ISSA Risk Assessment Presentation

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What we're discussing today

- Legal requirements for safety.
- What is a risk assessment?
- Why is a risk assessment necessary?
- What standards give us guidance on risk assessments?
- Who should you execute a risk assessment?
- What is the process for doing a risk assessment?
- Defining risks and hazards.
- Estimating risks and hazards.
- Managing risks and hazards.
- What does a risk good risk assessment look like?
- What is NOT a risk assessment?
- Should you consider fluid power as part of the risk assessment process?
- Closing Comments.

Laws Define the Legal Requirements

Machinery Directive

Laws set minimum requirements that companies are required to meet But do not tell you how to do anything. This is what the standards are for. Standards define the methods that are to be used to prove compliance!

In Europe, the Machinery Directive defines the safety requirements that must be followed!

Machinery Directive 2006/42

- « Directive Machine »
  - **Defines the specifications or the essential requirements on safety which have influence on the design and construction of the machine.**
  - **Address to the constructors, importers and vendors.**
- History :
  - **The 1st is established in 1989 : « Directive Machine 89/392/CEE »**
  - **Superseded by «Directive 98/37/CE » of 22 June 1998.**
  - **2006/42 application date : *30 December 2009***
- Visit the site :

  http://eur-lex.europa.eu/fr/index.htm

Machinery Directive

CE Marking is required for machinery coming into Europe to prove compliance to the Machinery Directive.

In United States, OSHA defines the safety requirements that must be followed.

- Safety is an obligation/requirement in the US
  - The requirements are published in CFR 29 part 1910.
    (Code of Federal Regulations)
  - The distinction between law and standards
    - **OSHA defines the legal requirements** in CFR29 part 1910
      - **Subpart J** – Environmental Controls Requirements (Also know as Lock-out & Tag-out)
      - **Subpart O** – Machinery Safety Requirements
      - **Subpart S** – Electrical Safety Requirements
  - **ANSI publishes a list of consensus and federal standards that must be followed.** These tell us how to implement solutions to meet the OSHA requirements.

OHSA defines the minimum requirements that must be met. Most states have stronger requirements that companies are also required to meet.

In Canada, CCOHS defines the safety requirements that must be followed.

- Safety is an obligation/requirement in Canada
- Canada has 14 jurisdictions that each have there own requirements.
  - There is 1 Federal Requirement
  - There are 10 Provincial Requirements
  - There are 3 Territorial Requirements

CCOHS Canadian Centre for Occupational Health and Safety

Alberta

NOVA SCOTIA

WorkSafe SASKATCHEWAN

Quebec CNESST

Prince Edward Safety Matters @Work Workers Compensation Board of PEI

Northwest Territories WSCC Workers' Safety & Compensation Commission

WORKSAFE BC

Ontario Ministry of Labour, Training and Skills Development

Manitoba Workplace Safety and Health

Yukon Workers' Compensation Health and Safety Board

In Canada most Provinces and Territories require a Pre-Start Health and Safety Review before equipment can be put in productive use.

Regional laws use standards to define the technical specifications that must be used to prove compliance.

Standard

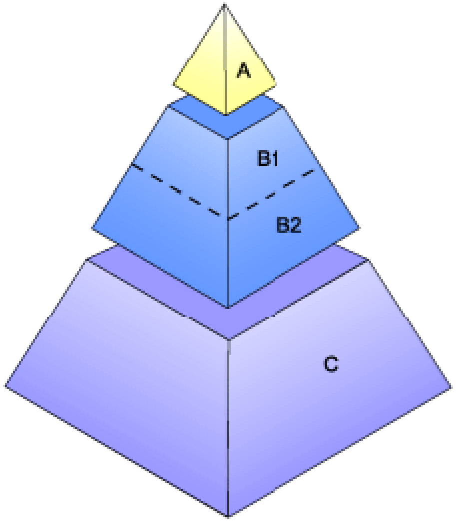
- **Purpose :**
  - Provide the technical specifications needed by the professionals to produce and to launch the equipments complied with the essential requirements of safety and health prescribed by the regulation.
- **Scope :**
  - Not obligatory application, but a machine built in accordance with these standards will benefit from a presumption of conformity to the essential requirements.
- **Revisions :**
  - Regularly revised : they represent the technical state of a given moment.
- **Distinctions :**
  - Standard type A and B : applicable to all machines
  - Standard type C : applicable to 1 machine

IEC ISO EN ANSI CSA GROUP™

There are 3 levels of standards! Type A, B & C

- **Three examples we will discuss are:**
  - **North America – OSHA Requirements**
  - **European – Machinery Directive Requirements**
  - **Canadian – CSA Requirements**
- There are three types of Standards
  - **"A" Standards (Basic Standards)**
    - basic concepts
    - principles for design
    - general aspects
  - **"B" Standards (Application Standards)**
    - B1 - safety distances, surface temps, noise
    - B2 - components or devices
  - **"C" Standards (Specific Machine Standards)**
    - Vertical standards covering a single type of machine or group of machines.
    - Use A and B standards to create C standards.

Three-tier Structure of International Safety Standards



Type A Fundamental safety standards applicable to all machinery. Type A standards deal with basic concepts, principles for design, and general aspects.

Type B Standards applicable to a wide range of machinery. Type B is divided into two catagories:

B1: Specific safety aspects (ie., safety distance, surface temperature, and noise)
B2: Safety related devices (ie., two-hand controls, interlocking devices, pressure sensitive devices, and guards)

Type C Detailed standards applicable to a specific machine or a particular group of machines.

Ok, so then what is a risk assessment?

- Definition, ISO 12100:2010

3.17

risk assessment

overall process comprising a risk analysis and a risk evaluation

What is a Risk Assessment ?

- Documented physical examination and inspection of a machine, process or activity carried out under the guidelines of international and/national standards

- Purpose of the Risk Assessment is:
  - To identify any hazards
  - Estimate the risk
  - Evaluate the risk
  - Determine the risk reduction that may be applied to reduce the risk in accordance with applicable legislation, standards and Good Engineering Practice

- Risk assessments must be:
  - Dynamic
  - Iterative process
    - ongoing as long as an unacceptable risk is present
  - Completed on a periodic basis

ISO 12100 definitions

Definitions

- **Harm**
  - Physical injury or damage to health
- **Hazard**
  - A potential source of harm
- **Hazardous Situation**
  - Circumstance in which a person is exposed to at least one hazard
- **Risk**
  - A combination of the probability of occurrence of harm and the severity of that harm
- **Hazard/ Danger Zone**
  - Any space within and/or around machinery in which a person is exposed to a hazard
- **Risk Estimation**
  - Defining likely severity of harm and probability of its occurrence

ISO 12100

Risk Assessment Standards

- ISO 12100: Safety of Machinery - General principles for design – Risk assessment and risk reduction
  - Type A standard
  - Defines basic terminology and specifies general design methods to achieve safety
  - Describes general procedures and principles for identifying hazards and assessing risks in all phases of the life of machinery
  - Defines documentation required to verify the assessment carried out
  - The standard **does not define any method for analyzing hazards and estimating risks**

ISO 12100

ISO12100:2010 abstract

- ISO 12100:2010 specifies basic terminology, principles and a methodology for achieving safety in the design of machinery. It specifies principles of risk assessment and risk reduction to help designers in achieving this objective. These principles are based on knowledge and experience of the design, use, incidents, accidents and risks associated with machinery. Procedures are described for identifying hazards and estimating and evaluating risks during relevant phases of the machine life cycle, and for the elimination of hazards or sufficient risk reduction. Guidance is given on the documentation and verification of the risk assessment and risk reduction process.

Risk Assessment Standards

- ISO/TR 14121-2: Safety of machinery - Risk assessment – Part 2: Practical guidance and examples of methods.

  - Technical Report
  - Gives practical guidance on the conducting of risk assessments for machinery in accordance with ISO 12100
  - **Describes various methods and tools for each step in the process**
  - Provides practical guidance on risk reduction (in accordance with ISO 12100) for machinery, giving additional guidance on the selection of appropriate protective measures for achieving safety
  - Provides a practical example on a complete risk assessment

ISO/TR 14121-2

Risk Assessment Standards

- CSA Z432-16: Safeguarding of machinery

  - It is not classified as Type A, B or C standard;
  - Intended to be applied to newly manufactured, rebuilt, and redeployed machinery;
  - However, it may also be used to set upgrade targets for existing machinery;
  - Provides advice on the basic principles of Safeguarding and safety control performance to the extent that a manufacturing engineer, plant engineer, manager, or safety manager may interpret the advice and apply it to any particular machine.
  - The latest edition (2016) has been expanded to harmonize, where possible and where appropriate, with international Standards;
  - For that reason, parts of this Standard are based on the latest editions of ISO 12100 and ISO 13849;
  - Specifies requirements for the design, manufacture (including remanufacture and rebuilding), installation, maintenance, operation, and safeguarding of industrial equipment to prevent injuries and accidents and enhance the safety of personnel who operate, assemble, and maintain machinery;
  - **It contains the methodology for performing a comprehensive risk assessment.**

CSA Z432-16

Who should be present ?

