B11.TR6-2010

ANSI Technical Report for Machines –

Safety Control Systems for Machine Tools

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Secretariat and Accredited Standards Developer, prepared by:
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Foreword

Recognizing the need for a guidance document on the subject matter, the ANSI B11 Accredited Standards Committee for Machine Safety formed a subcommittee consisting of professionals that are involved in manufacturing, safety, design, integration and controls to develop a technical report giving guidance in understanding and implementing safety control functions when applied to machines covered by the ANSI B11 series of machine safety standards.

The intent is to illustrate safety control circuit design concepts to help mitigate the 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 safeguarding 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 all installation and safety requirements.

The B11.TR6 Subcommittee began with current industrial circuit applications and provided examples of common solutions in use at the time of creating this document; these are not intended to limit innovation or the advancement of technology.

Industry users expressed the desire that example circuits be depicted in a NEMA format. To provide clarity and enhance understanding the committee 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 ANSI B11.TR3 risk level (now included within ANSI B11.0) and that of the Categories of ISO 13489.

The Circuit Analysis Table for each circuit diagram provides important guidance information on the performance of safety-related functions, identification and analysis of failures, and safety-related performance levels for categories B through 4 as referenced in section 4.13.

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Summary of ISO 13849-1 Categories:

Category B Circuit

- Is designed in accordance with relevant standards.
- Can withstand the expected influences.
- The occurrence of a fault can lead to loss of the safety function.

Category 1 Circuit (includes Category B):

- Is designed in accordance with relevant standards.
- Well-tried components and well-tried safety principles are used.
- The occurrence of a fault can lead to loss of the safety function.

Category 2 Circuit (includes Category B and well tried safety principles):

- Safety function shall be checked at suitable intervals by the machine control system.
- The occurrence of a (single) fault can lead to loss of the safety function between the checks.
- The loss of safety function is detected by the check (automatic or manual).

  NOTE: A suitable frequency of checking (periodic test interval) will be dependent on the reliability of components and the probability of failure. A tolerable probability of failure will be determined in the risk assessment.

Category 3 Circuit (includes Category B and well tried safety principles):

- A single fault does not lead to loss of the safety function, and whenever reasonably practicable the single fault is detected (i.e. some but not all faults will be detected).
- Accumulation of undetected faults can lead to loss of the safety function.

Category 4 Circuit (includes Category B and well tried safety principles):

- A single fault does not lead to loss of the safety function, and the single fault is detected at or before the next demand upon the safety function. If this is not possible, then an accumulation of faults shall not lead to loss of the safety function.
- The faults will be detected in time to prevent loss of the safety function.

Guide for using this document

Process steps needed to use this document:

- Conduct a risk assessment
- Determine the risk reduction required (e.g., Category, performance level, control reliability, SIL, etc.)
- Define the safety function (what needs to happen)
- Implement the safety function by selecting component(s) and designing the control circuit

Steps in the application of this document:

- Determine failure modes to be managed
- Select the safeguarding device and/or complementary equipment,
- Using the Table of Contents Clause 5 (Input devices (safeguarding devices complementary equipment)) subclause listings, choose the appropriate input device implementation
- Using the Table of Contents Clause 6 (Power controls and actuators) subclause listings, choose the appropriate output device implementation
- Evaluate the effectiveness of that system for the desired results

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While standards generally use the term *shall* to denote a requirement and the term *should* to denote a recommendation, this document is written using those terms consistent with how they are used in a standard (normative requirement vs. an informative recommendation). Nonetheless, nothing in this document is normative; Technical Reports are considered ~~i~~nformative" or ~~g~~uidance" documents.

This Technical Report was prepared by the B11.TR6 Subcommittee, processed by the B11 Accredited Standards Committee (ASC) on Safety Standards for Machines, and submitted by its Secretariat for ANSI registration.

