SAFEGUARDING & COMPLEMENTARY PROTECTIVE MEASURES

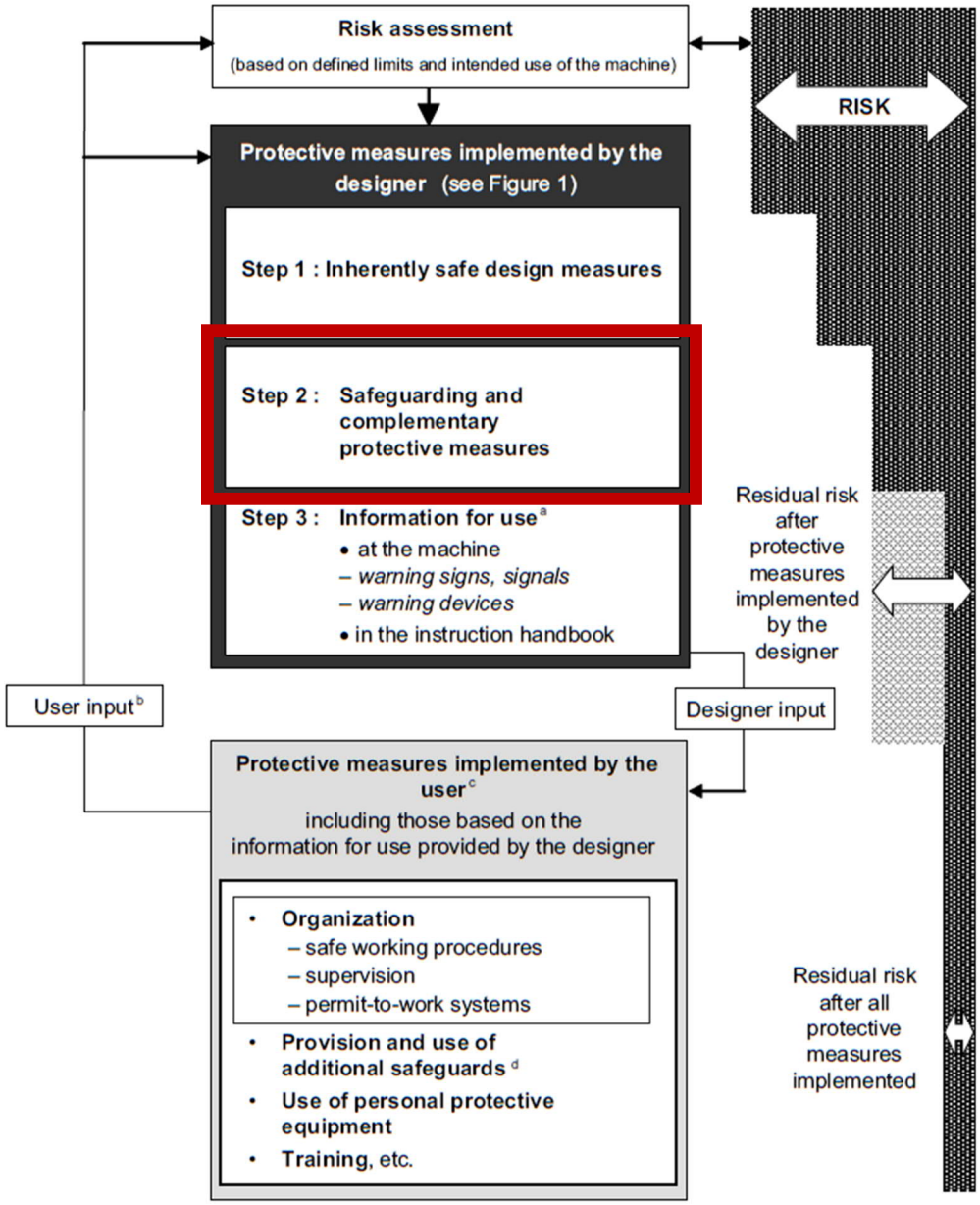
SICK
Sensor Intelligence.

