ANSI B11.26-2018

American National Standard for Machines-

Functional Safety for Equipment: General Principles for the Design of Safety Control Systems Using ISO 13849-1

ANSI-Accredited Standards Developer and Secretariat:



B11 Standards, Inc. POB 690905 Houston, TX 77269 www.b11standards.org

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Foreword (Not a normative part of ANSI B11.26-2018)

This American National Standard was first developed as ANSI Technical Report B11.TR6 and published in 2010. The B11 Accredited Standards Committee agreed to a revision as American National Standard ANSI B11.26 in order to address the dynamic state of ongoing international and national/regional standard revisions regarding functional safety. Given the advances in technologies and the proliferation of risk assessment as the foundational process for safety designs, it was essential for the B11 ASC to approve further committee work to improve the understanding of electrical, pneumatic and hydraulic safety circuits as well as how ISO 13849-1 relates to this topic. The primary attributes of this new B11.26 standard are the detailed schematic diagrams, the "Circuit Analysis Tables," and the detailed annexes for understanding performance levels and category block diagrams as outlined in ISO 13849-1. The intent is to clarify and provide direction for functional safety applications in current and future equipment installations. These detailed generic (non vendor-specific) schematic diagrams are based on actual applications that have been successfully implemented in commerce.

The B11.26 Subcommittee began with current industrial circuit applications and provided many examples of common solutions in use at the time of creating this document. It is important to understand that there are many ways to fulfil a given engineering requirement and the examples only present one option. These examples are not normative, nor intended to limit innovation or the advancement of technology.

ANSI B11.26 illustrates safety control circuit design concepts used to realize safety functions. These functions reduce risks identified by a risk assessment. The following example circuits, explanations, and minimum fault exclusions are for educational purposes and do not contain complete information on electrical, fluid power, and mechanical design requirements. Substitutions, additions, or changes to the circuits, components, safety modules, or engineering control – devices should be thoroughly researched and examined as to the extent of the impact on the integrity, reliability, and the level of performance of the safety functions. The designer should refer to relevant standards, regulations, and codes to address the installation and safety requirements.

Industry users expressed the desire that example circuits be depicted in a NEMA format. To provide clarity and enhance understanding, the writing subcommittee created symbols for safety components that previously did not exist. These new symbols distinguish safety-rated components from their non-safety-rated counterparts such as emergency stops and forced guided relays. This document also identifies the relationship between risk assessment (ANSI B11.0) and control circuit reliability, including the use of ISO 13849.

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 B11 Standards, Inc., POB 690905, Houston, TX 77269, Attention: B11 Secretariat.

This standard was prepared by the B11.26 Subcommittee, 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:

Alan Metelsky, Chairman Anne Mathias, PE, Vice-Chairman David Felinski, Secretary

Organizations Represented

AHT Insurance Aluminum Extruders Council American Society of Safety Professionals Association For Manufacturing Technology The Boeing Company Bridgestone **Bureau Veritas** Canadian Standards Association Deere & Co. Euchner Exponent FDR Safety **General Motors Corporation** Grantek Komatsu America Industries Liberty Mutual MAG Automotive Metal Powder Industries Federation National Institute for Occupational Safety & Health Occupational Safety & Health Administration Omron Scientific Technologies Incorporated Packaging Machinery Manufacturers Institute Pilz Automation Safety, LP Plastics Industry Association Precision Metalforming Association Presence-sensing Device Manufacturers Assoc. **Robotic Industries Association Rockwell Automation** Safe-T-Sense SICK, Inc. Sheet Metal & Air Cond. Contractors Nat'l. Assn. Sub-Zero Group Toyota Motor Manufacturing North America

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Introduction & Overview of the ANSI B11 Series of Machinery Safety Standards

Introduction

The main purpose of every machine tool is to process materials. Inadvertent interference with, or accidental misdirection of the released energy during production, maintenance, commissioning and de-commissioning can result in injury.

The purpose of the ANSI B11 series of machinery safety standards is to devise and propose ways to eliminate or minimize risks of the potential hazards associated with the required tasks. 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. This standard recognizes that zero risk does not exist and cannot be attained. However, a good faith approach to risk assessment and risk reduction should achieve an acceptable risk level.

Organization and Application of B11 Documents

The B11 standards and technical reports can be associated with the ISO "type A-B-C" structure as described immediately below, and as shown in Figure 1.

- **Type-A standards** (basis standards) give basic concepts, principles for design, and general aspects that can be applied to machinery;
- **Type-B standards** (generic safety standards) deal with one or more safety aspects or one or more types of engineering controls that can be used across a wide range of machinery:
- **Type-C standards** (machinery safety standards) deal with detailed safety requirements for a particular machine or group of machines.

