Portage County Safety Council

Safety Considerations for Robots in Manufacturing

May 13, 2021

Integrated Mill Systems

I'm not a robot

reCAPTCHA
Privacy - Terms

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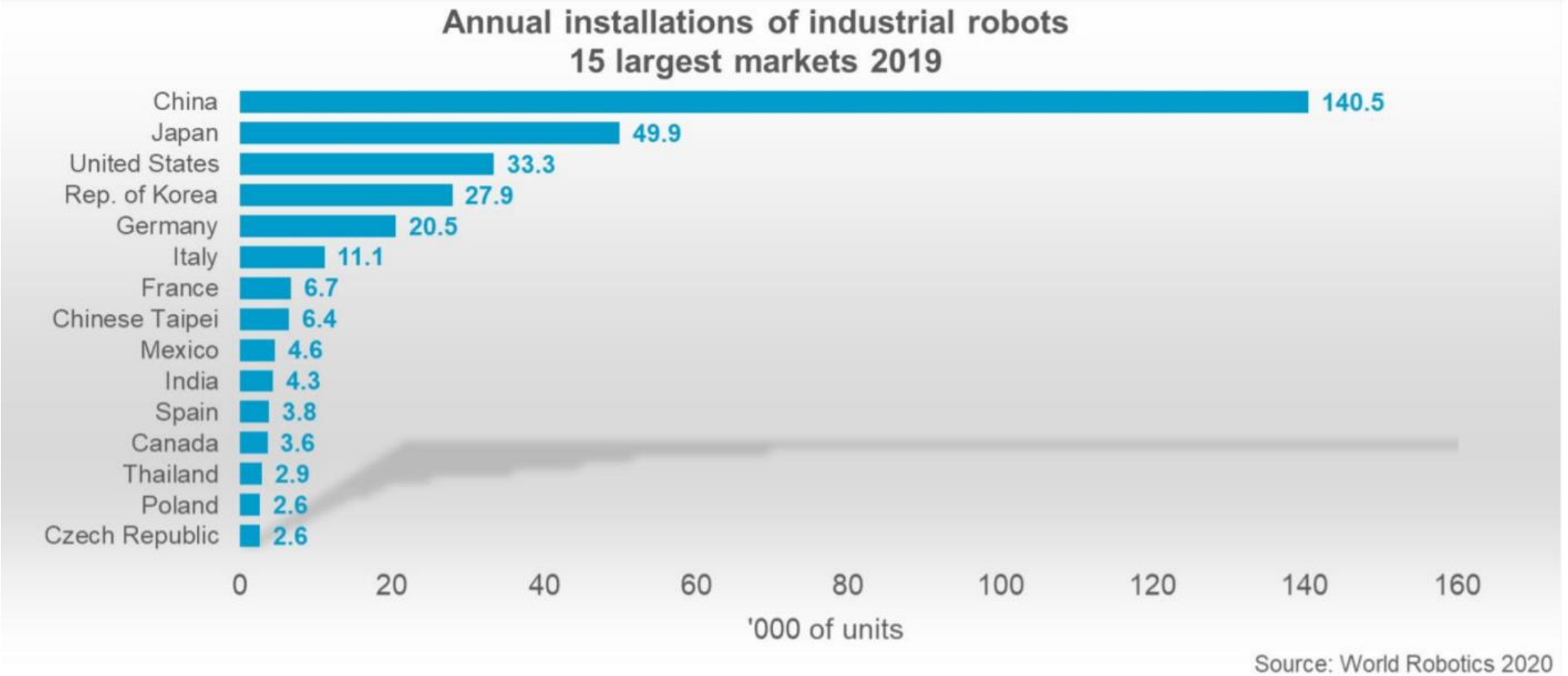
Industrial robot industry trends in manufacturing

- 88% of businesses worldwide plan to adopt robotic automation into their infrastructure “in the near term” *(Source: McKinsey)*
  - *Smarter - adaptive control & AI*
  - *Can “see” – advanced/3D/integrated vision systems*
  - *Easier to integrate, teach and use*
  - *Connected to each other, existing machines and IT*
  - *More cost effective…Robots as a Service (RaaS leasing)*
  - *Expanding into new markets*
  - *Demand to improve supply chain resilience (trade wars, Brexit, COVID-19, manufacture at home)*
  - *Energy efficiency*
  - *Transformation of the work environment, workers and definition of work*

Industrial Robot Use

- In 2019, ~75-80% of all industrial robotics installation took place in five countries.



Traditional Industrial Robot Types

Gantry Robot

Cartesian Robot

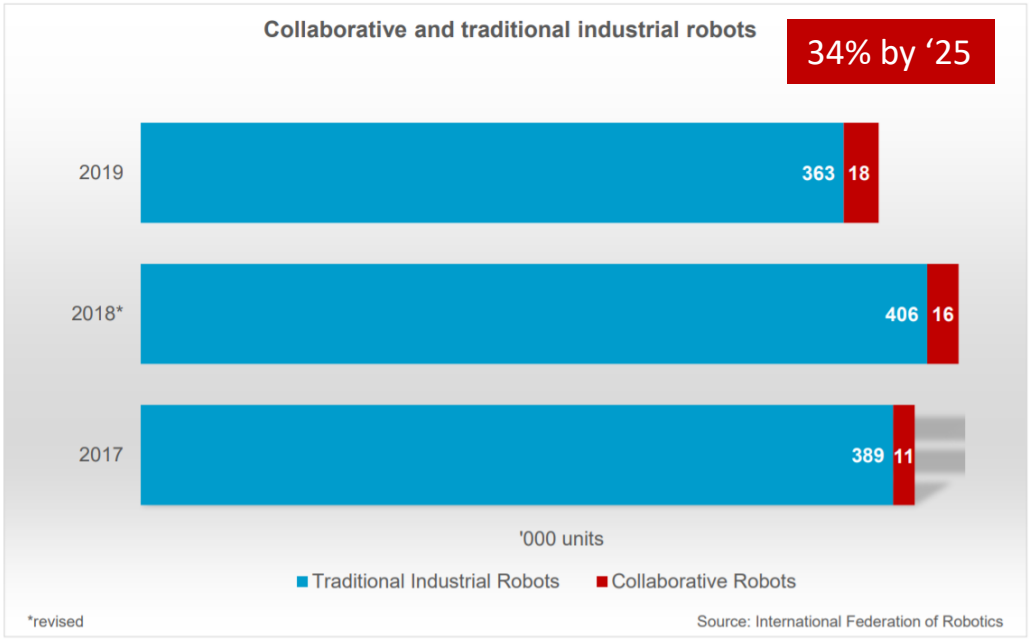
Cylindrical Robot

Delta Robot

SCARA Robot

6-Axis Robot

Cobots – still a niche, but growing

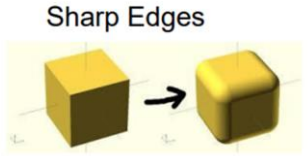


- **Hand-guiding operation**: Operator has direct contact & control of robot system
- **Speed & Separation Monitoring**: Robot system / hazard speed reduces as an operator gets closer. Protective stop is issued before contact.
- **Power & Force Limiting**: Incidental contact between robot and person will not result in harm to person.

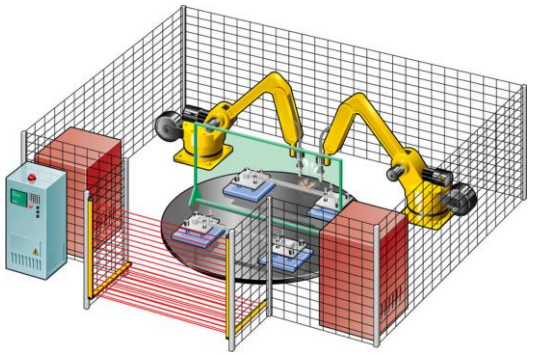
- Reference ISO TS 15066. Requires a risk assessment per each body region.

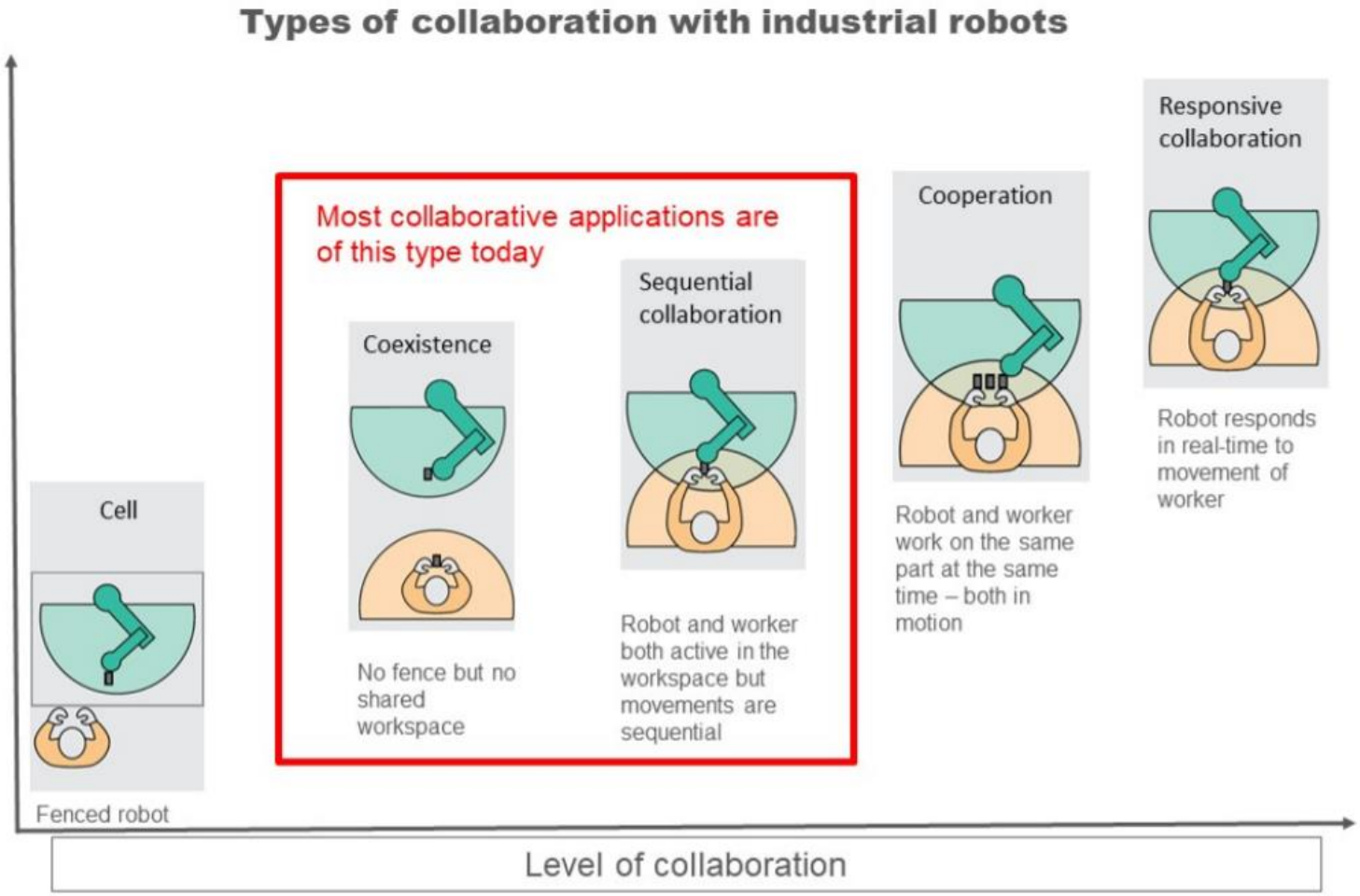
- Applications where WORST CASE is ONLY SLIGHT INJURY!