Otto Görnemann

SICK AG / R&D

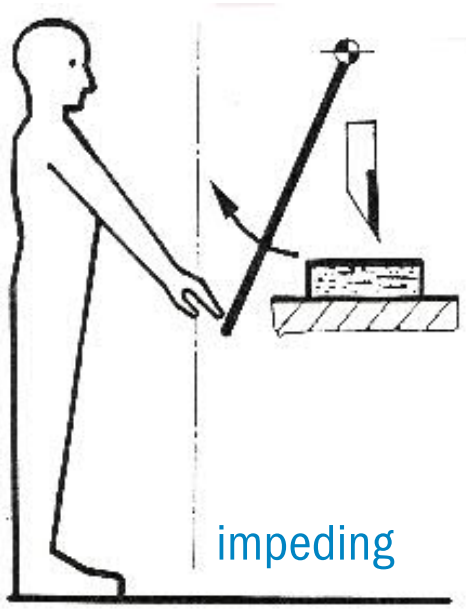
2022-05-24

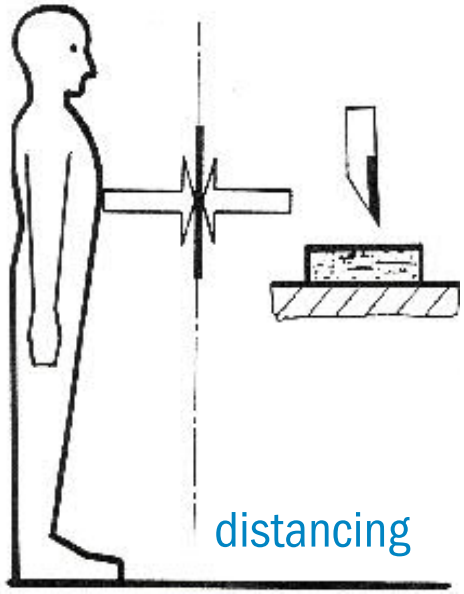
RISK REDUCTION
ISO 12100:2010

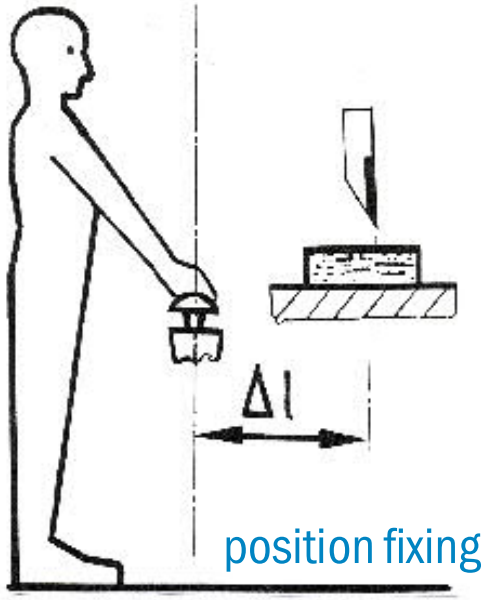


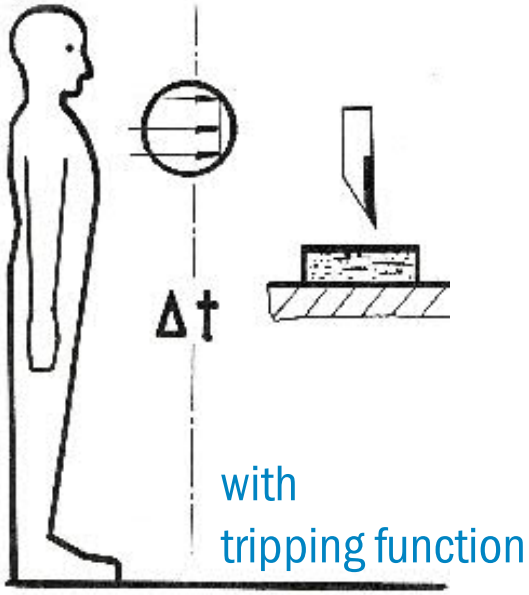
SAFEGUARDING AGAINST HAZARDS

SEPARATE PERSONS FROM DANGER BY MEANS OF SPACE OR TIME

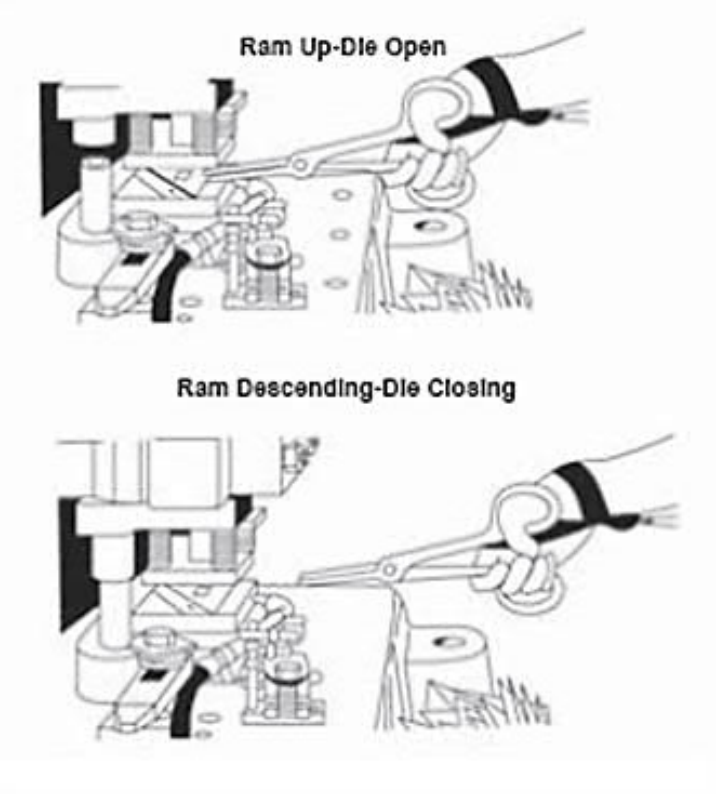


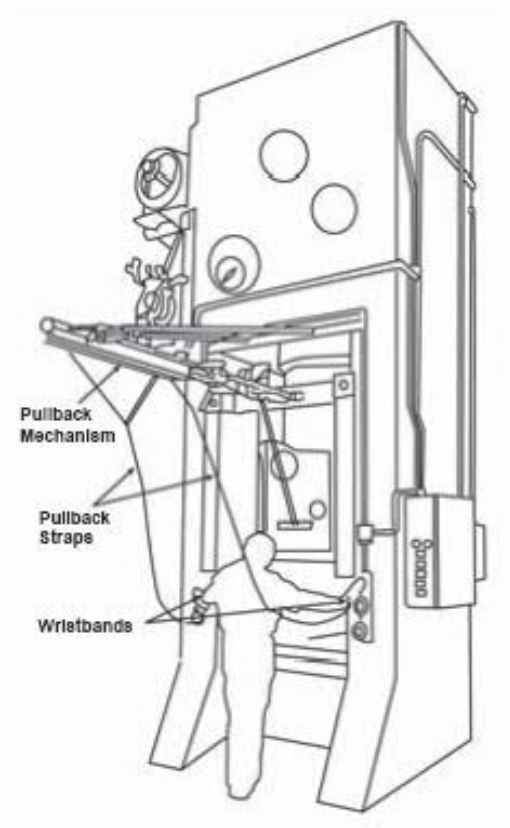






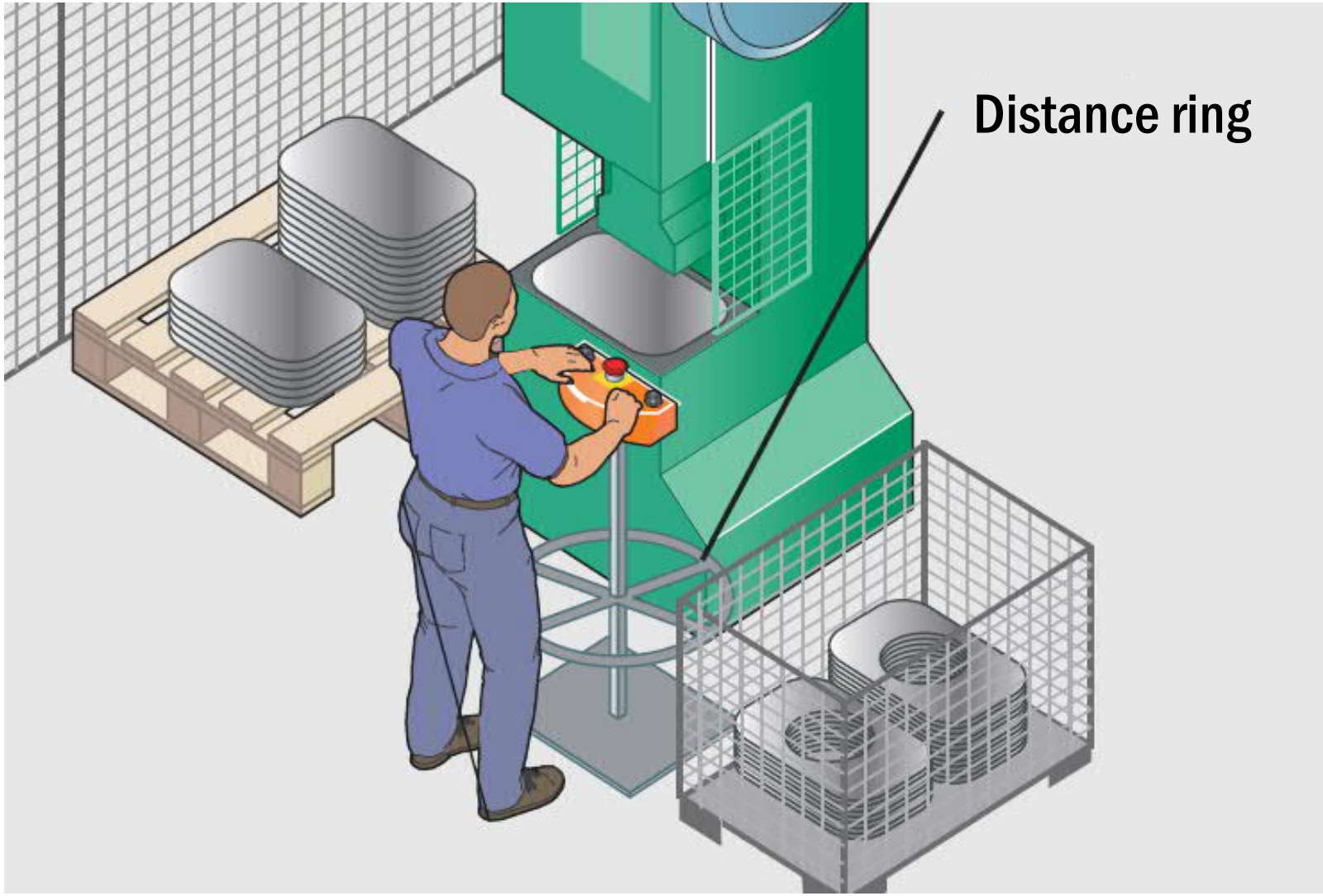
PULLBACK MECHANISM
DEFLECTING MEASURE





POSITION FIXING PROTECTIVE DEVICES

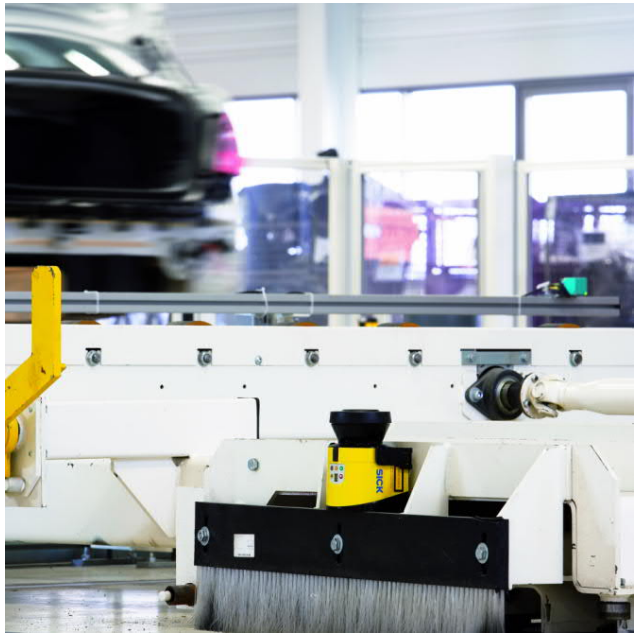
PROTECTION OF A SINGLE PERSON



PROTECTIVE DEVICES
TYPICAL EXAMPLES

Interlocking of movable guards

- Doors
- Gates
- Traps
- Barriers
- ...

