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Machine Safety – New and Updated Consensus Standards…What You Need to Know

James R. Harris, Ph.D., P.E.
Research Safety Engineer
Richard S. Current, P.E.
Research Engineer
National Institute for Occupational Safety and Health
Morgantown, WV

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Abstract

This paper informs readers of recent changes to the ANSI B11.0 and B11.19 standards and provides an overview of each standard. In addition, the reader is made aware of selected international standards and some of their differences with B11 machine safety standards in North America. Readers are encouraged to obtain the original sources for the most complete discussion. B11.0 and B11.19 are explained by discussing: a general overview; key points/new features; changes from the previous version; and selected applicable international standards. Some key points are selected for expanded discussion.

Introduction

According to Bureau of Labor Statistics (BLS) data, machines were the primary or secondary source of 604 work-related fatalities (BLS 2010b) in 2008. For this same year, machinery was also the source of 64,170 cases involving days away from work (BLS 2010b). Over 25% of all machinery-related injuries that involved days away from work resulted in more than 31 days away from work (BLS 2010a). The Occupational Safety and Health Administration (OSHA) has estimated the total cost of an amputation injury (indirect costs plus direct costs) to be $101,467 (OSHA 2010). It is easy to see that machine-related injuries take a heavy toll on employers and employees.

The ANSI B11 Accredited Standards Committee for Machine Safety Standards oversees more than 30 standards and technical reports. The standards are organized in an A-B-C manner. Type-A standards are known as “basis standards” and identify basic concepts, principles for design, and general aspects that are applicable to machinery in general. Type-B standards are known as "generic safety standards" and deal with safety aspects or safeguards that are applicable to many machine types. Type-C standards are known as "machinery-specific safety standards" and contain guidelines which are germane to certain specific machine types. Specific guarding situations covered by C-level machine specific standards like ANSI B11.1, "Safety Requirements for Mechanical Power Presses", or ANSI B11.3, "Machine Tools – Safety Requirements for Power Press Brakes," should be guarded using those specific standards. If the machines are interfaced with another machine or process, then ANSI B11.20, "Safety Requirements for Integrated Manufacturing Systems" or using B11.0/B11.19 for the interface would be appropriate. The C-level standards may have machine-specific exceptions to the rules in B11.19, but generally they should follow the rules of B11.19.

This paper concentrates on aspects of ANSI B11.0 and ANSI B11.19 concerning risk assessment and machine guarding. In addition, applicable sections of selected international standards, as they relate to ANSI B11.0 and B11.19, will also be briefly discussed.

Responsibilities in the B11 series of standards

The B11 series of standards defines responsibilities broadly in terms of Suppliers and Users. The category that an entity fits into is defined by the actions the entity performs. In general, a supplier is an entity that provides equipment or services. Based upon this definition, groups other than manufacturers could be called suppliers. Entities that are building, modifying, and/or integrating would be considered suppliers while they are performing that work activity. A user is an entity which utilizes a machine, machine production system, or related equipment.

ANSI B11.0

General Overview

ANSI B11.0, "Safety of Machinery – General Requirements and Risk Assessment", was most recently updated and approved in December 2010. As an A-level, basis standard, B11.0 provides basic guidelines applicable to many types of machines. The scope of the standard limits application to "new, modified or rebuilt power driven machines, not portable by hand, used to shape and/or form metal or other materials by cutting, impact, pressure, electrical or other processing techniques, or a combination of these processes" (ANSI 2010c). Additionally, requirements for risk assessment that were previously contained in ANSI B11.TR3 can now be found in B11.0. Although many of the B11 standards address engineering controls in the injury prevention hierarchy, ANSI B11.0 also attempts to address some of the higher-level injury prevention techniques such as elimination and substitution. A term that is gaining recognition within the safety and health community is Prevention through Design (PtD) (ASSE 2009). Terms such as "elimination by design," "design out," and "substitution" carry equivalent meanings and are discussed in the B11.0 document.

The B11.0-2010 standard has 9 clauses (or sections) and 11 annexes. The first four clauses have a similar format throughout the B11 series of standards. In order, these clauses deal with the scope, normative references, definitions, and responsibilities. In clauses 6-9, B11.0 addresses the risk assessment process, risk reduction, information for maintenance/use, and training. Of the 85 pages in the full B11.0 standard, the annexes account for over 30 pages. The annexes are very important for practical application of the standard. They provide sample lists of machinery hazards, additional guidance on the risk assessment process, and lists of other informative references.