At the time this Technical Report was processed and registered, the ANSI B11 Accredited Standards Committee was composed of the following member organizations:

John W. Russell, PE, CSP, Chairman
Gary D. Kopps, Vice-Chairman
David A. Felinski, Secretary

Organizations Represented	Name of Representative	
	Delegate	**Alternate**
Aerospace Industries Association of America	Willard J. Wood, ARM	Lance E. Chandler, PE
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
International United Automobile Workers	Tom Ford	

The B11.TR6 Subcommittee on safety control systems which developed this TR had the following members:

Sam Boytor	Fox Controls	Chairman
Chris Bacon	Nexteer	
Barry Boggs	Toyota	
Mike Carlson	Banner Engineering	
Eric Cummings	Ross Controls	
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Frank Webster	Omron STI	
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Cindy Haas	AMT	Secretary

Introduction and Overview of the ANSI B11 Series

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 tool safety standards and technical reports 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 and technical reports.

A general overview of the interaction between a typical ANSI B11 American National Standard and other standards / technical reports follows. Figure 1 provides a graphical overview of this scheme and in particular the responsibilities of and requirements for the manufacturer and user, including the user personnel. Numbers in parentheses denote the particular clause or subclause in the typical B11 standard.

The responsibility for the alleviation of these risks is divided between the equipment manufacturer, the user and the user's operating personnel, as follows (numbers in parentheses refer to the clause numbers in these ~~b~~base" B11 standards which address that responsibility).

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 manufacturer (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 manufacturer and user, the requirements of this clause may fall primarily on either entity (see ANSI B11.0 for further explanation of hazard/task identification and risk assessment/risk reduction).
6) Design and construction – It is assumed that the manufacturer 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 manufacturer will normally provide assistance either directly (providing personnel) or indirectly (instruction materials).
8) Safeguarding – This is normally a shared responsibility but often, either the manufacturer 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 manufacturer for training.

