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WHITE PAPER

RISK ASSESSMENT AND RISK REDUCTION FOR MACHINERY PART 4: IDENTIFYING RISK REDUCTION MEASURES AND THEIR CONTRIBUTION TO OVERALL RISK REDUCTION

RISK REDUCTION MEASURES (RRM) GUIDE, 2022-08

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ABSTRACT

When evaluating risk reduction measures, their contributions to risk reduction must be analyzed and, where necessary, additional and/or residual risks must be identified.

This white paper takes a closer look at the individual risk reduction measures and their overall classification into a hierarchy (Three Step Method). When a risk reduction measure is implemented to reduce risk to persons, it shall also be evaluated for the overall contribution to risk reduction. It may be necessary to repeat the entire process (risk assessment and risk reduction) to eliminate hazards as far as possible and to sufficiently reduce the identified or newly emerging risks.

Preface

This white paper is part of a series of papers describing the SICK process of risk assessment in combination with risk reduction:

- Part 1: Defining the scope of the risk assessment
- Part 2: Identifying task/hazard pairs
- Part 3: Conducting risk estimation
- Part 4: Identifying risk reduction measures and their contribution to overall risk reduction
- Part 5: Implementing emergency operations
- Part 6: Carrying out substantial modifications

Scope

Machine risk reduction consists of a series of measures used to reduce the factors which comprise risk. According to ISO 12100:2010, the probability of occurrence of harm can be estimated taking into account the frequency and duration of exposure to the hazard (E), the probability of occurrence of a hazardous event (O), and the technical and human possibilities to avoid or limit the harm (A). The combination of the severity of the possible harm (S) with these three probability parameters is used to estimate risk values which can then be used for comparison purposes. Risk reduction comprises three steps: inherently safe design measures, engineering controls (guards and devices), and administrative measures.

Whether evaluating existing risk reduction measures or proposing new risk reduction measures, risk estimation is carried out in an iterative approach for each identified hazard and hazardous situation. At the conclusion of the risk reduction process, the residual risks must be documented in order to clearly communicate the remaining risk which must be monitored over the entire lifecycle of the machine.

The scope of this white paper is to provide consistent guidance regarding the identification of risk reduction measures that have been proven to be robust and reliable, and their potential effect on reducing risk factors while preventing errors when estimating residual risk. The risk reduction measures included in this guide cover all three steps of risk reduction, not only measures directly related to the safety-related parts of the control system (SRP/CS). The risk reduction measures listed under Step 2B relating to the SRP/CS require integration into corresponding application safety functions in order to ensure the intended risk reduction.

Furthermore, some measures listed are not mentioned in international (ISO or IEC) type-B standards, but nonetheless are used in various regions of the world with the intention to reduce risk to operators. Therefore, this white paper is intended as a guide to better align competence and understanding in order to provide more consistent consulting and design services.

This white paper **IS NOT** a replacement for thorough training, experience and good judgement. Instead, it is an additional support tool to help standardize the recognition and understanding of various risk reduction measures in use in the market. The ultimate decision on whether a risk reduction measure is able to provide the intended effect on the identified risk factors depends not only on the risk reduction measure itself, but on its proper application for the specific hazardous situation. The exact choice of a safeguard for a particular machine needs to be made on the basis of the risk assessment for that machine. This white paper is intended to serve as further guidance when selecting the actual combination of risk reduction measure(s), and guide the designer when estimating the potential risk reduction achievable when the selected risk reduction measure(s) are applied correctly (in accordance with regulations, standards, and local norms).

NOTE: This white paper includes risk reduction measures that have been in use in industry for many years. It is important that acknowledgement of these measures intended to reduce risk is consistent, and that the reader understand the possible benefits (reduction of risk factors) as well as potential residual risks (potential misuse). Not all risk reduction measures listed in this guide represent the state of the art for an effective risk reduction, nor are they always intended to be recommended or applied to new risk reduction solutions.

