Trends in Machinery/ Automation Safety

by

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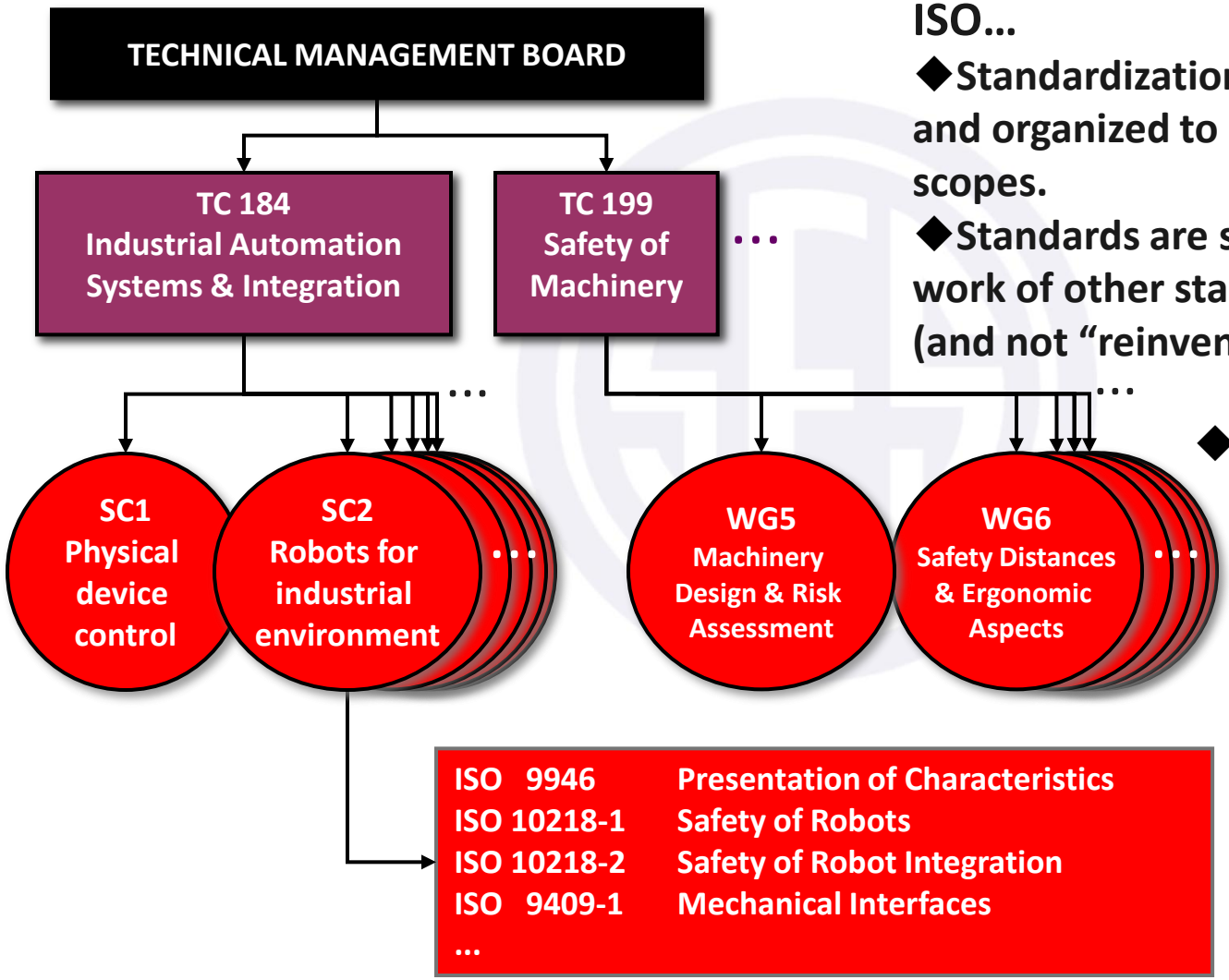
Why Machinery Safety Standards?

