means shall be provided to limit the duration of the mute condition.	***E6.7.8.1*** As an example, physical damage to the mounting surface could cause the muting devices to be knocked out of alignment, resulting in false muting input signals. Examples to reduce the possibility of failure due to mounting include but are not limited to: • secure (robust) mounting or mechanical guarding of the mute device(s); • a time limit after which the muted condition ends automatically when exceeded and can detect the unintended or inappropriate mute condition; • directional or sequence monitoring of the mute devices; • concurrent monitoring of the mute devices.
6.7.9 The devices or the means to initiate a mute condition shall be selected and installed such that they cannot be easily defeated, bypassed, or otherwise actuated by a single individual.	
6.7.10 The devices or the means to initiate a mute condition shall not use a delay or other timing functions if a single fault could extend the time of the mute condition and create a hazardous situation.	

Standard Requirements	Explanatory Information
6.7.11 When required by a risk assessment, an indicator shall be provided to identify the muting condition.	***E6.7.11*** This indicator warns that the protective function is suspended. It is not a requirement of this standard to provide indication of the mute cycle, but other standards may require this function. This indicator is to be readily observable from the location of the muted safeguard. Operation of the indicator should be verified at suitable intervals.
6.8 Presence-sensing Device Initiation (PSDI) When a presence-sensing device is used to perform both the safeguarding function and to initiate the machine cycle, the presence-sensing device, PSDI control logic, and the operator station shall be designed and installed to meet this clause.	***E6.8*** Typically, an electro-optical presence-sensing device is used for PSDI and is commonly known as a safety light curtain (screen) as described in IEC 61496-1/-2. Although safety light curtains are typically used, alternatives may be used for PSDI when the user can demonstrate, through tests and analysis by the user or supplier, that the alternative device: a) is as reliable as the safety light curtain; b) meets the conditions of this clause; c) has the same long term reliability as safety light curtains; and d) can be integrated into the entire safety system. Initiating a machine cycle by simply clearing an interruption of a presence-sensing device sensing field that has created a protective stop is not allowed, see 6.2.
6.8.1 PSDI shall be used only on machines which can be stopped anywhere in their cycle.	***E6.8.1*** Specific machine standards may have additional requirements.
6.8.1.1 When a stopping performance monitor is used, it shall be in accordance with 6.4.	***E6.8.1.1*** A stopping performance monitor is required when the stopping time of the machine can increase to a value where the calculated safety distance used in locating the safeguarding is no longer met.
6.8.2 PSDI shall be used to initiate a single machine cycle for normal production operation only.	***E6.8.2*** PSDI operating mode is not to be used for set-up or maintenance.
6.8.3 The presence-sensing device and the protective stop circuit (see 6.2) used for PSDI shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***E6.8.3*** This clause does not apply to the PSDI control logic of 6.8.9 unless required by a risk assessment.

Standard Requirements	Explanatory Information
6.8.3.1 The PSDI control logic shall not override the protective stop circuit (function).	
6.8.4 The presence-sensing device used in the PSDI system shall conform to the applicable clauses in 8.3.	
6.8.4.1 In addition to clause 8.3, the following shall apply:	***E6.8.4.1*** Blanking of the sensing field is permitted, provided the minimum object sensitivity is no greater than 32 mm (1.25”).
a) the minimum object sensitivity shall be no greater than 32 mm (1.25”);	If fixed blanking is used and the minimum object sensitivity exceeds 32 mm (1.25”), then it is required that the blanked area is completely obstructed (see 8.3.2.5).
b) Individual sensing fields of presence-sensing devices used to initiate cycles in the PSDI operating mode shall cover only one side or opening of the machine. Mirrors shall not be used with presence-sensing devices used in PSDI applications;	This does not preclude the use of segmented sensing fields used to create “L” shaped sensing fields.
c) The sensing field shall be located at a minimum safety distance per 6.3;	
• it shall not be possible for an individual to enter, pass through, and become clear of the presence-sensing device sensing field;	Examples to meet this requirement can include, but are not limited to: a) mechanical barriers; b) extended sensing field(s) of the presence-sensing device such as horizontal sensing segments; or c) supplemental safeguarding. A common cause of injury when using PSDI results from improper placement of the sensing field allowing reaching around, over, under, or passing through the sensing field and creating an unintended break.
• the entire area of the sensing field of a presence-sensing device used to initiate cycles in the PSDI operating mode shall be in clear view of the operator from the normal operating position.	The operator should be able to view the entire area of the sensing field so that the operator can warn others not to intrude into the sensing field, which could cause an unintended cycle.
6.8.5 The PSDI system shall discriminate between an intended break and rapid unintended interruptions of the presence-sensing device sensing field.	***E6.8.5*** Rapid changes of the presence-sensing device output may occur as a result of fingers or parts intermittently interrupting individual beams of the sensing field or minor misalignments between the transmitter and receiver. The effect would be to start a cycle, but then immediately stop since the sensing field is interrupted, and thus reduce the efficiency of the PSDI system. One method to meet this requirement is to establish a minimum time between presence-sensing field interruption and clear signals within the presence-sensing device. Another means is to have the PSDI control logic input(s) ignore rapid changes in state of the outputs of the presence-sensing device.

Standard Requirements	Explanatory Information
6.8.6 All other presence-sensing devices used only for safeguarding shall disable the PSDI mode when interrupted and meet the requirements of 8.3.	
6.8.7 Part-in-place sensing, when used, shall ensure that the part (workpiece) is in place in order for PSDI to initiate a cycle. The PSDI control logic shall prevent successive machine cycles if the sensor does not change state on every load and unload cycle.	***E6.8.7*** The operation of the part-in-place sensor is a peripheral function within the PSDI control logic. This sensor is intended to be a machine interlock function and not a safety function.
6.8.8 The diameter of the tool handle extension (when used), shall be greater than the minimum object sensitivity of the presence-sensing device(s).	***E6.8.8*** Examples may include but are not limited to tools for feeding parts, removal of scrap, lubrication of parts, or removal of parts that fail to be ejected in the PSDI operation:
6.8.9 PSDI Control Logic	***E6.8.9*** PSDI Control Logic can be part of or separate from the presence-sensing device.
6.8.9.1 The control logic shall require enabling (selecting) the PSDI operating mode and the number of interruptions to initiate a cycle.	***E6.8.9.1*** PSDI must be enabled (turned ON) as a first step. This can be a "PSDI ON/OFF" switch or part of the machine operating mode selector switch where PSDI is one of several machine operating modes. Selecting the number of interruptions (breaks) to initiate a cycle can be incorporated into the ON/OFF switch if only a single option is available or into the operating mode selector switch if multiple options are available (single-break and double break).
6.8.9.2 The control logic shall require a reset action by the operator to enable (arm) the PSDI function after: • power is applied if PSDI operating mode is enabled (selected); • selection of PSDI operating mode; • any change in the number of interruptions (breaks); • being disabled (disarmed) by the PSDI timer; • being disabled (disarmed) by any protective stop command by the PSD or other safeguarding device; and • being disabled (disarmed) by any stop command, except the PSDI end-of-cycle signal.	***E6.8.9.2*** The next step is to arm the PSDI function. One method of meeting this requirement is to perform the following sequence: 1) Select the PSDI operating mode; 2) Momentarily depress a PSDI Reset (arming) button; 3) Break the presence-sensing device sensing field the required number of times (single break or double break) within a predetermined time after the reset (arming) button is pressed to initiate a cycle. Another method is to actuate the manual cycle initiation means (e.g., cycle start button, two-hand control, etc.) to make the first cycle after PSDI is selected; or after PSDI has been disabled by any stop command, to arm or re-arm the PSDI function to initiate successive cycles. With this method:

Standard Requirements	Explanatory Information
	1) Select the PSDI operating mode; 2) Manually actuate the manual cycle initiation means to initiate the first cycle; 3) A end-of-cycle signal (switch) automatically arms PSDI function; 4) Break the presence-sensing device sensing field the required number of times (single break or double break) within a predetermined time after the first cycle is completed to initiate the next cycle with the presence-sensing device.
6.8.9.3 Any change in the selection of the PSDI operating mode, the number of interruptions (breaks), or other non-safety stop command, shall initiate a normal stop command and disable (disarm) the PSDI function. A stop command from the presence-sensing device or any safety-related source shall initiate an immediate stop command and disable (disarm) the PSDI function.	***E6.8.9.3*** A normal stop command allows the machine to complete the cycle and then stop. The stop command that may be generated by the PSDI end-of-cycle signal does not disable (disarm) the PSDI function.
6.8.9.4 A PSDI timer shall be provided to disable (disarm) the PSDI operating mode and prevent a cycle start if the time between machine cycles exceeds a predetermined time established by the user. Rearming of PSDI function shall require use of the reset action of 6.8.9.2. Adjustment means for the timer shall be capable of supervisory control.	***E6.8.9.4*** The time limit should be set for the shortest practicable duration for the production requirements of the operation being performed. A typical time period is not more than 30 seconds for a machine cycle that is 5 minutes or less. Methods of meeting this requirement include, but are not limited to, the use of key operated controls, controls located under lockable covers, or controls that require a tool or password to access. Adjustment or configuration should only be performed by authorized individuals.
6.8.9.5 The PSDI control logic shall initiate a single cycle after the correct number of interruptions (breaks) of the presence-sensing device sensing field.	
6.8.9.6 The PSDI control logic shall provide an input(s) for connection of a PSDI end-of-cycle signal. This signal shall initiate a normal stop command, enable (re-arm) the PSDI function (break sequence) for the next machine cycle, and start the PSDI timer.	***E6.8.9.6*** An example of an end-of-cycle signal for a mechanical power press are rotating cam limit switches, which are used to stop the machine cycle, provide a signal for the anti-repeat (stop at end-of-cycle) function, and automatically rearm the next PSDI cycle. This input should be evaluated during the risk assessment to determine if the requirements of 6.1 are applicable. The requirements of 6.1 should be complied with if this input is the only means of anti-repeat and an unexpected or unintended repeat cycle creates a hazard.

Standard Requirements	Explanatory Information
6.8.9.7 The PSDI control logic shall not override the protective stop function or the immediate stop command of the presence-sensing device.	***E6.8.9.7*** A common cause of injury when using PSDI results from non-safety rated control functions or logic (e.g., PESs or PLCs) preventing the stop of the machine cycle due to failure(s), fault(s), and the manipulation, both intended and unintended, of the control logic. See 6.6 for bypassing requirements and 6.7 for muting requirements.
6.8.10 In addition to its presence-sensing device, the operator station shall have the following controls: • a means to select the PSDI function; • a means to enable (arm) the PSDI function; • a means to select the number of interruptions (breaks) of the presence-sensing device sensing field to start a machine cycle if more than one interruption is required; • a means to disable (disarm) the PSDI function.	***E6.8.10*** See 6.8.9.1. See 6.8.9.2 Depending on the production operation, more than one interruption (break) may be used to initiate a cycle. See 6.8.9.1. Means include, but are not limited to: • a normal stop button; • an emergency stop; • the PSDI enable.
6.8.10.1 The operator station shall have readily visible indication of: • when PSDI is armed; • the position in the PSDI interruption (break) sequence when more than one interruption is required.	***E6.8.10.1*** One means of accomplishing this is with indicator lights that signal an interruption (break) is required.
6.8.10.2 When a means is provided to select the number of interruptions (breaks) required to initiate a cycle, the selection means shall be capable of supervisory control.	***E6.8.10.2*** Methods of meeting this requirement include, but are not limited to, the use of key operated controls, controls located under lockable covers, or controls that requires a tool or password to access.
6.8.11 If more than one operator is involved in the operation, each shall have their own presence-sensing device and their own controls as required by 6.8.10. The PSDI control logic shall require that each sensing field be interrupted the selected number of times prior to initiating a cycle.	
6.8.12 The user shall document the PSDI system and at a minimum include: • safety distance calculations; • control schematics; • software program (if used); • records of periodic maintenance checks.	
6.8.13 The user shall train all individuals on the operation of the PSDI system within the scope of their work activity.	***E6.8.13*** See 4.2.2 and clause 14.

Standard Requirements	Explanatory Information
6.8.14 Inspection Requirements The user shall establish a procedure for the inspection and testing of the PSDI system, perform periodic testing on a regular base, and document the results.	***E6.8.14*** Examples of criteria and procedures include but are not limited to: • Verifying the safety distance of the presence-sensing device; • Verify that it is not possible for an individual to enter, pass through, and become clear of the presence-sensing device sensing field; • Verify that the presence-sensing device is functioning correctly (e.g., immediate stop the machine cycle); • Verify that all other safeguarding is in place and functioning correctly; • Verify the operation of part-in-place sensors; • Verify the operation of the PSDI control logic functions (e.g., indications, mode selection, PSDI timer, etc.). See clause 13 for more information.

7 Guards: fixed, adjustable, and interlocked

Fixed, adjustable, and interlocked guards shall meet the applicable requirements of clause 6.

7.1 Design and construction

7.1.1 Material used in the construction of guards shall be of such design and strength as to protect individuals from identified hazards.

E7.1.1 The selection of the guard material (transparent or opaque) should take into account both the operational/performance characteristics as well as the applicable environmental factors which may degrade its strength (including but not limited to chemicals, UV, temperature, radiation etc).

7.1.2 Guards shall be free of sharp edges, burrs, slag welds, fasteners, or other hazards that may injure individuals when handling, removing or using the guards or equipment.

7.1.3 Handles placed on guards shall be secured to the guard so as not to create a pinch point between the handles and the guard, frame or machine.

7.1.4 The design and construction of the guard shall ensure that individuals cannot reach the hazard by reaching over, under, around, or through the guard.

E7.1.4 Other guards, safeguarding devices or methods may be used in conjunction with guards to accomplish this requirement. The safeguarding supplier should provide instructions to the user for the proper installation and use of the guard.

Guard openings should conform to Figure D.9 (Annex D). Additional methods might be used as determined by the supporting risk assessment documentation. See also ISO 13857.

Standard Requirements	Explanatory Information
7.1.5 Guards shall be designed and constructed so as to ensure ease of use.	***E7.1.5*** Guards that are burdensome (i.e., overly large, heavy or cumbersome) to personnel may discourage proper use.
7.1.6 The guard shall be designed and constructed to provide visibility of the hazard zone appropriate to the particular operation.	***E7.1.5*** Where visibility of the operation is required, appropriate materials and color for the device should be selected. For example: • the perforated material or wire mesh should provide adequate open viewing area; • the color should be darker than the area observed to enhance visibility.
7.1.7 Transparent guards shall provide the appropriate level of protection as determined by the risk assessment.	Vision (viewing) panels, when used as safeguarding are considered to be transparent guards. The appropriate level of protection can be achieved by the same or equivalent level of protection as the rest of the guarding by: • meeting minimum strength expectations; or • using other techniques (e.g., mirrors or vision based monitors) to provide visibility of the application.
7.1.8 The supplier shall provide a maintenance or replacement schedule or criteria to determine transparent guard replacement in their information for use.	***E7.1.5.1*** Transparent guards may deteriorate over time. The rate of deterioration is influenced by a number of variables, including but not limited to: • use; • mass and velocity of chips / swarf; • exposure to chemicals; • ultraviolet light; • temperature; • material used; • incorrect installation; • age. See Annex E.
7.1.9 Interlocked guards shall be designed and constructed to meet the following additional requirements:	***E7.1.6*** See 7.1.1.
a) Interlock devices used in conjunction with guards shall be specifically designed and constructed for use in safeguarding applications.	a) Some electrical interlock devices increase reliability of operation through the use of positive opening contacts that are forced open by the insertion or removal of the interlock actuator by non-resilient (non-spring) members. There are similar devices available for fluid power interlocking. The use of two interlock devices that are checked by electrical or fluid power circuits for proper operation can also greatly increase the reliability of the interlock function. See also, Annex C.

Standard Requirements	Explanatory Information
	Interlocks should be designed to discourage the capability to easily bypass the interlock with readily available items such as tape, pieces of metal, screws, tools, etc. Some interlock devices use special keys, trapped keys or actuators that make the interlock more difficult to bypass. There are also interlocking devices that physically obstruct or shield the interlock with the guard open, and others that use electrical, mechanical, magnetic, or optical coding.
b) Guard locking devices, when used, shall prevent the guard from being opened and shall prevent access to the hazard until the command has been given to release the guard.	Guard locking devices have various holding (retention) force ratings and should be sized appropriately for the application.
The risk assessment shall determine the need for a means to unlock the guard locking device or otherwise provide a means of egress from inside the safeguarded area.	There are two typical types of guard locking devices: • "Power (energy)-to-release" requires power (energy) during the unlock sequence. A loss of power will prevent these devices from opening, which may require a manual means to unlock the device. • "Power (energy)-to-lock" requires continuous power to lock the guard. These devices allow immediate access if power (energy) is lost. This type is not typically used where the hazard is not immediately eliminated with the loss of power (energy) to the locking device.
c) Interlock blocking devices, when used, shall prevent energizing the safety related circuit by securing or locking in an open position.	c) A mechanical device, capable of either being locked or otherwise secured in a position, used to physically block or hold the actuator of an interlock device to prevent its actuating or engaging the interlock device.
Components used as interlock blocking devices shall not allow the interlock guard to be secured or locked in a closed position.	This reduces the probability of an individual being trapped inside the hazardous area. Interlock blocking devices should not be confused with and are not intended to preclude the use of guard locking and trapped key devices. Interlock blocking devices can be used in conjunction with guard locking and trapped key devices.
7.2 Installation and operation	
7.2.1 Location of the guard with respect to the hazard shall ensure that individuals cannot reach the hazard by reaching over, under, around, or through the guard.	***E7.2.1*** Other guards, devices, or methods may be used in conjunction with guards to accomplish this requirement. Guard openings should conform to Figure D.9 (Annex D). Additional methods might be used as determined by the supporting risk assessment documentation. See also, ISO 13857

Standard Requirements	Explanatory Information
7.2.2 Adjustable guards shall be adjusted to ensure that individuals cannot reach the hazard by reaching over, under, around or through the guard.	***E7.2.2*** The adjustment of guards should be checked and readjusted, if necessary, after each set-up or tooling change.
7.2.3 Components, subassemblies or modules of the interlock and its interface or machine control system shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***E7.2.3*** See also, clause 5 and ANSI B11.0 (B11.TR3).
7.2.4 The interlocked guard(s) shall be prevented from opening until the hazard has ceased, or shall be located so that an individual cannot reach the hazard before cessation of the hazard when the interlocked guard is opened.	***E7.2.4*** Interlocked guards are not intended to be used as a normal stop command. See 7.1.6(b) for guard locking device requirements.
When a guard locking device is used, the means to generate the signal to unlock shall meet the requirements of 7.2.3.	The means to generate an unlock signal include but are not limited to: • zero speed switch; • safe-speed monitor; • signal from safe stop control/drive control; • timers.
	Annex D safety distance information can be used as a guide for placement of an interlocked guard to prevent access to the hazard, but may result in conservative distances. A risk assessment needs to be conducted to ensure that the distances and the interlocking means are suitable for the application. The location of the guard such that the individual cannot reach the hazard can be impacted by the size and design of the guard. Additional safeguarding or guards or other physical structures can minimize the distance between the guard and the hazard. A risk assessment can determine the required distance or if the guard must be locked or otherwise prevented from opening. Safe work procedures and training should incorporate information on any residual risk. See clauses 11 and 14; see also, ANSI B11.0 (B11.TR3).
7.2.5 When a machine is modified or relocated, the guard(s) shall be re-evaluated in accordance with clauses 4 and 5 or reinstalled to protect individuals from recognized hazards.	

Standard Requirements	Explanatory Information
7.2.6 The user shall ensure that guards are installed, maintained, and operated so as to protect against: • unauthorized adjustment or circumvention; • hazards between the guard and the moving machine or tooling parts;	***E7.2.6*** Guards installed in such a manner that tools are necessary for their adjustment or removal may satisfy this requirement. Training and supervision in the adjustment, maintenance, and operation of the safeguarding are necessary to ensure its proper operation. Examples of some types of fasteners that should not be used are: • slotted or Phillips head screws; • wing nuts; • magnets; • latches and hasps; • hooks and eyes. The devices should be checked frequently for proper operation.
• operation such that when the interlocked guard is opened, re-closing the interlocked guard shall not, in or of itself, cause a hazardous situation.	Restarting the equipment should require a deliberate action, such as reactivating the normal actuating control. Interlocks that serve as a safeguarding means are not, by themselves, always able to protect individuals in the area when jogging or cycling the machine during set-up or maintenance operations. Care should be taken to protect such individuals during these operations. A type A / B moveable barrier device(s) is not considered an interlocked guard. See Clause 8.1. Interlock blocking devices are typically used where full body access exists and to provide an additional level of personal control by ensuring that the safety system is not reinitiated or reactivated while individuals are located within the hazard zone. Since an interlocking device is not typically used as an energy isolating device, the application of the interlock blocking device in such cases does not comply with the requirements of lockout/tagout. See ANSI/ASSE Z244.1 on control of hazardous energy for additional guidance. The need for a lockable blocking device should be determined by a risk assessment. When an interlock blocking device is used to protect multiple individuals, each individual should apply their own means of control to the interlock blocking device. The means used (such as a padlock) should require that it can only be removed by the individual who applied it to the interlock blocking device.

Standard Requirements	Explanatory Information
7.2.7 Visibility of the hazard(s) shall be considered when locating the guard.	***E7.2.7*** Where visibility of the operation is required, appropriate materials and color for the device should be selected, for example: • perforated material or wire mesh should provide adequate open area; • color of the material should be darker than the area observed to enhance visibility.
7.2.8 The user shall ensure that guards that are frequently removed or that have movable or hinged sections are interlocked.	
7.2.9 Bypassing of the interlocked guard shall comply with 6.6.	
7.2.10 Muting of the interlocked guard shall comply with 6.7.	

8 Safeguarding devices

Safeguarding devices shall meet the requirements of clause 6.

E8

The scope of, and the devices that are included within, the classification of "Safeguarding Device" as defined by this standard is not as broad as the classification of "Protective Device" as defined by ISO 12100. Some of the devices that are considered "Protective Devices" do not meet the B11 definition of "Safeguarding Device" and are considered "Complementary Equipment" by this standard (see clause 12; see also, Annexes H & I).

8.1 Movable barrier devices

E8.1

Movable barrier devices may be powered open or closed by mechanical, electrical, hydraulic, or pneumatic means, or opened and closed physically by the operator. There are two types of movable barrier devices (type A and type B). The primary difference between the two is when the guard opens.

8.1.1 Design and construction

Standard Requirements	Explanatory Information
8.1.1.1 The type A movable barrier device shall be designed and constructed to enclose the hazard zone prior to the start of the hazardous portion of the machine cycle, and shall be held closed until the machine has ceased motion and is at its initial starting position. The device shall open or be opened at the end of the machine cycle in order to reset the system before initiation of a subsequent machine cycle.	***E8.1.1.1*** This function may be accomplished by a powered movable barrier or a manually operated barrier. In the manual mode, the barrier should be locked by a solenoid operated lock.
8.1.1.2 The type B movable barrier device shall be designed and constructed to enclose the hazard zone prior to the start of the hazardous portion of the machine cycle and shall be held closed until completion of the hazardous portion of the machine cycle. The device shall open at the completion of the hazardous portion and shall reset the system prior to the initiation of a subsequent machine cycle.	
8.1.1.3 The initiation of the machine cycle shall require: • the movable barrier device to be in the closed position; and • that the cycle initiation means be actuated; or • that a continuous operating mode has been selected and initiated.	
8.1.1.4 Movable barrier devices shall be designed to be capable of returning to the open position should the device encounter an obstruction while enclosing the hazard zone.	
8.1.1.5 Components, subassemblies or modules of the device shall meet the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***E8.1.1.5*** See also, clause 5 and ANSI B11.0 (B11.TR3).
8.1.1.6 Movable barrier devices shall not create a hazard in and of themselves.	
8.1.1.7 The movable barrier device shall be designed and constructed to provide visibility of the hazard zone when it is necessary to view the machine operation**.**	***E8.1.1.7*** Where visibility of the operation is required, appropriate materials and color for the device should be selected, for example: • perforated material or wire mesh should provide adequate open area; • color of the material should be darker than the area observed to enhance visibility.
8.1.2 Installation, operation and maintenance	
8.1.2.1 The user shall ensure that the movable barrier device is installed, maintained, adjusted, and operated in accordance with this standard.	***E8.1.2.1*** The user should follow the supplier's recommendations for proper operation of the device. The user should direct individuals to immediately report any apparent malfunction or improper operation of the device to a designated person.