Key points/New features

Responsibilities: The functional distinction in B11.0 between suppliers and users is explained in general terms as follows. The machine supplier is typically responsible for the design and construction of the machine. In addition, the supplier is responsible for providing information on operation and maintenance of the machine. The machine user is responsible for the actual operation and maintenance of the machine. A key concept in the delegation of machine safety responsibilities is that suppliers and users should collaborate on safety and risk reduction as early in the process as practicable and for as long as practicable. It is important to note that B- and C-level ANSI B11 standards may also apply to this process. Where specific C-level standards exist, they will generally take precedence over A- or B-level standards. If a machine is modified during its life cycle, the risk assessment/risk reduction process must be repeated. It is important to solicit the original supplier's input to this process if practicable.

Risk assessment: An important first step in the risk assessment process is ensuring that the risk assessment team is comprised of qualified personnel. The standard calls for individuals of "technical competence" and "relevant skill set." Operators, maintenance, or engineering personnel may have the most to offer in a risk assessment. Figure 1 comes from the B11.0 standard and shows the process flow for conducting a risk assessment. The numbers in parentheses in the figure indicate relevant clauses from the B11.0 standard.

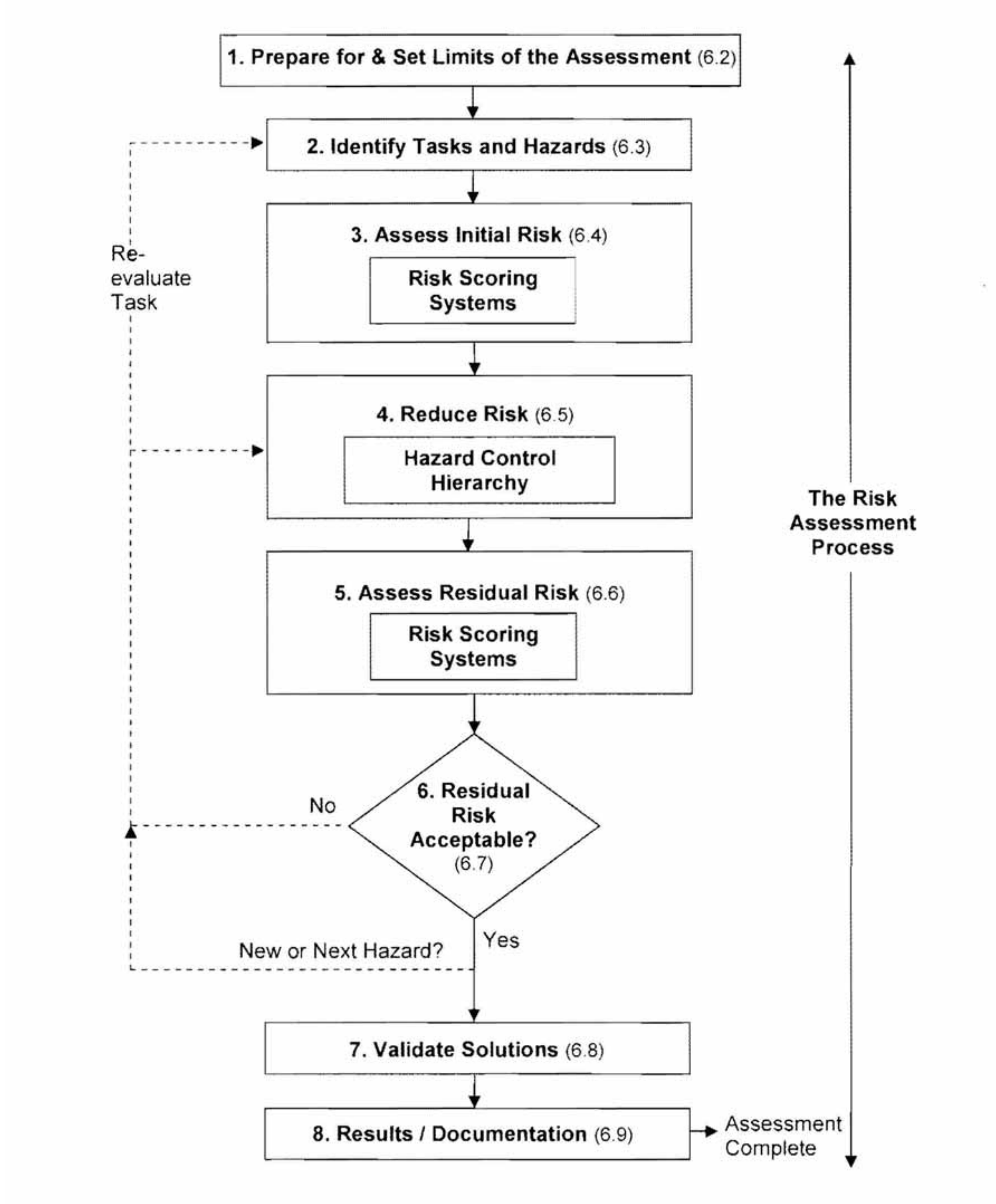

Figure 1 - The Risk Assessment Process. (Reprinted from ANSI B11.0-2010 with permission from B11 Standards, Inc. For additional information, refer to http://www.amtonline.org/TechnologyandStandards/ANSIB11SafetyStandards/ or www.ansi.org)