- Standards help level the market playing field when all players meet the standard(s).
- Standards provide risk management assistance by helping to limit liability for products meeting standard(s).
- Standards help meet market demands (presuming the market demands compliance with the standard(s)).
- Standards lower costs by standardizing designs & mfg.
- Globally harmonized standards allow products to be global, rather than regional designs. Equipment can be shipped between facilities of global companies.

ISO Standards Framework

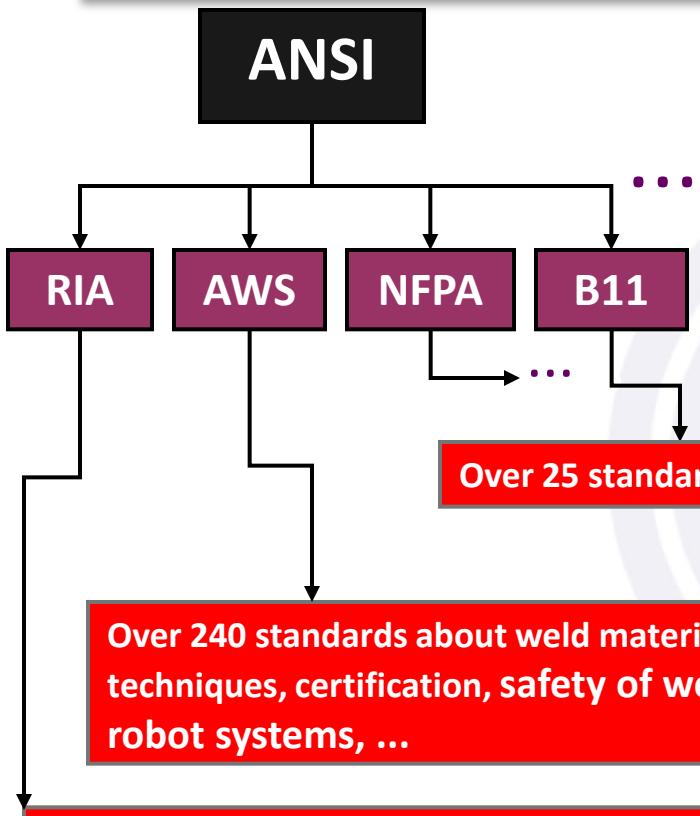


ISO…

- **Standardization is highly structured and organized to minimize overlapping scopes.**
- **Standards are supposed to use the work of other standards (and not "reinvent the wheel").**

- **For harmonized standards (EN ISO), CEN Consultants (technical experts) review the content to judge whether the standard complies with the various EU Directives.**

ANSI Standards Framework



ANSI…

- Standards are based on market demand without oversight as to technical content.
- Accredits an organization to be a SDO (Standards Development Organization) for a specific market/ scope.

Over 25 standards & technical reports relating to safety of machine tools. …

Over 240 standards about weld materials, techniques, certification, safety of weld robot systems, ...

- Oversight of ANSI stds development is to its processes and the development procedures.
- Standard(s) do not have to use the work of other ANSI standards.

ANSI/ RIA R15.02	Design of Robot Control Pendants - **inactive**
ANSI/ RIA R15.05	Performance Characteristics - **inactive**
ANSI/ RIA R15.06	**Safety of Robots,**
	+ Integration of Robots, Robot Systems, Robot Cells
ANSI/ RIA R15.07	Robot Offline Programming - **inactive**

RIA TR15.106, TR15.206, and more

Standards Comparison

- **ANSI Standards and Technical Reports**
  - Are **voluntary** – unless adopted as a regulation (law).
    - Can be adopted by OSHA (unusual) or other jurisdiction (state, county, city… For example, UL 1740 has been adopted by some states and localities)
  - Applies to one or more of the following:
    - the **manufacturer** of the component (e.g., connectors, cable, fasteners, component machine such as a conveyor).
    - the **integrator** of the component or machine.
    - the **user** of the component or machine (company using the machine).
  - Compliance can be used as a
    - Means of complying with OSHA requirements of a safe workplace (since there are many more ANSI standards than regulations) but NOT presumption of compliance.
    - Civil legal defense for providing a safe workplace based on current practices.