Standard Requirements	Explanatory Information
8.1.2.2 Movable barrier devices shall be installed and operated such that individuals cannot reach the hazard by reaching over, under, around, or through the device when in the closed position.	***E8.1.2.2*** Other guards or devices may be used in conjunction with guards to accomplish this requirement. Device openings should conform to Figure D.9 (Annex D). Additional methods might be used as determined by the supporting risk assessment documentation. See also ISO 13857.
8.1.2.3 Adjustments of the movable barrier device that affect the operational safety of the machine shall only be performed by authorized individuals.	
8.1.2.4 The motion of the movable barrier device shall not, in or of itself, create a hazard while enclosing or exposing the hazard zone.	***E8.1.2.4*** When the device encloses (or exposes) the hazard zone, it should not cause injury if it comes into contact with individuals.
8.1.2.5 Visibility of the hazard(s) shall be considered when locating the movable barrier device.	***E8.1.2.5*** When necessary to view the machine operation through the guard, it should be installed to provide visibility of the hazard.
8.2 Pull Back (pull out) and restraint devices	
8.2.1 Design and construction	
8.2.1.1 The pull back device shall be designed to protect the machine operator by keeping the operator's hands out of the hazard zone during the hazardous portion of the machine cycle.	
8.2.1.2 The restraint device shall protect the operator by holding the operator's hands away from the hazard zone at all times.	
8.2.1.3 The safeguarding supplier shall provide instructions with the pull back or restraint device for its proper installation and operation, and establish guidelines for its proper maintenance.	***E8.2.1.3*** See 4.1.2
8.2.1.4 Pull back and restraint devices shall be provided with hand or wrist attachments for the operator and a means of adjustment to allow for varying locations to the nearest point of operation hazard.	
8.2.1.5 Fasteners, pins, and other components used to secure and maintain the setting of the pull back or restraint device shall be applied in such a manner as to minimize loosening, slipping, or failure during operation.	
8.2.1.6 The pulling or holding members or cables and the hand or wrist attachments of the device shall be of a substantial material that is flexible, non-stretchable, and will resist wear from abrasion.	
8.2.2 Installation, operation and maintenance	

Standard Requirements	Explanatory Information
8.2.2.1 The user shall ensure that the pull back or restraint device is installed, maintained, adjusted, and used in accordance with the requirements of this standard.	***E8.2.2.1*** The user should: • make the supplier's instructions available to set-up personnel and operators; • provide additional instruction relative to the unique application of the device, if necessary; • provide training to ensure that the instructions are understood; • provide continuing supervision to ensure that the instructions are followed.
8.2.2.2 If more than one operator is required for a particular operation on the machine, and if the additional operator is exposed to the recognized hazard, then: • The device shall be designed to protect each operator; or • Each operator shall be provided with a separate device; or • Additional safeguarding shall be provided to ensure that individuals who are not safeguarded by the device and who are exposed to the recognized hazard are protected.	
8.2.2.3 The user shall ensure that the following conditions are met: • The hand attachments, including wristlets, snaps and cables are used in a manner prescribed by the supplier and required by this standard; • Die or tooling set-ups that have bolts, nuts, studs, stops, blow-off tubes, or other objects that protrude from the hazard zone shall be protected such that they will not interfere with the normal pulling action of the hand attachments.	
8.2.2.4 If gloves are used by the operator, the user shall ensure that the gloves are worn over the hand attachments in a manner such that a glove, if trapped in the machine or tooling, will not prevent the pull back device from removing the operator's hand from the hazard zone during the hazardous portion of the machine cycle.	
8.2.2.5 The user shall ensure that each pull back or restraint device is inspected, checked, and adjusted: • according to the user's established procedures at the start of each operator's shift; • following a new die or tooling change or adjustment; and • when the operators are changed.	***E8.2.2.5*** Special consideration should be given to the point of operation opening before and after the work cycle, since the opening may be reduced on some operations. Also, consideration of the relationship between the workpiece and the tooling, including mal-positioning of the workpiece, should be taken into account when making adjustments.
All necessary adjustments, maintenance and repairs shall be made and completed before operating the machine.	

8.3 Electro-optical, RF, and area scanning presence-sensing safeguarding devices

8.3.1 Design and construction

Standard Requirements	Explanatory Information
8.3.1.1 The presence-sensing device shall be designed and constructed to create a field that detects the presence of an individual(s). The presence-sensing device shall not create a hazard in and of itself.	***E8.3.1.1*** The presence-sensing device should be designed and constructed such that it does not present hazards to individuals from: • sharp edge or pinch point hazards; • radiated light or energy hazards; • electromagnetic interference hazards; • electrical shock hazards.
8.3.1.2 The presence-sensing device shall have a minimum object sensitivity such that an obstruction of a same or greater size will always be detected anywhere within its sensing field, regardless of the plane of intrusion. The RF (radio frequency) presence-sensing device shall provide means to adjust the sensitivity of the field. The field, once adjusted, shall not decrease in sensitivity below this established level.	***E8.3.1.2*** The presence-sensing device should have a minimum object sensitivity stated by the supplier. For example, an electro-optical device may detect an opaque object with a diameter of 32 mm (1.25”) anywhere in its sensing field, but allow an obstruction with a diameter of 25 mm (1”) to pass undetected at certain points in the field.
8.3.1.3 The presence-sensing device shall not fail to change its output state, if not bypassed or muted, when it detects the presence of an individual.	
8.3.1.4 Adjustment or configuration of presence-sensing devices shall be capable of being supervised.	***E8.3.1.4*** Methods of meeting this requirement include, but are not limited to, the use of key operated controls, controls located under lockable covers, or controls that require a tool or password to access. Adjustment or configuration should only be performed by authorized individuals. Adjustments or configuration can include, but are not limited to: • muting; • blanking; • power adjustments; • sensing field configuration; • reset functions.
8.3.1.5 The presence-sensing device shall incorporate visual means to indicate that the device is detecting an individual within the effective sensing field of the device.	***E8.3.1.5*** Indicators, (usually red and green), displays or meters should be provided to indicate the status of the presence-sensing device. The visual means may be integral to the presence-sensing device or part of the interface or machine control system. Due to the prevalence of color blindness (10% in males for red/green), methods such as unambiguous positioning, patterning, labeling or flashing of the indicators may be effective in providing the indication required.
8.3.1.6 The presence-sensing device shall have a maximum response time that shall not be affected by object sensitivity or environmental changes. The safeguarding supplier shall provide the maximum response time of the presence-sensing device.	

Standard Requirements	Explanatory Information
8.3.1.7 The electro-optical and area scanner presence-sensing devices shall not be affected by ambient light conditions or by changes in the device light source characteristics, such that an increase in response time or object sensitivity occurs.	***E8.3.1.7*** When the electro-optical and area scanner presence-sensing devices are exposed to signals from other electro-optical presence-sensing devices or to changes in ambient light commonly associated with windows, light fixtures, skylights, bay doors or work area lights, the response time or object sensitivity should not be adversely affected.
8.3.1.8 Components, subassemblies or modules of electro-optical, RF, and area scanning presence-sensing devices shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***E8.3.1.8*** See also, clause 5 and ANSI B11.0 (B11.TR3).
8.3.1.9 The area scanning presence-sensing device shall provide a means or operating mode to verify the size, shape, and detection capabilities of the detection area or zone. Information shall be provided by the area scanning device supplier to identify the: • maximum safeguarding range; • minimum object sensitivity within the stated safeguarding range; • maximum field of view in degrees; • tolerance in the range measurement; and • detection capabilities with respect to the reflectivity of an object versus the distance to the object.	***E8.3.1.9*** These presence-sensing devices typically operate on the principle of "diffuse reflectance," which is a principle of transmitting beam(s) of light to form a detection area or zone. When an object enters the detection area, it reflects the transmitted light back to the device, which then evaluates the object's position. The amount of reflected light (degree of reflectance in percent) that can be reliably detected typically ranges from 1.8% to over 90% and can be represented graphically by reflectivity versus distance. For more information see IEC 61496 parts 1 and 3.
8.3.2 Installation, operation and maintenance **8.3.2.1** Exposure to the hazard(s) shall not be possible by reaching over, under or around the sensing field of the presence-sensing device. Additional guards or safeguarding devices shall be provided to protect those areas.	***E8.3.2.1*** The user should select a presence-sensing device adequate to prevent individuals from reaching over, under or around the sensing field during the hazardous portion of the machine cycle. Additional safeguarding may be required in conjunction with the device to meet this requirement.

Standard Requirements	Explanatory Information
The effective sensing field shall be of adequate height, width, and depth so that entry of the individual into the hazard zone is detected.	If individuals can place themselves between the sensing field and the hazard zone, additional safeguarding should be used in conjunction with the device to prevent the individual from exposure to the hazard. It has been found by practical application that this situation can occur with as little as 75 mm (3”) depending on the positioning (e.g., height) and the minimum object sensitivity of the sensing field, and the ability of the individual to lean against the machine frame or guarding. It should not be possible to climb on or walk on the machine support structure to avoid detection by the presence-sensing device when the sensing field is orientated horizontally. When an individual can pass through the sensing field, it is considered perimeter guarding (see also, the requirements of 6.5 and 8.3.2.4). The electro-optical and area scanning presence-sensing devices may fail to detect an individual’s presence due to reflective workpieces or objects in the vicinity of the device. Care should be used to ensure that these reflections do not render the device ineffective. Some examples of reflective objects include, but are not limited to: • machine surfaces; • tooling; • work pieces; • hand tools; • auxiliary equipment; • workholding tables and fixtures. Testing each set-up for minimum object sensitivity should be done with an appropriate test rod, following the supplier’s recommendation. Where objects are placed within the defined sensing field of an area scanner presence-sensing device, care should be taken to ensure that: • no shadows exist behind the objects such that the device is rendered ineffective; • removal of the object will not allow undetected access to a hazard zone.

Standard Requirements	Explanatory Information
8.3.2.2 The presence-sensing device shall be installed such that it does not create additional hazards.	***E8.3.2.2*** Some installation hazards include, but are not limited to: • pinch point hazards created by interference between the presence-sensing device and moving members of the machine; • tripping hazards; • electrical shock hazards; • overhead or other "strike against" hazards; • thermal hazards. Where such conditions can exist, additional safeguarding may be required.
8.3.2.3 The presence-sensing device shall be installed at a location so that the effective sensing field prevents individuals from reaching the hazard(s) during the hazardous portion of the machine cycle.	***E8.3.2.3*** The safety distance calculation is dependent upon the: • speed of approach of the individual; • total response time of the safeguarding device as stated by the supplier; • response time of the interface; • response time of the control system; • time it takes the machine to stop hazardous motion; and • depth penetration factor of the safeguarding device. See Annex D for further explanation and an example method to calculate the safety distance. Additional methods might be used as determined by the supporting risk assessment documentation. For installations in which the direction of approach is perpendicular to the sensing field (i.e., normal approach), the minimum distance between the sensing field and the closest hazard should be no less than 100mm (4") regardless of the outcome of a safety distance calculation. Practical application has shown that less than 100 mm (4") of safety distance can result in increased risk of harm. See also, ISO 13855. RF presence-sensing devices have sensing fields that can vary due to: • antenna(e) design; • effects of adjacent machinery and equipment; • field sensitivity adjustments; and • environmental factors (such as humidity or temperature). Before the machine is used for production purposes, the RF presence-sensing device should be checked to ensure that the effective field protects individuals at the safety distance.

Standard Requirements	Explanatory Information
8.3.2.4 The presence-sensing device shall protect individuals from hazards by initiating an immediate stop command to the machine control system when the sensing field of the device is interrupted during the hazardous portion of the machine cycle. It shall require re-initiation of the normal actuating means prior to the start or continuation of motion of the machine.	***E8.3.2.4***
When an individual can pass through the sensing field of the presence-sensing device, the device shall initiate an immediate stop command to the machine control system and shall require that the device or machine control be manually reset before hazardous situation can occur.	The operator should ensure that no individual is in the safeguarded area before re-setting the presence-sensing device or machine control and initiating a hazardous situation.
The reset function and devices shall comply with 6.5.	
8.3.2.5 Indication that the sensing field is being blanked shall be provided. For fixed blanking, the blanked area shall be identified. Supplemental safeguarding shall be provided to prevent access to the hazard through the fixed blanked area.	***E8.3.2.5*** The blanking function of an electro-optical presence-sensing device desensitizes a portion of the sensing field by disabling one or more channels such that a specific interruption is ignored. Electro-optical presence- sensing devices can be provided with fixed or floating blanking. Floating blanking allows the blanked area to move within the sensing field. When floating blanking is enabled and the object sensitivity increases, the sensing field must be placed at a greater distance from the hazard, see 8.3.2.2 and Annex D and Figure D.1. For fixed blanking, the desensitized area does not move or change once configured. Means to identify the desensitized area may include but are not limited to: • indicators within the electro-optical presence-sensing device; • signage or marking of the fixed blanked area; • the physical location of the object in the blanked area if movement or removal of the object can be detected and results in a stop command. Means of supplemental safeguarding can include: • completely filling the fixed blanked area to restrict access to the hazard; • the electro-optical presence-sensing device installed at a distance that accounts for the worst case object sensitivity; (see 8.3.2.2) or • alternate safeguarding may be provided to prevent access to the hazard.

Standard Requirements	Explanatory Information
8.3.2.6 Components, subassemblies or modules of the interface or machine control system shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***E8.3.2.6*** See also, clause 5 and ANSI B11.0 (B11.TR3).
8.3.2.7 Bypassing of the presence-sensing device shall comply with 6.6.	
8.3.2.8 Muting of the presence-sensing device shall comply with 6.7**.**	
8.3.2.9 The RF presence-sensing device shall not be adversely affected by changes around the machine that may alter the sensitivity of the device such that individuals are no longer detected in the sensing field at the proper safety distance.	***E8.3.2.9*** The RF presence-sensing device may be affected by changes in the conditions around the machine such as ambient conditions, the placement of parts and tote boxes, grounding conditions of the operator, or the movement of industrial trucks. These changes should not adversely affect the performance of the device.
8.3.2.10 The total tolerance in the range measurement of an area scanning presence-sensing device shall be included in determining the distance from the nearest recognized hazard to the detection area or zone. This detection area shall be identified and tested to ensure that the device is able to detect individuals entering the detection area. The effective sensing field shall be verified for proper size and coverage upon installation, replacement, or changes of the detection area.	***E8.3.2.10*** When the area scanning presence-sensing device is horizontally mounted, the detection area or zone should be visibly marked on the floor. This verification can be accomplished by using a programming device or by physically identifying the perimeter of the detection area with an appropriate test rod, following the supplier's recommendation. This verification is to ensure that a pre-programmed area scanning presence-sensing device with a small or improper detection area is not used by mistake in an installation requiring a larger field. Area scanning presence-sensing device may not be suitable (effective) safeguards when used to protect an individual's hands or fingers from hazards. Items which can affect this suitability are: • response time; • minimum object sensitivity; • measurement accuracy.
8.4 Two-hand operating lever, trip and control devices This subclause (8.4) only applies when these devices are being used for safeguarding.	***E8.4*** For situations in which this clause does not apply, see NFPA 79 or IEC 60204-1 for minimum requirements for two-hand control.
8.4.1 Design and construction **8.4.1.1** Each two-hand device shall be designed and constructed to protect each hand control against unintended or inadvertent operation.	***E.8.4.1.1*** Protecting the hand controls against unintended or inadvertent operation is usually accomplished by the use of ring or palm guards or other fabricated shields.

Standard Requirements	Explanatory Information
8.4.1.2 The two-hand device shall have the individual hand controls arranged by design, construction, or separation to require the use of both hands for actuation.	***E.8.4.1.2*** The design or installation of the operator control should be such that the operator cannot operate the two controls by the use of one hand and an elbow (or other portion) of the same arm. For two-hand trip and control devices, one means to meet this requirement is to separate the hand controls (control actuating devices) by a distance equal to or greater than 550 mm (21 inches) in a single linear dimension. See also, ISO 13851 Annex A for other examples. See ANSI B11.TR1 Annex E for recommendations concerning possible ergonomic issues with hand controls.
8.4.1.3 Two-hand operating levers shall be designed and constructed to require concurrent operation of both operating levers to initiate the machine cycle. If more than one pair of levers is to be provided, each pair shall be interlocked such that the concurrent operation of all levers is required to cycle the machine. The two-hand trip and control devices shall be designed and constructed to require synchronous use of both hands (within 500 milliseconds) to initiate the machine cycle.	***E8.4.1.3*** Due to the mechanical design of two-hand operating levers, there is no timing requirement for actuation (i.e., no synchronous actuation).
The two-hand control device shall require the concurrent actuation of the operator's hand controls during the hazardous portion of the machine cycle such that the operator cannot reach the hazard before the hazardous motion has ceased. Release of either hand control during the hazardous portion of the machine cycle shall initiate an immediate stop command.	See 8.4.2.2 for safety distance requirements.
8.4.1.4 The two-hand device shall be designed and constructed to require the release of all hand operator controls and the re-actuation of all actuating controls before a machine cycle can be reinitiated.	
8.4.1.5 When used in single cycle mode, the two-hand device function shall incorporate an antirepeat feature.	***E.8.4.1.5*** For two-hand trip devices, characteristics of the total system of the two-hand trip and the drive or clutch mechanism may be combined to achieve antirepeat; that is, while the single-cycle limiting requirement may be achieved by the single-cycle mechanism in the clutch, the two-hand trip should have a feature that requires release of all operating mechanisms (e.g., buttons, valves, or levers) before another cycle or stroke can be initiated.
8.4.1.6 When the two-hand device (operator station) is selectable, means shall be provided to indicate to the operator that the two-hand device is selected or de-selected.	***E.8.4.1.6***

Standard Requirements	Explanatory Information
The selection of the hand control device (operator station) shall be capable of being supervised.	Methods of meeting this requirement include, but are not limited to, the use of key operated controls, controls located under lockable covers, or controls that requires a tool or password to access. Adjustment or configuration should only be performed by authorized individuals. A key selector switch is sometimes used to supervise the use of each operator control station.
The control system or mechanism shall be designed and constructed so as to prevent cycling of the machine if all operator stations are deselected.	
8.4.1.7 Components, subassemblies or modules of two-hand devices shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***E.8.4.1.7*** Clause 6.1 does not apply to purely mechanical two-hand operating lever devices, but does apply to electrical and fluid power aspects of these devices if used in combination. See also, clause 5 and ANSI B11.0 (B11.TR3).
8.4.2 Installation, operation and maintenance **8.4.2.1** It shall be the responsibility of the user to ensure that the two-hand operating lever, trip, or control device is installed, operated, and maintained in accordance with this standard.	
8.4.2.2 The operator's hand controls of the two-hand device shall be located and maintained at a distance from the nearest hazard such that the operator cannot reach the hazard before cessation of hazardous motion, in accordance with 6.2.	***E8.4.2.2*** See Annex D for further explanation and an example method to calculate the safety distance. Additional methods might be used as determined by the supporting risk assessment documentation. Methods to ensure the safety distance is maintained may include but are not limited to: • physical barriers or rings; • ensuring cabling does not allow or cause location closer than the safety distance; or • permanent mounting of the device. See ISO 13851 for additional methods.
8.4.2.3 If more than one operator is to be safeguarded by the use of two-hand trip or control devices, each operator shall have individual hand controls. Additionally, all individual hand operator controls (operator stations) shall be concurrently operated before initiating a machine cycle. The selection of the two-hand operator control station shall be capable of being supervised. Additionally, each selected two-hand operator control station shall be concurrently operated and shall require the release of all selected hand controls and the reactivation of all selected hand controls before a machine cycle can be re-initiated.	***E.8.4.2.3*** A common cause of injury when using a two-hand device is the improper practice of relying on a single device for safeguarding two or more operators or other individuals. Three situations that result in unprotected individuals are: • one individual actuating the device when the others are “clear;” or • two individuals each actuating one button on a single device; or • one individual actuating the device when not in full visual control of a hazard zone.

Standard Requirements	Explanatory Information
Means shall be provided to indicate to each operator that the hand control is selected or de-selected.	Methods of meeting this requirement include, but are not limited to: • the use of key operated controls; • controls located under lockable covers; or • controls that requires a tool or password to access.
If de-selecting the two-hand operator control station results in a hazard or hazardous situation, alternate protective measures shall be used. For two-hand operating levers, in situations with multiple operators, additional safeguarding shall be provided.	Adjustment or configuration should only be performed by authorized individuals.
8.4.2.4 Bypassing of the two-hand device shall comply with 6.6.	
8.4.2.5 Muting of the two-hand device shall comply with 6.7.	
8.4.2.6 Hand controls shall be inspected and tested regularly to verify proper operation.	***E8.4.2.6*** Spring wear or breakage, severe contamination, or other environmental influences (e.g., EMI/RFI with some electronic buttons) can result in a slow, sticky, or stuck actuator that increases the stopping time or could cause a false ON condition resulting in an operator's hand(s) being free during the cycle. See clause 13.
8.4.2.7 Components, subassemblies or modules of the interface or machine control system shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***E.8.4.2.7*** See also, clause 5 and ANSI B11.0 (B11.TR3).
8.5 Safety mat devices **8.5.1 Design and Construction** Safety mat devices, including multiple mats combined to form one sensing surface, shall be designed and constructed to detect the presence of individuals on its sensing surface.	***E8.5.1*** A safety mat device should have a minimum object sensitivity which detects a 30 kg (66 lbs) weight on an 80 mm (3 1/8") disc anywhere on the mat sensing surface, including the area where mats are joined to form a single sensing surface. In some industrial settings, values other than those suggested above may be used when justified.
The safety mat device shall not fail to change its output state, if not bypassed or muted, when it detects the presence of an individual.	
8.5.1.1 The safety mat device shall not create a hazard in and of itself.	***E8.5.1.1*** The safety mat device should be designed and constructed such that it does not present hazards to individuals from: • sharp edges; • slipping or tripping hazards; • electromagnetic interference hazards; • electrical shock hazards.

Standard Requirements	Explanatory Information
8.5.1.2 The safety mat device shall incorporate visual means to indicate that the device is detecting the presence of an individual on the sensing surface of the mat.	***E8.5.1.2*** Indicator lamps, usually red and green, should be provided to indicate that the safety mat device is functioning. If a bypass is provided, an amber light or other means should be used to indicate that the safety mat device is bypassed. The lights may be integral to the safety mat device, or part of the interface or machine control system. Due to the prevalence of color blindness (10% in males for red/green), methods such as unambiguous positioning, patterning, labeling or flashing of the indicators may be effective in providing the indication required.
8.5.1.3 The safety mat device shall have a maximum response time that shall not be affected by object sensitivity adjustments or environmental changes.	***E8.5.1.3*** The safeguarding supplier should state the maximum total response time, including output devices, of the safety mat device.
8.5.1.4 Components, subassemblies or modules of the device shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***E8.5.1.4*** See also, clause 5 and ANSI B11.0 (B11.TR3).
8.5.2 Installation, operation and maintenance **8.5.2.1** Adjustment or configuration of safety mat devices shall be capable of being supervised.	***E8.5.2.1*** Methods of meeting this requirement include, but are not limited to, the use of key operated controls, controls located under lockable covers, or controls that require a tool or password to access. Adjustment or configuration should only be performed by authorized individuals. Adjustment or configuration can include, but is not limited to: • muting; • mat configuration; • reset functions; • sensitivity adjustments.
8.5.2.2 Exposure to the hazard(s) shall not be possible by reaching over, under or around the sensing surface of the device. Additional guards or safeguarding devices shall be provided to protect those areas.	***E8.5.2.2*** The user should select a safety mat device that is adequate to prevent individuals from reaching over, under or around the sensing surface during the hazardous portion of the machine cycle. Additional safeguarding may be required in conjunction with the device to accomplish this requirement. It should not be possible to climb on or walk on the machine support structure to avoid stepping on the safety mat.

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The effective sensing surface shall be of adequate width and length so that an individual's entry into the hazard zone is detected.	If individuals can place themselves between the sensing surface and the hazard zone, additional safeguarding should be used in conjunction with the device to prevent the individual from exposure to a hazard. When an individual can cross over the mat surface, see 8.5.2.4.
The safety mat device installation shall not create a hazard in and of itself.	Some installation hazards include, but are not limited to: • sharp edges; • slipping or tripping hazards; • electromagnetic interference hazards; • electrical shock hazards.
8.5.2.3 The safety mat device shall be fixed at a location so that the effective sensing surface prevents individuals from reaching the hazard(s) during the hazardous portion of the machine cycle.	***E8.5.2.3*** The safety distance calculation is dependent upon the: • speed of approach of the individual; • total response time of the safeguarding device as stated by the supplier; • response time of the interface; • response time of the control system; • time it takes the machine to stop hazardous motion; and • depth penetration factor of the safeguarding device. See Annex D for further explanation and an example method to calculate the safety distance. Additional methods might be used as determined by the supporting risk assessment documentation.
The user shall ensure that only authorized individuals may relocate the safety mat.	Means to prevent inadvertent movement include, but are not limited to: • secured edging; • secured trim; • fasteners; • recesses; • size and weight of large mats.
8.5.2.4 The safety mat device shall protect individuals from hazards by initiating an immediate stop command to the machine control system when an individual is detected on the sensing surface of the device during the hazardous portion of the machine cycle, and shall require re-initiation of the normal actuating means prior to the start or continuation of machine motion.	***E8.5.2.4***
When an individual can cross over the sensing surface of the safety mat device, it shall initiate an immediate stopping command to the machine control system and shall require that the safety mat device or machine control be manually reset before hazardous motion can occur.	The operator should ensure that no individual is in the safeguarded area before resetting the device or machine control, and initiating hazardous motion.
The reset function and devices shall comply with 6.5.	

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8.5.2.5 Components, subassemblies or modules of the interface or machine control system shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***E8.5.2.5*** See also, clause 5 and ANSI B11.0 (B11.TR3).
8.5.2.6 Bypassing of the safety mat device shall comply with 6.6.	
8.5.2.7 Muting of the safety mat device shall comply with 6.7.	
8.5.2.8 Where safety mats are joined in combination and sensing strips are used at the joints, care shall be taken to ensure that foreign materials that could prevent actuation are not under the strips.	
8.5.2.9 A safety mat device shall not be used to allow or enable the initiation or continuation of hazardous machine motion by indicating that an individual is in a safe position relative to a hazard.	***E8.5.2.9*** The safety mat device is designed to detect intrusion and to affect a safe shutdown. There are three primary reasons why it is not to be used as an enable signal: • placement of a weighted object on the safety mat bypasses the intended safety function; • the failure of the safety mat controllers could result in a false enable signal; • only one individual standing on the mat can enable hazardous motion. Other individuals may be exposed to the hazard.
8.6 Safety edge devices **8.6.1 Design and construction** Safety edge devices shall be designed and constructed to detect the presence of individual(s) through the application of a pressure or force by the individual(s) along its sensing surface.	***E8.6.1*** The sensing surface is that part of the safety edge device defined by the sensing angle and sensing length.
The pressure or force necessary to actuate the safety edge device shall not create a hazard in and of itself.	The safety edge device should be designed and constructed such that it does not present hazards to individuals from: • sharp edges; • slipping or tripping hazards; • electromagnetic interference hazards; • electrical shock hazards.
8.6.1.1 The safety edge device shall have a minimum sensitivity such that an individual shall be detected anywhere along its sensing surface.	***E8.6.1.1*** Typically, these devices respond to a manual force in the range of 0.5 to 7 kg (1 to 15 lbs) that is applied to the safety edge. In some industrial settings, values other than those suggested above may be used when justified. The supplier should state the amount of force over a given area (pressure) necessary to actuate the device, and the effects of environmental conditions such as temperature.