Key ideas in the risk assessment process involve the terms "residual risk" and "acceptable risk." Residual risk is defined in the standard as "…the risk remaining after risk reduction measures (protective measures) are taken." Acceptable risk is defined within the standard as "…a risk level achieved after risk reduction measures have been applied. It is a risk level that is accepted for a given task (hazardous situation) or hazard." ANSI B11.0 treats acceptable risk as synonymous with "tolerable risk." The risk assessment process is continued until the residual risk is deemed acceptable. While the risk assessment team is identifying tasks and hazards, they are guided by the standard to include all reasonably foreseeable hazards *regardless of the existence of risk reduction measures*. For example, this requires the team to consider whether guards supplied with a machine are sufficient for hazards or if supplemental protection is necessary. Consideration should be given to reasonably foreseeable misuse of equipment and protective measures, as well as, machine malfunction.

When identifying tasks for the risk assessment, it is important to consider scenarios in addition to machine operation. As listed in the B11.0 standard, some situations might include: packing and transportation; unloading/unpacking; systems installation and assembly; start-up/commissioning; set-up/changeover; operation (all modes); maintenance; shutdown/lockout/tagout; recovery from jams; troubleshooting; cleaning; decommissioning, dismantling, and disposal. ANSI B11.0 also offers several suggestions for categories of identifying hazards and notes that *all reasonably foreseeable* hazards be included. Categories mentioned by the standard include: mechanical hazards; energy sources; unexpected starts; slips and falls; hot surfaces; combustible atmospheres or media; sharp edges; and operational hazards.

Step 3 in the risk assessment process as listed in Figure 1 is to assess initial risk. Risk is defined as a function of severity of harm and probability of occurrence of that harm. In some instances, an additional factor of frequency of exposure will be applied (Brauer 652). "Frequency of exposure" takes into consideration that an individual may not always be exposed to the risk under consideration. For example, the hazard may involve a maintenance procedure that is only required once per year. If frequency of exposure is considered, the example maintenance task would have a different risk than a maintenance procedure that is required daily, even if the probability of occurrence of harm is the same.

The information below is a simple example of a two-factor, qualitative risk scoring system from ANSI B11.0. Using this system, a severity of harm that is moderate coupled with a very likely probability of occurrence of harm would be considered high risk. In this sample system, risk has been divided into the categories of high, medium, low, and negligible risk. For this example, assigning severity and probability categories can be aided by the following sample definitions:

Severity

Catastrophic – death or permanently disabling injury or illness (unable to return to work)
Serious – severe debilitating injury or illness (able to return to work at some point)
Moderate – significant injury or illness requiring more than first aid (able to return to same job)
Minor – no injury or slight injury requiring no more than first aid (little or no lost work time)

Probability

Very likely – near certain to occur
Likely – may occur

Unlikely – not likely to occur
Remote – so unlikely as to be near zero

If the residual risk calculated during risk assessment is greater than the acceptable risk, risk reduction must be accomplished based upon the hazard control hierarchy. ANSI B11.0 lists risk reduction measures from most preferred to least preferred as: elimination or substitution (most preferred); guards and safeguarding devices; awareness devices; training and procedures; and personal protective equipment (least preferred). With risk reduction measures in place, the risk assessment is repeated until residual risk reaches acceptable risk.

After risk has been reduced to an acceptable risk level, the risk reduction measures must be verified. Care must be exercised to ensure that testing of risk reduction measures does not expose an individual to potential harm if the risk reduction measure fails. Use of programmable electronic safety control systems warrants special attention (see ANSI B11.TR6).

To complete the risk assessment process, B11.0 requires the following elements for documentation:

- The machinery for which the assessment has been made (e.g.,, specifications, limits, intended use);
- Any relevant assumptions which have been made (e.g., loads, strengths, safety [design] factors);
- The information on which the risk assessment was based;
- Names of the risk assessment team;
- Date(s) of the risk assessment;
- The tasks and hazards identified;
- Initial risks associated with the machinery;
- The risk reduction measures implemented to eliminate identified hazards or to reduce risk (e.g., from standards or other specifications);
- Residual risks associated with the machinery;
- The validation of risk reduction measures, including the responsible individual and the date of validation.