Standards Comparison

- **OSHA Standards**
  - Are **regulatory** standards **(required by law**).
  - Are NOT comprehensive. There are VERY few OSHA machine safety standards (e.g., mechanical power presses, forging machines, cooperage machines). There is **NO** OSHA robot standard, however OSHA references R15.06 as being the standard applicable to robot systems.
  - Applies to the **USER** (the company that uses the machine). There can be requirements that apply to EMPLOYEES (example lock-out).

Standards Comparison

- **ISO Standards, Technical Specifications, & Technical Reports**
  - Are **voluntary** unless adopted as a regulation.
  - Are meant to allow globalization of trade by unifying border requirements.
  - Are often adopted by the EU as a harmonized standard which means that the EN ISO standard provides a presumption of conformity (complies with Directives).
  - Applies to **SUPPLIER** of the component or machine:
    - the **manufacturer** of the component or machine.
    - the **integrator** of the component or machine
      (if the USER acts a the supplier, the USER is required to comply).
  - Compliance can be used as a
    - A LEGAL presumption of conformity with the machinery directive (if harmonized).
    - Civil legal defense of providing a safe workplace based on industry practices.

Standards Comparison

- **Country Workplace Safety Standards**
  - Are **regulatory** standards **(required by law**). This is same as OSHA for the USA.
  - In Europe, each country has its own workplace safety requirements, PLUS
    - Compliance with the Directives is a legal requirement, where EN standards compliance provides the means by which to meet the Directives. Suppliers have to meet the Directives for product import and sales within the EU.
    - The USER is required to acquire & use products complying with Directives.
  - Applies to the **USER**. There can be requirements that apply to EMPLOYEES.

Harmonization of Standards?

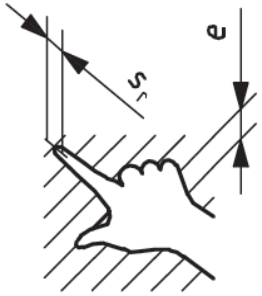
- Harmonization means that standards are the same across various countries.
  - Europe did this with all the countries in the European Union
  - NAFTA supposedly did this for requirements across North America.
- There are differences.
  - Europe places legal requirements on suppliers (machine builders) which this does not exist in many other countries (including the USA).

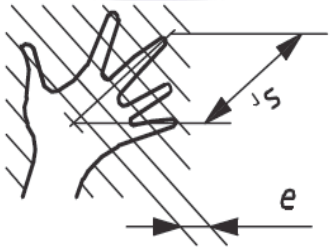
What are the trends?

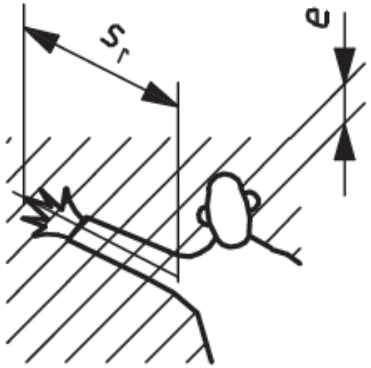
- Harmonization is a trend
  - Realizing this trend is difficult because there are higher requirements for machinery safety in Europe.
- Safety distances are being harmonized but still have differences..
  - The issue of guard openings, gaps, and safety distance for presence sensing devices is being evaluated for compliance to both domestic and ISO requirements.

Safety Distances

- For guards, their openings, and the distance to hazards – ISO and ANSI standards are different.
  - What is done?
    - Companies have standardized to comply with both.
      - ½ inch openings mean installation at least 4 inches away from the closest hazard.
      - ¾ inch openings mean installation at least 6.5 inches away from the closest hazard.