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









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1 – Inherently safe by design

Function: Eliminate / Limit Interaction

Icon	Terminology	Reference(s)	Hazard Elimination (initial risk reduction)	Possible Effect on Reducing Risk Factors				Residual Risk(s) / Foreseeable Misuse	Typically applied by:	
				S	E	A	O		Supplier	User
	Prevention through geometrical design	ISO 12100 ANSI/ASSP Z590.3	✓	✓	✓✓	✓	✓✓	• Modification of the geometrical design	✓✓	✓
	Increase distance to hazard	ISO 13857 ANSI B11.19		✓	✓	✓	✓	• Modifications to the workplace that decrease distance to hazard	✓✓	✓
	Minimum gaps to prevent crushing	ISO 13854 ANSI B11.19	✓	✓		✓	✓	• Exposure of other parts of the body • Addition of objects or decrease of gaps	✓✓	✓
	Maximum gaps to avoid exposure	ANSI B11.19	✓	✓	✓	✓	✓	• Modification of gaps introducing exposure to hazard	✓✓	✓
	Restricting movement with mechanical limiting devices	ISO 10218-1 ISO 10218-2			✓	✓	✓✓	• Failure to restrict movement following maintenance, repair or setup	✓✓	✓
	Reduce energy magnitude (force, speed, etc.) through selection of inherently safe components	ANSI B11.0		✓		✓	✓	• Substitution of components with inappropriate components	✓	
	Prevent standing / climbing	ISO/TR 20218-2 ANSI B11.19			✓		✓	• Modifications to the workplace that allow standing / climbing	✓	✓
	Appropriate dimensioning and material of components	ISO 12100	✓				✓	• Substitution of components with inappropriate components	✓	
	Observe ergonomic principles	ISO 12100 et. al.	✓	✓	✓	✓	✓	• Modifications to the workplace that create or increase ergonomic issues	✓	
	Appropriate application of hazardous energy (electrical, pneumatic, hydraulic)	ISO 12100 (6.2.11) IEC 60204-1 NFPA 79 ISO 4413 ISO 4414	✓	✓			✓	• Substitution of components with inappropriate components • Changes in the design of the energy distribution and control system	✓	










Function: Substitute

Icon	Terminology	Reference(s)	Hazard Elimination (initial risk reduction)	Possible Effect on Reducing Risk Factors				Residual Risk(s) / Foreseeable Misuse	Typically applied by:	
				S	E	A	O		Supplier	User
	Automate the process	ISO 12100	✓	✓	✓	✓	✓	• Modifications to the workplace that replace automated functions with manual interactions • Introduction of new hazards	✓	

S = severity of the possible harm | E = frequency and duration of exposure to the hazard | A = technical and human possibilities to avoid or limit the harm | O = probability of occurrence of a hazardous event

2A – Guards









Function: Separate

Icon	Terminology	Reference(s)	Possible Effect on Reducing Risk Factors				Residual Risk(s) / Foreseeable Misuse	Typically applied by:	
			S	E	A	O		Supplier	User
	Fixed guard	ISO 14120 ANSI B11.19		✓	✓	✓	<ul style="list-style-type: none"> Failure to replace guard following maintenance, repair or setup 	✓✓	✓
	Movable guard	ISO 14120 ANSI B11.19		✓	✓	✓	<ul style="list-style-type: none"> Failure to replace guard following maintenance, repair or setup 	✓✓	✓
	Adjustable guard	ISO 14120 ANSI B11.19		✓	✓	✓	<ul style="list-style-type: none"> Failure to replace guard following maintenance, repair or setup Failure to adjust guard before operation 	✓✓	✓
	Self-adjusting guard	ISO 14120 ANSI B11.19		✓	✓	✓	<ul style="list-style-type: none"> Failure to replace guard following maintenance, repair or setup 	✓✓	✓
	Partial guard	ISO 14120 ANSI B11.19			✓	✓	<ul style="list-style-type: none"> Failure to replace guard following maintenance, repair or setup 	✓✓	✓
	Perimeter guard	ISO 14120 ANSI B11.19		✓	✓	✓	<ul style="list-style-type: none"> Failure to replace guard following maintenance, repair or setup 	✓✓	✓
	Tunnel guard	EN 415-10 EN 415-7		✓	✓	✓	<ul style="list-style-type: none"> Failure to replace guard following maintenance, repair or setup 	✓✓	✓
	Nip guard	ISO 12643-1 ANSI B11.19			✓	✓	<ul style="list-style-type: none"> Failure to replace/adjust guard following maintenance, repair or setup 	✓✓	✓
	Shield	ISO 14120 ANSI B11.19			✓	✓	<ul style="list-style-type: none"> Failure to replace guard following maintenance, repair or setup Failure to adjust guard before operation Insufficient inspection and maintenance Failure due to deterioration of material 	✓✓	✓

