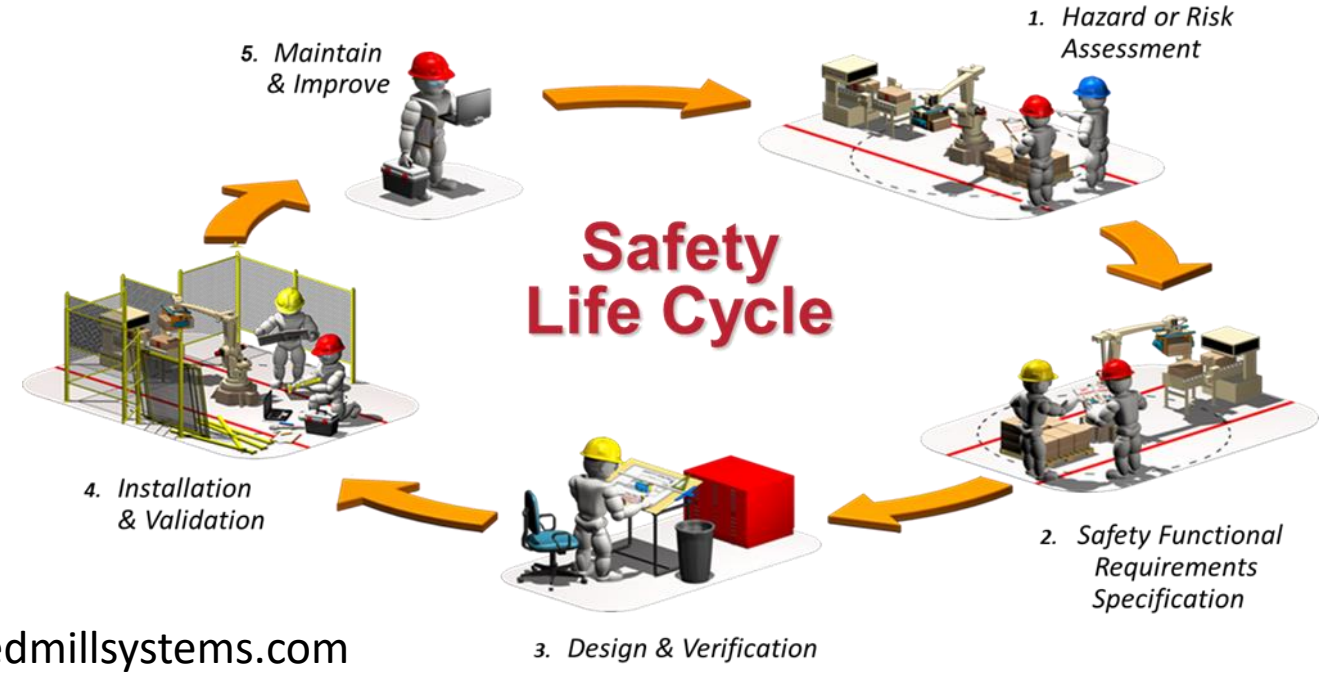
Integrated Mill Systems
Machine Safety Process

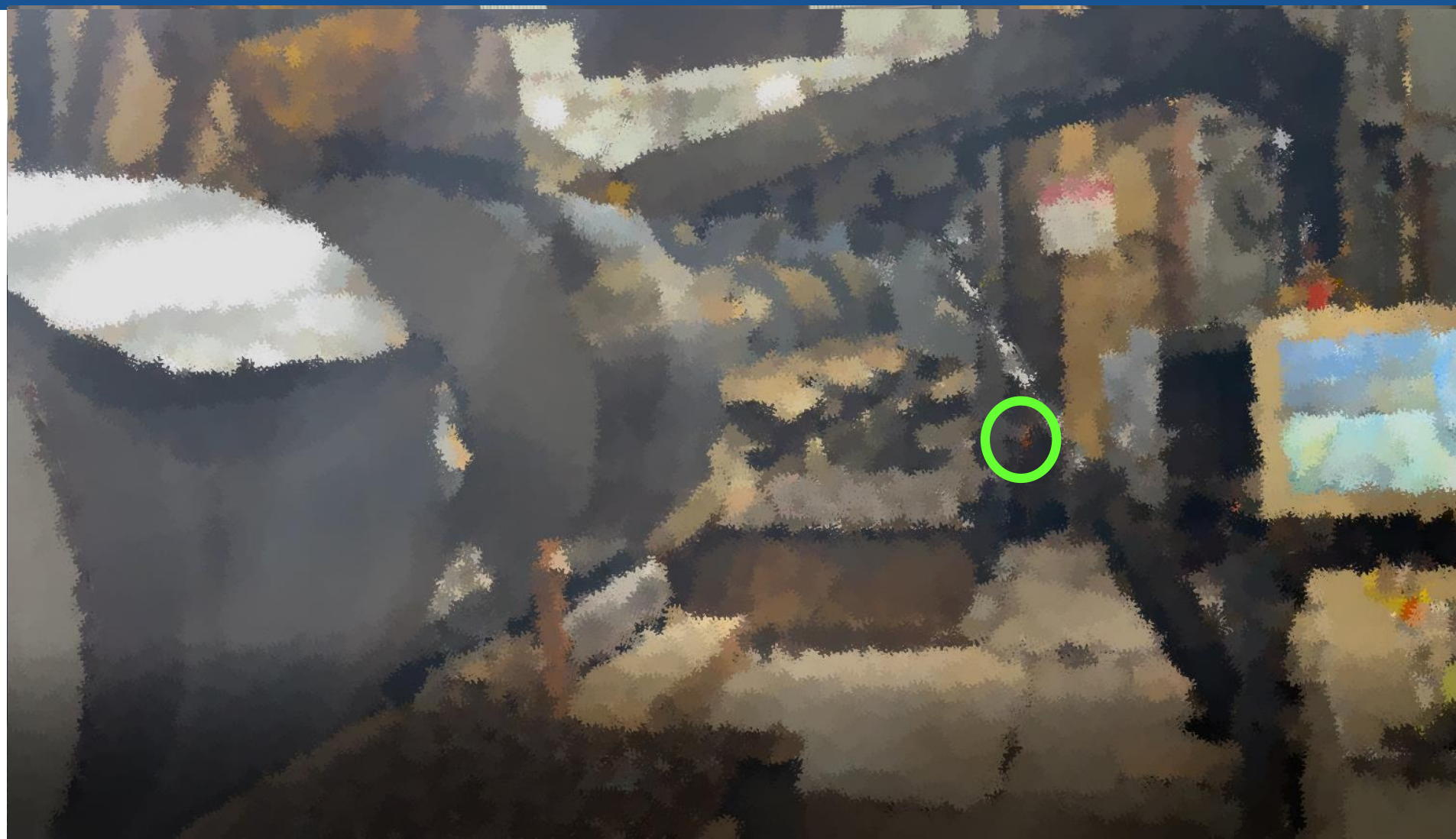
Standards-Based Risk Assessment & Mitigation Process



Mark Eitzman
216-339-2583, meitzman@integratedmillsystems.com

The “all-to-typical approach”

- “Wow, that looks dangerous”
- “I should install a guard or light curtain to keep people safe”
- “Looks good, let’s roll! “

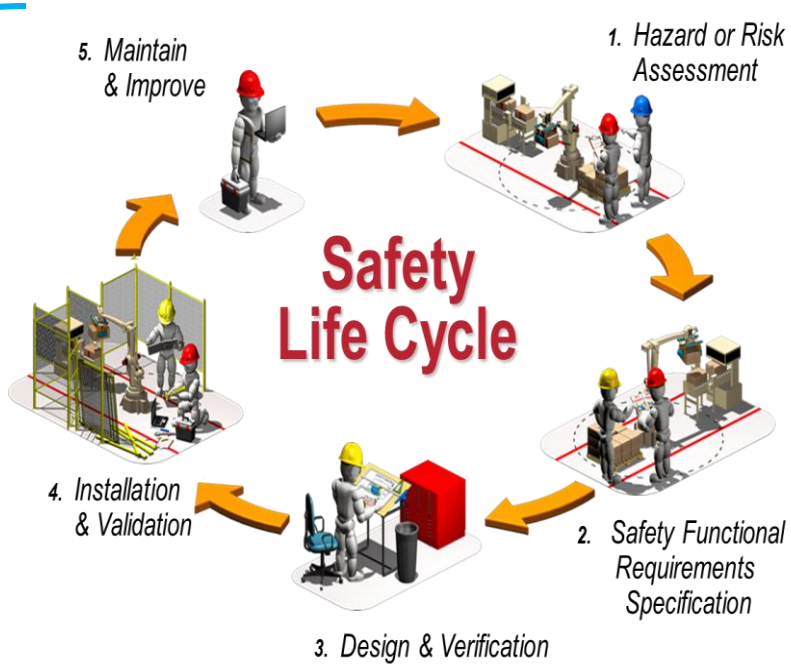


Machine Safety Standards Approach

ISO, IEC, ANSI, NFPA, RIA, etc.

Decades of revisions and updates

…about 2000 pages of standards



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ISO, IEC, ANSI, NFPA, RIA, etc.

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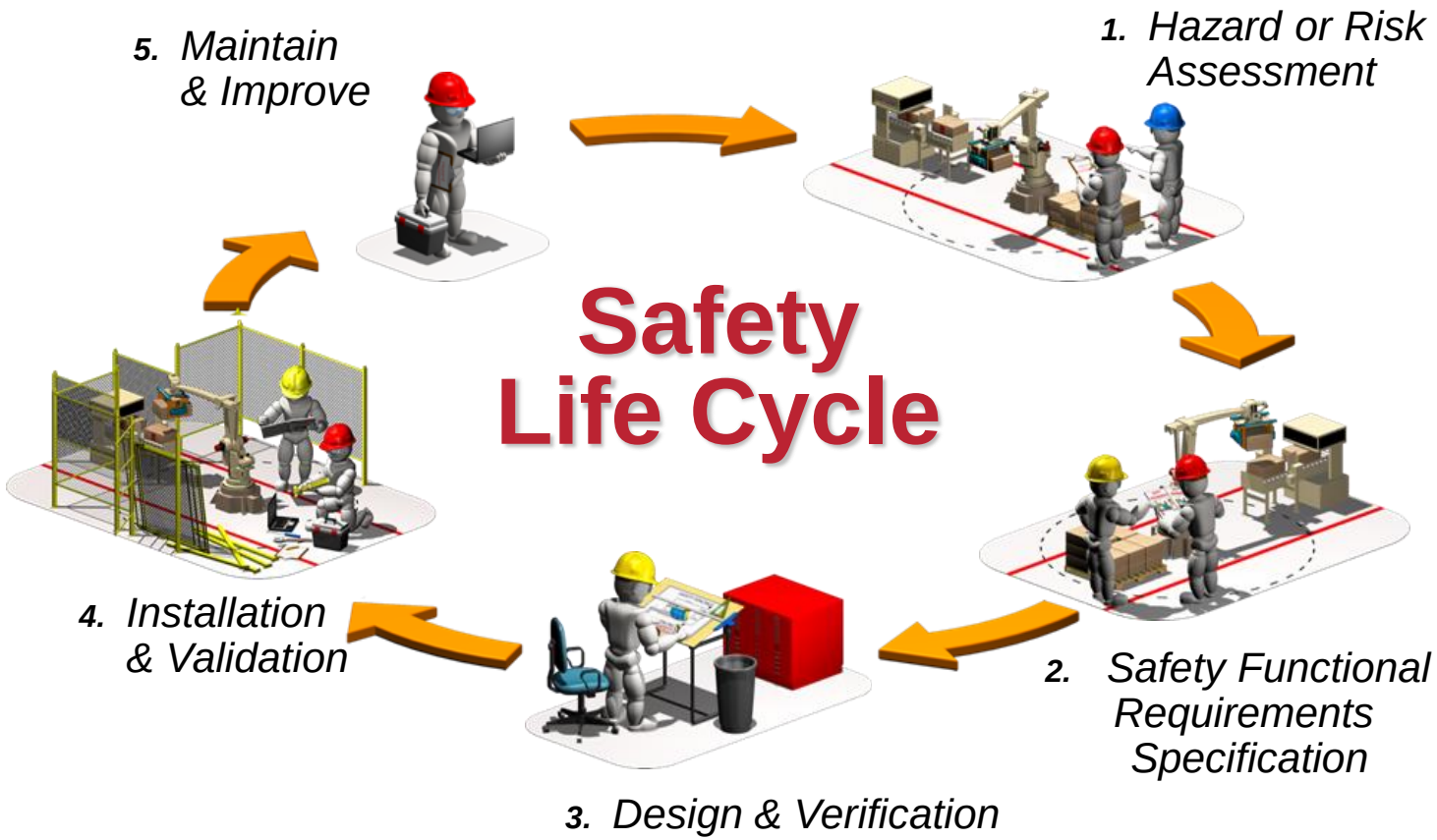
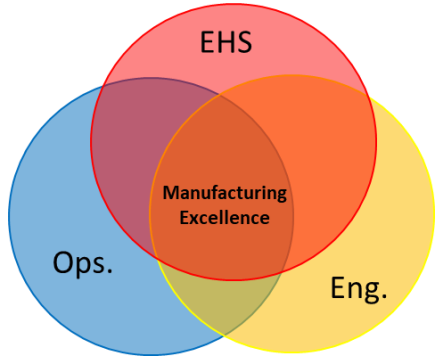
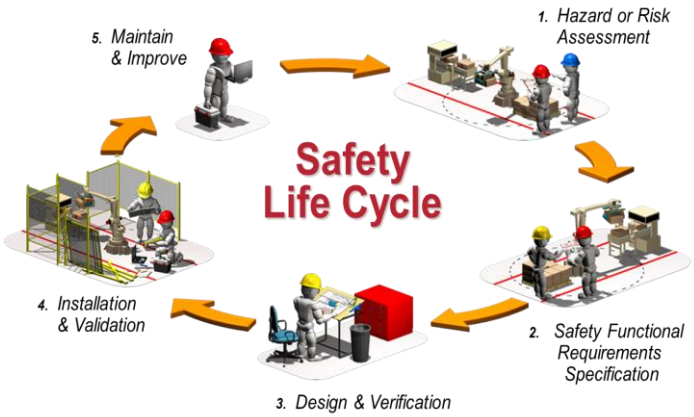


Reasons for a *Team/Task-Based Risk Assessment* :

- Considers all interaction/collaboration with the machine
  - Nearly 70% of safety incidents occur outside normal production/operations
- Selection of the most optimal mitigation to avoid:
  - Mitigation that is insufficient or overdone
  - False sense of “safety”
  - Productivity suffers
  - Safeguards bypassed
  - Investment is undermined





Documented proof of “due diligence” towards the general duty clause

When is a Risk Assessment Required?

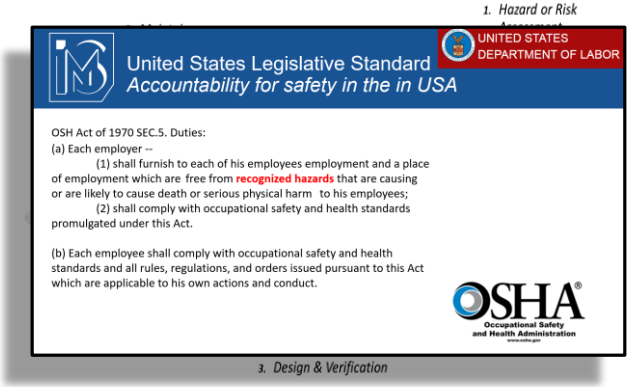
ANSI B11.0 – 2020 Safety of Machinery

Table 1 — Requirements for new and existing machinery

Scenario and Description	Requirement
1. New Machinery / System (created utilizing new or used components) ✓	Perform a risk assessment to confirm the risks are at an acceptable level. Comply with current applicable standard(s).
2. Repair / Rebuild / Refurbish Machinery (utilizing comparable components) ?	No risk assessment required. Comply with applicable standard(s) existing at time of manufacture or initial installation.
3. Rebuild / Refurbish Machinery (utilizing non comparable components, changing the use of the machinery) ✓	Perform a risk assessment to confirm the risks are at an acceptable level. Comply with current applicable standard(s) on any new hazards.
4. Reconfigure / Relocate Machinery (existing machinery is relocated or layout is reconfigured) ✓	Perform a risk assessment on any hazards created by the new layout or change in spatial configuration, and to confirm the risks associated with the reconfigured machinery are at an acceptable level.
?	Comply with current applicable standard(s) on any new hazards associated with relocation. All other (pre-existing) hazards comply with applicable standard(s) existing at time of manufacture or initial installation.
5. Modify, Reconfigure, or Remanufacture Machinery (machinery or components are added to or removed from an existing machinery system, or are modified to introduce new features) ✓	Perform a risk assessment to confirm the risks are at an acceptable level. Comply with current applicable standard(s).

?

Reconcile with the general duty clause…?



Risk Assessment Process

- IMS default process is ANSI B11.0-2020

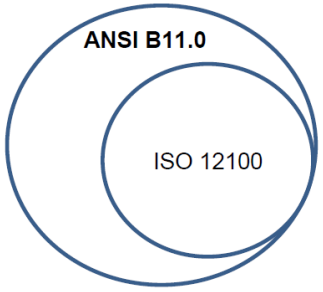
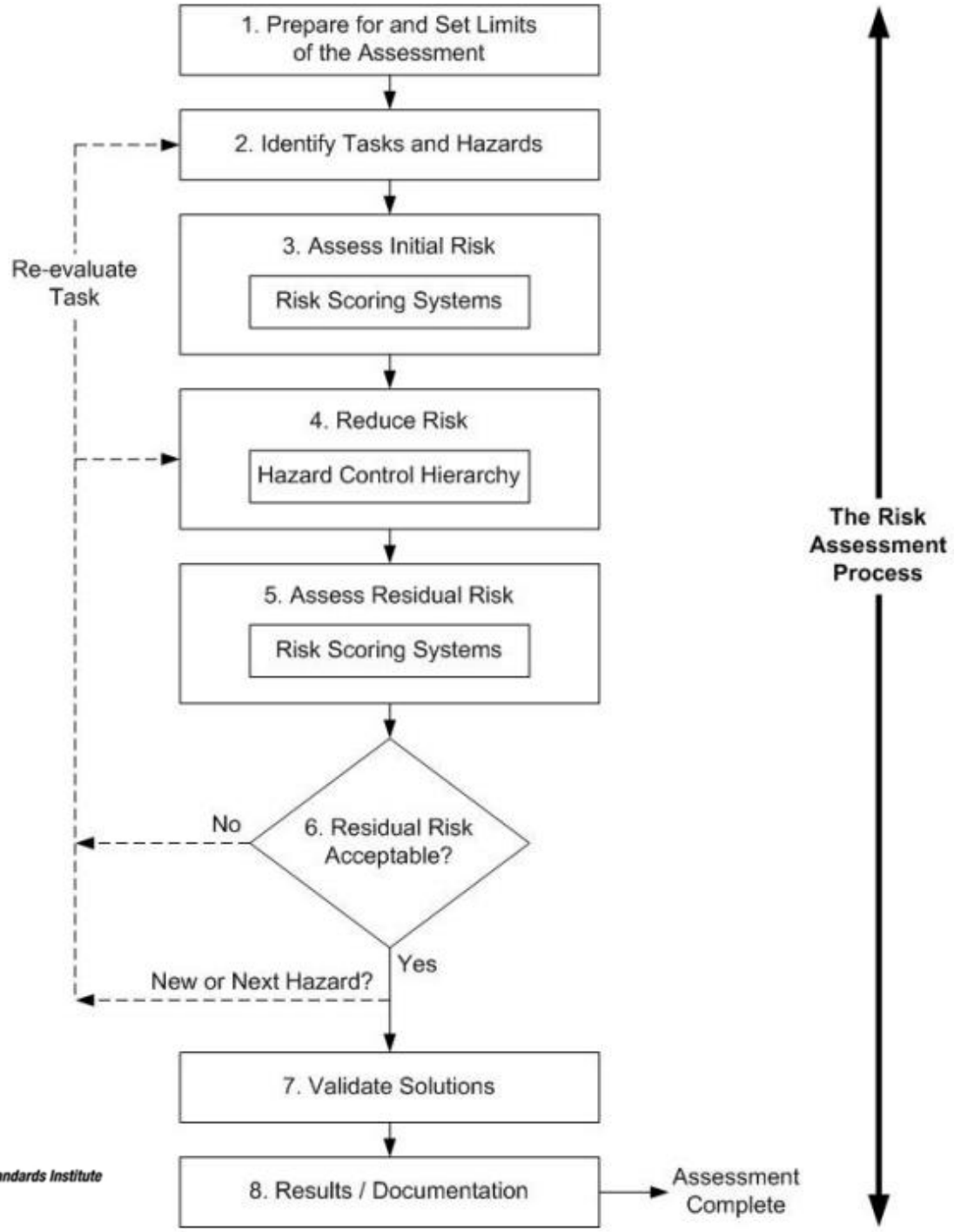


Figure 1 — Illustration of relationship between ISO 12100 and ANSI B11.0

- ***IMS will facilitate*** a team/task/hazard-based risk assessments by a cross-functional team of the customer
  - operators, engineering, maintenance staff, cleaners ,production supervisors and EH&S



