ISO/TS15066 Collaborative robots

PILZ
THE SPIRIT OF SAFETY

Guide to industry acceptance with the new „ISO TS 15066“ – colaborative robots“ standard

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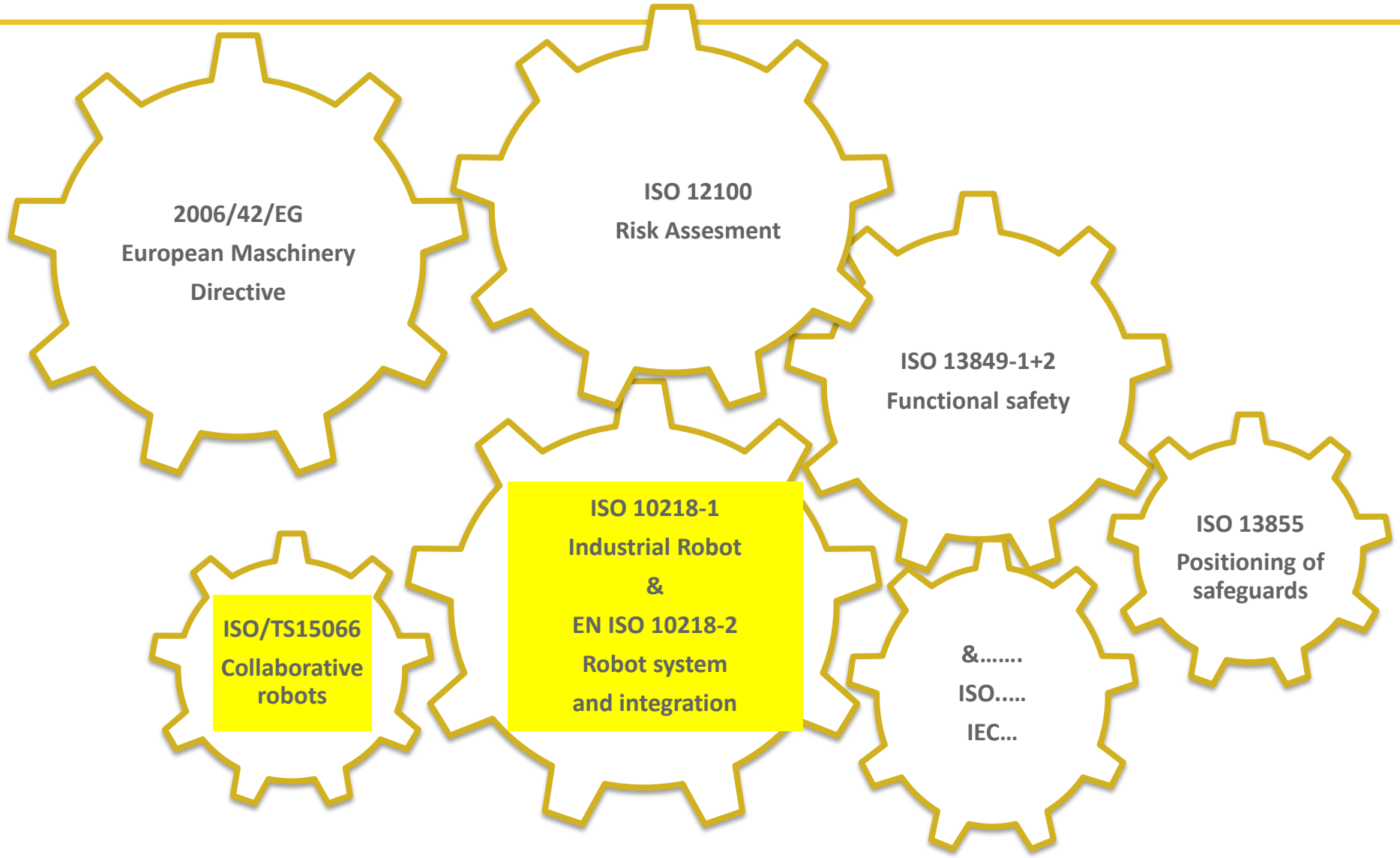
  3. Choise: safety functions => requirements *(……chapter 5, Annex A)*
  4. Create: Instruction manual *(ISO/TS 15066 chapter 7)*
  5. Effected: Verifcate and validate *(ISO/TS 15066 chapter 6)*