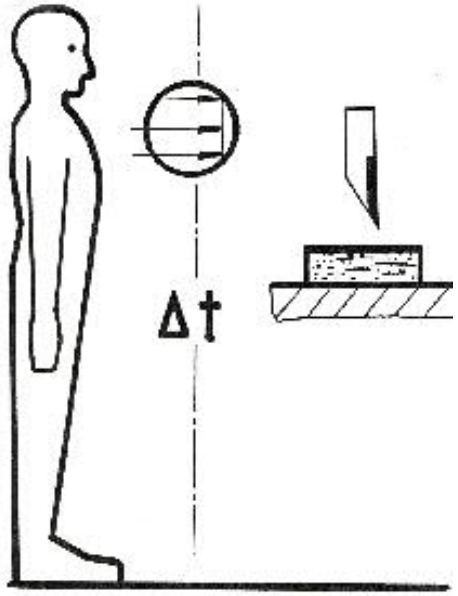


Electro-sensitive protective equipment

- Light curtains
- Through beam photo-cells
- Laser scanners
- Vision based protective equipment
- ...

SENSITIVE PROTECTIVE EQUIPMENT (SPE)
SEPARATE PERSONS FROM DANGER BY MEANS OF TIME

- SPE may be useable where **frequent** access is required
- SPE can **not** be used for protection against …
  - parts being ejected from the machine
  - substances being ejected like coolant, cutting oil etc.
  - noise, radiation
  - fumes, hazardous substances
  - hazards with unsuitable stopping times

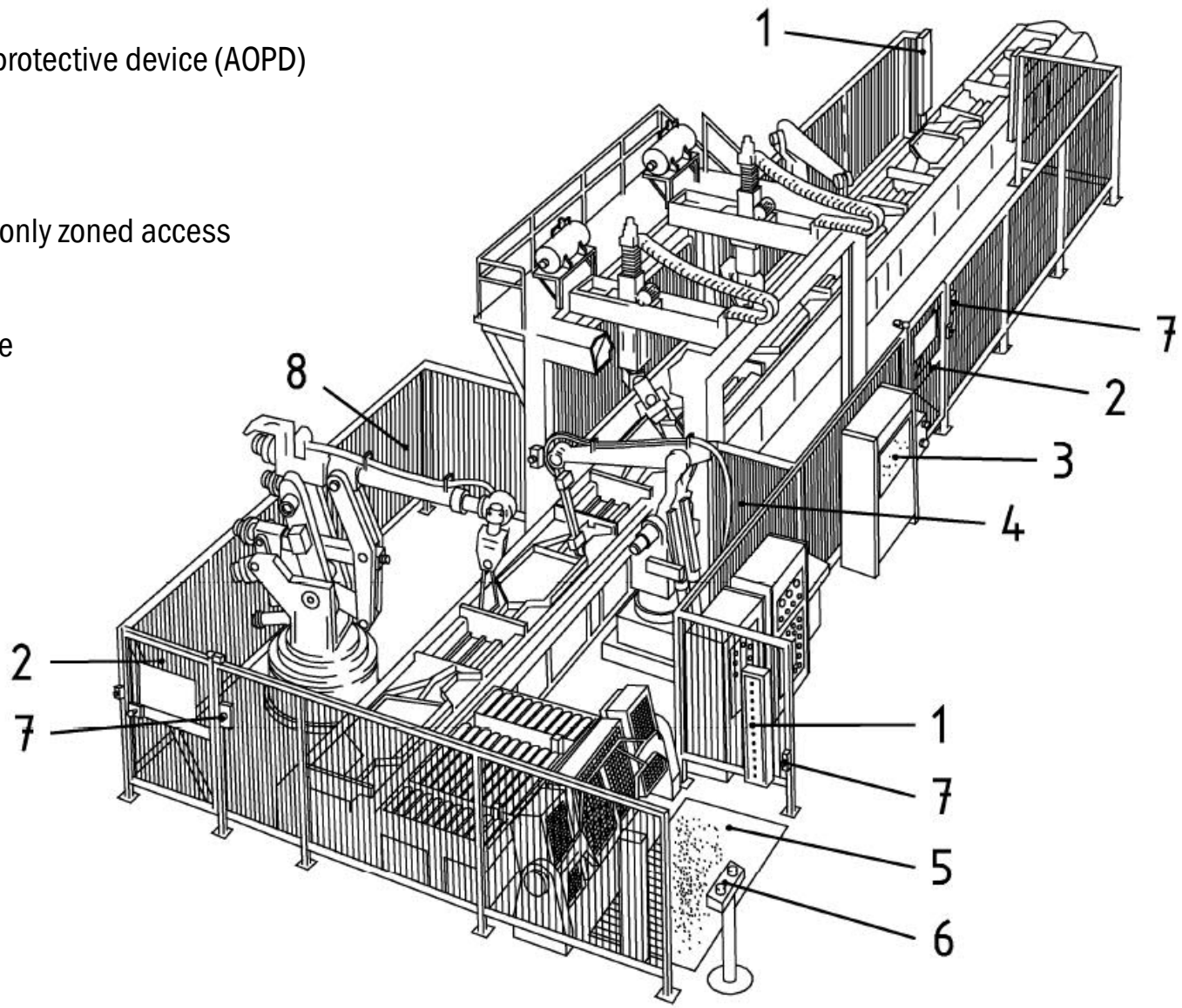


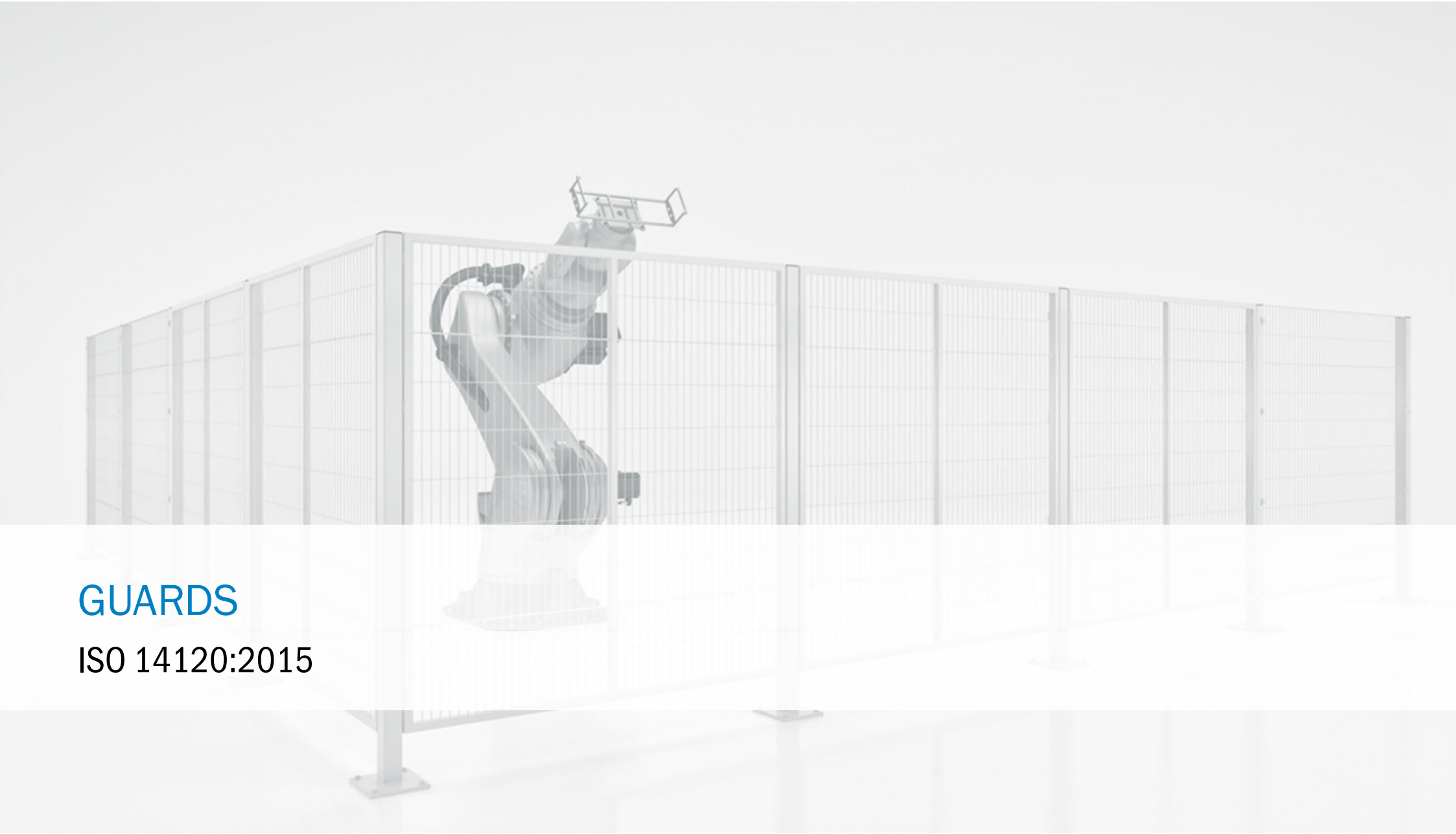
© Neudörfer

COMBINATION OF DIFFERENT GUARDS ...
... OR OF GUARDS WITH OTHER DEVICES

Key

1 Active opto-electronic protective device (AOPD)
2 Interlocking guard
3 Electrical cabinet
4 Internal fence allowing only zoned access
5 Pressure sensitive mat
6 Two-hand control device
7 Reset device
8 Distance guard