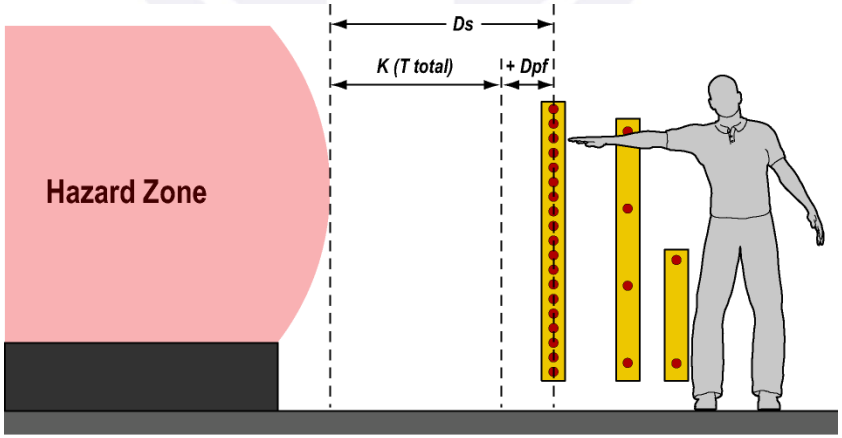






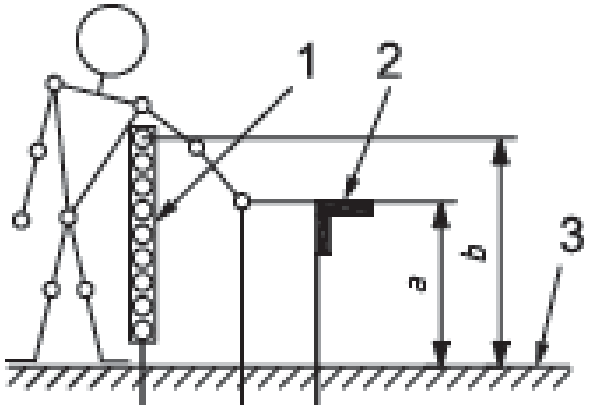
Safety Distances

- For presence-sensing devices, there has been NO harmonization due to the EU being more conservative and there being NO willingness to increase workspaces in North America since there have been no injuries due to the use of the North America safety distance formula.



Safety Distances

- The issue of reaching under or over is starting to be recognized in North America. This has prompted the willingness to adopt ISO & EU requirements for reach-over.



Risk Assessment

- Risk Assessment is required by ISO and European machinery safety standards.
  - Even if there is a specific machinery safety standard, risk assessment is required to identify any risks that the standard does not address.
- Risk Assessment is starting to become a requirement of many ANSI machinery safety standards.
- Sometimes methodologies are suggested.

Risk Assessment

- From the draft Robot Risk Assessment Technical Report, risk is estimated looking at 3 factors: severity, frequency of exposure to the hazard, and likelihood of avoiding the hazard or occurrence.
- Methodologies can include additional factors.
  - Can be HI/ LOW or varying degrees of selections.
  - Beginners prefer fewer choices, more experienced RA practioners prefer more choices