- Sharpness of end devices/piece



Human/Robot Collaboration



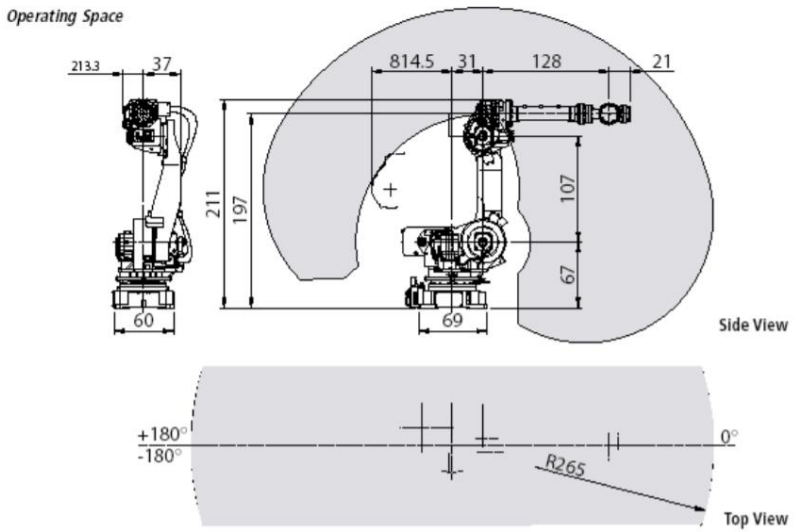


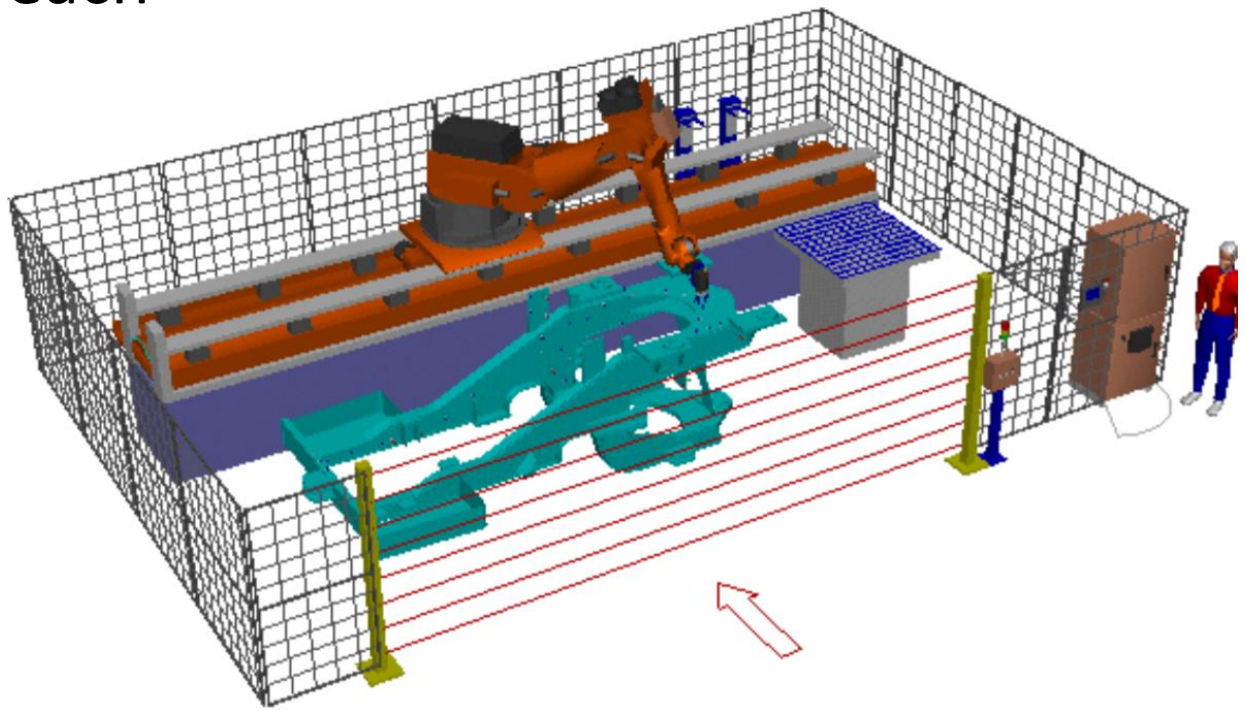
Green area: robot's workspace; yellow area: worker's workspace
Source: IFR, based on: Bauer et al. (2016).

Design the workspace

How will people be interacting with the robot/machine?

- Normal and foreseeably abnormal
- Include tooling & parts in robot reach





OSHA/US/State Law on Robots…?

Standards

There are currently no specific OSHA standards for the robotics industry. This section highlights OSHA standards and documents related to robotics.

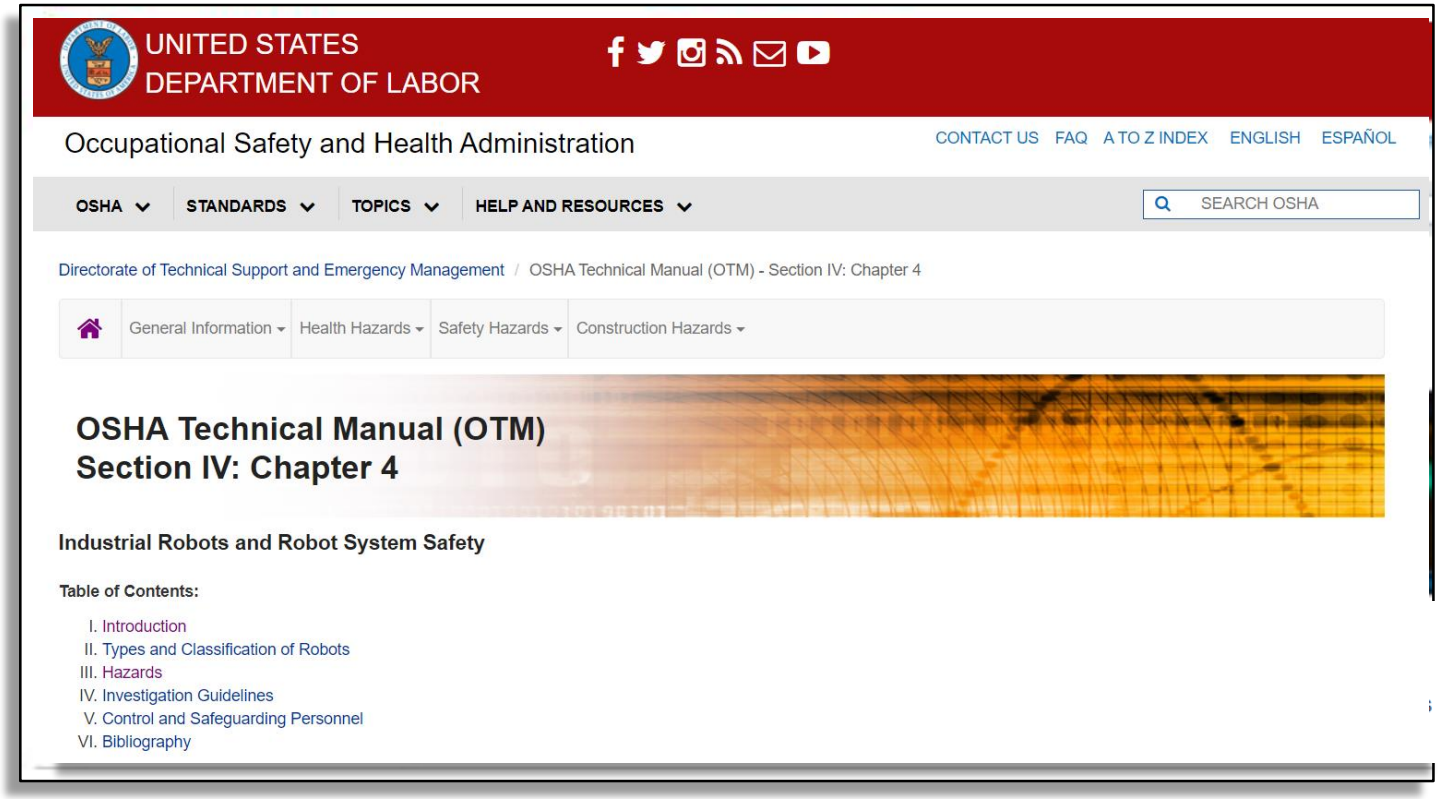
OSHA/US/State Law on Robots…?
No laws, but some guidance

CDC Centers for Disease Control and Prevention
CDC 24/7: Saving Lives, Protecting People™

Dept. Health & Human Services

Promoting productive workplaces through safety and health research NIOSH

- National Institute for Occupational Safety and Health (NIOSH) created the Center for Occupational Robotics Research (CORR) in September 2017.
  - https://www.cdc.gov/niosh/topics/robotics/default.html



OSHA Technical Manual
Industrial Robots and Robot System Safety

- https://www.osha.gov/otm/section-4-safety-hazards/chapter-4

United States Legislative Standard
Accountability for safety in the USA

UNITED STATES DEPARTMENT OF LABOR

OSH Act of 1970 SEC.5. Duties:

(a) Each employer --

(1) shall furnish to each of his employees employment and a place of employment which are free from **recognized hazards** that are causing or are likely to cause death or serious physical harm to his employees;

(2) shall comply with occupational safety and health standards promulgated under this Act.

(b) Each employee shall comply with occupational safety and health standards and all rules, regulations, and orders issued pursuant to this Act which are applicable to his own actions and conduct.

OSHA®
Occupational Safety and Health Administration
www.osha.gov

US Law = Requirements

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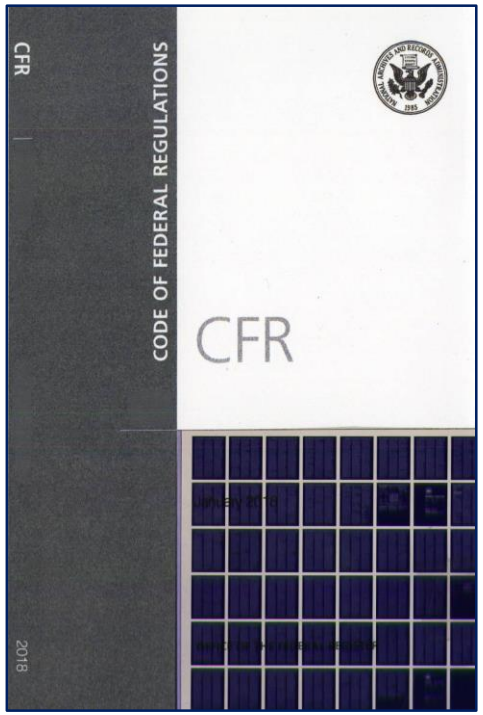
- OSHA defines the requirements in CFR29 part 1910 ("OSHA Standards")
  - https://www.osha.gov/laws-regs/regulations/standardnumber/1910/
  - **Subpart O** – *Machinery and Machine Guarding*
    - 1920.212 – General requirements for all machinery
    - 1910.219 – Mechanical power-transmission apparatus
  - **Subpart J** – *General Environmental Controls*
    - 1910.147 – Control of hazardous energy (lock-out/tag-out)



Keeping People Safe Around Machinery

OSHA Occupational Safety and Health Administration www.osha.gov

Rule #1:
If access to the machine is needed, turn it off

LOTO / Isolate Hazardous Energy

Rule #2:
If the machine is running, keep people away

Machine Guarding

US Law = Requirements

Machine Maintenance

- Regulation: Lockout / Tagout or Energy Isolation
- Requirement: Release stored energy
- Tasks: Isolation of Mechanical / Electrical Equipment for Service and Maintenance

Production Operation

- Regulation: Machine Guarding
- Requirement: Protect operators from machine production hazards
- Tasks: Operator Interaction for Regular Machine Production

US Law = Requirements

OSHA® Occupational Safety and Health Administration www.osha.gov

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Minor Service
Exception to Lockout Tagout

Must provide alternative
Measures that offer effective protection

Minor Servicing Exception

- Regulation: Machine Guarding or alternative protection means minor jams, minor tool changes & adjustments, exchange Requirement: Protect operators from machine production hazards when performing minor servicing
- Tasks: Minor servicing such as clearing jams, loading parts, etc.

Minor servicing must be routine, repetitive and integral to the operation of the system.

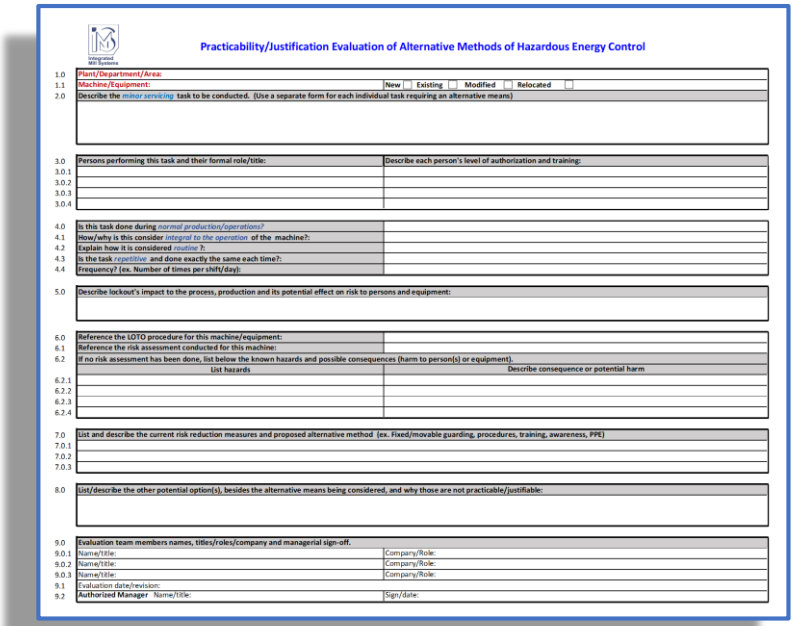
Minor Servicing Exception

1910.147 (a)(2)(ii)(B)

Note: ***Exception to paragraph (a)(2)(ii):*** Minor tool changes and adjustments, and other minor servicing activities, which take place during normal production operations, are not covered by this standard if they are routine, repetitive, and integral to the use of the equipment for production, provided that the work is performed using alternative measures which provide effective protection (See Subpart O of this Part).