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The safety edge device shall not fail to change its output state, if not bypassed or muted, when it detects the presence of an individual.	
8.6.1.2 The safety edge device shall incorporate visual means to indicate that the device is detecting the actuation of its sensing surface.	***E8.6.1.2*** Indicator lamps, usually red and green, should be provided to indicate that the device is functioning. If a bypass is provided, an amber light or other means should be used to indicate that the device is bypassed. The lights may be integral to the safety edge device or part of the interface or machine control system. Due to the prevalence of color blindness (10% in males for red/green), methods such as unambiguous positioning, patterning, labeling or flashing of the indicators may be effective in providing the indication required.
8.6.1.3 The safety edge device shall have a maximum response time that shall not be affected by sensitivity adjustments or environmental changes. The safeguarding supplier shall provide the maximum response time of the safety edge device.	
8.6.1.4 Components, subassemblies or modules of the device shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***8.6.1.4*** See also, clause 5 and ANSI B11.0 (B11.TR3).
8.6.2 Installation, operation and maintenance **8.6.2.1** Adjustment or configuration of safety edge devices shall be capable of being supervised.	***E8.6.2.1*** Methods of meeting this requirement include, but are not limited to, the use of key operated controls, controls located under lockable covers, or controls that require a tool or password to access. Adjustment or configuration should only be performed by authorized individuals. Adjustment or configuration can include, but is not limited to: • muting; • edge configuration; • reset functions; • sensitivity adjustments.
8.6.2.2 The effective sensing surface shall be adequate so that exposure of the individual to the hazard is detected. Additional guards or safeguarding devices shall be provided to prevent exposure to a hazard(s) by reaching over, under or around the sensing surface of the device.	***E8.6.2.2*** If individuals can place themselves between the sensing surface and the hazard zone, additional safeguarding should be used in conjunction with the device to prevent the individual from exposure to a hazard.

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8.6.2.3 The safety edge device in and of itself, shall not create a hazard(s).	***E8.6.2.3*** Some installation hazards include but are not limited to: • pinch point hazards created by interference between the device and members of the machine; • electrical shock hazards. The sensing surface should be inspected frequently. In the event of damage to the sensing surface, the device should not be used until it has been repaired or replaced. See clause 13.
When a safety edge device is used with a moving member and a fixed or another moving member, the following shall apply: • The maximum stopping distance(s) of the moving member(s) shall be determined; • The safety edge device shall have a collapse dimension which exceeds the maximum stopping distance(s) of the moving member(s).	The stopping distance will in part be determined by the safety edge device and controller response time. Under these conditions the safety edge device will prevent the crushing hazard and leave sufficient space between the stopped member(s) to prevent entrapment after the stop is accomplished.
8.6.2.4 The sensing surface of the safety edge device shall be securely mounted on a fixed or moving object to detect the presence of an individual and initiate a stop command. The user shall ensure that only authorized individuals may relocate the sensing surface.	***E8.6.2.4*** This safety edge device should not be applied to situations where momentum or force of the moving object cannot be stopped before injury to the individual can occur. The moveable machine component may be controlled by the machine control system as part of its normal machine cycle, or by an independent control system.
8.6.2.5 The safety edge device shall protect individuals from hazards by initiating a stop command when an individual is detected by the sensing surface of the device during hazardous motion, and shall require a reset function and re-initiation of the normal actuating means prior to the start or continuation of hazardous motion. The reset function and devices shall comply with 6.5.	
8.6.2.6 Bypassing of the safety edge devices shall comply with 6.6.	
8.6.2.7 Muting of the safety edge devices shall comply with 6.7.	

8.7 Probe detection devices

8.7.1 Design and construction

8.7.1.1 The probe detection device shall be designed and constructed to prevent initiation of (or stop) the machine cycle if an individual's hand or finger(s) is in the hazard zone.

8.7.1.2 The probe detection device shall not create a hazard in and of itself.

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8.7.1.3 Components, subassemblies or modules of the control, its interface or the machine control system shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***E8.7.1.3*** See also, clause 5 and ANSI B11.0 (B11.TR3).
8.7.2 Installation, operation and maintenance The probe detection device shall be installed, maintained, used and adjusted by authorized individuals.	
8.8 Single control safeguarding devices	
8.8.1 Design and construction	
8.8.1.1 Actuating controls used for single control safeguarding devices shall be properly positioned by one of the following methods:	***E8.8.1.1*** The actuating controls may be, but are not limited to: • one-hand control; • foot control. Actuating controls that are easily moved closer than the safe distance, or not securely fixed at the safe distance cannot meet this safeguarding requirement. A single control safeguarding device protects only the individual operating the actuating control.
• Actuating controls that require continuous actuation to complete the hazardous portion of the machine cycle shall be located at a safe distance, in accordance with 6.2; • Actuating controls that are tripped for single-cycle machine operation shall be located at a safe distance, in accordance with 6.2. The single control trip, when operated in single cycle mode, shall include an anti-repeat feature.	Characteristics of the total system of the single control trip and the drive or clutch mechanism may be combined to achieve anti-repeat; that is, while the single-cycle limiting requirement may be achieved by the single-cycle mechanism in the clutch, the single control trip should have a feature that requires release of all operating mechanisms (e.g., buttons, valves, or levers) before another stroke can be initiated.
8.8.1.2 Components, subassemblies or modules of the control, its interface or the machine control system shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***E8.8.1.2*** See also, clause 5 and ANSI B11.0 (B11.TR3).
8.8.1.3 The single control device shall be designed and constructed to protect the control against unintended or inadvertent actuation.	***E8.8.1.3*** Protecting the single control against unintended or inadvertent operation is usually accomplished by the use of ring or palm guards, or other fabricated shields.
8.8.2 Installation, operation and maintenance The single control safeguarding device shall be located, installed, used and maintained in accordance with this standard.	

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8.8.2.1 It shall be the responsibility of the user to ensure that the single control safeguarding device is installed, operated, and maintained in accordance with this standard.	***E8.8.2.1*** The safety distance calculation is dependent upon the: • speed of approach of the individual; • total response time of the safeguarding device as stated by the supplier; • response time of the interface; • response time of the control system; • time it takes the machine to stop hazardous motion; and • safeguarding device's depth penetration factor.
8.8.2.2 The single control safeguarding device shall be located at a distance from the nearest hazard such that the operator cannot reach the hazard before cessation of hazardous motion, in accordance with 6.2.	***E8.8.2.2*** See Annex D for further explanation and an example method to calculate the safety distance. Additional methods might be used as determined by the supporting risk assessment documentation.
8.8.2.3 The single control safeguarding device shall require continuous actuation during the hazardous portion of the machine cycle, such that the operator cannot reach the hazard before the hazardous motion has ceased.	
8.8.2.4 If more than one operator is to be safeguarded by the use of a single control safeguarding device, each operator shall have an individual single control safeguarding device. The selection of the single control safeguarding device shall be capable of being supervised. Additionally, each selected single control safeguarding device shall be concurrently operated and shall require the release of all selected individual single control safeguarding devices and the reactivation of all selected operator's single control safeguarding devices before a machine cycle can be initiated. Means shall be provided to indicate to each operator that the single control safeguarding device is selected or de-selected.	***E8.8.2.4*** Methods of meeting this requirement include, but are not limited to, the use of key operated controls, controls located under lockable covers, or controls that requires a tool or password to access. Adjustment or configuration should only be performed by authorized individuals.
8.8.2.5 Components, subassemblies or modules of the interface or machine control system shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***E8.8.2.5*** See also, clause 5 and ANSI B11.0 (B11.TR3).
8.8.2.6 Bypassing of the single control device shall comply with 6.6.	
8.8.2.7 Muting of the single control device shall comply with 6.7.	

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8.9 Close proximity point of operation AOPD (press brake AOPD)	***E8.9***
For information on application-specific Active Opto-Electronic Protective Devices (AOPDs) for press brakes, see ANSI B11.3.	These AOPDs are commonly referred to as “Laser actuated AOPDs” and are described by EN 12622 and CSA Z142. At the time of the release of this standard, other technologies used as the means of detection are available. This style of AOPD, which may go by other names, is only applicable to power press brakes meeting particular criteria.
9 Awareness barriers, signals and signs	
9.1 Awareness barriers	
9.1.1 Design, construction, installation & operation	***E9.1.1***
Awareness barriers shall be designed, constructed, and installed such that an individual cannot reach into the hazard zone without a conscious effort and/or contact with the barrier. The awareness barrier shall not create a hazard in and of itself.	An awareness barrier may move or be adjusted to allow entry of work pieces of varying sizes, but prevents the operator from reaching the hazard without the operator's awareness. In addition, it provides visual boundaries to the operator's movements and indicates the hazard zone. Operators should be made aware of the nature of the hazards and the significance of the awareness barrier by instructions, training, or the use of signs in the vicinity of the hazard zone. See clause 14. Since the operator may not be aware of a failure of the awareness barrier, it should be inspected regularly. See clause 13.
9.2 Awareness signals	
9.2.1 Design, construction, installation & operation	***E9.2.1***
Awareness signals shall be designed, constructed, and installed to provide a recognizable audible or visual signal of an approaching or present hazard.	Indicator lamps, usually red and green, should be provided to indicate that the device is functioning. Due to the prevalence of color blindness (10% in males for red/green), methods such as unambiguous positioning, patterning, labeling or flashing of the indicators may be effective in providing the indication required. Individuals should be made aware of the nature of the hazards and the significance of the signals by instructions, training, and the use of signs in the vicinity of the hazard zone. See also, clause 14.

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	Audible awareness signals should not be used in conjunction with paging systems or for start and stop work signals. They should have a distinctive sound and intensity such that they will be distinguished from the highest ambient noise level in the hazard zone. They should be inspected and tested regularly, since individuals may not be aware of the failure of the signal. See clause 13. Sufficient awareness signals should be provided so individuals can be made aware of potential or existing hazards for those that may be exposed to the hazards. This is intended to ensure that blind spots are accounted for.
9.3 Awareness (safety) signs Awareness signs that are used shall meet the requirements of ANSI Z535.1, Z535.3, Z535.4 and Z535.5.	***E9.3*** Operators should be made aware of the nature of the hazards and the significance of the awareness signs through instructions and training. See clause 14.
10 Safeguarding methods These include safe-distance safeguarding, safe-holding safeguarding, safe-opening safeguarding, and safe-location safeguarding. Proper training and supervision are essential to the use of methods used to safeguard individuals. Care shall be taken to ensure that individuals are aware of the proper use.	***E10*** Safeguarding other individuals should be considered and their protection may require additional or supplemental safeguarding. See 4.2 and 4.3 for user and personnel responsibilities.
10.1 Safe-distance safeguarding method Safe-distance safeguarding shall meet the following requirements: a) A safety program which includes work procedures, training and re-training, and supervision to ensure the proper use of this method shall be established; b) When material position gages are used, they shall be of sufficient height and size or shape to prevent slipping of the material past the gages. Positioning of the gage shall be such that the operator cannot inadvertently place any part of the body closer than the safe distance;	***E10.1*** It should be noted that the requirements for ANSI B15.1 “Safe Distance” have been incorporated into clause 10.4 Safe Location Safeguarding. Operators should be made aware of the nature of the hazards and the significance of safe-distance safeguarding through the use of instructions, training, and the use of signs in the vicinity of the hazard zone. See also, clause 14.

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c) The safe distance for each job set-up shall be determined and visually identified at the machine.	c) Identification can include awareness barriers, signals and signs or machine frame or footprint Methods of maintaining a safe distance include but are not limited to: • operator using both hands on the workpiece but no closer than the safe distance; • operator using a single hand and additional means are provided to protect the free hand; • awareness barriers, signals and signs indicating the safe distance (e.g., a yellow line painted on floor to separate vehicular and pedestrian traffic). If a workpiece is not involved, some other means such as safe work procedures should be used meet this requirement.
10.2 Safe-holding safeguarding method Safe-holding safeguarding shall meet the requirement below.	***E10.2*** Safe-holding safeguarding may also be known as "safe workpiece" safeguarding. Safe-holding safeguarding protects only the operator. Operators should be made aware of the nature of the hazards and the significance of the safe-holding safeguarding by instructions, training, and the use of signs in the vicinity of the hazard zone. See also, clause 14. The use of one or more parts sensors may enhance the effectiveness of this method. Care should be taken when applying sensors so that they meet the requirements of clause 6.
The operator's hands shall be located away from the recognized hazard during the hazardous portion of the machine cycle by one of the following methods:	For purposes of this subclause, the workpiece may include machine components being installed, adjusted or removed.
a) Require that both hands are used to hold or support the workpiece; or	a) A workpiece may be one that is too large, heavy, or unwieldy so that both hands are required to support it at all times during which the workpiece is in the hazard zone and while the operation is being performed.
b) Require that one hand holds or supports the workpiece, while the other hand operates the machine.	b) A workpiece may be small or light enough that it may be held or supported by one hand, while the other hand is used to cycle the machine.
10.3 Safe-opening safeguarding method When the workpiece is considered part of the safeguarding, any opening(s) shall prevent individuals from reaching the recognized hazard. Safe–opening safeguarding, when used, shall conform to the following requirements:	***E10.3***

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a) When the workpiece is in place, the remaining opening in the safeguarding shall be small enough to prevent any part of the operator's body from entering the hazard zone;	a) For guidelines on permissible openings with the part in place, which should conform to Figure D.9 (Annex D). Additional methods might be used as determined by the supporting risk assessment documentation. See also ISO 13857.
b) When absence of the workpiece provides access to the hazard, a means shall be provided to prevent the machine from cycling when the workpiece is not in place. These means shall be in conformance with 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	b) Caution should be taken so that the means to prevent cycling cannot be easily defeated by the operator(s).
	Operators should be made aware of the nature of the hazards and the significance of safe-opening safeguarding by instructions, training, and the use of signs in the vicinity of the hazard zone. See also clause 14.
10.4 Safe-location safeguarding method Safe-location safeguarding shall meet the following requirements:	***E10.4*** For the purposes of ANSI B11.19, safe-location safeguarding incorporates the requirements of the prior ANSI B15.1 clause 3 “Safe Distance” and “Safe Location.” See ANSI B11.0 for additional information and guidance on safeguarding Mechanical Power Transmission Apparatus. Note: The requirements of ANSI B15.1 have now been incorporated into ANSI B11.0 and ANSI B11.19.
	Individuals should be made aware of the nature and location of the hazards through the use of awareness device(s) in the vicinity of the hazard.
a) Inadvertent access from a walking or working surface to the hazard shall be prevented by: • vertical distance of sufficient height; • horizontal distance; or • the combination of vertical & horizontal distance.	The mechanical power transmission apparatus should be located at least the distance from personnel as that described in Figure D.10 (Annex D).
or:	
b) Access to the recognized hazard shall be limited by locating the hazard: • in a room, vault, or similar enclosure; • behind permanent, substantial partitions fencing/railing or screens that comply with appropriate requirements clause 7;	Access to mechanical power transmission apparatus in a vault, room, or closet, or in an area surrounded by a wall, screen or fence that is controlled by lock and key or other approved means is considered to be restricted access. A wall, screen, or fence less than the distances described in Figure D.10 is not considered adequate to prevent access unless other protective measures are provided.
• on an elevated platform where persons cannot come into accidental contact with the hazardous moving parts.	Access to these locations is restricted to trained personnel who are aware of the hazards. These areas are not workstations.

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10.5 Other safeguarding methods When other safeguarding methods appropriate for the task are used, the user shall assess the experience and ability of personnel, and implement the appropriate training and safe work procedures. The user shall ensure the initial and continued competency of personnel to utilize other safeguarding methods.	***E10.5*** Operators should be made aware of the nature of the hazards and the significance of the safeguarding method by instructions, training, and the use of signs in the vicinity of the hazard zone. See also, clause 14.
11 Safe work procedures The user shall review the guards, safeguarding devices or methods, and the training used to determine if safe work procedures are required. Where required, the user shall develop the procedure(s) and ensure its (their) use.	***E11*** Factors to consider in determining whether safe work procedures are required may include, but are not limited to, the following: • where tasks are complex; • where tasks have high risk; • where training, skill or work experience is limited; • where other safeguarding is removed or bypassed; • where required to augment other safeguarding. When determined to be necessary, safe work procedures should be developed and used to ensure that a safe work practice is implemented for the task(s) performed. Where practical, it is recommended that the user consult with the machine or safeguard supplier(s) to identify the tasks and associated hazards. Safeguarding procedures should be written by the user, with the assistance and recommendation of those suppliers. When developing the safe work procedure, the user should consider the supplier's performance specifications, schematics, diagrams, installation, operating and maintenance instructions, and warnings. See also, clause 14.

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12 Complementary equipment and measures	***E12***
The requirements of this section shall apply to the design, construction, and operation of complementary equipment and measures used in conjunction with safeguarding described in clauses 7 through 11.	Complementary equipment and measures are used to augment the selected safeguarding.
12.1 Safety blocks, chain locks, locking pins, limiting/blocking pins	
12.1.1 Design and construction	***E12.1.1***
Safety blocks, locking pins, limiting/blocking pins or other mechanisms that restrict hazardous motion shall be designed, constructed and installed, to either:	Caution should be exercised when designing mechanisms so they will not create a hazard to individuals due to broken or damaged machine components. The locking pin may be designed to prevent motion resulting only from gravity or prevent motion from the additional force of the drive system.
a) hold the full working force of the machine and tooling members when machine actuation can take place while the mechanism is in place; or	
b) be interlocked with the machine to prevent actuation of hazardous motion of the machine when removed from its storage position and be designed and constructed to hold the maximum anticipated load.	b) The maximum anticipated load is normally the static weight of moving parts of the machine tooling and all attachments that apply downward force due to gravity, and also includes reasonably foreseeable dynamic forces such as settling inertia. Where practical, handles should be provided on manually installed mechanisms, such as safety blocks, to assist in their installation and removal. The mechanisms should be colored in such a manner that they are highly visible. The locking pin may be designed to prevent motion resulting only from gravity or prevent motion from the additional force of the drive system.
12.1.1.1 Materials	***E12.1.1.1***
Materials used in the construction of the mechanisms shall not fail under rated load. The safety factor of these devices shall be a minimum of 2, based on the maximum anticipated load.	Safety factors commonly range from 1.5 to 6 and greater, which may be required depending on rated load, machine actuator, static or dynamic situations, design and construction of the locking/blocking mechanisms, or the probability of misuse / misapplication. Safety factors should be based on the material used and should take into account inconsistencies from the manufacturing process (e.g., voids, process variance, wall thickness variation, imperfections, etc.)

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12.1.1.2 Visual means Visual means shall be provided to indicate that the locking mechanism is fully engaged or disengaged.	***E12.1.1.2*** Indicator lights or other visual means may be used to meet this requirement, including but not limited to: • mechanical indicator; • reliable electrical indication e.g., LED based indicator, HMI, etc; • combination electrical and mechanical indication; • vision / camera systems; • visual observation from the operator station. In some applications, two independent indications verifying engagement of the mechanism may be required to provide reliable indication of the status of the mechanism to the operator.
12.1.1.3 Electrical and fluid power requirements When complying with 12.1.1 (b), the electrical interlocking shall be designed such that upon removal of the locking mechanism pin from its storage position, the following conditions are satisfied: • on clutch-brake driven machines, the clutch is disengaged, the brake is engaged and the main drive motor is de-energized; or • on direct drive machines, the drive motor is de-energized and when used, the brake is engaged; or • on hydraulic or pneumatic machines, the circuits (electrical or fluid power) which can cause closing motion are de-energized.	***E12.1.1.3*** It should not be possible to place the blocking/limiting mechanism into any part of the machine without disconnecting the interlock.
The means of interlocking shall be designed to enable users to personally secure the system in the engaged state.	Typically a means of achieving this would be a lockable device.
Electrical and fluid power components used in monitoring the locking mechanism or pin location and controlling motion shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	
12.1.2 Installation and maintenance The mechanism shall be installed in the machine such that it will not be expelled or create a hazard when supporting the machine, its members, or other attachments.	***E12.1.2*** When safety blocks are used, tapered wedges of hardwood or other substantial material should be used to completely fill any remaining space between the block and the machine members to be held.
The interlocking system of the mechanism shall be located a sufficient distance from the area of use such that the mechanism cannot be placed into service without removing power that can cause hazardous motion.	

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12.1.3 Inspection Requirements The supplier of mechanisms that restrict hazardous motion shall establish and document criteria and procedures for a mechanical integrity program including the type and frequency of inspections and periodic testing.	***E12.1.3*** Examples of criteria and procedures include but are not limited to: • Visual inspections of mechanical system and components such as gears, pins, bushings, fasteners, bolts, and gauges; • Nondestructive examination requirements for safety critical components (e.g., pins); • Operational inspection and testing (e.g., verification of fault messages; component functional tests); • Preventive maintenance and predictive maintenance; and • Electrical diagnostic checks – review supplier's recommendations.
12.2 Slide locks For information on slide locks see ANSI B11.1 or B11.2.	
12.3 Workholding equipment Workholding equipment shall not: • create a hazard in and of itself ; • reduce the effectiveness of the safeguarding (e.g., guard, device, or method); • restrict the visibility to the hazard zone necessary for the safe operation of the machine.	***E12.3*** Workholding equipment is not used to feed or remove the workpiece, but rather, to hold it in place during the hazardous portion of the machine cycle. The equipment should be designed, constructed, installed, and used to reduce or eliminate the need for hands within the hazard zone. Some examples of workholding equipment are clamps, magnetic gages, electromagnetic back gages, pneumatic clamps, jigs, and fixtures.
12.4 Stopping performance monitor **12.4.1** The stopping performance monitor, when used, shall be designed, constructed, installed and used to prevent the initiation of a successive normal machine cycle if the stopping time of the machine or specific hazard has deteriorated to a point where the safety distance used in determining the location of the safeguarding is no longer adequate.	***E12.4.1*** Stopping performance monitoring systems are intended to indicate deterioration of the stopping performance of the machine. A stopping performance monitor may not prevent a repeat cycle in the event of catastrophic failure. Stopping performance monitors are typically used on machine applications where the operator's hands are in the point of operation for loading and unloading. When determining the stopping time of the machine, measurements should be taken using a stop time measurement device at various points of the machine cycle to determine the maximum time it takes to stop or complete hazardous motion. The longest measured time should be used when determining the safety distance to locate the safety device. See Annex D for calculating the appropriate safety distance.

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12.4.2 The stopping performance monitor shall indicate that the stopping performance has deteriorated beyond the established parameters.	
12.4.3 Components, subassemblies or modules of the stopping performance monitor shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***E12.4.3*** See also, clause 5 and ANSI B11.0 (B11.TR3).
12.4.4 The safety distance shall be recalculated if the stopping performance monitor is installed on a machine utilizing safeguarding and: • the cycle stop or top stop command points are readjusted; or • the stopping performance time or angle is readjusted.	***E12.4.4*** The following factors may affect stopping performance of the machine: • clutch air supply; • counterbalance air supply; • relief valve settings to avoid excessive pressure intensification when stopping a hydraulic machine; • tooling weight or tonnage requirements; • machine cycle speed; • brake wear; • clutch wear adjustment; • exhaust restrictions; • servo motor drive tuning.
Adjustment or configuration of stopping performance monitor shall be capable of being supervised.	Methods of meeting this requirement include, but are not limited to: • the use of key operated controls; • controls located under lockable covers; or • controls that require a tool or password to access. Adjustment or configuration should only be performed by authorized individuals.
The safeguarding shall be located no closer than the new calculated safety distance.	When the stopping time changes as a result of these conditions, it may become necessary to change the top stop limit switch position, readjust the stopping performance monitor or adjust the stopping mechanism. If such readjustment is made, care should be taken that the safety distance used to locate the safeguarding is recalculated and, if necessary, the safeguarding should be relocated to ensure safe operation of the machine.
12.5 Process malfunction, detection and monitoring equipment The requirements of this subclause shall apply when this equipment is used to stop the machine or process for safety-related purposes. The equipment or machine control system shall incorporate provisions to prevent unintended continuation of machine motion or cycles when a malfunction is detected.	***E12.5*** This equipment is commonly applied to machines to detect part ejection, misfeed, transfer, overload, or other related problems. Normally it is interfaced such that the machine is signaled to stop in the event of a malfunction.

