

# ANSI B11.19-2019

*AMERICAN NATIONAL STANDARD FOR MACHINERY SAFETY*

## ***Performance Requirements for Risk Reduction Measures: Safeguarding and other Means of Reducing Risk***

ANSI-Accredited Standards Developer and Secretariat:



**B11 Standards, Inc.**  
POB 690905  
Houston, TX 77269, USA

**APPROVED: 11 OCTOBER 2019**

by the American National Standard Institute  
Board of Standards Review



**COPYRIGHT PROTECTED DOCUMENT**

**Copyright © 2019 by B11 Standards, Inc.**

**All rights reserved. Printed in the United States of America**

**No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of B11 Standards, Inc.**

Currently in preview, click buy full version

## **AMERICAN NATIONAL STANDARDS**

By approving this American National Standard, the ANSI Board of Standards Review confirms that the requirements for due process, consensus, balance, and openness have been met by B11 Standards, Inc., (the ANSI-accredited standards developing organization). American National Standards are developed through a consensus process. Consensus is established when substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward resolution. This process brings together volunteers and/or seeks out the views of persons who have an interest in the topic covered by this publication. While B11 Standards, Inc., administers the process and establishes procedures to promote fairness in the development of consensus, it does not write the document and it does not independently test, evaluate or verify the accuracy or completeness of any information or the soundness of any judgments contained in its standards or guidelines.

American National Standards are promulgated through ANSI for voluntary use; their existence does not in any respect preclude anyone, whether they have approved the standards or not, from manufacturing, marketing, purchasing or using products, processes, or procedures not conforming to the standards. However, users, distributors, regulatory bodies, certification agencies and others concerned may apply American National Standards as mandatory requirements in commerce and industry.

**Neither B11 Standards, Inc. nor any of the organizations or individuals that assisted in authoring, developing, editing or distributing this standard (B11 Standards, Inc. and such organizations and individuals collectively referred to as the "Contributing Parties") makes any warranty, either expressed or implied as to the fitness of merchantability or accuracy of the information contained within this standard. The Contributing Parties disclaim and make no warranty that the information in this document will fulfill any of your particular purposes or needs. The Contributing Parties disclaim liability for any personal injury, property or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, application or reliance on this document. The Contributing Parties do not undertake to guarantee the performance of any individual manufacturer or seller's products or services by virtue of this standard or guide, nor does it take any position with respect to the validity of any patent rights asserted in connection with the items which are mentioned in or are the subject of this document. The Contributing Parties disclaim liability for the infringement of any patent resulting from the use of or reliance on this document. Users of this document are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.**

**In publishing or making this document available, the Contributing Parties are not undertaking to render professional or other services for or on behalf of any person or entity, nor are the Contributing Parties undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment, or as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances. In addition to conforming to the requirements of this standard, the responsible personnel must also make an independent determination as to whether a machine, activity or condition complies with the applicable legal requirements in the relevant jurisdiction(s).**

B11 Standards, Inc., has no power nor does it undertake to police or enforce conformance to the requirements of this document. B11 Standards, Inc., does not certify, test or inspect products, designs, or installations for safety or health purposes. Any certification, approval or statement of conformance to any health or safety-related information in this document shall not be attributable to B11 Standards, Inc., and is solely the responsibility of the certifier or maker of the statement. The American National Standards Institute does not develop standards and will in no circumstances give an interpretation of an American National Standard. Moreover, no person shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute. Requests for interpretations should be addressed to the Secretariat (B11 Standards, Inc.).

**NOTICE:** This American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken periodically to reaffirm, revise, or withdraw this standard. You may contact the Secretariat for current status information on this, or other B11 standards.

Published by: B11 Standards, Inc.  
POB 690905, Houston, Texas 77269, USA

Copyright © 2019 by B11 Standards, Inc.