1. Performed during normal operations
2. Is routine, repetitive and integral to the use of the equipment for production
3. Just as effective – does not increase risk

ANSI/ASSE Z244.1 *Control of Hazardous Energy - Lockout/Tagout and Alternative Methods*



Practicability/Justification Evaluation of Alternative Methods of Hazardous Energy Control

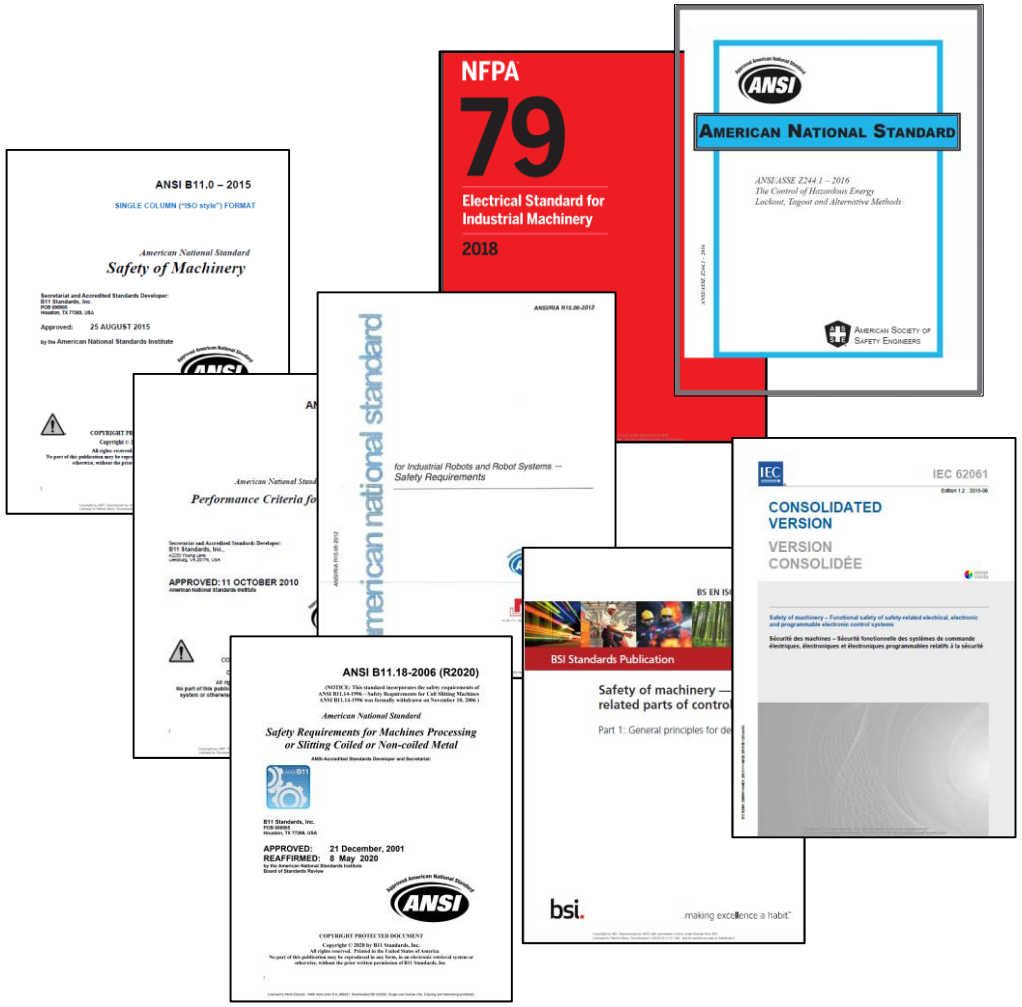
1.0	Plant/Department/Area:	
1.1	Machine/Equipment:	New ☐ Existing ☐ Modified ☐ Relocated ☐
2.0	Describe the *minor servicing* task to be conducted. (Use a separate form for each individual task requiring an alternative means)	
3.0	Persons performing this task and their formal role/title:	Describe each person's level of authorization and training:
3.0.1		
3.0.2		
3.0.3		
3.0.4		
4.0	Is this task done during *normal production/operations?*	
4.1	How/why is this consider *integral to the operation* of the machine?:	
4.2	Explain how it is considered *routine* ?:	
4.3	Is the task *repetitive* and done exactly the same each time?:	
4.4	Frequency? (ex. Number of times per shift/day):	
5.0	Describe lockout's impact to the process, production and its potential effect on risk to persons and equipment:	
6.0	Reference the LOTO procedure for this machine/equipment:	
6.1	Reference the risk assessment conducted for this machine:	
6.2	If no risk assessment has been done, list below the known hazards and possible consequences (harm to person(s) or equipment).	
	List hazards	Describe consequence or potential harm
6.2.1		
6.2.2		
6.2.3		
6.2.4		
7.0	List and describe the current risk reduction measures and proposed alternative method (ex. Fixed/movable guarding, procedures, training, awareness, PPE)	
7.0.1		
7.0.2		
7.0.3		
8.0	List/describe the other potential option(s), besides the alternative means being considered, and why those are not practicable/justifiable:	
9.0	Evaluation team members names, titles/roles/company and managerial sign-off.	
9.0.1	Name/title:	Company/Role:
9.0.2	Name/title:	Company/Role:
9.0.3	Name/title:	Company/Role:
9.1	Evaluation date/revision:	
9.2	Authorized Manager Name/title:	Sign/date:

Q: How is regulatory compliance attained and demonstrated?
A: Documented compliance to voluntary standards

- **Assessment** – Identify and remediate hazards properly
  - ANSI B11.0, RIA TR15.306-2016 *Safety Requirements – Task-based Risk Assessment Methodology*
- **Product** – Designed correctly
  - ANSI/RIA R15.06-2012 *American National Standard for Industrial Robots and Robot Systems —Safety Requirements* (part 1)
- **Application** – Devices and technology is applied, installed and used properly
  - ANSI B11.19-2019 *Performance Requirements for Risk Reduction Measures,* ANSI/RIA R15.06-2012 American National Standard for Industrial Robots and Robot Systems — Safety Requirements (part 2)
- **Performance** – Safety systems designed to work even in the event of a failure
  - ISO 13849-1 2015 *Safety of machinery — Safety-related parts of control systems Part 1: General principles for design*
- **Validation** – Safety system properly reduced risk
  - ISO 13849-2 2012 *Safety of machinery — Safety-related parts of control systems Part 2: Validation*

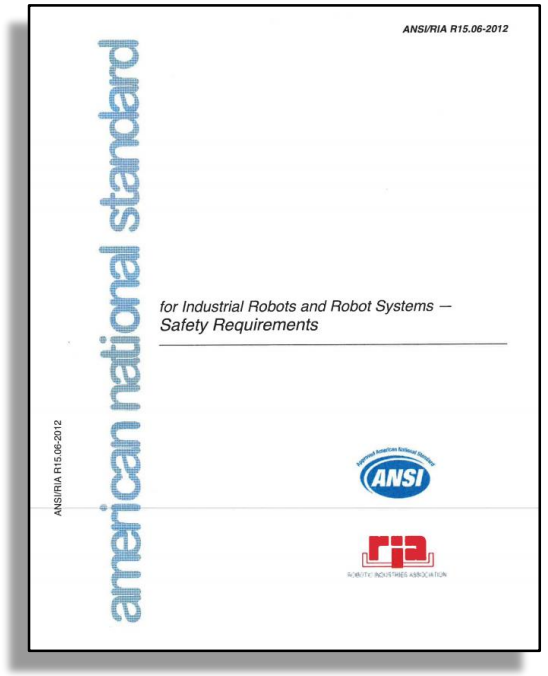
Recommended Standards for Machine Safety Design and Integrations

- **ANSI B11.0-2020** Safety of Machinery
- **ANSI B11.19-2019** Performance Requirements for Risk Reduction Measures
- **ANSI B11.26-2018** (Machines - Functional Safety For Equipment: General Principles For The Design Of Safety Control Systems Using ISO 13849-1)
- **ANSI B11.20-2017** Safety Requirements for Integrated Manufacturing Systems
- **NFPA79-2018** Electrical Standards for Industrial Machines
- **NFPA70e-2021** Standard for Electrical Safety in the Workplace
- **ANSI/ASSE Z244.1 – 2016** The Control of Hazardous Energy Lockout, Tagout and Alternative Methods
- **ISO 13849-1-2015** Safety of machinery — Safety-related parts of control systems Part 1: General principles for design
- **ISO 13849-2-2012** Safety of machinery — Safety-related parts of control systems Part 2: Validation
- **IEC 62061-2021** Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
- **ANSI/RIA15.06-2012** – Safety Requirements for Industrial Robots and Robot Systems
- **RIA TR R15.306-2016** – Safety Requirements – Task-based Risk Assessment Methodology
- **ISO 14120-2015** General Requirements for the design and Construction of Fix and Moveable Guards



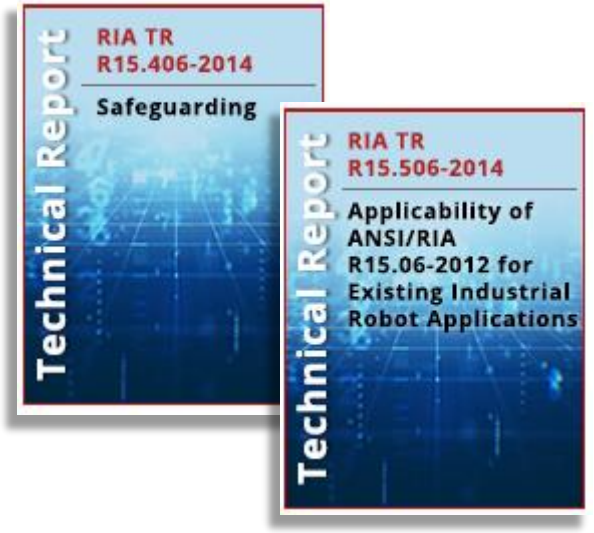
Robot Safety Standards

- **ANSI/RIA15.06-2012 -** *American National Standard for Industrial Robots and Robot Systems —Safety Requirements*
  - The national adoption of ISO 10218-1 and ISO 10218-2 in one RIA publication
- ISO 10218-1,2 revision expected 2021
  - Part 1 - *Guidance for the assurance of safety in the design and construction of the robot (product)*
  - *Part 2 - Guidelines for the safeguarding of personnel during robot integration, installation, functional testing, programming, operation, maintenance and repair (integrators & owners)*
- ANSI/RIA15.06-2012 – revision expected in 202?
- RIA TR R15.306-2016 – revision expected in 2023
  - *Safety Requirements – Task-based Risk Assessment Methodology*



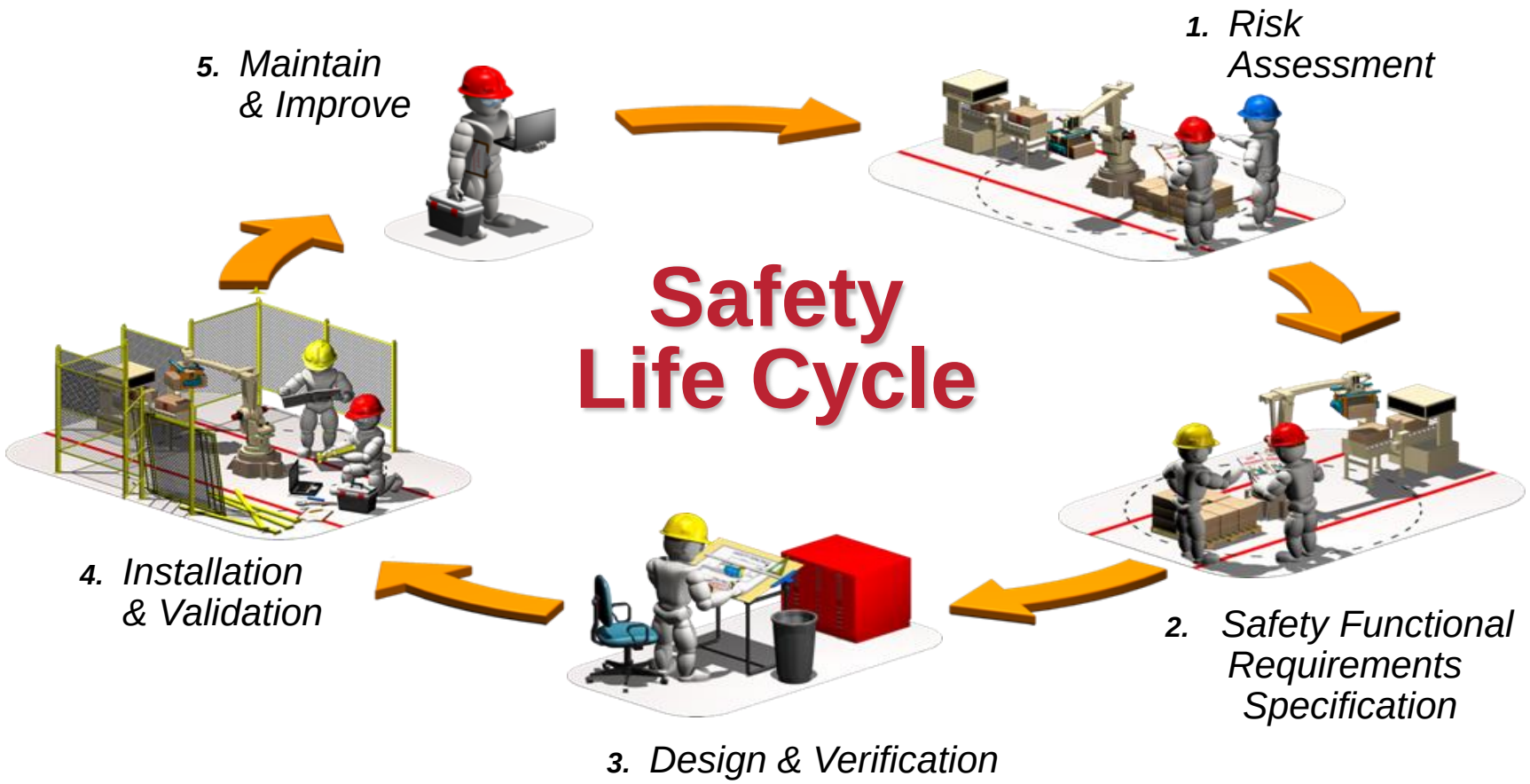
Robot Safety Standards

- TR R15.406-2014 - Safeguarding, pulls many requirements from various ISO safety standards.
  - ISO13849-1,2 - SRP/CS
  - ISO14120 - Guarding
  - ISO14119 - Interlocking Guards
  - ISO13850 - Emergency Stops
  - ISO13855 - Safe Distance PSD
  - ISO13857 - Safe Distance Guarding