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Restarting of the machine, after a malfunction is detected, shall require start-up of the machine system at the operator's station.	Process malfunction detection and monitoring equipment represents no guarding implications; however, it may reduce the probability of introducing a hazard.
12.6 Hand tools Hand tools shall be of sufficient length and configuration to allow the individual's hands to remain outside of the hazard zone.	***E12.6*** The length of the hand tool should be such that an unintended or inadvertent trip or machine repeat will only cause damage to the hand tool and not to an individual.
The materials used in the design and construction of hand tools shall not shatter in the event of involvement with the machine or its tooling. They shall be designed and constructed such that they do not create a hazard in and of themselves.	Materials such as aluminum or other material softer than the machining, fixtures, or other components will satisfy this requirement. Hand tools should incorporate human factors engineering (ergonomics) principles in their design to minimize fatigue and stress to the hand, wrist, arm, and shoulder. See ANSI B11.TR1 for further information.
12.7 Safety interface (safety relay) modules Safety interface modules shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***E12.7*** A safety interface module usually consists of monitored, multiple, force-guided, captive contact (mechanically linked) relays, or other devices. A single discrete force-guided, captive contact (mechanically linked) relay does not meet the requirements of this standard. See also, clause 5 and ANSI B11.0 (B11.TR3).
12.8 Shields When shields are used to perform a safeguarding function, they shall meet the appropriate requirements of clause 7.	
12.9 Emergency stop devices Emergency stop devices are not safeguarding devices. They are complementary to the guards, safeguarding devices, awareness barriers, signals and signs, safeguarding methods and safeguarding procedures in clauses 7 through 11.	***E12.9*** A safeguarding device detects or prevents inadvertent access to a hazard, typically without overt action by the individual or others. Since an individual must manually actuate an emergency stop device to issue the stop command, usually in reaction to an event or hazardous situation, it neither detects nor prevents exposure to a hazard. When an emergency stop device is to be interfaced into the control system, it should not reduce the performance of the safety-related function (see 12.9.1.1(g), 6.1 and Annex C).
Emergency stop devices shall meet the requirements of NFPA 79.	In the event of any conflicting requirements with NFPA 79 or ANSI B11 base standards, the ANSI B11 base standard should take precedence.

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	Another source for the design of emergency stop equipment, including functional aspects, is given in ISO 60204-1, ISO 13850 and IEC 60947-5-5. The types of devices for emergency stop include, but are not limited to, the following: • pushbutton-operated devices; • rope pull (cable pull) operated devices; • foot-operated device without a mechanical guard; • rod-operated device; • push-bar-operated device.
12.9.1 Design and construction **12.9.1.1 General** a) The device shall be actuated by a single human action and initiate an immediate stop command.	***E12.9.1.1*** a)
The emergency stop command shall: • override all other functions and operations in all modes for hazardous motion;	This is not intended to affect circuitry or logic not associated with the hazards controlled by the emergency stop function.
• remove power to the machine actuators, which causes a hazardous situation(s), as quickly as possible without creating other hazards; • have a reset function if the device does not have a latching function;	This is intended to ensure that it takes separate deliberate actions to recover from emergency stop command.
• not initiate a restart of hazardous situation when reset; • be sustained until it is reset. This reset shall be possible only at that location where the command has been initiated. The reset of the command shall not restart the machinery but only permit restarting,	Reset can be rearming of the emergency stop device or rope/cable pull device. Rearming is typically a twisting or a pulling action. Additional reset functions can be located at other locations.
b) It shall not be possible to restart the machine until all emergency stop device(s) and the emergency stop command(s) have been reset.	
c) Provisions to connect additional emergency stop devices shall be provided.	
d) The emergency stop command shall be either a Category 0 or a Category 1 stop. The choice of the category of the stop command shall be determined by the risk assessment of the machine.	d) Category 0 is an uncontrolled stop by immediately removing power to the machine actuators. Category 1 is a controlled stop with power to the machine actuators available to achieve the stop then remove power when the stop is achieved. See also, NFPA 79.
e) Category 0 and Category 1 stops shall operate by de-energizing the relevant circuit and shall override their related start functions.	

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f) The machine actuators shall have a holding or braking function if a Category 0 or Category 1 stop results in uncontrolled motion or hazards.	f) Holding or braking functions can include: • mechanical braking; • slide locks; • home (homing) position; • counterbalances; • blocking valves.
g) The emergency stop command shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	g) This requirement is intended to include control systems incorporating software and firmware based controllers. This requirement is not intended to preclude single channel emergency stop circuit architecture, such as Category 2 Performance Level d per EN/ISO 13849-1. See the "Effective Date" information in the Foreword for recommendations on retrofit or modification of existing installations.
h) The interfacing of an emergency stop command shall not negatively affect the safety performance of safeguarding devices and their circuits.	h) See protective stop, 6.2. See also, ANSI B11.0 (B11.TR3), ANSI B11.TR4, and NFPA 79.
i) Final removal of power to the machine actuators shall be by means of electromechanical components or solid state output devices that are designed for safety related functions when designed according to relevant safety standards.	i) IEC 61508, IEC 62061, ISO 13849-1/-2, NFPA 79 and ANSI B11.TR4 all give guidance on how to design safety related functions.
j) Where relays are used to accomplish a Category 0 emergency stop function, they shall be non-retentive (non-latching) relays.	
k) Emergency stop actuators shall be red in color.	
l) The color red for the emergency stop actuator shall not depend on illumination of the actuator.	l) A clear lens in combination with a red light source should not be used.
12.9.1.2 Pushbutton-type E-stop devices Push-type devices for emergency stop shall be of the self-latching type and shall have direct opening operation.	***E12.9.1.2*** For further information on direct opening operation, see IEC 60947-5-1, and for pushbutton-type devices, see IEC 60947-5-5.
Pushbutton-type devices for emergency stop devices shall be colored RED. The background immediately around pushbuttons and disconnect switch actuators used as emergency stop devices shall be colored YELLOW.	The red/yellow combination is reserved exclusively for the emergency stop and emergency switching off applications.
The actuator of a pushbutton-operated device shall be of the palm or mushroom-head type and shall affect an emergency stop when depressed.	
Emergency stop devices shall not be a flush or membrane style switch or graphic representation based on software applications on an HMI or flat panel display.	

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12.9.1.3 Rope or cable pull-type E-stop devices Rope or cable pull-type of devices for emergency stop devices shall: • provide a latching function that requires a manual reset after actuation; • have direct opening operation; • detect a slack condition or a break of the rope or cable; • have the capability to react to a force in any direction.	***E12.9.1.3*** Rope pull or cable pull emergency stop devices provide emergency stop actuation continuously along a distance. This may require a spring at the anchor point or an opposing rope/cable pull device. For further information on direct opening operation, see IEC 60947-5-1, and for rope/cable pull devices, see IEC 60947-5-5.
The actuator of the rope or cable pull-type device for emergency stop shall be colored RED.	The RED color applies to the rope or cable, as well as any flags or markers identifying the rope or cable.
12.9.1.4 Foot-operated E-stop devices Foot-operated device for emergency stop shall be of the self-latching type and shall have direct opening operation.	***E12.9.1.4*** For further information on direct opening operation, see IEC 60947-5-1.
The actuator of a foot-operated device for emergency stop shall be colored RED. The actuator shall not have a mechanical guard and shall affect an emergency stop when depressed.	Where practicable, the background immediately around the actuator of the foot-operated devices used as an emergency stop device should be colored YELLOW. The RED/YELLOW combination is reserved exclusively for the emergency stop and emergency switching off applications.
The base of the foot-operated device shall be anti-slip or capable of being permanently mounted.	Anti-slip should be on the actuator surface and the base.
12.9.1.5 Rod-operated E-stop devices Rod-operated devices for emergency stop shall have direct opening operation.	***E12.9.1.5*** For further information on direct opening operation, see IEC 60947-5-1. This device is not the main disconnect, nor does it typically incorporate mechanical latching requirements of ISO 13850, and it is generally considered a specialized application and not typically used.
The actuator of a rod-operated device for emergency stop shall be colored RED.	Where practicable, the mounting of the rod actuator should be colored YELLOW. The RED/YELLOW combination is reserved exclusively for the emergency stop and emergency switching off applications.
12.9.1.6 Push-bar-operated E-stop devices Push-bar-operated devices for emergency stop shall be of the self-latching design and shall have direct opening operation.	***E12.9.1.6*** For further information on direct opening operation, see IEC 60947-5-1.

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The actuator of a push-bar-operated device for emergency stop shall be colored RED.	Where practicable, the mounting of the push-bar actuator should be colored YELLOW. The RED/YELLOW combination is reserved exclusively for the emergency stop and emergency switching off applications.
The actuator of the push-bar shall withstand the intended use.	The design should be robust enough not to bend, break or deflect upon actuation.
If a limit switch is used, the mechanical linkage or actuator of the switch shall be a plunger or keyed lever arm and shall be mounted in a positive operating mode.	The intent is to ensure actuation. A positive operating mode relies on direct contact or rigid elements and not spring force for actuation. See also, ANSI / ISO 12100.
12.9.2 Installation, operation and maintenance **12.9.2.1 General** a) Emergency stop devices shall not be used as an alternative for proper safeguarding.	***E12.9.2***
b) Emergency stop devices shall be continuously operable, clearly identified, clearly visible and readily accessible.	
c) Actuators of emergency stop devices shall be colored RED.	This includes the rope or cable of rope pull (cable pull) devices, and the actuator of foot-operated devices, rod and bar devices. The intent is to give the operator an identifiable target to activate the emergency stop.
d) The background immediately around pushbuttons and disconnect switch actuators used as emergency stop devices shall be colored YELLOW.	The red/yellow combination is reserved exclusively for the emergency stop and emergency switching off applications.
e) When provided, an emergency stop device shall be readily accessible at each location where the operator has control of the process, and at other locations where emergency stop is required by a risk assessment. The location of the emergency stop device shall not expose individuals to hazards.	The specific machine standard may provide greater clarification and guidance on the appropriate location(s) of an emergency stop.
f) The emergency stop device shall remain unguarded.	If it is necessary to protect an emergency stop device from inadvertent operation, other measures may be incorporated which do not impede intentional operation of the actuator. As an example, for pushbutton-type devices with a diameter of 60mm or less, a clear area of 120mm (diameter centered on the actuator) is considered not to impede operation. Anything within the clear area cannot extend above a plane defined by the actuated (pressed) button. The 120mm dimension is considered to be the breadth of a hand by U.S. and EU anthropometric standards.

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	At no time may anything cover an unactuated (armed) pushbutton. An actuated button may be covered, locked, or secured by other means to prevent re-arming or resetting. The intent of this subclause is to provide a clear and unobstructed operation of the emergency stop.
g) Operator control stations that can be disconnected or have cableless operation shall be designed in such a manner that the emergency stop device cannot be mistaken as being active, or shall not have an emergency stop device.	Cableless operation includes wireless communication (see NFPA 79). Methods of achieving this include: • indication that the operator control station is active; • provision for appropriate storage (e.g., location out of view); • information for use (e.g., signage); • indication of loss of communication for cableless operation.
h) The emergency stop device(s) shall be inspected and tested for proper operation at a suitable interval(s) as determined by the risk assessment, but not at an interval greater than one year.	The interval should be based upon severity of the operating environment and the frequency of switch actuations.
12.9.2.2 Pushbutton-type E-stop devices Pushbutton-type emergency stop devices hall be installed such that it is unobstructed and can be actuated by the palm of the hand.	***E12.9.2.2*** Obstructions should be prevented from falling or resting on or behind the device that can prevent actuation. These measures include but are not limited to physical design of the device, mounting, training, signage, etc. See also, 12.9.2.1(f).
12.9.2.3 Rope pull (cable pull) E-stop devices Rope pull (cable pull) emergency stop devices shall:	***E12.9.2.3*** For further information for rope/cable pull type devices, see IEC 60947-5-5.
• have mounting points, including support points, that are rigid;	
• be easily accessible and visible along its activation length;	Markers or flags may be fixed on the rope to increase its visibility.
• not run rope/cable through conduit or other tubing;	
• mount the switch and the anchor point for rope/cable securely on a solid, stationary surface able to withstand the constant tension of the rope;	
• be installed to have the capability to react to a force in any direction as determined by risk assessment (this does not apply to drop pulls from the main rope/cable);	Limited response to perpendicular forces may exist between the device and the first support.
• minimize friction at all supports and change of direction;	Use of pulleys, multiple eyebolts or other physical guides may be used to allow easy actuation from any point in the cable system. Pulleys and other moving parts associated with the rope should be periodically lubricated.

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• not exceed manufacturer's recommendations;	Items include but are not limited to: • maximum rope length; • positioning of rope/cable supports; • types of tensioning methods (e.g., springs and turnbuckles); • type and design of rope/cable.
• provide constant tension of the rope/cable.	Temperature affects rope tension. The rope expands (lengthens) when temperature increases, and contracts (shrinks) when temperature decreases. Significant temperature variations require frequent checks of the tension adjustment. Weights without a mechanical stop that limits travel and are attached to the rope/cable should not be used. The pull force of the individual can pull the weight, thus providing unreliable actuation. When weights or springs are used at the anchor point care needs to be taken to limit the pulling force and travel.
12.9.2.4 Foot-operated E-stop devices Foot operated emergency stop devices shall: • be easily accessible and visible; • minimize the risk of trip hazards.	***E12.9.2.4*** Ways to minimize trip hazards can include but are not limited to: • protecting or securing the cable; • locating outside of personnel movement or traffic patterns; • being contrasting in color to the environment; • mounting above walking surface.
12.9.2.5 Rod-operated E-stop devices Rod-operated emergency stop devices shall: • be easily accessible and visible; • clearly identified if it does not have a YELLOW background; • have a reset function if the device does not have a latching function. The reset device shall be located in the same location as the rod-operated device.	***E12.9.2.5*** These devices are generally considered a specialized application and not typically used. This is intended to ensure that it takes a separate deliberate action to recover from emergency stop command.
12.9.2.6 Push-bar operated E-stop devices Push-bar operatedemergency stop devices shall: • be easily accessible and visible; • identify the direction of actuation; • not cause a hazard in and of itself.	***E12.9.2.6*** Labeling or signage are two means to comply. A hazard can be caused by pinch points of mechanical linkages.

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12.10 Enabling devices	
12.10.1 Design and construction	
12.10.1.1 The enabling device shall use three positions such that when continuously held in a midpoint-enabled position, it allows machine function. Release of, or compression past the midpoint-enabled position of the device, shall initiate an immediate stop command.	***E12.10.1.1*** See also, NFPA 79. Position 1 (released or not operated) is off, Position 2 (the midpoint) is enabled and Position 3 (operated past its midpoint) is off.
The enabling function shall only be activated when actuating from Position 1 to Position 2.	When returning from Position 3 to Position 2, the function is not enabled.
12.10.1.2 The device shall not create a hazard in and of itself.	***E12.10.1.2*** The device should be designed and constructed such that it does not present hazards including but not limited to: • sharp edge or pinch point hazards; • electromagnetic interference hazards; • electrical shock hazards; • ergonomic issues (force, posture, etc.) of sustained activation.
12.10.1.3 The enabling device shall not be affected by environmental conditions.	
12.10.1.4 Components, subassemblies or modules of the device shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	***E12.10.1.4*** See also, clause 5 and ANSI B11.0 (B11.TR3).
12.10.2 Installation and operation	
12.10.2.1 The user shall ensure that the enabling device is installed, maintained, and operated in accordance with this standard.	***E12.10.2.1*** The user should follow the manufacturer's recommendations for proper operation of the enabling device. The user should ensure that only trained and qualified individuals are allowed to operate the enabling device, and that safe work procedures are developed and used. The safe work procedure should include, but is not limited to the use of the device and hazards that are associated with the task requiring the use of the device. See also, clause 14.
12.10.2.2 The selection of the enabling device shall be capable of being supervised by the user to prevent: • unauthorized selection; • de-selection of the enabling device while in use.	***12.10.2.2*** Methods of meeting this requirement include, but are not limited to, the use of key operated controls, controls located under lockable covers, or controls that requires a tool or password to access. Adjustment or configuration should only be performed by authorized individuals.

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12.10.2.3 The machine control system shall ensure that only one actuating control or station can initiate machine function when an enabling device is in use.	***12.10.2.3*** The enabling device(s) does not initiate motion but only enables the functionality of the actuation control or station. The purpose of this requirement is to provide the individual operating the enabling device exclusive control of the machine function when the enabling device is actuated. This limits the possibility of unexpected machine function. If it is possible to start the same machine function by means of several actuating controls, the control circuit should be so arranged that only selected controls are effective at a given time.
12.10.2.4 If multiple individuals are in the hazard zone, each shall have their own enabling device.	
12.10.2.5 Additionally, each selected enabling device shall be concurrently operated before machine motion can be initiated.	***12.10.2.5*** Some applications may require the release of all selected enabling devices after a protective stop command is issued and then the reactivation of all selected enabling devices to allow initiation. This is to ensure that all operators are aware of the situation that caused the stop command. This can also reduce the motivation to defeat the enabling device.
12.10.2.6 The user shall ensure that each enabling device is inspected, checked, and adjusted according to the supplier's recommendation and the user's established procedures. All necessary adjustments, repairs and maintenance shall be made, and shall be complete before operating the machine.	***12.10.2.6*** The user should refer to the supplier's recommendations in order to establish operating procedures. The enabling device should be function tested prior to entering the hazard zone when power is available to ensure its proper operation.
12.10.2.7 The enabling device shall initiate an immediate stop command to the machine control system when the enabling device is interrupted during the machine function. It shall require re-initiation of the actuating means prior to the start or continuation of the machine function.	***12.10.2.7*** Simply actuating the enabling device should not initiate machine function. The enabling device should initiate a permissive command to the machine control system while the three position device is held in the center position and each machine function is enabled by a separate pushbutton or pendant function.
12.10.2.8 The means of returning the machine control to production shall be located outside of the hazard zone such that it cannot be reached from within the hazard zone, and shall not occur until the hazard zone is clear of individuals.	***12.10.2.8*** Returning the machine control to production includes reestablishing all safeguarding such that they are in place and functioning.
12.10.2.9 Components, subassemblies or modules of the interface or machine control system shall conform to the requirements of 6.1, or shall meet the safety performance level (risk reduction) as determined by a risk assessment.	***12.10.2.9*** See also, clause 5 and ANSI B11.0 (B11.TR3).

Standard Requirements	Explanatory Information
12.11 Hold-to-run controls The requirements within this subclause apply when a hold-to-run control device: • is in sole control of the hazardous motion; and • exposes an individual to a hazardous situation(s); and • is being used for safeguarding.	***E12.11*** Hold-to-run controls are typically used in conjunction with other complementary equipment and measures or other methods to reduce risk. Other methods to reduce risk include but are not limited to reduced speed, reduced power / force, step-by-step operation, i.e., with a limited movement control device. When used with other complementary equipment and measures or safeguarding devices (clause 8), the hold-to-run is a logic device only, and may not serve as a safety function within the safety related part of the control system. If the hold-to-run control is used in conjunction with two hand control see 8.4, or with enabling devices see 12.10
12.11.1 Design and construction	
12.11.1.1 The hold-to-run control device shall require continuous actuation to achieve operation. Release of the control device shall initiate an immediate stopping command.	***E12.11.1.1*** Hold-to-run control device(s) can be designed as, but not limited to: • momentary pushbuttons; • footswitches; or • other machine/operator interfaces.
12.11.1.2 The hold-to-run control device shall not create a hazard in and of itself.	***E12.11.1.2*** The device should be designed and constructed such that it does not present hazards including but not limited to: • sharp edge or pinch point hazards; • electromagnetic interference hazards; • electrical shock hazards; • ergonomic issues (force, posture, etc.) of sustained activation.
12.11.1.3 The hold-to-run control device shall not be affected by environmental conditions.	
12.11.1.4 Components, subassemblies or modules of the device shall conform to the requirements of 6.1, or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment. When used in conjunction with an enabling device or other safeguarding devices (clause 8), this requirement does not apply to the hold-to-run control.	***E12.11.1.4*** See also, clause 5 and ANSI B11.0 (B11.TR3).
12.11.2 Installation and operation	
12.11.2.1 The user shall ensure that the hold-to-run control device is installed, maintained, and operated in accordance with this standard.	***E12.11.2.1*** The user should follow the manufacturer's recommendations for proper operation of the enabling device.

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	The user should ensure that only trained and qualified individuals are allowed to operate the hold-to-run control device, and that safe work procedures are developed and used. The safe work procedure should include, but is not limited to, the use of the device, and hazards that are associated with the task requiring the use of the device. See also, clause 14.
12.11.2.2 The selection of the hold-to-run control device shall be capable of being supervised by the user to prevent: • unauthorized selection; • de-selection of the hold-to-run control device while in use.	***E12.11.2.2*** Methods of meeting this requirement include, but are not limited to: • the use of key operated controls; • controls located under lockable covers; or • controls that requires a tool or password to access. Adjustment or configuration should only be performed by authorized individuals.
12.11.2.3 The machine safety related part of the control system shall ensure that only one hold-to-run control can initiate machine function when a safeguard has been bypassed. This control shall be located within site of the hazard for which the safeguard has been bypassed.	***E12.11.2.3*** The purpose of this requirement is to provide the individual operating the hold-to-run control device exclusive control of the machine function when the device is actuated. This limits the possibility of unexpected machine function. If it is possible to start the same machine function by means of several actuating controls, the control circuit should be so arranged that only selected controls are effective at a given time.
12.11.2.4 If multiple individuals are exposed to the hazard, only a single individual shall be in control of the hold-to-run device. All other individuals shall be provided an enabling device.	***E12.11.2.4*** See also, 12.3 enabling devices.
12.11.2.5 The user shall ensure that each hold-to-run control device is operational according to established safe work procedures. All necessary adjustments, repairs and maintenance shall be made, and shall be complete before operating the machine.	***E12.11.2.5*** Operating procedures should be established by referencing the supplier's recommendations, and the user should also evaluate the need for an emergency stop device within immediate reach of the hold-to-run control device based on a risk assessment. See 12.9 and ANSI B11.0 (B11.TR3).
12.11.2.6 Components, subassemblies or modules of the interface or machine control system shall conform to the requirements of 6.1, or shall meet the safety performance level (risk reduction) as determined by a risk assessment.	***E12.11.2.6*** See also, clause 5 and ANSI B11.0 (B11.TR3). See 12.10 for enabling device requirements.
12.11.2.7 When a hold-to-run control is used in conjunction with an enabling device and they are both operated by the same individual or it is used in conjunction with other safeguarding devices (clause 8), this requirement does not apply to the hold-to-run control.	

Standard Requirements	Explanatory Information
12.12 Zero speed (monitoring) device When required to augment or ensure proper operation of safeguarding, this subclause applies.	***E12.12*** A number of methods and devices exist to monitor the motion of a hazardous device and provide an output signal when motion has stopped.
There are two basic means of zero speed monitoring of rotating motion: • monitoring of the drive motor shall only be used when de-coupling of a directly driven load can be reasonably excluded; • monitoring the load side shall be used on belt or chain driven loads.	Electric motor drives are typically monitored by the use of Back EMF in across-line monitoring or with encoder/resolvers attached to the motor. Care should be taken to evaluate and test the Back EMF units on variable speed drives. Noise from other VFD and non-sinusoidal supply at low rpm <10% of full speed may cause erroneous outputs. Load speed monitoring is typically done with a pair of sensors monitoring discontinuity in the revolving member, such as keys, coupling bolts, and gear teeth. The output pulses are fed to a zero speed monitoring device or logic which monitors the frequency or time between pulses and outputs a signal when the monitored value falls below the minimum speed set point.
The speed monitoring circuit shall conform to the requirements of 6.1 or shall be designed and constructed to meet the safety performance level (risk reduction) as determined by a risk assessment.	Linear motion is more difficult to detect and frequently requires linear variable differential transformer (LVDT) devices or time-based position monitoring. Variable speed and servo drives may feature safety rated, on-board zero speed or stand still capability. These may be used within their safety rating. These devices may feature maximum speed capability and be used to monitor maximum speed for jog and other supplementary safeguarding applications.
13 Inspection and maintenance of safeguarding	***E13***
The user shall document the safeguarding.	The documentation of the safeguarding should at a minimum, include the following where applicable: • safety distance calculations; • control schematics; • software program; • records of periodic maintenance checks.
The user shall provide maintenance instructions, recommendations, and procedures to maintenance personnel for all safeguarding used to protect individuals from the hazards associated with the machine.	The user (who can be the machine supplier that provides or modifies the safeguarding, the integrator of the safeguarding, or the user of the machine) should consider the safeguarding supplier's instructions and recommendations in determining the maintenance program.

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The user shall ensure that the safeguarding is maintained and inspected, and shall ensure the initial training and the continued competency of personnel responsible for the maintenance and inspection of the safeguarding.	The user should determine the period between inspections based on the use of the safeguarding and the safeguarding supplier's recommendations.
The user shall establish a procedure for the inspection and testing of the safeguarding, perform periodic testing on a regular basis, and document the results.	Examples of criteria and procedures include but are not limited to verification: • of the safety distance; • that all safeguarding is in place and functioning correctly; • that complementary equipment are functioning correctly (e.g., emergency stops).
Following any maintenance to the safeguarding, the user shall ensure that the safeguarding performs as intended.	
When the safeguarding is removed or disabled for maintenance, alternate safeguarding shall be provided to protect maintenance or operating personnel, or other individuals. See ANSI Z244.1.	Alternate safeguarding or lockout/tagout procedures may be required. See 29 CFR 1910.147 and 29 CFR 1910.333(b)(2) for further information.

14 Training on the use of safeguarding *E14*

The user shall ensure that an appropriate training program is developed for operators, helpers, maintenance personnel, supervisors and other individuals who may be exposed to the hazards of the machine.	The user should take into account the safeguarding supplier's instructions, specifications, recommendations, etc., when developing a training program. Training should include, but not be limited to: • types of safeguarding; • capabilities/options of safeguarding; • description of safeguarding for a specific application and hazard; • function of the safeguarding; • proper installation and operation of the safeguarding; • functional testing of the safeguarding; • limitations of the safeguarding; • abnormal or unexpected operation of the safeguarding.
The user shall ensure that individuals listed above are trained based on the program developed.	
For those individuals trained above, the user shall verify their understanding and provide for their continued competency.	
Individuals listed above shall be responsible for following the training and safety procedures provided by the user in the maintenance and use of the safeguarding.	