All rights reserved. Printed in the United States of America

**No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.**

Table of Contents	Page
<b>Foreword</b> .....	<b>v</b>
General.....	v
Application.....	v
Effective Date.....	v
Alignment.....	v
History.....	vi
Terminology.....	vii
Context.....	vii
Introduction.....	x
<b>1 Scope</b> .....	<b>12</b>
<b>2 References</b> .....	<b>13</b>
2.1 Normative references.....	13
2.2 Informative References.....	13
<b>3 Definitions</b> .....	<b>15</b>
<b>4 Responsibility</b> .....	<b>27</b>
4.1 Supplier responsibilities.....	27
4.2 User responsibilities.....	27
4.3 Integrator / modifier / rebuilder responsibilities.....	28
4.4 Personnel responsibilities.....	28
<b>5 Risk assessment process</b> .....	<b>29</b>
<b>6 Risk reduction measures</b> .....	<b>30</b>
6.1 General requirements for risk reduction measures.....	30
<b>7 Inherently safe by design</b> .....	<b>32</b>
7.1 General requirements for inherently safe design measures.....	32
7.2 Prevention through design.....	32
7.3 Safe-opening safeguarding method.....	32
7.4 Safe-location safeguarding method.....	33
7.5 Minimum gaps to avoid crushing of parts of the human body.....	34
7.6 Maximum gaps to avoid exposure to hazards.....	34
<b>8 Engineering controls – guards</b> .....	<b>36</b>
8.1 General requirements for guards.....	36
8.1.1 Guard design and construction.....	36
8.1.2 Guard visibility.....	38
8.1.3 Guard location.....	38
8.1.4 Guard operation and maintenance.....	39
8.2 Fixed guards.....	39
8.3 Movable guards.....	40
8.4 Interlocked guards.....	40
8.5 Adjustable guards.....	42
8.6 Self-adjusting guards.....	42
8.7 Partial guards.....	43
8.8 Perimeter guards.....	44
8.9 Nip guards.....	45
8.10 Shields.....	46
<b>Engineering controls – control functions</b> .....	<b>47</b>
9.1 General requirements for control functions.....	47
9.2 Performance of safety functions.....	47
9.2.1 General requirements for safety functions.....	47
9.2.2 Safety interface (safety relay) modules.....	48

9.2.3	Considerations for safety-related application software (SRASW)	49
9.3	Monitoring functions	50
9.3.1	General requirements for monitoring functions	50
9.3.2	Safe condition (stopping performance) monitoring systems	51
9.3.3	Speed monitoring function	52
9.4	Stop functions	53
9.4.1	Normal stop function	54
9.4.2	Emergency stop function	54
9.4.3	Protective stop function	55
9.5	Safety-related reset	58
9.5.1	General requirements for reset	58
9.5.2	Automatic reset	59
9.5.3	Manual reset	59
9.6	Safety distance	60
9.7	Suspension of safety functions	62
9.7.1	Manual suspension (bypassing)	62
9.7.2	Muting	64
9.8	Variable sensing functions	68
9.8.1	Safety-related sensing field switching	68
9.8.2	Safety-related sensing field blanking	75
9.9	Presence-Sensing Device Initiation (PSDI)	77
9.9.1	General requirements for PSDI	77
9.9.2	PSDI control logic	79
9.9.3	PSDI operation	81
9.9.4	User responsibilities for PSDI	81
9.10	Perimeter risk reduction measures	82
9.11	Whole body access	82
9.11.1	General requirements for whole body access	83
9.11.2	Control of hazardous energy	85
9.11.3	Prevent undetected presence of individuals within the safeguarded space	85
9.11.4	Manual reset	85
9.11.5	Location of safety-related manual control devices	86
9.11.6	Inhibit function	87
9.11.7	Interlock devices capable of internal opening	88
9.11.8	Initiation warning system	88
9.12	Span of control	93
9.12.1	Layout analysis	93
9.12.2	Level of safety performance	95
9.12.3	Identification	95
<b>10</b>	<b>Engineering controls – devices</b>	<b>95</b>
10.1	General requirements for devices	95
10.2	Interlock devices	96
10.3	Trapped (capture) key systems	101
10.3.1	General requirements for trapped key systems	101
10.3.2	Trapped key system design	102
10.3.3	Trapped key system installation	103
10.3.4	Trapped key system operation	103
10.4	Interlock blocking devices	104
10.5	Movable barrier devices	105
10.5.1	General requirements for movable barrier devices	105
10.5.2	Type A movable barrier devices	106
10.5.3	Type B movable barrier device	106
10.6	Pull back (pull out) and hold out (restraint) devices	107
10.6.1	General requirements for pull back and hold out (restraint) devices	107
10.6.2	Pull back and hold out (restraint) device operation	107
10.7	Presence-sensing devices	108