Risk Assessment Process *ANSI B11.0 2020*

1) Prepare for and set limits of the assessment

2) Identify tasks and hazards

3) Assess initial/existing risk

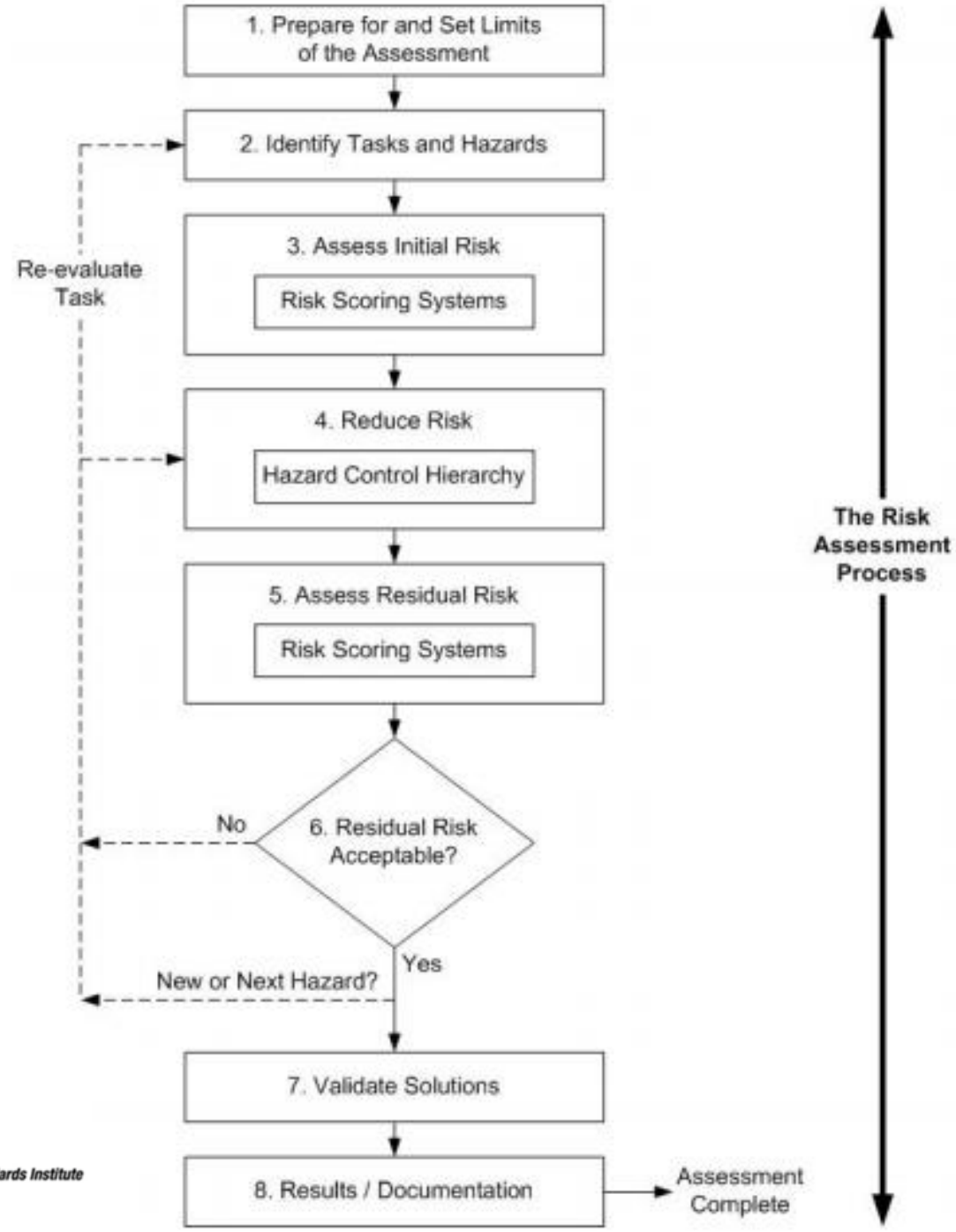
4) Reduce risk

5) Assess residual risk

6) Residual Risk Acceptable?

7) Validate solutions

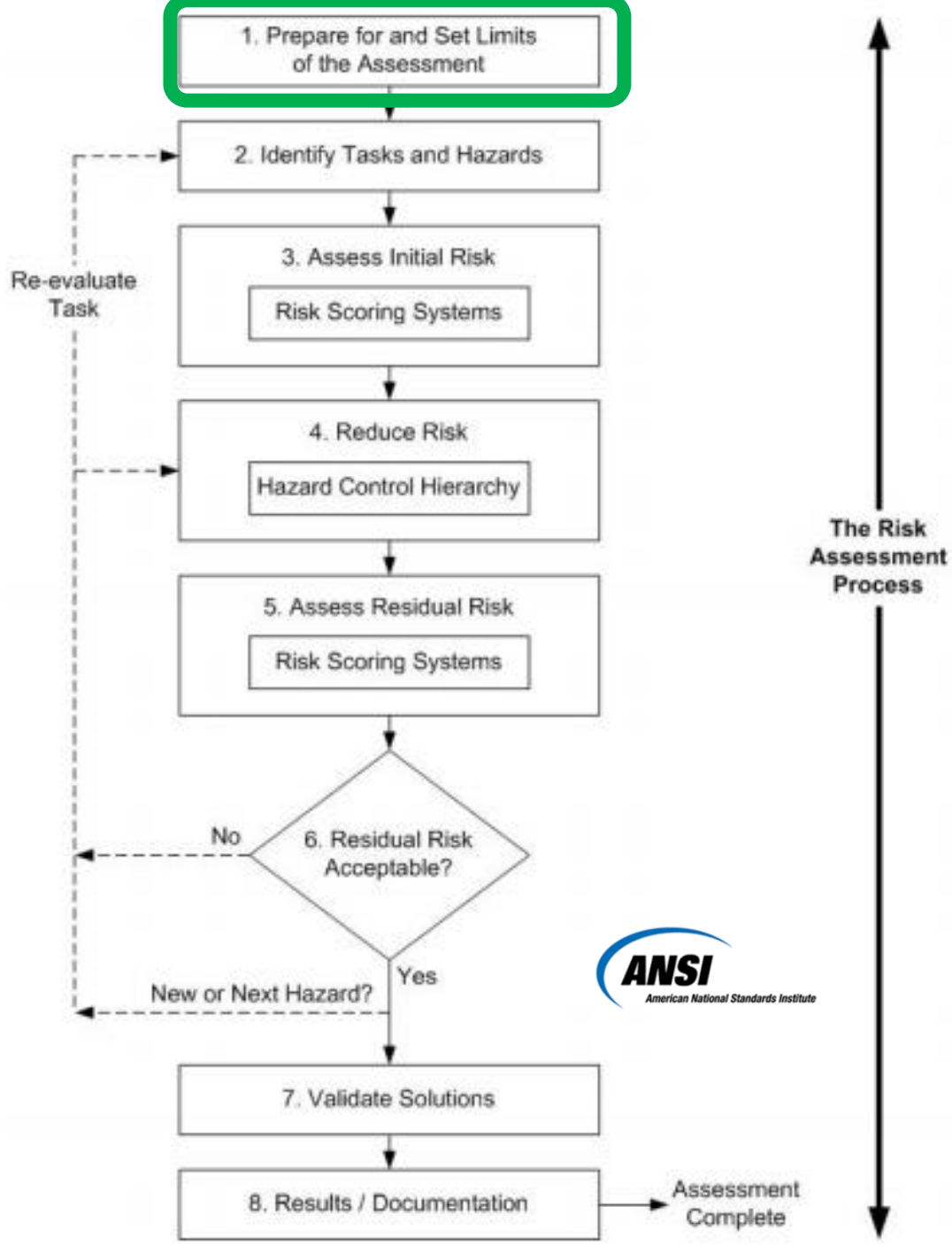
8) Document the process



ANSI American National Standards Institute

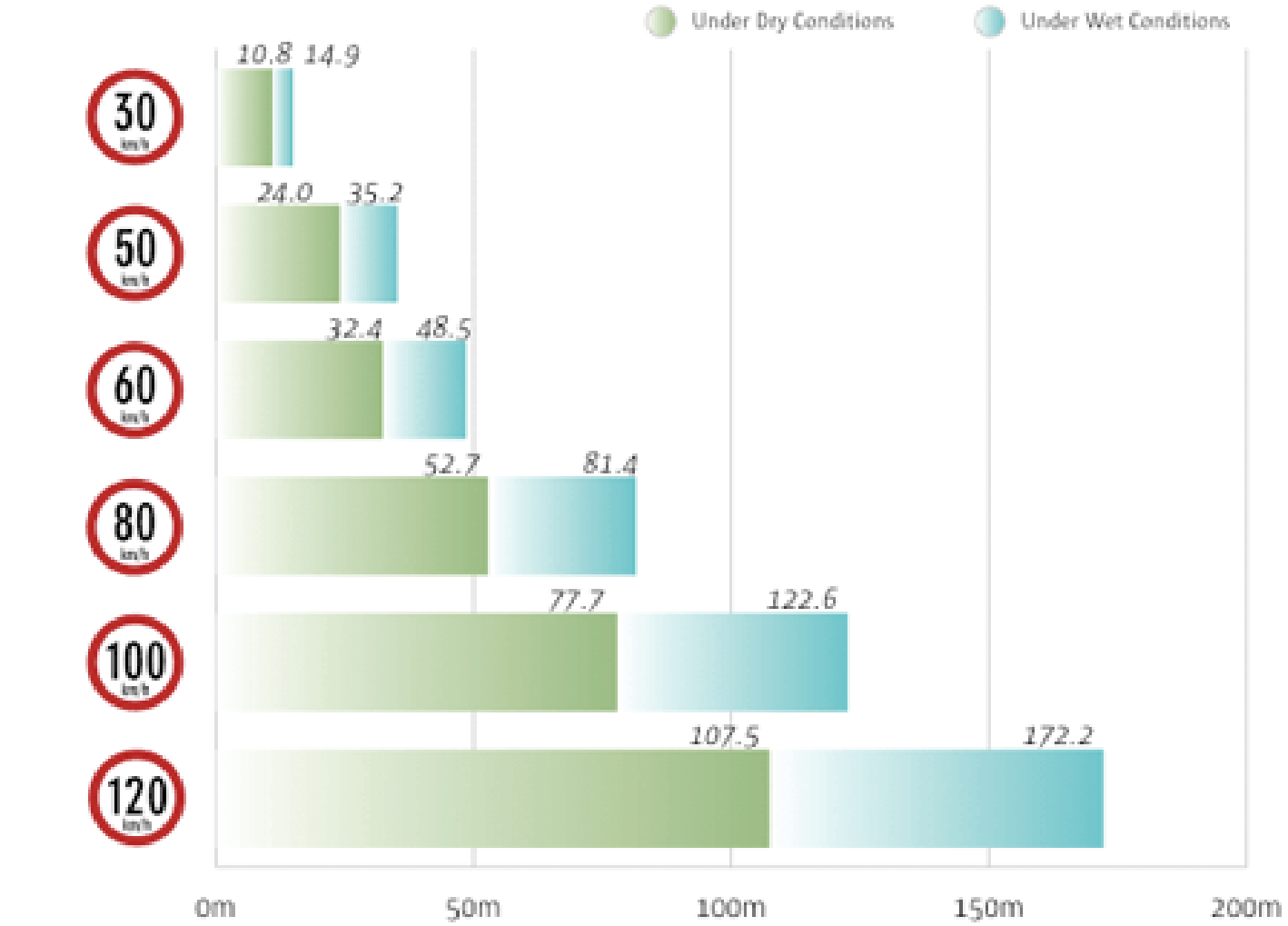
Risk Assessment Process

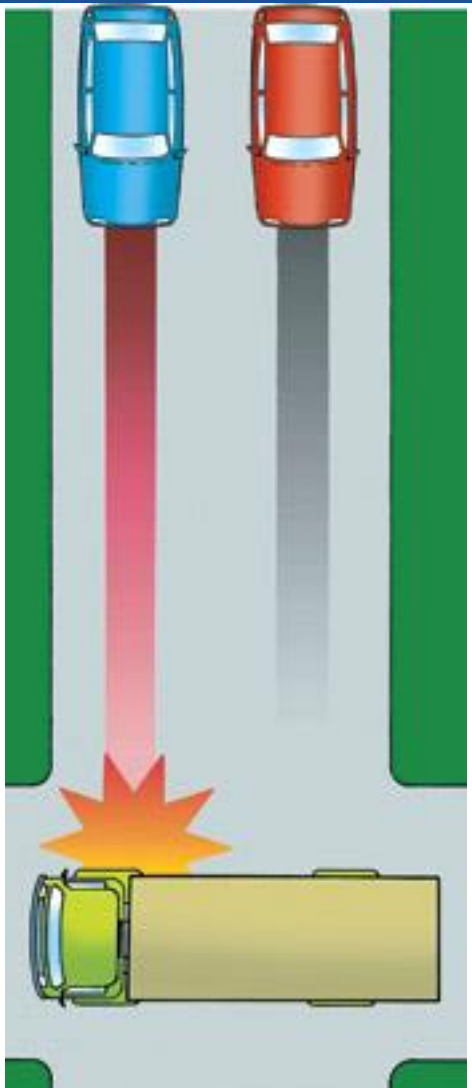
- The information for risk assessment should include;
  - machine life cycle phase(s) in scope
  - production rates, cycle times, speed, forces, material to be used
  - identify all persons involved throughout the machine's life
  - anticipated preventative maintenance tasks, times and intervals
  - environmental limits (temperature, humidity, moisture, noise, location, lighting day & night)
  - other machines or equipment integrated with the machine
  - energy sources, auxiliary/remote command/control or automation and LOTO procedures
  - tooling wear, maintenance of mechanical, electrical, fluid devices
  - space required for installation, maintenance, and operation



Machine characteristics

ex. - Stopping distance

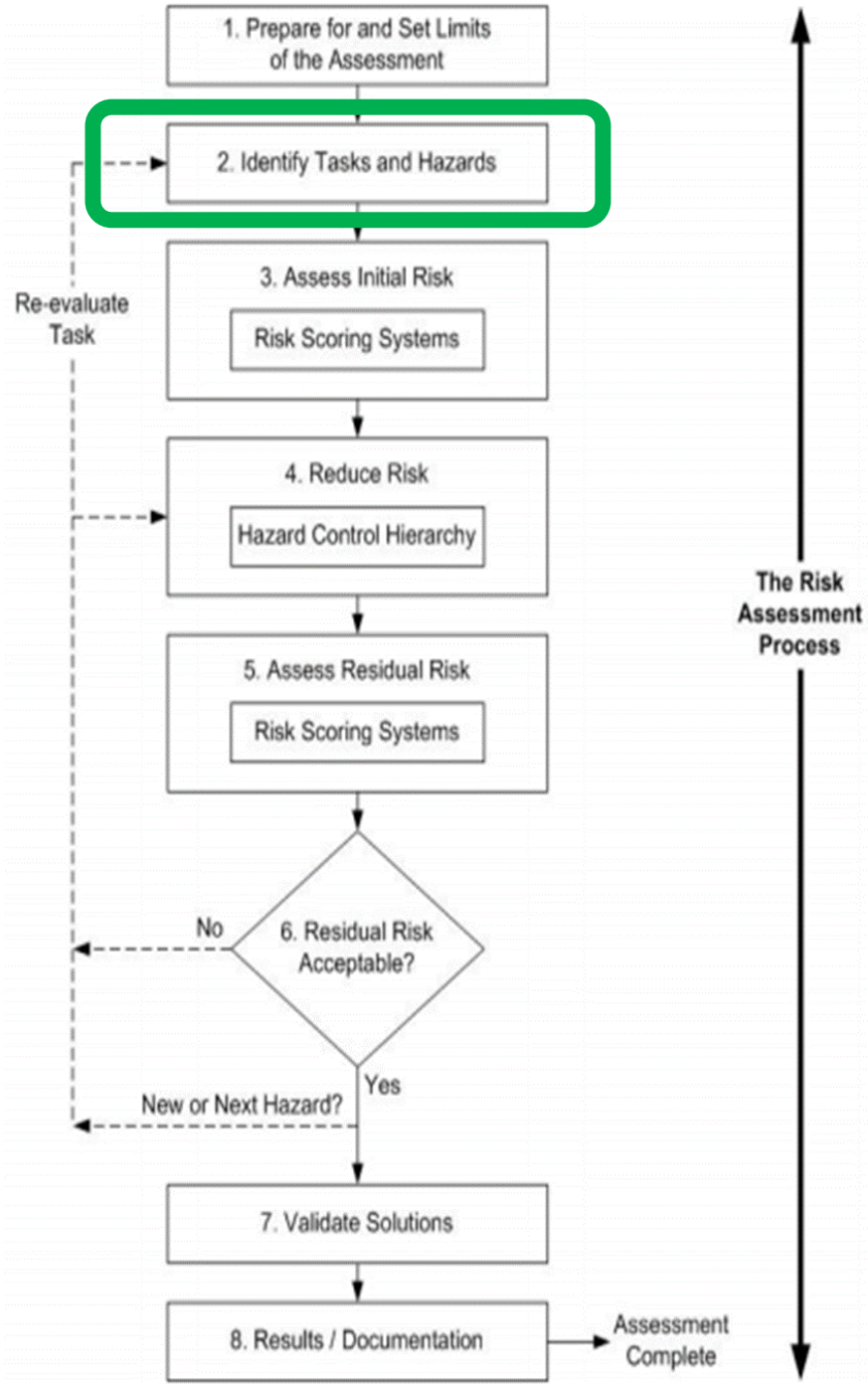




Team-Based Risk Assessment

All affected people, all task and all steps of those task

- Directly collaborating
  - operators
  - maintenance
  - electricians
  - mechanics
  - technicians
  - installers
  - uninstallers
- Indirectly collaborating
  - engineers
  - managers
  - supervisors
  - EHS
- By-standers or potential collaborators/helpers
  - passers-by
  - HR
  - consultants
  - fork trucks/drivers
  - sales personnel
  - administrative
  - temporary employees
  - material handling
  - visitors
- Consider the level of training/experience
  - Operators
  - Helpers
  - Maintenance
  - Trainees



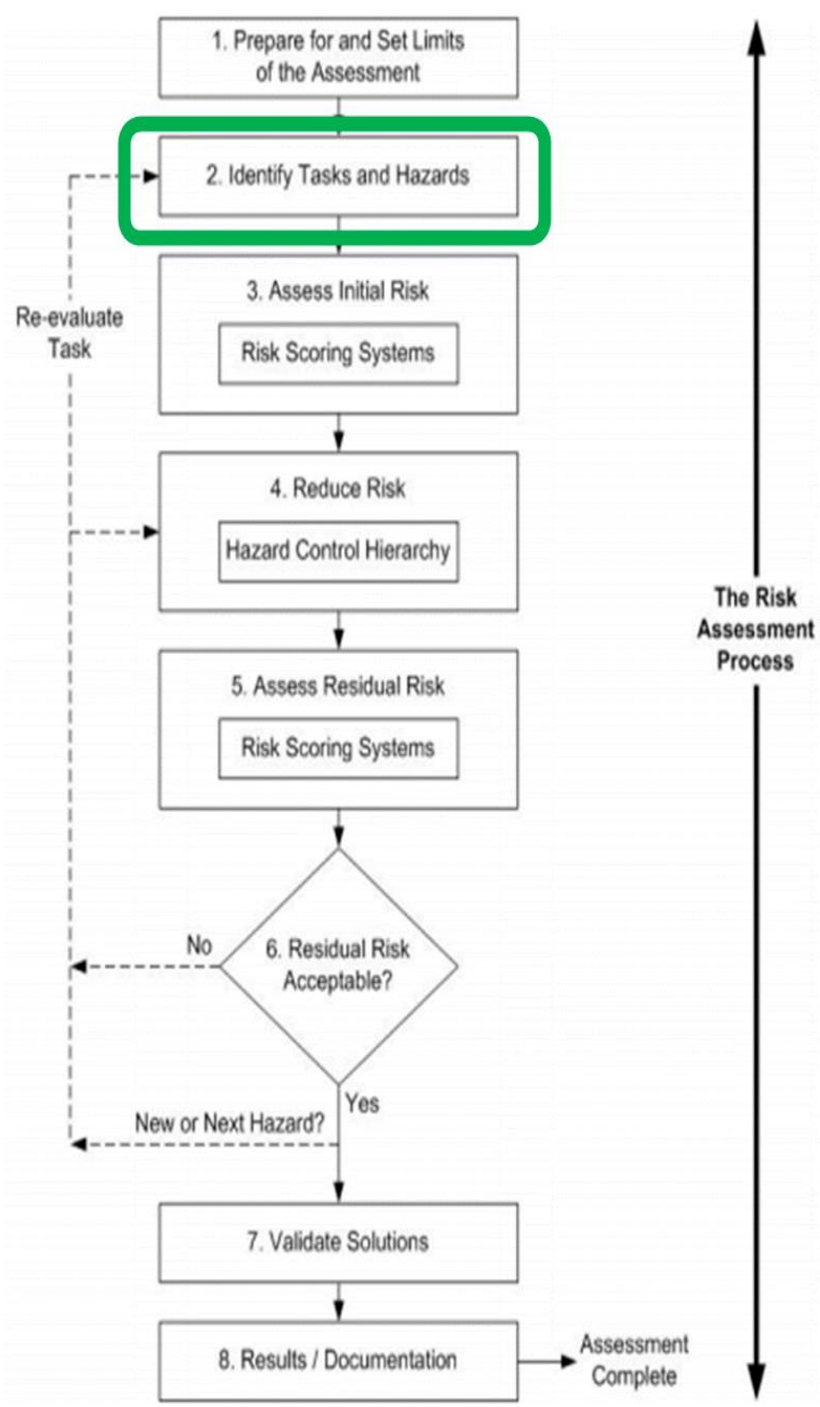
Identify Hazards *ex. ANSI B11.0, B11.18, RIA TR R15.306*

Hazard Types

- Mechanical
- Electrical
- Thermal
- Noise
- Vibration
- Radiation
- Inhalation
- Biological
- Viral or bacterial
- Ergonomic
- Visual

Reasonably Foreseeable Scenarios

- Power failure
- Falling/ejected objects or fluids
- Structural stress/overload
- Inadequate location of controls/display
- Control/software failure
- Human error
- Unexpected influence on machine (ex. wind)
- Mismatch of human characteristic
- Breach of hazardous container/conduit
- Lack/neglected PPE
- Unexpected starts
- Over/under speed
- Inadequate lighting



Identify Hazards - During normal and foreseeable malfunctions or abnormal operations

Machine Life Cycle

- packing and transportation;
- unloading / unpacking;
- machine / system installation;
- start-up / commissioning;
- operation (all modes);
- planned maintenance;
- unplanned maintenance;
- major repair;
- recovery from control failure;
- recovery from process failure;
- troubleshooting;
- housekeeping;
- decommissioning;
- disposal;

Person.task.step.hazard

Operation (all modes):

- coil / plate handling;
- threading and re-threading;
- handling and servicing tooling;
- equipment cleaning;
- quality control checks;
- scrap handling;
- monitoring / controlling machine operation;
- handling finished product;

For each of the above tasks, there may be numerous hazards.