Annex H of B11.0 provides an example of risk assessment documentation.

Changes from previous version

In 2009 the ANSI B11 ASC initiated the process of revising ANSI B11-2008 and also combining ANSI B11.TR3 into the existing standard. The result was ANSI B11.0-2010 which was approved by ANSI on December 2, 2010. The new revision reduces duplication between standards and places many of the A-level requirements in one document.

Selected applicable international standards

ISO 12100-2010, "Safety of machinery – General principles for design – Risk assessment and risk reduction", cancels and replaces ISO 12100-1:2003, ISO 12100-2:2003, and ISO 14121-1:2007 (ISO 2010a). Like ANSI B11.0, ISO 12100 is considered an A-level standard. ISO 12100 is organized into seven clauses and three annexes. The first three clauses address scope, normative references, and terms and definitions. Clause 4 provides the strategy for risk assessment and risk reduction. Clauses 5 and 6 discuss risk assessment and risk reduction. Documentation for the activities of Clauses 5 and 6 is described in Clause 7.

One major difference between ISO 12100 and ANSI B11.0 is the explicit assignment of responsibilities within clause 4 of ANSI B11.0. Duties are typically delegated within the ANSI standard to the general categories of Supplier and User. Within ISO 12100, another standard is referenced (ISO/TR 14121-2, an examples document for 14121 that was not included in the new compilation document 12100) which provides specific methods for systematic identification of hazards. During risk estimation, ISO 12100 specifically cautions about the possibility of defeating or circumventing protective measures in the following four situations: (1) the protective measure slows down production or interferes with another activity or preference of the user; (2) the protective measure is difficult to use; (3) persons other than the operator are involved; or (4) the protective measure is not recognized by the user or not accepted as being suitable for its function. During the iterative process of risk estimation, risk evaluation, and risk reduction, care must be taken to not introduce unaccounted for risk through new protective measures. ISO 12100 does not use the term "acceptable risk" but instead mentions "adequate risk reduction." Risk reduction is organized in this standard in the context of a three-step method: (1) inherently safe design methods, (2) safeguarding and/or complementary measures, and (3) information for use. Much like the ANSI B11.0 standard, the annexes of ISO 12100 provide more detailed guidance on hazard identification for the risk assessment.

ANSI B11.19

General Overview

ANSI B11.19-2010, "Performance Criteria for Safeguarding", is designed to be used with the ANSI B11.0 standard as well as machine-specific C-level standards. This is the third revision of the B11.19 standard, and it establishes "…requirements for the design, construction, installation, operation and maintenance of the safeguarding, complementary equipment and measures, and safe work procedures…" for risk mitigation associated with machines (ANSI 2010a). Clauses 1-4 are uniform for the B11 family of standards and cover the scope, references, definitions, and responsibilities. Clause 5 and 6 address hazard control and general safeguarding requirements, respectively. Clauses 7-10 discuss the following safeguarding topics: guards; safeguarding devices; awareness devices; safeguarding methods. B11.19 also has performance requirements for safe work procedures and complementary equipment and measures. In the final two clauses, information is provided on inspection and maintenance of safeguarding and training on the use of safeguarding.

Key Points/New Features

Topics which have been added or changed in B11.19 include: protective safety stops, emergency stops, perimeter guarding, muting, bypass, hold-to-run control, guard interlocking switches, and presence-sensing device initiation (PSDI). Requirements for transparent guarding (viewing windows) have been added. Also, the requirements of ASME B15.1, "Mechanical Power Transmission Apparatus", have been absorbed into B11.0 and B11.19 with additions of safe-distance guarding and safe-location guarding. The standards were harmonized, where possible or practical, with ISO-13857 and other ISO standards. There have been many changes, with about 60 new pages.

Responsibility. B11.19 requires that the safeguarding supplier (may be the user if the user acts as a supplier) meets the design, construction, integration and installation requirements in addition to providing the installation, operation, and maintenance instructions and maintenance requirements. The user (usually the employer) is responsible for ensuring that the safeguarding has been provided, integrated, installed, maintained and used properly. If the user orders equipment without safeguarding, they are responsible for determining appropriate safeguarding or providing it. If the user designs, constructs, installs or modifies the safeguarding, they become the supplier. The user is responsible to ensure that if changes are made to the process or tooling, the safeguarding is still effective and proper. The user is also responsible for the proper training of all associated personnel within the scope of their work activity. Finally, personnel have the responsibility of following the training and operating procedures set forth by the user.

