ANSI B11.26–2024

American National Standard for Machines –

Functional Safety:

General Principles for Designing Safety–Related Parts of Control Systems for Machinery

ANSI-Accredited Standards Developer and Secretariat:

B11 Standards, Inc.
Houston, Texas, USA
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Board of Standards Review

AMERICAN NATIONAL STANDARDS

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Foreword (The Foreword is NOT a normative part of ANSI B11.26-2024)

The content of this American National Standard was first developed and released as ANSI Technical Report B11.TR6 and published in December 2010. In the subsequent years of use, the B11 Standards Development Committee decided that the content of the document was sufficiently important to be elevated to a standard and agreed to a revision of B11.TR6 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 and in particular, to provide a more practical "application-type" document for the complicated ISO 13849 standard. The primary attributes of the first edition of the ANSI B11.26 standard were the allowance of different methodologies to characterize reliability, detailed example schematic diagrams, and "Circuit Analysis Tables" that provided additional technical detail for each example. Detailed annexes for understanding performance levels and category block diagrams as outlined in ISO 13849-1 were also provided. The detailed, generic (non-supplier specific) schematic diagrams were based on actual applications that have been successfully implemented in industry.

The current revision further expands on the 2016 edition and includes the following significant changes:

- **Changed title to clarify that the standard is intended to address requirements for functional safety – using a variety of accepted methodologies;**
- **Definitions updated and harmonized with other ANSI B11 standards where practical;**
- **Added and clarified requirements in clause 4, when using categories to specify reliability;**
- **Provided historical information on "control reliability;"**
- **Included Safety integrity level (IEC 62061) methodology as an approved methodology to specify reliability;**
- **Modified Risk Graph for Categories to clarify selection;**
- **Provided information/requirements for trapped key applications;**
- **Provided basic requirements for software used in functional safety applications;**
- **Provided basic requirements for management of change;**
- **Fluid power output applications reorganized by safety function; for example, "directional valves" were separated into exhaust, return, or stopping functions;**
- **Additional fluid power example functions added for safe pressure, closed center stopping, and rod lock applications;**
- **Fluid power monitoring was expanded to explain different methods of monitoring;**
- **Fluid power application chart data simplified;**
- **addition of Annex Q (Example of using ISO 13849 to avoid overly complex designs).**

The B11.26 Subcommittee provided many examples for common solutions of current industrial circuit applications. It is important to understand that there are many ways to fulfil a given engineering requirement, and the examples provided in this standard only present one of those many options. 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 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 devices 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 13849-1.

Internal (intra-document) references are hotlinked to their source; to activate, position the cursor over the hotlink and use control and left-click.

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.: cfelinski@B11standards.org Attention: B11 Secretariat / B11.26.

This standard was prepared by the B11.26 Subcommittee, processed and submitted for ANSI approval by the B11 Standards Development Committee on Safety Standards for Machines. At the time this standard was approved as an American National Standard, the ANSI B11 Standards Development Committee was composed of the following member organizations:

Alan Metelsky, FS Eng, Chair / Anne Mathias, PE, Vice-Chair / David Felinski, Secretary

Organizations Represented	**Name of Representative**	
	Delegate	**Alternate**
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American Society of Safety Professionals	Ted Sberna, Sr.	Anne Mathias, PE
Association for Advancing Automation	Maren Roush	Jeff Fryman
Association For Manufacturing Technology	Doug Otte	Alan Metelsky, FS Eng
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Eli Lilly	Bryan Harrell, FS Eng	Danny Deighton
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IDEM Safety	Mark Witherspoon	Amir Mohtasham
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Liberty Mutual	Ashlee Blum, CSP, CSE	Julie Thompson, CSP
MAG Automotive	Erik Carrier	Doug Watts
Metal Powder Industries Federation	Bill Edwards	James Adams
National Inst. for Occupational Safety & Health	Rick Current, PE	
Occupational Safety & Health Administration	Ken Stevanus	Mary Bauer, CIH, CSP, B11 LMSS
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Sheet Metal & Air Cond. Contractors Nat'l. Assn.	Justin Crandol, CSP	Rick Di Ioli
Toyota Motor Manufacturing North America	Chip Boertlein	Mike Collier, B11 LMSS

At the time this standard was approved, the **B11.26 Functional Safety Subcommittee** had the following members who participated in and contributed to the development of this American National Standard:

Alan Metelsky, Chairman	Gleason Works	Eric Cummings, Vice-Chair	Ross Controls
Jim Barrett	Link Systems	Marc Lewandowski	Proctor & Gamble
Craig Brockway	Machine Safety Specialists	Bruce Main	design safety engineering
Chris Brogli	Ross Controls	Rhiannon McPherson	Boeing
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Patric Brown	Grantek	Alex Parry	Safe-T-Sense
Eric Carrier	MAG Automotive	Mike Poynter	Safe-T-Sense
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Chase Davis	EOSYS Group	Ted Sberna, Sr.	White Horse Safety
Todd Dickey	Honda	Jeread Sines	Amazon
Bryant Eismeier	Flexware Innovation	Marco Tacchini	GT Engineering, Italy
Kenji Furukawa	Bridgestone	Marty Timm	Centigrade Services
Bryan Harrell	Eli Lilly	Jenny Tuertscher	Fortress Safety
Ryan Hayworth	Airline Hydraulics	Mark Witherspoon	IDEM Safety
Jim Holton	International UAW	Chris Felinski, Secretary	B11 Standards, Inc.