Collaborative robots



ISO/TS15066 Collaborative robots

- **The information in this PPT is based on ISO/PDTS15066** (Date 27.08.15)
  ISO/TC 184 SC2 working group WG3: Robots and robotic devices
  The goal of the working group is to published a FDIS Version
  at the end of 2015.

- **ISO/TS 15066 Robots and robotic devices — Collaborative robots**

- This Technical Specification supplements and specifies **additional guidance** for collaborative industrial robot operation as described in ISO 10218-1:2011 and ISO 10218-2:2011

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What is TS Technical Specification?

- A normative document representing the technical consensus within an ISO committee

- Link to ISO: Find a lot of information about Standards Committees,....

  http://www.iso.org/iso/home/standards_development/deliverables-all.htm?type=ts

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(chapter 3 Terms and defintions)

What is a collaborative operation?

3.1 collaborative operation

state in which a purposely designed robot system and an operator work within a collaborative workspace (modified from ISO 10218-1)

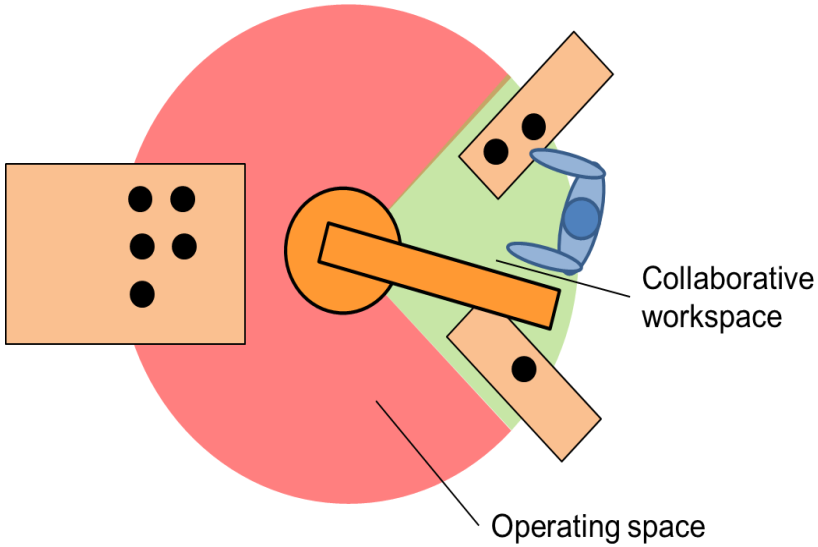

Figure 1 — Example of a collaboratve workspace

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(chapter 3 Terms and defintions)

What is a Quasi-static contact?

3.4 Quasi-static contact

Contact between an operator and part of a robot system where the operator body part can be clamped between a moving part of a robot system and another fixed or moving part of the robot cell

What is a Transient contact / Dynamic contact?

3.5 Transient contact / Dynamic contact

Contact between an operator and part of a robot system where the operator body part is not clamped and can recoil or retract from the moving part of the robot system

Steps to a safe collaborativ robobts system with ISO/TS 15066

General:

Make first theoretical the concept for the design and indentificate the hazards in a risk assessment => then by the robot with the saftey functions you need. (see 4.3.1….the Integrator is responsible for selection the appropriate robot system….)

Steps to a safe collaborative robots system with ISO/TS 15066

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(chapter 4.2 collaborative application design)

What is to consider by design?