- More thorough and effective when performed by a team
- Knowledge on different disciplines and a variety of experience and expertise

Team should include individuals who:

- a) can answer technical questions about the design and functions
- b) have actual experience of how the machinery is operated, set-up, maintained, serviced, etc.
- c) have knowledge of the accident history of this type of machinery
- d) have a good understanding of the relevant regulations, standards, and in particular ISO 12100, and any specific safety issues
- e) understand human factors

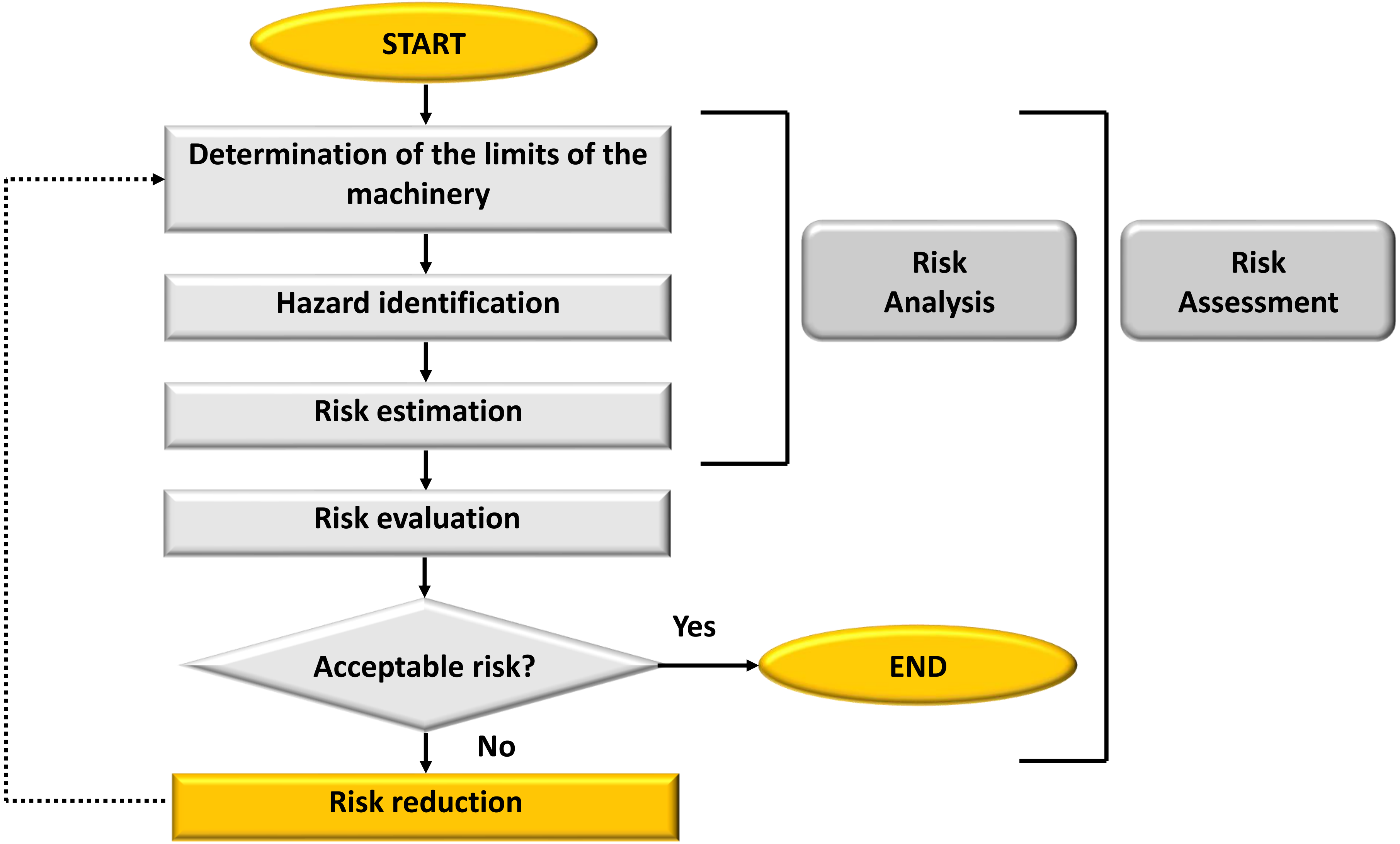
The Risk Assessment should be done by competent people

- Competence can be described as the combination of training, skills, experience and knowledge that a person has and their ability to apply them to perform a task in a safe and proper way.

This could be obtained from e.g.:

- Education
- Training
- Knowledge from standards and technical reports
- Review of existing risk assessments
- Practical Experience

Risk Assessment Process according to ISO 12100



Risk Assessment Process

• Information for Risk Assessment

- Risk Assessment Team should obtain:

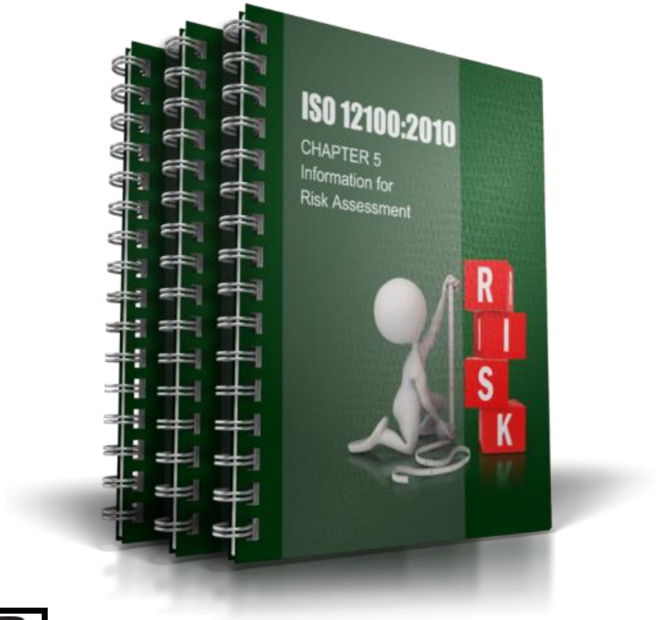
- **Machine Information:**

  - User specification
  - Design Drawings
  - Energy Source Drawing e.g. Electrical, Pneumatic, Hydraulic
  - Manuals
  - Spare Parts List
  - Etc.

Risk Assessment Team should establish:

Standards and other Documentation:

- Relevant standards (i.e. ISO 12100 and applicable
- Type-B and C-standards)
- Relevant technical specification (i.e. ISO/TR 14121-2)
- Relevant data sheets



Risk Assessment Process

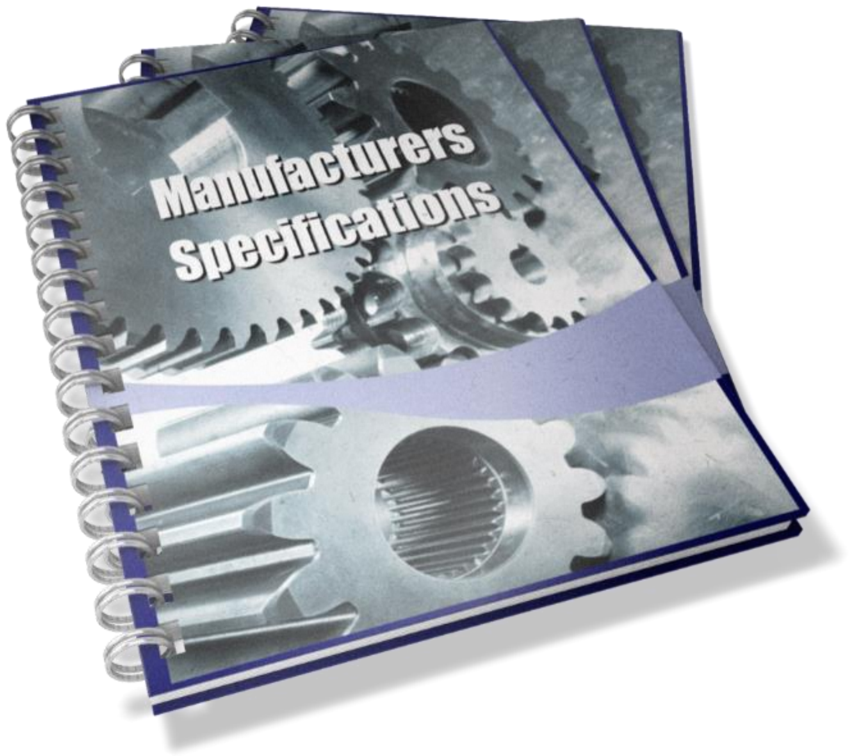
• Information for Risk Assessment (continued)

Risk Assessment Team should establish:

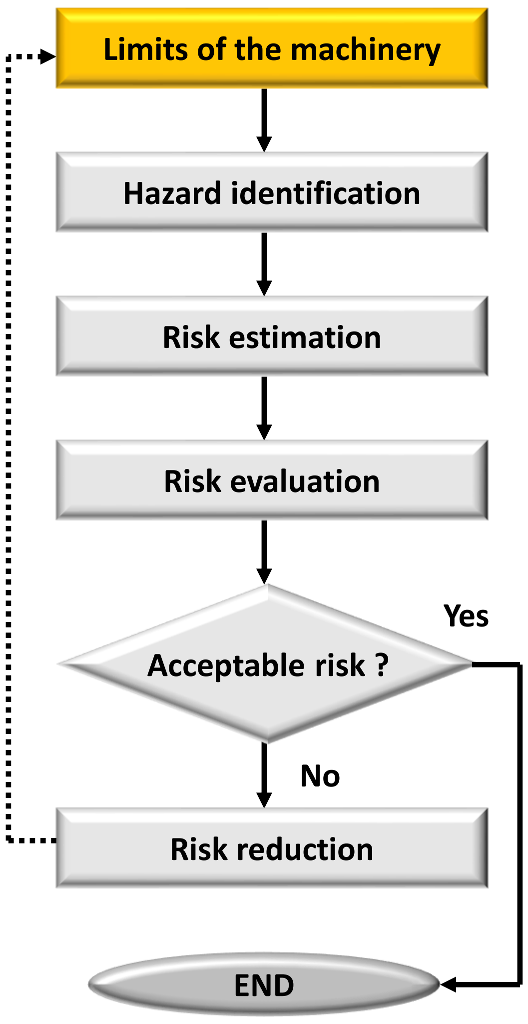
- **Experience of use** (from similar machines)
  - Accident history
  - History of damage to health caused by emissions (noise, chemicals, dust...)
  - User experience (operators experience)

- **Ergonomic principles**
  - Standards
  - Data from databases

Ergonomic information must be updated as
the design develops and in case of modification



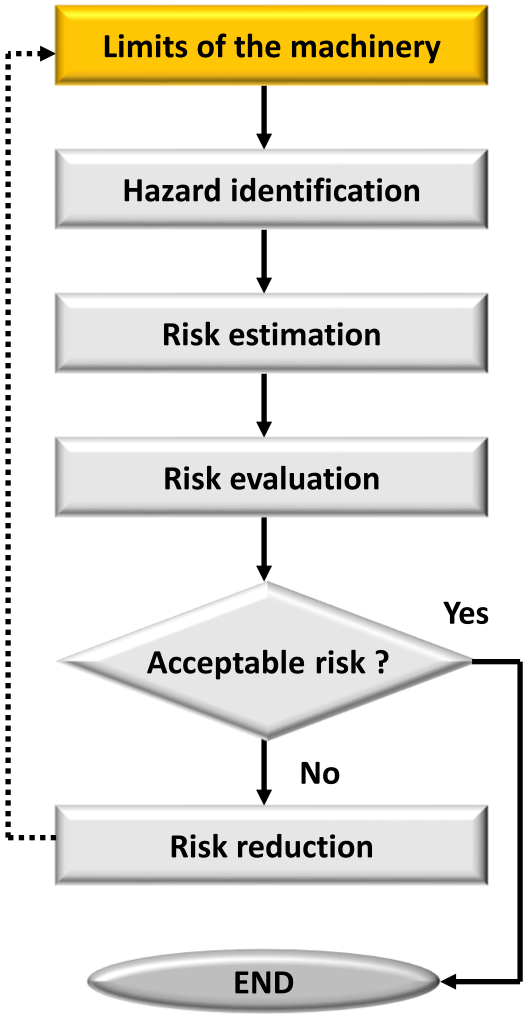
Risk Assessment Process



- The first step in the risk assessment is to determine the limits of the machinery.
- This step provides the basis for the following steps in the risk assessment.
- In this step the functional capabilities of the machine is clarified.
- *- What is the intended use?*
- *- How must it be used?*
- *- Who is in contact with the machine?*
- *- Where is it used?*
- *- Known or foreseeable misuse?*
- *- Which life phases is relevant?*
- *- What tasks are performed?*

- In which environment is the machine used?