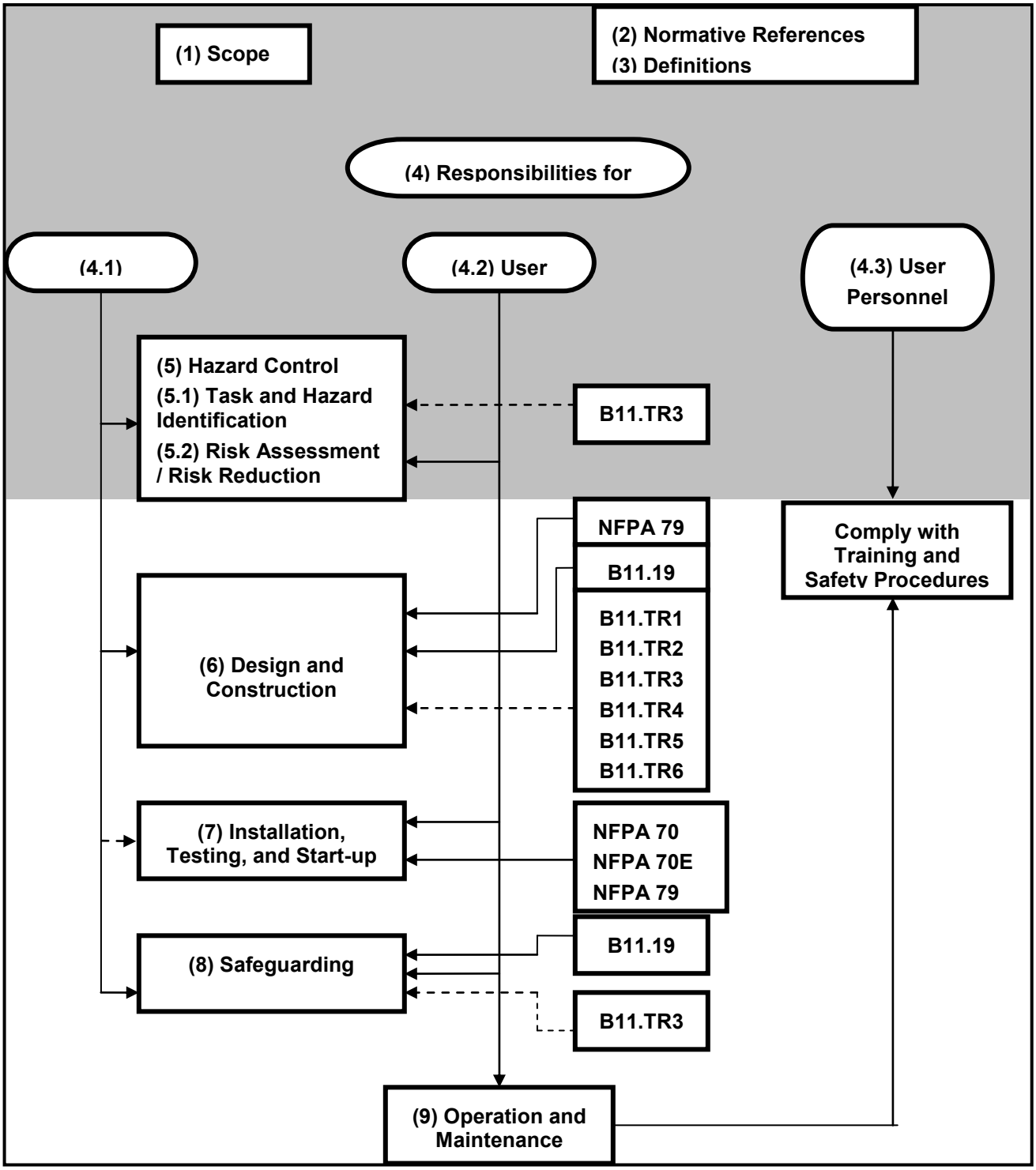

Figure 1 – Typical layout of B11 base standards showing the various responsibilities

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. See clause 2 for further information on standards referenced in Figure 1.

ANSI B11.TR6
Safety Control Systems for Machines

1 Scope

This Technical Report provides guidance in understanding and implementing safety-related control functions (functional safety) as they relate to electrical, electronic, mechanical, pneumatic, hydraulic components and systems for machines covered by the B11 series of safety standards.

NOTE 1: The terminology used in this document may not be used consistently throughout the industry, but this document does represent concepts which are important when using and designing safety-related control systems.

NOTE 2: Usage of [machine] in the following text means any of the specific machines/machine tools covered by the ANSI B11 ‗base' series of safety standards.

NOTE 3: This document is not intended to address programmable electronic systems/programmable electronic devices (PES/PED). See B11.TR4.

2 References

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

ANSI B11.19 – 2010 Performance Criteria for Safeguarding

ANSI / NFPA 79 – 2007 Electrical Standard for Industrial Machinery

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 / U.L. 1998 – 2000 Software and programmable systems

ANSI / RIA R15.06 – 1999 Industrial Robots and Robot Systems – Safety Requirements

CSA Z434-03 – Industrial Robots and Robot Systems – General Safety Requirements

CSA Z432-04 – Safeguarding of Machinery

ISO 12100 – 2010 Safety of machinery—General principles for design—Risk assessment and risk reduction

ISO 13849-1:1999 Safety of machinery – Safety-related part of control systems – Part 1: General Principles for Design

ISO 13849-2:2003 Safety of machinery – Safety-related part of control systems – Part 2: Validation

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 1219-1 2006- Fluid power systems and components -- Graphic symbols and circuit diagrams -- Part 1: Graphic symbols for conventional use and data-processing applications

ISO 1219-2 1995 - Fluid power systems and components -- Graphic symbols and circuit diagrams -- Part 2: Circuit diagrams

IEC 617-7 - Graphical symbols for diagrams

ISO 1436 - Rubber hoses and hose assemblies -- Wire-braid-reinforced hydraulic types for oil-based or water-based fluids -- Specification

ISO 8573 2001 - Compressed air -- Part 1: Contaminants and purity classes

ISO 4414 1998 - Pneumatic fluid power -- General rules relating to systems

IEC 60947-5-8:2006 – Low voltage switchgear and control gear– Part 5-8: Control circuit devices and switching elements – Three-position enabling switches

NFPA T2.25.1 R2-2005 - Pneumatic fluid power - Systems standard for industrial machinery - Supplement to ISO 4414:1998 - Pneumatic fluid power - General rules relating to systems (third edition)

EN 853 - Rubber hoses and hose assemblies. Wire braid reinforced hydraulic type. Specification

SAE 100Rx - Test and Test Procedures for SAE 100R Series Hydraulic Hose and Hose Assemblies