- 4.2 collaborative application design
  - a) Limits (three dimensionals)
  - b) Collaborative workspace, access and clearance
    - Foreseeable contact, access routes,.....
  - c) Ergonomics and human interface with equipment
    - Possible stress, required training,....
  - d) use limits
    - Identicate persons with access,....
  - e) transitions (time limits):
    - Starting and ending,.....

Steps to a safe collaborative robots system with ISO/TS 15066

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(chapter 4.3 Hazard identification and risk assessment)

- **What is to consider in a hazard indetification and risk assessment?**

- ISO10218-2: 4 Hazard identification and risk assessment
- Additional 4.3 Hazard identification and risk assessment
  - The user should participate in the risk assessment
  - …..

- **The risk assestment is the most important work for a a safe collaborative system. Do it very carefully in 4.3.2 Hazard Indentification you have a list of hazards.**

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(chapter 4.3 Hazard identification and risk assessment)

- Additional 4.3.2 Hazard identification

  .....

  a) robot related hazards, including:
  robot characteristic, quasi static-contact, operation location,....

  b) hazards related **to the robot system**, including:
  end-effector and workpiece hazard, fixture design, design and location of any manually controlled robot guiding devices,.....

  c) application related hazards, including:
  process-specific hazards,....

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(chapter 4.3 Hazard identification and risk assessment)

- **As well in the risk assestment is 4.3.3 Task idendification**

- ISO10218-2: 4 Hazard identification and risk assessment
- Additional 4.3.3 Task identification
  In consultation with the user, the integrator shall identify and **document** the tasks....

- The collaborative tasks can be characterized by:
  Frequency and duration, automatic or manual restart,...

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(chapter 4.3 Hazard identification and risk assessment)

- **As well in the risk assestment is 4.3.4 Hazard elimination and risk reduction**
- ISO10218-2: 4.1.2
- Additional 4.3.3 Hazard elimination and risk reduction
  After hazards are identified, it is necessary to assess the risks associated with the collaborative robot system before applying risk reduction measures....
  E.g. the elimination of hazards by inherently safe design or their reduction by substitution,....

- For traditional robot systems, risk reduction is typically achieved through safeguards that separate the operator from the robot system. For collaborative operation, the risk reduction is **primarily addressed by the design** and **application** of the robot system and of the **collaborative workspace.**

Steps to a safe collaborative robots system with ISO/TS 15066

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(chapter 5 Requirements for collaborative robot system applications*)*

- **What are the requirements for the safety functions?**

- ISO10218-2: 5.11 Collaborative robot operation
  ISO 10218-1: 5.10 Collaborative operation requirements
  Additional 5 Requirements for collaborative robot system applications

- 5.2 Safety-related control system performance
  (electric, hydraulic, pneumatic and software)
  - Comply with ISO 10218-1 chapter 5.4
    - **PL = d with structure category 3**
    - ….
  - Comply with ISO 10218-2 chapter 5.2
    - **PL = d with structure category 3**
    - ….

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(chapter 5.3 Design of the collaborative workspace)

- **What is to mind of the collaborative workspace?**

- ISO10218-2: 5.11Collaborativ robot operation
- Additional 5.3 Design of the collaborative workspace controlled.
  - **Risks associated** with whole body trapping or crushing between the robot system and, for example, parts of buildings, structures, utilities, other machines, and equipment, shall be eliminated or safely controlled.
  - …..

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(chapter 5.4 Design of the collaborative robot operation)

- **What is to mind by design the collaborative operation?**

- ISO10218-2: 5.11Collaborativ robot operation
- Additional **5.4 Design of the collaborative robot operation**

- Additional **5.4.2 Protective measure**
  - **All persons** within the collaborative workspace shall be protected by **protective measures.**

  - safety parameters shall be capable of being viewed and documented with a unique identifier **(e.g., checksum)**
  - Settings and adjusting collaborative safety parameters shall be protected by **password protection** or similar security measures.