Risk Assessment Process

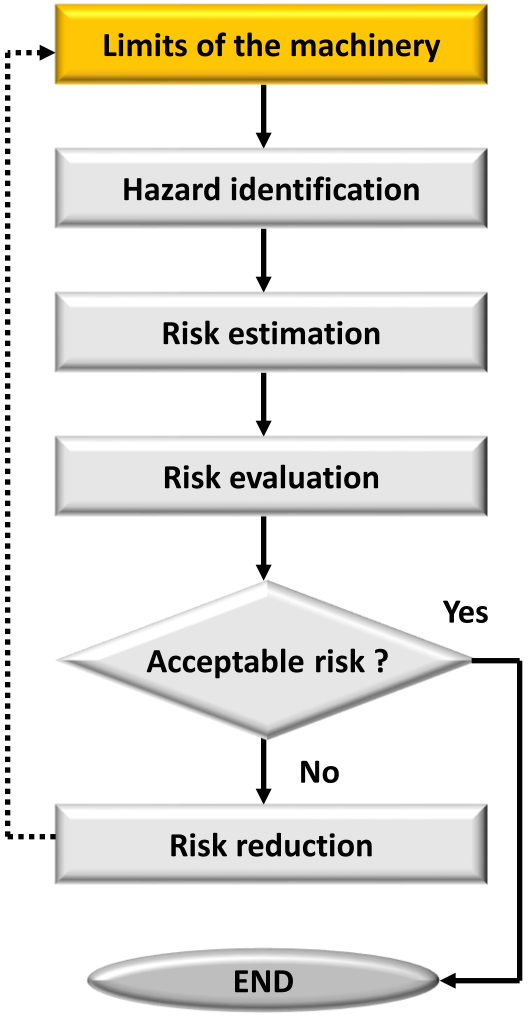


- **Use Limits:**
- Both intended use and foreseeable misuse of the machine must be considered.

- Following aspects must be taken into account:

a) Operating modes
b) Use of the machine (industrial/non-industrial)
c) Users level of experience, training or ability
   - Operators
   - Maintenance personnel
   - Trainees
   - General public
d) Exposure of other persons
   - Persons with good awareness of specific hazards (Operators of adjacent machinery)
   - Persons with little awareness of specific hazards, but good awareness of general site safety (Administration staff)
   - Persons with no awareness of specific hazards (General public, children)

Risk Assessment Process



- **Space limits:**
- Includes space requirement and limits for both machine and humans. Following aspects must be taken into account:

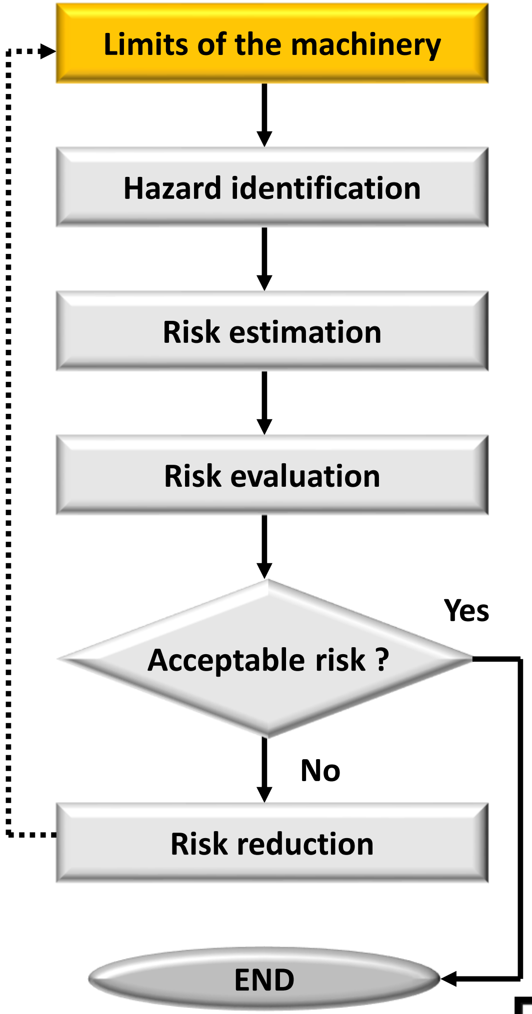
a) Range of movements

b) Space requirements for persons interaction during operation/ service

c) Human interaction (operator-machine interface)

d) Power-supply

Risk Assessment Process



- **Time limits:**
- Determines the foreseeable life limit of the machine or its components. Especially relevant for safety related parts of the control system.

a) Machine and/or component life limit

b) Recommended service intervals

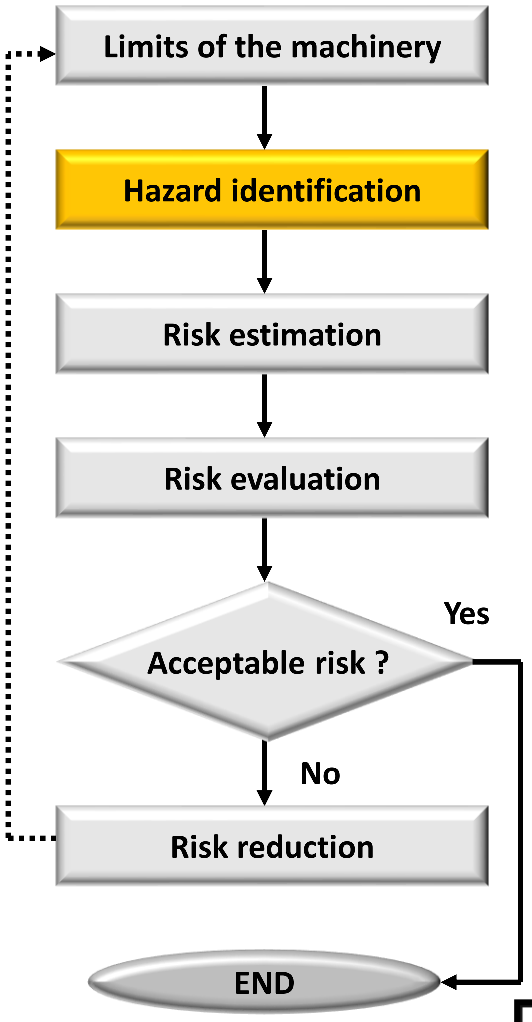
- **Other limits:**
- Various limits determined by use of the machine, location and ambient environment, e.g.:

a) Properties of materials being processed or manufactured

b) Housekeeping – the level of required cleaning (especially food or medical machines)

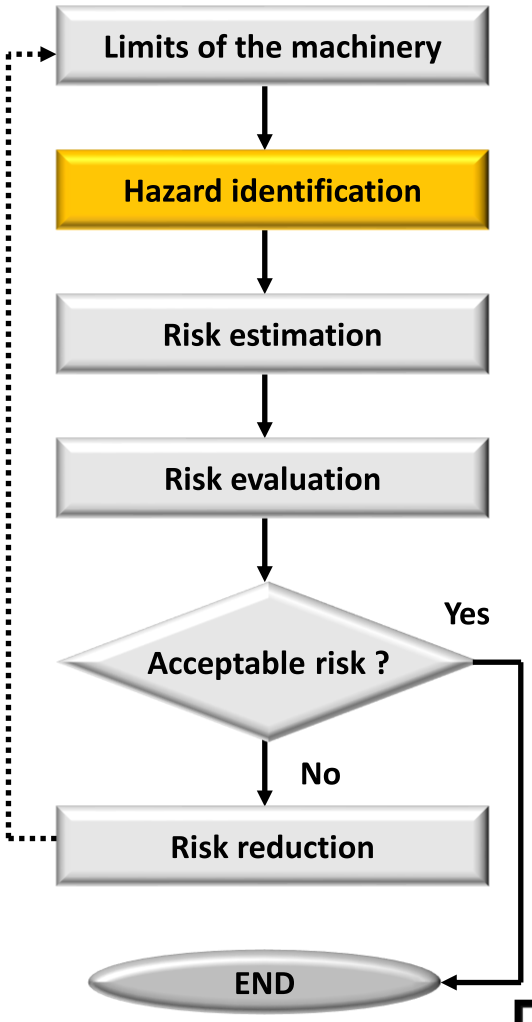
c) Environment, the acceptable level of temperatures, vibrations, humidity...

Risk Assessment Process



- The second step in the risk assessment procedure is to identify all hazards present on the machine.
- In order to be able to make appropriate risk reduction on the machine and achieve conformity with the applicable legislation, it is essential to locate all hazards related to and caused by the machine.
- All reasonably foreseeable hazards must be identified in **all tasks** in **every life phase**, performed by **all personnel** involved.