- Scrap handling:
  - sharp edges
  - strip / scrap motion
  - in-running nip or pinch points
  - noise
  - tripping
  - falling into open pit
  - uncontrolled scrap motion

Risk Estimation/Score in three states

Machine Task/Hazard-Based Risk Assessment

Three machine state version: without, existing, and future risk reduction measures

Risk Assessment Team	Titles/Roles:
	Note: Validation is required before E0 is achieved (test results required). Third party validation recommended.

Machine Info.		Assessment Info.	
Name / ID:		Date of Assessment:	
Plant:		Revision:	
Department:		RA Scope and limits:	

Zone/Area	x.x.x.x Person Task Step Hazard	Person/Task	Steps	Potential Hazards	Ref pic	Initial Risk Estimate (without Risk Reduction Measures) ANSI/RIA TR R15.306- Severity	Exposure	Avoidance	Risk Level	Is a Control Circuit required ?	Minimum Functional Performance Required			Existing Estimate (with existing Risk Reduction Measures) Design	Engineering Controls	Administrative Controls	Existing Actions / Measures	Existing Risk Estimate ANSI/RIA TR R15.306- Severity	Exposure	Avoidance	Risk Level	Future Estimate (with proposed Risk Reduction Measures) Design	Engineering Controls	Administrative Controls	Future Actions / Measures	Future Risk Estimate ANSI/RIA TR R15.306-2016 Severity	Exposure	Avoidance	Risk Level
FC2/charging table north	1.1.1.4	Heater/Forklift Operator charges a plate	measures L x W of top/next plate on scissor lift to be loaded	Mechanical - crushing from plate moving north and failing to stop until contacting the hardstop barrier on the north side of the charge table (due to laser sensor failing to detect leading/upstream edge of plate	2	S3	E2	A2	High	Yes	d	3	Control Reliable			X	Blocking / rigging - hard stop/barrier on north side of charging table to stop a plate's northern travel in the event of a failure of the controls to perform a normal process stop	S3	E2	A2	High		X	X	prevent hazardous motion while people are detected when exposed to the hazard incorporating a safety function controlling the charge table rolls, awareness of impending automatic motion with horn/light	S3	E0		Low
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Person.Task.Steps.Hazards

Initial/No Risk Reduction

Existing Measures

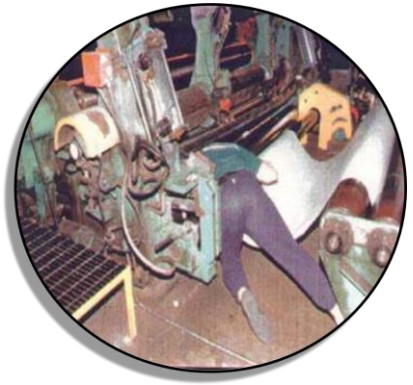
Future Measures/Residual

Risk Estimation (score, rate, etc.)

A clear and consistent means to determine a risk level

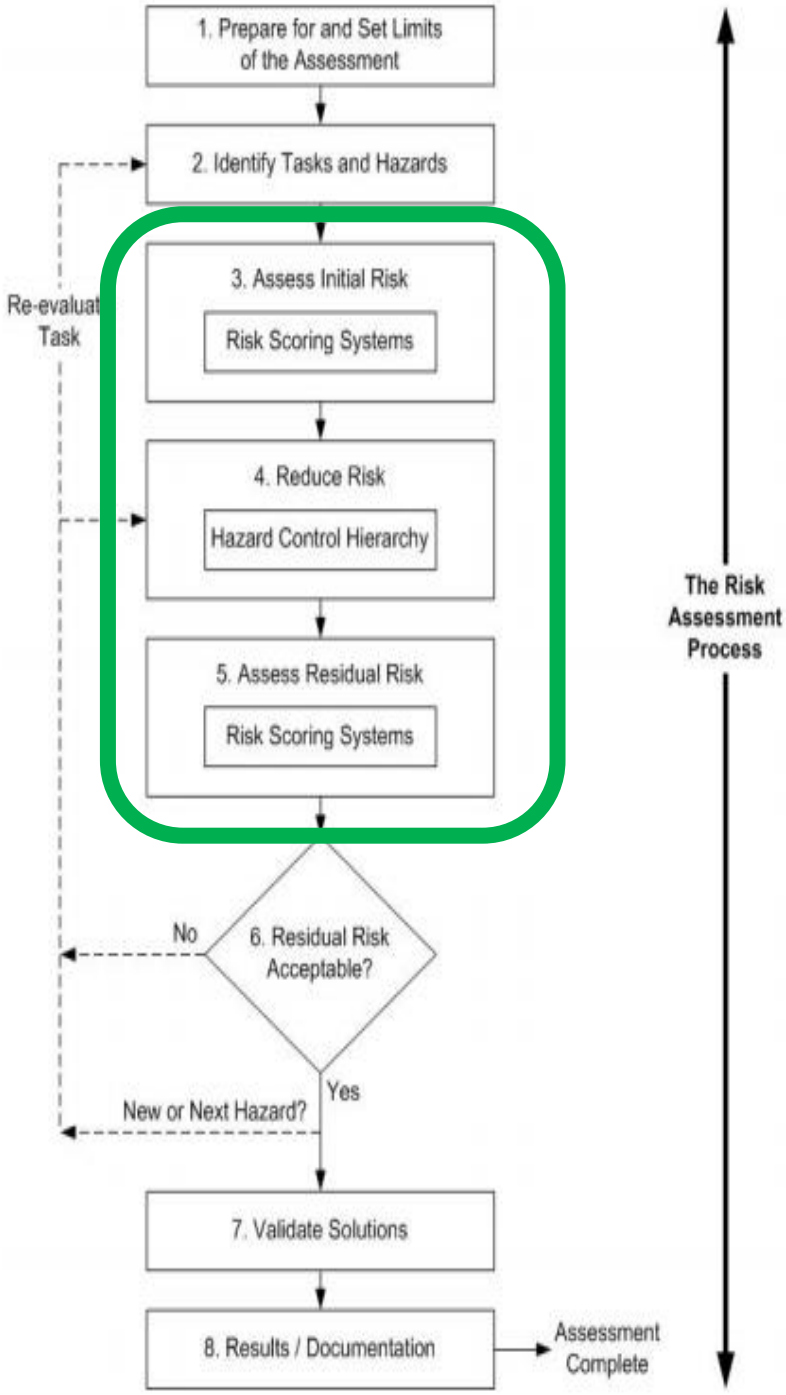
Risk Level				
VERY HIGH	HIGH	MEDIUM	LOW	NEGLIGIBLE

Hazard + People = Risk



Risk is the combination of the;

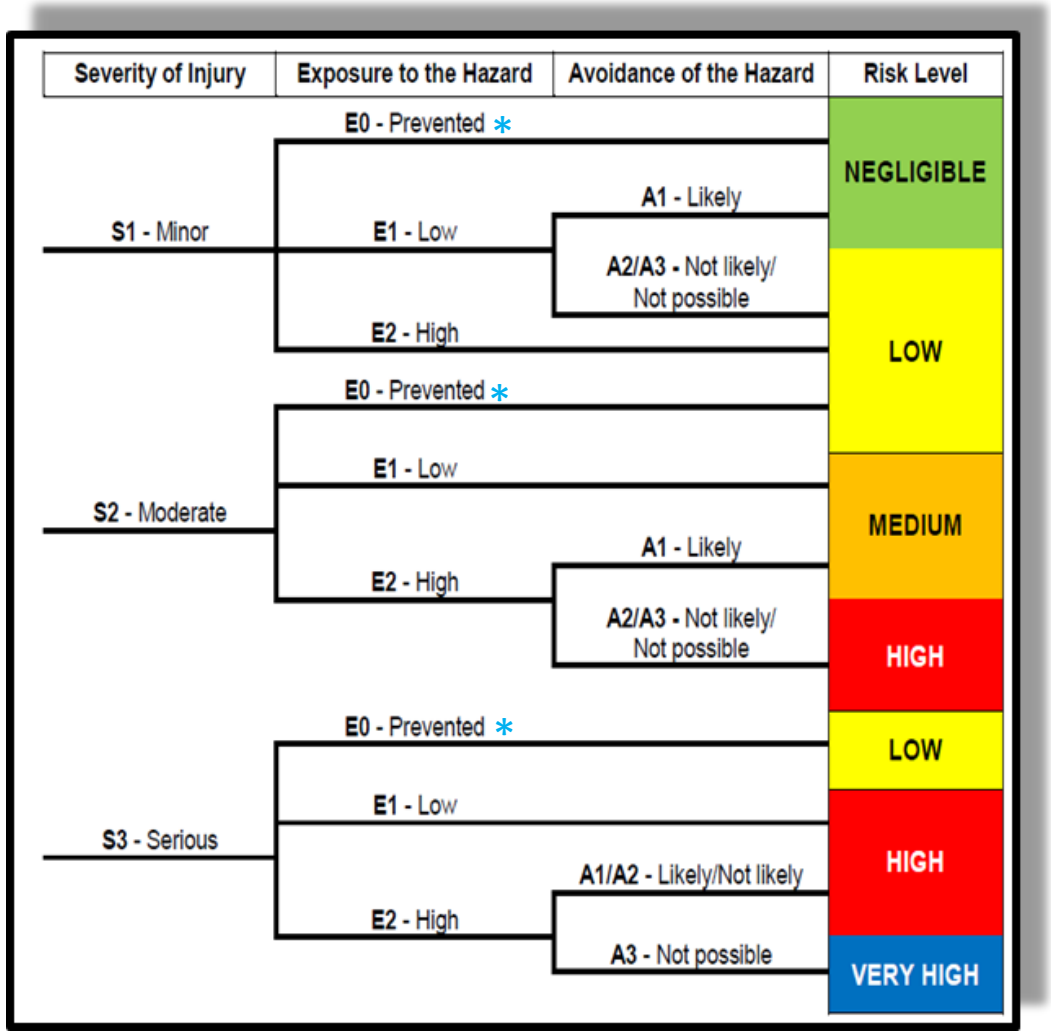
- **Severity of harm + Probability of occurrence**
- **Probability is frequency of exposure + avoid-ability**



RIA 15.06 Risk Estimating System

RIA TR R15.306-2016

- 3 factors of the rating
  - **S**everity of Injury
  - **E**xposure to Hazard
    - E0 only after mitigation *
  - **A**voidance of Hazard
- 5 risk ratings or levels



Risk estimation/rating determines the recommended **primary** risk reduction measure

RIA TR R15.306-2016

Table 4 – Minimum risk reduction measures as a function of the risk level

	Risk Reduction Measure	Risk Level				
		VERY HIGH	HIGH	MEDIUM	LOW	NEGLIGIBLE
Most Preferred	Elimination	Use of one or a combination of these risk reduction measures are required as a primary means to reduce risks.			Any of the risk reduction measures that would reduce risks to an acceptable level may be used.	
	Substitution					
	Limit Interaction					
	Safeguarding/ SRP/CS					
	Complementary Protective Measures	Use of one or a combination of these risk reduction measures may be used in conjunction with the above risk reduction measures but shall not be used as the primary risk reduction measure.				
	Warnings and Awareness Means					
	Administrative Controls					
Least Preferred	PPE					

ANSI B11.0 2020

Table 6 — Potential Effects/Additional Characteristics of Risk Reduction Measures

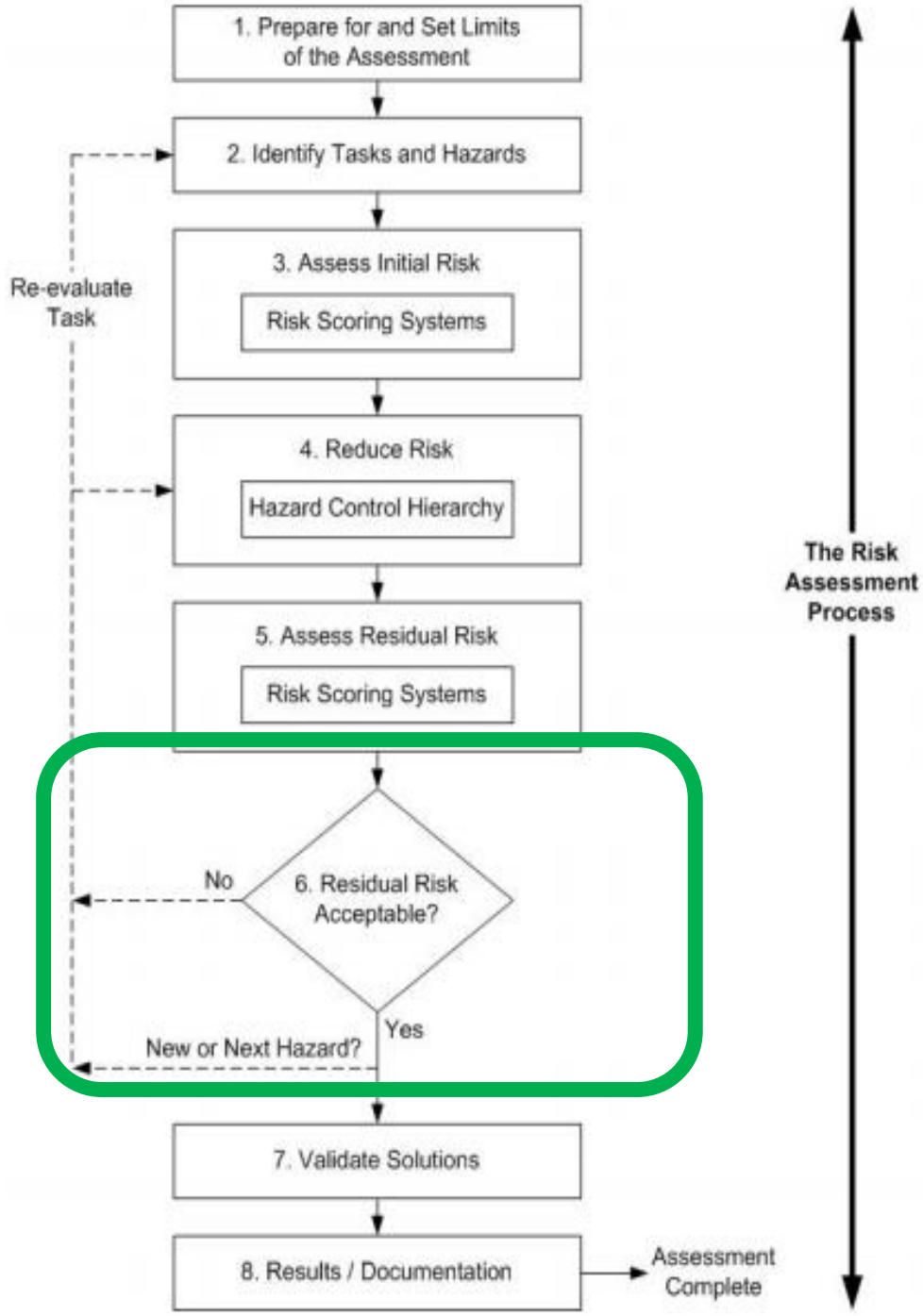
Risk Reduction Measures			Possible Effect on Risk Factors				Possibly susceptible to: (even when properly applied)	
				Probability				
Hierarchy		Examples	Severity	Expo-sure	Avoid-ance	Occur-rence	Failure	Error / Misuse
Classification	Type							
Inherently Safe by Design (Redesign)	Limiting Interaction	modify the process to eliminate/reduce human interaction		•		•		•
	Elimination	replace task, increase clearance	•	•				
		energy magnitude reduction	•			•	•	
	Substitution	automated material handling	•	•	•	•	•	•
		use less hazardous chemicals	•			•		•
		reduce force, speed, etc. through selection of inherently safe components	•		•			
Engineering Controls (Guards, Devices and Control Functions)	Separation	fixed guards, shields		•		•	•	•
	Detect / Control Access	Interlock devices, presence sensing devices		•		•	•	•
	Control Hazardous Motion	two-hand / single actuating controls		•	•	•	•	•
		enabling devices, jog controls			•	•	•	•
	Restricting Operation	controlled selection of operating modes				•		•
	Monitor / Limit Hazards	speed / force monitoring and limiting	•		•	•	•	
	Emergency Action	emergency stop devices	•		•	•	•	
Administrative Controls	Awareness Means (Warnings & Instructions)	awareness barriers		•	•	•		•
		awareness signals (audible and/or visible)			•	•	•	•
		awareness signs / markings			•	•		•
	Information for Use (Training & Procedures)	safe work procedures, training			•	•		•
	Administrative Methods	safe-holding safeguarding method			•	•		•
	Supervision	supervisory control of configurable elements			•	•		•
	Control of hazardous energy	isolation of hazardous energy	•	•		•		•
	Tools	hand tools	•		•	•	•	•
	PPE	safety glasses, hearing protection, gloves	•		•	•	•	•

Risk Evaluation:
Is the risk acceptable or unacceptable?