As Figure 2 shows, B11.19 recommends a process flow of hazard identification, risk assessment and risk reduction strategies; this is covered in B11.0. If the hazards cannot be eliminated then guards, safeguarding devices, awareness devices, or safeguarding methods should be used. If these four options will not work, safe work procedures, complementary equipment, or training and maintenance should be used (in that order). With safeguarding in place, residual risk must be assessed to ensure it is below acceptable risk. In this assessment, it is important to make sure that new risks have not been introduced. An explanation of each of these safeguarding approaches follows.

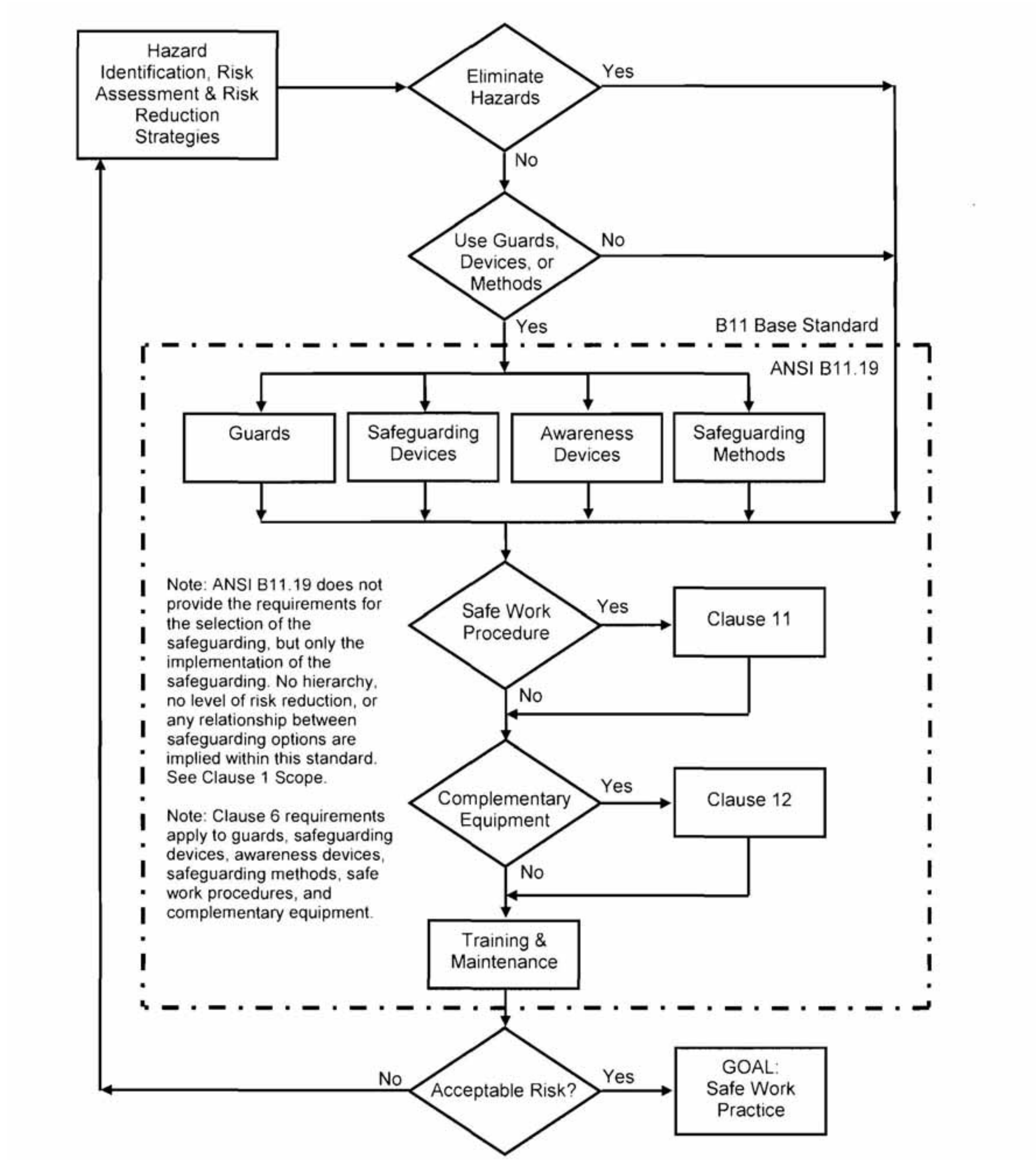

Figure 2 - Safeguarding Flowchart. (Reprinted from ANSI B11.19-2010 with permission from B11 Standards, Inc. For additional information, refer to http://www.amtonline.org/TechnologyandStandards/ANSIB11SafetyStandards/ or www.ansi.org)

General safeguarding requirements. Basic to safeguarding is the concept that if an unsafe act or presence is detected the machine must be stopped prior to contact. Protective Safety Stops are physical or virtual within a controller, and are initiated by the actuation of a safeguarding device. These are used to stop a machine in a safe and determined manner when, for example, an operator crosses through a light curtain and into a hazard zone. Because there are requirements specific to their interface with the machine and operation, they are included in this version of the B11.19.