Risk Assessment Process



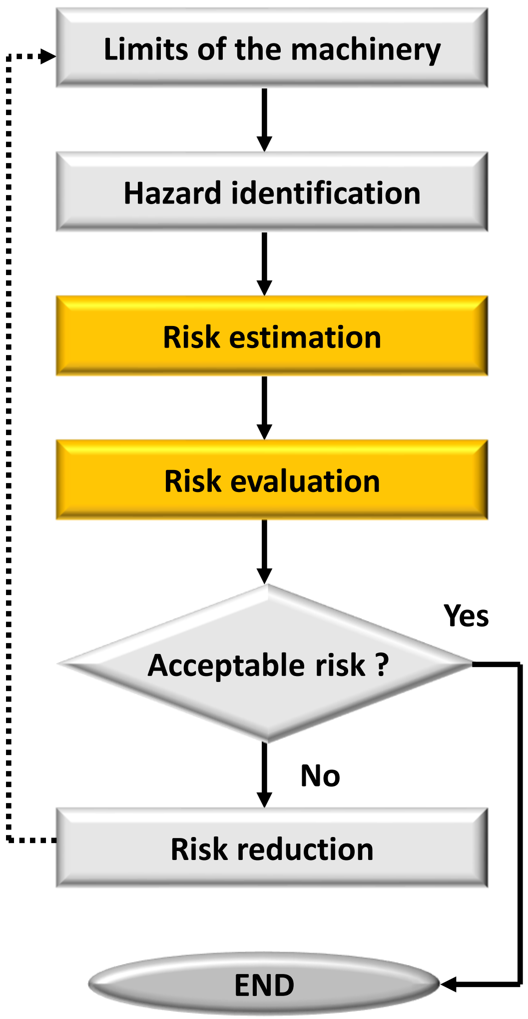
- **Types of Hazards**

- Hazards can be split into 10 main types or groups defined primarily by its physical characteristics

- Each main group contains several possible hazards (origin) and potential consequences related to them

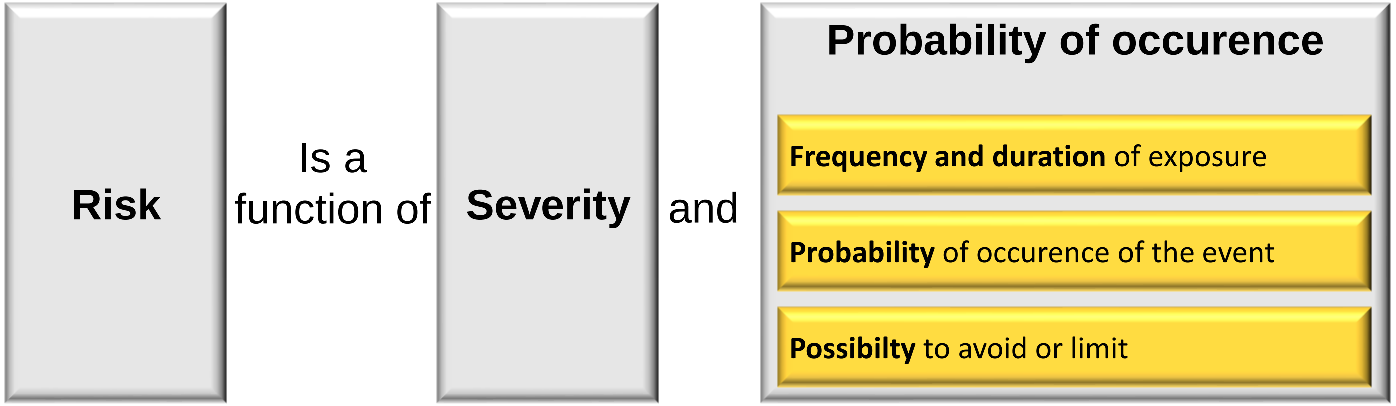
1. Mechanical Hazards
2. Electrical Hazards
3. Thermal Hazards
4. Noise Hazards
5. Vibration Hazards
6. Radiation Hazards
7. Material/substance Hazards
8. Ergonomic Hazards
9. Environmental Hazards
10. Combination of Hazards

Risk Assessment Process



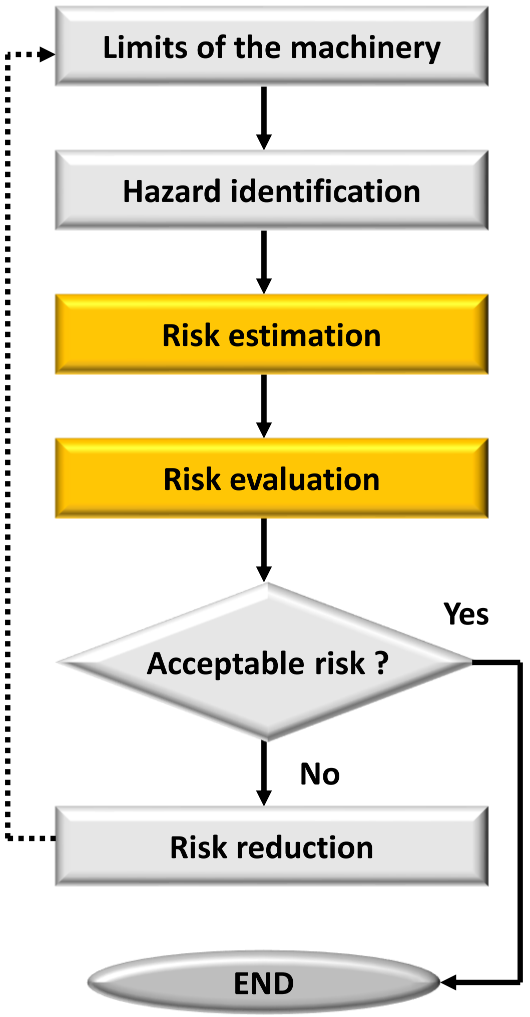
- **Risk Estimation and Evaluation**

- **What is a risk?**



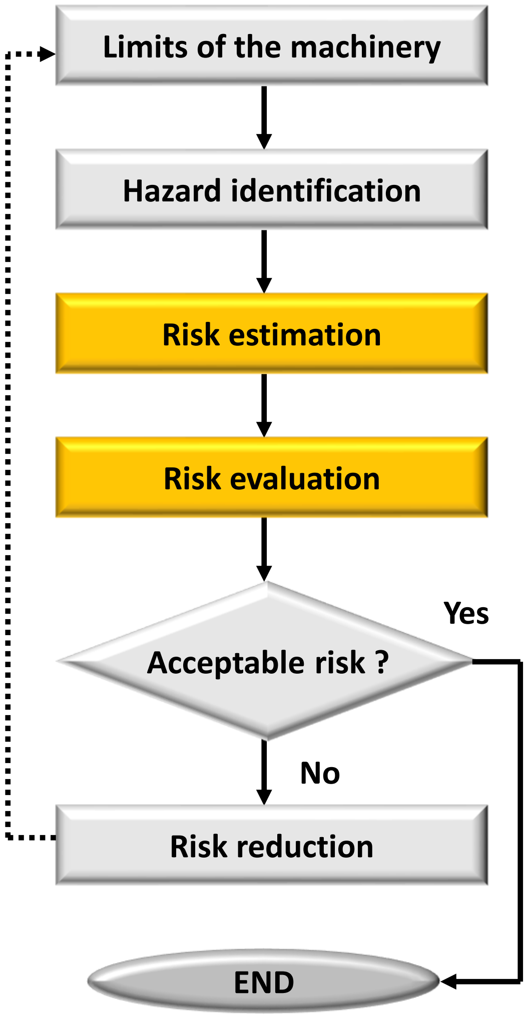
- The third and fourth step in the risk assessment procedure is to estimate and evaluate all risks related to the hazards identified in the second step

Risk Assessment Process



- **Severity of Harm**
- The severity can be estimated by taking into account:
  - The severity of injuries or damage to health
  - slight (normally reversible)
  - serious (normally irreversible)
  - death
  - The extent of harm
    (for the specific hazard)
  - one person
  - several persons

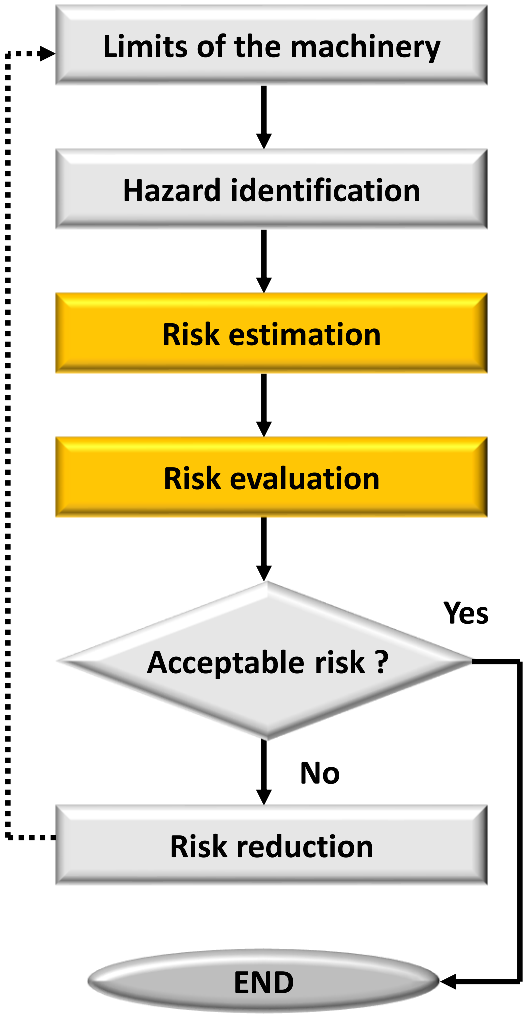
Risk Assessment Process



- **Probability of Occurrence of Harm**
- The probability of occurrence is determined on the basis of three parameters:

1. **Exposure** of persons to the hazard
   - need for access to the danger zone
   - nature of access
   - time spent in the danger zone
   - number of persons requiring access
   - frequency of access
2. **Likelihood of occurrence** of a hazardous event
   - reliability and other statistical data
   - accident history
   - history of damage to health
   - comparison of risks
3. Possibility of **avoiding or limiting harm**
   a) Is the operator skilled/unskilled?
   b) Movement is sudden, quick, slow?
   c) Operator has an awareness of the risk?
   d) Operator has ability to avoid or limit harm (reflex, agility, escape)
   e) Operator has practical experience and knowledge

Risk Assessment Process

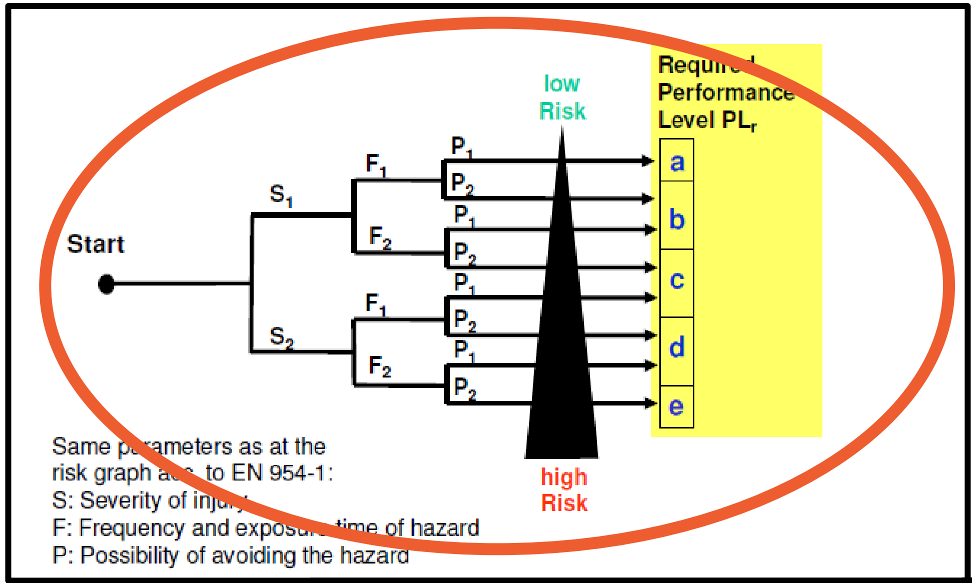


- **Risk Matrix**
- Risk matrix according to ISO/TR 14121-2 table A.3 (original from ANSI B11 TR3:2000)
- In this method there are 4 probability and severity levels which in the table will result in 4 risk levels: High, Medium, Low or Negligible.
- There is no exact definition when risk reduction must be carried out, and when the risk level is acceptable. This will depend on the specific hazard and the risk reduction possibilities