- TR R15.506-2014 Applicability of R15.06-2012 for existing robots, robot systems and applications.
  - An assumption…a big one…*the application was compliant at the time of it's original commissioning*

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



Risk Assessment Process *ANSI B11.0 2020*

1) Prepare for and set limits of the assessment

2) Identify tasks and hazards

3) Assess initial risk

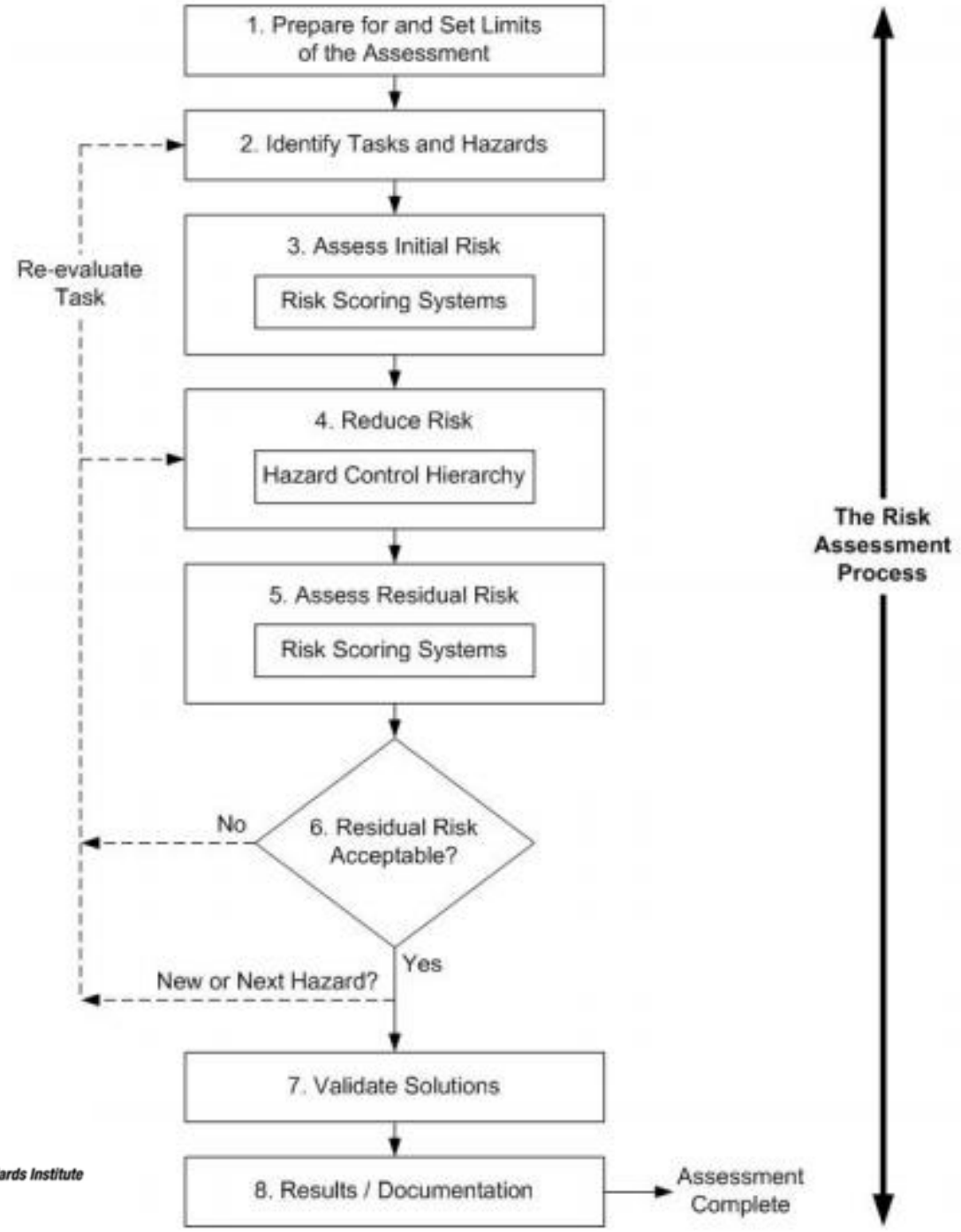
4) Reduce risk

5) Assess residual risk

6) Achieve acceptable risk

7) Validate solutions

8) Document the process



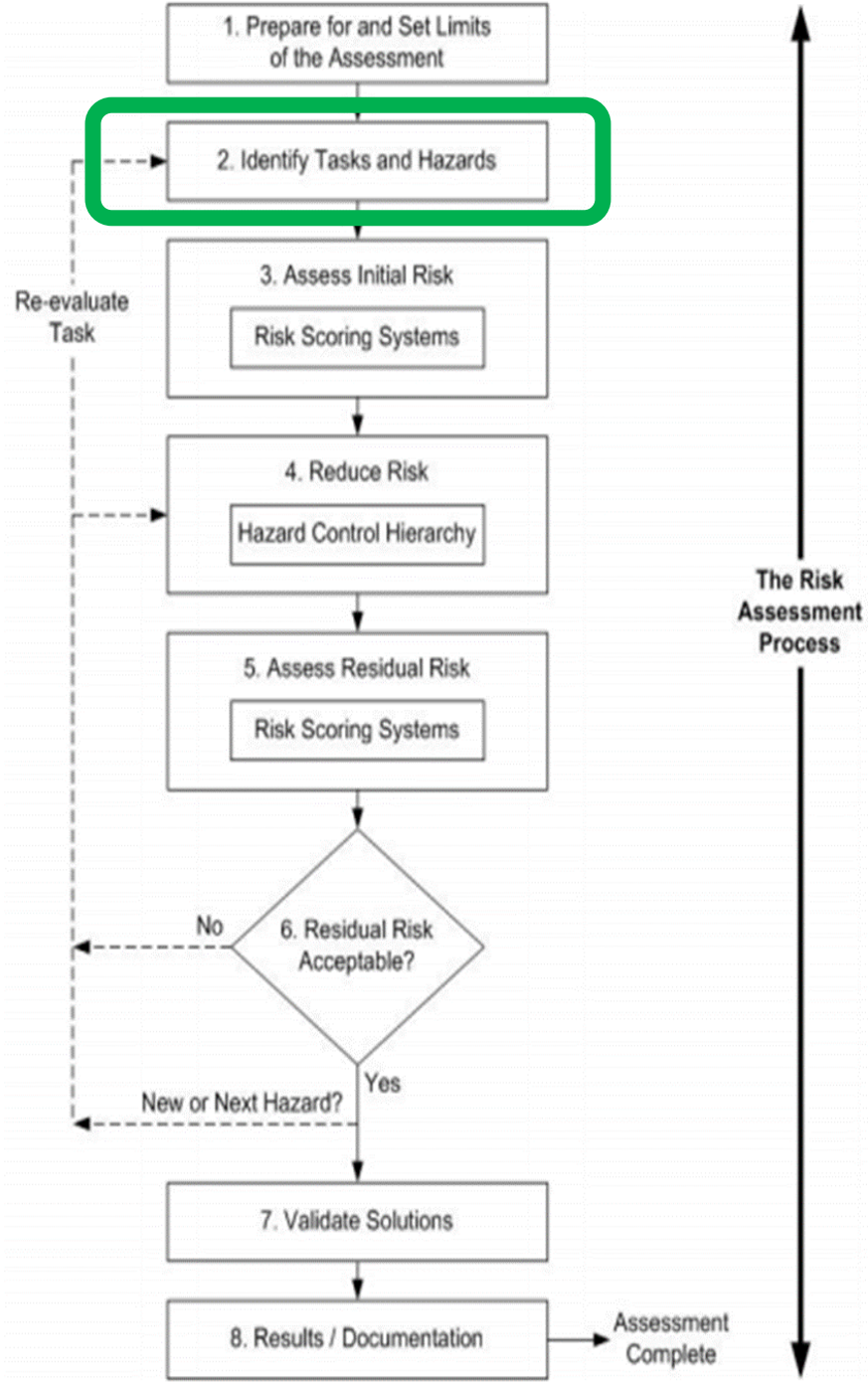
ANSI
American National Standards Institute

Team-Based Risk Assessment

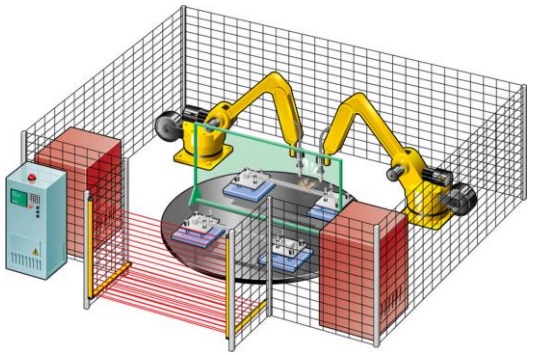
All affected people for all task, then associate hazards per task

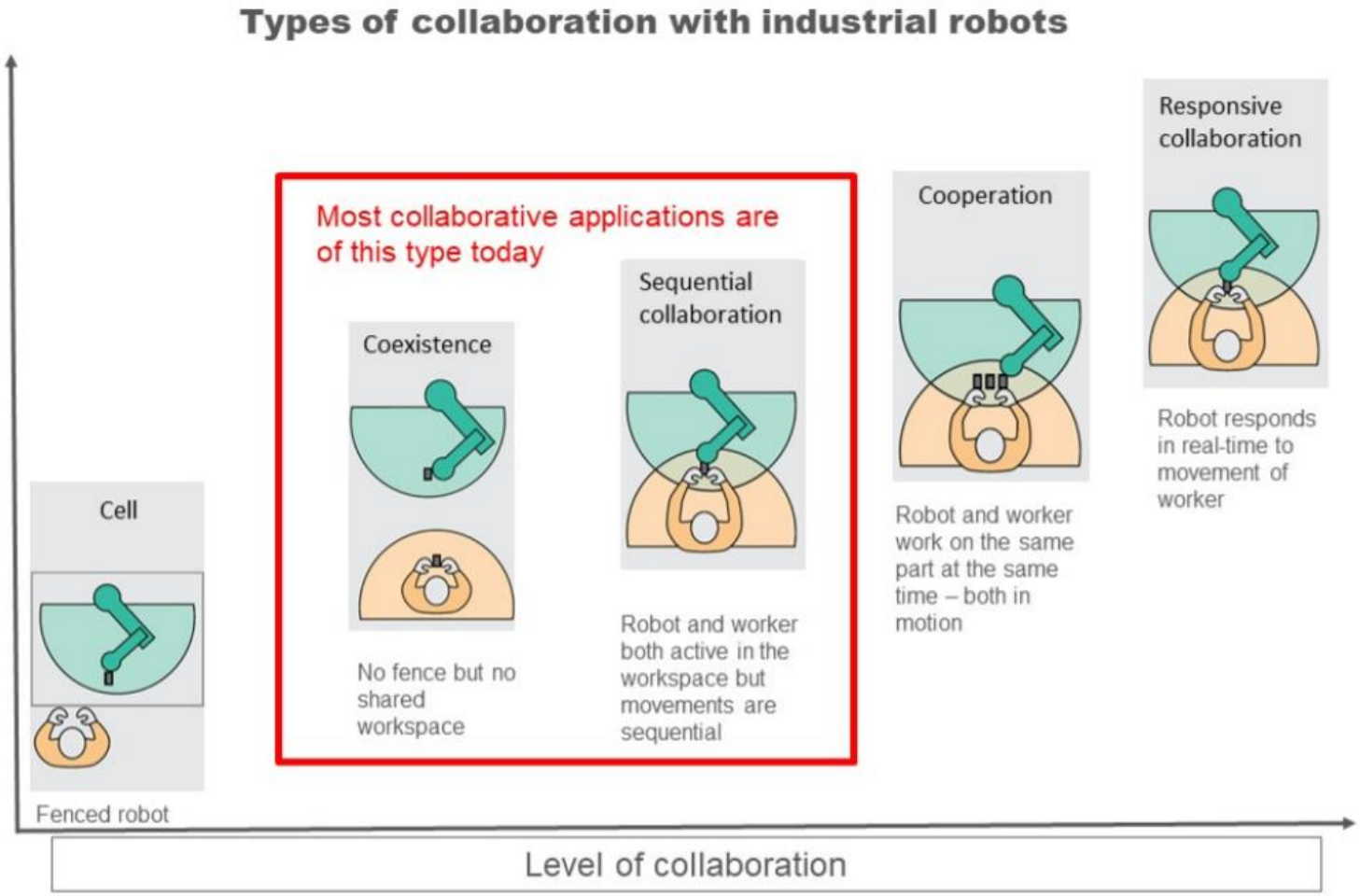
- operators
- maintenance
- engineers
- electricians
- mechanics
- technicians
- EHS