- Any level of risk can be acceptable or unacceptable for a given task/step
  - You decide

Risk Level				
VERY HIGH	HIGH	MEDIUM	LOW	NEGLIGIBLE

- Document the decision and rationale
- Corporate guidance/policy
- Continue adding layers of risk reduction



Risk Reduction Measures

Machine Task/Hazard-Based Risk Assessment

Three machine state version: without, existing, and future risk reduction measures

Machine Info.		Assessment Info.	
Name / ID:		Date of Assessment:	
Plant:		Revision:	
Department:		RA Scope and limits:	

Risk Assessment Team	Titles/Roles:

Note: Validation is required before E0 is achieved (test results required). Third party validation recommend

Zone/Area	x.x.x.x Person Task Step Hazard	Person/Task	Steps	Potential Hazards	Ref pic	Initial Risk Estimate (without Risk Reduction Measures) ANSI/RIA TR R15.306-				Is a Control Circuit required ?	Minimum Functional Performance Required			Existing Estimate (with existing Risk Reduction Measures)				Existing Actions / Measures	Existing Risk Estimate ANSI/RIA TR R15.306-				Future Estimate (with proposed Risk Reduction Measures)			Future Actions / Measures	Future Risk Estimate ANSI/RIA TR R15.306-2016			
						Severity	Exposure	Avoidance	Risk Level					Design	Engineering Controls	Administrative Controls			Severity	Exposure	Avoidance	Risk Level	Design	Engineering Controls	Administrative Controls		Severity	Exposure	Avoidance	Risk Level
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Person.Task.Steps.Hazards

Initial/No Risk Reduction

Existing Measures

Future Measures/Residual

Redesign the machine or change the process

Machine Guarding

Minor Servicing Exception

E-stop

Signs, lights, horns, training

Boss, keys

Lockout/Tagout

Safety glasses, hardhat, tools

Most Preferred

Least Preferred

Table 6 — Potential Effects/Additional Characteristics of Risk Reduction Measures

Risk Reduction Measures			Possible Effect on Risk Factors				Possibly susceptible to: (even when properly applied)	
Hierarchy		Examples	Severity	Probability				
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	Elimination	replace task, increase clearance	•	•				
		energy magnitude reduction	•			•	•	
	Substitution	automated material handling	•	•	•	•	•	•
		use less hazardous chemicals	•			•		•
		reduce force, speed, etc. through selection of inherently safe components	•		•			
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	Detect / Control Access	Interlock devices, presence sensing devices		•		•	•	•
	Control Hazardous Motion	two-hand / single actuating controls		•	•	•	•	•
		enabling devices, jog controls			•	•	•	•
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	Monitor / Limit Hazards	speed / force monitoring and limiting	•		•	•	•	
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		awareness signals (audible and/or visible)			•	•	•	•
		awareness signs / markings			•	•		•
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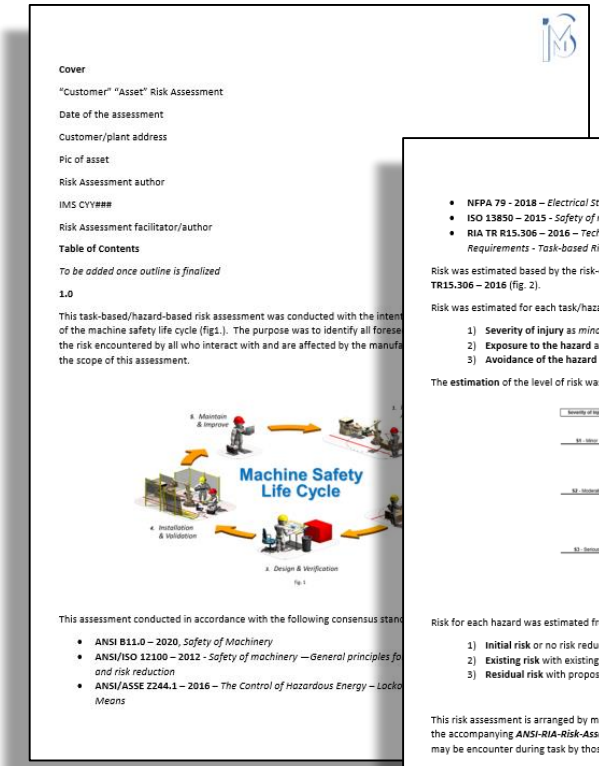
	Administrative Methods	safe-holding safeguarding method			•	•		•
	Supervision	supervisory control of configurable elements			•	•		•
	Control of hazardous energy	isolation of hazardous energy	•	•		•		•
	Tools	hand tools	•		•	•	•	•
	PPE	safety glasses, hearing protection, gloves	•		•	•	•	•

IMS Risk Assessment Documentation



Cover

"Customer" "Asset" Risk Assessment

Date of the assessment

Customer/plant address

Pic of asset

Risk Assessment author

IMS CYY###

Risk Assessment facilitator/author

Table of Contents

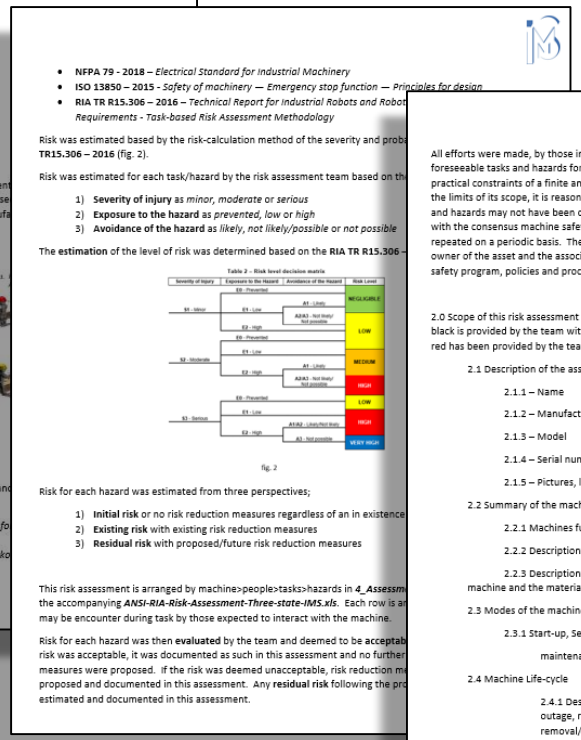
To be added once outline is finalized

1.0

This task-based/hazard-based risk assessment was conducted with the intent of the machine safety life cycle (fig1.). The purpose was to identify all foreseeable the risk encountered by all who interact with and are affected by the manufa the scope of this assessment.

This assessment conducted in accordance with the following consensus stand

- **ANSI B11.0 – 2020**, *Safety of Machinery*
- **ANSI/ISO 12100 – 2012** - *Safety of machinery —General principles fo and risk reduction*
- **ANSI/ASSE Z244.1 – 2016 –** *The Control of Hazardous Energy – Locko Means*



- **NFPA 79 - 2018 –** *Electrical Standard for Industrial Machinery*
- **ISO 13850 – 2015 -** *Safety of machinery — Emergency stop function — Principles for design*
- **RIA TR R15.306 – 2016 –** *Technical Report for Industrial Robots and Robot Requirements - Task-based Risk Assessment Methodology*

Risk was estimated based by the risk-calculation method of the severity and proba **TR15.306 – 2016** (fig. 2).

Risk was estimated for each task/hazard by the risk assessment team based on th

1) **Severity of injury** as *minor, moderate or serious*
2) **Exposure to the hazard** as *prevented, low or high*
3) **Avoidance of the hazard** as *likely, not likely/possible or not possible*

The **estimation** of the level of risk was determined based on the **RIA TR R15.306 –**

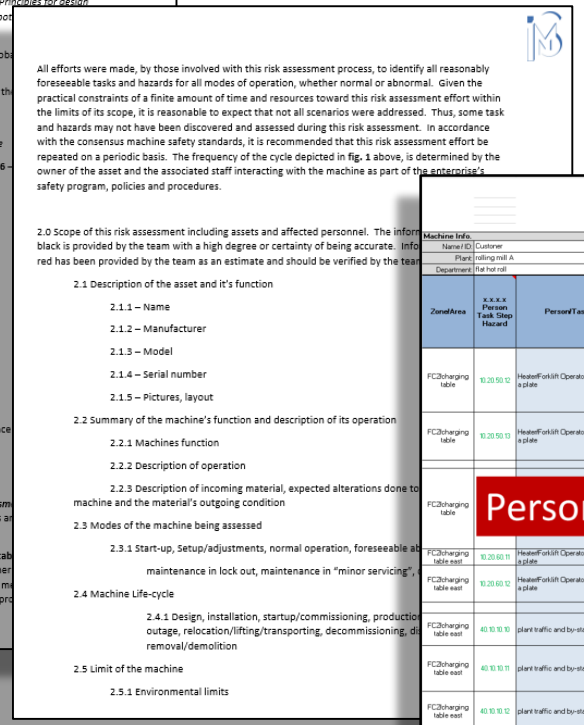
fig. 2

Risk for each hazard was estimated from three perspectives;

1) **Initial risk** or no risk reduction measures regardless of an in existence
2) **Existing risk** with existing risk reduction measures
3) **Residual risk** with proposed/future risk reduction measures

This risk assessment is arranged by machine>people>tasks>hazards in ***4_Assessm*** the accompanying ***ANSI-RIA-Risk-Assessment-Three-state-IMS.xls***. Each row is a may be encounter during task by those expected to interact with the machine.

Risk for each hazard was then **evaluated** by the team and deemed to be **acceptab** risk was acceptable, it was documented as such in this assessment and no further measures were proposed. If the risk was deemed unacceptable, risk reduction m proposed and documented in this assessment. Any **residual risk** following the pro estimated and documented in this assessment.



All efforts were made, by those involved with this risk assessment process, to identify all reasonably foreseeable tasks and hazards for all modes of operation, whether normal or abnormal. Given the practical constraints of a finite amount of time and resources toward this risk assessment effort within the limits of its scope, it is reasonable to expect that not all scenarios were addressed. Thus, some task and hazards may not have been discovered and assessed during this risk assessment. In accordance with the consensus machine safety standards, it is recommended that this risk assessment effort be repeated on a periodic basis. The frequency of the cycle depicted in **fig. 1** above, is determined by the owner of the asset and the associated staff interacting with the machine as part of the enterprise's safety program, policies and procedures.

2.0 Scope of this risk assessment including assets and affected personnel. The inform black is provided by the team with a high degree or certainty of being accurate. Info red has been provided by the team as an estimate and should be verified by the tea

2.1 Description of the asset and it's function

2.1.1 – Name

2.1.2 – Manufacturer

2.1.3 – Model

2.1.4 – Serial number

2.1.5 – Pictures, layout

2.2 Summary of the machine's function and description of its operation

2.2.1 Machines function

2.2.2 Description of operation

2.2.3 Description of incoming material, expected alterations done to machine and the material's outgoing condition

2.3 Modes of the machine being assessed

2.3.1 Start-up, Setup/adjustments, normal operation, foreseeable ab

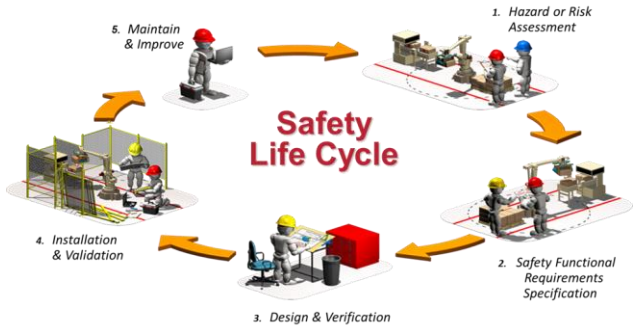
maintenance in lock out, maintenance in "minor servicing",

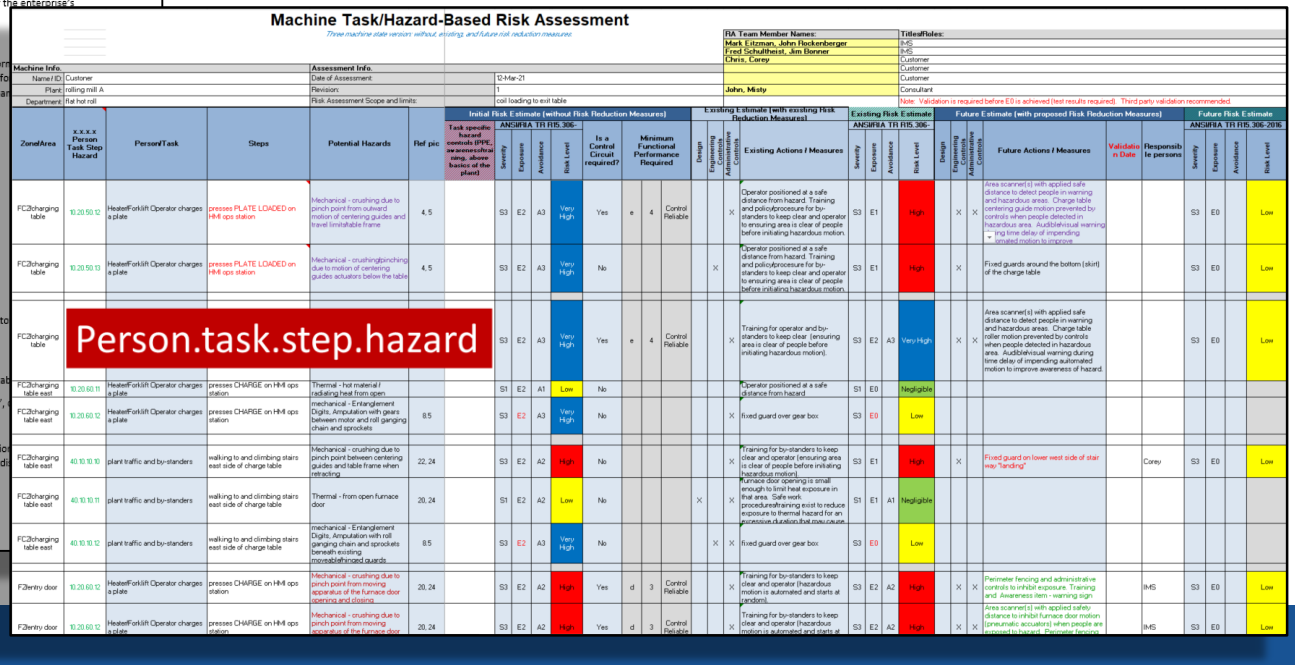
2.4 Machine Life-cycle

2.4.1 Design, installation, startup/commissioning, productio outage, relocation/lifting/transporting, decommissioning, di removal/demolition

2.5 Limit of the machine

2.5.1 Environmental limits





Machine Task/Hazard-Based Risk Assessment

Three machine state versions without, existing and future risk reduction measures

RIA Team Member Names: Mark Eitzman, John Rockenberger, Fred Schultheist, Jim Bonner, Chris, Corey

Titles/Roles: IMS, IMS, Customer, Customer, Customer, Consultant

Machine Info.: Name/ID: Customer; Plant: rolling mill A; Department: flat hot roll

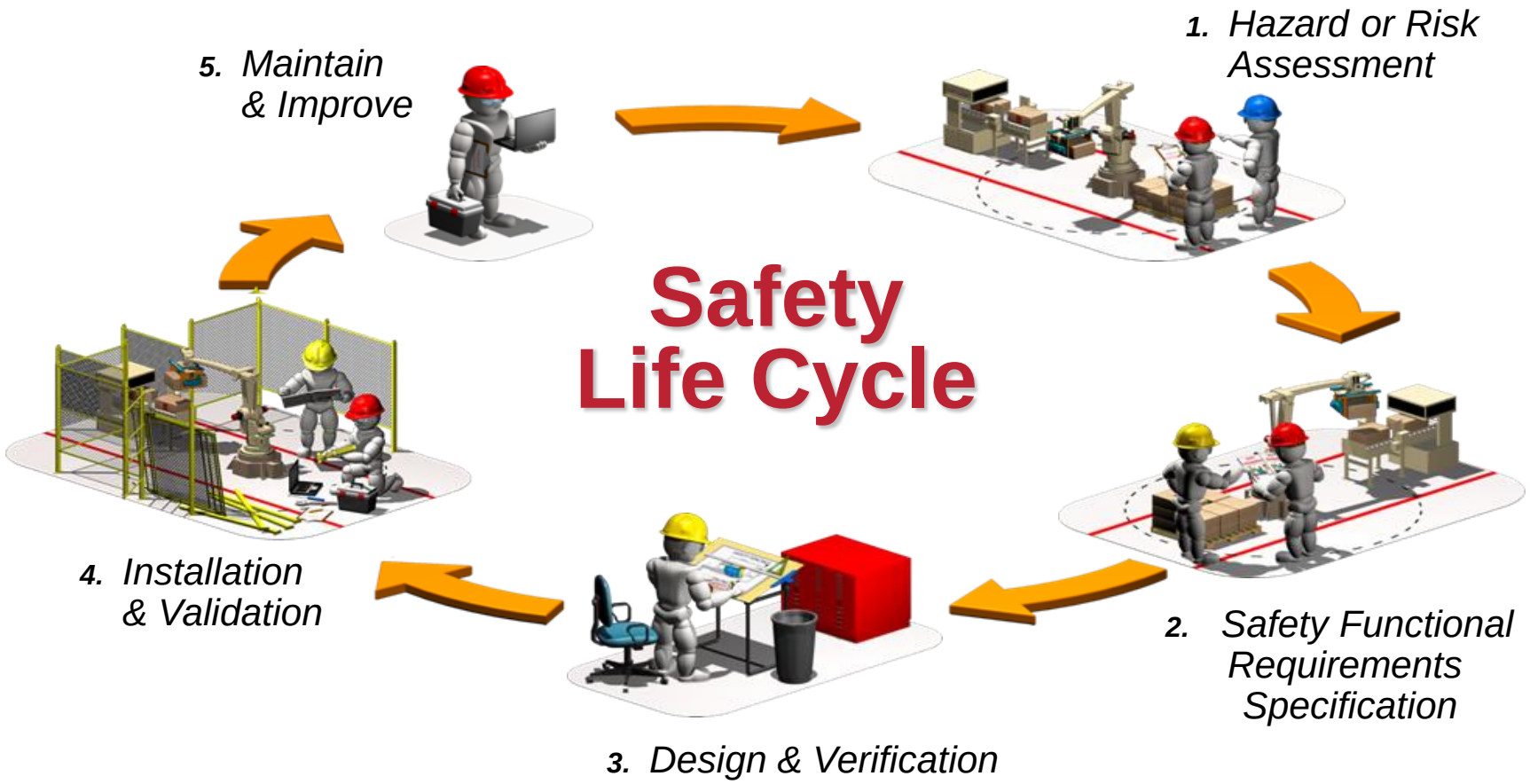
Assessment Info.: Date of Assessment: 12-Mar-21; Revision: 1; Risk Assessment Scope and limits: coil loading to exit table

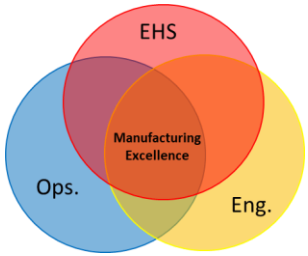
Note: Validation is required before E0 is achieved (test results required). Third party validation recommended.

Zone/Area	x.x.x.x Person Task Step Hazard	Person/Task	Steps	Potential Hazards	Ref pic	Initial Risk Estimate (without Risk Reduction Measures): Task specific hazard controls (PPE, awareness/training, above basics of the plant)	ANSI/RIA TR R15.306- Severity	Exposure	Avoidance	Risk Level	Is a Control Circuit required?	Minimum Functional Performance Required			Existing Estimate (with existing Risk Reduction Measures): Design	Engineering Controls	Administrative Controls	Existing Actions / Measures	Existing Risk Estimate ANSI/RIA TR R15.306- Severity	Exposure	Avoidance	Risk Level	Future Estimate (with proposed Risk Reduction Measures): Design	Engineering Controls	Administrative Controls	Future Actions / Measures	Validation Date	Responsible persons	Future Risk Estimate ANSI/RIA TR R15.306-2016 Severity	Exposure	Avoidance	Risk Level
FC2charging table	10.20.50.12	Heater/Forklift Operator charges a plate	presses PLATE LOADED on HMI ops station	Mechanical - crushing due to pinch point from outward motion of centering guides and travel limit/stable frame	4, 5		S3	E2	A3	Very High	Yes	e	4	Control Reliable			X	Operator positioned at a safe distance from hazard. Training and policy/procedure for by-standers to keep clear and operator to ensuring area is clear of people before initiating hazardous motion.	S3	E1		High		X	X	Area scanner(s) with applied safe distance to detect people in warning and hazardous areas. Charge table centering guide motion prevented by controls when people detected in hazardous area. Audible/visual warning ing time delay of impending imated motion to improve			S3	E0		Low
FC2charging table	10.20.50.13	Heater/Forklift Operator charges a plate	presses PLATE LOADED on HMI ops station	Mechanical - crushing/pinching due to motion of centering guides actuators below the table	4, 5		S3	E2	A3	Very High	No						X	Operator positioned at a safe distance from hazard. Training and policy/procedure for by-standers to keep clear and operator to ensuring area is clear of people before initiating hazardous motion.	S3	E1		High		X		Fixed guards around the bottom (skirt) of the charge table			S3	E0		Low
FC2charging table							S3	E2	A3	Very High	Yes	e	4	Control Reliable			X	Training for operator and by-standers to keep clear (ensuring area is clear of people before initiating hazardous motion).	S3	E2	A3	Very High		X	X	Area scanner(s) with applied safe distance to detect people in warning and hazardous areas. Charge table roller motion prevented by controls when people detected in hazardous area. Audible/visual warning during time delay of impending automated motion to improve awareness of hazard.			S3	E0		Low
FC2charging table east	10.20.60.11	Heater/Forklift Operator charges a plate	presses CHARGE on HMI ops station	Thermal - hot material / radiating heat from open			S1	E2	A1	Low	No						X	Operator positioned at a safe distance from hazard	S1	E0		Negligible										
FC2charging table east	10.20.60.12	Heater/Forklift Operator charges a plate	presses CHARGE on HMI ops station	mechanical - Entanglement Digits, Amputation with gears between motor and roll ganging chain and sprockets	8.5		S3	E2	A3	Very High	No						X	fixed guard over gear box	S3	E0		Low										
FC2charging table east	40.10.10.10	plant traffic and by-standers	walking to and climbing stairs east side of charge table	Mechanical - crushing due to pinch point between centering guides and table frame when retracting	22, 24		S3	E2	A2	High	No						X	Training for by-standers to keep clear and operator (ensuring area is clear of people before initiating hazardous motion)	S3	E1		High		X		Fixed guard on lower west side of stair way "landing"		Corey	S3	E0		Low
FC2charging table east	40.10.10.11	plant traffic and by-standers	walking to and climbing stairs east side of charge table	Thermal - from open furnace door	20, 24		S1	E2	A2	Low	No					X	X	Furnace door opening is small enough to limit heat exposure in that area. Safe work procedures/training exist to reduce exposure to thermal hazard for an excessive duration that may occur.	S1	E1	A1	Negligible										
FC2charging table east	40.10.10.12	plant traffic and by-standers	walking to and climbing stairs east side of charge table	mechanical - Entanglement Digits, Amputation with roll ganging chain and sprockets beneath existing moveable/hinged guards	8.5		S3	E2	A3	Very High	No					X	X	fixed guard over gear box	S3	E0		Low										
F2entry door	10.20.60.12	Heater/Forklift Operator charges a plate	presses CHARGE on HMI ops station	Mechanical - crushing due to pinch point from moving apparatus of the furnace door opening and closing.	20, 24		S3	E2	A2	High	Yes	d	3	Control Reliable			X	Training for by-standers to keep clear and operator (hazardous motion is automated and starts at random).	S3	E2	A2	High		X	X	Perimeter fencing and administrative controls to inhibit exposure. Training and Awareness item - warning sign		IMS	S3	E0		Low
F2entry door	10.20.60.12	Heater/Forklift Operator charges a plate	presses CHARGE on HMI ops station	Mechanical - crushing due to pinch point from moving apparatus of the furnace door	20, 24		S3	E2	A2	High	Yes	d	3	Control Reliable			X	Training for by-standers to keep clear and operator (hazardous motion is automated and starts at	S3	E2	A2	High		X	X	Area scanner(s) with applied safety distance to inhibit furnace door motion (pneumatic actuators) when people are exposed to hazard. Perimeter fencing		IMS	S3	E0		Low