Annex A – Guidance to understand the B11 Series of Standards & Technical Reports
(Informative)

The primary purpose of every machine tool is to process parts. This is accomplished by the machine imparting process energy onto the workpiece. Inadvertent interference with, or accidental misdirection of the released energy during production, maintenance, commissioning and de-commissioning may result in injury.

The primary purpose of the ANSI B11 series of machine safety standards is to devise and propose ways to minimize risks of the potential hazards. This can be accomplished either by an appropriate machine design or by restricting personnel or other individuals' access to hazard zones, and by devising work procedures to minimize personnel exposure to hazardous situations. This is the essence of the ANSI B11 series of safety standards.

The responsibility for the alleviation of these risks is divided between the equipment supplier, the user and the user's operating personnel, as follows (numbers in parentheses refer to the clause numbers in these "base" B11 standards which address that responsibility). NOTE – B11.19 and B11.0 are the only B11 standards that depart from the formatting convention indicated below:

The requirements of this ANSI standard are grouped according to those that apply to the supplier (i.e., manufacturer, rebuilder, modifier) and user. Some are shared between the supplier and user and are so indicated. Figure 1 provides an overview of this standard and in particular the responsibilities of and requirements for the supplier and user, including the user personnel. Numbers in parentheses denote the particular clause or subclause of the standard.

Notes for Figure 1:

1) Scope – Provides the boundaries or limits of the standard (i.e., what is/is not included).
2) Normative references – Other standards which in whole or in part provide additional requirements when referenced in the normative text (i.e., left-hand column of clauses 4 – 9) of this standard.
3) Definitions – Terms used in this standard, together with their definitions (terms used in the same context as are generally understood and commonly used in everyday English are not defined).
4) Responsibility – The general responsibilities of the supplier (builder), user, and the user personnel are listed in clause 4 together with which of the remaining clauses they have primary responsibility.
5) Hazard control (task/hazard identification & risk assessment/risk reduction) – Although clause 5 is intended to require a shared responsibility between supplier and user, the requirements of this clause may fall primarily on either entity (see B11.0 for further explanation of hazard/task identification and risk assessment/risk reduction).
6) Design and construction – It is assumed that the supplier will be responsible for the requirements of clause 6 with the understanding that the user may add to or modify these requirements through the purchase agreement.
7) Installation, testing and start-up – Although the requirements of clause 7 are predominantly the responsibility of the user, the supplier will normally provide assistance either directly (providing personnel) or indirectly (instruction materials).
8) Safeguarding – This is normally a shared responsibility but often, either the supplier or the user will provide and/or meet the requirements of clause 8.
9) Operation and maintenance – The user is normally responsible for the requirements of clause 9 with possible assistance from the supplier for training.

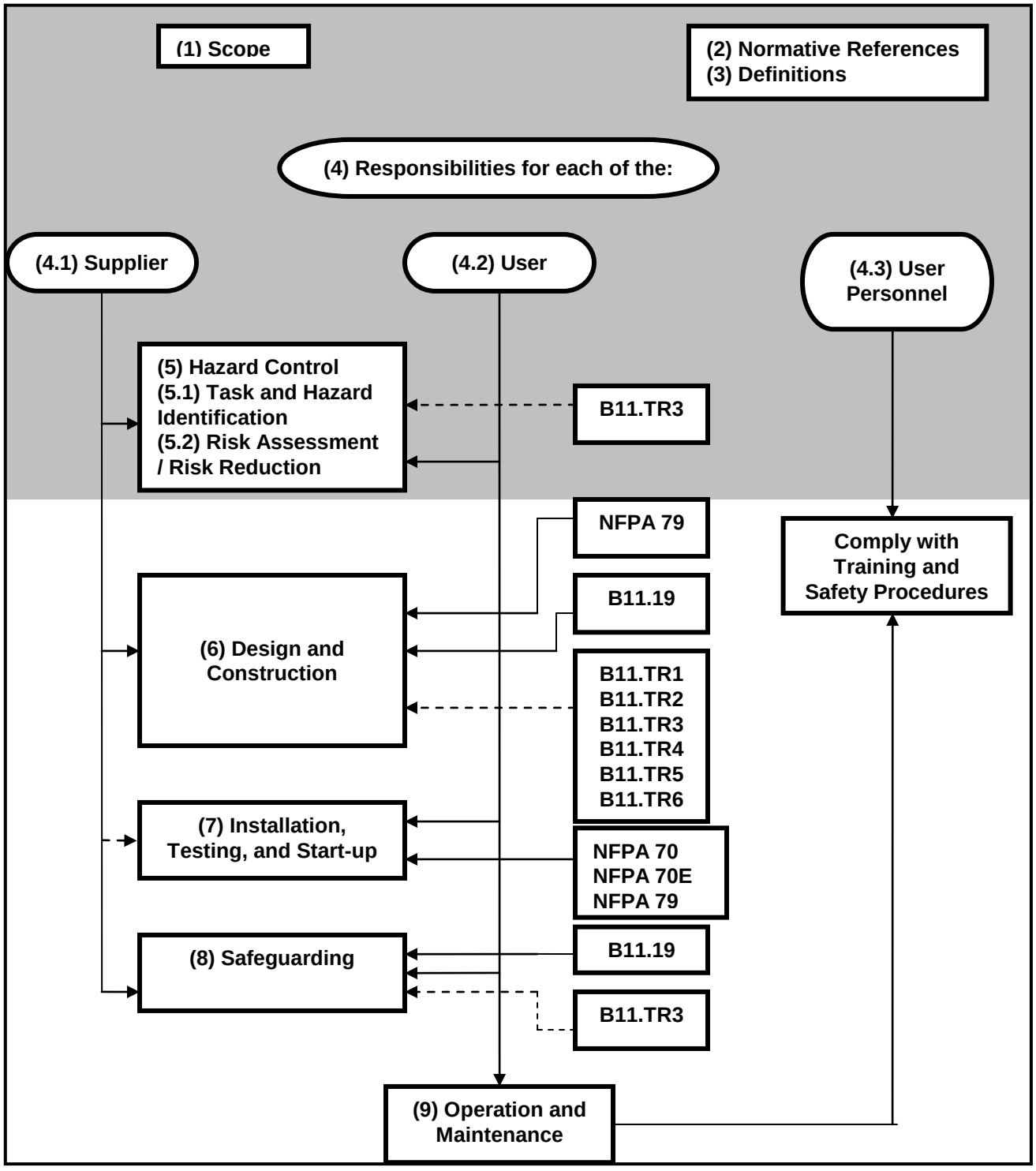


Figure 1 – Typical layout of B11 base standards showing the various responsibilities

The gray shading represents ANSI B11.0. A solid line between a block showing reference standard(s) and a block showing a normative clause denotes part of the requirements. A dashed line denotes an informative reference.

Annex B –Hazard List for Safeguarding
(Informative)

The groups of potential hazards listed below are associated with tasks performed during the design, construction, maintenance and use of the safeguarding, and do not include those hazards associated with the design, construction, maintenance and use of the machine.

B.1 Hazards associated with the design and construction of safeguarding (guards, safeguarding devices, awareness devices, and safeguarding methods) include, but are not limited to the following: (each of these hazards refer to the safeguarding)

a) Pinch, shear, or crush;
b) Loosening or fracturing of bolts, fasteners or other components;
c) Loss or disturbances of external power sources;
d) Failure of electrical, pneumatic or hydraulic components;
e) Hazardous energy;
    i. Interferences:
    ii. Electromagnetic emissions and immunity;
f) Electrostatic discharge.
g) Shock, vibration;
h) Humidity, contaminated air, ambient noise, light, temperature, liquids;
i) Human factors;
j) Electrical shock.

B.2 Hazards associated with the installation of the safeguarding include, but are not limited to:

a) Hazards associated with the work area;
b) Hazardous energy;
c) Work surfaces;
d) Housekeeping;
e) Accessibility, space limitations.

B.3 Hazards associated with the integration of the safeguarding include, but are not limited to:

a) Pinch, shear or crush points between the safeguarding and the machine;
b) Improper (re-)mounting and (re-)positioning;
c) Improper selection and connection of power sources;
d) Improper interfacing to the machine control;
e) Machine motion;
f) Electrical shock;
g) Hazards associated with the validation process;
h) Interaction between the safeguarding and the machine and its auxiliary equipment;
i) Human factors.

B.4 Hazards associated with the use of the safeguarding include, but are not limited to:

a) Improper set-up and adjustment of the safeguarding;
b) Safeguarding functionality;
c) Inadequate safeguarding;
d) Interference between the safeguarding and tote boxes, workholding devices tables, work pieces, etc.;
e) Housekeeping;
f) Human factors.

B.5 Hazards associated with the maintenance of the safeguarding include, but are not limited to:

a) Stored energy;
b) Inadequate testing procedures or improper testing and verification;
c) Work procedures;
d) Housekeeping;
e) Human factors.

Annex C – Performance of the safety-related function(s)
(Informative)

The purpose of the requirements of this standard is to prevent exposure to hazardous motion (or situations). The level of performance of the safety-related function(s) depends on the level of risk associated with the hazard. See clause 5.

There are various design strategies that may be used to ensure that failures of components, modules, devices or systems meet the level of performance required above. Some design strategies may allow an accumulation of single failures and yet still stop (or prevent the re-initiation of) hazardous motion (or situations) when the next critical failure would cause loss of the safety-related function. Other strategies include self-diagnosis to determine and respond to failures. Still other strategies use tried and proven components and design principles to reduce the probability of a failure to a tolerable risk. Control reliability is a design strategy, method or feature that separates the safety-related functions of a system into components, modules, devices or systems that can be monitored or checked by other components, modules, devices or systems. It is axiomatic that protection from the loss of safety-related functions due to multiple, simultaneous failures (common cause) of components, sometimes referred to as "fail-safe", is not practically achievable. Catastrophic failure of the machine actuator (electrical, mechanical or fluidic) may result in the loss of the safety-related function. The use of redundant components, modules, devices or systems (with or without monitoring or checking) is frequently used in process control systems where the goal is to maintain the process in the event of a failure. Aircraft systems, chemical processing plants and electrical power transmission systems are examples of applications where the process must continue in the presence of a failure. Control reliability is not provided by simple redundancy. There must be monitoring to assure that redundancy is maintained. Control reliability uses monitoring and checking to determine that a discernable component, module, device or system has failed and that the hazardous motion (or situation) is stopped, or prevented from starting or restarting. Control reliability ensures that a failure of the control system or device will not result in the loss of the safety-related function(s).

NOTE - Because some failures cannot be detected until the completion of a cycle or a portion of the cycle, loss of safety-related functions may occur for a portion of the cycle.

Control reliability of electrical, electronic, pneumatic, or hydraulic systems or devices frequently consists of monitored, multiple and independent parallel or series components, modules, devices or systems. Control reliability of machine control systems or devices can be achieved by the use of, but not limited to, one or both of the following:

- The use of two or more dissimilar components, modules, devices or systems, with the proper operation of each being verified (monitored) by the other(s) to ensure the performance of the safety function(s).
- The use of two or more identical components, modules, devices or systems, with the proper operation of each being verified (monitored) by the other(s) to ensure the performance of the safety function(s).

These methods require that the safeguarding device, its interface to the control system (or directly to the actuator control) and actuator control meet the above requirements.

Another control reliability strategy may be used when the machine motion is stopped and reinitiated at least once per cycle. This strategy requires that the control system and the actuator control utilize the design methods above. The safeguarding device and its interface may or may not be control reliable. To ensure that these elements cannot cause a loss of the safety-related function(s), the control system must be designed to require that the device and its interface is exercised automatically or by the operator (e.g., releasing hand controls or interrupting an electro-optical device) before a subsequent machine cycle may be initiated.

The achievement of control reliability is dependent upon the selection and integration of components, modules, devices and systems that have been specifically designed and intended for use in safety-related functions. A disciplined design process, including design guidelines, peer review and other elements, is important for achieving completeness and accuracy of the design, and should be implemented to ensure that control reliability is achieved.

Annex D – Safety Distance
(Informative)

The safeguarding devices listed below do not prevent an individual from reaching into a hazard zone. In order for these devices to be effective, they must either prevent the start of, or stop hazardous motion (or situation) when an individual is exposed to the hazard. For the devices to accomplish this requirement, they must be located at a distance from the hazard such that hazardous motion (or situation) is prevented, completed or stopped before the individual can be harmed.

Devices that require location at a safety distance include, but are not limited to:

1. interlocked guards (non-locking);
2. two hand control devices;
3. two hand trip devices;
4. single control safeguarding devices;
5. electro-optical presence-sensing devices;
6. RF presence-sensing devices;
7. safety mat devices;
8. safety edge devices.

The first four devices protect individuals by positioning the individual at or beyond the safety distance before hazardous motion can be initiated, or by maintaining the individual's position at the safety distance after hazardous motion has been initiated. The remaining four devices protect individuals by detecting an individual entering (or their presence within) a hazard zone at or within the safety distance.

NOTE - Guards and movable barrier devices with various openings are located at a position away from the hazard zone based on the ability of the operator to reach through the opening. Figure D.9 is one method that may be used to locate guards.

The safety distance may be calculated using the following equation:

$Ds = K(T)$ Equation (1)

Where: $Ds =$ the safety distance

$K =$ the maximum speed that an individual can approach the hazard

$T =$ the total time to stop hazardous motion which includes various factors as described below

The factor K is the speed constant and includes hand and body movements of an individual approaching a hazard zone. The following factors should be considered when determining K:

a) Hand and arm movement;
b) Twisting of the body or shoulder, or bending at the waist;
c) Walking or running.

One of the accepted values for K is the hand speed constant (it is usually considered as the horizontal motion of the hand and arm while seated). Its common value is 1.6 m/s (63 in/s) although other values (typically greater) are also used. The hand speed constant does not include other body movements, which can affect the actual approach speed. Consideration of the above factors should be included when determining the speed constant for a given application.

The factor T is the total time that it takes for the hazardous motion to stop, or for the hazardous portion of the machine cycle to be completed. A power press may present a hazard during the closing portion of its cycle or a machining center may present a hazard during a tool change or while the tool is approaching the workpiece (trapping zone), but not present a hazard during the balance of the machine cycle.

T includes portions of time that vary by machine type and by the safeguarding device applied. The following affect the total stopping time:

a) Type of actuator;

I) Full revolution clutch, or machines that cannot be stopped during a machine cycle. See note 1.
II) Part revolution friction clutch, or machines that can be stopped at any point in the machine cycle or anywhere during the hazardous portion of the machine cycle. See note 2.
III) Braking mechanism. See note 3.
IV) Stopping capability of the motors and drive. See note 4.

b) Reaction time of valves. See note 5.
c) Reaction time of the machine control system. See note 6.
d) Reaction time of the safeguarding device, including its interface. See note 7.
e) Additional time required by the use of braking performance monitor. See note 8.

Note 1: Full revolution (pin) clutches have one or more engaging points within a rotation of the flywheel where the clutch can be engaged. Once engaged, the clutch completes a full revolution or cycle (stroke) before it is disengaged and brought to a stop. After the machine is tripped by the control system or mechanical treadle, pedal, hand controls or levers, the clutch typically engages after the flywheel rotates to the engaging position. Therefore, it is possible that the tripping device could have tripped the clutch just after the flywheel engaging point has passed and will not engage the clutch until the flywheel has rotated one full revolution. Assuming that the hazard exists during the closing portion of the cycle or stroke (provided that no hazards are generated during the opening portion), the time to stop hazardous motion could take up to one and a half times the time it takes the machine to complete one cycle (stroke). For clutches with only one engaging point the stopping time, Ts, is:

$$Ts = 1.5(Tmc) \quad \text{Equation (2)}$$

Where: $Tmc =$ the time it takes to complete a machine cycle (stroke)

Some clutches have multiple engaging points on the flywheel. Therefore, the clutch has more than one position where engagement can occur. The equation for calculation of this time, the stopping time Ts is:

$$Ts = (1/2 + 1/N)(Tmc) \quad \text{Equation (3)}$$

Where: $N =$ the number of engaging points on the flywheel

For machines that are tripped (or sequenced) to initiate the machine cycle, which in turn initiates immediate motion and which cannot be stopped until the completion of the machine cycle, the stopping time Ts is:

$$Ts = Thm \quad \text{Equation (4)}$$

Where: $Thm =$ the time, after initiation of motion, until hazardous motion is completed

Note 2: The stopping time, Ts, of part revolution clutch driven machines or machines that can be stopped at any point in the machine cycle or stopped anywhere during the hazardous portion of the machine cycle is equal to the time it takes to stop hazardous motion (see also, Note 3). If eddy current or other electro-magnetic clutches are used, see Note 4.

Note 3: The stopping time, Ts, is the time it takes to disengage the clutch, the time it takes to apply the brake and the time it takes the brake to stop motion.

Note 4: The stopping time, Ts, for direct drive, motor driven machines utilizing full voltage motors, servo systems, vector systems or other variable speed systems, is equal to the time it takes to stop hazardous motion after a stop command or signal is given to the motor contactor or drive system. This time should take into consideration both uncontrolled stops (category 0) and controlled stops (categories 1 and 2) including dynamic braking. See ANSI / NFPA 79.

Note 5: The stopping time, Ts, of machines actuated or controlled by pneumatic or hydraulic valves must include the reaction time of the valve measured from the time that the valve is de-energized until motion is stopped. Stopping time for systems using valves may be affected by high or low supply pressures, exhaust restrictions, sluggish spools or poppets or performance of the pilot sections.

Note 6: Control systems inherently have a delay from the time its inputs or the system logic initiate a stop command, until the system's output de-energizes the actuator. This time, Tc, is the reaction time of the control system.

Note 7: Safeguarding devices also have a delay from the time that they sense the presence, or absence (for hand controls and trips or hostage controls) of individuals. Additionally, there may be a delay caused by the interface between the device and the control system. The interface may, as an example, include interposing relays. The interface delay must be added to the total delay time. This time, Tr, is the reaction time of the device and its interface. The reaction time of the device, without the interface, is stated by the device manufacturer.

Note 8: Stopping performance monitors are used to assure that a gradual increase in the stopping time caused by the degradation of components does not exceed the stopping time used to calculate the safety distance for the safeguarding device. Stopping time at the end of a machine cycle is usually different than the stopping time during the hazardous portion(s) of the cycle, and since these times may vary due to such factors as machine temperature, tool loading and energy transferred to the workpiece, a factor, $Tspm$, must be added to the total stopping time.

$Tspm$ is a calculated factor. As an example, if the monitor is set to a point or time 5% greater than the normal stopping position or time, then $Tspm$ is equal to 5% of Ts ...

Therefore, the total stopping time is the sum of these factors and may be represented by the following equation:

$$T = Ts + Tc + Tr + Tspm \quad \text{Equation (5)}$$

Stop time measuring devices are normally used to measure these times. When using these devices, Ts can be measured from the output of the control system until motion is stopped. Likewise, $Ts + Tc$ can be measured from the input to the control system. Some stop time measuring devices include plungers and flags that are used to simulate operation by an individual. When using this type of device, it is possible to measure $Ts + Tc + Tr$. (Use the manufacturer's value for Tr, when provided).

Substituting $Ts + Tc + Tr + Tspm$ for T in Equation 1, the equation for calculating the safety distance becomes:

$$Ds = K(Ts + Tc + Tr + Tspm) \quad \text{Equation (6)}$$

An additional distance needs to be added to the safety distance when using electro-optical devices, safety mats, single control safety devices and RF devices.

Electro-optical and RF devices do not detect the presence of individuals at the plane or within the field of the device until an amount of penetration into the plane or field occurs. This amount is known as the distance (depth) penetration factor. The distance that must be added is called Dpf. See Figures D.1 -- D.6 and D.8.

When using safety mats and single control safety devices, it is possible for the individual to be reaching into the hazardous area or stepping onto the mat beyond its edge. The amount of reach or stride should be added to the safety distance and can be called Dpf. See Figures D.2 and D.6.

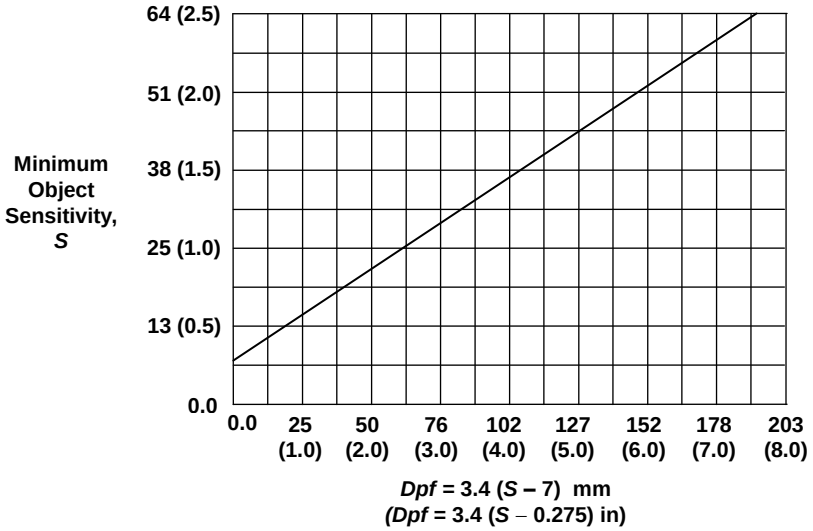
The equation for calculating the safety distance for these devices, therefore, is:

$$Ds = K(Ts + Tc + Tr + Tspm) + Dpf \quad \text{Equation (7)}$$

Equation 7 can be used to calculate the safety distance for the eight safeguarding devices listed in paragraph 2 by substituting the non-zero values or combination of values as determined above.

NOTE ON THE FOLLOWING FIGURES: Figures D.1 through D.3 provide the reader with the means to find the value of Dpf they need to use in the safety distance formula. Figures D.4 through D.8 are examples per the different applications of how to use the safety distance formula once the reader has determined Dpf.

Figure D.1: Penetration factor, *Dpf*, for presence-sensing devices used in a vertical application with object sensitivity less than 64 mm (2.5 inches)



Dpf is the distance added to the safety distance due to the penetration factor that compensates for varying object sensitivities (resolution) of electro-optical presence-sensing devices.

When blanking is used and when the blanked area is not completely filled by the workpiece or part, or by mechanical guarding, the minimum object sensitivity can be calculated as:

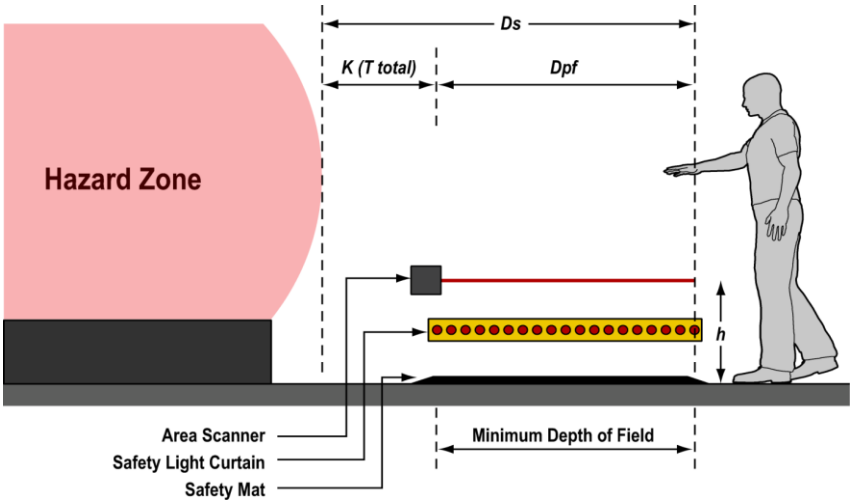
Object sensitivity = size of the blanked area plus minimum object sensitivity without blanking.

Once this value is found, then *Dpf* can be determined.

If the entire blanked area is filled with mechanical guarding or other fixed material or guards, use the minimum object sensitivity to determine *Dpf*.

Figure D.2: Dpf for ground level devices that can be reached over (30° or less).
Examples include safety mats, area scanners, and horizontally mounted electro-optical devices.

Dpf = 1200mm (48 in) for horizontal sensing field applications without vertical sensing.



Allowable Sensing Field Heights in mm. (in)
Maximum Height 1000 (39)

Objects Sensitivity (*S*)	Minimum Height (*h*)
≤ 50 (2)	0
64 (2.5)	190 (7.5)
76 (3.0)	380 (15)
89 (3.5)	570(22.5)
102 (4.0)	760 (30)
108 (4.25)	860 (33.75)
117 (4.6)	1000 (39)

Minimum mounting height (*h*) can also be determined by the following,
$h = 15 (S – 50)$ mm
$h = 15 (S – 2)$ in
where *S* is the object sensitivity.

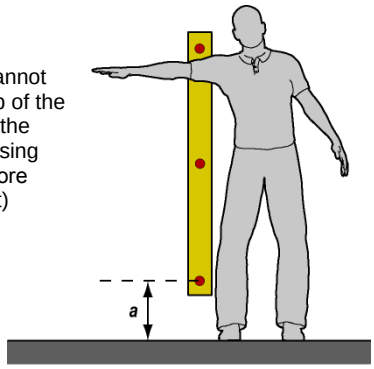
Minimum depth of field (or sensing area) must hinder an individual from stepping over the presence-sensing device or safety mat. This distance is 1.2 m (4 ft) if an individual can step over and pass unrestricted, 900 mm (3 ft) if supplemental safeguarding or physical barriers are used such that an individual must stand within the sensing area. Minimum depth of field addresses a different installation consideration than the Penetration Factor (*Dpf*).