- sales personnel
- installers
- uninstallers
- administrative
- managers
- supervisors
- temporary employees
- passers-by
- fork trucks/drivers
- material handling
- HR
- consultants



Human/Robot Collaboration



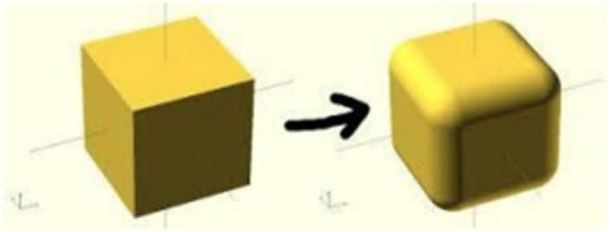


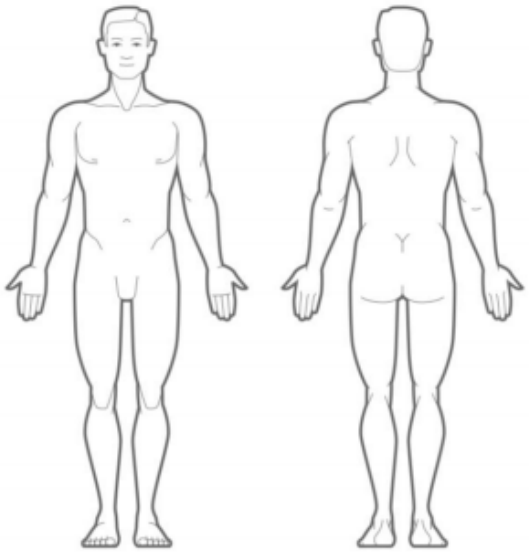
Green area: robot's workspace; yellow area: worker's workspace
Source: IFR, based on: Bauer et al. (2016).

Robot Safety Standards

- A Guide to Testing Pressure and Force in Collaborative Robot Applications - RIA TR R15.806 – 2018

Sharp Edges





Although we are not Doctors, we need to be aware of the potential contact area(s), forces.

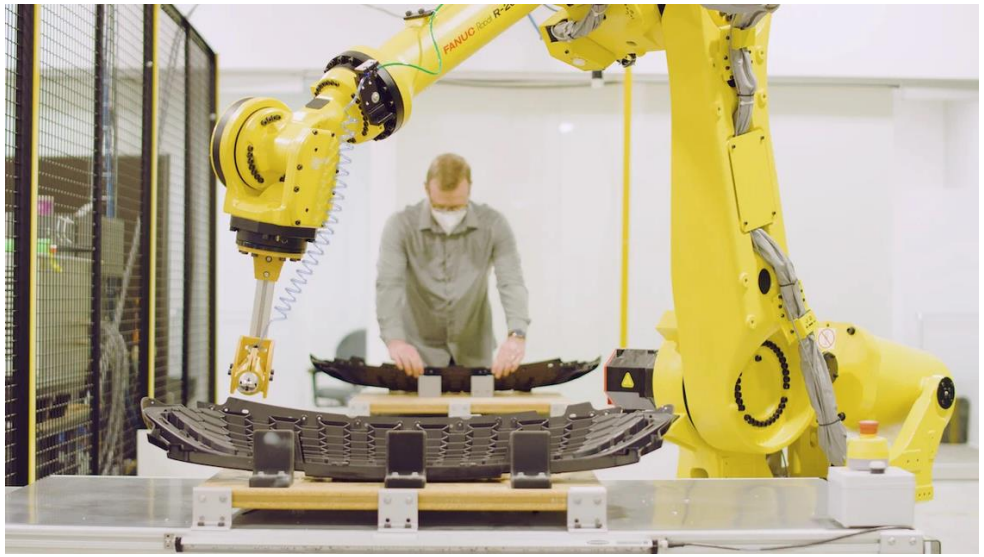
Body Region	Specific Body Area	Quasi-Static Contact		Transient Contact	
		Maximum Allowable Pressure [N/cm²]	Maximum Allowable Force [N]	Maximum Allowable Pressure Multiplier	Maximum Allowable Force Multiplier
Skull and forehead	Middle of forehead	130	130	N/A	N/A
	Temple	110		N/A	
Face	Masticatory muscle	110	65	N/A	N/A
Neck	Neck muscle	140	150	2	2
	Seventh neck muscle	210		2	
Back and shoulders	Shoulder joint	160	210	2	2
	Fifth lumbar vertebra	210		2	2
Chest	Sternum	120	140	2	2
	Pectoral muscle	170		2	
Abdomen	Abdominal muscle	140	110	2	2
Pelvis	Pelvic bone	210	180	2	2
Upper arms and elbow joints	Deltoid muscle	190	150	2	2
	Humerus	220		2	
Lower arms and wrist joints	Radial bone	190	160	2	2
	Forearm muscle	180		2	
	Arm nerve	180		2	
Hands and fingers	Forefinger pad D	300	140	2	2
	Forefinger pad ND	270		2	
	Forefinger end joint D	280		2	
	Forefinger end joint ND	220		2	
	Thenar eminence	200		2	
	Palm D	260		2	
	Palm ND	260		2	
	Back of the hand D	200		2	
	Back of the hand ND	190		2	
Thighs and knees	Thigh muscle	250	220	2	2
	Kneecap	220		2	
Lower legs	Middle of shin	220	130	2	2
	Calf muscle	210		2	

Transient vs. Quasi Static Contact

- The kind of contact between the operator and the robot need to be understood and managed.
- These include quasi static (pinching) and transient “moving contact before retract”

Human/Robot Collaboration Hazard Identification

- crushing
- shearing
- cutting or severing
- entanglement
- drawing–in or trapping
- impact
- stabbing or puncture
- friction, abrasion
- high pressure fluid/gas injection or ejection



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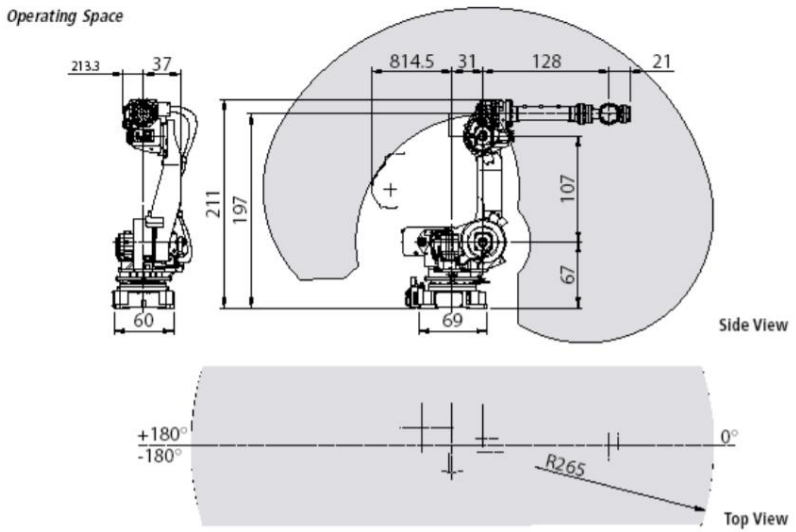
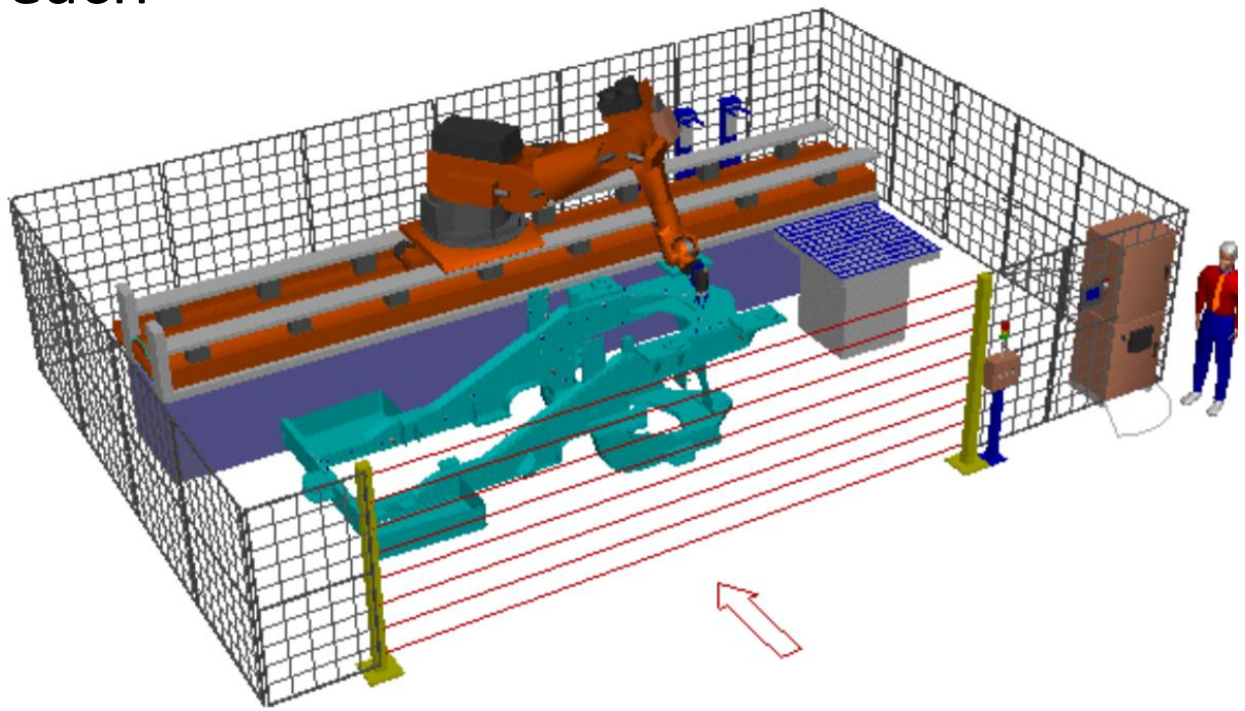
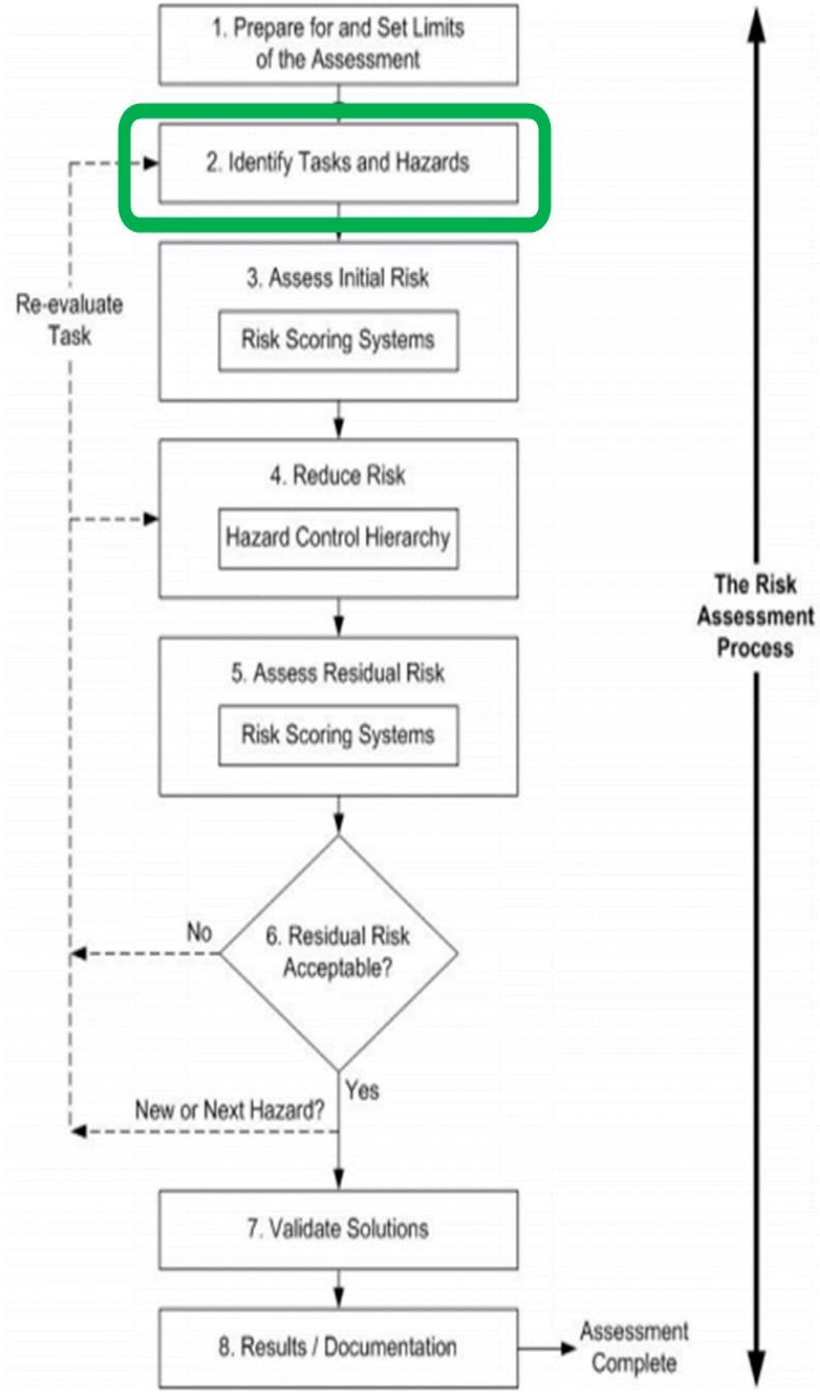