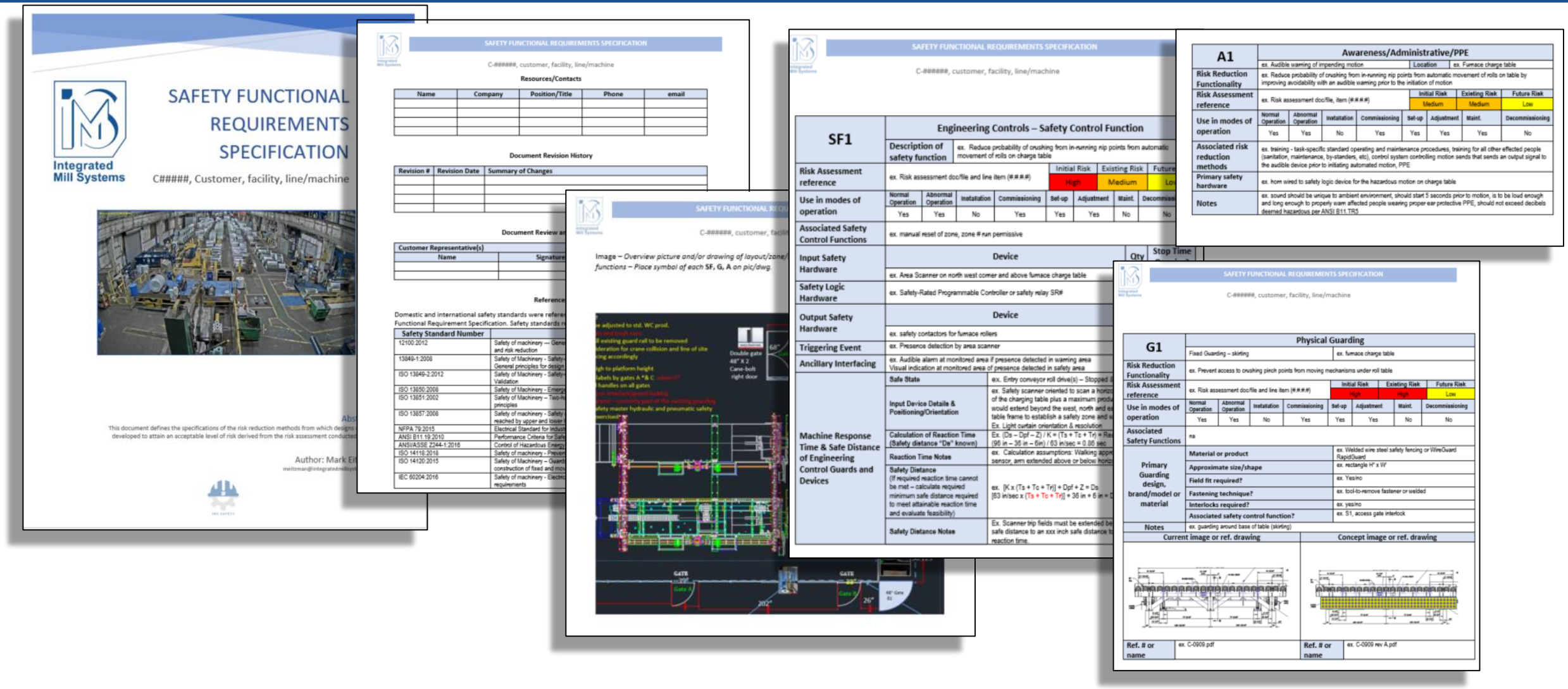
Person.task.step.hazard

ISO, IEC, ANSI, RIA, etc.
Functional Safety Life Cycle





Safety Functional Requirement Specification - SFRS



SAFETY FUNCTIONAL REQUIREMENTS SPECIFICATION

Integrated Mill Systems

C#####, Customer, facility, line/machine

SAFETY FUNCTIONAL REQUIREMENTS SPECIFICATION

C-######, customer, facility, line/machine

Resources/Contacts

Name	Company	Position/Title	Phone	email

Document Revision History

Revision #	Revision Date	Summary of Changes

Customer Representative(s)

Name	Signature

Safety Standard Number	
12100:2012	Safety of machinery — Gene and risk reduction
13849-1:2008	Safety of Machinery - Safety- General principles for design
ISO 13849-2:2012	Safety of Machinery - Safety- Validation
ISO 13850:2008	Safety of Machinery - Emerg
ISO 13851:2002	Safety of Machinery – Two-h principles
ISO 13857:2008	Safety of machinery - Safety reached by upper and lower
NFPA 79:2015	Electrical Standard for Indust
ANSI B11.19:2010	Performance Criteria for Safe
ANSI/ASSE Z244-1:2016	Control of Hazardous Energy
ISO 14118:2018	Safety of machinery - Preven
ISO 14120:2015	Safety of Machinery – Guard construction of fixed and mov
IEC 60204:2016	Safety of machinery - Electric requirements

SAFETY FUNCTIONAL REQUIREMENTS SPECIFICATION

C-######, customer, facility, line/machine

Image – *Overview picture and/or drawing of layout/zone/ functions – Place symbol of each* **SF, G, A** *on pic/dwg.*

SF1	Engineering Controls – Safety Control Function							
Description of safety function	ex. Reduce probability of crushing from in-running nip points from automatic movement of rolls on charge table							
Risk Assessment reference	ex. Risk assessment doc/file and line item (####)				Initial Risk: High	Existing Risk: Medium	Future: Low	
Use in modes of operation	Normal Operation: Yes	Abnormal Operation: Yes	Installation: No	Commissioning: Yes	Set-up: Yes	Adjustment: Yes	Maint.: No	Decommissioning: No
Associated Safety Control Functions	ex. manual reset of zone, zone # run permissive							
Input Safety Hardware	Device						Qty	Stop Time
	ex. Area Scanner on north west corner and above furnace charge table							
Safety Logic Hardware	ex. Safety-Rated Programmable Controller or safety relay SR#							
Output Safety Hardware	Device							
	ex. safety contactors for furnace rollers							
Triggering Event	ex. Presence detection by area scanner							
Ancillary Interfacing	ex. Audible alarm at monitored area if presence detected in warning area Visual indication at monitored area of presence detected in safety area							
Machine Response Time & Safe Distance of Engineering Control Guards and Devices	Safe State	ex. Entry conveyor roll drive(s) – Stopped						
	Input Device Details & Positioning/Orientation	ex. Safety scanner oriented to scan a horiz of the charging table plus a maximum produ would extend beyond the west, north and e table frame to establish a safety zone and Ex. Light curtain orientation & resolution						
	Calculation of Reaction Time (Safety distance "Dx" known)	Ex. (Ds – Dpf – Z) / K = (Ts + Tc + Tr) = Re (96 in – 36 in – 6in) / 63 in/sec = 0.86 sec						
	Reaction Time Notes	ex. Calculation assumptions: Walking appr sensor, arm extended above or below horiz						
	Safety Distance (If required reaction time cannot be met – calculate required minimum safe distance required to meet attainable reaction time and evaluate feasibility)	ex. [K x (Ts + Tc + Tr)] + Dpf + Z = Ds [63 in/sec x (Ts + Tc + Tr)] + 36 in + 6 in = D						
	Safety Distance Notes	Ex. Scanner trip fields must be extended be safe distance to an xxx inch safe distance t reaction time.						

A1	Awareness/Administrative/PPE							
	ex. Audible warning of impending motion				Location: ex. Furnace charge table			
Risk Reduction Functionality	ex. Reduce probability of crushing from in-running nip points from automatic movement of rolls on table by improving avoidability with an audible warning prior to the initiation of motion							
Risk Assessment reference	ex. Risk assessment doc/file, item (####)				Initial Risk: Medium	Existing Risk: Medium	Future Risk: Low	
Use in modes of operation	Normal Operation: Yes	Abnormal Operation: Yes	Installation: No	Commissioning: Yes	Set-up: Yes	Adjustment: Yes	Maint.: Yes	Decommissioning: No
Associated risk reduction methods	ex. training - task-specific standard operating and maintenance procedures, training for all other effected people (sanitation, maintenance, by-standers, etc), control system controlling motion sends that sends an output signal to the audible device prior to initiating automated motion, PPE							
Primary safety hardware	ex. horn wired to safety logic device for the hazardous motion on charge table							
Notes	ex. sound should be unique to ambient environment, should start 5 seconds prior to motion, is to be loud enough and long enough to properly warn affected people wearing proper ear protective PPE, should not exceed decibels deemed hazardous per ANSI B11.TR5							

SAFETY FUNCTIONAL REQUIREMENTS SPECIFICATION

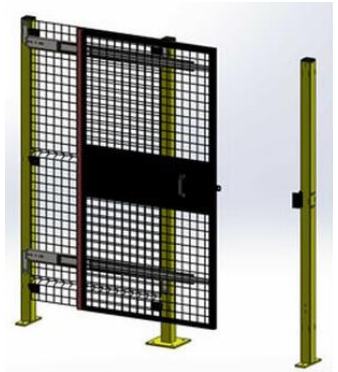
C-######, customer, facility, line/machine

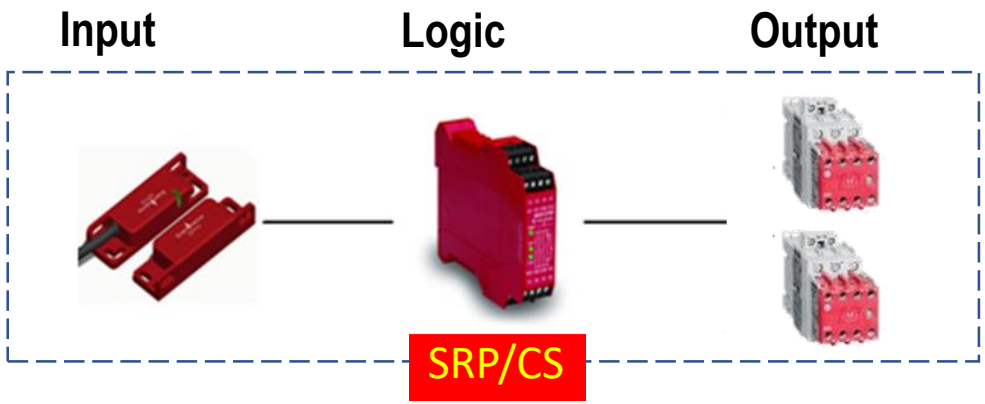
G1	Physical Guarding							
	Fixed Guarding – skirting				ex. furnace charge table			
Risk Reduction Functionality	ex. Prevent access to crushing pinch points from moving mechanisms under roll table							
Risk Assessment reference	ex. Risk assessment doc/file and line item (####)				Initial Risk: High	Existing Risk: High	Future Risk: Low	
Use in modes of operation	Normal Operation: Yes	Abnormal Operation: Yes	Installation: No	Commissioning: Yes	Set-up: Yes	Adjustment: Yes	Maint.: No	Decommissioning: No
Associated Safety Functions	na							
Primary Guarding design, brand/model or material	Material or product	ex. Welded wire steel safety fencing or WireGuard RapidGuard						
	Approximate size/shape	ex. rectangle H' x W'						
	Field fit required?	ex. Yes/no						
	Fastening technique?	ex. tool-to-remove fastener or welded						
	Interlocks required?	ex. yes/no						
	Associated safety control function?	ex. S1, access gate interlock						
Notes	ex. guarding around base of table (skirting)							
Current image or ref. drawing				Concept image or ref. drawing				
Ref. # or name	ex. C-0909.pdf			Ref. # or name	ex. C-0909 rev A.pdf			

Functional Safety – *Safety Rated Part of the Control System (SRP/CS)*

- **Functional Safety** of machinery are those parts of the machine control system that are specifically used to reduce risk, particularly with regard to human safety
  - An example of Functional Safety is a simple interlock circuit.

Access Gate (Movable Guard)





- The **Safety Function** could be described as follows:
  - *The Safety Gate is opened, causing the gate monitoring sensor to turn off (input). The Monitoring Safety Relay (logic) detects this change of state and de-energizes the contactors (output), thus stopping the associated motor and hazardous motion.*

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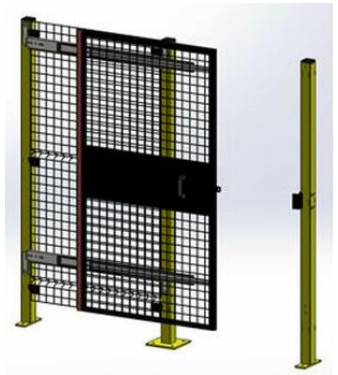
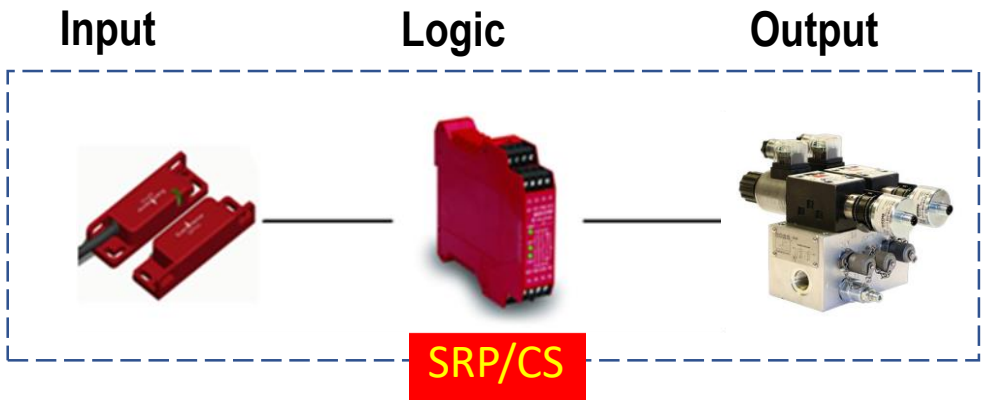
Fluid Power!

Access Gate (Movable Guard)

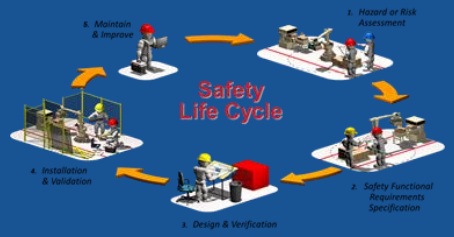




Hydraulic Actuator

- The **Safety Function** could be described as follows:
  - *The Safety Gate is opened, causing the gate monitoring sensor to turn off (input). The Monitoring Safety Relay (logic) detects this change of state and de-energizes the contactors (output), thus stopping the associated motor and hazardous motion.*

Safety Functional Requirement Specification - SFRS



Example of the details on a controls solution

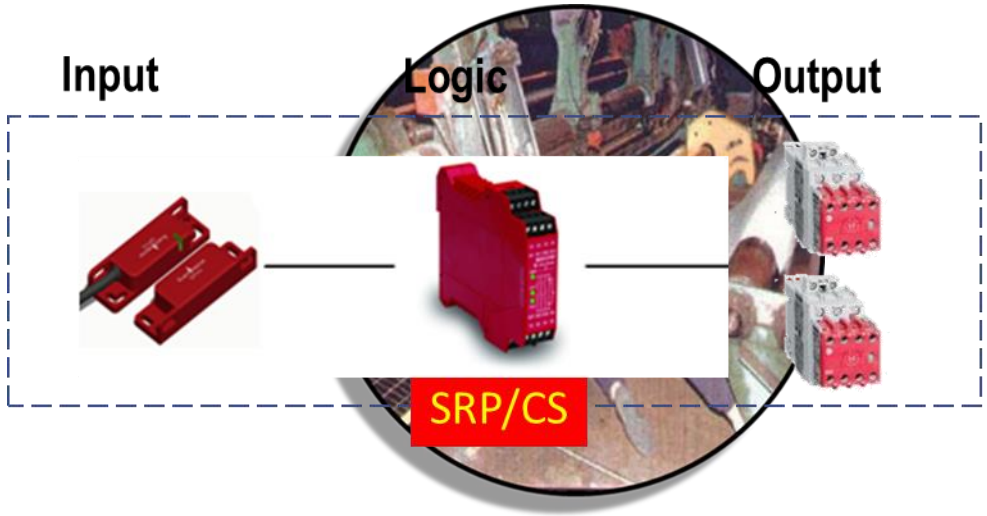
- Triggering event
- Functional sequence
- Safe state
- Control of hazardous energy
- Reaction (function and time)
- Diagnostics
- Circuit performance
- Reset
- Standards compliance
- BOM outline

SF1	Engineering Controls – Safety Control Function							
	Description of safety function	ex. Reduce probability of crushing from in-running nip points from automatic movement of rolls on charge table						
Risk Assessment reference	ex. Risk assessment doc/file and line item (#.#.#.#)				Initial Risk: High	Existing Risk: Medium	Future Risk: Low	
Use in modes of operation	Normal Operation	Abnormal Operation	Installation	Commissioning	Set-up	Adjustment	Maint.	Decommissioning
	Yes	Yes	No	Yes	Yes	Yes	No	No
Associated Safety Control Functions	ex. manual reset of zone, zone # run permissive							
Input Safety Hardware	Device						Qty	Stop Time Require?
	ex. Area Scanner on north west corner and above furnace charge table						1	yes
Safety Logic Hardware	ex. Safety-Rated Programmable Controller or safety relay SR#							
Output Safety Hardware	Device							
	ex. safety contactors for furnace rollers							
Triggering Event	ex. Presence detection by area scanner							
Ancillary Interfacing	ex. Audible alarm at monitored area if presence detected in warning area Visual indication at monitored area of presence detected in safety area							
Machine Response Time & Safe Distance of Engineering Control Guards and Devices	Safe State	ex. Entry conveyor roll drive(s) – Stopped						
	Input Device Details & Positioning/Orientation	ex. Safety scanner oriented to scan a horizo of the charging table plus a maximum produ would extend beyond the west, north and ea table frame to establish a safety zone and w Ex. Light curtain orientation & resolution						
	Calculation of Reaction Time (Safety distance "Ds" known)	Ex. (Ds – Dpf – Z) / K = (Ta + Tc + Tx) = Rea (96 in – 36 in – 6in) / 63 in/sec = 0.86 sec						
	Reaction Time Notes	ex. Calculation assumptions: Walking appr sensor, arm extended above or below horiz						
	Safety Distance (If required reaction time cannot be met – calculate required minimum safe distance required to meet attainable reaction time and evaluate feasibility)	ex. [K x (Ta + Tc + Tx)] + Dpf + Z = Ds [63 in/sec x (Ta + Tc + Tx)] + 36 in + 6 in = D						
	Safety Distance Notes	Ex. Scanner trip fields must be extended beyond the perimeter of the machine safe distance to an xxx inch safe distance to accommodate system reaction time.						

Safe-state of associated SFs	ex. All motion on charge table is stopped ex. Safety contactors are de-energized/opened preventing mill feed rolls from rotating ex. Safety pneumatic valves are in their safe state position preventing C-frame travel in or out ex Safety hydraulic valves are in their safe state position preventing lift table motion up or down
Means of reset	ex. after closing gate, press blue *Reset* pushbutton on outside of gate to indicate to the safety logic device to put system into ready-to-run state.
Conditions to Permit Reset	ex. output device free of faults, safety logic device receives appropriate simultaneous dual channel input transitions from device on gate, all e-stop actuators in non-estop position, trapped-key for exclusive control is in interlocked device on gate and in locked position
Description of functional safety sequence from trigger to safety state to reset	ex. Depress white *Request Access* pushbutton on guard-locking gate device. The safety logic controller issues commands to the safety output devices and actuators to go to their safety-state. The safety contactors open, the hydraulic vales transition to blocked position, the pneumatic valves go to closed/blocked position and the water valves go to safe state. As machine transitions to safe-state, green *Access* indicator on guard-locking gate device flashed and then illuminates solid when safe-state is achieved and the red *Locked* illuminated indicator turns off. Upon reaching safe-state, the safety logic controller issues a command to unlock gate's guard-lock allowing the operator to turn the handle and open the gate. The PLC monitors the state of the output/actuators for faults while access is granted and the open/unlocked state of the gate. Upon closing the gate, machine motion will not resume. The operator pressed and releases the blue *Reset* button on the guard-locking gate device that signals to the safety logic device to allow for the normal start of the machine operation. The green *Access* indicator on the gate guard-locking device turns off and the red *Locked* indicator illuminates solid. The operator can start the machine with a *Start* button on the ops. station. The output safety devices return to normal run position. The safety logic device monitors the state of all output devices for faults and if none are present, allows the machine to return to operation.
Notes	ex. Emergency stop pushbuttons shall be installed at all operator station locations and areas where tasks are performed. Quantity to be determined as operator stations have not yet been defined. Safety function shall be verified and validated in accordance with ISO 13849-1 & -2.