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2B – Devices




Function: Detect / Control Access

Icon	Terminology	Reference(s)	Possible Effect on Reducing Risk Factors				Residual Risk(s) / Foreseeable Misuse	Typically applied by:	
			S	E	A	O		Supplier	User
	Interlock – Type 1 (mechanical, uncoded)	ISO 14119 ANSI B11.19		✓		✓	<ul style="list-style-type: none"> Improper location of interlocking guard relative to hazard zone(s) Improper maintenance / alignment Insufficient inspection Inappropriate modification of equipment / fastening solution Failure due to mechanical wear 	✓	✓
	Interlock – Type 2 (mechanical, coded)	ISO 14119 ANSI B11.19		✓		✓	<ul style="list-style-type: none"> Improper location of interlocking guard relative to hazard zone(s) Improper maintenance / alignment Insufficient inspection Inappropriate modification of equipment / fastening solution Use of uncontrolled spare actuators Failure due to mechanical wear 	✓	✓
	Interlock – Type 3 (electro-sensitive, uncoded)	ISO 14119 ANSI B11.19		✓		✓	<ul style="list-style-type: none"> Improper location of interlocking guard relative to hazard zone(s) Inappropriate modification of equipment / fastening solution Use of uncontrolled spare actuators 	✓	✓
	Interlock – Type 4 (electro-sensitive, coded)	ISO 14119 ANSI B11.19		✓		✓	<ul style="list-style-type: none"> Improper location of interlocking guard relative to hazard zone(s) Inappropriate modification of equipment / fastening solution Use of uncontrolled spare actuators 	✓	✓
	Interlock – Type 5 (trapped/captive key, key transfer systems)	ISO 14119 ISO/TS 19837 ANSI B11.19		✓		✓	<ul style="list-style-type: none"> Improper location of interlocking guard relative to hazard zone(s) Inappropriate modification of equipment / fastening solution Use of uncontrolled spare actuators Failure due to mechanical wear 	✓	✓
	Interlock – guard locking	ISO 14119 ANSI B11.19		✓		✓	<ul style="list-style-type: none"> Improper location of interlocking guard relative to hazard zone(s) Inappropriate modification of equipment / fastening solution Use of uncontrolled spare actuators Improper parameterization of unlock signal Failure due to mechanical wear 	✓	✓
	Light curtain	IEC 61496-1 & 2 IEC 62046 ANSI B11.19		✓		✓	<ul style="list-style-type: none"> Inappropriate modification of equipment / fastening solution Improper location of detection zone relative to hazard zone(s) 	✓	✓
	Multi-beam device	IEC 61496-1 & 2 IEC 62046 ANSI B11.19		✓		✓	<ul style="list-style-type: none"> Inappropriate modification of equipment / fastening solution Improper location of detection zone relative to hazard zone(s) 	✓	✓







S = severity of the possible harm | E = frequency and duration of exposure to the hazard | A = technical and human possibilities to avoid or limit the harm | O = probability of occurrence of a hazardous event