Identify Hazards *ex. ANSI B11.0, RIA TR R15.306*

- Mechanical ✓
- Electrical
- Thermal
- Noise
- Vibration
- Radiation
- Inhalation
- Fire
- Biological
- Viral or bacterial
- Ergonomic
- Lack/neglected PPE
- Unexpected starts
- Over/under speed
- Inadequate lighting

- 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



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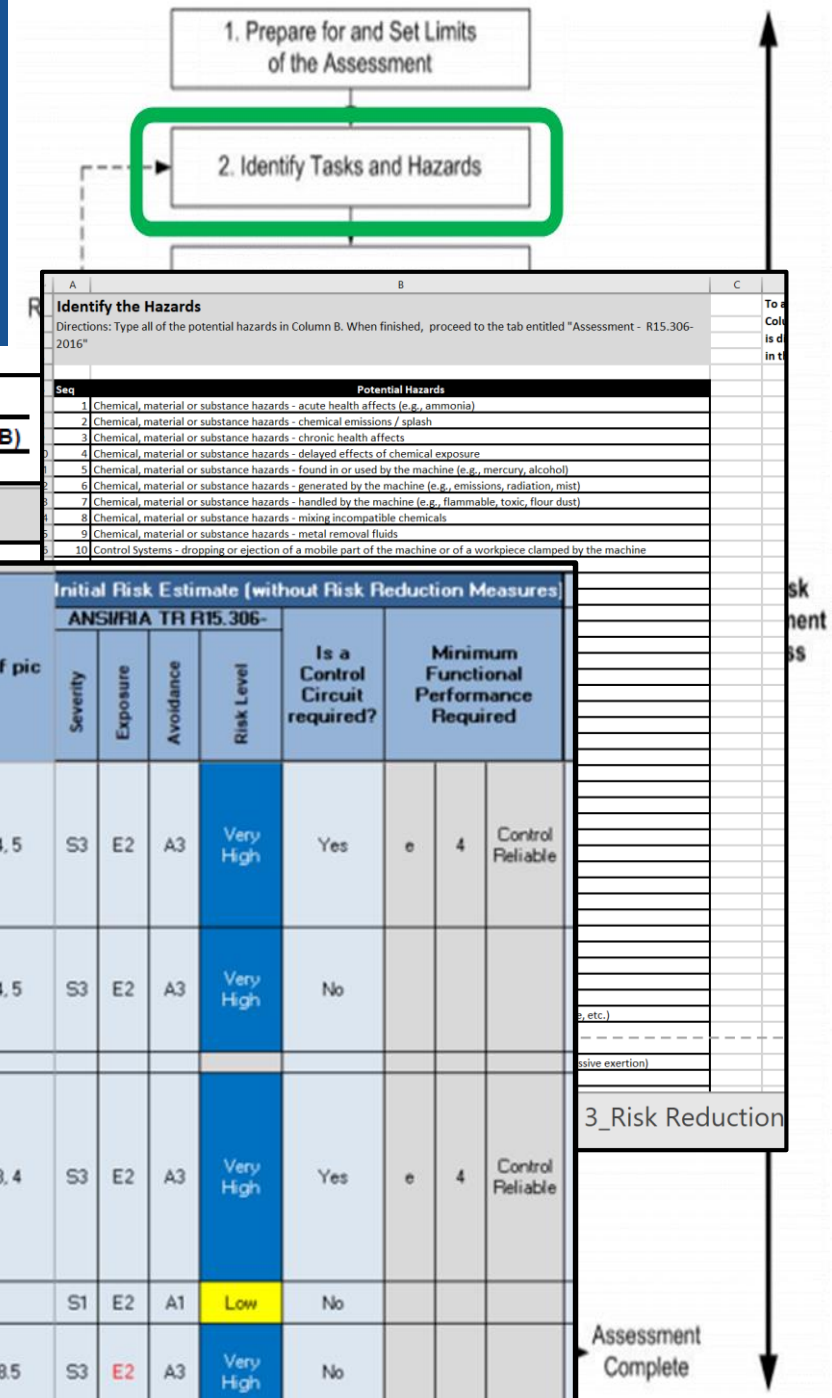

AMERICAN NATIONAL STANDARD B11.0 – 2015 (Annex – B)

Identify the Hazards

Directions: Type all of the potential hazards in Column B. When finished, proceed to the tab entitled "Assessment - R15.306-2016"

Seq	Potential Hazards
1	Chemical, material or substance hazards - acute health affects (e.g., ammonia)
2	Chemical, material or substance hazards - chemical emissions / splash
3	Chemical, material or substance hazards - chronic health affects
4	Chemical, material or substance hazards - delayed effects of chemical exposure
5	Chemical, material or substance hazards - found in or used by the machine (e.g., mercury, alcohol)
6	Chemical, material or substance hazards - generated by the machine (e.g., emissions, radiation, mist)
7	Chemical, material or substance hazards - handled by the machine (e.g., flammable, toxic, flour dust)
8	Chemical, material or substance hazards - mixing incompatible chemicals
9	Chemical, material or substance hazards - metal removal fluids
10	Control Systems - dropping or ejection of a mobile part of the machine or of a workpiece clamped by the machine

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		
FCZ/charging 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 limits/table frame	4, 5	S3	E2	A3	Very High	Yes	e	4	Control Reliable
FCZ/charging 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			
FCZ/charging table	10.20.60.10	Heater/Forklift Operator charges a plate	presses CHARGE on HMI ops station	mechanical - crushing between plate and roller due to unexpected automated motion when plate moves to be measured by lasers and/or moves into furnace	3, 4	S3	E2	A3	Very High	Yes	e	4	Control Reliable
FCZ/charging 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			
FCZ/charging 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			

Robot modes

- All affected persons' tasks
- Operations
- Maintenance
- Programming/teaching
  - People location
  - Training
  - Authorized access control
  - T1, T2

60-80% of incidence occur outside of normal operation

Mode	Graphical symbol
Automatic	
Manual reduced speed	
Manual high-speed	

Risk Estimation/Score in three states

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:

Cross-functional team

E0 is achieved (test results required). Third party validation

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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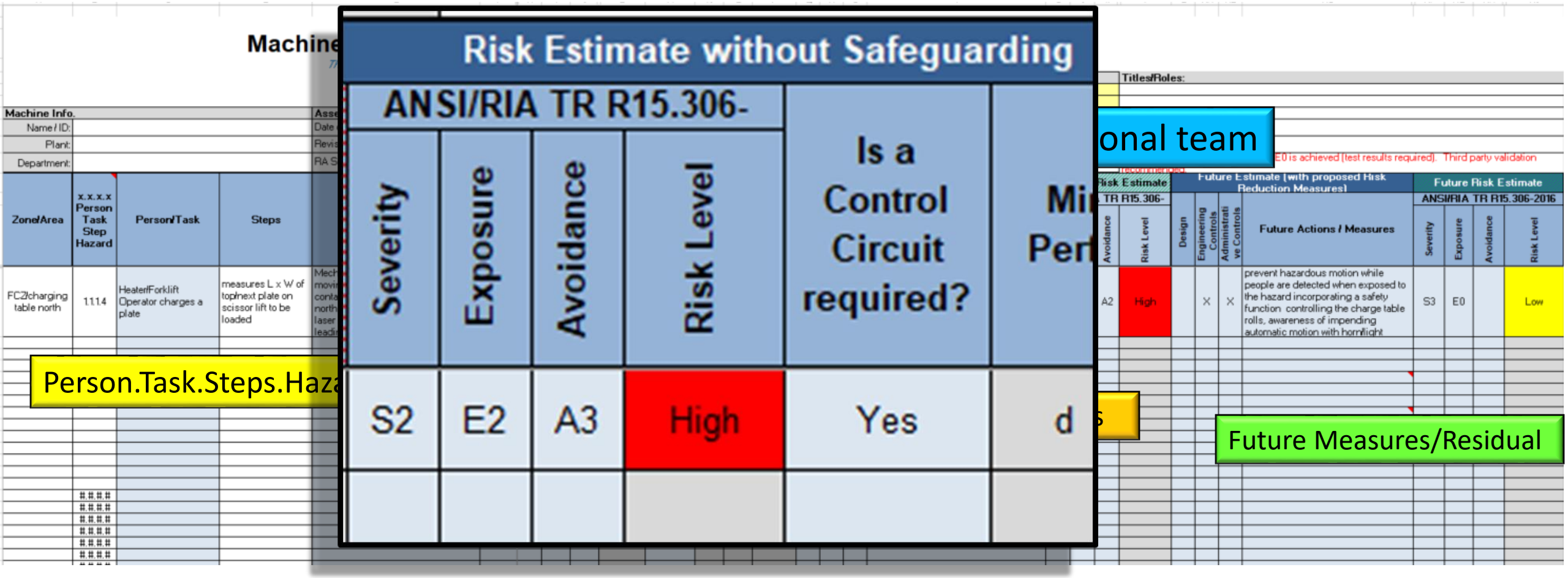
Person.Task.Steps.Hazards