Performance Level (PL a-e) of Control Circuits (electrical/electronic, pneumatic, hydraulic)

- ISO 13849-1 safety design
- Choose the most suitable combination of:
- Structure (Category), Diagnostic Coverage (DC), and Reliability (MTTFd)



RIA TR R15.306-2016

Table 5 – Minimum functional safety performance

Risk Level	PL_r	Structure Category
NEGLIGIBLE (see 6.5.3.1)	b	-
LOW	c	2
MEDIUM	d	2
HIGH	d	3
VERY HIGH (see 6.5.3.2)	e	4

		Category	B	1	2	2	3	3	4
PFHd		DC	none	none	60 to <90%	90 to 99%	60 to <90%	90 to <99%	99%
1/10,000	Performance Level	a	3-11		3-7	3-5	3		
1/100,000		b	12-27	30-36	7-20	5-15	4-10	3-5	
1/333,333		c		>39	22-56	16-33	11-22	5-12	
1/1,000,000		d			>62	>36	>24	13-56	
1/10,000,000		e						>62	>30
			MTTFd (Years)						

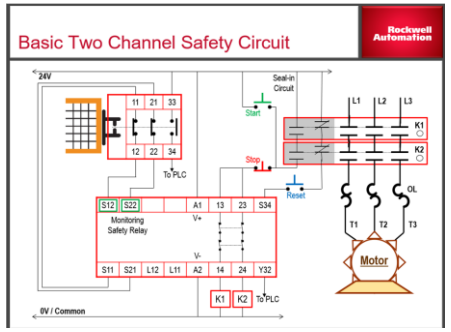
Ref: 13849-1 Table K.1

Calculated Probability

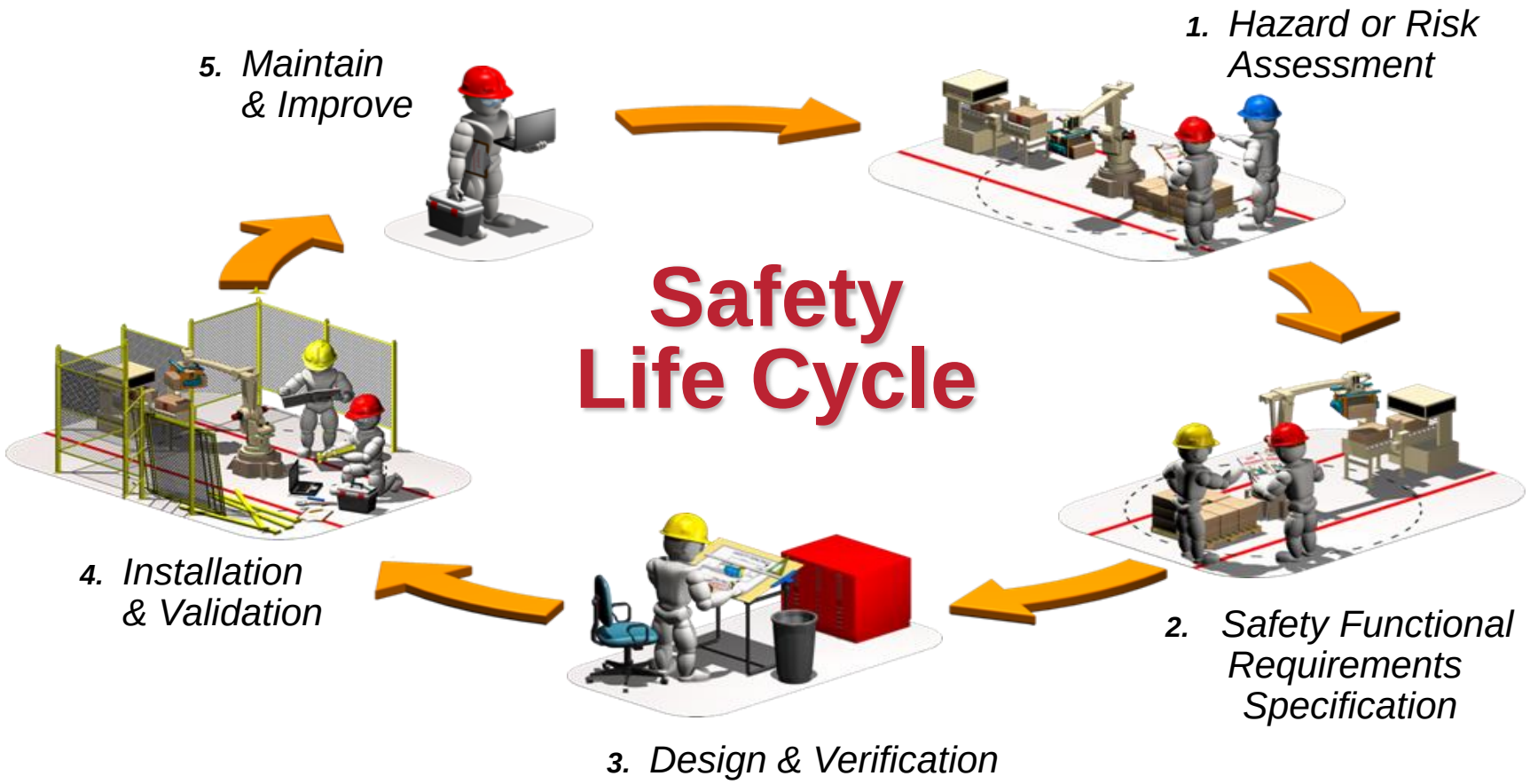
PL	SIL	PFHd – Average Probability of a Dangerous Failure per Hour	PFHd – Average Probability of a Dangerous Failure per Hour	Dangerous failures in a 20 year mission time (as high as)	Control Reliable
A	*na*	1 in 10,000 to 100,000	$\geq 10^{-5}$ to $<10^{-4}$	17.52	
B	1	1 in 100,000 to 3 in 1,000,000	$\geq 3 \times 10^{-6}$ to $<10^{-5}$	1.752	
C	1	3 in 1,000,000 to 1 in 1,000,000	$\geq 10^{-6}$ to $<3 \times 10^{-6}$	0.5256	
D	2	1 in 1,000,000 to 10,000,000	$\geq 10^{-7}$ to $<10^{-6}$	0.1752	√
E	3	1 in 10,000,000 to 100,000,000	$\geq 10^{-8}$ to $<10^{-7}$	0.01752	√

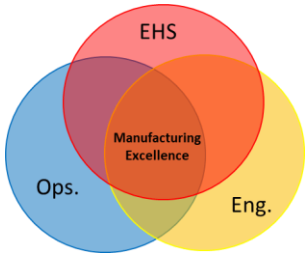
Control Reliable

- OSHA 1910.211 – Sub part O - *Machinery and Machine Guarding*
  - A control system must be constructed in such a way that:
    - a fault that occurs inside the system does not prevent the normal stop process from being activated
    - another machine cycle cannot be executed before the fault has been removed
    - the fault can be revealed by a simple test, or displayed by the control system
- *ANSI B11.19-2019 Subpart 3.15 defines Control Reliability as follows:*
  - The capability of the [machine] control system, the engineering controls – devices, other control components, and related interfacing to achieve a safe state in the event of a failure within the safety-related parts of the control system.
- *ISO 13849-1 PLd, Category 3* comes relatively close to the OSHA/ANSI requirements:
  - A single fault in each of these parts does not cause the loss of the safety function
  - If a single fault occurs, the safety function is always maintained
  - Single faults are detected whenever this is reasonably possibly
  - Some but not all faults are detected.*
    - An accumulation of undetected faults can lead to loss of the safety function.*



ISO, IEC, ANSI, RIA, etc.
Functional Safety Life Cycle





Redesign the machine or change the process

Machine Guarding

Minor Servicing Exception

E-stop

Signs, lights, horns, training

Boss, keys

Lockout/Tagout

Safety glasses, hardhat, tools

Most Preferred

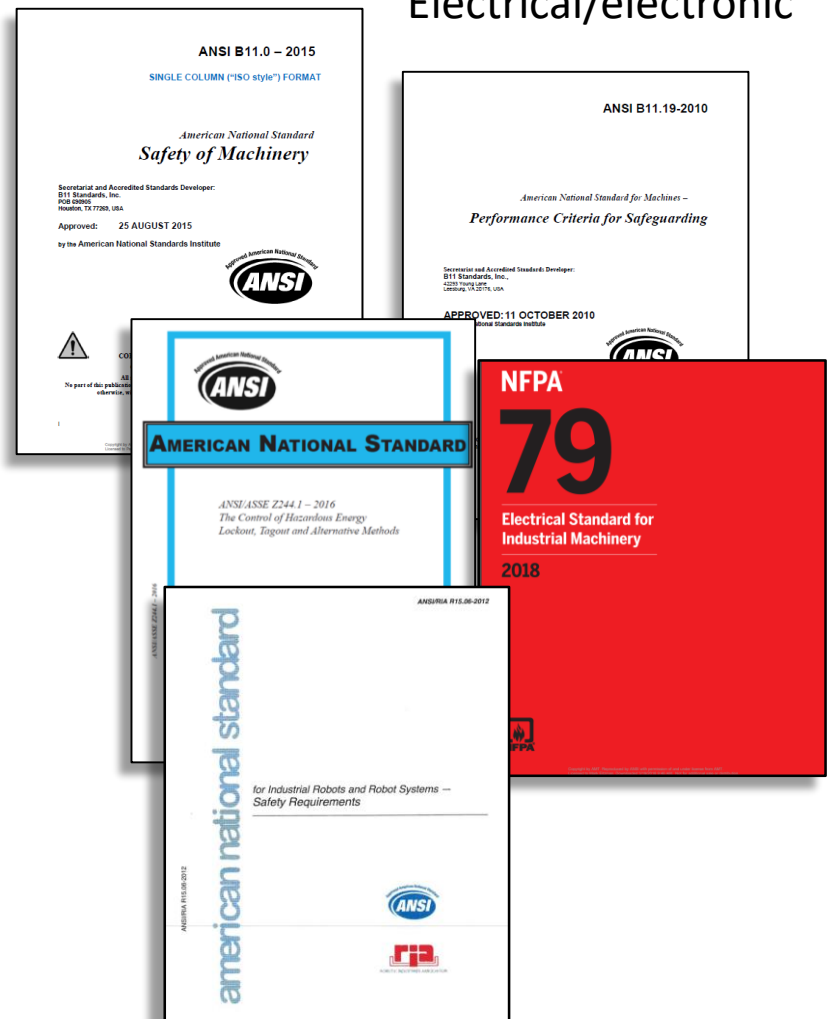
Least Preferred

Table 6 — Potential Effects/Additional Characteristics of Risk Reduction Measures

Risk Reduction Measures			Possible Effect on Risk Factors				Possibly susceptible to: (even when properly applied)	
Hierarchy		Examples	Severity	Probability				
Classification	Type			Exposure	Avoidance	Occurrence	Failure	Error / Misuse
Inherently Safe by Design (Redesign)	Limiting Interaction	modify the process to eliminate/reduce human interaction		•		•		•
	Elimination	replace task, increase clearance	•	•				
		energy magnitude reduction	•			•	•	
	Substitution	automated material handling	•	•	•	•	•	•
		use less hazardous chemicals	•			•		•
		reduce force, speed, etc. through selection of inherently safe components	•		•			
Engineering Controls (Guards, Devices and Control Functions)	Separation	fixed guards, shields		•		•	•	•
	Detect / Control Access	Interlock devices, presence sensing devices		•		•	•	•
	Control Hazardous Motion	two-hand / single actuating controls		•	•	•	•	•
		enabling devices, jog controls			•	•	•	•
	Restricting Operation	controlled selection of operating modes				•		•
	Monitor / Limit Hazards	speed / force monitoring and limiting	•		•	•	•	
	Emergency Action	emergency stop devices	•		•	•	•	
Administrative Controls	Awareness Means (Warnings & Instructions)	awareness barriers		•	•	•		•
		awareness signals (audible and/or visible)			•	•	•	•
		awareness signs / markings			•	•		•
	Information for Use (Training & Procedures)	safe work procedures, training			•	•		•
	Administrative Methods	safe-holding safeguarding method			•	•		•
	Supervision	supervisory control of configurable elements			•	•		•
	Control of hazardous energy	isolation of hazardous energy	•	•		•		•
	Tools	hand tools	•		•	•	•	•
	PPE	safety glasses, hearing protection, gloves	•		•	•	•	•

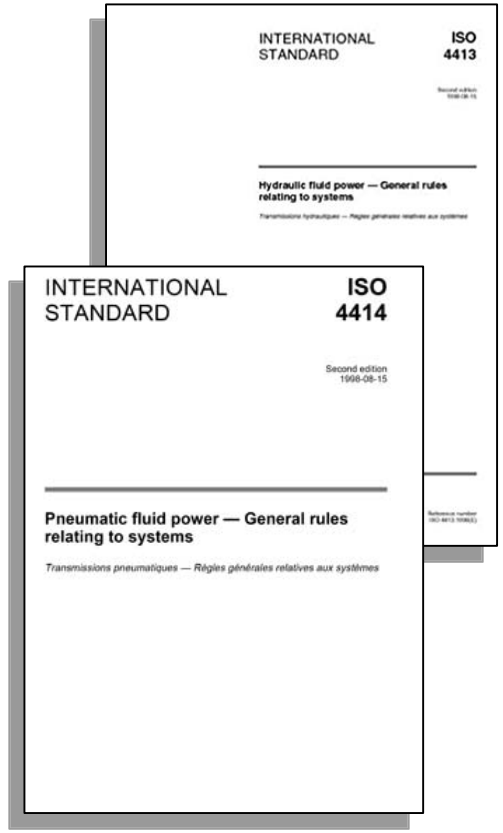
Machine Safety Control Systems Designed to Global Consensus Standards

Electrical/electronic



Automation

Hydraulics/Pneumatics



13849-1 Design & Verification (SISTEMA - *Safety Integrity Software Tool for the Evaluation of Machine Applications*)

Project – machine or zone being analyzed

Safety Function – function of the machine whose failure can result in an immediate increase of the risk(s)

Subsystem – largest unit of components which executes the safety function

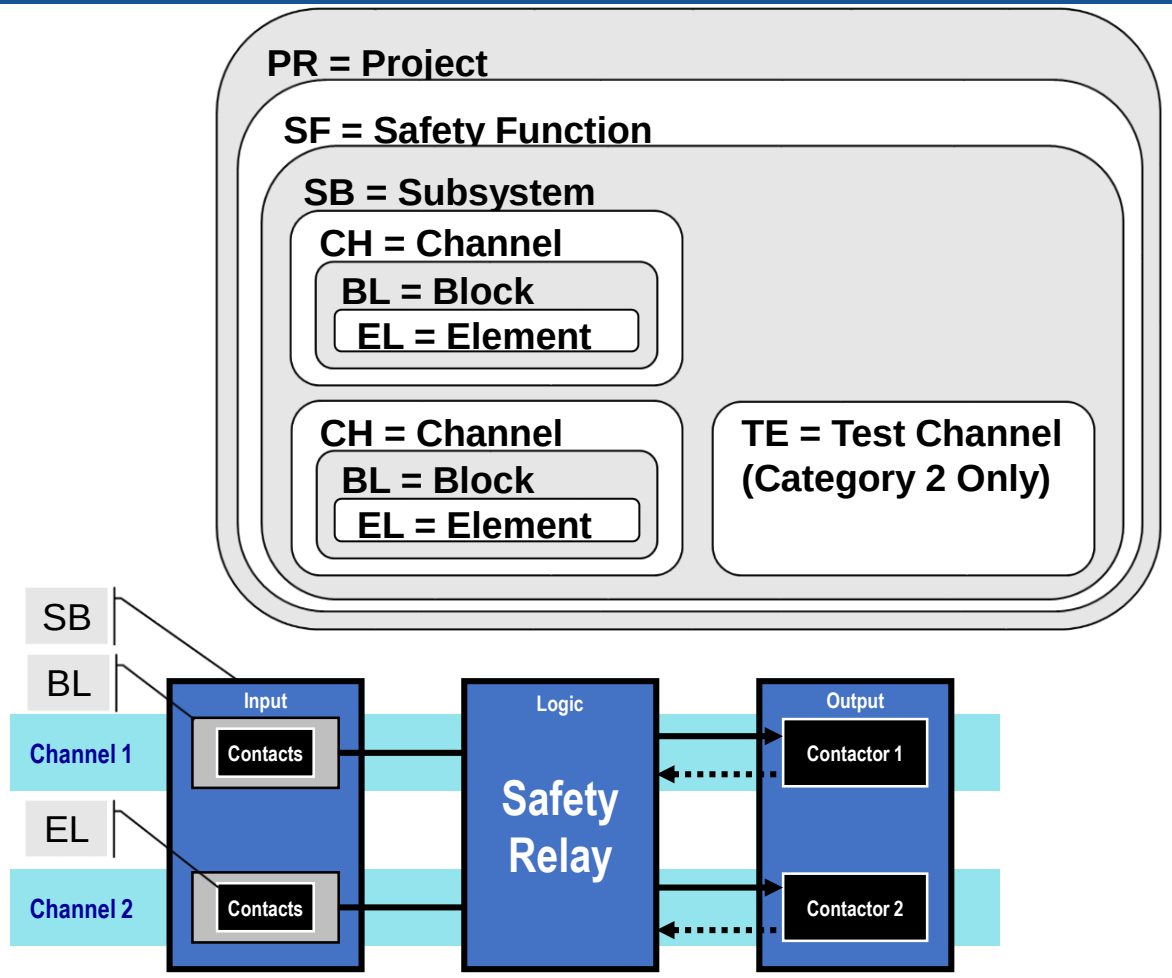
Ex: Input, Logic, Output

Channel – chains of components which execute the safety function. Ex: Single or Dual

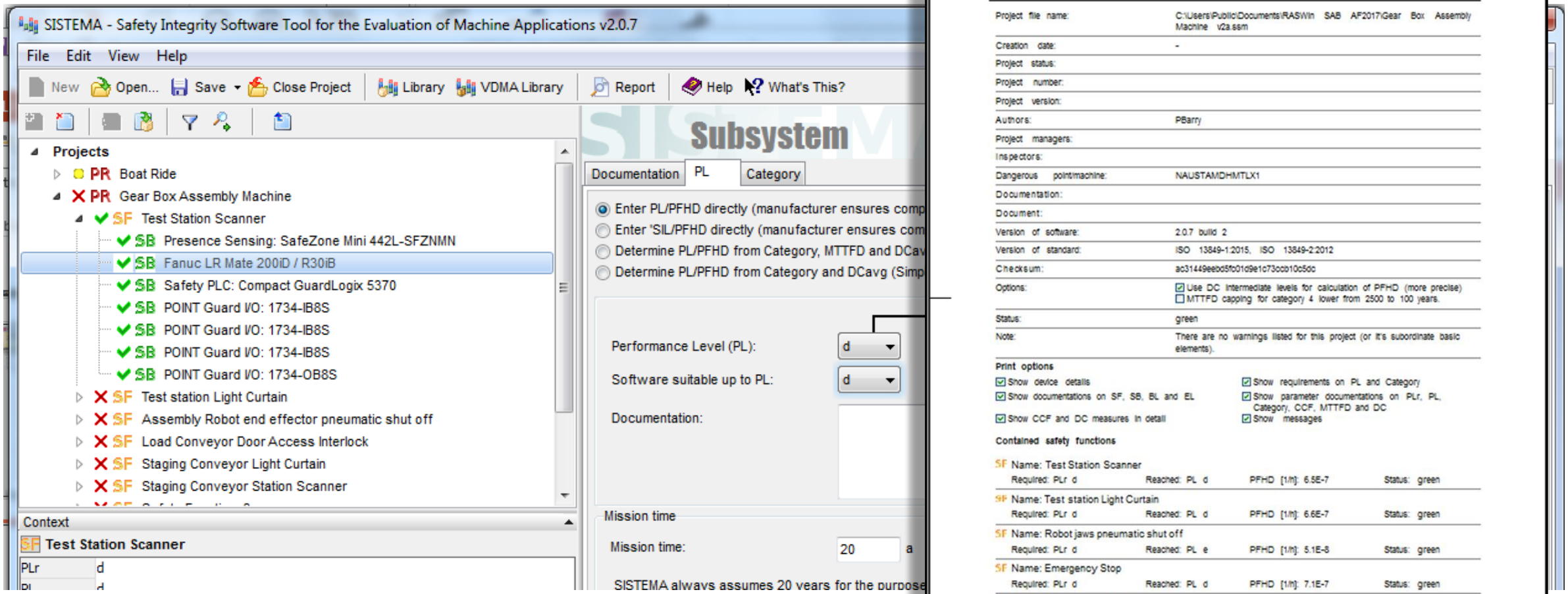
Test channel – part of a subsystem that determines whether the functional channel is executed properly

Block – individual component of a channel

Element – lowest hierarchical level, used to further subdivide a block



SISTEMA - Verification



SISTEMA - Safety Integrity Software Tool for the Evaluation of Machine

Project name: Gear Box Assembly Machine

File date: 09/11/2017 07:42:14 Report date: 11/9/2017 Checksum: ac31449eebd5fb01d9e1c73ccb10c5dc

PR Project name: Gear Box Assembly Machine

Project file name:	C:\Users\Public\Documents\RASWin SAB AF2017\Gear Box Assembly Machine v2a.ssm
Creation date:	-
Project status:	
Project number:	
Project version:	
Authors:	PBarry
Project managers:	
Inspectors:	
Dangerous point/machine:	NAUSTAMDHMTLX1
Documentation:	
Document:	
Version of software:	2.0.7 build 2
Version of standard:	ISO 13849-1:2015, ISO 13849-2:2012
Checksum:	ac31449eebd5fb01d9e1c73ccb10c5dc
Options:	☑ Use DC intermediate levels for calculation of PFHD (more precise) ☐ MTTFD capping for category 4 lower from 2500 to 100 years.
Status:	green
Note:	There are no warnings listed for this project (or it's subordinate basic elements).