Figure D.3: *Dpf* for object sensitivities greater than 64 mm (2.5 inches)

For electro-optical presence-sensing devices using large blanked areas, or if an individual can otherwise reach through or over the sensing field and not be detected, the distance between any two adjacent detection points shall not be greater than 600 mm (24 in), i.e., from one active point to the next active point above.

REACH-THROUGH
Dpf = 900 mm (36 in) for reach through applications.

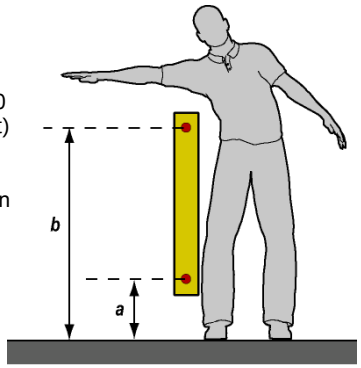
If the individual cannot reach over the top of the sensing field and the bottom of the sensing field ("A") is no more than 300 mm (1 ft) above the floor.



a = Bottom of sensing field

REACH-OVER
Dpf = 1200 mm (48 in) for reach over applications.

The top of the sensing field ("B") is between 900 and 1200 mm (3 and 4 ft) above the floor. The bottom of the sensing field ("A") is no more than 300 mm (1 ft) above the floor.

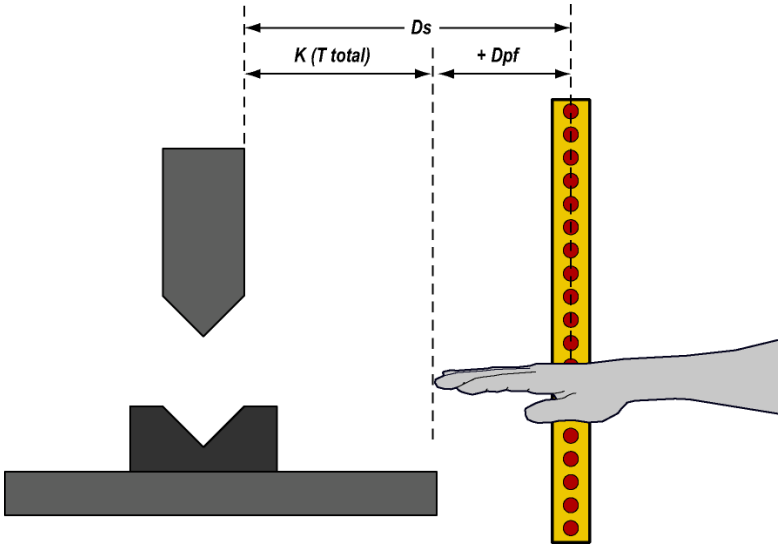


a = Bottom of sensing field
b = Top of sensing field

NOTE: An application is considered to be a "reach-through" if the individual cannot reach over the top of the sensing field without being detected. A "reach-over" application allows an individual to approach farther into the safeguarded area by binding at the waist thus requiring a larger Dpf to increase the separation between the hazard and the point of detection.

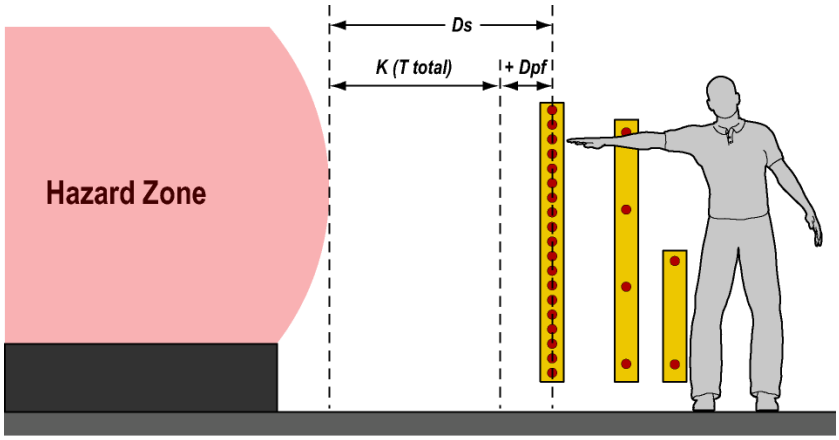
NOTE - Where individuals can place themselves between the safeguarding device and the hazard zone and remain undetected, additional measures must be taken.

Figure D.4: Example of guarding with object sensitivity less than 64 mm (2.5 inches)



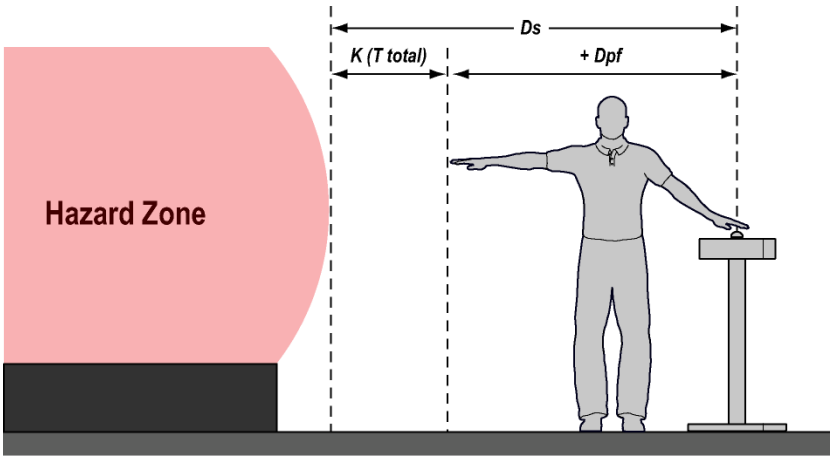
NOTE - Where individuals can place themselves between the safeguarding device and the hazard zone and remain undetected, additional measures must be taken.

Figure D.5: Example of guarding with various object sensitivities



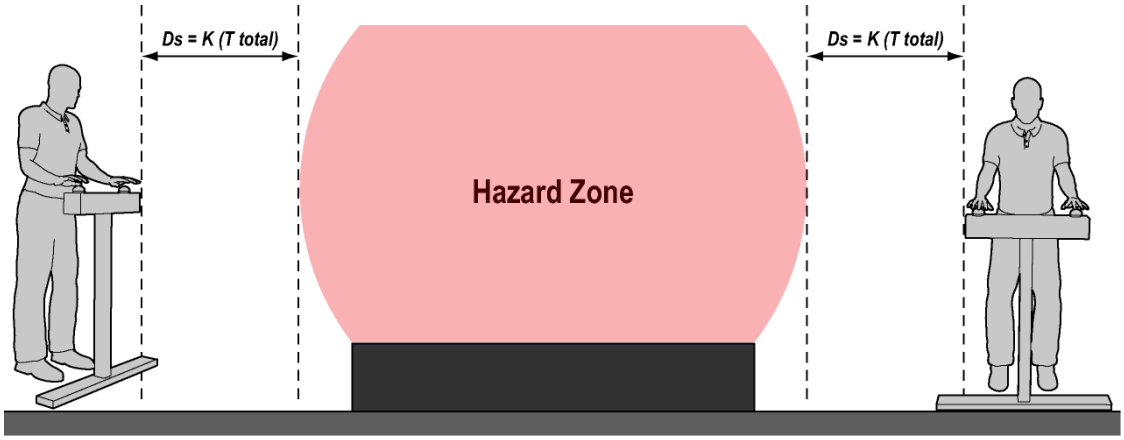
Safety Distance (*Ds*) for devices with a larger value for object sensitivity must be placed farther from the hazard than a device with a smaller value for object sensitivity.

Figure D.6: Single Control Device



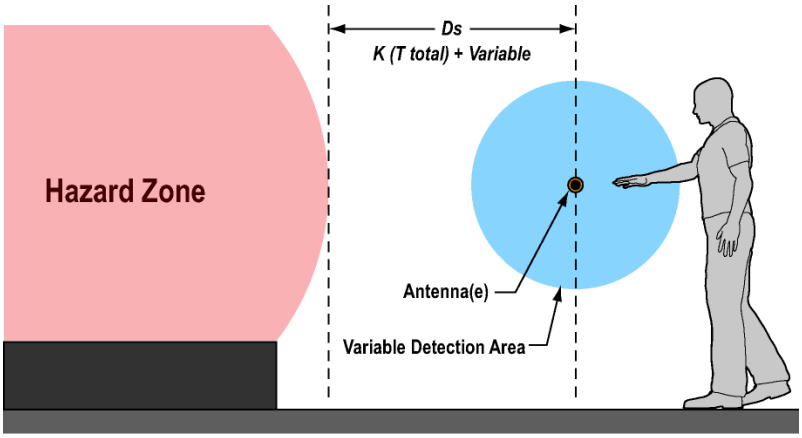
Safety Distance (*Ds*) for a Single Control Device includes a large *Dpf* of 2 meters (6.5 feet) due to the ability of the operator to stand between the device and reach towards the hazard.

Figure D.7: Two-hand Control & Two-Hand Trip Devices



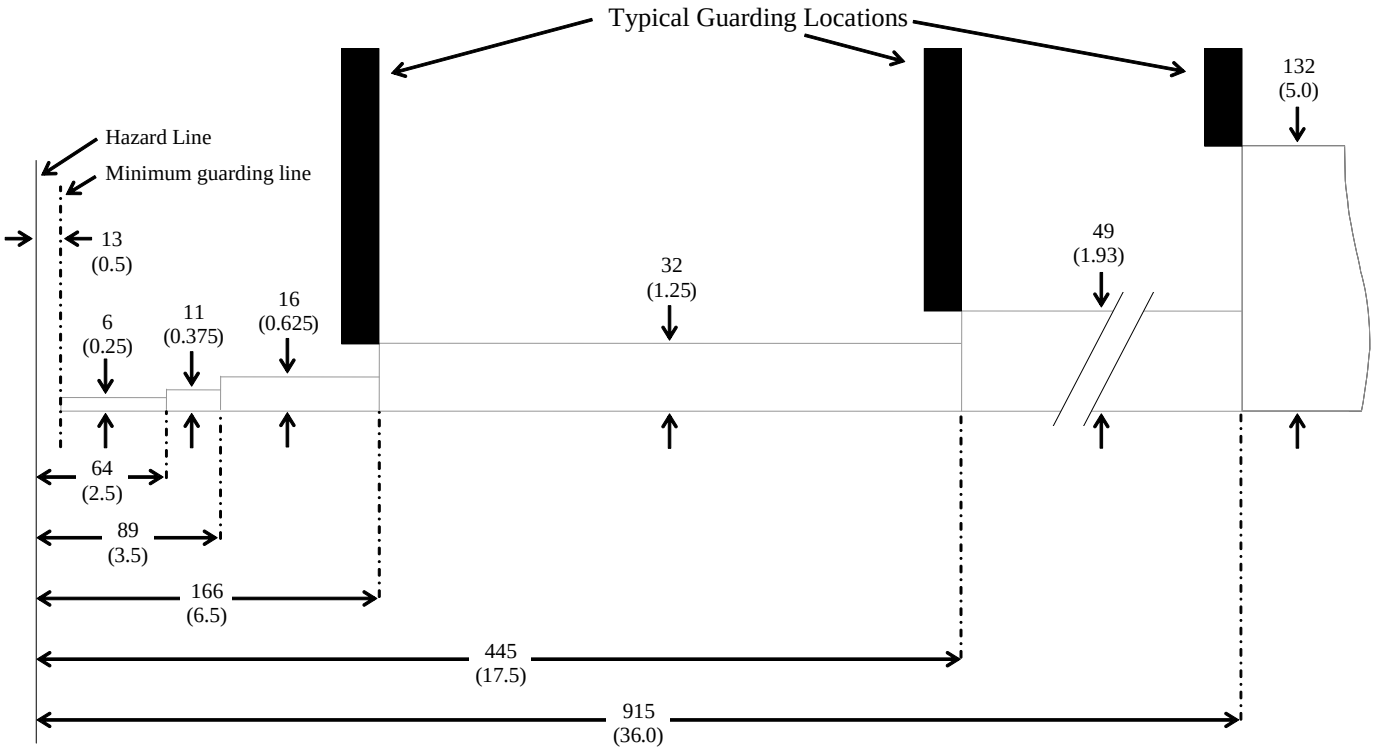
Safety Distance (*Ds*) for Two-Hand Control and Two-Hand Trip applications have a *Dpf* = 0. When used as a safeguarding device, the position must be placed such that the safety distance is measured from the closest hand control to the hazard.

Figure D.8: RF Presence-sensing Devices



The point of detection must take into account fluctuations and variances in the field density and sensitivity due to environmental conditions and physical changes in the work area. This amount must be added to *K(T total)* to determine the total safety distance, *Ds.*

Figure D.9a: Location of Guards vs Slotted Openings; Distance from hazard in millimeters (inches)



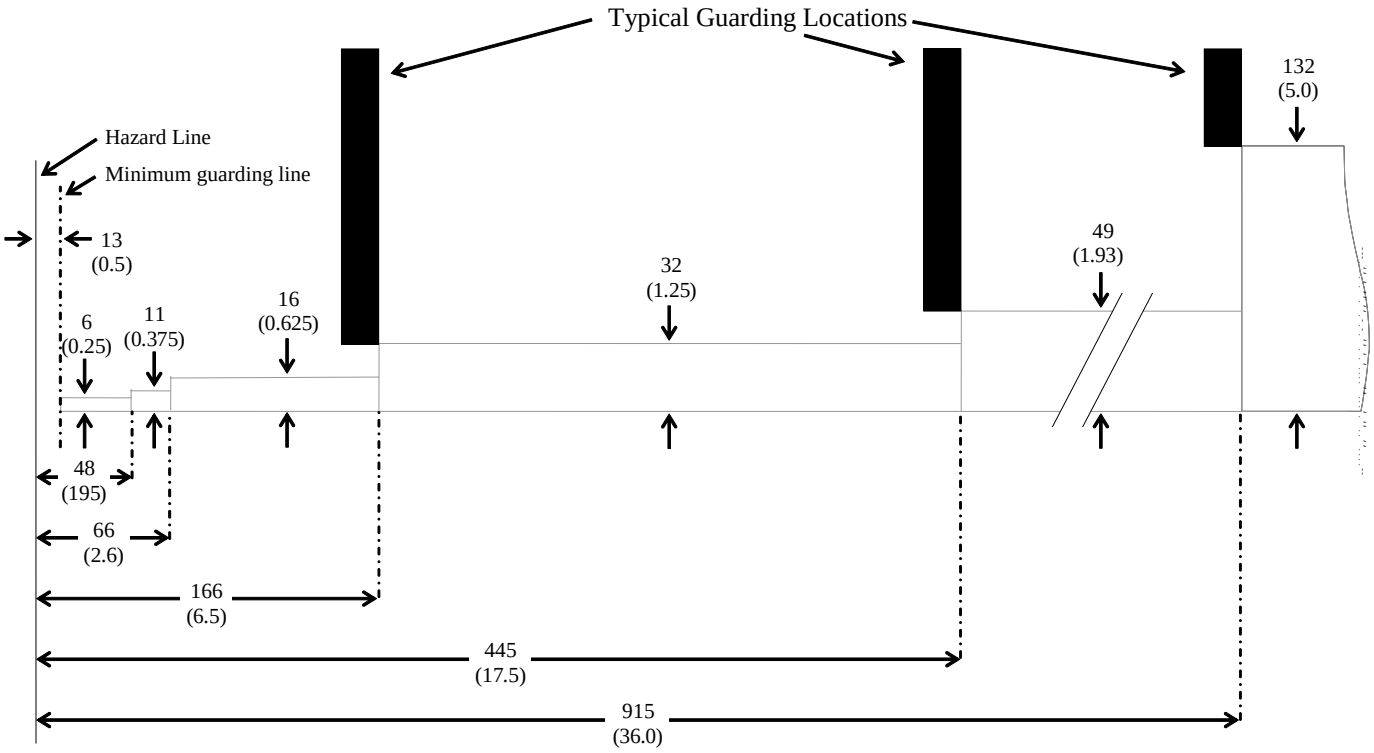
Maximum Guard slotted openings vs. Distance from Hazard Zone in millimeters (inches)

As a function of gap size				As a function of distance			
Known Gap		Minimum Distance		Known Distance		Maximum Gap	
0 – 6	(0 – 0.250)	13	(0.5)	< 13	(< 0.5)	Not permitted	
6.1 – 11	(0.251 – 0.375)	64	(2.5)	13 – 63.9	(0.5 – 2.49)	6	(0.25)
11.1 – 16	(0.376 – 0.625)	89	(3.5)	64 – 88.9	(2.5 – 3.49)	11	(0.375)
16.1 – 32	(0.626 – 1.250)	166	(6.5)	89 – 165.9	(3.5 – 6.49)	16	(0.625)
32.1 – 49	(1.251 – 1.875)	445	(17.5)	166 – 444.9	(6.5 – 17.49)	32	(1.25)
49.1 – 132	(1.876 – 5.0)	915	(36.0)	445 – 914.9	(17.5 – 35.99)	49	(1.875)
> 132	(> 5.0)	See Note below		≥ 915	(≥ 36.0)	See Note below	

NOTE: For guard openings greater than 132mm (5.0”), a risk assessment must determine the appropriate distance from the hazard based on the guard design and human anthropometrics, or see Figure D-10 (reach over distance). These values are not intended to replace the Dpf values listed in Figures D.1, D.2 and D.3.

Based on data presented in *Applied Ergonomics*, Vol. 26, No 22, p.p. 141-145, *A Review of Machine-Guarding Recommendations*, Donald R. Vaillancourt & Stover H. Snook, The Liberty Mutual Research Center for Safety and Health; and Standard Drawing 2063-2, ©1998 Liberty Mutual Group. Used with permission.

Figure D.9b: Location of Guards vs. Square Openings; Distance from hazard in millimeters (inches)



Maximum Guard square openings vs. Distance from Hazard Zone in millimeters (inches)

As a function of gap size				As a function of distance			
Known Gap		Minimum Distance		Known Distance		Maximum Gap	
0 – 6	(0 – 0.25)	13	(0.5)	< 13	(< 0.5)	Not permitted	
6.1 – 11	(0.25 – 0.375)	48	(1.95)	13 – 47.9	(0.5 – 1.88)	6	(0.25)
11.1 – 16	(0.376 – 0.625)	66	(2.6)	48 – 65.9	(1.89 – 2.59)	11	(0.375)
16.1 – 32	(0.626 – 1.25)	166	(6.5)	89 – 165.9	(3.5 – 6.53)	16	(0.625)
32.1 – 49	(1.25 – 1.93)	445	(17.5)	166 – 444.9	(6.54 – 17.49)	32	(1.25)
49.1 – 132	(1.93 – 5.0)	915	(36.0)	445 – 914.9	(17.5 – 35.99)	49	(1.875)
> 132	(> 5.0)	See Note below		≥ 915	(≥ 36.0)	See Note below	

NOTE: For guard openings greater than 132mm (5.0”), a risk assessment must determine the appropriate distance from the hazard based on the guard design and human anthropometrics, or see Figure D-10 (reach over distance). These values are not intended to replace the Dpf values listed in Figures D.1, D.2 and D.3.

Based on data presented in *Applied Ergonomics*, Vol. 26, No 22, p.p. 141-145, *A Review of Machine-Guarding Recommendations*, Donald R. Vaillancourt & Stover H. Snook, The Liberty Mutual Research Center for Safety and Health; and Standard Drawing 2063-2, ©1998 Liberty Mutual Group. Used with permission.

Figure D.9c: Location of Guards vs. Irregular Openings; Distance from hazard in millimeters (inches)
In the case of irregular openings, the following steps shall be carried out in the order given.

a) Determine the dimension (size) of:
   - the width of the narrowest slot opening (#1),or
   - the side of the smallest square opening (#2), into which the opening can be completely inserted

b) b) Select the distance according to either Figure D.9a for #1 or Figure D.9b for #2.

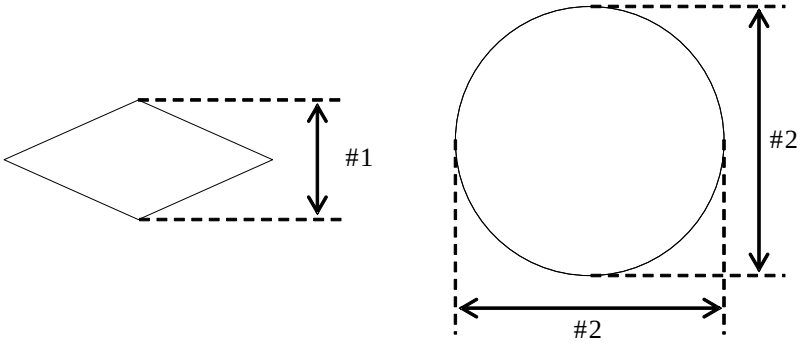
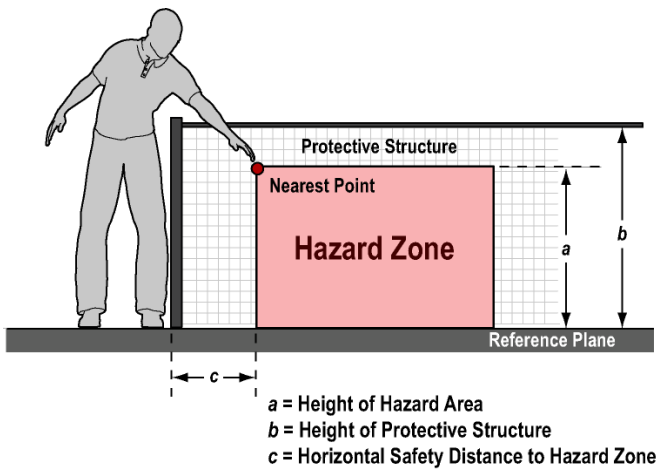
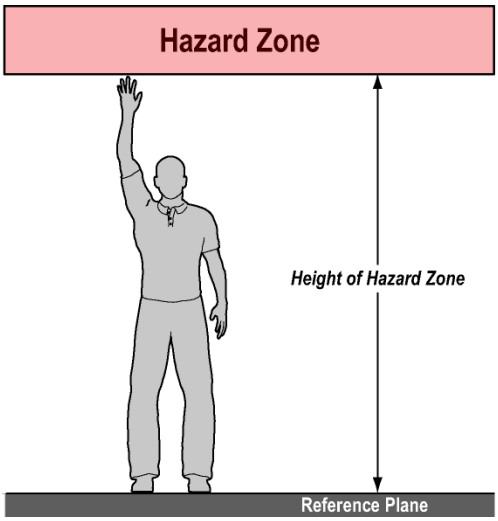


Figure D.10: Location of Guards vs. Distance from hazard in millimeters (inches)
The following values are considered to be minimum reach over distances and may reduce the probability of inadvertent access, but may not prevent intentional access to the hazard (see 9.1 on awareness barriers). Depending on a risk assessment, different set back (safe) distances or structure height may be required. Although the below tables start at a minimum height of a 1000 mm (39”), lower heights may be suitable for certain applications as determined by a risk assessment. See also ISO 13857.

A protective structure can be a guard, awareness barrier, or other physical obstruction (e.g., a part of a machine) which restricts or impedes the movement of an individual toward the hazard. These values are not intended to replace the Dpf values listed in Figures D.1, D.2 and D.3. The recommended distances in the below tables have been derived by making the following assumptions (from ISO 13857):

- the protective structures and any openings in them retain their shape and position;
- recommended distances are measured from the surface restricting the relevant part of the body;
- persons may force parts of the body over protective structures or through openings in an attempt to reach the hazard zone;
- the reference plane is a level at which persons would normally stand, but is not necessarily the floor (e.g., a working platform could be the reference plane);
- there is some contact with the reference plane (climbing and jumping are not included);
- no aids such as chairs or ladders are used to change the reference plane;
- no aids such as rods or tools are used to extend the natural reach of the upper limbs that may reach or become entangled with the hazard.





Reaching over protective structures — Low risk

Source ISO 13857 (2008) - Dimension in millimeters

Height of hazard Zone 2 a	Height of protective structure 1 b									
	1 000	1 200	1 400	1 600	1 800	2 000	2 200	2 400	2 500	2 700
	Horizontal safety distance to hazard zone c									
2 500	0	0	0	0	0	0	0	0	0	0
2 400	100	100	100	100	100	100	100	100	0	0
2 200	600	600	500	500	400	350	250	0	0	0
2 000	1 100	900	700	600	500	350	0	0	0	0
1 800	1 100	1 000	900	900	600	0	0	0	0	0
1 600	1 300	1 000	900	900	500	0	0	0	0	0
1 400	1 300	1 000	**900**	800	100	0	0	0	0	0
1 200	1 400	1 000	900	500	0	0	0	0	0	0
1 000	1 400	1 000	900	300	0	0	0	0	0	0
800	1 300	900	600	0	0	0	0	0	0	0
600	1 200	500	0	0	0	0	0	0	0	0
400	1 200	300	0	0	0	0	0	0	0	0
200	1 100	200	0	0	0	0	0	0	0	0
0	1 100	500	0	0	0	0	0	0	0	0

[1] Protective structures less than 1 000 mm (39”) in height are not included because they do not sufficiently restrict movement of the body.

[2] For Safe Location Safeguarding (clause 10.4a) the hazard is 2500 mm or greater vertical distance above reference plan (e.g., floor).