Initial/No Risk Reduction

Existing Measures

Future Measures/Residual

Risk Estimation/Score in three states

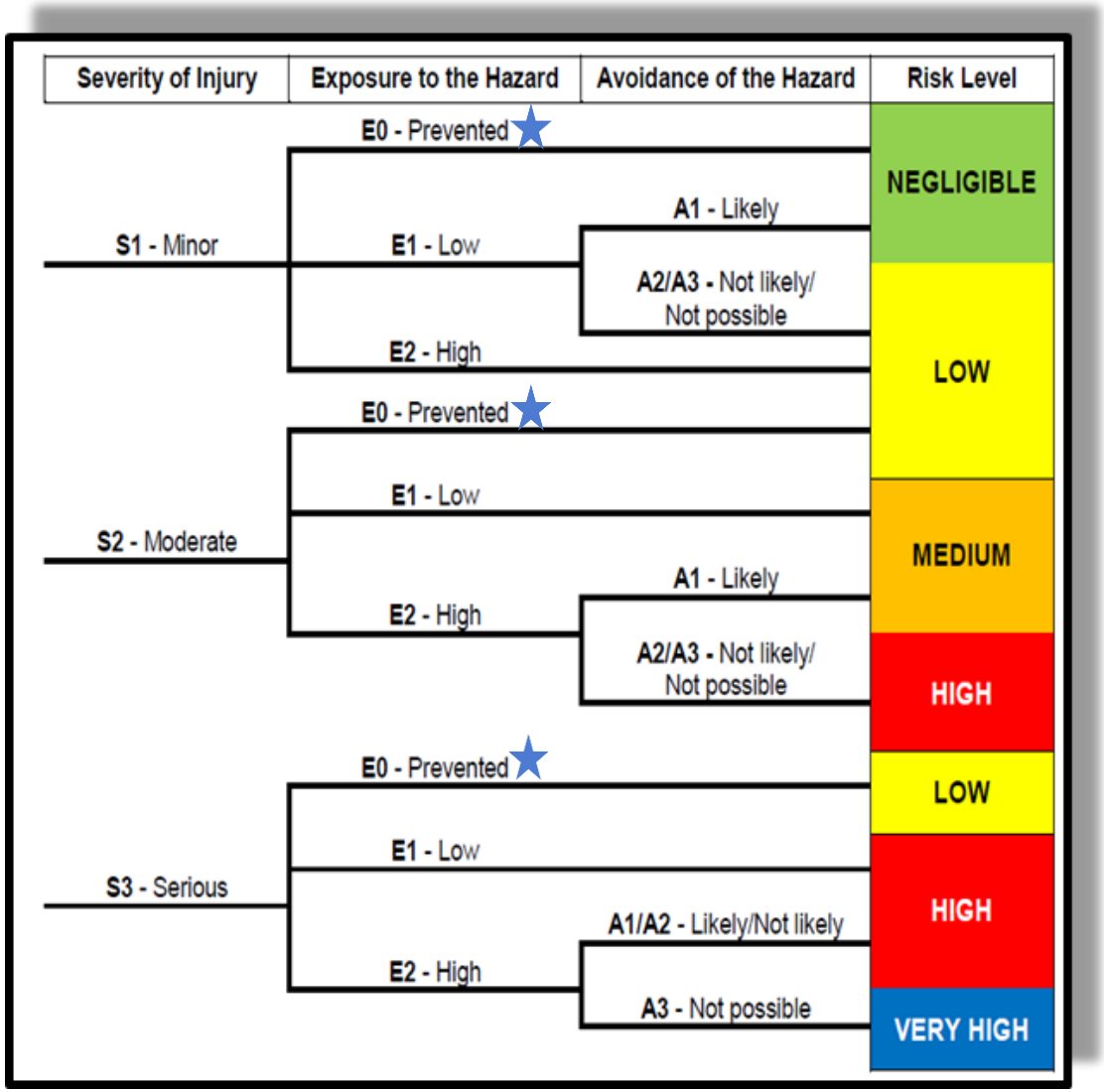


RIA 15.06 Risk Scoring System

RIA TR R15.306-2016

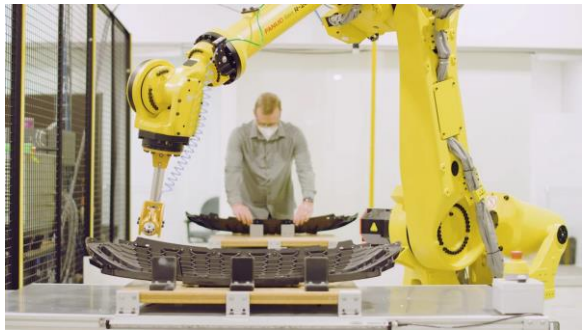
- 5 risk ratings to be evaluated
- 3 factors of the hazard
  - **S**everity of Injury
  - **E**xposure to Hazard
    - E0 only after mitigation★
  - **A**voidance of Hazard

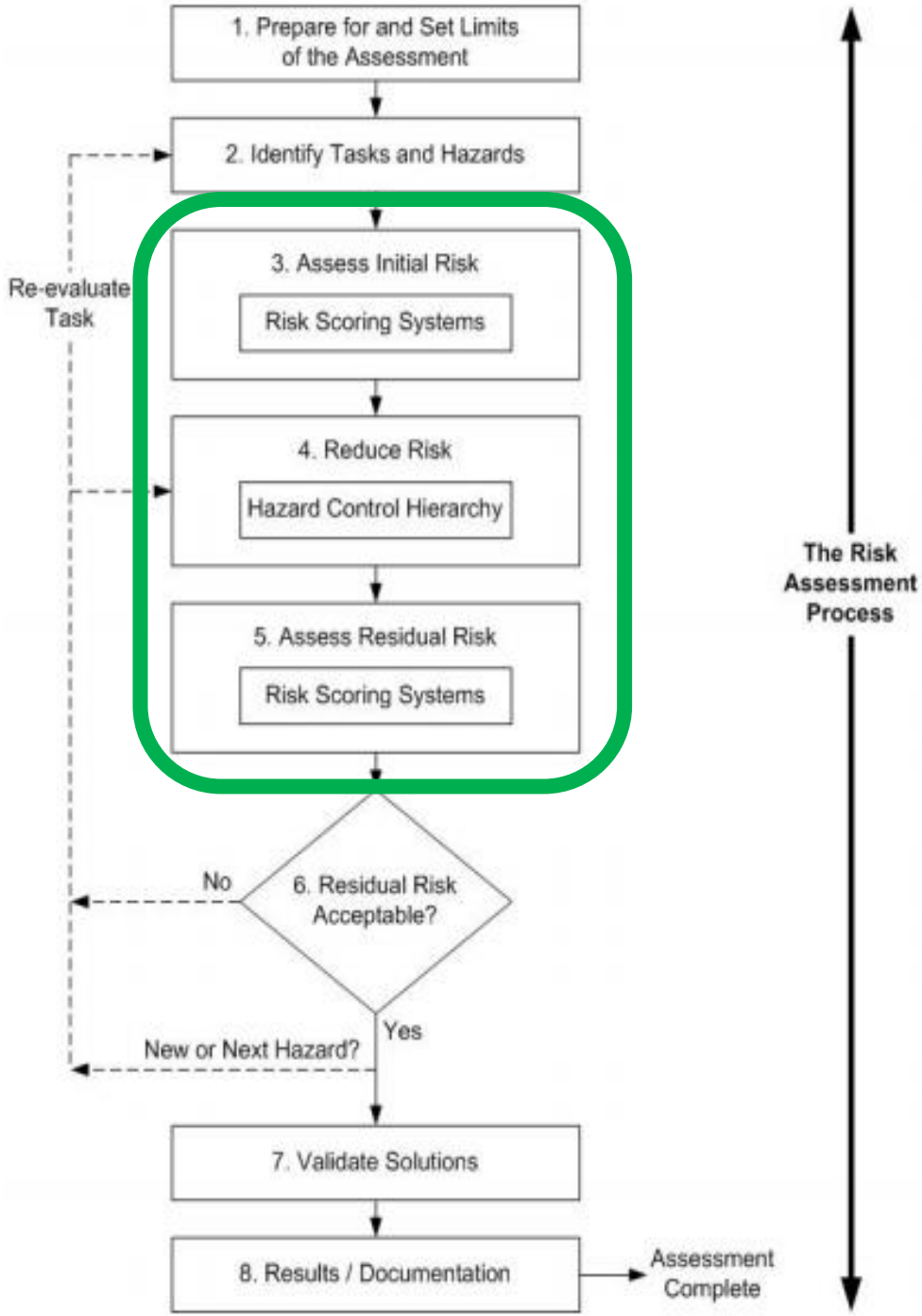
Risk Estimate without Safeguarding					
ANSI/RIA TR R15.306-					
Severity	Exposure	Avoidance	Risk Level	Is a Control Circuit required?	Mi Per
S2	E2	A3	High	Yes	d



Risk Estimation & Risk Reduction Methods

- Estimation to get a rating or score
- A consistent means to determine if risk is acceptable or unacceptable
- **Risk** is the <u>combination</u> of the;
  - **Severity of harm**
  - ✚
  - **Probability of occurrence of that harm**
    - **frequency of exposure**
    - ✚
    - **avoidability**





Risk rating determines the recommended risk reduction measures

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 Z244.1

Table 3 – Hierarchy of risk reduction measures

More preferred	Inherently Safe Design Measures	Elimination	• Process design, redesign or modification including changing layout to eliminate hazards (e.g. falls, hazardous materials, noise, confined spaces, eliminating pinch points, or reduce manual handling)
		Substitution	• Use of less hazardous materials • Intrinsically safe (energy containment) • Reduce energy (e.g. lower speed, force, amperage, pressure, temperature, volume or noise)
		Limit Interaction	• Eliminate or reduce human interaction in the process • Automate tasks, automate material handling (e.g. lift tables, conveyors, balancers)
	Safeguarding and Complementary Protective Measures	Safeguards and Safety-Related Parts of the Control System (SRP/CS)	• Guards • Interlocks or interlocking devices • Sensitive protective equipment • Two-hand control devices • Safety controls and logic • Safety-related functions and safety parameters or configurations, (e.g. safety-rated speed, position, location, axis limits) • Integration of protective devices, possibly including complementary protective measures
		Complementary Protective Measures	railing (building codes or standards can apply) • Measures for escape and rescue of people • Measures for safe access to machinery • Provisions for easy or safe handling of machines and their heavy component parts • Energy isolation or dissipation means • Controlled selection of operating modes • Enabling devices • Emergency stop devices and functions
	Information for Use	Warnings and Awareness Means	• Flashing lights, beacons or strobes • Audible alarms, beepers, horns or sirens • Signs, placards, markings or labels
		Administrative Controls	• Training and safe job procedures • Confined space policy and procedures • Control of hazardous energy procedures (lock-out) used with energy isolation or dissipation means • Rotation of workers, changing work schedule • Equipment safety inspections • Hazard communications
Less preferred		Personal Protective Equipment (PPE)	• Safety glasses, face shields, respirators, hearing protection • Safety harnesses or lanyards • Gloves, hard hats, clothing or footwear used for specific safety purposes (e.g. Kevlar sleeves, metatarsal protection)

If we are using a control circuit…

RIA TR R15.306-2016 references 13849-1 required safety circuit Performance Level (PLr)

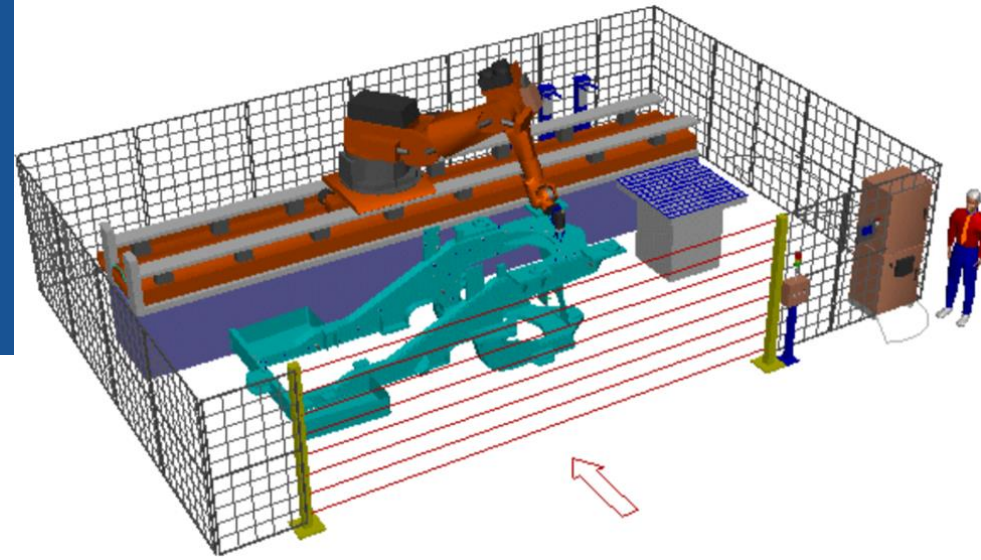


Table 4 – Minimum risk reduction measures as a function of the risk level

	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					

RIA TR R15.306-2016

13849-1 Safety circuit Performance Level (PL)

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

Robot Safety Standard
Safety Functions *Inherent* or *Integrated*

TR R15.306, *table 5*

Risk Level	Minimum functional safety performance	
	PL_r	Structure Category
NEGLIGIBLE (see 5.6.1)	b	--
LOW	c	2
MEDIUM	d	2
HIGH	d	3
VERY HIGH (see 5.6.2) did not exist in R15.06-1999	e	4

Robot safety standards require PLd, Cat 3 unless a risk assessment determines another PL and Cat is needed. Functional safety could be lower or higher, based on application – with end-effector and part(s). **A higher requirement is not expected due to hazards associated with a robot system but could be required for other application risks.**

PLd, Cat 3 is equivalent to Control Reliable & can be validated.