Safeguarding can protect an area, point of operation, or perimeter. Perimeter guarding is any guarding that encloses an area and only detects on the perimeter. Once a person has passed through the perimeter, the guarding does not know where they are, and there could be multiple safety hazards in the area. There are specific safety implications due to perimeter guarding and guidance is found in new material of B11.19.

An important concept in evaluating the hazard mitigation strategy is the performance or reliability of the safety-related function. The concern is that a component or system failure will prohibit the safety-related function when a stop command is issued. To prevent this scenario, the safety-related function must do the following until the failure is corrected or the control system is manually reset: prevent initiation of hazardous machine motion; initiate an immediate stop command and prevent re-initiation of hazardous machine motion; or prevent re-initiation of hazardous machine motion at the next normal stop command. The standard also requires when the user recognizes the failure of the safety-related function, repetitive manual reset not be used to circumvent the state.

While the operation of the safeguarding must be reliable, sometimes it must be manually or automatically suspended to enhance usability or allow for a specific operation; a risk assessment of this altered mode is still required. Bypass means to temporarily render any part of the safety function unusable or ineffective. Muting is a temporary automatic suspension of a safety function. For instance, muting would allow a workpiece or worker to pass through the safeguarding at specified times. The standard provides requirements to help ensure safety during use and guidance for restart. While muting and bypass are certainly not new ideas, its new inclusion in B11.19 will guide safety professionals to appropriately consider risk of these modes.

Safe-Distance Calculations. Safeguarding is often of a presence-sensing or location based-nature. Many safeguarding items are subject to a safety-distance calculation which determines the minimum distance from the hazard to install the safeguard in order to make it difficult for the operator to reach the point of operation or hazard zone. These calculations are used for palm-buttons, single-start controls, light-curtains and pressure-mats for instance.

The calculation is based on the following: individual approach speed; safeguarding device response time; interface response time; hazardous motion braking time of the machine; and, depth of penetration factor for the device. B11.19 recommends 63 in/s as used in OSHA or greater, in addition to having information on depth of penetration. The depth of penetration is the extra distance a human body-part will penetrate into a safeguarding device prior to activating it.

Guards. Guards, sometimes referred to as barrier guards, are defined in B11.19 as "…a barrier that prevents exposure to a hazard" and are classified as fixed, adjustable, or interlocked. They are generally considered a highly reliable choice for risk reduction which is why they are located high in the structure of Figure 2.

Previously there were questions about the performance and application of transparent guarding or viewing windows. All guards (whether transparent or opaque) have certain performance criteria. Some of these requirements include that guard construction material must be of sufficient strength to protect individuals from the hazards. Because guard material, plastic or metal, may deteriorate over time (especially with environmental considerations such as cutting fluid), suppliers shall provide a replacement schedule for guards or other guidance to determine when replacement is needed.

Additionally, the risk of individuals reaching over, around, or through the guard to access the hazard must be considered. Guard openings and gaps should follow Figure D.9 of B11.19. In 2003, B11.19 was revised with modified gap opening requirements. Data in B11.19 for guard openings are more conservative than OSHA requirements except for between the distance of 6.5 to 7.5 inches where the ANSI standard allowable gap is greater than the OSHA value.

Guards that can be removed (such as access doors and panels) may be required to be interlocked to shut down circuits or secured with difficult to remove fasteners. Requirements for guard interlocking switches are new to B11.19 and guidance is provided for their design and operational use.

Safeguarding devices. B11.19 defines a safeguarding device as "…a device that detects or prevents inadvertent access to a hazard." The ISO 12100 category of "protective device" is a broader category than the B11.19 "safeguarding device" category. The ISO 12100 category would include items considered "complementary equipment" in B11.19. Safeguarding devices with B11.19 are divided into the following groups:

- movable barrier devices
- pull back (pull out) and restraint devices
- presence-sensing safeguarding devices (electro-optical, RF, area scanning)
- two-hand operating lever, trip and control devices
- safety mat devices
- safety edge devices
- probe detection devices
- single control safeguarding devices
- close proximity point of operation Active Opto-Electronic Protective Devices (AOPDs) (applies to press brakes)

Movable barrier devices can be classified as type A or type B. The primary difference between the two concerns when the barrier is open. Type A movable barrier devices are designed to prevent access to the hazard zone prior to the hazardous portion of the machine cycle and remain closed until motion is stopped and the machine is at the initial starting position. Type B movable barrier devices prevent access to the hazard zone only during hazardous portion of machine motion.