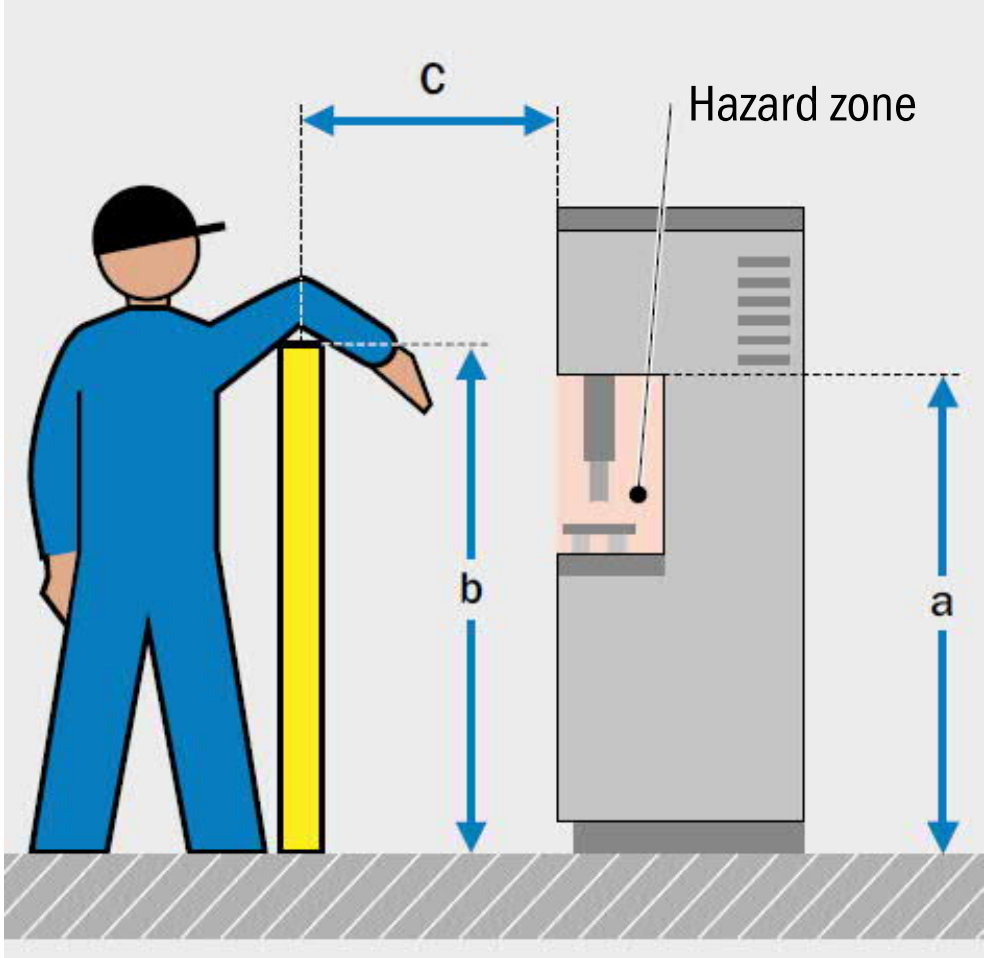




GUARDS

ISO 14120:2015

FIXED (PHYSICAL) GUARDS
REQUIREMENTS FOR GUARDS



- General requirements for the design, construction and selection of fixed and movable guards
  ISO 14120:2013

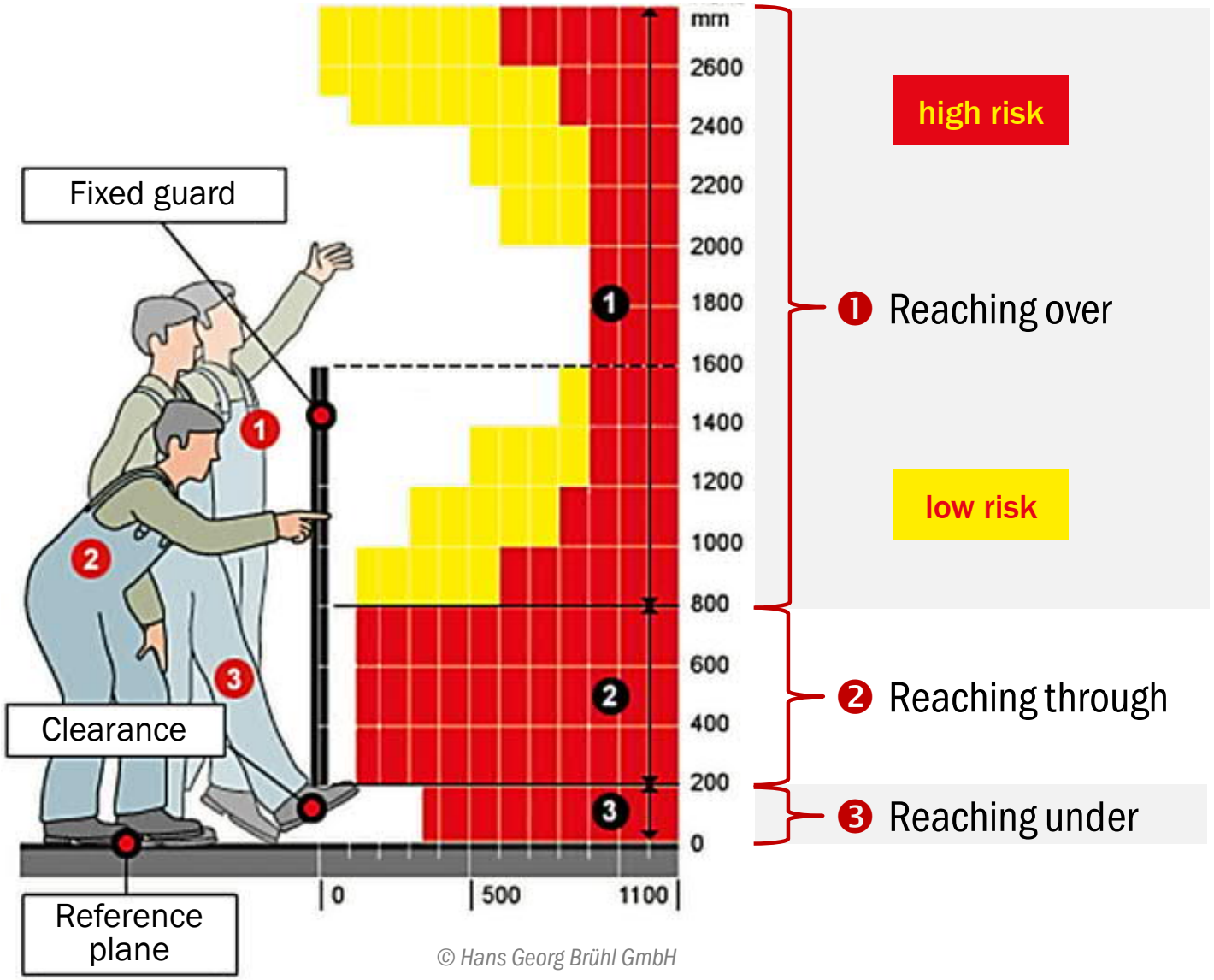
- Safety distances to prevent hazard zones being reached by upper and lower limbs
  ISO 13857:2018