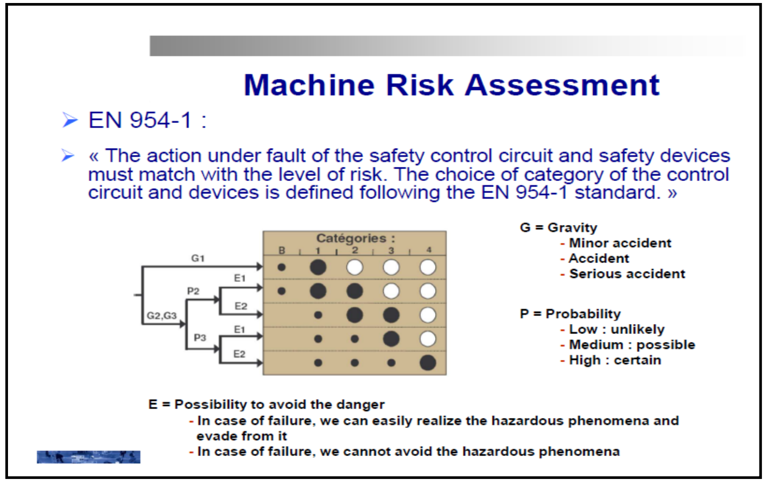
Probability of occurrence of harm	**Severity of harm**			
	Catastrophic	Serious	Moderate	Minor
Very likely	High	High	High	Medium
Likely	High	High	Medium	Low
Unlikely	Medium	Medium	Low	Negligible
Remote	Low	Low	Negligible	Negligible

Unfortunately there are more than 100 risk estimation methods on the internet.

Insignificant	**Category 1**	**Category 1**	**Category 1**	**Category 1**	**Category 1**
Minor	**Category 1**	**Category 1**	**Category 2**	**Category 2**	**Category 2**
Moderate	**Category 2**	**Category 2**	**Category 2**	**Category 3**	**Category 3**
Serious	**Category 3**	**Category 3**	**Category 3**	**Category 3**	**Category 4**
Critical	**Category 3**	**Category 3**	**Category 3**	**Category 4**	**Category 4**



The problem is that many of the risk esitation methods are obsolete, withdrawn and/or insufficient.



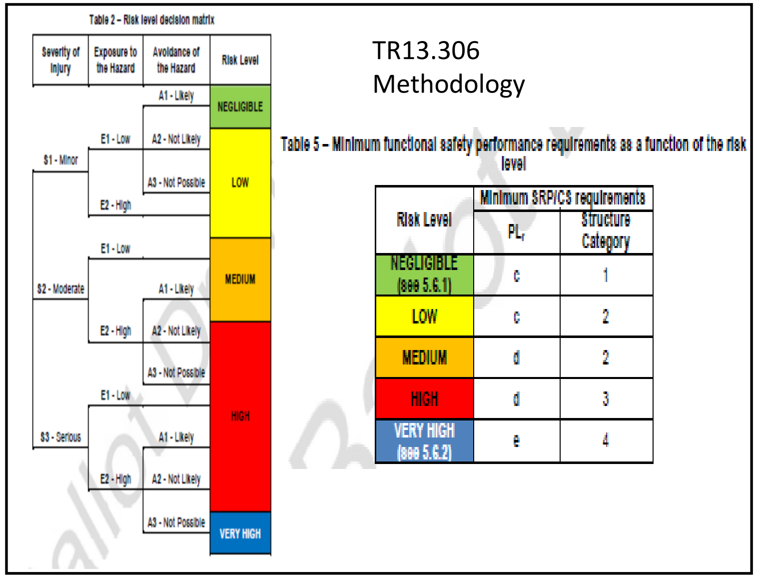


Table 5 – Minimum functional safety performance requirements as a function of the risk level

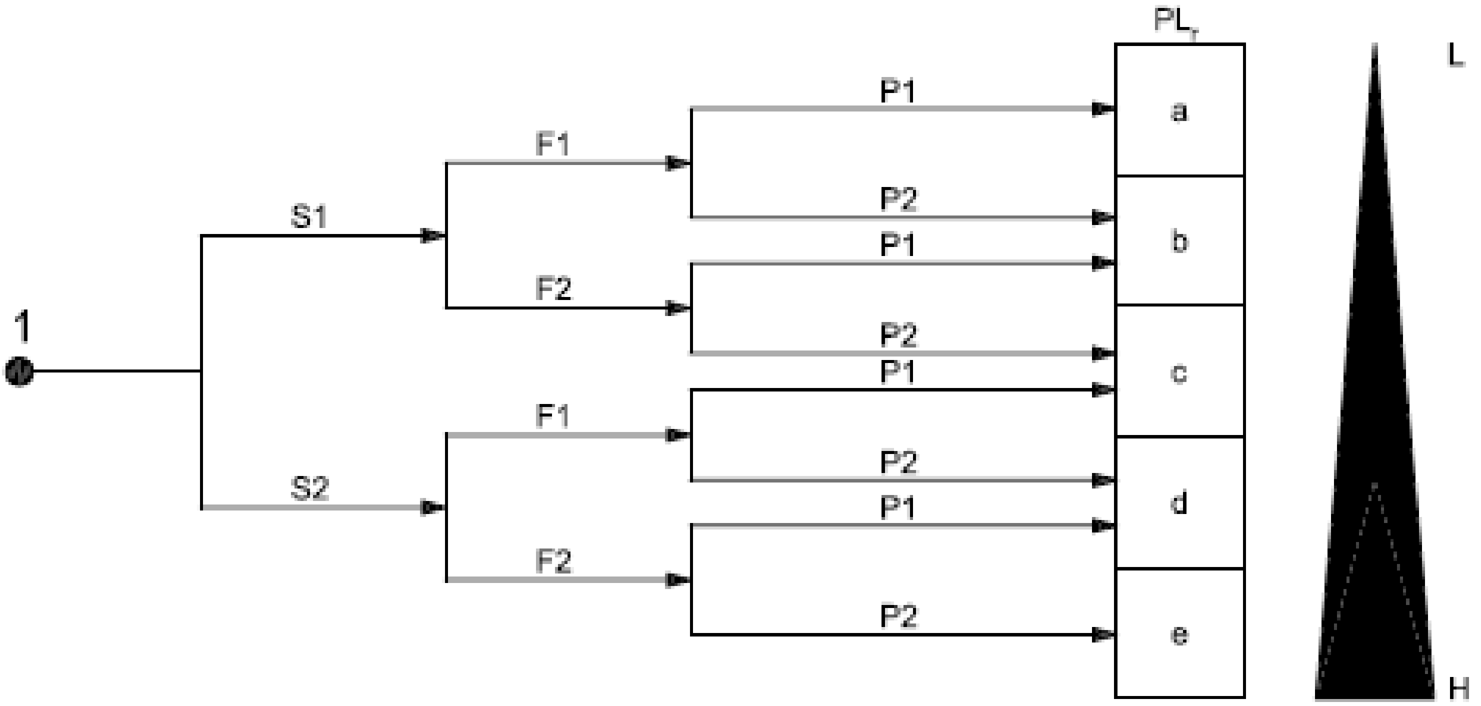
Risk Level	Minimum SRP/CS requirements: PL_r	Minimum SRP/CS requirements: Structure Category
NEGLIGIBLE (see 5.6.1)	c	1
LOW	c	2
MEDIUM	d	2
HIGH	d	3
VERY HIGH (see 5.6.2)	e	4

Risk Assessment Process

- **Risk Graph**
- Risk graph according to ISO13849-1:2015

Figure A.1 — Graph for determining required PL_r for safety function

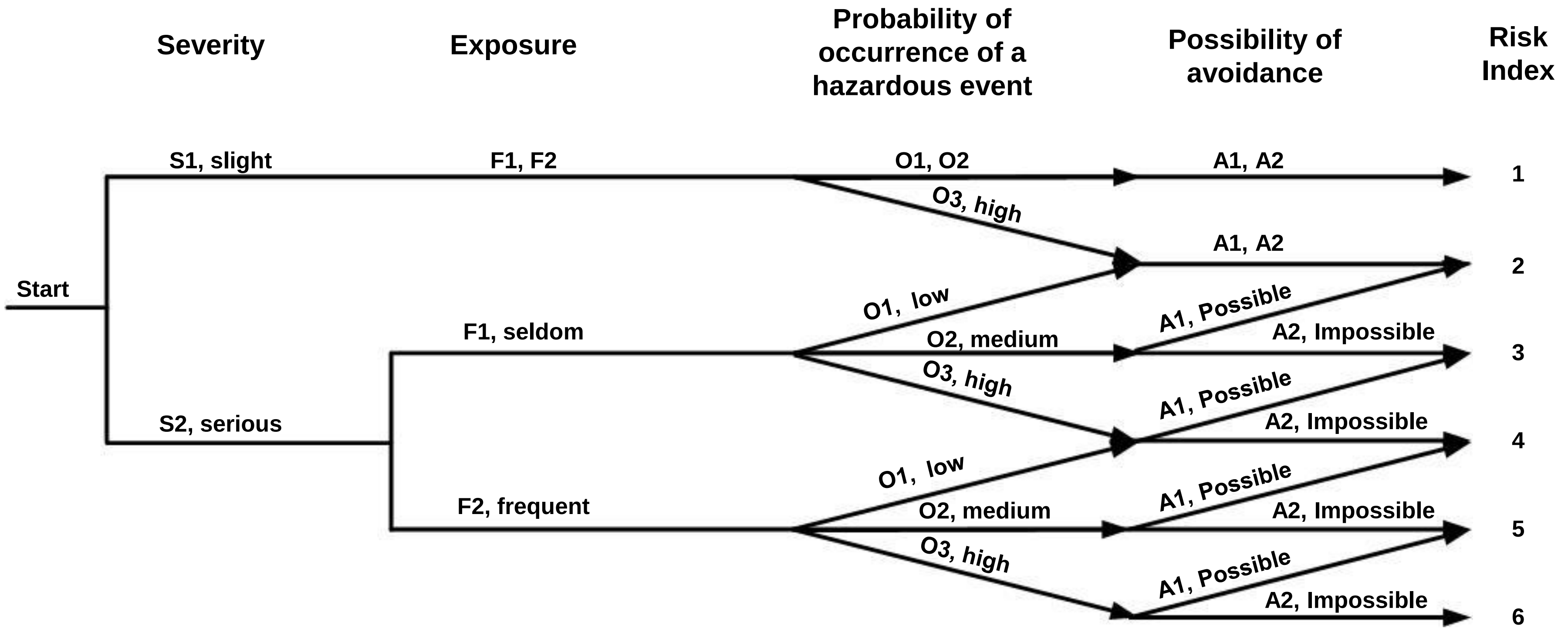
S	severity of injury
S1	slight (normally reversible injury)
S2	serious (normally irreversible injury or death)
F	frequency and/or exposure to hazard
F1	seldom-to-less-often and/or exposure time is short
F2	frequent-to-continuous and/or exposure time is long
P	possibility of avoiding hazard or limiting harm
P1	possible under specific conditions
P2	scarcely possible