Reaching over protective structures — High risk

Source ISO 13857 (2008) - Dimension in millimeters

Height of hazard Zone 2 a	Height of protective structure 1 b									
	1 000	1 200	1 400	1 600	1 800	2 000	2 200	2 400	2 500	2 700
	Horizontal safety distance to hazard zone c									
2 700	0	0	0	0	0	0	0	0	0	0
2 600	900	800	700	600	600	500	400	300	100	0
2 400	1 100	1 000	900	800	700	600	400	300	100	0
2 200	1 300	1 200	1 000	900	800	600	400	300	0	0
2 000	1 400	1 300	1 100	900	800	600	400	0	0	0
1 800	1 500	1 400	1 100	900	800	600	0	0	0	0
1 600	1 500	1 400	1 100	900	800	500	0	0	0	0
1 400	1 500	1 400	1 100	900	800	0	0	0	0	0
1 200	1 500	1 400	1 100	900	700	0	0	0	0	0
1 000	1 500	1 400	1 000	800	0	0	0	0	0	0
800	1 500	1 300	900	600	0	0	0	0	0	0
600	1 400	1 300	800	0	0	0	0	0	0	0
400	1 400	1 200	400	0	0	0	0	0	0	0
200	1 200	900	0	0	0	0	0	0	0	0
0	1 100	500	0	0	0	0	0	0	0	0

[1] Protective structures less than 1 000 mm (39”) in height are not included because they do not sufficiently restrict movement of the body.

Protective structures lower than 1 400 mm (55”) should not be used without additional safety measures.

[2] For Safe Location Safeguarding (clause 10.4a) the hazard is 2700 mm or greater vertical distance above reference plan (e.g., floor).

Annex E – Considerations for Transparent Guards
(Informative)

Context

Vision panels have been successfully used in a very wide range of applications, particularly where tasks require personnel to see machinery operations inside a guard. Vision panels are made from a variety of different plastic and glass materials each with different performance characteristics. Although all vision panels allow viewing through the panel, there are many differences in the panels and applications of use. Some panels perform as shields keeping fluids, machining chips, swarf, noise, etc inside the shield and prevent inadvertent contact by persons, dust, contaminants, ventilation, etc outside the shield. Other panels are designed as guards that prevent exposure to a hazard and to prevent harm associated with ejected parts or tooling. Some machinery suppliers intentionally design their machinery to include shields and not guards, emphasizing the need to prevent material ejection. Vision panels that are not used as transparent guards or shields are not addressed in this Annex. This Annex pertains to transparent guards constructed in part of plastic (such as polycarbonate, acrylic, PETG [glycol-modified polyethylene terephthalate], CAB [Cellulose Acetate Butyrate], etc.) where parts or tooling ejection is a concern and the performance of the panels are subject to degradation (material strength/integrity and visibility) from one or more environmental causes. Transparent guards constructed partly or entirely of glass (e.g., standard/regular, tempered, tempered with wire, safety glass with plastic laminate, etc.) have similar considerations, but typically have lower reactivity to environmental influences. See 7.1.1, 7.1.5 and 7.1.5.1.

Primary risk reduction method

The primary method to reduce the risk of harm from parts or tooling ejection is to prevent the ejection. Operating a machine beyond the intended operating limits for a given part, tool or clamping device constitutes misuse and must be avoided. Many serious injuries associated with transparent guards involve misuses where machines are operated at excessive speeds for the part size, shape, mass, tool, operation, and/or clamping system. Yet other instances occur which cannot be completely prevented such as tooling fracture, and this Annex addresses performance characteristics of certain transparent guards as an additional measure to minimize the risk of harm.

Background

Plastic (such as polycarbonate) panels have physical properties which can degrade over time when exposed to environmental influences such as exposure to ultraviolet or visible light, swarf, coolant, lubricants, or cutting fluids. Unexpected failure of the polycarbonate panel, or similar material, used in the construction of transparent guards, shields, or vision panels can result in harm to individuals and damage to the machine or surrounding structure. Note that when vision panels are used to protect individuals they are considered transparent guards (see 3.89 and 7.1.5).

There have been reports of incidents causing injury where polycarbonate panels used as transparent guards that were unable to contain tooling, broken cutters, swarf and work pieces thrown from the machinery; such as occurs with a tool/cutter breakage, work piece release, part rupture, etc. The deterioration of polycarbonate panels is very complex, and is impacted by many different variables including size, shape, exposure to abrasive coolants, exposure to chip impacts (swarf), age, modification of the vision panel, coatings applied to the vision panel, etc.

In order to ensure that transparent guards when constructed from material such as polycarbonate continue to provide the protection originally intended, they must be designed to compensate for the environmental influences that can degrade their performance or be replaced on a periodic schedule. The periodic replacement schedule should be established based on the use, the environment, age of the panel and by information provided by the original equipment (machine, shield, vision panel or transparent guard) manufacturer/supplier.

The intended level of protection provided by transparent guards is also influenced by the manner of its installation. Connection methods to surrounding sheet metal should satisfy the requirements of low-stress installation, large-surface load transmission, and elasticity necessary to allow the transparent panel to perform as intended to contain impact energy.

Risk

Catastrophic failure of tooling fixtures, cutters or work pieces can, and does, occur. The severity of potential harm is serious because a high velocity projectile has significant energy. However, the probability of the occurrence of harm is low if the transparent guard (vision panel) has been designed to contain the hazard, installed correctly, and maintained properly.

The protective measures provided should be in proportion to the risk. For this reason, adopting a policy solely based on replacement intervals is not recommended as it is not directly related to risk. However, periodic replacement of transparent guards can be used to maintain an acceptable risk level as established by the risk assessment. The cost of replacing or upgrading transparent guards can be significant. Upgrading vision panels

to the fully laminated type is not necessarily required and alternative methods can be adopted. The costs of upgrading should not be incurred unnecessarily and there are circumstances when the user could establish that no further action is required to control the risk.

As polycarbonate panels deteriorate, the probability of the occurrence of harm increases depending on the level of degradation. Four effects are: crazing (cracking), opaqueness, diminished strength and embrittlement, which decrease the effectiveness of the polycarbonate panel as a guard. This deterioration can create an unacceptable risk.

Effects of coolants, solvents and other environmental issues

Polycarbonate is a member of a family of thermoplastic polymers and is well suited for use in transparent guards, shields and vision panels due to high impact resistance to fracture by shock loading. This resistance is generally expressed as the impact strength of the polymer and determined by test, such as the Izod impact test (ASTM D256), the Charpy impact test (DIN 53453), or ISO 23125 Annex B "Impact test method for guards on turning machines."

The physical properties can vary depending on the manufacturer of the polycarbonate panel. Brand names include, but are not limited to, Makrolon®, Dynaglas®, Lexan®, Makrolife®, and Calibre™. The manufacturer may incorporate additives and coatings that can affect the properties of the panel. The manufacturer/supplier of the transparent guard must take into account all factors that will affect the performance of the guard. Factors include, but are not limited to:

- impact strength;
- additives or coatings (e.g., ultraviolet stabilizer);
- chemical resistance;
- toughness (the ability of a material to withstand shock loading);
- ductility (the ability to be deformed by elongation, without fracture);
- flammability and smoke emission.

It should be noted that surface coatings may not prevent the effects of aging (e.g., crazing and embrittlement).

The primary concern with the use of polycarbonate in transparent guards (vision panels) is the loss of the impact strength over time due to exposure to ultraviolet (UV) light, various chemicals in the industrial environment, and impact damage that creates scratches, cracks, dents, crazing and holes. Polycarbonate with an ultraviolet stabilizer additive provides good protection against the effect of UV light from sources like sunlight.

Research by various organizations, such as the German Institute for Occupational Safety and Health (BGIA); have shown that the impact resistance of unprotected polycarbonate can degrade significantly over time with exposure to common metal cutting fluids (see Figure E.1).

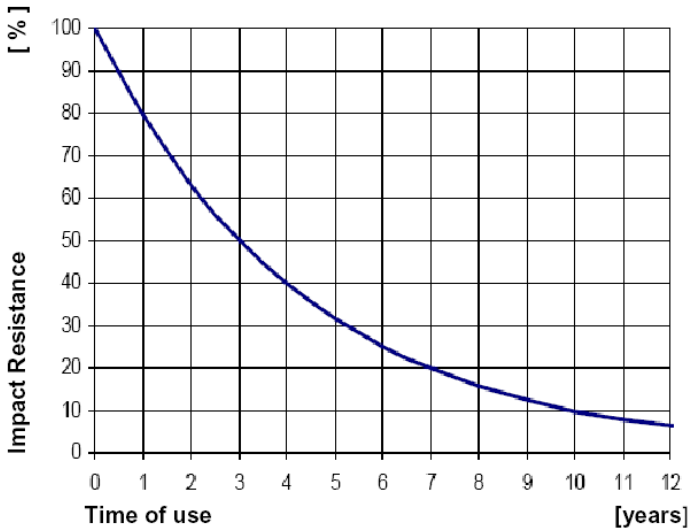


Figure E.1 Ageing curve of unprotected polycarbonate (averaged test points) From ISO 23125.

Note: This data pertain to a particular polycarbonate with particular characteristics tested in a research application. Exercise care in attempting to extrapolate these results to other materials (e.g., acrylics, glass, PETG, CAB, etc.).

Exposure to substances such as coolants, lubricants, hydraulic/pneumatic fluids, metalworking/cutting fluids, swarf and the chemical resistance (compatibility) of the polycarbonate with these substances must be evaluated by the user. The manufacturer (supplier) of the polycarbonate panel or the transparent guard should be able to provide an analysis of the effects of various chemicals. Many manufacturers also provide testing services to identify the chemical compatibility of a specific substance.

Reduction of impact resistance due to crazing and embrittlement of polycarbonate depends mainly on the chemical, the contact time, temperature and stress (applied external force). Chemical incompatibility can also result in discoloration, softening, or swelling of the polycarbonate. Various chemicals have differing effects, and the combination of factors (metal chips, light and multiple chemical mixtures) can accelerate the degradation.

BGIA research also determined that there was only marginal loss of the impact resistance if the polycarbonate was protected from environmental factors (see “Design and Construction recommendations” below).

Impact damage from sources like flying metal chips or swarf, rubbing or vibration, abrasion and incidental contact can cause scratches, cracks, crazing, dents and holes that will allow the ingress of fluid or other contamination that could accelerate the ageing process and reduction of impact resistance. Where practicable, flying material should be deflected or otherwise protect the transparent guard from impact.

Problem complexity

The design and construction of transparent guards is a complex problem which is not well understood. The plastic materials used, the guard design and construction, the method of installation, the chemicals and solvent exposures, the UV and environmental conditions, physical contact of chips or swarf, care and maintenance, and other factors all combine to impact the performance of the transparent guards over time. The influence of these combined factors is a subject of current research worldwide. Unfortunately, the characteristics of a particular application play a very large role in predicting panel degradation, further complicating the design challenges. For this reason the machinery specific standards should contain additional guidance for applying transparent guards for specific machinery. Fortunately, some general design and construction guidelines can be offered.

Known incident descriptions

Reports of injury relating to transparent guards have resulted from:

- parts or tooling ejected through transparent guards (the panel fractures);
- panels separating from the frame (the panel remains intact but injury results from the panel impacting the individual);
- doors or structures separating from the machine structure (the panel remains intact but injury results from the door impacting the individual);
- spall (shards) from exterior glass ejected during impact (the panel remains intact but exterior glass shards impacting the individual).

Three different incidents illustrate typical occurrences.

Scenario #1: A machine operator detects that something unusual is occurring with a machine in operation. The operator moves to the vision panel to better understand or diagnose the problem which is located to provide the best viewing possible but also has the highest exposure to the hazard. At that time a tool or part ruptures sending metal shards flying into the vision panel. The aged, embrittled panel does not stop the projectile resulting in an injury. In this instance the operator is drawn to the hazardous area by the visibility afforded by the vision panel.

Scenario #2: With larger vision panels, the operator is not necessarily drawn to a specific location. When a tool or part ruptures it may pierce an aged or embrittled vision panel. Although the exposure to harm is less focused in this scenario, the inability to contain the released tool or part can still result in significant injury.

Scenario #3: The viewing panel is opaque or otherwise does not afford as clear a view of the workpiece/tooling as desired. The operator opens the panel to gain a better view. A rupture of the tooling or part ejection occurs through the opening.

Design and construction recommendations

As with all risk reduction measures, the risk assessment process should be used to guide efforts to achieve acceptable risk on machinery incorporating transparent guards. As with all guards, the material used to construct the guard must be designed to be of sufficient strength as to protect individuals from identified hazards.

The guard may also be required to protect the machine and other structures. When a transparent guard is constructed from polycarbonate (or other clear plastic material) there are two primary options:

- protect the clear plastic material from the environmental influences that can degrade performance; or
- over-design (e.g., increase thickness) the clear plastic material panel to take into effect the expected degradation and then replace the transparent guard on a periodic schedule.

Polycarbonate's high impact strength makes it a good choice for a transparent guard, but to ensure this physical property, the polycarbonate must be protected from the chemicals, light, swarf and other environmental factors that would otherwise degrade that strength.

Means to protect the polycarbonate is typically done by providing layers of dissimilar materials and then sealing the periphery edges completely. This sealed, multi-layer or laminated construction will maximize the physical properties of each of the materials (see Figure E.2). Typical exterior materials include polyethylene terephthalate (PET) and polymethylmethacrylate (PMMA). Glass, when used as a component of multilayer construction, should be used on the interior surface only, in order to prevent glass from being ejected from exterior glass surface during impact. The interior and exterior material is primarily chosen for chemical compatibility and the polycarbonate is chosen for good impact strength.

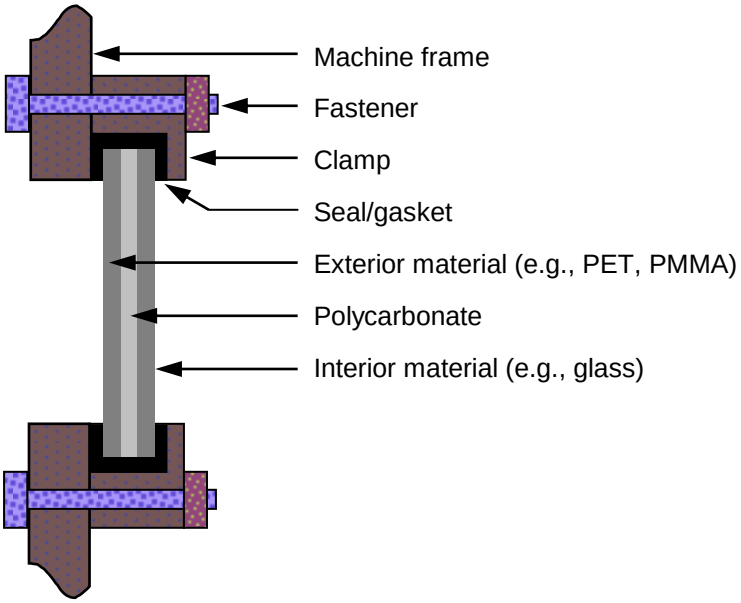


Figure E.2 Typical construction of a multi-layered transparent guard (Note: Not to scale)

Multi-layered transparent guards are typically two or three layers. In two-layered guards, the exposed polycarbonate (operator's side) still must be protected from exposure of degrading environmental influences. In three-layered guards, the inside surface of the panel is often tempered glass that will absorb energy (shatter) in the event of an impact yet protect the polycarbonate inner layer from chemical, environmental and ambient hazards. At a minimum, maintenance personnel must be trained and understand manufacturers/suppliers installation requirements, maintenance procedures and cleaning instructions.

The other primary means of addressing degrading impact strength is by over-sizing the thickness of the polycarbonate panel and then replacing the transparent guard on a periodic schedule. As an example, if a polycarbonate panel was expected to absorb a relatively light impact of 1500 J of energy, a 6 mm (0.25") thick panel would be required (if not exposed to degrading chemicals or environmental factors). Assuming that Figure E.1 is an accurate representation of the degradation for the application, a designer would have to install a 12 mm (0.5") thick panel and have it replaced after 3 years when the impact resistance is expected to be 50% of the initial value. See ISO 23125 for further information.

Research has also shown that several thin polycarbonate panels laminated together achieves a better impact resistance than using one single panel of the same thickness. Experience has shown that special attention is necessary in constructing a multi-layered transparent guard. The weak link of the transparent guard may be the materials, the assembly of the materials, the seal around the materials, the means to secure the guard to the door or structure, or the hinges or attaching mechanisms of the door or structure. When designing and constructing a multi-layered guard, special attention is required to evaluate the weak link in the system.

It is important not to drill holes, bevel, rabbit, or otherwise machine the polycarbonate (unless the machining has been appropriately over-sized and sealed to prevent stress and ingress of fluids). Mounting should be via a clamping mechanism specialized mounting hardware (such as PTFE/Teflon® bolts and sleves) or adhesive to distribute the holding force over as wide of a surface area as possible. Adequate allowance for expansion and contraction must also be considered.

The polycarbonate panel must also overlap the frame, machined part or hole such that it is not forced through the opening and actually becomes a hazard itself (e.g., as a projectile). ISO 23125 (Machine tools – Safety - Turning machines) recommends that for a 450 mm x 450 mm opening (16" x 16"), a minimum overlap of 40 mm (1.6") for a 8 mm (0.3") thick panel and a minimum overlap of 25 mm (1") for a 12 mm (0.5") thick panel. For openings of other sizes, the overlap must be increased or decreased accordingly.

Application of close fitting metal grills, or surrounding sheet metal enclosures having multiple surface perforations as an outside layer to transparent panels, is not recommended as they interfere with the ability of the polycarbonate panel to transmit impact energy over the largest possible load surface. As an example, in impact testing, test panels measuring 500 mm square exhibited flexure of up to 200 mm without failure of the panel. Restraining the panel increases stresses and concentrates the impact energy to a small area, substantially decreasing the impact resistance of the transparent guard.

Other possible solutions to address the loss of impact strength include, but are not limited to:

- locate the vision panel away from the expected path of the projectile;
- the use of mirrors so that the vision panel is not in the expected path of a projectile;
- the use of video/vision equipment in combination with a guard to replace the transparent guard;
- screening or other reinforcement on the interior of the transparent guard (periodic replacement may still be required);
- the use of specialty viewing ports.

Testing and visual inspections

Unfortunately, the impact strength characteristics of polycarbonate (and other plastics) vision panels cannot be determined by visual inspection alone. The lack of damage, crazing, cracking, discoloration, or other visually detectible changes in the panels may not reliably indicate the need for replacement.

The conditions listed below are some visual indications that damage may have occurred. A vision panel should be immediately replaced if there are obvious defects.

- Cracks and Scratches
  - Inspect for thin long crazes and cracks;
  - Inspect for visible scratches, pits, gouges, scoring and similar damage.
- Holes
  - There should not be any holes, unless provided by the manufacturer/supplier.
- Bulges or dents caused by an impact event(s)
- In the case of multi-layered transparent guards:
  - Damage to the edge sealing;
  - Fluid penetration into the composite design;
  - Damaged or destroyed protective layer;
  - Delamination of panel layers; or
  - Bubbles in interlayer adhesives (urethane).
- Other appearance changes
  - Frosting;
  - Hazing;
  - Whitish or yellowing appearance, or other discoloration.

See the following for information on methods to test polycarbonate panels

- Charpy Impact Test (DIN 53453);
- Izod Impact Test (ASTM D256);
- ISO 23125 Machine tools - Safety - Turning machines: Annex B and C.

Instruction for use and labeling

Manufacturer/supplier instructions for use for transparent guards should include (at a minimum):

- Recommended cleaning compound and procedure;
- The frequency of visual inspections;

- Inspection method, process or procedure;
- Description of defects or damage that require replacement (see above for examples);
- Any other recommendations for the replacement of the transparent guard (vision panel);
- Installation (replacement) or assembly instructions;
- Recommendations to assist the user in developing a replacement schedule.

Transparent Guards that are constructed solely from polycarbonate, or other similar materials, should be labeled on the operator's side stating:

- Installation date and scheduled replacement date;
- The material that the guard is constructed of (including coatings);
- The thickness of the material; and
- Identification of the product (brand name), if known.

Additional information/resources

There is an abundance of information on polycarbonate degradation available on the internet. The supplier of the transparent material should be able to provide guidance on the application of their material to a specific guarding application. Contact the supplier where practicable. The panel or machine supplier should also have information that may be useful.

Research studies and other documents to reference include but are not limited to:

- BIA Project 6054;
- HSE E33;
- ISO 23125;
- ASTM D256;
- DIN 53453

Annex F – Applications and Attributes
(Informative)

The safeguarding and complementary devices described in the following chart, with the applications and attributes of each, are NOT intended as an all-inclusive list, but merely as additional information or guidance on some potential uses and capabilities of each.

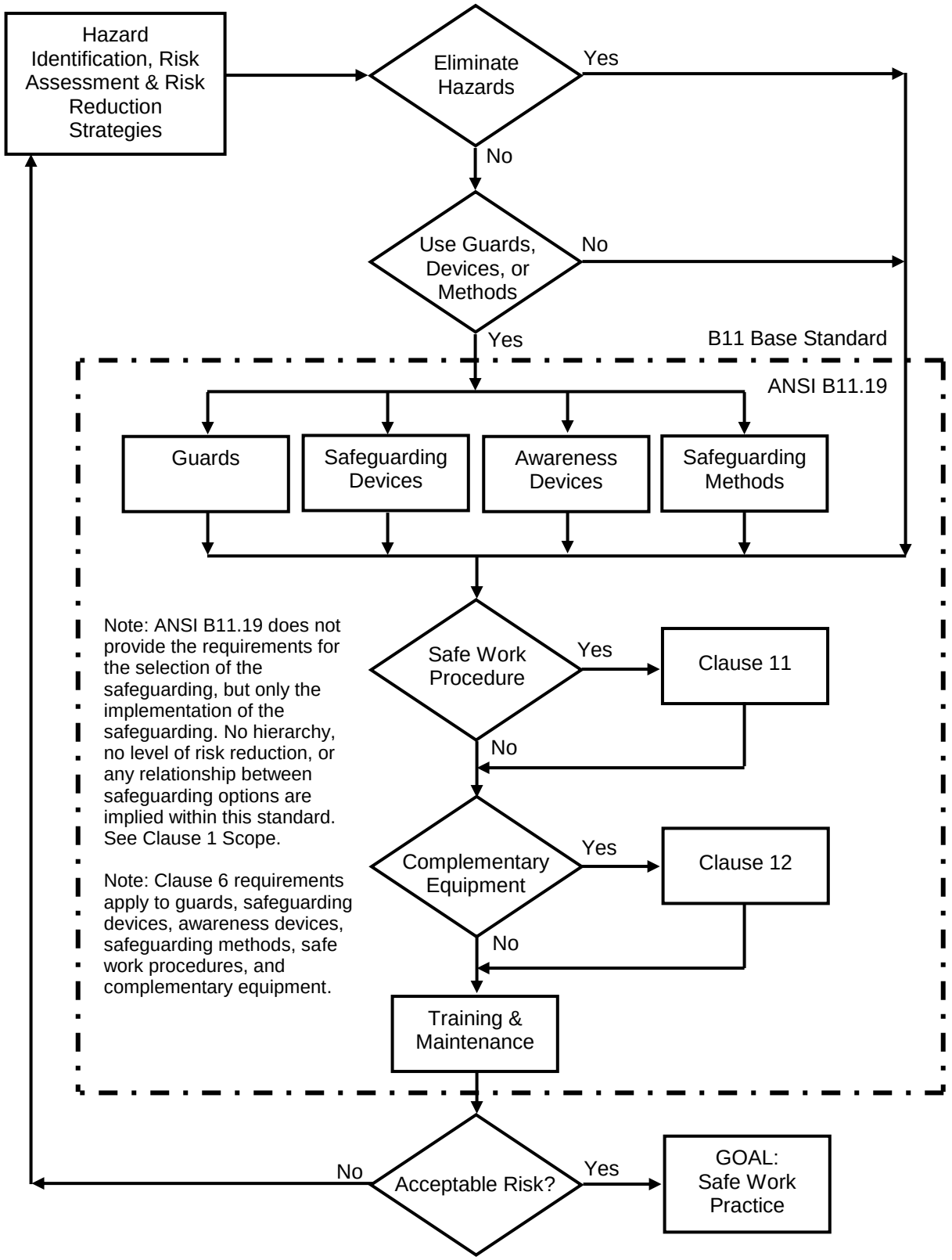
Safeguarding	Application(s) for safeguarding hazard zones where:	Attribute(s)
Shields	• necessary to contain chips or coolant; • necessary if there is significant risk for the ejection of broken tooling or workpiece fragments. Dependent on design and construction, a shield can reduce the risk of ejection of broken tooling or workpiece fragments.	• protects individuals in the vicinity of the hazard zone being guarded; • independent of any interaction with the individual(s) being guarded; • individuals may have the ability to reach around the shield; • secured by means which may or may not require the use of tools to remove or open.
Fixed guard	• access to the hazard zone is prevented; • used when infrequent access is required.	• protects individuals in the vicinity of the hazard zone being guarded; • prevents a body part from reaching the hazard zone; • prevents access by the location and size of the guard slot or opening; • prevents a body part from reaching through the guard slot or opening even when the material, workpiece, or scrap is not present; • secured by means which requires the use of tools to remove; • independent of any interaction with the individual(s) being guarded unless they remove it.
Interlocked guard	• access to the hazard zone for servicing is routine, repetitive, and integral to the use of the machine.	• protects individuals in the vicinity of the hazard zone being guarded; • independent of any interaction with the individual(s) being guarded; • interrupts or prevents the machine cycle whenever the interlock detects an open condition allowing access.
Adjustable guard	• access to the hazard zone is prevented; • allows adjustment to accommodate various tooling or production set-ups, in and out feed of material or other process variables.	• protects individuals in the vicinity of the hazard zone being guarded; • prevents access by the location of the adjustable guard; • prevents a body part from reaching through the adjustable guard slot or opening when the material, workpiece, or scrap is not present; • independent of any interaction with the individual(s) being guarded; • depends on the training and supervision of set-up personnel for effective guarding.