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

Introduction

The purpose of the ANSI B11 series of machinery safety standards and technical reports 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 ANSI B11 series of 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 Standards Development Committee recognizes that an additional type of standard has emerged, which we categorize as a so-called "**Hybrid standard."** These hybrid standards represent an evolutionary development in machinery safety standardization that combines some unspecified percentage of the typical content and requirements found in any two (or even all three) of the standard types described above. Usually, there are some combinations of requirements generally found in type-A and type-C standards. With the possible exception of ANSI B11.0, none of the other documents in the B11 portfolio fit into this new type, numerous examples of these hybrid machinery safety standards exist outside of ANSI B11.

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.

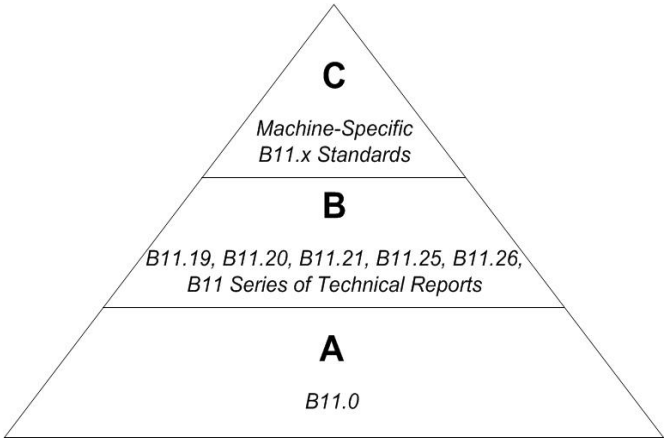

Figure 1: Organization of the B11 Series of Documents

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. Figure 2 (below) 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. Figure 2 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.

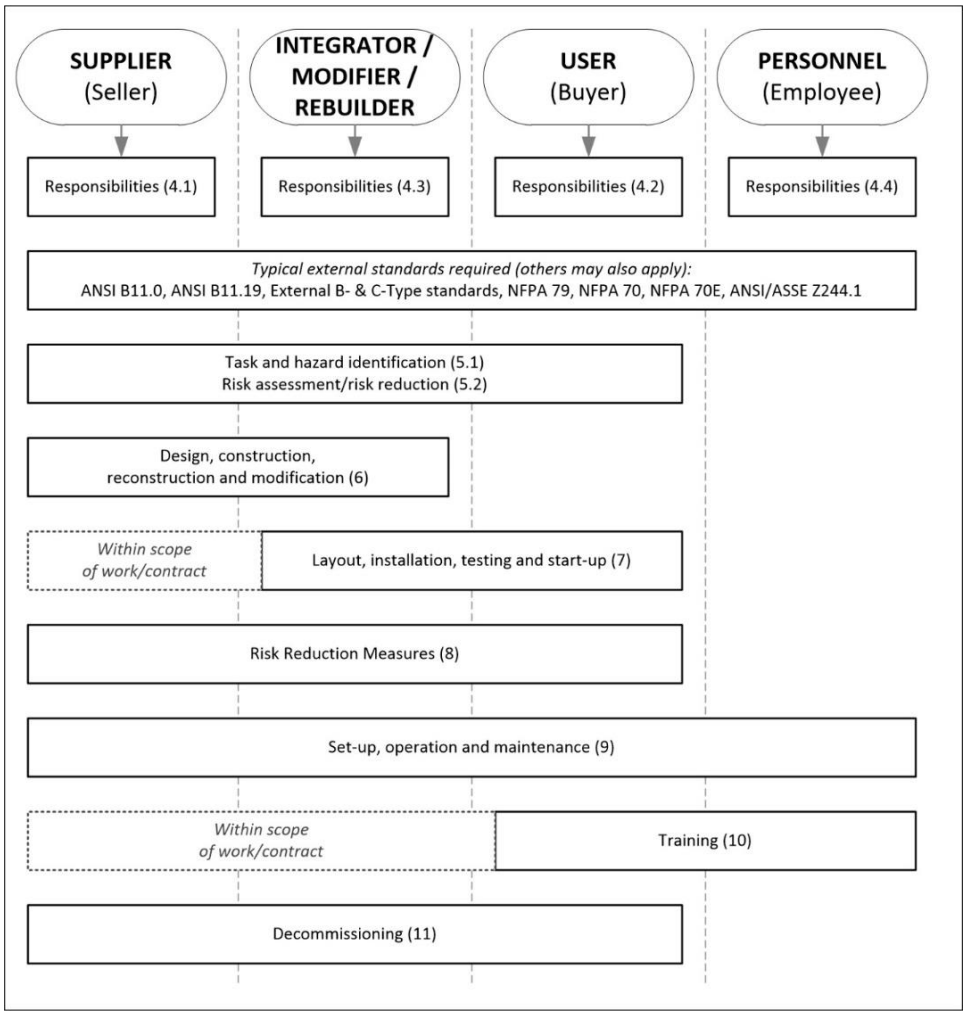

Figure 2: Typical clause layout of B11 base (type-C) standards showing the various responsibilities