10.7.1	General requirements for presence-sensing devices .....	108
10.7.2	Light curtains and single/multiple beam devices .....	110
10.7.3	Area scanning devices.....	112
10.7.4	Close proximity point of operation AOPDs .....	115
10.7.5	Vision-based protective devices .....	116
10.7.6	Safety mat devices .....	116
10.7.7	Safety edge/bumper devices .....	117
10.7.8	Probe detection devices .....	119
10.7.9	Radio frequency devices .....	119
10.8	Two-hand actuating controls .....	121
10.8.1	General requirements for two-hand actuating controls .....	121
10.8.2	Two-hand control devices.....	123
10.8.3	Two-hand trip devices.....	124
10.8.4	Two-hand operating levers .....	124
10.9	Single actuating controls.....	124
10.9.1	General requirements for single actuating controls.....	124
10.9.2	Single control devices.....	126
10.9.3	Single trip devices.....	126
10.10	Hold-to-run control devices .....	127
10.11	Enabling devices .....	128
10.12	Emergency stop (E-stop) devices .....	129
10.12.1	General requirements for E-stop devices .....	129
10.12.2	Pushbutton-type E-stop devices.....	131
10.12.3	Rope or cable pull-type E-stop devices.....	131
10.12.4	Foot-operated E-stop devices.....	132
10.12.5	Rod-operated E-stop devices .....	133
10.12.6	Push-bar-operated E-stop devices .....	133
10.13	Slide locks .....	134
<b>11</b>	<b>Administrative controls.....</b>	<b>134</b>
11.1	General requirements for administrative controls.....	134
11.2	Awareness means.....	134
11.2.1	General requirements for awareness means .....	134
11.2.2	Awareness barriers.....	135
11.2.3	Awareness signals.....	135
11.2.4	Awareness (safety) signs.....	137
11.2.5	Awareness (safety) markings .....	137
11.3	Information for use (human and organizational) .....	137
11.3.1	Instruction manual (handbook) .....	137
11.3.2	Safe work procedures.....	138
11.3.3	Training.....	139
11.3.4	Inspection and maintenance.....	141
11.4	Administrative safeguarding methods.....	142
11.4.1	Safe-distance safeguarding method.....	142
11.4.2	Safe-holding safeguarding method.....	143
11.4.3	Other safeguarding methods .....	143
11.5	Supervision.....	143
11.5.1	Supervision of the workplace.....	144
11.5.2	Avoidance of unauthorized changes .....	144
11.5.3	Management of change .....	147
11.6	Control of hazardous energy.....	147
11.6.1	Lockout / tagout .....	147
11.6.2	Alternative methods.....	147
11.6.3	Restraint mechanisms .....	148
11.7	Tools.....	150
11.7.1	Workholding equipment.....	150
11.7.2	Hand tools.....	150

11.8 Personal Protective Equipment (PPE) .....	151
Annex A – Guidance to Understand the ANSI B11 Series of Standards & Technical Reports .....	152
Annex B – Hazard List for Risk Reduction Measures .....	153
Annex C – Performance of the Safety Function(s) .....	154
Annex D – Comparison of Physical Barriers .....	157
Annex E – Reaching Distance Considerations for Protective Structures .....	158
Annex F – Nip Guards .....	169
Annex G – Considerations for Transparent Guards .....	174
Annex H – Safety Distance Calculations for Engineering Controls – Devices .....	180
Annex I – Reaching Distance Considerations for Engineering Controls – Devices .....	186
Annex J – Measurement & calculation of system performance to achieve a safe condition .....	209
Annex K – Achieving a Safe Condition .....	212
Annex L – Safety Functions for Power Drive Systems .....	213
Annex M – Supplier Information for Time and Distance to Achieve a Safe Condition .....	223
Annex N – Awareness Means .....	224
Annex O – Risk Reduction Measures in Use .....	228
Annex P – Cross-Reference Mapping of ANSI B11.19: 2010 vs. 2019 .....	236
Bibliography of Informatively Referenced International Documents .....	249