a height of the hazard zone

b height of the guard

C horizontal distance

DISTANCING GUARDS
REACHING OVER/THROUGH/UNDER PROTECTIVE STRUCTURES

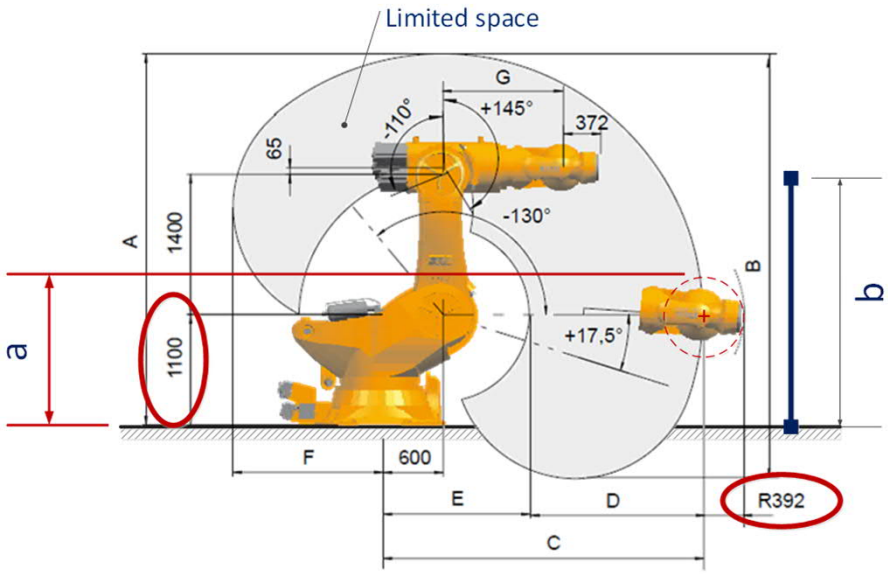


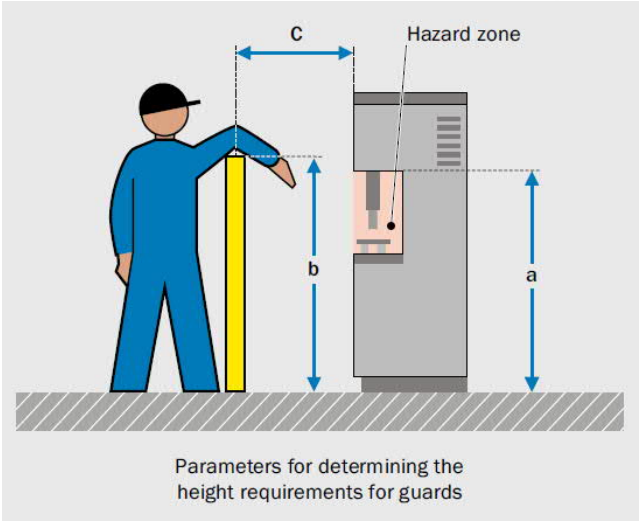
REACHING OVER GUARDS

TABLE 2 (HIGH RISK), ISO 13857

SICK
Sensor Intelligence.

High risk:





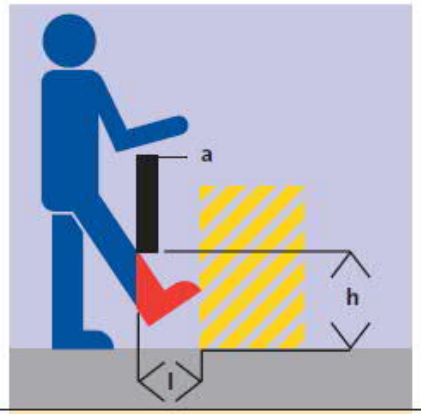
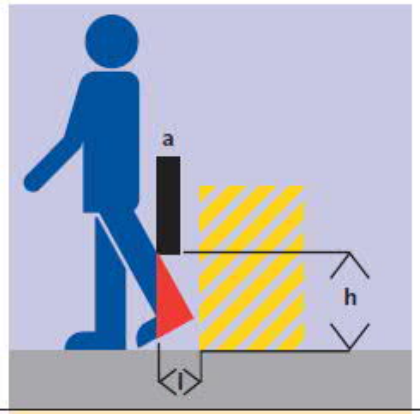
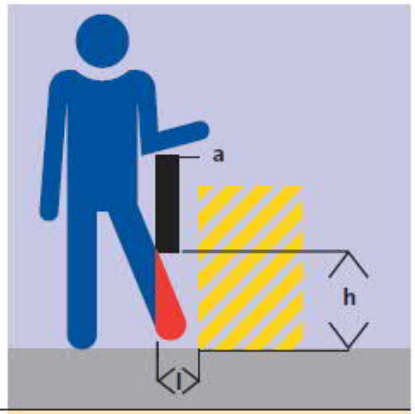
Parameters for determining the height requirements for guards

of the hazardou	Horizontal distance c to the hazardous zone									
2.700	0	0	0	0	0	0	0	0	0	0
2.600	900	800	700	600	600	500	400	300	100	0
2.400	1.100	1.000	900	800	700	600	400	300	100	0
2.200	1.300	1.200	1.000	900	800	600	400	300	0	0
2.000	1.400	1.300	1.100	900	800	600	400	0	0	0
1.800	1.500	1.400	1.100	900	800	600	0	0	0	0
1.600	1.500	1.400	1.100	900	800	500	0	0	0	0
1.400	1.500	1.400	1.100	900	800	0	0	0	0	0
1.200	1.500	1.400	1.100	900	700	0	0	0	0	0
1.000	1.500	1.400	1.000	800	0	0	0	0	0	0
800	1.500	1.300	900	600	0	0	0	0	0	0
600	1.400	1.300	800	0	0	0	0	0	0	0
400	1.400	1.200	400	0	0	0	0	0	0	0
200	1.200	900	0	0	0	0	0	0	0	0
0	1.100	500	0	0	0	0	0	0	0	0
Distances in mm	**Hight b of the guard**									
	1.000	**1.200**	**1.400**	**1.600**	**1.800**	**2.000**	**2.200**	**2.400**	**2.500**	**2.700**

REACHING UNDER GUARDS

TABLE B.1, ISO 13857

SICK
Sensor Intelligence.

			
h ≤ 200	l ≥ 340	l ≥ 665	l ≥ 290
200 < h ≤ 400	l ≥ 550	l ≥ 765	l ≥ 615
400 < h ≤ 600	l ≥ 850	l ≥ 950	l ≥ 800
600 < h ≤ 800	l ≥ 950	l ≥ 950	l ≥ 900
800 < h ≤ 1000	l ≥ 1125	l ≥ 1195	l ≥ 1015

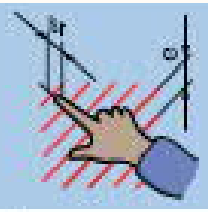
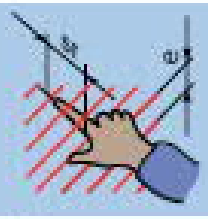
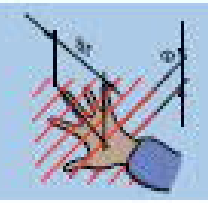
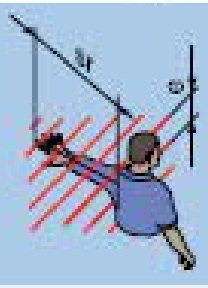
NOTE: *Slot openings with h > 180mm will allow access for the whole body*