The B11.0 standard on general safety requirements common to ANSI B11 machines is primarily a "Type -A" standard in that it applies to a broad array of machines and contains very general requirements. However, in many areas it also contains very specific requirements. B11.19, B11.20, B11.21, B11.25, B11.26, as well as the entire B11 series of Technical Reports are all typical "Type-B" documents addressing general safety elements that can be used across a wide range of machinery (such as B11.19 and B11.26) or as a standard when combining machines (B11.20). The B11 series of Technical Reports are informative documents that may be generally applied to many different machines, and as such would fall into the "Type-B" category. The machine-specific ("Type-C") B11 standards contain detailed safety requirements for a particular machine or group of machines (such as this standard). The Type-A B11.0 and the Type-C (machine-specific) B11 standards are intended to be used concurrently by the supplier and user of machines. When a Type-C standard deviates from one or more provisions dealt with by this standard or by a Type-A standard, the Type-C standard requirement generally takes precedence. Any deviation in conforming to a requirement of any standard should be carefully evaluated and based on a documented risk assessment.



Figure 1: Organization of the B11 Series of Documents

ANSI B11.26 applies when a control system is used as a risk reduction measure. The responsibility for reducing these risks to an acceptable level is divided between the equipment supplier, the equipment modifier, the equipment user and its operating personnel, as addressed in Figure 2. This Figure provides the structure of a typical type-C standard and in particular, the responsibilities of and requirements for the supplier, modifier, user, and the user personnel. It is provided so the reader can better understand the responsibilities for reducing risk, since this type-B standard applies when a control system is used as a risk reduction measure. Parenthetical numbers denote the particular clause/subclause of the type-C standard.



Figure 2: Typical clause layout of B11 base standards showing the various responsibilities

- **SUPPLIER:** The early stages of a project present the greatest opportunity to determine project requirements and to anticipate and eliminate hazards and hazardous situations.
- **MODIFIER:** The entity (OEM, Supplier, or the expert) in that discipline responsible for creating or modifying the system, machinery or equipment, shall have all relevant design standards documentation. The entity shall begin by working with the end user to list all tasks to achieve an appropriate comprehensive task list base of the "context of use" for the system, machine or equipment.
- **USER:** The company representatives (can be from many disciplines) where the system, machinery or equipment will reside during its productive life. They should engage in participating or reviewing the risk assessment and what will be necessary for a final safety buy-off at the final location.
- **PERSONNEL:** The group "at risk" from any hazards or hazardous situation presented by the system, machinery, or equipment while performing their tasks to achieve the company's desired productive life. This would include at a minimum, operators, maintenance personnel for both planned and unplanned maintenance, housekeeping and safety representatives. This group would evaluate the engineering controls and administrative controls (see ANSI B11.19).

As of the date of approval of this standard, the ANSI B11 series of American National Standards and Technical Reports on machinery safety consisted of the following documents shown in the list below. The user should check a licensed reseller such as ANSI (www.ansi.org) for the current versions of any of these documents. All archival / historical versions of the documents are available at www.b11standards.org.

List of the ANSI B11 Series of Safety	/ Standards and Technical Reports
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#	SHORT TITLE / TOPIC	YEAR	TYPE	
B11.0	Safety of Machinery	2015	А	
B11.1	Mechanical Power Presses	2009 (R14)	С	
B11.2	Hydraulic & Pneumatic Power Presses	2013	С	
B11.3	Power Press Brakes	2012	С	
B11.4	Shears	2003 (R13)	С	
B11.5	Ironworkers	1988 (R13)	С	
B11.6	Manual Turning Machines w/ or without Auto Control	2001 (R12)	С	
B11.7	Cold Headers and Cold Formers	1995 (R15)	С	
B11.8	Manual Milling, Drilling, & Boring Machines	2001 (R12)	С	
B11.9	Grinding Machines	2010 (R15)	С	
B11.10	Sawing Machines	2003 (R15)	С	
B11.11	Gear and Spline Cutting Machines	2001 (R12)	С	
B11.12	Roll Forming and Roll Bending Machines	2005 (R15)	С	
B11.13	Single & Multiple-Spindle Automatic Bar and Chucking Machines	1992 (R12)	С	
B11.14	Coil Slitting Machines (combined into B11.18)	Withdrawn		
B11.15	Pipe, Tube and Shape Bending Machines	2001 (R12)	С	
B11.16	Powder / Metal Compacting Presses	2014	С	
B11.17	Horizontal Hydraulic Extrusion Presses	2004 (R15)	С	
B11.18	Machines Processing or Slitting Coiled or Non-Coiled Metal	2006 (R12)	С	
B11.19	Performance Requirements for Risk Reduction Measures (Safeguarding)	2010	В	
B11.20	Integration of Machinery into Systems	2017	В	
B11.21	Machine Tools Using Lasers for Processing Materials	2006 (R12)	В	
B11.22	Turning Centers and Automatic Numerically Controlled Turning Machines	2002 (R12)	С	
B11.23	Machining Centers & CNC Milling, Drilling & Boring Machines	2002 (R12)	С	
B11.24	Transfer Machines	2002 (R12)	С	
B11.25	Large Machines	2015	В	
B11.26	Functional Safety for Equipment	2018	В	
B11.27	Electro-Discharge Machines	201x	С	
B11.TR1	Ergonomics	2016	В	
B11.TR2	Metal Working Fluids	1997	В	
B11.TR3	Risk Assessment / Risk Reduction	2000 (R15)	В	
B11.TR4	Selection of Programmable Electronic Systems (PES/PLC)	2004 (R15)	В	
B11.TR5	Noise Measurement	2006	В	
B11.TR6	Safety Control Systems for Machines	2010	В	
B11.TR7	Integration of Lean and Safety	2007 (R17)	В	
B11.TR8	Inspection and Maintenance of Risk Reduction Measures	201x	В	
B11.TR9	201x	В		
ANSI/ISO 12100 Safety of machinery (identical adoption of ISO 12100-2010) 2012 A				