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(chapter 5.4 Design of the collaborative robot operation)

- **What is to mind by design the collaborative operation?**

- Additional **5.4.3 Stopping functions**

Examples of means to stop robot motion can include,
but are not limited to:

a) an enabling device
b) an emergency stop device
c) stopping the robot by hand, in the case of robots that include this feature.

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(chapter 5.4 Design of the collaborative robot operation)

- **What is to mind by non-collaborative/collaborative operation?**

- Additional **5.4.4 Transitions between non-collaborative operation and collaborative operation**

  …are particularly critical parts of a collaborative application.

  These shall be designed such that the robot system shall not pose **unacceptable risks** to the operator during the transition.

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(chapter 5.4 Design of the collaborative robot operation)

What is to mind by the enabling device ?

- ISO10218-1: 5.8.3 Enabling deviceCollaborativ robot operation
- Additional **5.4.5 Enabling device requirements**
  - Decide in the risk assessment enabling device yes or no
  - Without enabling device
    The safety-rated limiting functions (e.g. speed, force, or range) shall always remain active,.....
    Information for use is necessary

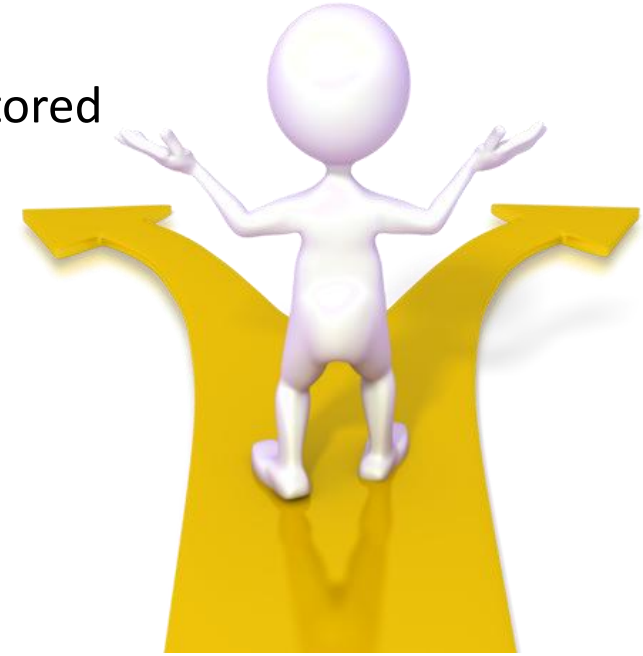
What is to mind by the collaborative operations?

5.5 Collaborative operations

Collaborative operations may include **one or more** of the following methods:

a) safety-rated monitored stop

b) hand guiding



c) speed and separation monitoring

d) power and force limiting.

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(chapter 5.5 Collaborative operations)

- ISO10218-2: 5.11 Collaborative robot operation

- Additional 5.5 Collaborative operations

Collaborative operations may include **one or more** of the following methods:

a) safety-rated monitored stop

b) hand guiding

c) speed and separation monitoring

d) power and force limiting

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(chapter 5.5.1 Safety-rated monitored stop)

- When did you use the method **Safety-rated monitored stop**?

Table 1 – Truth table for safety-rated monitored stop operational requirements

Robot motion or stop function		Operator's proximity to collaborative workspace	
		Outside	Inside
Robot's proximity to collaborative workspace	Outside	Continue	Continue
	Inside and moving	Continue	Protective stop
	Inside, at Safety-Rated Monitored Stop	Continue	Continue

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(chapter 5.5.1 Safety-rated monitored stop)

- **What are the requirements for Safety-rated monitored stop**?