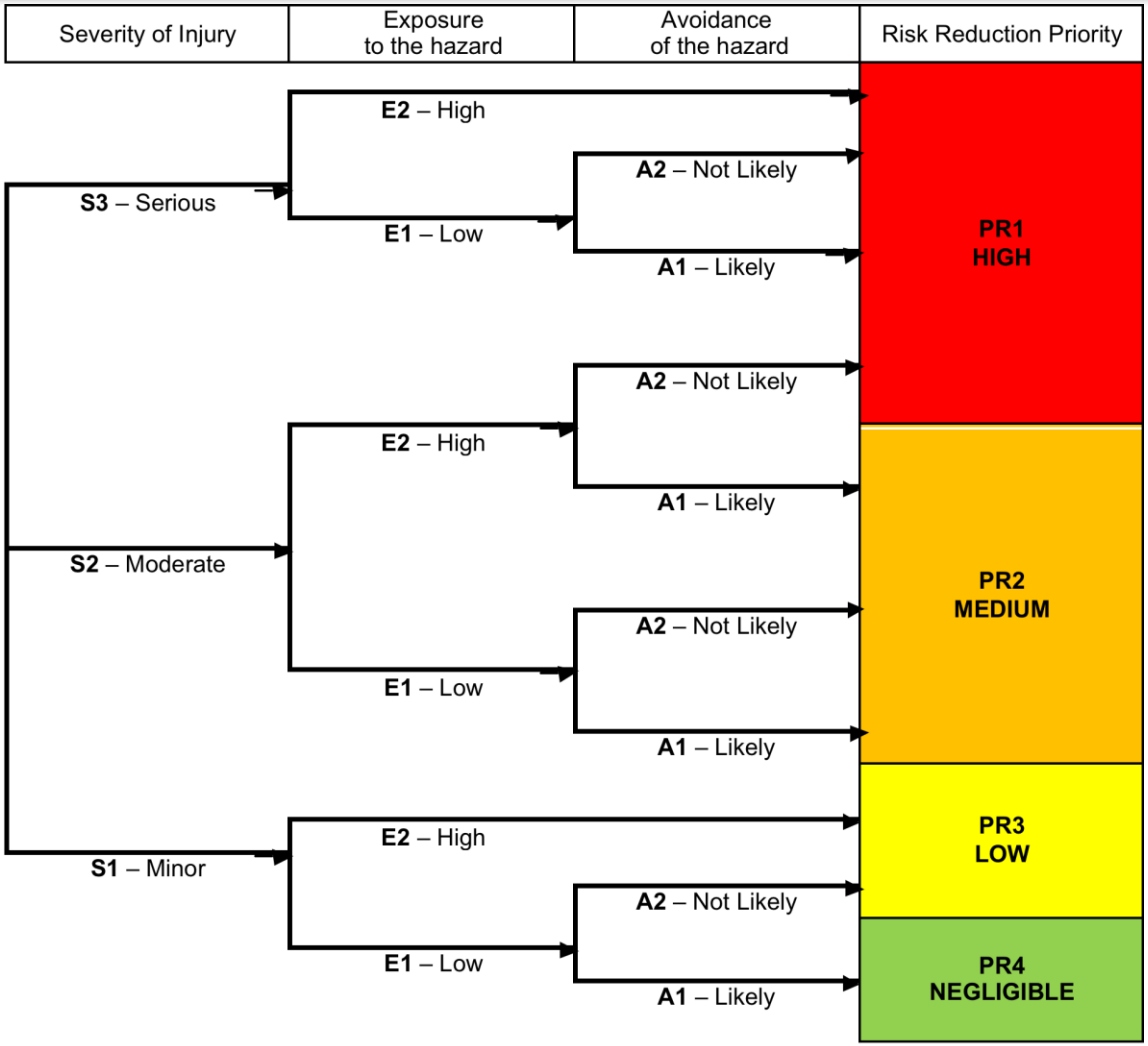
Draft Robot RA TR

Factor	Rating	Criteria (Examples) - choose most restrictive *The decision process starts at the top*
Injury Severity	**Serious S3**	Normally non-reversible: – fatality – limb amputation – long term disability – chronic illness – permanent health change If any of the above are applicable, the rating is SERIOUS
	Moderate S2	Normally reversible: – broken bones – severe laceration – short hospitalization – short term disability – loss time (multi-day) – finger tip amputation (not thumb) If any of the above are applicable, the rating is MODERATE
	Minor S1	First aid: – bruising – small cuts – no loss time (multi-day) – does not require attention by a medical doctor If any of the above are applicable, the rating is MINOR