American National Standard for Machines-

Functional Safety for Equipment: General Principles for the Design of Safety Control Systems Using ISO 13849-1

1 Scope

This American National Standard provides both requirements and guidance for the implementation of safetyrelated control functions (functional safety) as they relate to electrical, electronic, pneumatic, hydraulic, and mechanical components of control systems.

Informative Note 1: This document includes a large number of detailed schematic circuit diagrams that are provided as EXAMPLE circuits only, representing common solutions in use at the time of creating this document. It is important to understand that there are many ways to fulfil a given engineering requirement and the examples only present one option. These examples are not normative, nor intended to limit innovation or the advancement of technology.

Informative Note 2: This document references ISO 13849-2 – Validation as part of an annex. Informative Note 3: This document is not intended to address the programming or software of programmable electronic systems/programmable electronic devices (PES/PED). See ANSI B11.TR4. Informative Note 4: See also, clause 4 on "How to use this standard."

2 References

The following normative documents contain provisions that, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements subject to this American National Standard should consider applying the most recent editions of the normative documents listed below. This standard is intended to be used in conjunction with the following American National Standards:

2.1 Normative References

ANSI B11.0 – 2015, Safety of Machinery

ANSI B11.19 – 2010, Performance Criteria for Safeguarding

ANSI / NFPA 79 - 2018, Electrical Standard for Industrial Machinery

ANSI / ASSE Z244.1-2016, Control of Hazardous Energy – Lockout, Tagout and Alternative Methods SAE 100Rx, Hydraulic Hose and hose fittings

2.2 Informative References

ANSI B11.TR3 – 2000 (R16), Risk Assessment and Risk Reduction – A guide to estimate, evaluate and reduce risks associated with machine tools (see ANSI B11.0)

ANSI B11.TR4 – 2004 (R16), Selection of Programmable Electronic Systems (PES/PLC) for Machine Tools ANSI / ISO 12100:2012 (ISO 12100:2010 IDT), Safety of machinery – General principles for design – Risk assessment and risk reduction

ASME Boiler and Pressure Vessel Code Section VIII Division 1.

- ISO 13849-1:2015, Safety of machinery Safety-related part of control systems Part 1: General Principles for Design
- ISO 13849-2:2012, Safety of machinery Safety-related part of control systems Part 2: Validation
- ISO 4413 2010, Hydraulic fluid power General rules and safety requirements for systems and their components
- ISO 4414 2010, Pneumatic fluid power General rules and safety requirements for systems and their components
- ISO 1219-1: 2012, Fluid power systems and components Graphical symbols and circuit diagrams
- Part 1: Graphical symbols for conventional use and data-processing applications
- IEC 60204-1 Safety of electrical equipment of machinery used for general electrical safety aspects
- IEC 61508 Parts 1-7 Functional safety of E/E/PE safety-related systems used for the design of complex subsystems
- IEC 62061 Safety of machinery Functional safety of safety-related electrical, electronic and programmable electronic control systems
- ISO 8573 2001 Compressed air -- Part 1: Contaminants and purity classes
- IEC 60947-5-8:2006 Low voltage switchgear and control gear Part 5-8: Control circuit devices and switching elements Three-position enabling switches