- ISO10218-1: 5.10.2 Safety-rated monitored stop (only 7 lines)
- ISO10218-2: 5.11.5.2 Safety-rated monitored stop

- Additional 5.5.1 Safety-rated monitored stop
  For collaborative operation with safety-rated monitored stop...
  a) When robot motion is limited, the limits shall comply with ISO 10218-2:2011, 5.12

  b) Stop category 0 or 1 or 2

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(chapter 5.5 Collaborative operations)

- ISO10218-2: 5.11 Collaborative robot operation

- Additional 5.5 Collaborative operations

Collaborative operations may include **one or more** of the following methods:

a) safety-rated monitored stop

b) hand guiding

c) speed and separation monitoring

d) power and force limiting

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(chapter 5.5.2 Hand guiding)

What are the requirements for hand guiding?

- ISO10218-1: 5.10.3 Hand guiding
- ISO10218-2: 5.7.4 Hand guiding of robot systems (collaborative robots)

- Additional 5.5.2 **Hand guiding**
  - Before the operator enter the collab. Workspace => safety-rated monitored stop

- Additional 5.5.2.2 **Requirements**
  The robot shall utilize a safety-rated monitored speed function (ISO 10218-1:2011, 5.6.4) and a safety-rated monitored stop function (5.5.1).
  A risk assessment shall be used to determine the safety-rated monitored speed limit.

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(chapter 5.5 Collaborative operations)

- ISO10218-2: 5.11 Collaborative robot operation

- Additional 5.5 Collaborative operations

Collaborative operations may include **<u>one or more</u>** of the following methods:

a) safety-rated monitored stop

b) hand guiding

c) speed and separation monitoring

d) power and force limiting

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(chapter 5.5.3 Speed and separation monitoring)

What are the requirements for speed and separation monitoring?

- ISO10218-1: 5.10.4 Speed and separation monitoring
- ISO10218-2: 5.11.5.4 Speed and separation monitoring

- Additional 5.5.3 **Speed and separation monitoring**
- Additional 5.5.3.2 **Requirements**
  - shall be equipped with a **safety-rated monitored speed function** and a **safety-rated monitored stop function**
  - If operator safety is dependent on limiting the range of motion of the robot, the robot shall be equipped with **safety-rated soft axis and space limiting** (ISO 10218-1:2011, 5.12.3). The speed and separation monitoring system shall meet the requirements of 5.2.
  - .....

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(chapter 5.5.3 Speed and separation monitoring)