Icon	Terminology	Reference(s)	Possible Effect on Reducing Risk Factors				Residual Risk(s) / Foreseeable Misuse	Typically applied by:	
			S	E	A	O		Supplier	User
	Single beam device	IEC 61496-1 & 2 IEC 62046 ANSI B11.19		✓		✓	<ul style="list-style-type: none"> Inappropriate modification of equipment / fastening solution Improper location of detection zone relative to hazard zone(s) 	✓	✓
	Laser-actuated AOPD	IEC 61496-1 & 2 EN 12622 ANSI B11.3 CSA Z142		✓		✓	<ul style="list-style-type: none"> Inappropriate modification of equipment / fastening solution Improper location of detection zone relative to tooling 	✓	✓
	Reflection-actuated AOPD	IEC 61496-1 & 2 IEC 62046		✓		✓	<ul style="list-style-type: none"> Inappropriate modification of equipment / fastening solution Improper location of detection zone relative to hazard zone(s) 	✓	✓
	Laser scanner	IEC 61496-1 & 3 IEC 62046 ANSI B11.19		✓		✓	<ul style="list-style-type: none"> Inappropriate modification of equipment / fastening solution Improper location / configuration of detection zone relative to hazard zone(s) 	✓	✓
	Vision-based protective device	IEC 61496-1 & 4 IEC 62046 ANSI B11.19		✓		✓	<ul style="list-style-type: none"> Inappropriate modification of equipment / fastening solution Improper location / configuration of detection zone relative to hazard zone(s) 	✓	✓
	Radar-based protective device	IEC 61496-1 & 5		✓		✓	<ul style="list-style-type: none"> Inappropriate modification of equipment / fastening solution Improper location / configuration of detection zone relative to hazard zone(s) 	✓	✓
	Pressure-sensitive mat / floor	ISO 13856-1 IEC 62046 ANSI B11.19		✓		✓	<ul style="list-style-type: none"> Inappropriate modification of equipment / fastening solution Improper location of detection zone relative to hazard zone(s) Failure due to mechanical wear 	✓	✓
	Pressure-sensitive edge / bumper	ISO 13856-2/3 ANSI B11.19		✓		✓	<ul style="list-style-type: none"> Inappropriate modification of equipment / fastening solution Improper selection / application of device relative to stopping distance of the hazard(s) Failure due to mechanical wear 	✓	✓
	Probe detection device ² only to prevent cycle initiation	ANSI B11.19 ¹ not according to ISO 12100		✓		✓	<ul style="list-style-type: none"> Inappropriate modification of equipment / fastening solution Improper location of actuator relative to hazard zone(s) 	✓	✓
	Radio frequency device	ANSI B11.19 ¹ not according to ISO 12100		✓		✓	<ul style="list-style-type: none"> Inappropriate modification of equipment / fastening solution Improper location of detection zone relative to hazard zone(s) Improper sensitivity setting for the environment Use of PPE rendering device incapable of detection 	✓	✓
	Control guard / Movable barrier – Type A	ISO 12100 ISO 14120 ANSI B11.19		✓		✓	<ul style="list-style-type: none"> Inappropriate modification of equipment / fastening solution Insufficient maintenance resulting in misalignment Failure due to mechanical wear 	✓	✓

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Icon	Terminology	Reference(s)	Possible Effect on Reducing Risk Factors				Residual Risk(s) / Foreseeable Misuse	Typically applied by:	
			S	E	A	O		Supplier	User
	Early opening control guard / Movable barrier – Type B	ISO 12100 ISO 16092-x ANSI B11.19		✓		✓	<ul style="list-style-type: none"> Inappropriate modification of equipment / fastening solution Insufficient maintenance resulting in misalignment Failure due to mechanical wear 	✓	✓
	Pull back device	ANSI B11.19 ¹ not according to ISO 12100		✓		✓	<ul style="list-style-type: none"> Inappropriate modification of equipment / fastening solution Insufficient adjustment and documentation between shifts Failure due to mechanical wear Ergonomic strain due to repetitive motion 	✓	✓✓
	Hold out device	ANSI B11.19 ¹ not according to ISO 12100		✓		✓	<ul style="list-style-type: none"> Inappropriate modification of equipment / fastening solution Insufficient adjustment and documentation between shifts Failure due to mechanical wear 	✓	✓✓