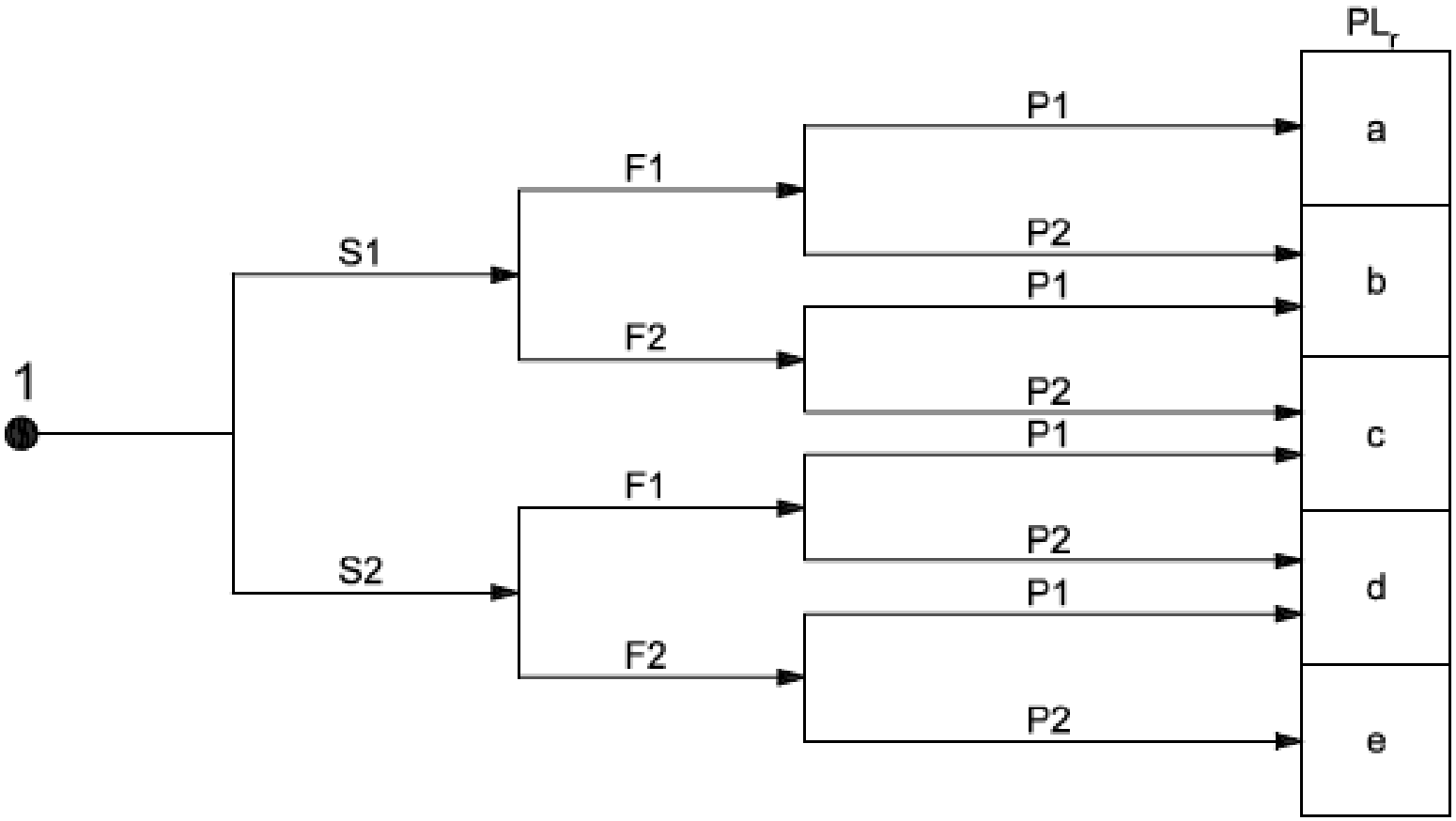
Draft Robot RA TR

Exposure	**High** **E2**	– Typically more than once per hour – Frequent or multiple short duration – Durations/situations which could lead to task creep and does not include teach, see Note 1 If any of the above are applicable, the rating is HIGH
	Low **E1**	– Typically less than or once per day or shift – Occasional short durations If either of the above are applicable, the rating is LOW
Avoidance	**Not likely** **A2**	– insufficient clearance to move out of the way – inadequate warning/reaction time – hazard is moving faster than reduced speed (250mm/s) – may not perceive the hazard exists If any of the above are applicable, the rating is NOT LIKELY
	Likely **A1**	– sufficient clearance to move out of the way – adequate warning/reaction time – hazard is moving at or less than reduced speed (250mm/s) If any of the above are applicable, the rating is LIKELY

Draft Robot RA TR



ISO 13849-1



Risk Assessment's Link to Functional Safety

Functional Safety

- What is it?
  - It is a description of the systems' safety integrity.
  - Depending on the risk, higher safety integrity is required to reduce the probability of it happening.
  - In the process industry, this integrity is described as a SIL level (with SIL 4 being the highest). Reference IEC 61508
  - In the machinery industry, it is called either a SIL (reference IEC 62061) or a Performance Level.
    - Performance levels can be further described by the architecture of controls. Ref ISO 13849.