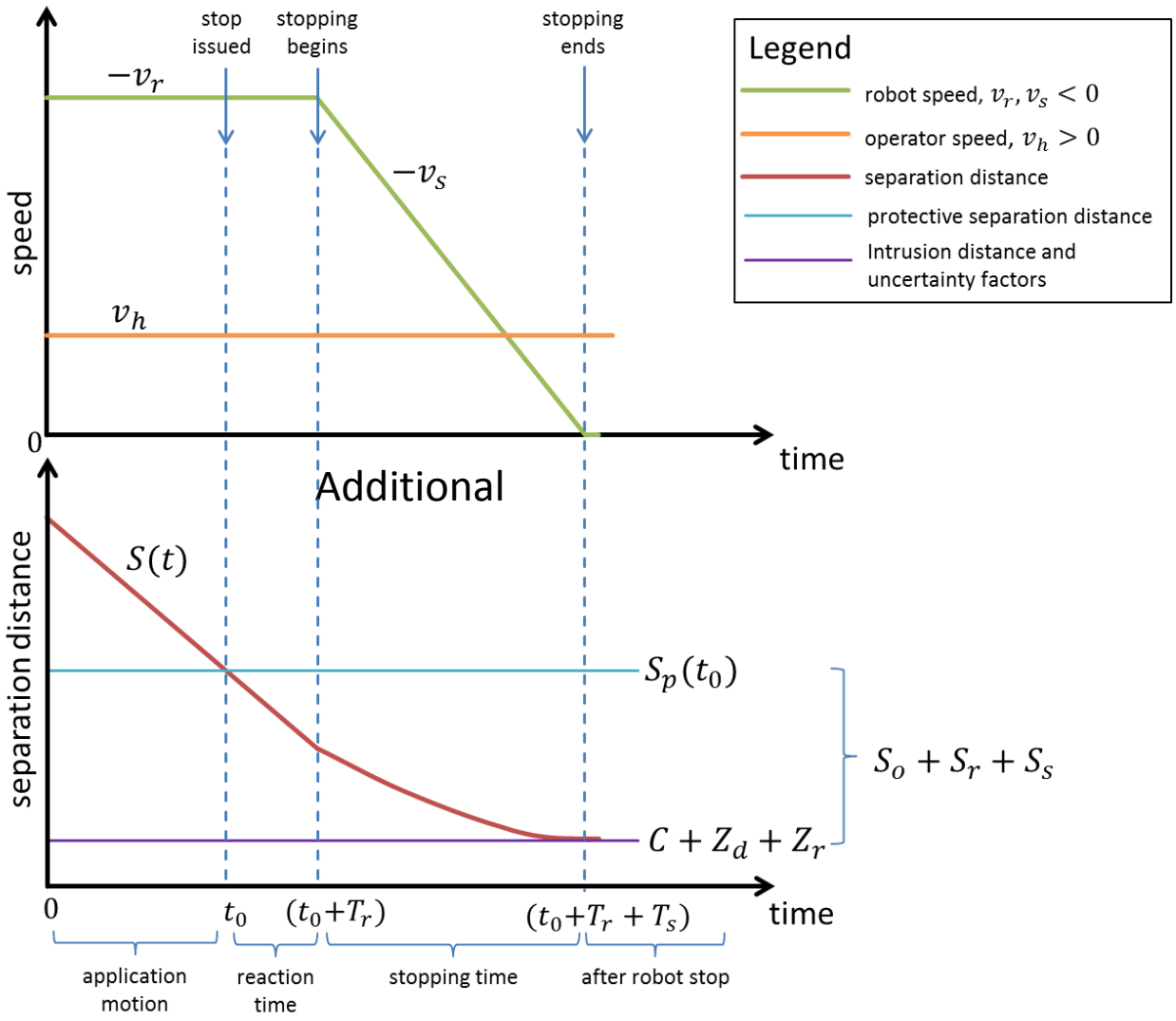

Figure 2 — Graphical representation of the contributions to the protective separation distance between an operator and a robot

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- ISO10218-2: 5.11 Collaborative robot operation

- Additional 5.5 Collaborative operations

Collaborative operations may include **one or more** of the following methods:

a) safety-rated monitored stop

b) hand guiding

c) speed and separation monitoring

d) power and force limiting

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(chapter 5.5.4 Power and force limiting*)*

What are the requirements for Power and force limiting?

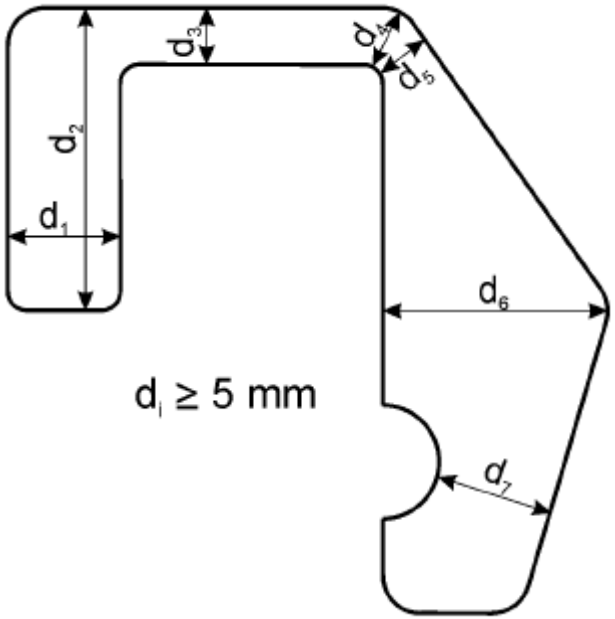
- ISO10218-1: 5.10.5 Power and force limiting by inherent design or control
- ISO10218-2: 5.11.5.5 Power and force limiting by design or control