Function: Control Hazardous Situation








Icon	Terminology	Reference(s)	Possible Effect on Reducing Risk Factors				Residual Risk(s) / Foreseeable Misuse	Typically applied by:	
			S	E	A	O		Supplier	User
	Two-hand actuating control	ISO 13851 ANSI B11.19		✓	✓	✓	<ul style="list-style-type: none"> Improper location of device relative to hazard zone(s) Inappropriate modification of equipment / fastening solution Control of hazard by person other than exposed operator 	✓	✓
	Single actuating control – hand actuated	ANSI B11.19		✓	✓	✓	<ul style="list-style-type: none"> Improper location of device relative to hazard zone(s) Inappropriate modification of equipment / fastening solution Control of hazard by person other than exposed operator 	✓	✓
	Single actuating control – foot actuated	ANSI B11.19		✓	✓	✓	<ul style="list-style-type: none"> Improper location of device relative to hazard zone(s) Inappropriate modification of equipment / fastening solution Control of hazard by person other than exposed operator Trip hazard Inappropriate design of control device (e.g., shroud / cover / hood) 	✓	✓
	Enabling device ³ Must be used with additional RRM	IEC 60204-1 NFPA 79 ANSI B11.19			✓	✓	<ul style="list-style-type: none"> Control of hazard by person other than exposed operator Insufficient number of devices for expected number of operators 	✓	✓
	Hold-to-run control (jog / inch) ³ Must be used with additional RRM	IEC 60204-1 NFPA 79 ANSI B11.19			✓	✓	<ul style="list-style-type: none"> Control of hazard by person other than exposed operator Inappropriate design of control device 	✓	✓
	Hand guiding ⁴ Must be comprised of: 1) reduced speed AND 2) hand guiding device: a) enabling device OR b) hold-to-run control	ISO/TS 15066 ISO/DIS 10218-2	✓		✓	✓	<ul style="list-style-type: none"> Control of hazard by person other than exposed operator Insufficient reduced speed setting Inappropriate design of hand guiding (control) device 	✓✓	

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Function: Monitor / Limit Hazards








Icon	Terminology	Reference(s)	Possible Effect on Reducing Risk Factors				Residual Risk(s) / Foreseeable Misuse	Typically applied by:	
			S	E	A	O		Supplier	User
	Power & force limiting through monitoring features	ISO/TS 15066 ISO 10218-2	✓		✓	✓	• Improper threshold / parameterization for application	✓	✓
	Speed / position monitoring through monitoring features	IEC 61800-5-2 ISO/TS 15066 ISO/CD 13855 RIA TR R15.1006	✓		✓	✓	• Improper threshold / parameterization for application	✓	✓
	Restricting movement with non-mechanical limiting devices	ISO 10218-1 ISO 10218-2		✓	✓	✓✓	• Failure to restrict movement following maintenance, repair or setup	✓✓	✓

Function: Avoid Unexpected Start-Up

Icon	Terminology	Reference(s)	Possible Effect on Reducing Risk Factors				Residual Risk(s) / Foreseeable Misuse	Typically applied by:	
			S	E	A	O		Supplier	User
	Energy-isolating device – electrical ³ Must be used with additional RRMs	IEC 60204-1 NFPA 79 ISO 14118 ANSI/ASSP Z244.1	✓	✓		✓	• Failure to follow documented procedures	✓	✓
	Energy-isolating device – fluid power ³ Must be used with additional RRMs	ISO 14118 ANSI/ASSP Z244.1	✓	✓		✓	• Failure to follow documented procedures	✓	✓
	Initiation warning system ³ Must be used with additional RRMs	ANSI B11.19		✓	✓✓		• Failure to follow documented procedures	✓	✓
	Mechanical restraint mechanism ³ Must be used with additional RRMs	ISO 14118 ISO 16092-1 (5.3.6) ANSI/ASSP Z244.1 ANSI B11.19	✓	✓		✓	• Failure to follow documented procedures	✓	✓
	Mechanical restraint mechanism – interlocked ³ Must be used with additional RRMs	ISO 14118 ISO 16092-1 (5.3.6) ANSI/ASSP Z244.1 ANSI B11.19	✓	✓		✓	• Failure to follow documented procedures • Inappropriate design or modification allowing interlock actuator to remain engaged while mechanical restraint is located in path of motion	✓	✓
	Fixed element to prevent persons being undetected ³ Must be used with additional RRMs	ANSI B11.19		✓		✓	• Inappropriate modification of equipment / fastening solution	✓	✓
	Reset of safety functions ³ Must be used with additional RRMs	ISO 13849-1 ANSI B11.19		✓		✓	• Inappropriate modification of equipment / fastening solution • Failure to confirm safeguarded space clear of other individuals • Control of reset by person other than exposed operator	✓	✓