Pullback and restraint devices are designed to keep the operator's hands away from the hazard zone during the hazardous portion of the machine cycle. Special consideration is required for more than one operator to ensure adequate protection.

Presence-sensing devices operate by creating a field to detect the presence of an operator. Use of these devices requires attention to minimum object sensitivity of the presence-sensing device as well as safety distance from the hazard zone. B11.19 provides guidance on the effective sensing field size (height, width, depth) so an individual can be detected entering the hazard zone.

Two-hand safeguarding devices are configured so that each hand is required to actuate a device in a near simultaneous manner (within 500 milliseconds) for continued operation of the machine during hazardous motion. If either hand is released during the hazardous portion of the machine cycle, an immediate stop command must be initiated. Location of the two-hand safeguarding device involves calculation of an appropriate safety distance (detailed in Annex D of B11.19) so that the operator cannot reach the hazard zone before hazardous motion ceases. Individual hand controls are required for each operator if there is more than one operator, and they are to be safeguarded by using two-hand trip or control devices.

Safety mats are designed to detect the presence of individuals on the sensing surface and initiate an immediate stop command to prevent hazardous operation of the machine. Individuals must not be able to access the hazard zone by reaching over, under, or around the sensing surface of the safety mat. The safety mat must not be used as an enabling device for initiation or continuation of hazardous motion.

Safety edge devices detect the presence of an individual through force or pressure applied along its sensing surface. The device is required to have a sufficient sensing surface so that exposure of the individual to the hazard is detected.

A probe detection device is designed to prevent initiation or stop the machine cycle if an individual's hand or finger is in the hazard zone.

A single control safeguarding device requires only single actuation to initiate machine motion. The single control device must be located a safe distance to ensure the operator cannot reach the hazard zone during hazardous machine motion. Controls that can easily be moved closer than the safe distance to the hazard do not meet the requirements of a single control safeguarding device.

Awareness devices. Awareness barriers, signals, and signs can all be considered awareness devices. Awareness barriers must be designed so that individuals cannot reach into the hazard zone without conscious effort and/or contact with the barrier. Awareness signals must generate a noticeable (distinctive by sound and intensity) audible or visual signal to warn of an approaching or present hazard. Awareness (safety) signs must meet consensus standard requirements of ANSI Z535.1, Z535.3, Z535.4 and Z535.5.

Safeguarding methods. Safeguarding methods fit one of four categories: safe-distance safeguarding; safe-holding safeguarding; safe-opening safeguarding; and safe-location safeguarding. The use of safeguarding methods requires specific training and supervision.

Safe-distance safeguarding must include a safety program which details work procedures, training and re-training, and supervision. Material position gages of sufficient height and size/shape must be used to prevent slipping of the material beyond the gages. The gages should also prevent the operator from unintentionally getting closer to the hazard than the safe distance. The safe distance will be determined based upon the job and visually identified at the machine.

Safe-holding safeguarding requires that the operator's hands be away from the hazardous zone during the hazardous portion of the machine cycle by requiring that both hands are used to hold or support the workpiece or that one hand holds or supports the workpiece while the other hand operates the machine.

Safe-opening safeguarding utilizes the workpiece itself as part of the safeguard to ensure that openings are small enough to prevent the operator from accessing the hazard zone. The machine must be prevented from hazardous motion when the workpiece is not in place, and the hazard zone can be accessed.

Safe-location safeguarding includes the previous "ANSI B15.1 safe distance" and "ANSI B15.1 safe location" requirements. Access to the hazard zone from a walking or working surface must be prevented through vertical distance of sufficient height, horizontal distance, or the combination of vertical and horizontal distance. Safe-location safeguarding can also limit access to the hazard by placing the hazard: in an enclosure (e.g. room, vault); behind permanent, substantial partitions/fencing/railing or screens that meet other B11.19 requirements; on an elevated platform where incidental contact is not possible.

Safe work procedures. ANSI B11.19 lists some circumstances where safe work procedures may be needed (maybe in addition to other protective measures):

- 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.

Complementary equipment and measures. ANSI B11.19 defines complementary equipment as "…devices or methods used to ensure or augment the proper operation of safeguarding". These devices include: safety-blocks, chain-locks, locking-pins, limiting/blocking pins; slide locks; workholding equipment; stopping performance monitor; process malfunction, detection and monitoring equipment; hand-tools; safety interface relay modules; shields; emergency stop devices; enabling devices; hold-to-run controls; zero-speed monitoring devices.