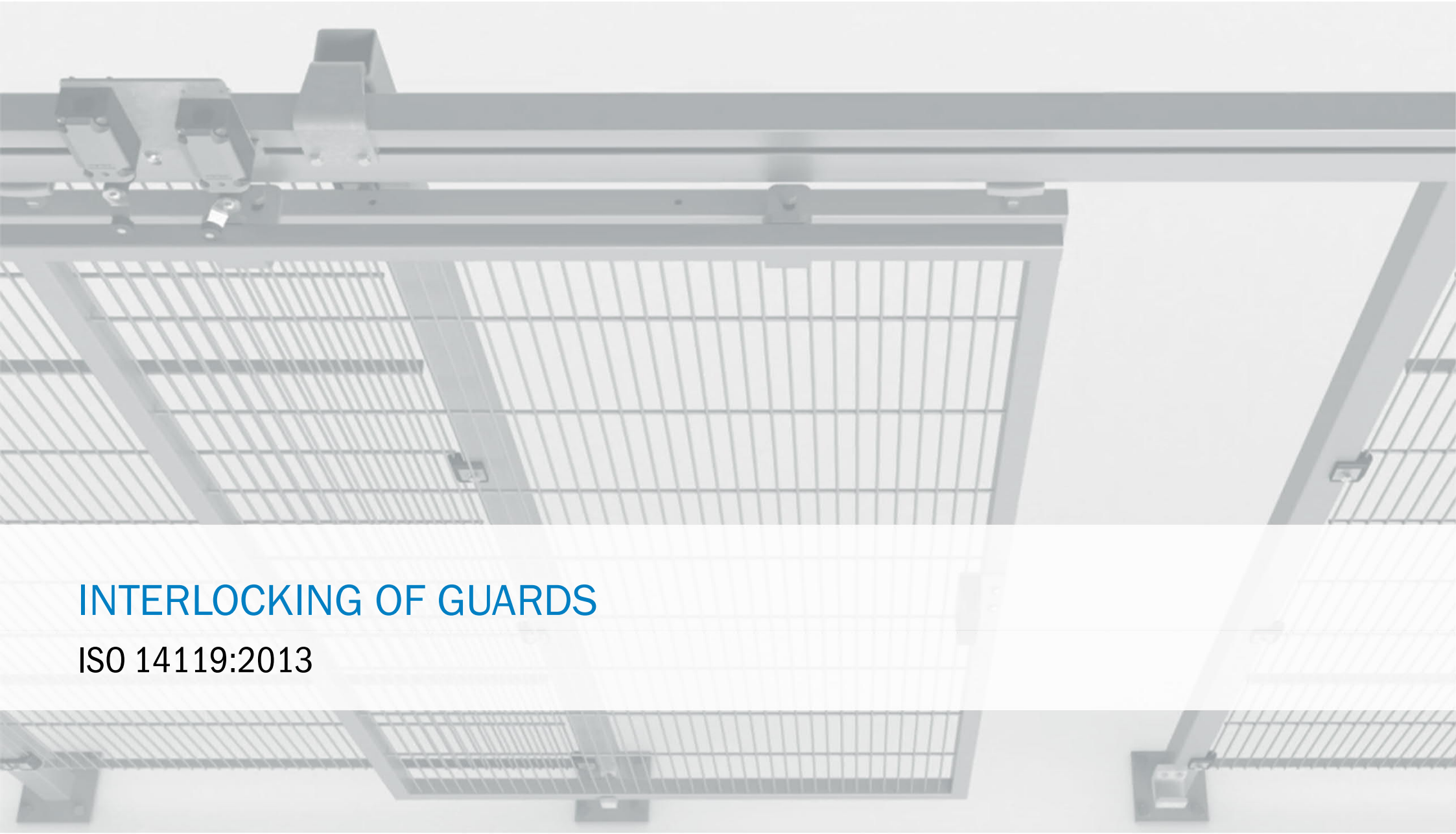
REACHING THROUGH GUARDS

TABLE 4, ISO 13857

SICK
Sensor Intelligence.

e.g., Mesh, aperture 20 x 20 mm:

Part of the body		Opening e (mm)	Safety distance (mm)		
			Slot	Square	Circle
Fingertip		e ≤ 4	≥ 2	≥ 2	≥ 2
		4 < e ≤ 6	≥ 10	≥ 5	≥ 5
Finger up to wrist		6 < e ≤ 8	≥ 20	≥ 15	≥ 5
		8 < e ≤ 10	≥ 80	≥ 25	≥ 20
		10 < e ≤ 12	≥ 100	≥ 80	≥ 80
		12 < e ≤ 20	≥ 120	≥ 120	≥ 120
		20 < e ≤ 30	≥ 850	≥ 120	≥ 120
Arm up to shoulder		30 < e ≤ 40	≥ 850	≥ 200	≥ 120
		40 < e ≤ 120	≥ 850	≥ 850	≥ 850



INTERLOCKING OF GUARDS

ISO 14119:2013

INTERLOCKING OF GUARDS
ISO 14119:2013

Guard

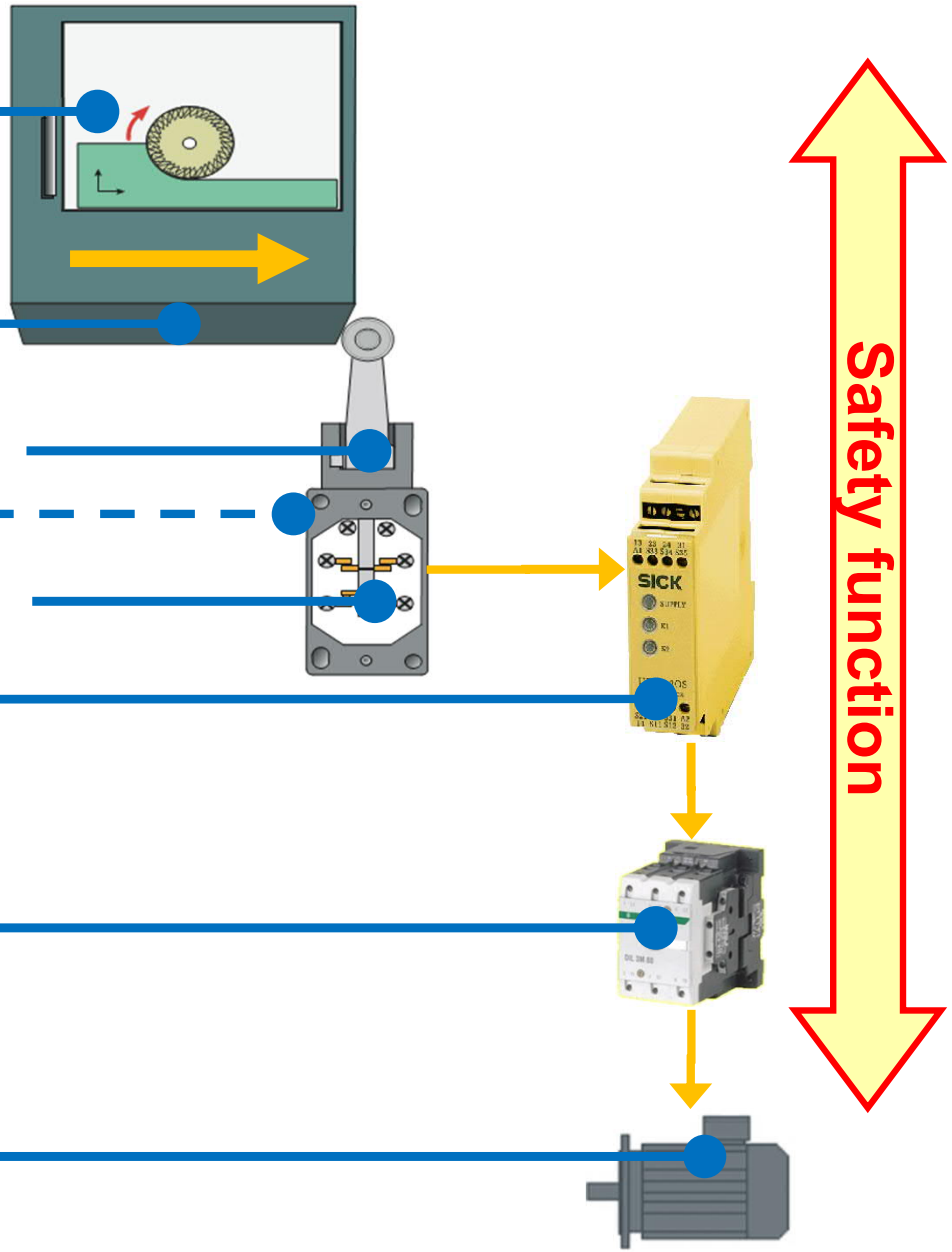
Interlocking device

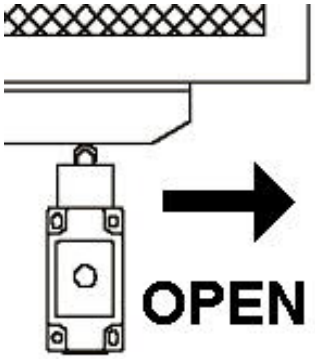
- Actuator
- Position switch
  - Actuating system
  - Output system

Logic unit for safety functions

Power control element

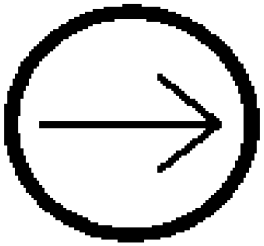
Driving element with possible hazard(s)





Direct mechanical action

movement of a mechanical component that arises inevitably from the movement of another mechanical component either by direct contact or via rigid elements
(ISO 14119:2013 – Definition 3.10)