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Function: Emergency Action

Icon	Terminology	Reference(s)	Possible Effect on Reducing Risk Factors				Residual Risk(s) / Foreseeable Misuse	Typically applied by:	
			S	E	A	O		Supplier	User
	Emergency stop – push-button device	ISO 13850 IEC 60204-1 NFPA 79 ANSI B11.19	✓		✓✓	✓✓	<ul style="list-style-type: none"> • Operation for purposes other than emergency • Device not readily accessible • Introduction of obstruction preventing actuation 	✓	✓
	Emergency stop – rope/cable pull device	ISO 13850 IEC 60204-1 NFPA 79 ANSI B11.19	✓		✓✓	✓✓	<ul style="list-style-type: none"> • Operation for purposes other than emergency • Device not readily accessible • Introduction of obstruction preventing actuation • Inappropriate maintenance affecting actuation 	✓	✓
	Emergency stop – foot-operated device	ISO 13850 NFPA 79 ANSI B11.19	✓		✓✓	✓✓	<ul style="list-style-type: none"> • Operation for purposes other than emergency • Device not readily accessible • Introduction of obstruction preventing actuation 	✓	✓
	Emergency stop – rod-operated device	NFPA 79 ANSI B11.19	✓		✓✓	✓✓	<ul style="list-style-type: none"> • Operation for purposes other than emergency • Device not readily accessible 	✓	✓
	Emergency stop – push-bar-operated device	NFPA 79 ANSI B11.19	✓		✓✓	✓✓	<ul style="list-style-type: none"> • Operation for purposes other than emergency • Device not readily accessible 	✓	✓
	Emergency stop – electrical energy-isolating device	IEC 60204-1 NFPA 79	✓		✓✓	✓✓	<ul style="list-style-type: none"> • Failure to follow documented procedures • Operation for purposes other than emergency • Device not readily accessible 	✓	✓
	Emergency stop – fluid power energy-isolating device	ISO 4413 ISO 4414 ISO 14118 ISO 13850 ANSI/ASSP Z244.1	✓		✓✓	✓✓	<ul style="list-style-type: none"> • Failure to follow documented procedures • Operation for purposes other than emergency • Device not readily accessible 	✓	✓

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3 – Administrative Controls

Function: Awareness Means





Icon	Terminology	Reference(s)	Possible Effect on Reducing Risk Factors				Residual Risk(s) / Foreseeable Misuse	Typically applied by:	
			S	E	A	O		Supplier	User
	Awareness barrier – rail	ANSI B11.19		✓	✓	✓	<ul style="list-style-type: none"> • Failure to heed warning 	✓	✓
	Awareness barrier – chain	ANSI B11.19		✓	✓	✓	<ul style="list-style-type: none"> • Failure to heed warning • Failure due to replacement of component(s) 	✓	✓
	Awareness signal – visible	IEC 60073 IEC 60204-1 NFPA 79 ANSI B11.19			✓		<ul style="list-style-type: none"> • Failure to heed warning • Mental overload of the operator • Increased light intensity in work environment • Reaction caused by fright • Tampering to reduce light • Inconsistent use of colors to represent condition 	✓	✓
	Awareness signal – audible	IEC 60073 ISO 7731 ISO 11429 ANSI B11.19			✓		<ul style="list-style-type: none"> • Failure to heed warning • Mental overload of the operator • Increased noise level in work environment • Reaction caused by fright • Tampering to reduce sound 	✓	✓
	Awareness sign	ISO 3864-x ISO 7000 ISO 7010 ANSI Z535.4 ANSI B11.19			✓		<ul style="list-style-type: none"> • Failure to heed warning • Failure to maintain visibility / legibility 	✓	✓
	Awareness marking	ISO 3864-x ANSI B11.19			✓		<ul style="list-style-type: none"> • Failure to heed warning • Failure to maintain visibility / legibility 	✓	✓✓

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Function: Reduce Likelihood of Persons Inside Safeguarded Space