Safety-blocks, chain-locks, locking-pins, limiting/blocking pins; slide locks are a class of devices designed to hold the static load of a machine and prevent hazardous motion. They are required to hold the full load at actuation or to be interlocked. Machine specific standards such as B11.1 (mechanical power presses) and B11.2 (hydraulic power presses) may have other guidance than that found in B11.19.

Workholding equipment such as clamps, jigs, fixtures and back gages should not create new hazards such as restricted visibility or the need for the operator to enter the hazard zone. They may reduce the possibility of part ejection.

The stopping performance monitor assesses the performance of the stopping function. It will prevent process initiation if the stopping time is found to be less than the required time to maintain the safety distance as determined by a risk assessment.

Process malfunction, detection and monitoring equipment is used to detect hazardous situations which arise such as part ejection, misfeed, transfer, overload, or other problems. Such systems are not directly a guard but monitor hazards and usually shut down the machine accordingly. Hand-tools are not guarding but are expected to be of sufficient size and shape as to keep hands out of the hazard zone. Materials should not shatter and the tool itself should not create a hazard in and of itself.

Safety interface relay modules are a part of the safety system and should meet the requirements of clause 6.1 (Performance of the Safety Related Function) as well as meet the proper safety level as required by the risk assessment.

Shields appear in different work processes. When shields are used as safeguarding, they are required to meet the requirements of clause 7 (Guards). Shields may need to block particle ejections, part ejections, or to stop hands from entering the area like a guard does.

Emergency stop devices are not safeguarding devices because they require action by someone usually after a hazardous event has occurred. They do not prevent access or exposure. However, emergency stop devices can limit exposure. Possible design references are ISO 60204-1, ISO 13850, and IEC 60947-5-5. Example devices might be pushbuttons, rope-pull, cable-pull, foot-operated device, rod-operated device, push-bar-operated device. They are required to remove all power to the entire machine and to be sustained until a full reset. The device should not interfere with the safe operation of other safeguarding.

Enabling devices and hold-to-run controls are used to ensure that an operator is paying attention or that multiple operators have given consent to machine operation and are located away from the hazard zone. Enabling devices are configured in a three position format (off-run-off); run is the center position. Hold-to-run controls require the operator(s) to physically hold the button(s) in place to operate the machine. They operate similar to a voting button for multiple operators to ensure all are ready and in the proper location.

Zero-speed monitoring devices detect that motion has completely stopped in a dynamic process. These might be used to interlock a door or a guard. Again, these devices must meet the appropriate safety performance level as determined by a risk assessment.

Training, Inspection, and Maintenance. Users are required to document safeguarding and provide maintenance instructions, recommendations, and procedures to maintenance personnel for the safeguarding. This material can be found in manufacturer recommendations, in the standard, and in the requirements identified in the risk assessment. The safeguarding must perform as intended.

Procedures are written and do not become actions unless the personnel executing them are trained to do so. Also personnel need to be trained in the use of the safeguarding and to recognize hazards. Training can increase safety by informing workers of hazardous processes and the consequences of improper actions. Training is required for safety and maintenance operations.

Changes from Previous Version

PSDI. Presence-sensing device initiation (PSDI) has been added to B11.19 and is also covered in B11.0. ANSI B11.19 and B11.0 give recommendations for utilizing PSDI on many devices. PSDI is a mechanism of using a presence-sensing device such as a light curtain as a safeguard and as a process initiation device. Because the device allows someone to penetrate the hazard zone with the machine in a ready state and actuate after they withdraw, a poorly designed system could easily injure a worker.

ANSI B15.1 inclusion in standards and discontinuation of standard. ANSI B15.1, "Safety Standard for Mechanical Power Transmission Apparatus", was a base standard used in the power transmission applications in many industries. This standard has been discontinued, and the information has been incorporated into B11.0 and B11.19.

Selected applicable international standards

There are many supporting and international standards for safeguarding. Although there are only a few machine specific international standards, ISO is in the process of writing more. The implementation of international standards in the United States can be problematic because of possible references to European Union regulations or testing certifications not available in the United States. B11.19 does a very good job of referring the reader to complementary ISO standards. Annex I includes a table of 76 Safeguarding devices and their applicable ANSI and international references. The B11.19 document makes reference to the ISO standards in the explanatory information throughout as informative references but not as normative references; a normative reference is a mandatory reference.

Summary

This paper has provided an overview of key features in the newly revised ANSI B11.0 and B11.19 standards. ANSI B11.0-2010 is an A-level standard with machine safety requirements common to many machines. Risk assessment guidance from ANSI B11.TR3 has been incorporated into B11.0. ANSI B11.19-2010 has also been substantially revised with changes in the following key areas: 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).

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