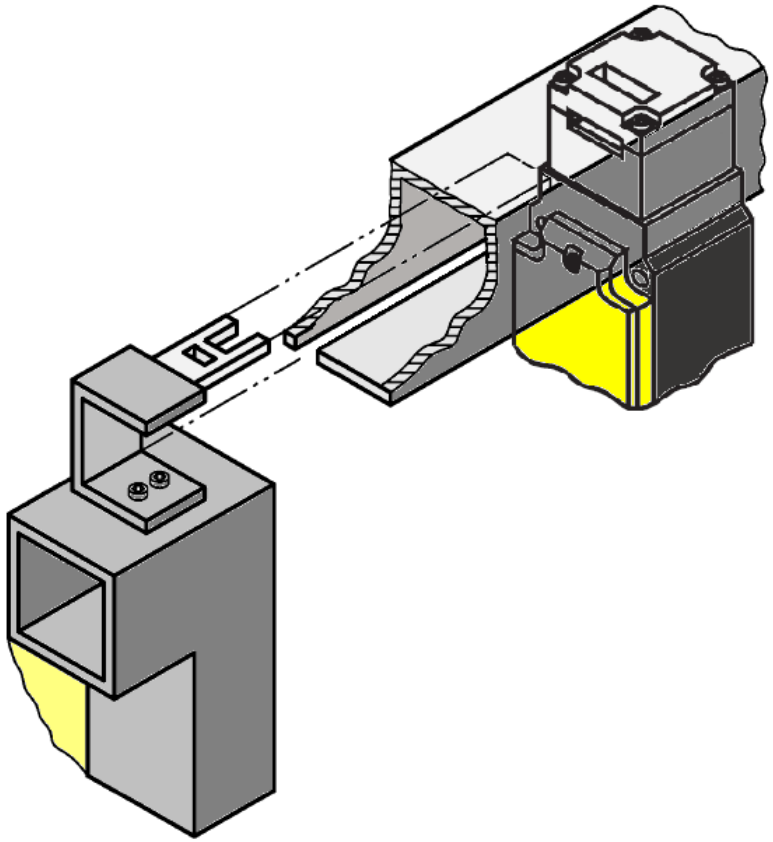
IEC 60947-5-1 Annex K

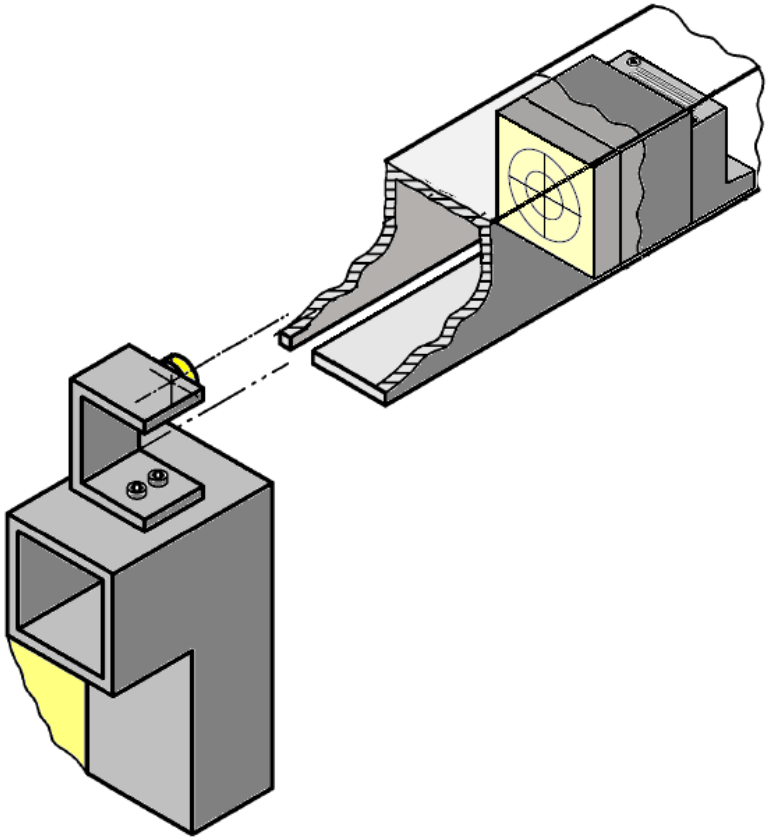
Direct opening action

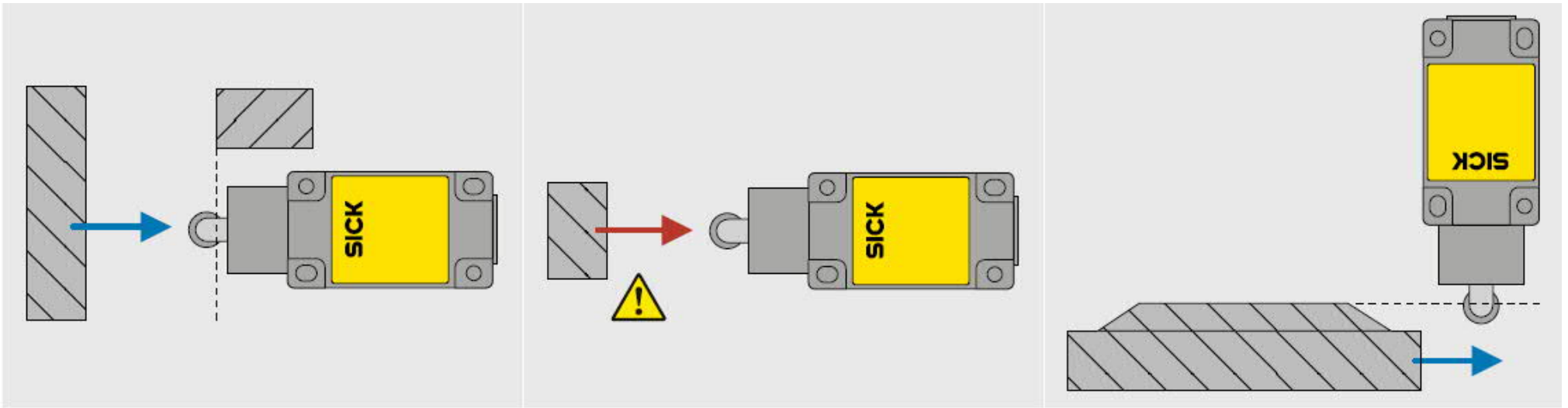
achievement of contact separation as a direct result of a specified movement of the switch actuator through non-resilient members (for example not dependent upon springs)
(ISO 14119:2013 – Definition 3.10 ~ IEC 60947-5-1:2003, K 2.2.)

MINIMIZE DEFEAT POSSIBILITIES

PHYSICAL OBSTRUCTION OR SHIELDING







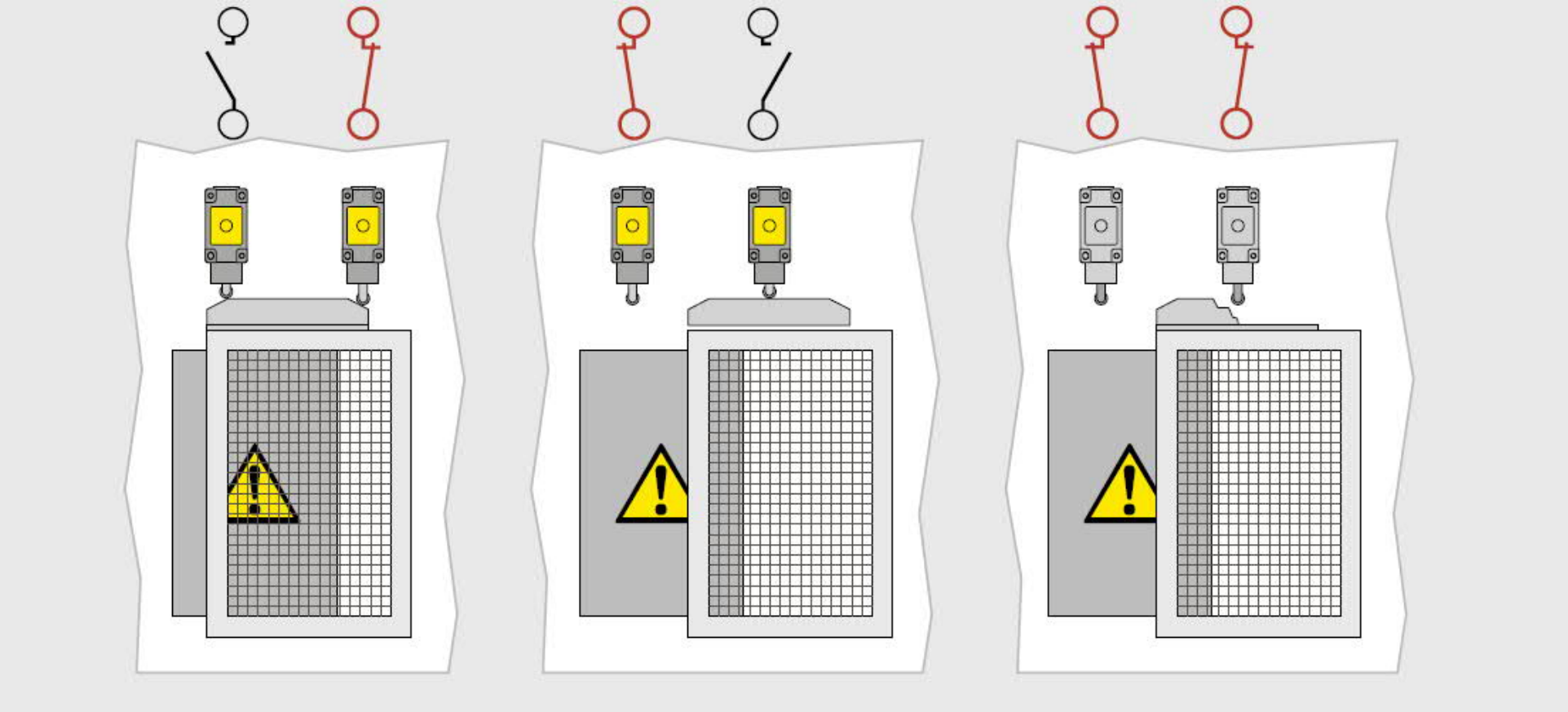
Correct assembly: The position switch is protected by a mechanical stop.