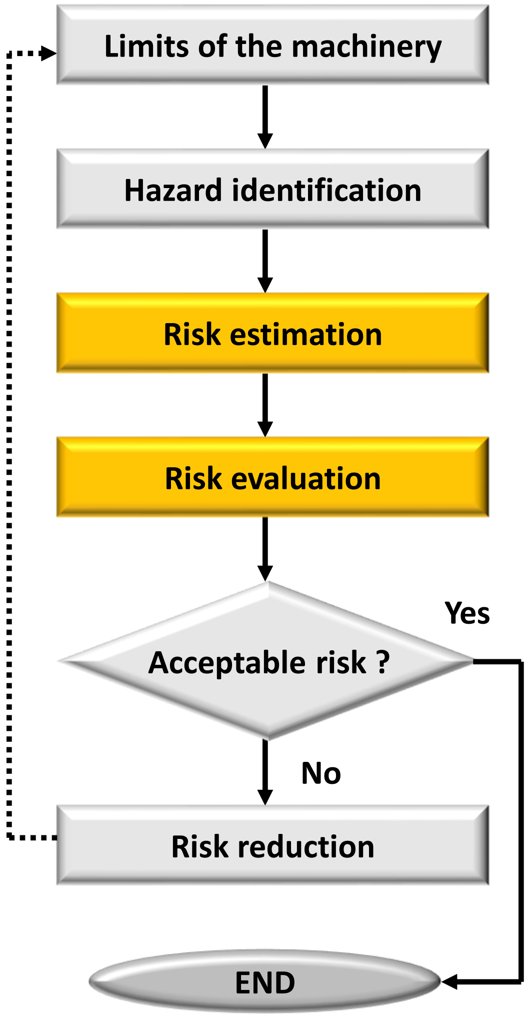
Risk Assessment Process

- **Risk Graph**

- Risk graph according to ISO/TR 14121-2 figure A.3



Risk Assessment Process

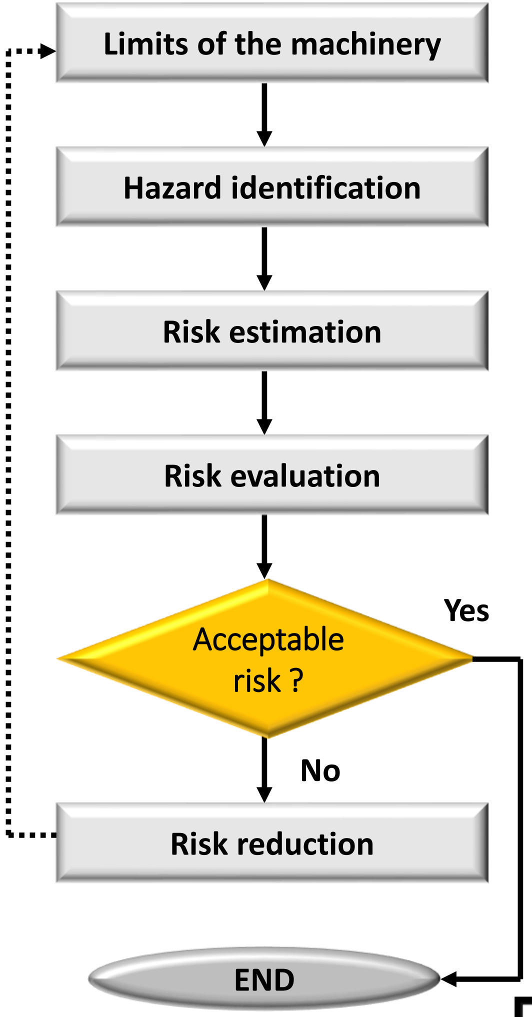


- **Hazard Rating Number system (HRN)**
- Origin: Article on the British Magazine Safety & Health Practitioner (SHP)
  - Chris Steel, 1990
- Numerical values are assigned to the following factors in order to evaluate the risk related with a hazard
  - The likelihood of occurrence (LO)
  - The frequency of exposure (FE)
  - The degree of possible harm (DPH)
  - The number of persons at risk (NP)
- Multiplication of the factors yields the HRN:

$$HRN = LO \times FE \times DPH \times NP$$

- The HRN determines a priority for corrective action based on a numeric range.

Risk Assessment Process



Risk Evaluation

If an acceptable level is not achieved then Risk Reduction Measures must be implemented.

Risk Reduction: 3-step method

- Administrative Controls - Job Rotation, Increasing Signage
- Safe Operating Procedures
- Personal Protective Equipment

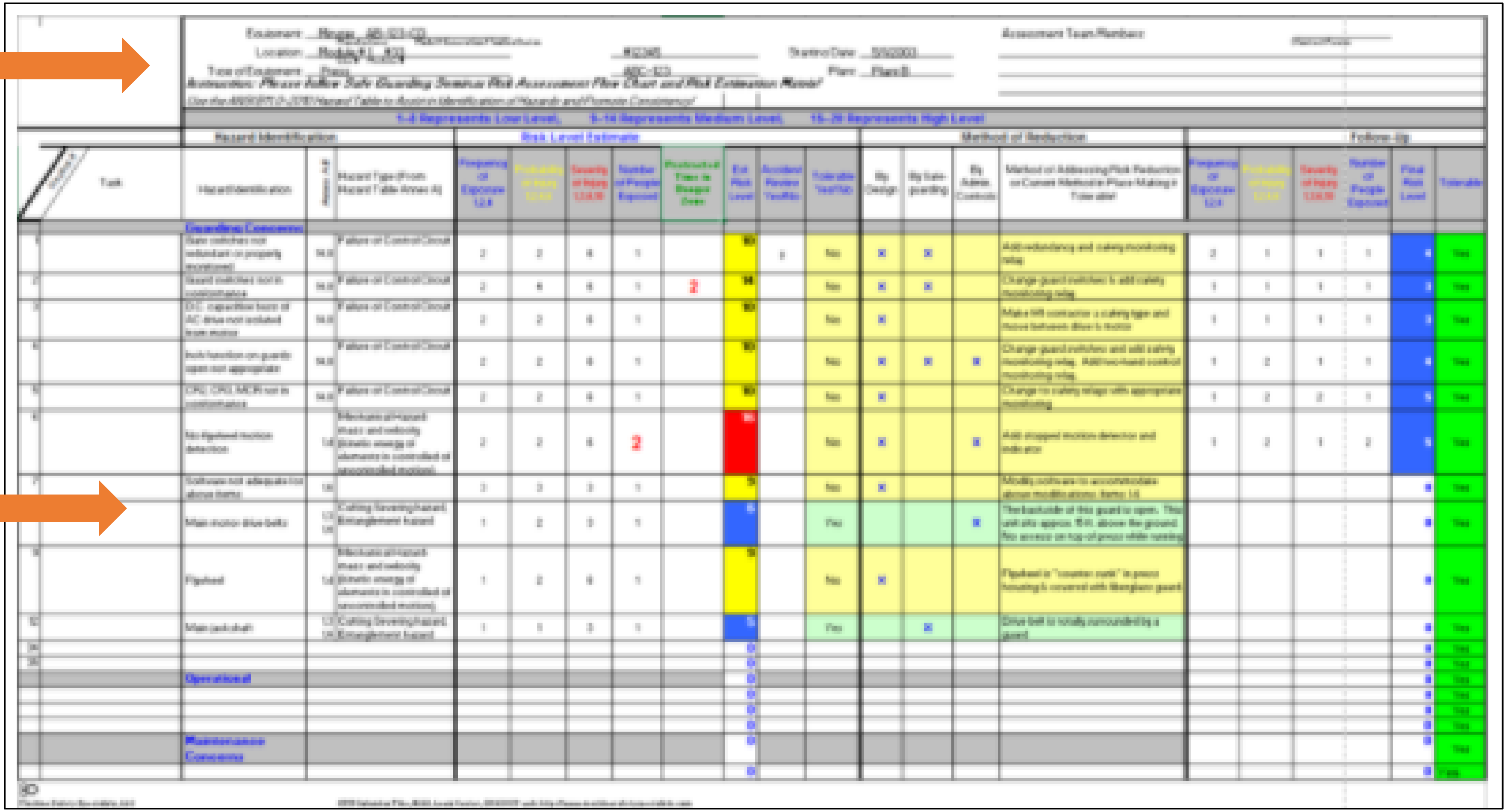
- Engineering Controls
- Complementary Protective Measures

- Elimination
- Substitution
- Modification of Physical Features
- Elimination of Repetitive Activities

What does a good risk assessment look like?