- Additional 5.5.4 Power and force limiting
  - Risk reduction is achieved, inherently safe robot machinery or through a safety-related control system => **Limits in accordance with Annex A**

- Additional 5.5.4.2 **Contact situations**
  - quasi-static contact
  - transient contact
  - Tipp Risk assessment. The TCP is important but think about the complete kinematik => manipulator arm, linkages, tooling and workpiece

Additional 5.5.4.4 **Passive and active risk reduction measures**
Risk reduction measures with “benifits”

– **increasing** the contact surface area. Round edges/corner, smooth/comliant surfaces



Source: BGIA Ausgabe Oktober 2009, Fassung Februar 2011 U 001/2009

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(chapter 5.5.4 Power and force limiting*)*

Additional 5.5.4.4 **Passive and active risk reduction measures**

Risk reduction measures with “benifits”

- **absorbing** energy, extending energy transfer time, or reducing impact forces
- **limiting** moving masses

Active safety **design methods** include, but are not limited to:

- **limiting** forces or torques, velocities of moving parts, momentum
- **safety-rated** soft axis and space limiting function,monitored stop function
  use of sensing to anticipate or detect contact

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(chapter 5.5.4 Power and force limiting*)*

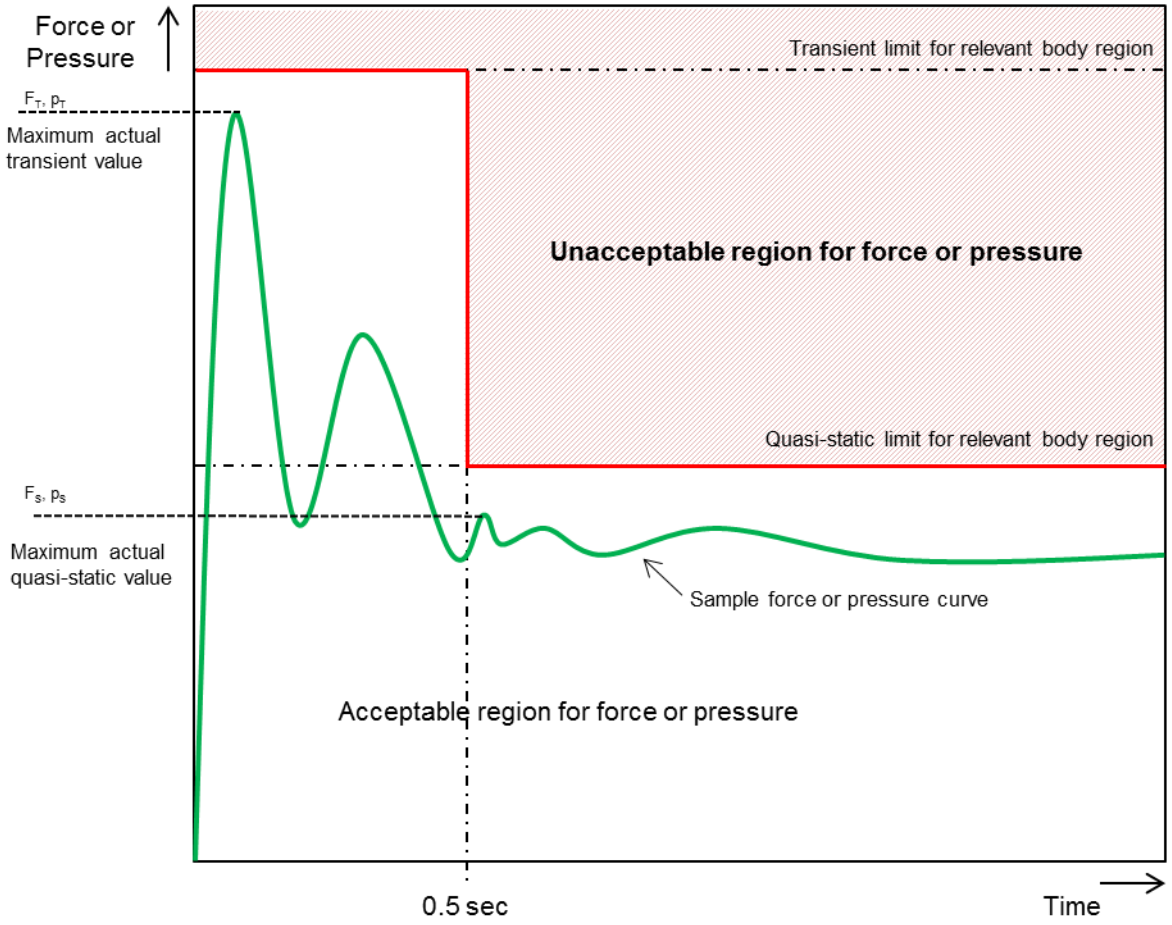

Figure 3 — Graphical representation of acceptable and unacceptable forces or pressures

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(Annex A Table A.2 Biomechanical limits)

Table A.2 — Biomechanical limits¶

Body Region¤		Specific Body Area¤	Quasi-Static Contact¤		Transient Contact¤	
			Maximum Allowable Pressure ¶ p_s [N/cm2]¶ (see NOTE 1)¤	Maximum Allowable Force¶ [N]¶ (see NOTE 2)¤	Maximum Allowable Pressure Multiplier P_T (see NOTE 3)¤	Maximum Allowable Force Multiplier F_T¶ (see NOTE 3)¤