Icon	Terminology	Reference(s)	Possible Effect on Reducing Risk Factors				Residual Risk(s) / Foreseeable Misuse	Typically applied by:	
			S	E	A	O		Supplier	User
	Visibility of undetected area – mirror ³ Must be used with additional RRM	ANSI B11.19				✓	<ul style="list-style-type: none"> Failure to follow documented procedures Improper maintenance / alignment 	✓	✓
	Visibility of undetected area – vision system ³ Must be used with additional RRM	ANSI B11.19				✓	<ul style="list-style-type: none"> Failure to follow documented procedures Improper maintenance / alignment 	✓	✓
	Interlock blocking device ³ Must be used with additional RRM	ISO/DIS 14119 ANSI B11.19		✓		✓	<ul style="list-style-type: none"> Failure to follow documented procedures 	✓	✓
	Photo-electric blocking device ³ Must be used with additional RRM	N/A		✓		✓	<ul style="list-style-type: none"> Failure to follow documented procedures Inappropriate size of obstruction for effective detection capability 	✓	✓
	Escape release ³ Must be used with additional RRM	ISO 14119 ISO 14120 ANSI B11.19				✓	<ul style="list-style-type: none"> Failure to follow documented procedures 	✓	✓

Function: Information for Use


Icon	Terminology	Reference(s)	Possible Effect on Reducing Risk Factors				Residual Risk(s) / Foreseeable Misuse	Typically applied by:	
			S	E	A	O		Supplier	User
	Instruction manual / handbook	ISO 12100 ISO 20607 ANSI B11.0			✓	✓	<ul style="list-style-type: none"> Failure to follow documented instruction Documentation not readily available to operator Documentation not in appropriate language(s) 	✓	✓
	Safe work procedure	ISO 12100 ANSI B11.19			✓	✓	<ul style="list-style-type: none"> Failure to follow documented procedures Procedure not provided or unknown to operator 		✓
	Training	ISO 12100 ANSI B11.0 ANSI B11.19			✓	✓	<ul style="list-style-type: none"> Failure to follow documented training Initial / regular training not provided or unknown to operator 		✓
	Inspection & maintenance	ISO 12100 ANSI B11.19 ANSI B11.TR8	✓	✓	✓	✓	<ul style="list-style-type: none"> Failure to perform regular inspection Failure to maintain risk reduction measures 		✓

S = severity of the possible harm | E = frequency and duration of exposure to the hazard | A = technical and human possibilities to avoid or limit the harm | O = probability of occurrence of a hazardous event



Function: Avoidance of Unauthorized Changes

Icon	Terminology	Reference(s)	Possible Effect on Reducing Risk Factors				Residual Risk(s) / Foreseeable Misuse	Typically applied by:	
			S	E	A	O		Supplier	User
	Tamper resistant fastener	ISO 14119 ISO 14120 ANSI B11.19			✓	✓	<ul style="list-style-type: none"> Special tool accessible by unauthorized personnel Failure to replace tamper resistant fastener after completion of task 	✓	✓
	Key / password access	ANSI B11.19			✓	✓	<ul style="list-style-type: none"> Key / password accessible by unauthorized personnel 	✓	✓


Function: Control of Hazardous Energy

Icon	Terminology	Reference(s)	Possible Effect on Reducing Risk Factors				Residual Risk(s) / Foreseeable Misuse	Typically applied by:	
			S	E	A	O		Supplier	User
	Lockout / tagout procedure ³ Must be used with additional RRM's	ISO 14118 ANSI/ASSP Z244.1					<ul style="list-style-type: none"> Failure to follow documented procedures 		✓

Function: Tools

Icon	Terminology	Reference(s)	Possible Effect on Reducing Risk Factors				Residual Risk(s) / Foreseeable Misuse	Typically applied by:	
			S	E	A	O		Supplier	User
	Workholding equipment	ANSI B11.19	✓	✓	✓	✓	<ul style="list-style-type: none"> Failure to follow documented procedures Incorrect use of workholding equipment 	✓	✓
	Hand tool	ANSI B11.19	✓	✓	✓	✓	<ul style="list-style-type: none"> Failure to follow documented procedures Incorrect use of hand tool 	✓	✓✓

Function: Personal Protective Equipment

Icon	Terminology	Reference(s)	Possible Effect on Reducing Risk Factors				Residual Risk(s) / Foreseeable Misuse	Typically applied by:	
			S	E	A	O		Supplier	User
	PPE	ISO/TC 94 ANSI/ISEA	✓		✓	✓	<ul style="list-style-type: none"> Failure to properly use and maintain PPE 		✓

S = severity of the possible harm | E = frequency and duration of exposure to the hazard | A = technical and human possibilities to avoid or limit the harm | O = probability of occurrence of a hazardous event

Notes