Trends…

- Because of the capability of building safety into machinery… by inherent design and combined with control measures (that meet the required functional safety)…
  - New machines & capabilities are being offered.
    - Standards can drive suppliers to improve their machines, like embedded safety in robots.
  - This has also resulted in products before standards exist for the product.
    - For example… collaborative robots!

Collaborative

- **Collaborative Robot**,
  Definition: Part 1, 3.4 & Part 2, 3.2
  - robot designed for direct interaction with a human within a defined collaborative workspace
- **Collaborative Workspace**,
  Definition: Part 1, 3.5 & Part 2, 3.3
  - workspace within the safeguarded space where the robot and a human can perform tasks simultaneously during production operation

Collaborative Robots

- Some implementations have existed for some time.
  - Person approaches robot, robot stops.
  - Person leaves workspace, operation resumes.
- Some are new.
  - Power and force limiting.
- Some do not exist yet
  - Separation monitoring.

Power and Force Limiting

New Types of Robots…

High density warehousing by the case.
All handled by robots.

Typical Safeguarding Mistakes
(no particular order)

1. NO safeguarding provided.
2. Personnel can still access hazards (typically moving parts but may be other hazards).
   - Guards / barriers installed too close to hazards.
3. Safeguards are NOT properly installed.
   - NOT securely anchored/ installed.
4. Risk assessment NOT performed to select appropriate risk reduction (safeguarding) per the hierarchy of controls.
5. Safeguards are NOT properly integrated.
6. Safeguarding control system does NOT conform with appropriate standards.

Typical Safeguarding Mistakes

7. Safeguards create additional hazards.
   - Safeguards create interference(s) (usually seen with guards/ barriers).
8. Safeguards do NOT address hazards associated with falling objects.
9. Safeguards can be easily removed, bypassed, or tampered.
10. Movable guards/ barriers are NOT interlocked.
11. Mechanical power transmission under 84” NOT guarded (or NOT guarded when accessible during foreseeable tasks).

Typical Safeguarding Mistakes

12. Safety distance NOT considered or NOT calculated properly for safeguards that signal a stop (Presence Sensing Safeguards, 2 Hand Controls, Interlocked guards).
13. Using an Estop pushbutton as a safeguard.
14. Emergency stop pull cord (cable pull) devices selected and used as a safeguard.
15. Improperly installed Estops.
16. Estop span-of-control not known/ labelled/ functions other than would be obvious.
    - Required to identify the span-of-control if it is NOT system-wide (or obvious).

Typical Safeguarding Mistakes

17. Estop cable pull devices NOT installed properly.
    - Detect push or pull actuation, including at both ends.
    - SHALL require manual reset after actuation.
18. RED/YELLOW color combination not applied properly to emergency stop actuators, such as pushbutton or cable pull type devices.
19. Estop automatically resets (requirement is for a manual reset is at the DEVICE).

Typical Safeguarding Mistakes

20. Inadequate "control of hazardous energy" training, materials, placarding, accessibility, instructions, …
    - Lock-out procedure is NOT specific to machine/ system.
21. Disconnects can be locked in ON position.
22. Design does not provide access to expected tasks.
    - No access for work locations at a height or within cell.
23. No attention to infrastructure maintenance needs around equipment.
    - How do you change the light bulbs?
    - How do you maintain fire protection system?
20. No attention to slips/ trips/ falls in design.

How to prevent these mistakes?

- Be familiar with the associated standards.
- Develop a network of associates that can provide guidance and assistance.
- If needed, train internal personnel or develop a network of experts that can be used when needed.
- Develop internal standards and have them validated to ensure consistency with standards.

Standards Issues

- While harmonization is reducing differences, there will always be regional / country specific requirements
  - Electrical codes/ regulations, differences in voltage / current, technical expertise, expectations…
- Sometimes confusion of security vs. safety internationally (same word in many languages).
- Standards writers try to think towards the future, but it is difficult to write safety requirements for an application or use or need that does not yet exist or hardly exists.
  - Innovation leads, standards lag.
  - Hopefully, standards enable new technology & ideas.
    - **This is the goal.**

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