Identifies the who, what, when and where

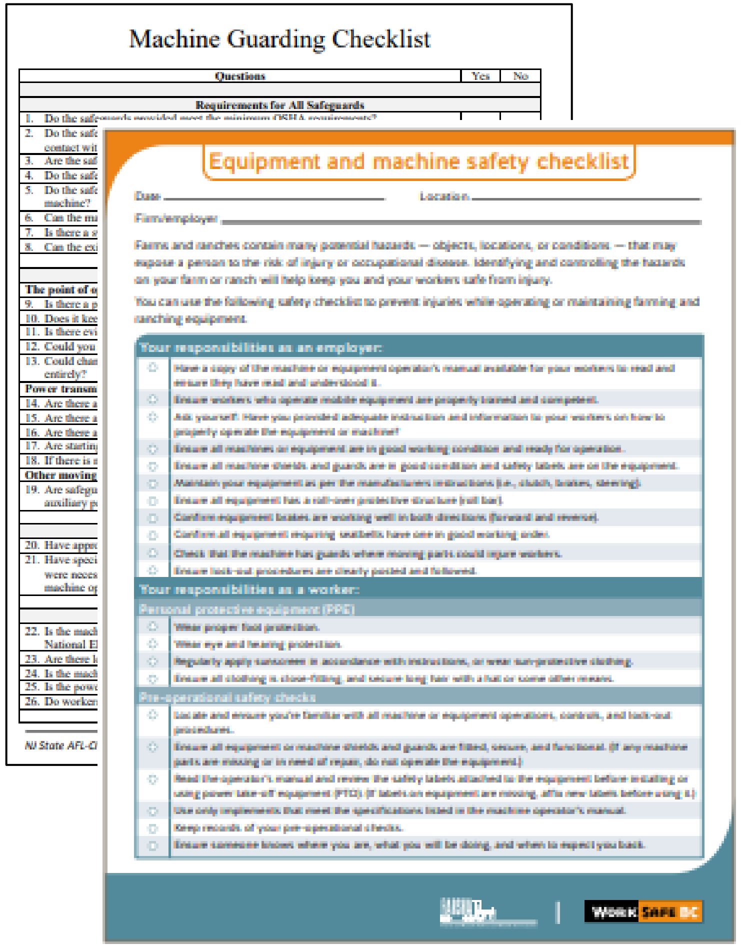
Identifies task and hazard pairs for each mode of operation for every energy source



Task | Hazard | Risk | Initial Risk Estimation | Result | Risk Reduction | Residual Risk Estimation | Result

What is not a risk assessment!

Checklists are not risk assessments!

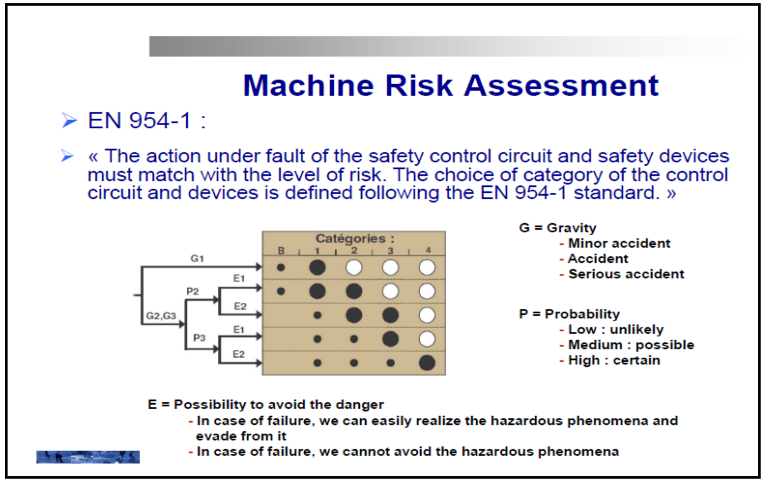


Assessments without risk estimation are not risk assessments!

Hazard	Who might be harmed and how	What are you already doing	Anything else?	Whom?	When?	Done?
Data loss	If we mistake, data can be deleted.	We can backup files on web hard and write noticeboard.	'Always saving' sign attach our staff computers.	All staff	20, Feb	15, Mar
Slips and trips	Anyone can slips and trips walk office like water or equipment.	We always do arrangement and clean the stairs.	'Danger' sign attach in stair and electric cord.	Manager	20, Feb	15, Mar
Weather rains	If we film the video, equipment can be wet. Then can be break down.	Cover up the equipment and filming the video at indoor.	We check the weather often.	Manager Director	20, Feb	15, Mar
Equipment failure	It can be break down by anyone. Anyone can be drop.	We have equipment failure damage insurance	Always be careful and teach how to handle equipment	Manager Director	20, Feb	15, Mar
Traffic accident	If we film the video, we can be car accident.	We drive safety and slowly.	We join the public liability insurance.	Manager	20, Feb	15, Mar

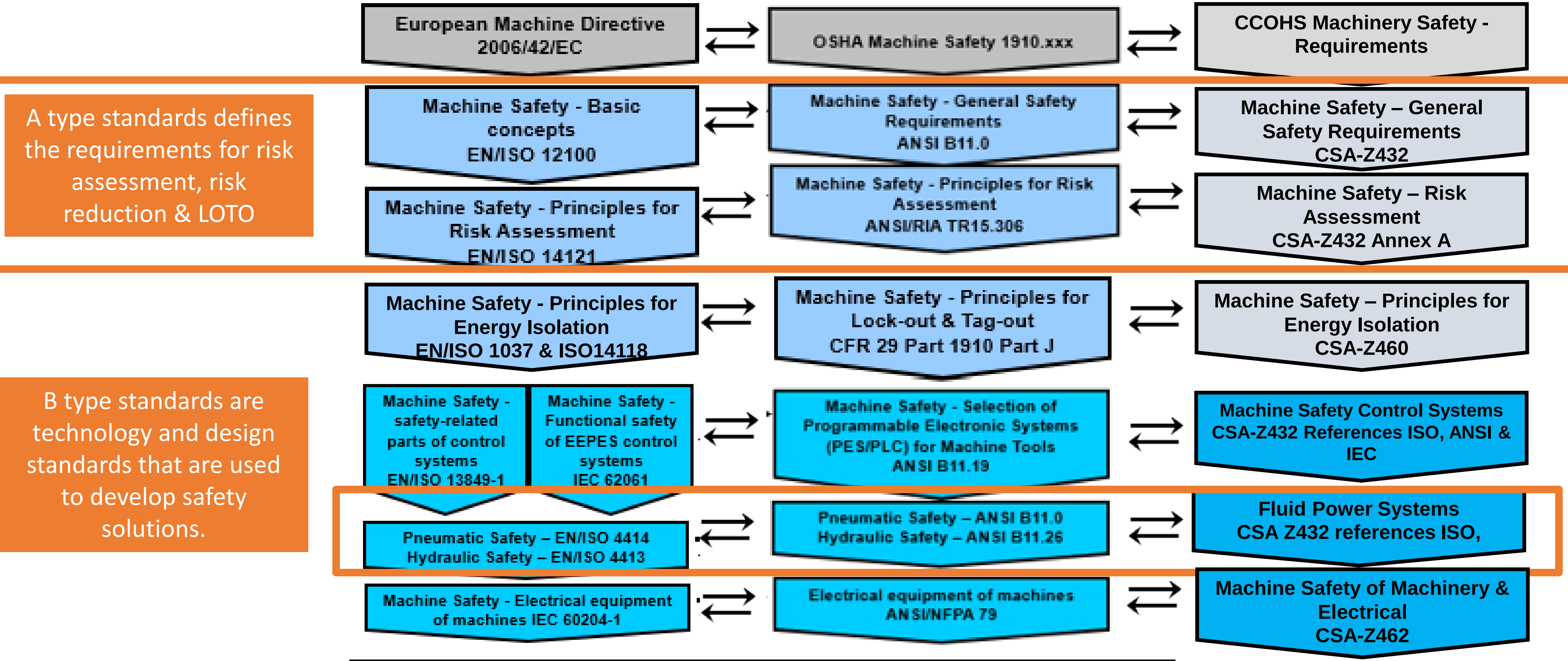
(1) Hazards Identified i.e.: what can cause harm?	(2) Activity / Area of Concern i.e.: what is taking place as part of the event?	(3) Persons at Risk i.e.: who could be harmed by the hazard?	(4) Current Risk Factor (high, medium or low) i.e.: determine the level of risk	(5) Actions to be Taken to Minimize each Risk i.e.: what action can you take to lower the level of risk	(6) New Risk Factor (high, medium or low) i.e.: risk factor after action taken to minimize the risk
Falling over	The main character is running down the garden to the shed.	The main male character.	Moderate	Make sure the weather conditions are alright, with no slippery surfaces, and check the surface for an obstacles.	Low
Electrical shocks	If at any point during the filming there is any use of electrical equipment outside especially if raining	Actors and crew	Moderate	Make sure anything electrical is looked after and that if weather conditions turn then all electric must be turned off and brought inside.	Low

Assessments that result in Categories are not proper assessments!



Insignificant	Category 1	Category 1	Category 1	Category 1	Category 1
Minor	Category 1	Category 1	Category 2	Category 2	Category 2
Moderate	Category 2	Category 2	Category 2	Category 3	Category 3
Serious	Category 3	Category 3	Category 3	Category 3	Category 4
Critical	Category 3	Category 3	Category 3	Category 4	Category 4

The risk assessment should also consider fluid power safety!



ISO4413 & 4414 define the safety requirements for implementing pneumatic & hydraulic safety solutions.

ROSS a global family

DIN EN ISO 4414

Pneumatic fluid power - General rules and safety requirements for systems and their components (ISO 4414:2010)

Fluidtechnik - Allgemeine Regeln und sicherheitstechnische Anforderungen an Pneumatikanlagen und deren Bauteile (ISO 4414:2010)

Standard Number	BS EN ISO 4413:2010
Title	Hydraulic fluid power. General rules and safety requirements for systems and their components (CD-ROM)
Status	Current
Publication Date	31 July 2011

How do these standards affect safety design and implementation?

ISO4413 & ISO4414 say Fluid Power Risk Must be Considered

INTERNATIONAL STANDARD

ISO 4414

Third edition
2010-11-15

5. General rules and safety requirements

5.1 General

5.1.1 When designing pneumatic systems for machinery, all intended operations and use of systems shall be considered. Risk assessment, e.g. in accordance with ISO 14121-1, shall be carried out to determine the foreseeable risks associated with systems when they are used as intended. Reasonably foreseeable misuse shall not cause hazards. The risks identified shall be eliminated by design and, where this is not practicable, safeguards (first preference) or warnings (second preference) against such risks shall be incorporated, in accordance with the hierarchy established in ISO 12100.

NOTE This International Standard provides requirements for components of fluid power systems; some of these requirements are dependent on the hazards associated with the machine in 3which the system is installed. Therefore, the final specification and construction of the pneumatic system could need to be based on risk assessment and agreement between purchaser and supplier.

5.1.2 The control systems shall be designed in accordance with the risk assessment. This requirement is met when ISO 13849-1 is used.

There are specific requirements for risk assessment and the use, implementation and utilization of hydraulic and pneumatic components in control systems according to ISO13849-1.

ISO13849-1 says that pneumatics and hydraulics are part of the safety system and that it must be evaluated.

ISO13849-1 says that pneumatics and hydraulics are part of the Safety Related Parts of the Control System. This means they must be considered and evaluated as well.