## LIST of FIGURES

Figure 1 — Organization of the B11 Series of Documents .....	x
Figure 2 — Example of sensing field switching .....	74
Figure 3 — Example of sensing field switching of a light curtain to allow passage of material .....	74
Figure 4 — Example of sensing field switching of an area scanner to allow passage of material .....	75
Figure 5 — Determining effective detection capability of a light curtain .....	76
Figure 6 — Example of Whole body Access .....	84
Figure 7 — Example of pre-start warning system used for momentary jog control .....	93
Figure 8 — Example of a mechanical interlock .....	96
Figure 9 — Examples of interlock devices that control energy .....	97
Figure 10 — Example of trapped key transfer system .....	104
Figure 11 — Examples of two-hand actuating device design .....	122
Figure A.1 — Typical clause layout of ANSI B11 Series standards showing the various responsibilities ..	152
Figure E.1 — Reaching over a protective structure .....	160
Figure E.2a — Protective structure location versus opening size for slotted openings .....	163
Figure E.2b — Protective structure location versus opening size for square openings .....	163
Figure E.2c — Protective structure location versus opening size for round openings .....	163
Figure E.3 — Reaching through a protective structure with openings of irregular shape .....	165
Figure E.4 — Prevention of whole body access through a protective structure .....	165
Figure E.5 — Reaching through a protective structure indirectly .....	166
Figure E.6 — Reaching under a protective structure .....	167
Figure E.7 — Consideration of all reaching factors for protective structures .....	168
Figure F.1 — Examples of in-running nip hazards .....	169
Figure F.2 — Examples of nip guards .....	169
Figure F.3 — Examples of protecting nip points from side entry .....	170
Figure F.4 — Locating hazard points of in-running nips .....	171
Figure F.5 — Minimum cylinder-to-guard angle (a preferred, b acceptable) .....	171
Figure F.6 — Nip guards that create wedge pockets .....	171
Figure F.7 — Nip guards that do not create wedge pockets .....	172
Figure F.8 — Nip guard clearance .....	172
Figure F.9 — Example determining guard distances and openings .....	173
Figure G.1 — Aging curve of unprotected polycarbonate (averaged test points) .....	175
Figure H.1 — Reaction time block diagram .....	182
Figure I.1 — Vertical application of a presence-sensing device .....	189
Figure I.2 — Horizontal application of a presence-sensing device .....	189
Figure I.3 — Reaching over a vertical presence-sensing device .....	190

Figure I.4 – Reaching over a vertical presence-sensing device with an additional protective structure ..	192
Figure I.5 – Reaching through a vertical sensing field with $d_e \leq 64$ mm (2.52") .....	193
Figure I.6 – Reaching distance when reaching through a vertical sensing field for PSDs .....	194
Figure I.7 – Reaching through a vertical sensing field with $64$ mm $< d_e \leq 600$ mm $d_{dt} = 850$ mm .....	194
Figure I.8 – Reaching under a vertical presence-sensing device .....	195
Figure I.9 – Reaching under a vertical presence-sensing device with an additional protective structure	196
Figure I.10 – Consideration of all reaching factors for a vertical sensing field .....	197
Figure I.11 – Reaching over a horizontal presence-sensing device .....	198
Figure I.12 – Height of a horizontal sensing field .....	199
Figure I.13 – Allowable height of a horizontal sensing field, $H_s$ .....	199
Figure I.14 – Minimum Depth of Sensing Field .....	200
Figure I.15 – Distance from end of horizontal sensing field to nearest obstruction .....	201
Figure I.16 – Safety distance for single beam devices $d_{ds} = 1200$ mm (47.74") .....	201
Figure I.17 - Safety distance for two-hand actuating controls (no shroud) $d_{ds} = 550$ mm (21.65") ..	202
Figure I.18 - Safety distance for hand-operated single actuating controls $d_{ds} = 2200$ mm (86.61") ..	202
Figure I.19 - Safety distance for foot-operated single actuating controls $d_{ds} = 2500$ mm (98.43") ..	203
Figure I.20 – Safety distance for radio frequency devices .....	203
Figure I.21 – Example of interlocked linear movable guard .....	204
Figure I.22 – Example of interlocked angular movable guard .....	205
Figure I.23 – Variables for determining opening (e) for a movable guard with a fringe switch .....	205
Figure I.24 – Diagram of force-travel relationship .....	208
Figure L.1 – Safe Torque Off (STO) .....	214
Figure L.2 – Safe Stop 1 Deceleration Controlled (SS1-d) .....	214
Figure L.3 – Safe Stop 1 Ramp Monitored (SS1-r) .....	215
Figure L.4 – Safe Stop 2 Deceleration Controlled (SS2-d) .....	215
Figure L.5 – Safe Stop 2 Ramp Monitored (SS2-r) .....	215
Figure L.6 – Safe Operating Stop (SOS) .....	216
Figure L.7 – Safely-Limited Acceleration (SLA) .....	216
Figure L.8 – Safe Acceleration Range (SAR) .....	218
Figure L.9 – Safely-Limited Speed (SLS) .....	218
Figure L.10 – Safely Speed Range (SSR) .....	218
Figure L.11 – Safely-Limited Position (SLP) .....	219
Figure L.12 – Safely-Limited Increment (SLI) .....	219
Figure L.13 – Safe Direction (SDi) .....	220
Figure L.14 – Safe Cam (SCa) .....	220
Figure L.15 – Safe Speed Monitor (SCM) .....	221
Figure L.16 – Safe Maximum Speed (SMS) .....	221
Figure L.17 – Safe Braking and Holding System (SBS) .....	221
Figure L.18 – Safe Door Locking (SDL) .....	222
Figure N.1 — Selection Criteria for Signal Word .....	225