Safeguarding	Application(s) for safeguarding hazard zones where:	Attribute(s)
Type A Movable barrier device	• access to the hazard zone is routine and repetitive during normal operation of the machine.	• protects individuals in the vicinity of the hazard zone being guarded; • encloses hazardous area for the full operation as long as any motion or hazard exists; • contains material and hazards; • decreases machine productivity as it may increase the time required to complete a production cycle.
Type B Movable barrier device	• access to the hazard zone is routine and repetitive during normal operation of the machine • typically used on cyclic or single cycle machines.	• protects individuals in the vicinity of the hazard zone being guarded; • contains material and hazards; • decreases machine productivity as it may increase the time required to complete a production cycle, but not as much as Type A.
Pullback (pull out) devices	• access to the hazard zone is necessary during normal operation of the machine.	• protects only the individual(s) using the device; • provides no obstruction between the operator(s) and the operation being performed; • depends on the training and diligence of the operator, set-up and supervisory personnel; • can cause additional hazards due to misuse.
Presence-sensing devices	• access to the hazard zone is necessary for the manufacturing process during normal operation of the machine • prevents normal operation of the machine if a body part is sensed by the device.	• protects all individuals from the guarded hazard; • provides no physical obstruction between an individual and the operation being performed; • independent of any interaction with the individual(s) being guarded.
Single trip device	• access to the hazard zone is necessary for the manufacturing process during normal operation of the machine.	• protects only the individual operating the device; • actuation of the trip control is momentary and does not require continuous contact; • actuation causes one complete machine cycle whenever the trip controls are momentarily actuated; • provides no obstruction between the operator and the operation being performed; • requires placement at a safe distance which may affect productivity.
Restraint device	• access to the hazard zone is necessary during normal operation of the machine	• protects only the individual(s) using the device; • provides no obstruction between the operator(s) and the operation being performed; • depends on the training and diligence of the operator, set-up and supervisory personnel; • can cause additional hazards due to misuse.

Safeguarding	Application(s) for safeguarding hazard zones where:	Attribute(s)
Drop probe device	• prevents normal operation of the machine if an object is detected by the device; • access to the hazard zone is necessary during normal operation of the machine.	• protects all individual(s) from the guarded hazard; • depends on the training and supervision of set-up personnel for effective safeguarding.
Two-hand control device	• access to the hazard zone, by one or more individuals is necessary during normal operation of the machine;	• protects only the individual(s) operating the device(s); • actuation of the control device(s) is continuously required during the hazard portion of the machine cycle; • interrupts the hazardous portion of the machine cycle whenever the control device is released; • provides no obstruction between individual(s) and the operation being performed; • requires placement at a safe distance which may affect productivity.
Two-hand trip device	• access to the hazard zone, by one or more individuals is necessary during normal operation of the machine.	• protects only the individual(s) operating the device(s); • provides no obstruction between any individual(s) and the operation being performed • actuation of the trip control is momentary and does not require continuous contact; • actuation causes one complete machine cycle after the trip controls are momentarily actuated; • requires placement at a safe distance which may affect productivity.
Single control device	• access to the hazard zone is necessary for the manufacturing process during normal operation of the machine.	• protects only the individual operating the device; • actuation of the control device is required during the hazard portion of the machine cycle; • interrupts the machine cycle whenever the control device is released; • provides no obstruction between the operator and the operation being performed; • requires placement at a safe distance which may affect productivity.
Awareness barriers	• access to the hazard zone may be necessary for the manufacturing process during operation of the machine.	• alerts an individual of or defines a transition between a safe area and a hazardous area; • depends on interaction of the individual(s) being guarded.
Awareness signals	• warns individuals of an impending or approaching hazard.	• alerts individuals by a audible or visual signal; • depends on interaction of the individual(s) being guarded.
Awareness signs	• alerts individuals to the process by providing information about the hazard.	• depends on interaction of the individual(s) being guarded.

Safeguarding	Application(s) for safeguarding hazard zones where:	Attribute(s)
Safe-distance safeguarding	• positioning of the workpiece and the operator location eliminates the need for an operator to be in or near the hazard zone during the hazardous portion of the machine cycle.	• protects only the operator who is constrained to maintain a position at a safe distance from the hazard zone; • dependent on the interaction of the individual with the workpiece; • depends on the training and supervision of set-up and supervisory personnel.
Safe-holding safeguarding	• access to the hazardous area during the hazardous portion of the machine cycle is prevented by requiring that both hands are used to hold or support the workpiece, or by requiring that one hand holds the workpiece while the other hand operates the machine, such as a hold-to-run device.	• protects only the operator(s) who are required to hold the workpiece with both hands outside of the hazard zone during the hazardous portion of the machine cycle; • depends on interaction with the individual(s) being safeguarded; • depends on the training and supervision of set-up and supervisory personnel.
Safe-opening safeguarding	• access to the hazard zone is prevented when the workpiece is in place, extending through a guard during normal operation of the machine.	• protects individuals from the hazard being safeguarded only when the workpiece is in place; • independent of any interaction of the individual(s) being safeguarded.
Safe work procedures	• exposure to a hazard may be reduced by procedures: • where tasks are complex; • where tasks have high risk; • where training, skill or work experience is limited • where other safeguarding is removed, bypassed or cannot be used • where required to augment other safeguarding. • are developed and used to identify and describe a safe work practice to implement the task(s) to be performed in a safe manner.	• depends on interaction with the individual(s) being guarded • depends on the training and supervision of set-up personnel for effective guarding.

Annex G – Safeguarding Flowchart
(Informative)



Annex H – Outline of Protective Measures
(Informative)

This annex presents an outline of different Protective Measures and whether the Supplier (S) or the User (U) is typically responsible for implementing them. The following is a non-inclusive list of terms found in ANSI B11.19. This list is informative only with no implication of priority or effectiveness.

Protective Measures / Risk Reduction Measures (Supplier and User)

Inherently Safe Design Measures (Supplier)

Safeguarding/Safeguards (Supplier and User)

Guards
- Fixed
- Interlocked (with or without locking mechanism)
- Adjustable

Safeguarding devices
- Movable barrier devices
- Pull Back (pull out) and restraint devices
- Electro-optical presence-sensing safeguarding devices
  - Safety Light Curtains (Screens)
  - Safety Single/Multiple Beam devices
- RF presence-sensing safeguarding devices
- Area scanning presence-sensing safeguarding devices
- Two-hand operating lever, trip and control devices
- Safety mat devices
- Safety edge devices
- Single control safeguarding devices

Awareness devices
- Awareness barriers
- Awareness signals
- Awareness (safety) signs

Safeguarding methods
- Safe-distance safeguarding
- Safe-holding safeguarding
- Safe-opening safeguarding
- Safe-location safeguarding

Complementary Equipment and Measures (Supplier)
- Emergency Stop Devices
  - Palm/Push Buttons
  - Rope/Cable Pull
- Safety blocks, locking pins, limiting/blocking pins
- Slide locks
- Workholding equipment
- Stopping performance monitor
- Process malfunction, detection and monitoring equipment
- Hand tools
- Safety interface (safety relay) modules
- Safety PES/PLC, safety controllers (including the safety-bus systems)
- Shields
- Enabling devices
- Hold-to-run controls
- Measures for the escape and rescue of trapped persons
- Measures for isolation and energy dissipation
- Provisions for easy and safe handling of machines and their heavy component parts
- Measures for safe access to machinery

Information for Use (Supplier and User)
- Signage/Awareness means
- Instructions/Manuals

Organizational (User)
- Safe Work Procedures
- Supervision
- Permit-to-work systems

Personal Protective Equipment (User)

Training (User)

***Informative Note**: A safeguarding device is different than the protective device as defined in ANSI/ISO 12100.*

Annex I – Safety Solutions in Use
(Informative)

The following list, while extensive, is not all inclusive. It contains safety solutions in use at the time of the approval of ANSI B11.19-2010. Inclusion should in no way be considered a sanction, verification of certification status, judgment on the effectiveness, or otherwise any endorsement of the listed safety solution. In addition, exclusion from the list should be in no way construed as a negative comment of any safety solution not listed.

Caution should be used since the solutions listed below may have similar names/terms, but have different functions. Conversely, similar functions may have several different names/terms. Not all references are listed; those that are, are deemed current and reliable at the date of approval of ANSI B11.19, but may change without notice.

The following are listed in alphabetical order and segmented into four groups as defined by ANSI B11.19 or ANSI ISO12100:

Guards
Safeguarding Devices
Complementary Equipment and Measures
Other items that impact the safe use of machinery

Type	Group	ANSI References	Other References	See also/Notes
Active Opto-electronic Protective Device (AOPD)	Safeguarding Devices	ANSI B11.19 ANSI/ISO 12100 ANSI/ASSE Z244.1 ANSI/RIA R15.06	IEC 61496-1/-2 ISO 13855 CSA Z432 CSA Z142 CSA Z434 CSA Z460	- Safety Light Curtains (Screens) - Safety Multiple/Single Beam systems
Active Opto-electronic Protective Devices Responsive to Diffuse Reflection (AOPDDR)	Safeguarding Devices	ANSI B11.19 ANSI/ISO 12100 ANSI/ASSE Z244.1 ANSI/RIA R15.06	IEC 61496-1/-3 ISO 13855 CSA Z432 CSA Z142 CSA Z434 CSA Z460	- Safety Laser Scanners - Area Scanning Presence-Sensing Safeguarding Devices
Adjustable Guards	Guards	ANSI B11.19	ISO 14120	- Guards
Arc Flash Safety Devices	Other	NFPA 79 ANSI/IEEE 1584	OSHA 29 CFR 1910.303/.333/.335	
Area Scanning Presence-Sensing Safeguarding Devices.	Safeguarding Devices	ANSI B11.19 ANSI/ASSE Z244.1 ANSI/RIA R15.06	IEC 61496-1/-3 ISO 13855 CSA Z432 CSA Z142 CSA Z434 CSA Z460	- Electro-Sensitive Protective Equipment (ESPE) - Safety Laser Scanners - Active Opto-electronic Protective Device Responsive to Diffuse Reflection" (AOPDDR).
Awareness Devices, including: Barriers, Signals, and Signs	Other	ANSI B11.19 ANSI Z535		- Safety Markings
Barrier Guards	Guards	ANSI B11.19		- Guards
Blocking Pins	Complementary Equipment & Measures	ANSI B11.19 ANSI/ISO 12100	CSA Z142	- Limiting pins

Type	Group	ANSI References	Other References	See also/Notes
Close Proximity Point of Operation AOPD	Safeguarding Devices	ANSI B11.3	EN 12622 CSA Z142	- Laser Actuated AOPD - Press Brake Laser (Collimated Light) Safeguarding Device - Electro-optical Devices
Collision Avoidance (Devices to prevent interference with other machines or structures)	Other	ANSI ISO 12100	ISO 12100 IEC 61496-3	
Covers	Complementary Equipment & Measures		CSA Z432	
Die Protection Systems	Other	ANSI/ISO 12100	ISO 12100	
Electrical Safety Devices	Other	NFPA 79	IEC 60204-1	
Electro-optical Devices	Safeguarding Devices	ANSI B11.19 ANSI/ISO 12100 ANSI/ASSE Z244.1 ANSI/RIA R15.06	IEC 61496-2/-3 ISO 13855 CSA Z432 CSA Z142 CSA Z434 CSA Z460	- Electro-Sensitive Protective Equipment (ESPE) - Safety Light Curtains (Screens) - Safety Multiple/Single Beam (Grid/Point) Systems - Safety Laser Scanners - Laser Actuated AOPD - Close Proximity Point of Operation AOPD
Emergency Stop Devices	Complementary Equipment & Measures	ANSI B11.19 ANSI B11.TR1 NFPA 79 ANSI/ASSE Z244.1 ANSI/RIA R15.06	ISO 13850 IEC 60204-1 CSA Z432 CSA Z434 CSA Z460	
Emissions Monitoring, Devices for	Other	ANSI/ISO 12100	ISO 12100	
Enabling Devices	Complementary Equipment & Measures	ANSI B11.19 ANSI/ISO 12100 NFPA 79 ANSI/ASSE Z244.1 ANSI/RIA R15.06	IEC 60204-1 CSA Z432 CSA Z434 CSA Z460	- ANSI/ISO 12100 classifies as Protective Device (Safeguard)
Ergonomics	Other	ANSI B11.TR1		

Type	Group	ANSI References	Other References	See also/Notes
Electro-Sensitive Protective Equipment (ESPE)	Safeguarding Devices		IEC 61496-1	- Electro-optical devices - Safety Light Curtains (Screens) - Safety Multiple/Single Beam (Grid/Point) Systems - Safety Laser Scanners - Laser Actuated AOPD
Fall Protection Equipment	Other	ANSI/ASSE Z359	ISO 10333	
Fixed (Hard) Guards	Guards	ANSI B11.19 ANSI/ASSE Z244.1 ANSI/RIA R15.06	ISO 14120 CSA Z432 CSA Z142 CSA Z434 CSA Z460	- Guards
Guards	Guards	ANSI B11.19 ANSI/ASSE Z244.1 ANSI/RIA R15.06	ISO 14120 ISO 12100 CSA Z432 CSA Z142 CSA Z434 CSA Z460	- Adjustable Guards - Barrier Guards - Fixed Guards - Interlocked Guards - Movable Guards
Hand Tools	Complementary Equipment & Measures	ANSI B11.19	OSHA 29CFR1910.217	
Hold-to-Run Control Device.	Safeguarding Devices	ANSI B11.19 ANSI/ISO 12100 NFPA 79 ANSI/ASSE Z244.1	IEC 60204-1 CSA Z432 CSA Z460	
Impeding Device	Other	ANSI/ISO12100		
Interlocked Guards	Guards	ANSI B11.19 ANSI/ISO 12100 NFPA 79 ANSI/ASSE Z244.1 ANSI/RIA R15.06	ISO 14120 IEC 60204-1 CSA Z432 CSA Z142 CSA Z434 CSA Z460	- Moveable Guards that use interlocking devices
Interlock / Interlocking Devices (used in conjunction with Interlocked Guards)	Safeguarding Devices	ANSI B11.19 ANSI/ISO 12100 NFPA 79 ANSI/ASSE Z244.1 ANSI/RIA R15.06	ISO 14119 IEC 60204-1 CSA Z432 CSA Z142 CSA Z434 CSA Z460	
Laser Actuated AOPD	Safeguarding Devices	ANSI B11.3	EN 12622 CSA Z142	- Close Proximity Point of Operation AOPD - Press Brake Laser (Collimated Light) Safeguarding Device Electro-optical Devices

Type	Group	ANSI References	Other References	See also/Notes
Lifting Operations, Devices to Prevent (unless stabilizers are in place)	Other	ANSI/ISO 12100	ISO 12100	
Limiting Pins	Complementary Equipment & Measures	ANSI B11.19 ANSI/ISO 12100	CSA Z142	- Blocking pins
Limiting Device	Other	ANSI/ISO12100	ISO 12100	
Limiting Movement (distance, angle, velocity, acceleration), Devices for	Other	ANSI/ISO 12100 ANSI/RIA R15.06	ISO 12100 ISO 10218	- Note: such as Safety Rated “Soft” Limits or Stops for robot control
Locking Pins	Complementary Equipment & Measures	ANSI B11.19 ANSI/ISO 12100	CSA Z142	
Lockout / Tagout Equipment	Other	ANSI/ASSE Z244.1	OSHA 29CFR1910.147 CSA Z460 ISO 14118	- Note: ISO 12100 refers to “Measures for Isolation and Energy Dissipation”
Movable Guards	Safeguarding Devices	ANSI/ISO 12100	ISO 12100 ISO 14120	- Guards - Interlocked guards
Operator Absence Detection	Other	ANSI/ISO 12100	ISO 12100	- Prevent Operation in the Absence of the Operator at the Control Position
Part-Position Systems	Other	ANSI/ISO 12100	ISO 12100	
Personnel Protection Equipment (PPE)	Other	ANSI/ASSE Z244.1	CSA Z432 CSA Z460	
Press Brake Laser (Collimated Light) Safeguarding Device	Safeguarding Devices	ANSI B11.3	EN 12622 CSA Z142	- Laser Actuated AOPD - Electro-optical Devices
Presence-Sensing (Safety) Devices (PSD, PSSD)	Safeguarding Devices	ANSI B11.19		- Safety light curtains and screens - Safety multiple beam systems - Safety laser scanners - Pressure-sensitive edge devices - Pressure-sensitive mats
(Drop) Probe Detection Devices	Safeguarding Devices	ANSI B11.19	ISO 13856-3	

Type	Group	ANSI References	Other References	See also/Notes
Pressure Limiting, Devices for	Other	ANSI/ISO 12100	ISO 12100	
Pressure-Sensitive Edge Devices	Safeguarding Devices	ANSI B11.19 ANSI/ASSE Z244.1	ISO 13856-2 ISO 13856-3 CSA Z460	- Safety Edge Devices
Pressure-Sensitive Mat and Pressure-Sensitive Floor Devices	Safeguarding Devices	ANSI B11.19 ANSI/ASSE Z244.1 ANSI/RIA R15.06	ISO 13856-1 ISO 13855 CSA Z432 CSA Z142 CSA Z434 CSA Z460	- Safety Mats
Process Malfunction, Detection And Monitoring Equipment	Complementary Equipment & Measures	ANSI B11.19		
Pull Back and Pull Out Devices	Safeguarding Devices	ANSI B11.19	CSA Z432 CSA Z142	
Radio Frequency (Capacitance) Devices	Safeguarding Devices	ANSI B11.19 ANSI/RIA R15.06	CSA Z432 CSA Z142 CSA Z434	
Restraint Devices (Personnel)	Safeguarding Devices	ANSI B11.19	CSA Z432 CSA Z142	
Safe Servo-Drives.	Complementary Equipment & Measures		IEC 61800	
Safe Work Procedures	Other	ANSI B11.19 ANSI B11 ANSI/PMMI B155.1	ISO 12100	
Safeguarding Methods	Other	ANSI B11.19		
Safety Blocks	Complementary Equipment & Measures	ANSI B11.19 ANSI/ISO 12100	CSA Z142	
Safety Communication (BUS) Systems	Complementary Equipment & Measures		IEC 61508-1 IEC 62061	
Safety Edge Devices	Safeguarding Devices	ANSI B11.19 ANSI/ASSE Z244.1	ISO 13856-2 ISO 13856-3 CSA Z460	- Pressure-Sensitive Edge Devices
Safety Interface Modules	Complementary Equipment & Measures	ANSI B11.19 ANSI/ASSE Z244.1	IEC 61508 IEC 62061 CSA Z460	- Safety Relay Modules
Safety Laser Scanners	Safeguarding Devices	ANSI B11.19 ANSI/ISO 12100 ANSI/ASSE Z244.1 ANSI/RIA R15.06	IEC 61496-1/-3 ISO 13855 CSA Z432 CSA Z142 CSA Z434 CSA Z460	- Active Opto-electronic Protective Devices responsive to Diffuse Reflection (AOPDDR) - Area Scanning Presence-Sensing Safeguarding Devices

Type	Group	ANSI References	Other References	See also/Notes
Safety Light Curtains (Screens)	Safeguarding Devices	ANSI B11.19 ANSI/ISO 12100 ANSI/ASSE Z244.1 ANSI/RIA R15.06	IEC 61496-2 ISO 13855 CSA Z432 CSA Z142 CSA Z434 CSA Z460	- Active Opto-electronic Protective Devices (AOPD)
Safety Logic Controllers	Complementary Equipment & Measures	ANSI B11.TR4 ANSI/ASSE Z244.1 ANSI/RIA R15.06	IEC 61508 IEC 62061 CSA Z432 CSA Z434 CSA Z460	
Safety Mat	Safeguarding Devices	ANSI B11.19 ANSI/ASSE Z244.1 ANSI/RIA R15.06	ISO 13856-1 ISO 13855 CSA Z432 CSA Z142 CSA Z434 CSA Z460	- Pressure-Sensitive Mat
Safety Multiple/Single Beam (Grid/Point) Systems	Safeguarding Devices	ANSI B11.19 ANSI/ISO 12100 ANSI/ASSE Z244.1 ANSI/RIA R15.06	IEC 61496-2 ISO 13855 CSA Z432 CSA Z142 CSA Z434 CSA Z460	- Active Opto-electronic Protective Devices (AOPD)
Safety (Rated) Power Drive Systems (SRPDS)	Complementary Equipment & Measures		IEC 61800	
Safety Relay Modules	Complementary Equipment & Measures	ANSI B11.19 ANSI/ASSE Z244.1	IEC 61508 IEC 62061 CSA Z460	- Safety Interface Modules
Safety (Rated) Wireless Networks	Complementary Equipment & Measures	NFPA 79	IEC 60204-1	
Sensitive Protective Equipment (SPE)	Safeguarding Devices		ISO 12100	
Shields	Complementary Equipment & Measures	ANSI B11.19	CSA Z432	
Single Control Safeguarding Devices.	Safeguarding Devices	ANSI B11.19 ANSI/ISO 12100 NFPA 79 ANSI/ASSE Z244.1	IEC 60204-1 CSA Z432 CSA Z460	
Slide Locks	Complementary Equipment & Measures	ANSI B11.1 ANSI B11.2 ANSI/ISO 12100	CSA Z142	
Stop Devices	Other	NFPA 79	IEC 60204-1	
Stopping Performance Monitor	Complementary Equipment & Measures	ANSI B11.19	CSA Z142	
Temperature Limiting, Devices for	Other	ANSI/ISO 12100	ISO 12100	

Type	Group	ANSI References	Other References	See also/Notes
Torque Limiting, Devices for (Breakage Points to Prevent Excessive Stress of Components and Assemblies)	Other	ANSI/ISO 12100	ISO 12100	
Training	Other	ANSI B11.19 ANSI/ASSE Z244.1 ANSI/RIA R15.06	CSA Z432 CSA Z142 CSA Z434 CSA Z460	
Two-Hand Devices, including: Operating Lever Trip Devices Control Devices	Safeguarding Devices	ANSI B11.19 ANSI/ISO 12100 NFPA 79 ANSI/ASSE Z244.1 ANSI/RIA R15.06 ANSI B11.TR1	OSHA 29CFR1910.217 ISO 13851 IEC 60204-1 ISO 13855 CSA Z432 CSA Z142 CSA Z434 CSA Z460	
Type A & B Movable Barrier Devices	Safeguarding Devices	ANSI B11.19		
Vision Based Protective Device	Safeguarding Devices		IEC TR 61496-4	
Workholding Equipment	Complementary Equipment & Measures	ANSI B11.19		

Standards referenced in Annex I:

Note: This listing is only provided for the convenience of the reader.

ANSI B11.19 – Performance Criteria for Safeguarding
ANSI/ISO 12100 – Safety of machinery – General principles for design, risk assessment and risk reduction
(ANSI) NFPA 70E - Standard for Electrical Safety Requirements for Employee Workplaces
(ANSI) NFPA 79 – Electrical Standard for Industrial Machinery
ANSI/ASSE Z244.1 – Control of Hazardous Energy – Lockout/Tagout and Alternative Methods
ANSI/ASSE Z359 – Fall Protection
ANSI/IEEE 1584 – Guide for Performing Arc Flash Hazard Calculations
ANSI/RIA R15.06 – For Industrial Robots and Robot Systems – Safety Requirements
OSHA 29 CFR 1910.147 – The control of hazardous energy (lockout/tagout)
OSHA 29 CFR 1910.217 – Mechanical power presses
OSHA 29 CFR 1910.303 – Electrical, General Rrequirements
CSA Z142 – Code for Power Press Operation: Health, Safety, and Guarding Requirements
CSA Z432 – Safeguarding of Machinery – Occupational Health and Safety
CSA Z434 – Industrial Robots and Robot Systems – General Safety Requirements
CSA Z460 – Control of Hazardous Energy – Lockout and Other Methods
ISO 10333 – Personal fall-arrest systems
ISO 13851 – Safety of Machinery – Two-hand control devices – Functional aspects and design principles
ISO 13855 – Safety of machinery – Positioning of protective equipment with respect to the approach speeds of parts of the human body
ISO 13856-1 – Safety of machinery – Pressure-sensitive protective devices – Part 1: General principles for design and testing of pressure-sensitive mats and pressure-sensitive floors
ISO 13856-2 – Safety of machinery – Pressure-sensitive protective devices – Part 2: General principles for the design and testing of pressure-sensitive edges and pressure-sensitive bars
ISO 13856-3 – Safety of machinery – Pressure-sensitive protective devices – Part 3: General principles for the design and testing of pressure-sensitive bumpers, plates, wires and similar devices
ISO 14118 – Safety of machinery – Prevention of unexpected start-up
ISO 14119 – Safety of machinery – Interlocking devices associated with guards – Principles for design and selection
ISO 14120 – Safety of machinery – Guards – General requirements for the design and construction of fixed and movable guards
IEC 60204-1 – Safety of machinery – Electrical equipment of machines – Part 1: General requirements
IEC 61496-2 – Safety of machinery – Electro-sensitive protective equipment – Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs)
IEC 61496-3 – Safety of machinery – Electro-sensitive protective equipment – Part 3: Particular requirements for active opto-electronic protective devices responsive to diffuse reflection (AOPDDR)
IEC TR 61496-4 – Safety of machinery – Electro-sensitive protective equipment – Part 4: Particular requirements for equipment using vision based protective devices (VBPD)
IEC 61508 – Functional safety of electrical/electronic/programmable electronic safety-related systems
IEC 61800 – Adjustable speed electrical power drive systems
IEC 62061 – Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
EN 12622 – Safety of machine tools – Hydraulic press brakes