Skull and forehead¤	1¤	Middle of forehead¤	130¤	130¤	N/A¤	N/A¤
	2¤	Temple¤	110¤		N/A¤	
Face¤	3¤	Masticatory muscle¤	110¤	65¤	N/A¤	N/A¤
Neck¤	4¤	Neck muscle¤	140¤	150¤	2¤	2¤
¤	5¤	Seventh neck muscle¤	210¤		2¤	
Back and shoulders¤	6¤	Shoulder joint¤	160¤	210¤	2¤	2¤
	7¤	Fifth lumbar vertebra¤	210¤		2¤	2¤
Chest¤	8¤	Sternum¤	120¤	140¤	2¤	2¤
¤	9¤	Pectoral muscle¤	170¤		2¤	
Abdomen¤	10¤	Abdominal muscle¤	140¤	110¤	2¤	2¤
Pelvis¤	11¤	Pelvic bone¤	210¤	180¤	2¤	2¤

CRITICAL ZONE¶

Annex A Table A.2 Biomechanical limits

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(chapter 7 Information for use*)*

What are the requirements for Power and force limiting?

- ISO10218-1: 7 Information for use
- ISO10218-2: 7 Information for use
- Additional 7 Information for use

7.1Information specific to collaborative robot operations

- The documentation that acompanies a collab. Robot system is directed towards a **specific** collaborative application.
- ....

7.2 Description of the collaborative robot system,....

7.3 Description of the workplace application, ...

7.4 Description of the work task, ...

7.5 Information specific to power and force limiting applications, ...

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What are the requirements for Verification and validation?

- ISO10218-2: 6 Verification and validation

- Additional 6 Verification and validation
  - integrator shall provide for the verification and validation of design and construction
  - The risk assessment(s) should be reviewed to assess if all reasonably foreseeable hazards have been identified and corrective actions taken

  - Recommendation: Create your one ckecklist for validation. If you use power and force limiting a measurement for validation is necessary

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Questions?

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