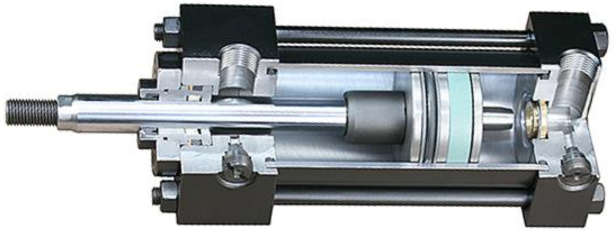
- Pneumatics and hydraulics are part of the SRP/CS
  - safety related parts of the control system
  - Requires "proven in use" or "well tried components"
  - Requires "well tried safety principles"

ISO13849-1 lists ISO4413 and ISO4414 as standards to utilize when pneumatic and hydraulics are used and implemented on machinery. IEC 62061 does not.

This means that we need to think about pressure and force.

Pneumatic & Hydraulic Risk

- Does it create motion?
- Vertical or Horizontal?
    - Gravity / Weight of tooling
    - Speed / Inertia to stop?
    - Tooling > Crushing? Piercing? Cutting?
    - Pressure / Force?



Pneumatic Risk

- Force with pneumatic energy
    - 1” Bore at 100 psi = 79#
    - 2” Bore at 100 psi = 314#

We need to think about powered and unpowered hazards, like falling loads!

Today's standards give us exact requirements for assessing and reducing fluid power risk.

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

Table 4 — Injury and Severity Correlations

Following are some values extrapolated from literature referenced in the notes below the Table. Values may differ based on application specific data or individual susceptibilities

Injury Type	Catastrophic	Serious	Moderate	Minor
Burns, Thermal **Hot Surface** * [1] The severity of injury is relative to the amount of body surface area, the duration of exposure, and the temperature of the hot surface.	3rd degree burns typically caused by temperatures > 68° C (>154° F) with exposure durations of one second, and on skin surface areas over 1% or more of the body i.e., palm of hand.	3rd degree burns typically caused by temperatures > 68°C (>154° F) with exposure durations of one second, and on skin surface areas less than 1% of the body.	2nd degree burns typically caused by temperatures 60° - 68°C (140°F – 154°F) with exposure durations of one second.	1st degree burns typically caused by temperatures (44 °C - 59°C (111°F – 139°F) with exposure durations of one second.
Burns, Thermal **Vapor or splash of viscous material** [1] Vapor exposure assumes instantaneous contact; viscous materials assume continuous contact greater than 1 second.	3rd degree burns typically caused by temperatures > 60°C (>140° F) and on skin surface areas over 1% or more of the body i.e., palm of hand.	3rd degree burns typically caused by temperatures > 60° C (>140°F) and on skin surface areas less than 1% of the body.	2nd degree burns typically caused by temperatures 44° C - 59° C (111°F – 139° F).	1st degree burns typically caused by temperatures 38° C – 43° C (100° F – 110° F).
Lacerations** [2] Amputation force is derived from literature search that identified pain and fracture thresholds at 150 N (33.7 lbf), 400 N (89.9 lbf), 2000 N (449.6 lbf) 80 mm (3.15 in)diameter load cell.	Lacerations or amputations that could result in death or permanently disabling injury such as blindness.	Lacerations of the head or face requiring sutures or other closure in lieu of sutures or partial blindness typically caused by: • flying projectiles; • stationary sharp edges; • blunt, sharp edges. Amputation, typically caused by: • sharp edges mechanically in motion (e.g. rotating, reciprocating, shearing); • offset, blunt edges with loads exceeding 28 kPa (4psi).	Lacerations, not involving the face, requiring sutures or other closure in lieu of sutures typically caused by: • stationary sharp edges; • blunt, sharp edges.	Minor cuts requiring bandaging treatment; typically caused by: • stationary blunt surfaces; • offset, blunt edges with loads less than 28 kPa (4psi).
Fracture [2] Fracture and amputation force are derived from literature search that identified pain and fracture thresholds at 150 N, 400 N and 2000 N using an 80mm diameter load cell. 150 N (33.7 lbf), 400 N (89.9 lbf), 2000 N (449.6 lbf) 80 mm (3.15 in).	**399.9 kPa (58 psi)**	Fracture of long bones in arms, legs or fracture of the skull or spine, typically caused by loads exceeding 297 kPa (43 psi) and 399.9 kPa (58 psi)under certain test conditions.	Fracture of small bones (e.g., hands, fingers, toes), typically caused by loads between 297 kPa (43 psi) and 399.9 kPa (58 psi).	Contusions and skin abrasions typically caused by loads between 83 kPa (12 psi) and 297 kPa (43psi)under certain test conditions. No physical signs typically caused by loads less than 83 kPa

These standards identify several risk levels based on the risk of fluid power energy and categorizes them into Catastrophic, Serious, Moderate and Minor.

Moderate, Serious & Catastrophic injuries require the use of safety solutions that meet Performance Levels C, D and E according to ISO13849.

- Per EN 13736 there is a Risk of injury if:

  Force > 150 N (33.8 lbf)

  Weight of tooling > 15 kg (33 lbs)

- Per ANSI B11.0 the Risk is:

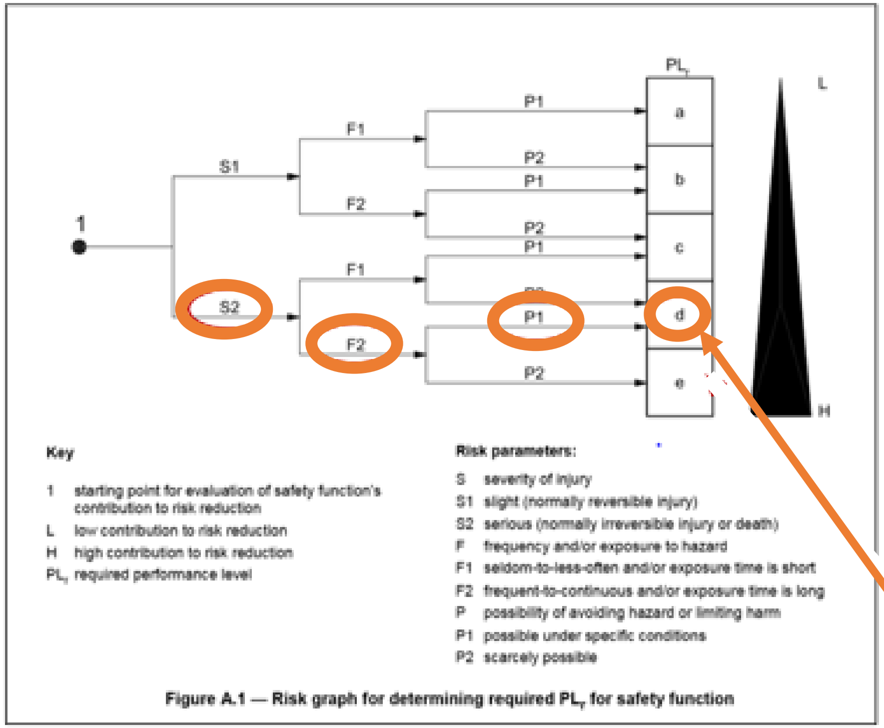
Moderate	150 N (33.7 lbf) < Force < 400 N (90)	PLc
Serious	400 N (90 lbf) < Force < 2000 N (450)	PLd
Catastrophic	Force > 2000 N (450 lbf)	PLe

Bore	Area	Force (60 psi)	Force (80 psi)	Force (100 psi)
0.75	0.44	27	35	44
1	0.79	47	63	79
1.25	1.23	74	98	123
1.5	1.77	106	141	177
2.5	4.91	295	393	491
3	7.07	424	565	707
4	12.57	754	1005	1257

Bore	Area	Force (5.5 BAR)	Force (7 BAR)	Force (10 BAR)
14	153.94	85	108	154
22	380.13	209	266	380
27	572.55	315	401	573
50	1963.49	1080	1374	1963
63	3117.24	1714	2182	3117
80	5026.54	2765	3519	5027

The problem is that the performance levels defined with this method may vary from the basic assessment methods.

Use of a basic risk estimation tool might recommend PLd system performance for the press below



Most people don't evaluate fluid power hazards because they do not evaluate pressure and force! They use a simplified tool like ISO1349 which results in an insufficient requirement.

The combination of a S2 severe injury, an F2 frequent access and a P1 possible to avoid would result in a Required Performance Level of PLd.

The Problem is That We Never Looked at Pressure and Force

Bore	Area	Force (60 psi)	Force (80 psi)	Force (100 psi)
0.75	0.44	27	35	44
1	0.79	47	63	79
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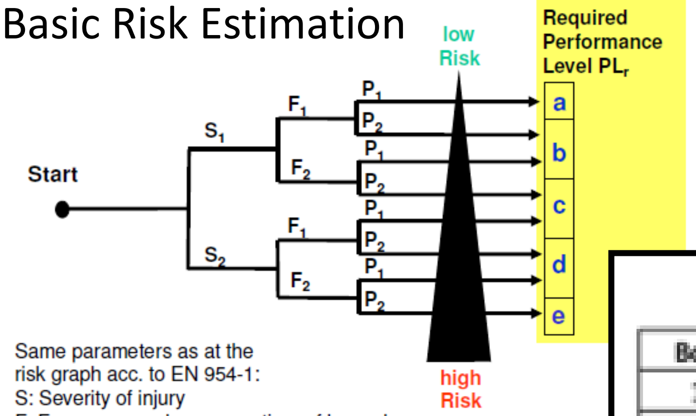
- Most Presses operate at pressures in the 7 to 10 bar range
- Most Presses have cylinders that are 70mm or larger.
- This means the pressure and force could be in the red area of the table above. **This could drive a design requirement of PLe because we are over the 2000 N range.**

Situations like this are driving companies to use 2 or 3 Step in Assessment Processes

Task Type Assessment
- Energy Isolation
- Machinery Safety
- Task Based Isolation

Basic Risk Estimation



Same parameters as at the risk graph acc. to EN 954-1:
S: Severity of injury
F: Frequency and exposure time of hazard
P: Possibility of avoiding the hazard

Things to think about:
- Do you need to do a PL calculation for a task that is a maintenance service and repair task?
- Could a basic risk estimation using severity, frequency, avoidance and probability lead to an insufficient PLr?
- Should you consider pressure and force in your risk assessment to ensure that your design is adequate?

Pressure & Force Analysis

Bore	Area	Force (5.5 BAR)	Force (7 BAR)	Force (10 BAR)
14	153.94	85	108	154
22	380.13	209	266	380
27	572.55	315	401	573
50	1963.49	1080	1374	1963
63	3117.24	1714	2182	3117
80	5026.54	2765	3519	5027

These steps would result in an accurate Performance Level Requirement with all tasks mapped by job function. This points us in a defined direction when it come to reducing risk.

Thank you for attending.

Have a safe and productive day!