Print options

☑ Show device details
☑ Show documentations on SF, SB, BL and EL
☑ Show CCF and DC measures in detail
☑ Show requirements on PL and Category
☑ Show parameter documentations on PLr, PL, Category, CCF, MTTFD and DC
☑ Show messages

Contained safety functions

SF Name: Test Station Scanner
Required: PLr d Reached: PL d PFHD [1/h]: 6.5E-7 Status: green

SF Name: Test station Light Curtain
Required: PLr d Reached: PL d PFHD [1/h]: 6.6E-7 Status: green

SF Name: Robot jaws pneumatic shut off
Required: PLr d Reached: PL e PFHD [1/h]: 5.1E-8 Status: green

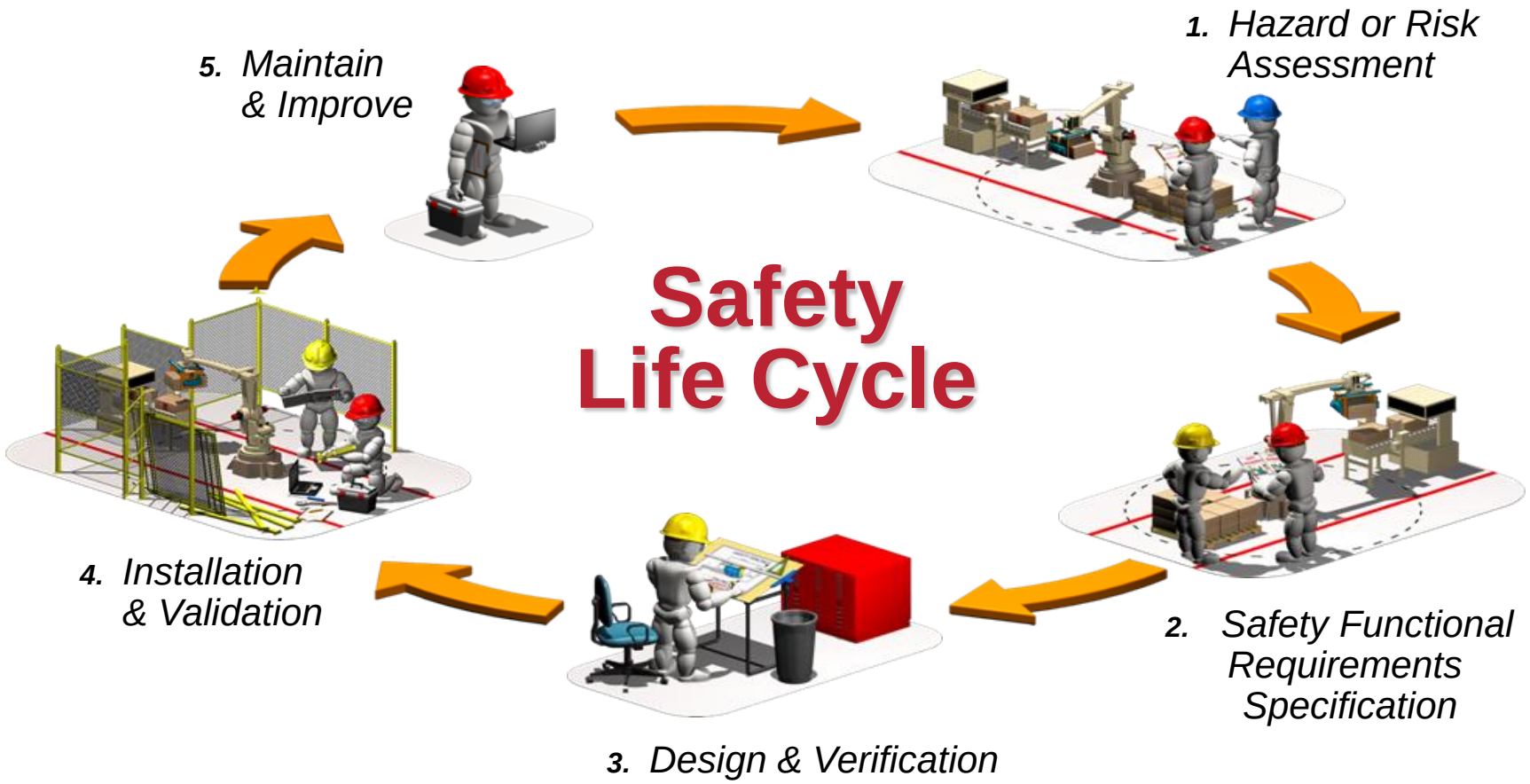
SF Name: Emergency Stop
Required: PLr d Reached: PL d PFHD [1/h]: 7.1E-7 Status: green

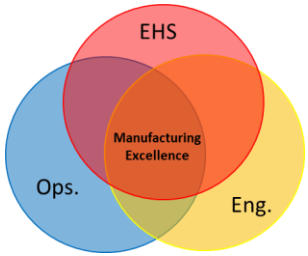
SF Name: Load Conveyor Door Access Interlock
Required: PLr d Reached: PL d PFHD [1/h]: 6.4E-7 Status: green

SF Name: Staging Conveyor Light Curtain
Required: PLr d Reached: PL e PFHD [1/h]: 5.1E-8 Status: green

SISTEMA a free of charge tool from IFA Page 1 / 109

ISO, IEC, ANSI, RIA, etc.
Functional Safety Life Cycle





Installation

Integrated
Mill Systems

Turnkey Installation & Integrated Automation Solutions

Validation

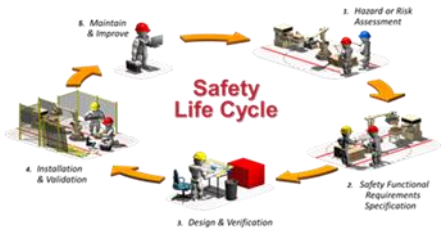
Have we attained an acceptable level of risk per the Risk Assessment and SFRS?

4. *Installation & Validation*

- Items to be considered for validation include but not limited to:
  - Normal Operation
  - Abnormal Operation
  - Reasonable/foreseeable defeats
  - Installation & Wiring
  - Safety Devices & Circuits
    - Fail to safe
    - Monitoring and fault detection
    - Redundancy
  - Controller & Network
  - Software Program
  - Access & Cybersecurity
  - Output Devices
  - Actuators
  - Guards/barriers
  - Complimentary Devices
  - All stops
  - Stop times/distances
  - LOTO
  - SOPs
  - Training
  - Manuals
  - Warning labels
  - Environment
  - Ergonomics
  - No new hazards
  - Review interval

Validation Report

Validation Plan
Validation Check Lists
Changes/Modifications
Re-Validate
Report



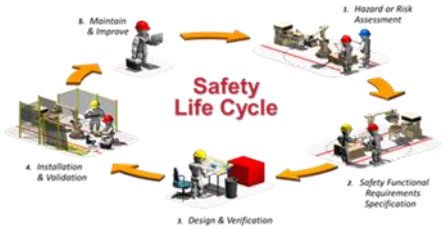
	Machine Safety Validation (Post Installation/Commissioning Functional Safety Test)				Customer Logo
	Customer - City, State/Province				
	Project Name - C22xxx				
	Validators :				

Area	FCZ/charging table west	**Risk Reduction Item**	**SF5**	**SFRS & RA ##.##.##.##**	10.10.10.14-15, 10.10.10.17, 10.10.25.11-12, 10.10.25.14, 10.10.35.10-12, 10.10.40.10, 40.10.10.11, 40.10.10.14-15, 40.10.10.17, 40.10.10.18-19, 40.15.10.11, 40.15.10.13-14, 40.15.10.15-19
Summary Description	Area scanner detects persons/equipment inside the hazard area and prevents the start of hazardous motion. It will also stop motion, but will require additional risk reduction measures (A5,A6)				

Validation Step	Step Description	Pass/ Fail	Changes/Modification	Name/date
1	With system in normal/automatic production mode, enter the area scanner's warning zone, separately penetrating all three perimeter boarders and observe that the hazardous motion does not stop and the illuminated awareness lights turns from green to yellow.			
2	With system in normal/automatic production mode, leave the warning zone and observe that the illumination awareness lights change from yellow to green.			
3	With system in normal/automatic production mode, enter the area scanner in the hazard/trip zone, by penetrating all three perimeter boarders and observe that the hazardous motion stops and the awareness lights turn red. Check the system status to ensure the drives are in STO and the hydraulics are in block and bleed.			
4	Attempt to stand between the area scanner's hazard/trip zone and the edge of the charge table and observe that there is no place that does not trip the safety function.			
	By pressing and releasing the blue illuminated reset button on the ops station			

Validation Report

Validation Plan
Validation Check Lists
Changes/Modifications
Re-Validate
Report



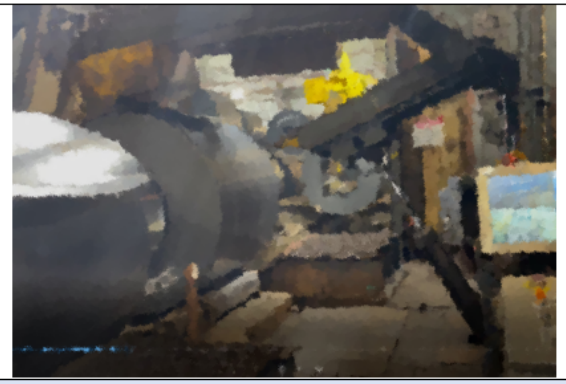
	• saddle to the unwinder • Shear coil tail	10.35.5.1-4, 10.35.10.2-5, 10.35.25.1-4, 10.35.35.1-4, 10.35.35.7, 10.35.40.1, 10.50.5.2-3, 10.60.5.1, 15.5.5.3-5, 15.5.5.8-9, 15.5.5.11	collapse or unexpected motion of the blocker roll						
			Crushing between the moving hold down arm's roller and the coil as the motion is continuous once initiated and stops only upon reaching a hard stop such as the coil or the end of travel	High	High	Low			

Use in modes of operation	Normal Operation	Abnormal Operation	Installation	Commissioning	Set-up	Adjustment	Maint.	Decommissioning
	yes	yes	no	no	yes	yes	yes	no

Associated Safety Control Functions	G1, SF2		
Input Safety Hardware	**Device**	**Qty**	**Stop Time Require?**
	Area Scanner (two sensing heads)	1	yes
Safety Logic Hardware	Safety PLC	1	yes
Output Safety Hardware	**Device**	**PLr/Cat**	**Stop Cat.**
	PREP COIL CAR TRAVERSE REV. (CW/CCW) BLOCK & DUMP	PLd/Cat3	1
	PREP COIL CAR LIFT/DOWN, BLOCK & HOLD	PLd/Cat3	1
	PREP BLOCKER ROLL REV. HYD. DRIVE, BLOCK & DUMP	PLd/Cat3	0
	PREP HOLDDOWN ROLL LIFT/LOWER, BLOCK & HOLD	PLd/Cat3	1
	PREP HOLDDOWN REVERSING ROLL DRIVE, BLOCK & DUMP	PLd/Cat3	0
	PREP PEELER TABLE RAISE/LOWER, BLOCK & HOLD	PLd/Cat3	1
	PREP PEELER TABLE EXTEND/RETRACT, BLOCK & HOLD	PLd/Cat3	1

Control Guards and Devices	**Calculation of Reaction Time and Safety distance "Ds"**	This is based on an estimated stop time of the machine. The safety distance cannot be met, so this SF will prevent the start of motion. ex. [K x (Ts + Tc + Tr)] + Dpf + Z = Ds [63in/sec x (Ts + Tc + Tr)] + 47.24 in + 4 in = Ds Current estimates…. [63" x (.05 sec + .22 sec + .17 sec)] + 47.24 in + 4" = 79.96"
	Reaction Time Notes	Ts, Tc and Tr are best estimates. Efforts to make them more accurate are deems unnecessary since the resulting safety distance calculation would still be farther away than current location of the ops. station.
	Safety Distance Definitions per ANSI B11.19-2019	Ds = [K x (Ts + Tc + Tr)] + Dpf + Z • Ds = the minimum safe distance between safeguarding device and the hazard • K= speed constant; 1.6 m/sec (63 inches/sec) minimum based on the movement being the hand/arm only and the body being stationary • Ts = machine/equipment stopping time • Tc = control system stopping time • Tr = detecting device response time • Dpf = maximum travel towards the hazard within the presence sensing safeguarding devices (PSSD) field that may occur before a stop is signaled • Z = Supplemental distance factor
	Safety Distance Notes	This safety function will adequately prevent the start of motion, but the stop time and safety distance calculation make is impractical to use this safety function to stop existing motion. Additional layer(s) of administrate control (A1) is required to meet an acceptable level of risk as determined by Metals.
Means of reset	Blue, illuminated reset button on the prep area ops station	
Conditions to Permit Reset	Nothing being sensed by the area scanner in the hazard zone	
Description of functional safety sequence from trigger to safety state to reset	Access sequence; • A person or object is detected by the area scanner • The safety PLC puts all actuators into their safe positions (block & dump/hold) stopping all hazardous motion and turns the blue illuminated push button from on to off. • To reset, all people/objects are clear of the area scanner's hazard tip zones. The blue illuminated reset button goes from off to flashing. • The operator presses and releases the blue illuminated reset button allowing operations to be restarted with a separate restart action. The blue button goes from flashing to solid on.	
Notes	Reset button will be a physical button added to the ops station, rather than a button in the HMI. There is a separate reset button for the cat walk reset.	

SF1



Engineering Controls – Safety Control Function

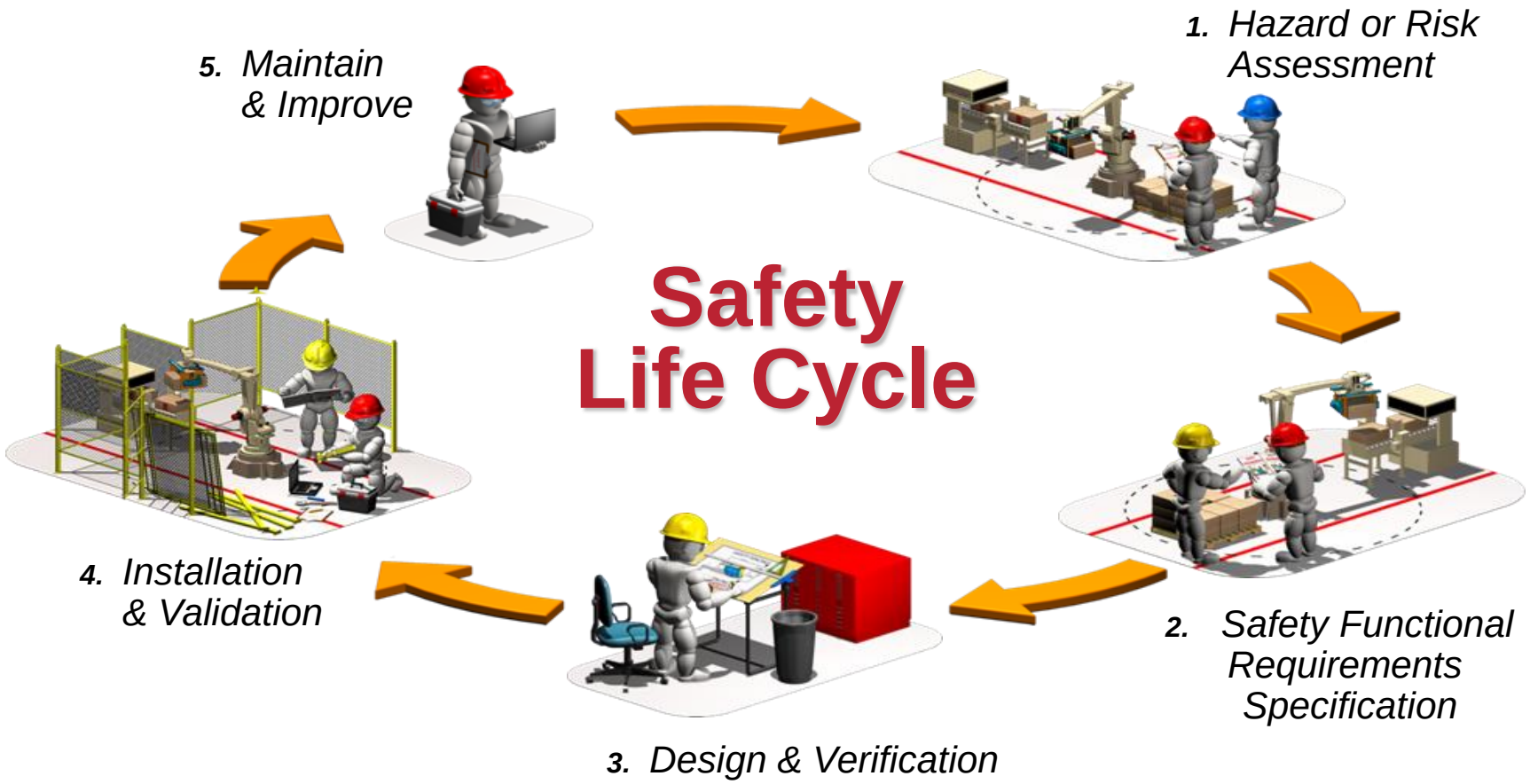
Description of safety function	With an area safety scanner with two heads, detect a person(s) in proximity to the hazards in the defined area between the blocker rolls, around the sides of the coil on the blocker rolls, the coil peeler and puts all hazardous motion from the blocker rolls, holddown and coil peeler into a safe stop state.
Span of Control	Coil prep area of the pickle line

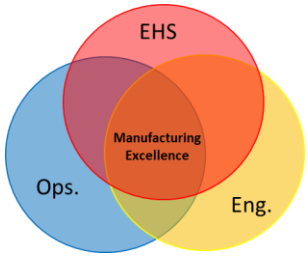
Risk Assessment reference: Risk assessment Metals IMS ANSI-RIA-Risk-Assessment-Pickle coil prep rev 0 5 25 22, tab 4_Assessment - R15.306-2016, line items;

Task(s)	person.task.step.hazard	Hazard	Initial Risk	Existing Risk	Future Risk
• Transfer coil from "hot band saddles" to the blocker roll • Deband • Bend the coil tail up • Move coil from the blocker rolls to the entry #2 saddle • Move coil from the entry #2 saddle to #1 • Move coil from the entry #1	5.5.10.2, 5.5.15.1, 5.5.15.3, 5.5.20.1, 5.5.25.1-3, 5.5.30.1-2, 5.10.5.2-3, 5.10.10.1-2, 5.10.15.1-3, 5.15.5.1-4, 5.15.10.1, 5.15.15.1-5, 5.15.20.1-2, 5.15.25.1-4, 5.20.5.1, 5.20.10.2, 5.35.5.2-4, 5.35.10.2-7, 5.35.25.1-4, 5.35.35.1-4, 5.35.35.7, 5.35.40.1, 5.50.5.2-3, 5.60.5.1, 10.5.5.1, 10.5.10.1-2, 10.5.15.1-3, 10.5.25.1-3, 10.5.30.1-3, 10.10.5.2-3, 10.10.10.1-2, 10.10.15.1-3, 10.15.5.1-4, 10.15.10.1, 10.15.15.1-5, 10.15.20.1-2, 10.15.25.1-4, 10.20.5.1, 10.20.10.2,	Crushing/pinching between the traversing coil & coil car (with or without a coil on it) and the stationary saddles, pit edges/walls/floor and the stationary coil on the saddle	High	High	Low
		In running nip of the coil rotating on the blocker rolls	High	High	Low
		Crushing, severing due to unexpected movement of the coil peeler	High	High	Low
		Struck or cut by a broken band or tail (when tail is freed when the coil rotates)	High	High	Low
		Pinching between the lowering coil and the #2 position saddle	High	High	Low
		Crushing under coil that may fall off of the moving coil car	High	High	Low
		Struck by the coil tail "clock-springing" once freed from underneath the coil.	High	High	Low
		Crushing under coil that may fall off of the blocker rolls due to a coil	High	High	Low