- **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 based on 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 in 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

#	SHORT TITLE / TOPIC	YEAR	TYPE
B11.0	Safety of Machinery	2023	A
B11.1	Mechanical Power Presses	2009 (R2020)	C
B11.2	Hydraulic & Pneumatic Power Presses	2013 (R2020)	C
B11.3	Power Press Brakes	2022	C
B11.4	Shears	2003 (R2020)	C
B11.5	Ironworkers	1988 (R2020)	C
B11.6	Manual Turning Machines w/ or without Auto Control	2022	C
B11.7	Cold Headers and Cold Formers	2020	C
B11.8	Manual Milling, Drilling, & Boring Machines	2022	C
B11.9	Grinding Machines	2010 (R2020)	C
B11.10	Sawing Machines	2003 (R2020)	C
B11.11	*Withdrawn* (Gear and Spline Cutting Machines; covered by B11.0)	2001 (R2012)	C
B11.12	Roll Forming and Roll Bending Machines	2005 (R2020)	C
B11.13	Single & Multiple-Spindle Automatic Bar and Chucking Machines	2020	C
B11.14	*Withdrawn* (Coil Slitting Machines; combined into B11.18)	(1996)	C
B11.15	Pipe, Tube and Shape Bending Machines	2022	C
B11.16	Powder / Metal Compacting Presses	2014 (R2020)	C
B11.17	Horizontal Extrusion Presses	2023	C
B11.18	Machines Processing or Slitting Coiled or Non-Coiled Metal	2006 (R2020)	C
B11.19	Performance Requirements for Risk Reduction Measures (Safeguarding)	2019	B
B11.20	Integration of Machinery into a System	2017 (R2022)	B
B11.21	Machine Tools Using Lasers for Processing Materials	2006 (R2020)	B
B11.22	Turning Centers and Automatic Numerically Controlled Turning Machines	2002 (R2020)	C
B11.23	Machining Centers & CNC Milling, Drilling & Boring Machines	2002 (R2020)	C
B11.24	Transfer Machines	2002 (R2020)	C
B11.25	Large Machines	2022	B
B11.26	Functional Safety: Designing SRP/CS for Machinery	2024	B
B11.27	Electro-Discharge Machines	2024	C
B11.TR0	Guide to Establishing a Machine Safety Process Using ANSI B11 Stds	2024	B
B11.TR1	Ergonomics	2016	B
B11.TR2	*Withdrawn (*Metal Working Fluids)	1997 (R2016)	B
B11.TR3	*Withdrawn* (Risk Assessment / Risk Reduction Guide)	(2000 R2015)	B
B11.TR4	Selection of Programmable Electronic Systems (PES/PLC)	2004 (R2015)	B
B11.TR5	Noise Measurement	2006 (R2017)	B
B11.TR6	*Withdrawn* (Safety Control Systems for Machines)	(2010)	B
B11.TR7	Integration of Lean and Safety	2007 (R2017)	B
B11.TR8	Sustainable Safety Systems Thru Inspection of Risk Reduction Measures	2022	B
B11.TR9	Cybersecurity	2019	B
B11.TR10	Guidance on Artificial Intelligence into Machinery Safety Applications	2020	B
B11.TR11	Using ANSI Standards for CE-marking of Machinery	2024	B
ANSI/ISO 12100	Safety of machinery (identical adoption of ISO 12100-2010)	2012	A

Functional Safety:
General Principles for Designing Safety-Related Parts of Control Systems for Machinery

1 Scope

This American National Standard provides requirements and guidance for the implementation of safety-related control functions (also known as "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: *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 – 2023, Safety of Machinery

ANSI B11.19 – 2019, Performance Requirements for Risk Reduction Measures: Safeguarding and Other Means for Reducing Risk

NFPA 79 – 2024, Electrical Standard for Industrial Machinery

ANSI / ASSP Z244.1-2016, Control of Hazardous Energy – Lockout, Tagout and Alternative Methods

Informative Note 1: *At the time of approval of ANSI B11.26, this reference standard has been revised and approved and is expected to be published relatively soon – check the ANSI Standards Store.*

2.2 Informative References

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 1219-1:2012, Fluid power systems and components – Graphical symbols and circuit diagrams Part 1: Graphical symbols for conventional use and data-processing applications

ISO 4406:2021 Hydraulic fluid power. Fluids. Method for coding the level of contamination by solid particles

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 13849-1:2023, 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

Informative Note: *At the time of approval of ANSI B11.26, this informative reference standard was in revision and is expected to be approved sometime in 2026.*

ISO 14119:2024 Interlocking devices associated with guards – Principals for design and selection