## LIST of TABLES

Table 1 — Values for Minimum Gaps to Avoid Crushing of Parts of the Human Body .....	35
Table 2 — Comparison of stop, emergency stop, and protective stops .....	57
Table 3 — Comparison of initiation warning systems defined in 9.11.8 .....	92
Table 4 — Types of Actuation of Interlock Devices (Informative) .....	98
Table 5 — Examples of changes which could increase risk .....	145
Table 6 — Examples of means to prevent unauthorized changes .....	146
Table E.1 – Variable key for reaching factors associated with protective structures .....	159
Table E.2 – Horizontal reaching distance when accessing over a protective structure .....	161
Table E.3 – Reaching through regular openings in a protective structure .....	162
Table E.4 – Reaching through (around) a protective structure with limitation of movement .....	164
Table E.5 – Horizontal reaching distance when accessing under a protective structure .....	168
Table H.1 – Safety distance equation for engineering controls – devices .....	180
Table H.2 – Variable key for determining safety distance for engineering controls – devices .....	181

Table I.1 – Variable key for reaching factors associated with engineering controls – devices .....	188
Table I.2 – Classification of optical presence-sensing devices used in vertical orientation .....	190
Table I.3 – Horizontal reaching distance when accessing over a sensing field .....	191
Table I.4 – Horizontal reaching distance when accessing under a vertical sensing field.....	196
Table I.5 – Sample calculation of $b$ for typical hinge switch actuating angles ( $\alpha$ ) .....	206
Table J.1 – Measured stopping times .....	210
Table J.2 – Comparison of stopping time values .....	211
Table N.1 – Selection Guidance for Awareness (Safety) Signs.....	224
Table N.2 – Preferred Colors for Indicator Lights and Icons .....	226
Table N.3 – Alternate Colors for Indicator Lights and Icons.....	226
Table N.4 – Example Selection Guidance for Awareness (Safety) Markings .....	227
Table O.1 – List of Risk Reduction Measure Reference Standards .....	228

Currently in preview, click buy full version

## Foreword

**(This Foreword is not part of the requirements of American National Standard B11.19-2019)**

### General

The primary objective of this standard is to establish the requirements for the design, construction, installation, operation and maintenance of the risk reduction measures used to eliminate or control hazards to individuals associated with machines. This standard relies on other standards to determine which risk reduction measure(s) is required or allowed to control identified hazards / 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 any relevant ANSI B11 "base" standard for a given machine. To accomplish this objective, this standard has established responsibilities for the supplier (e.g., manufacturer, rebuilder, installer, integrator, and modifier), the user, and individuals in the working environment. The overall goal is to achieve acceptable risk in the work practices and work environment.

### Application

Other industry sectors may benefit from applying this standard. Where a machine-specific "base" (type-C) safety standard exists, ANSI B11.19 may be constructively used to supplement that 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.

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

### Effective Date

The following information on effective dates 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 and machinery systems within 30 months of the approval date of this standard.

The B11.19 Subcommittee recommends that users evaluate whether existing machinery and machinery systems have acceptable risk within 30 months of the approval date of this standard using generally recognized risk assessment methods. If the risk assessment shows that modification(s) is necessary, refer to the requirements of this standard or the machine-specific "base" safety standard to implement risk reduction measures (protective measures) for appropriate risk reduction.

### Alignment

The requirements of this standard have been harmonized with similar requirements in several international (ISO and IEC) and European (EN) standards. Harmonization means that the requirements have been aligned in essence to achieve a similar level of risk reduction. Harmonization does not necessarily mean duplication of exact requirements.

ANSI B11.19 implements a standardization philosophy that differs significantly from that often found in some ISO, IEC, and EN standards. ISO, IEC, and EN standards tend towards individual documents for each type of risk reduction measure (e.g., light curtains, emergency stop controls, prevention of unexpected start-up, etc.). ANSI B11.19 has historically combined the various requirements into this single standard, thereby allowing readers to understand and compare the requirements for different approaches to reducing risk.