4	function.
	By pressing and releasing the blue illuminated reset button on the ops. station

ISO, IEC, ANSI, RIA, etc.
Functional Safety Life Cycle

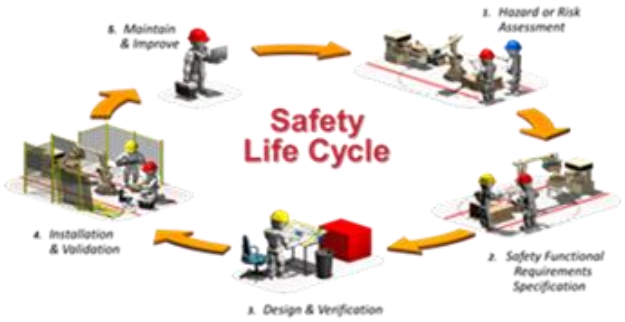


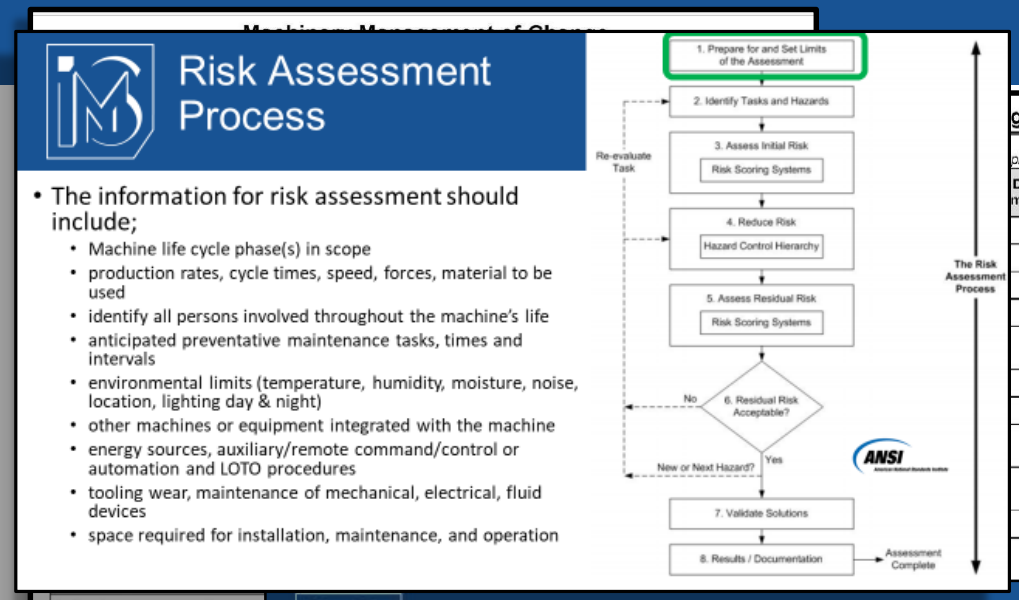


Management of Change

ANSI Z244.1-2016 Annex E

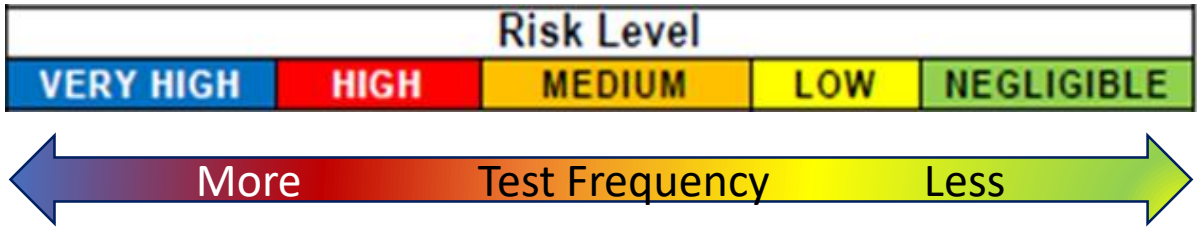
- Part of existing corp. policy
- Changes to the limits of the machine
- Changes to the process, materials
- Refinements of ops. from run-time
- Actual vs Engineered by assumption
- Manual or Automated tracking
  - Industry 4.0?





Safety Testing Procedures and Frequency

- ANSI B11.0 - 2020, 7.2.1 - *The user shall test the SRP/CS* ***periodically*** *to verify that it is functioning according to the manufacturer's specifications as determined by the risk assessment*
- Primary risk level reduction by an engineered control

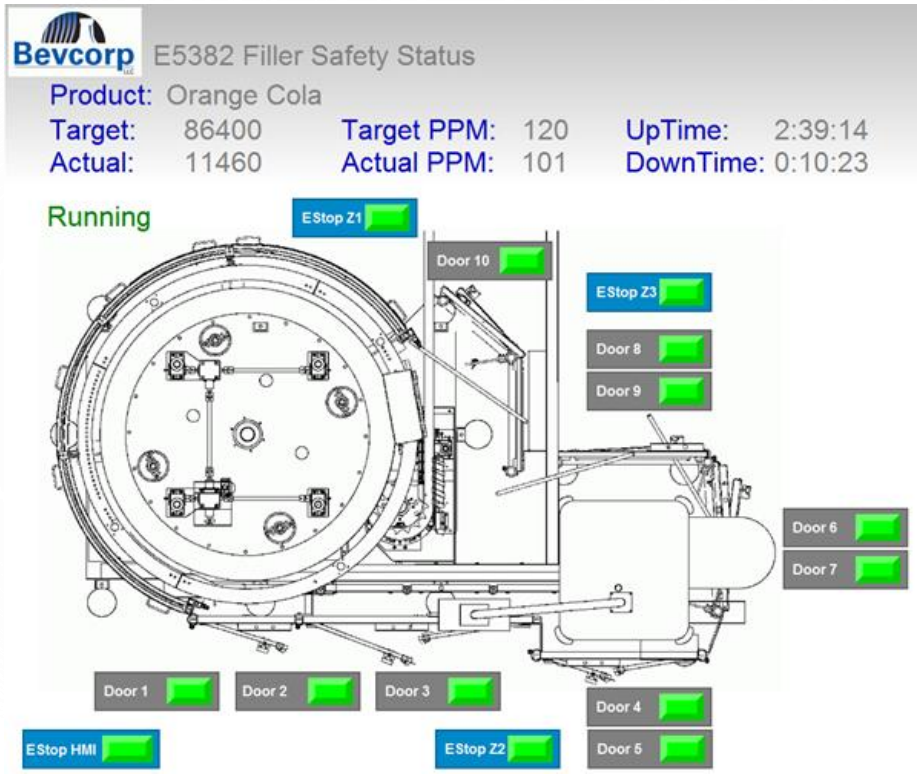


- Most important - SRP/CS that depends on "limit values"
  - Time, speed, acceleration, incremental motion, direction, distance, force, kinetic or thermal energy, contact pressure with an individual
    - Example – stop time calculation Ds = [K x (Ts + Tc + Tr)] + Dpf + Z

Safety in I4.0 Smarter, Safer Machines

Real-time Data

Running Time,
E-stops, Guard Status



Information → Knowledge → Wisdom/Action

CONTEXTUALIZATION
Quality, OEE, Safety

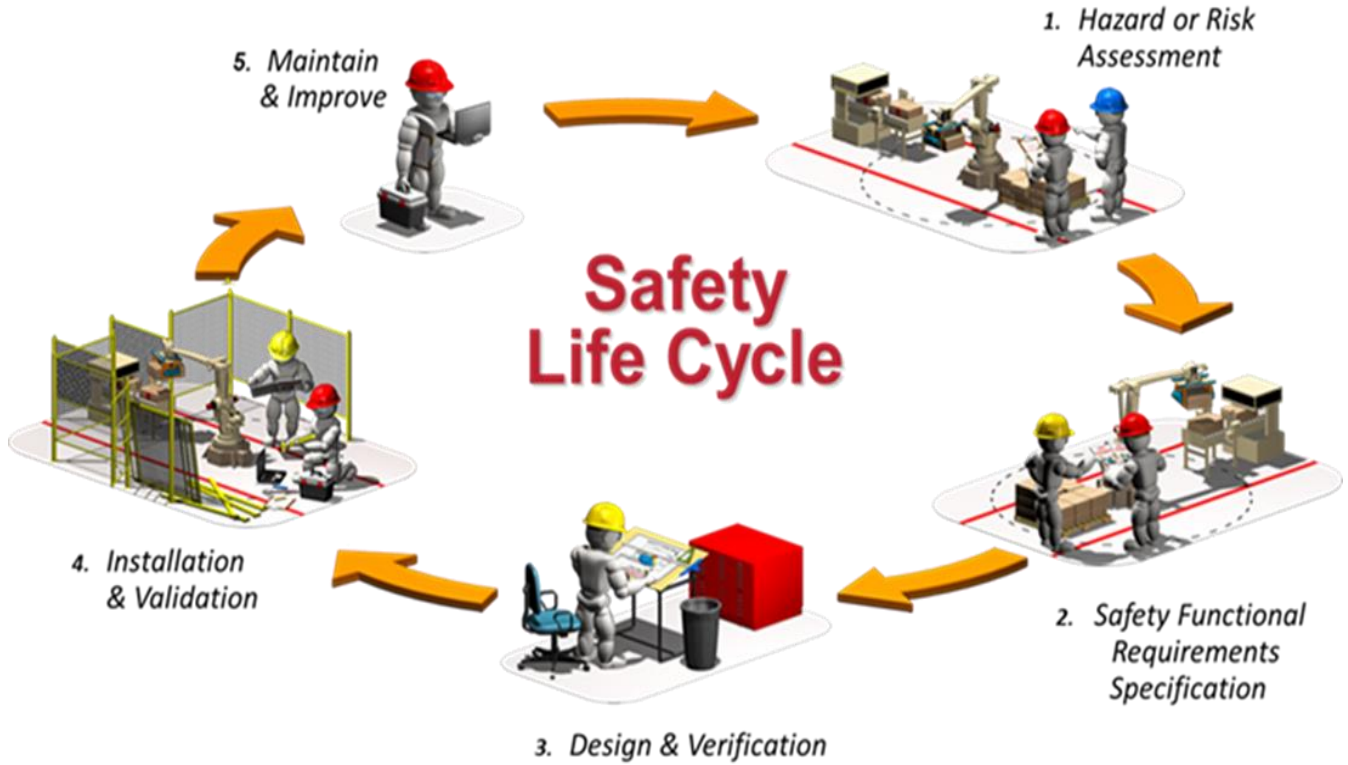
ANALYTICS
Safety System use/abuse

OPTIMIZE
More safe & efficient process workflows

IMS Machine Safety Workshop

For a Cross-Functional Audience

1. *Safety and Productivity*
   - *Societal & Industry Demands*
   - *Safety RIO*
   - *Aspects of Manufacturing Safety Maturity*
2. *Regulatory Compliance*
   - *Laws and Regulations*
   - *Machine Safety Standards*
   - *Risk Assessments*
3. *Contemporary Risk Reduction*
   - *Method Hierarchy*
   - *The Latest Technologies and Techniques*
   - *Compliance Machinery Safety*
4. *Risk Reduction with Engineered Controls*
   - *Minor Servicing Exception*
   - *Electric/Hydraulic/Pneumatic Safety Circuits*
   - *Design Verification*
5. *Installation and Validation*
   - *Post Commissioning Management of Change*
   - *Safety Management Systems*
   - *Integrated Safety Solutions with Industry 4.0 (Digital Transformation)*



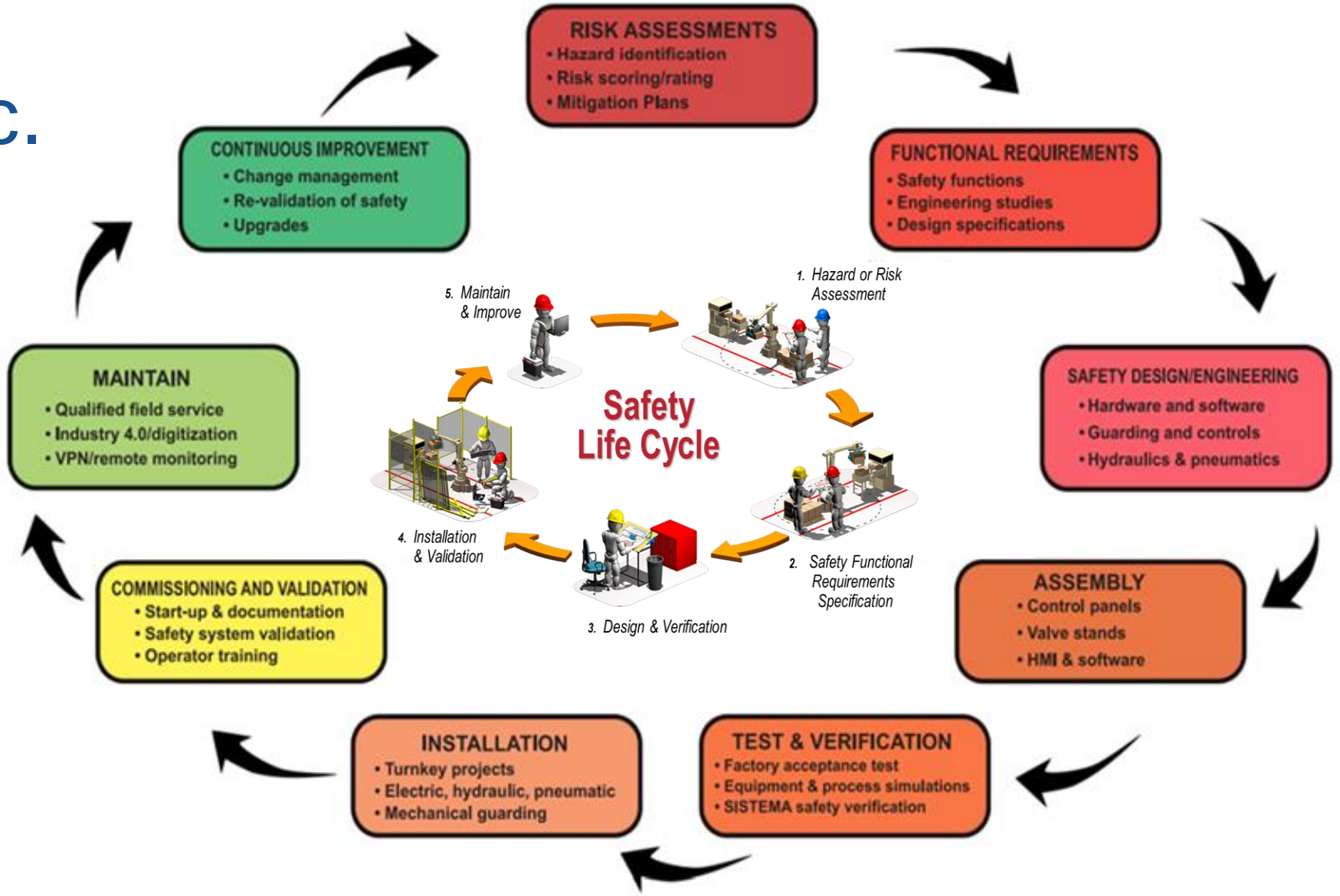
Machine/Equipment Risk Audit

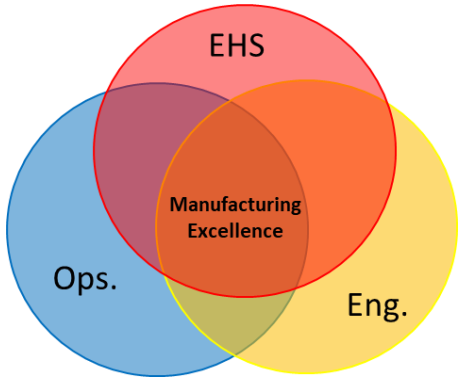
- Prioritize the plant/enterprise-wide effort
- Simple risk rating

Probability of Occurrence of Harm	*Severity of harm* Catastrophic	Serious	Moderate	Minor
Very Likely	High	High	High	Medium
Likely	High	High	Medium	Low
Unlikely	Medium	Medium	Low	Negligible
Remote	Low	Low	Negligible	Negligible

Manufacturing Plant Niles, IL			B11 TR3 Risk Rating			Priority		
Plant/Dept.	Asset #	Asset/Machine Name	Probability	Severity	Rating	Low	Med.	High
Chemical processing	9121	Aquamaster Tray Washer CB1200D / No. 711-0714	1	3	3	x		
Chemical processing	9124	Deoxidizer	1	1	1	x		
Chemical processing	9128	Aqueous Ultrasonic Cleaner	2	2	4	x		
Production	1405	Myford MG12-CNC O.D. Grinder	3	4	12			x
Production	1905	Overbeck lathe & Dayton polisher	3	4	12			x
Production	1904	Star JNC-16 Swiss Screw Machine w/Spego Turnamic Bar Feeder	3	4	12			x
Production	1914	Affolter Gear Hobbing	2	3	6		x	
Production	2719	HARDINGE LATHE	3	4	12			x
Production	2720	OTEC parts tumbler	2	4	8		x	
Production	2721	Baldor grinder	3	4	12			x
Production	2708	HARDINGE SPEED LATHE	3	4	12			x
Production	2204	LNS America lathe	3	4	12			x
Production	9079	Tsugami BH20 / No. 622	1	4	4	x		
Production	2728	Tornos Deco20a CNC Swiss Screw Machine w/LNS Hydrobar Bar Feeder	1	4	4	x		
Production	9156	Tsugami BO205-II / No. 3535	1	4	4	x		

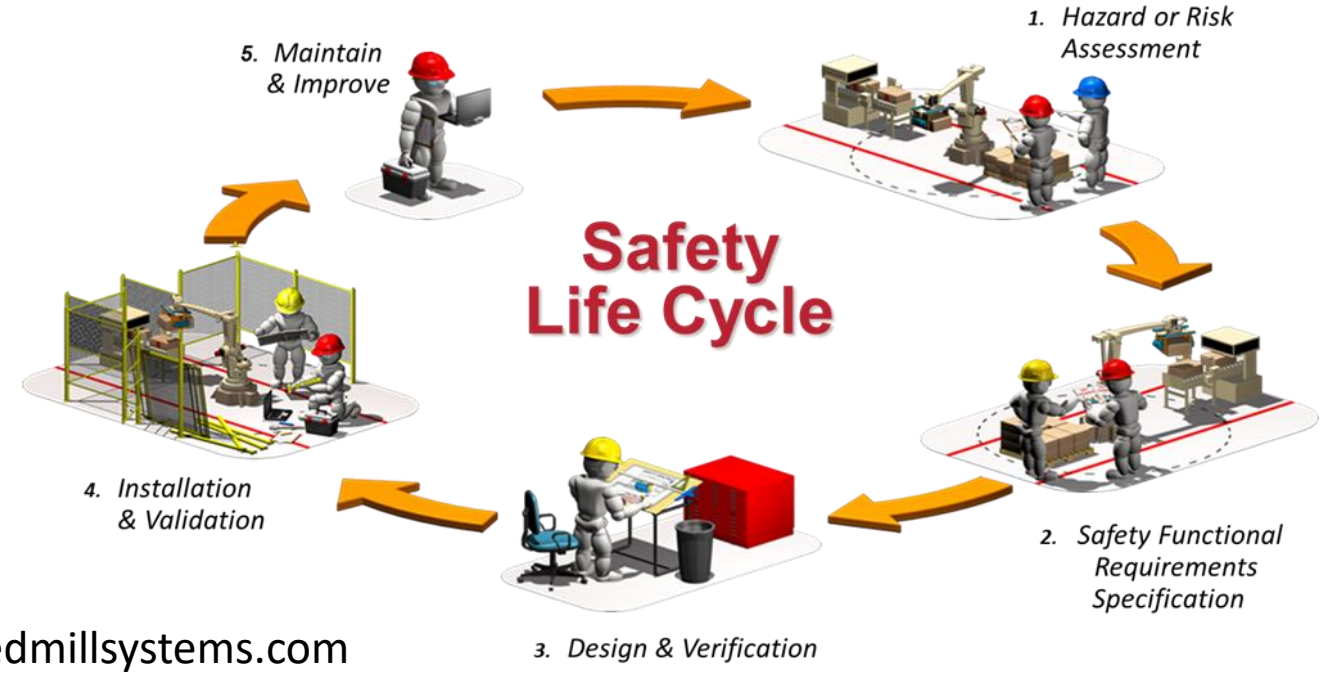
ISO, IEC, ANSI, RIA, etc. *Functional Safety Life Cycle*





Integrated Mill Systems
Machine Safety Process

Standards-Based Risk Assessment & Mitigation Process



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