Control Reliable

- a single fault in any of these parts does not lead to the loss of the safety function;
- whenever reasonably practicable, the single fault shall be detected at or before the next demand upon the safety function;
- when the single fault occurs, the safety function is always performed and a safe state shall be maintained until the detected fault is corrected; and
- all reasonably foreseeable faults shall be detected.
- These requirements are considered to be equivalent to structure category 3 as described in ISO 13849-1:2015

“Cage-free” Collaborative Applications

Safety is inherent in the robot controller

Type 1 – safety rated monitoring stop (SRMS)

Type 3 – speed and separation monitoring (SSM)

Type 2 – hand guidance (HG)

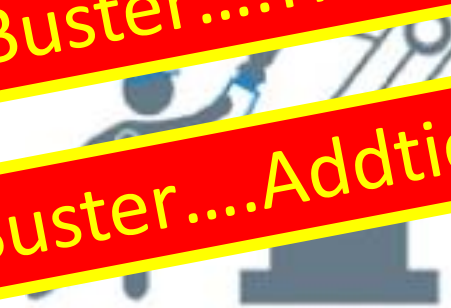
Type 4 – power and force limiting (PFL)

“Cage-free” Collaborative Applications

Safety is inherent in the robot controller

Type 1 – safety rated monitoring stop (SRMS)

and separation monitoring



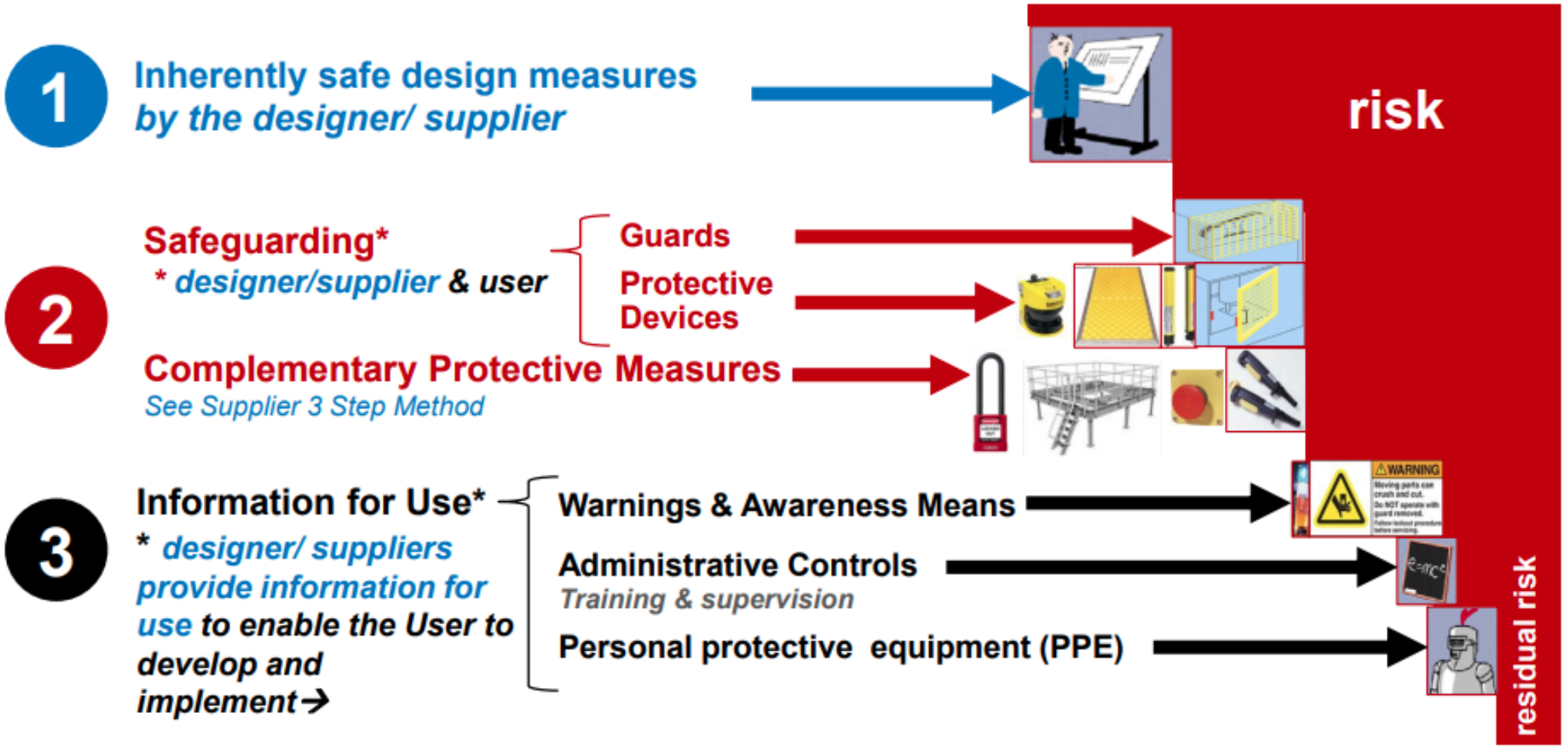
Type 2 – hand guidance (HG)

Type 4 – power and force limiting (PFL)

Myth Buster….The Risk Assessment is Still Required

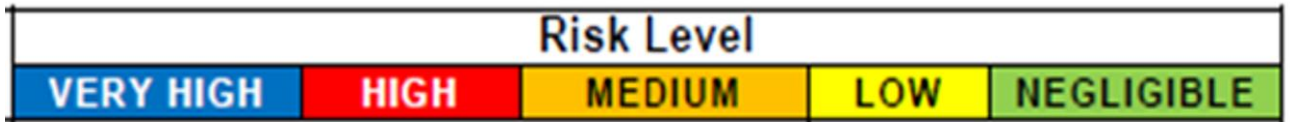
Myth Buster….Addtional Risk Reduction is Still Required

Risk Reduction Measures – 3 Step Method

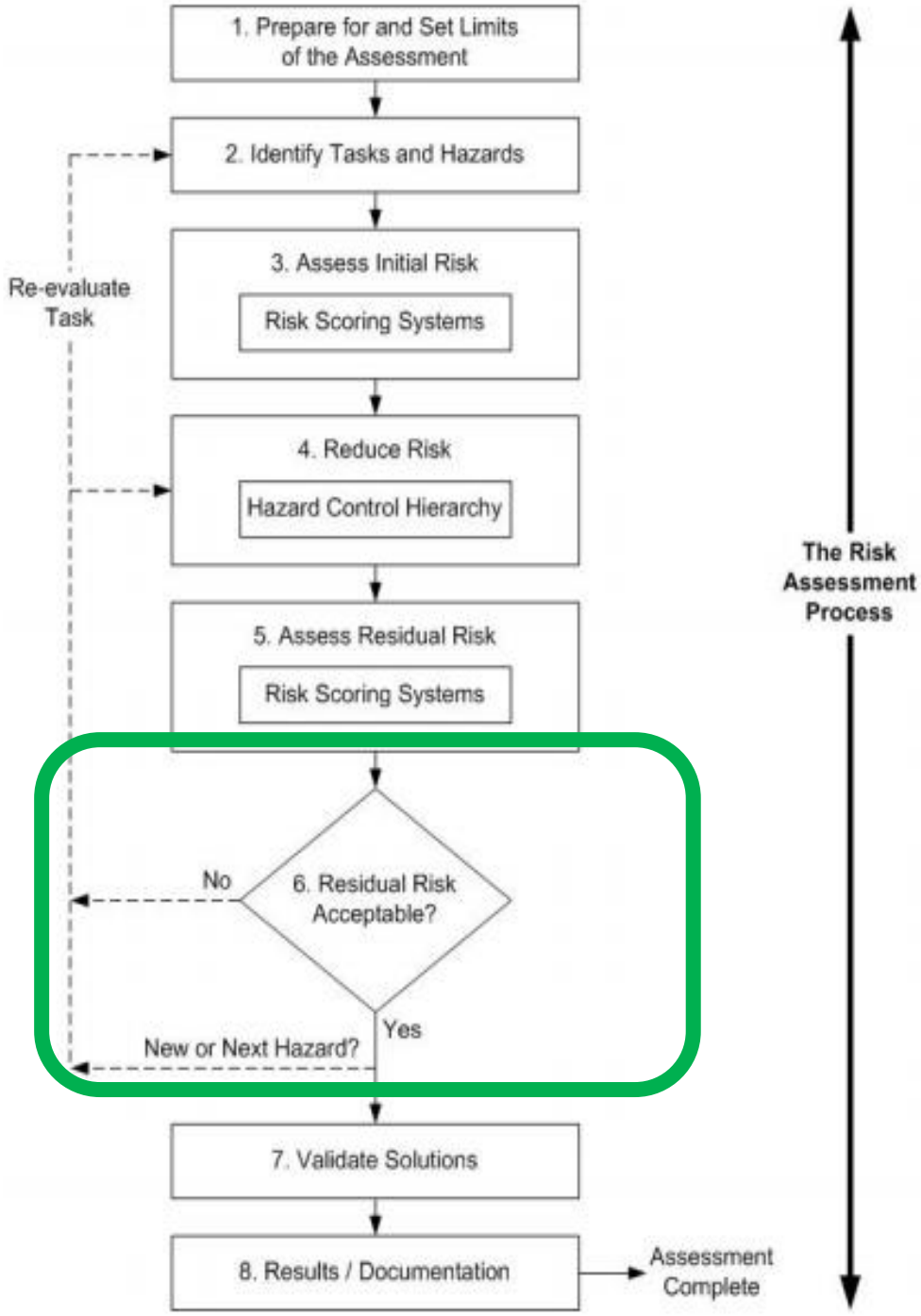


Risk Evaluation:
Is the risk acceptable or unacceptable?

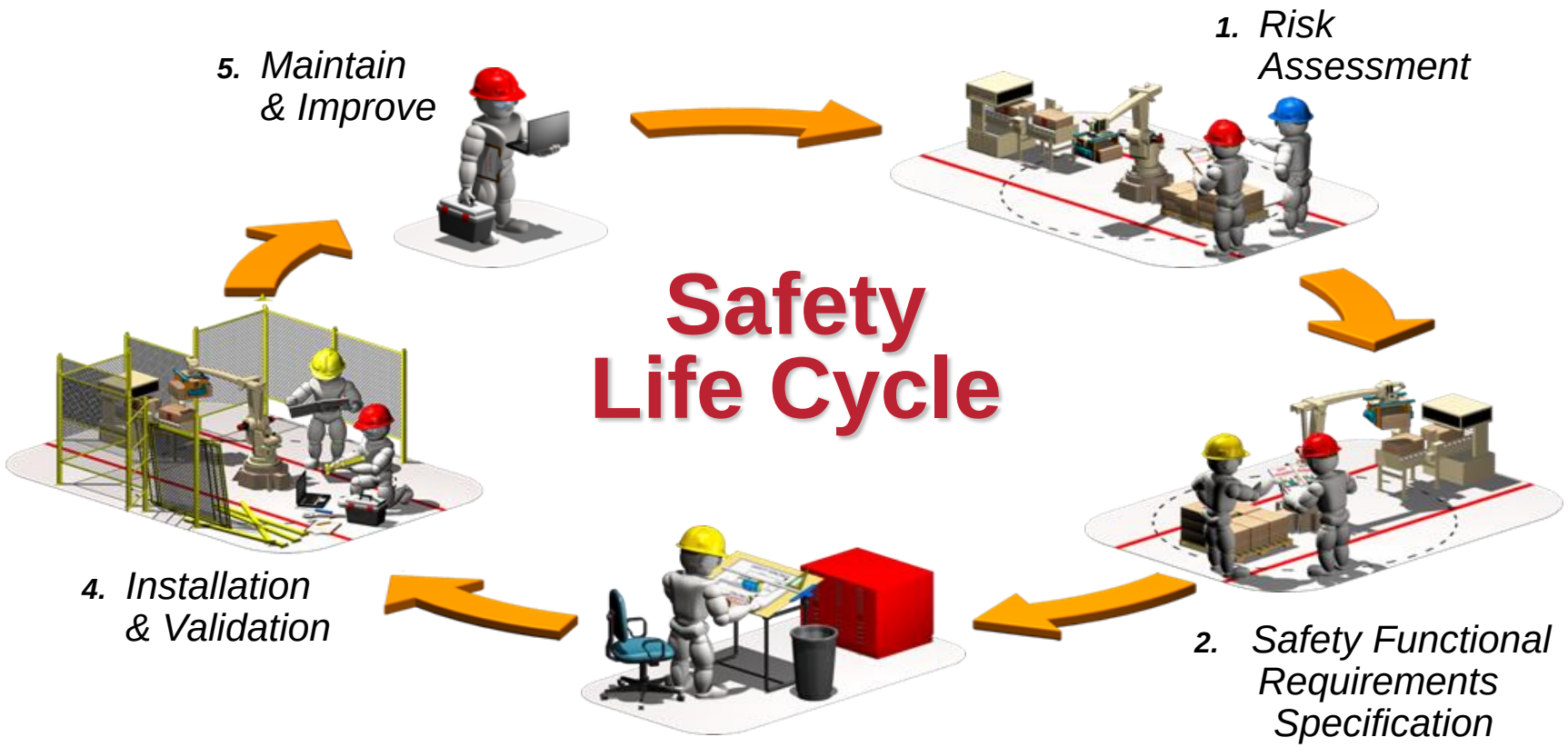
- User's consistent means of evaluating the rating or score



- Establishes the foundation and framework for the an effective machine safety program
- Provides a method for determining levels of protection when designing safeguards
- An active, documented process that can be maintained for the life of the machine



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



Portage County Safety Council

Safety Considerations for Robots in Manufacturing

May 13, 2021

Integrated Mill Systems

I'm not a robot

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