Incorrect assembly: The position switch is used as a stop.

Correct assembly: The height of the cam has been matched to the position switch.

DETECTION OF MECHANICAL FAULTS

PREVENTION OF COMMON CAUSE FAILURES



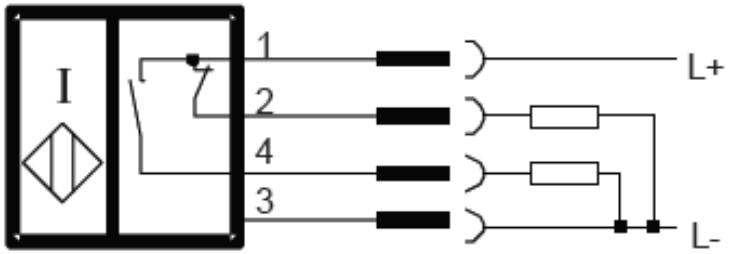
INTERLOCKING DEVICES
OPERATING PRINCIPLES

SICK
Sensor Intelligence.

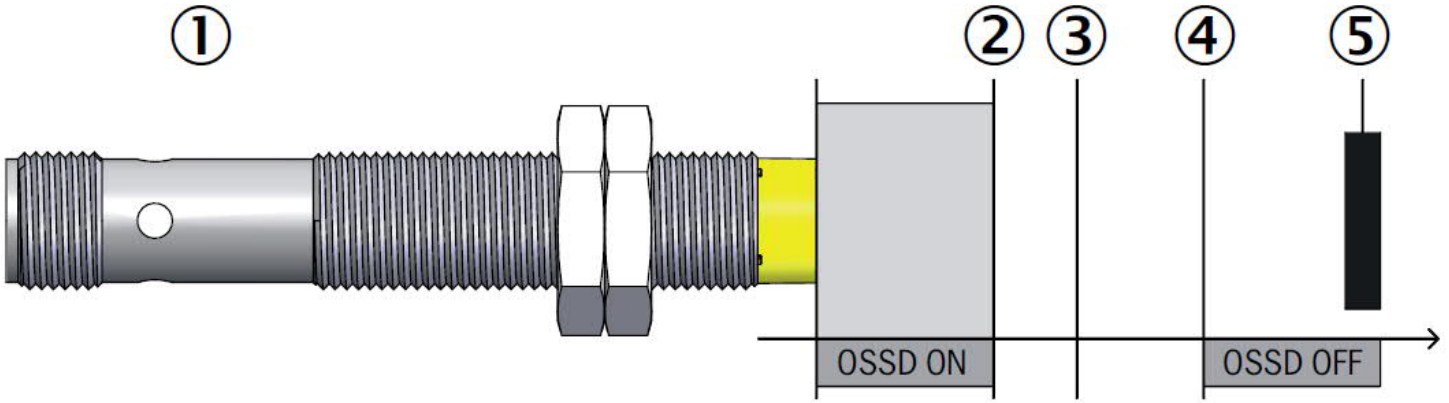
Designation	Actuation		Actuator		SICK product	
	Principle	Example	Principle	Examples	Example	
Type 1	Mechanical	Physical contact, force, pressure	Not coded	Switching cam	i10P	
				Turning lever	i10R	
				Hinge	i10H	
Type 2			Coded	Shaped actuator (switching rod)	i16S	
				Key	–	
Type 3	Electro-sensitive	Inductive	Not coded	Suitable ferromagnetic materials	IN4000	
		Magnetic		Magnets, electromagnets	MM12 [1]	
		Capacitive		All suitable materials	CM18 [1]	
		Ultrasonic		All suitable materials	UM12 [1]	
		Optical		All suitable materials	WT 12 [1]	
Type 4		Magnetic	Coded	Coded magnet	RE11	
		RFID		Coded RFID transponder	TR4 Direct	
		Optical		Coded optical actuator	–	

IEC 60947

- Part 1: General rules
- ...
- Part 5: Control-circuit devices and switching elements
  - ...
  - **Part 5-2: Proximity switches**
  - Part 5-3: Requirements for proximity devices with defined behavior under fault conditions (PDDB)
  - ...
- ...



NOMINAL SENSING RANGE
STANDARD TARGET



1 Position switch

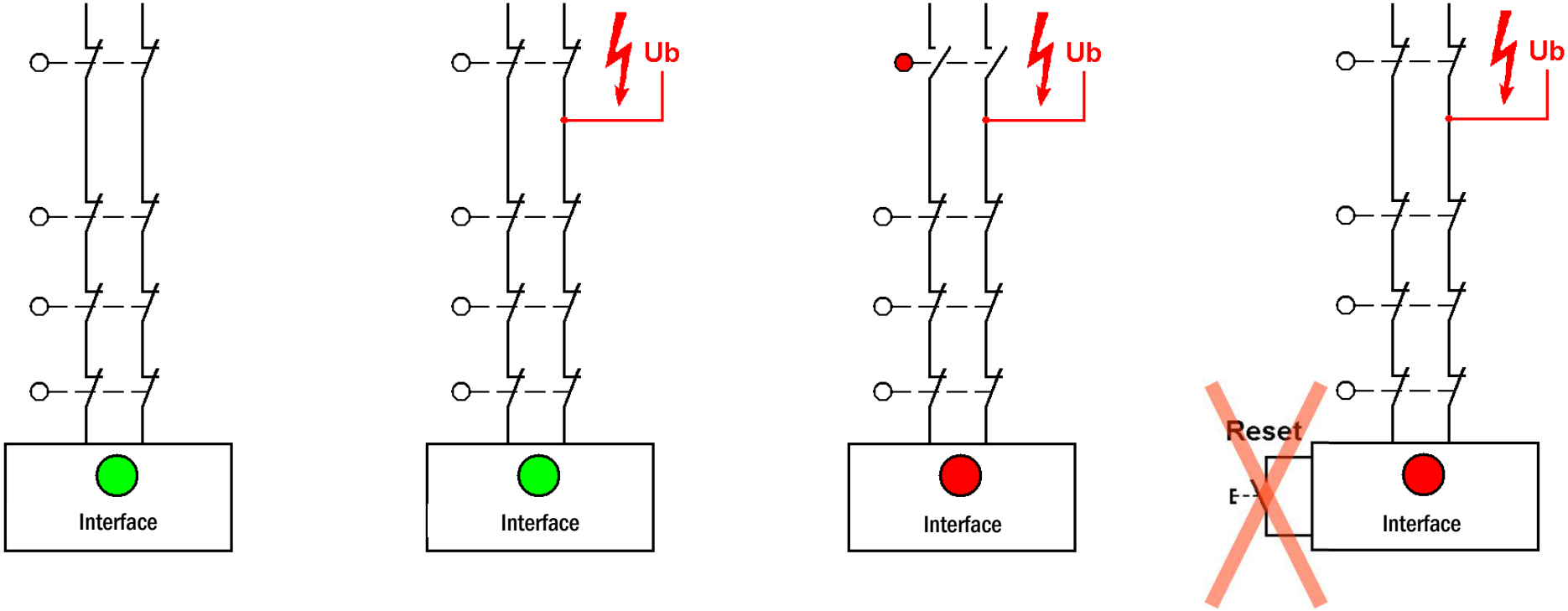
2 Assured switch-on distance S_{ao}

3 Rated sensing range S_n (switch-on distance under laboratory conditions)

4 Assured switch off distance Sar

5 Actuating element

SERIAL CONNECTION OF POTENTIAL FREE CONTACTS
PART 1 / 2



Normal Status

Machine operation

Fault Occurrence

Cable damage leads to short circuit with 24 VDC and the loss of one channel

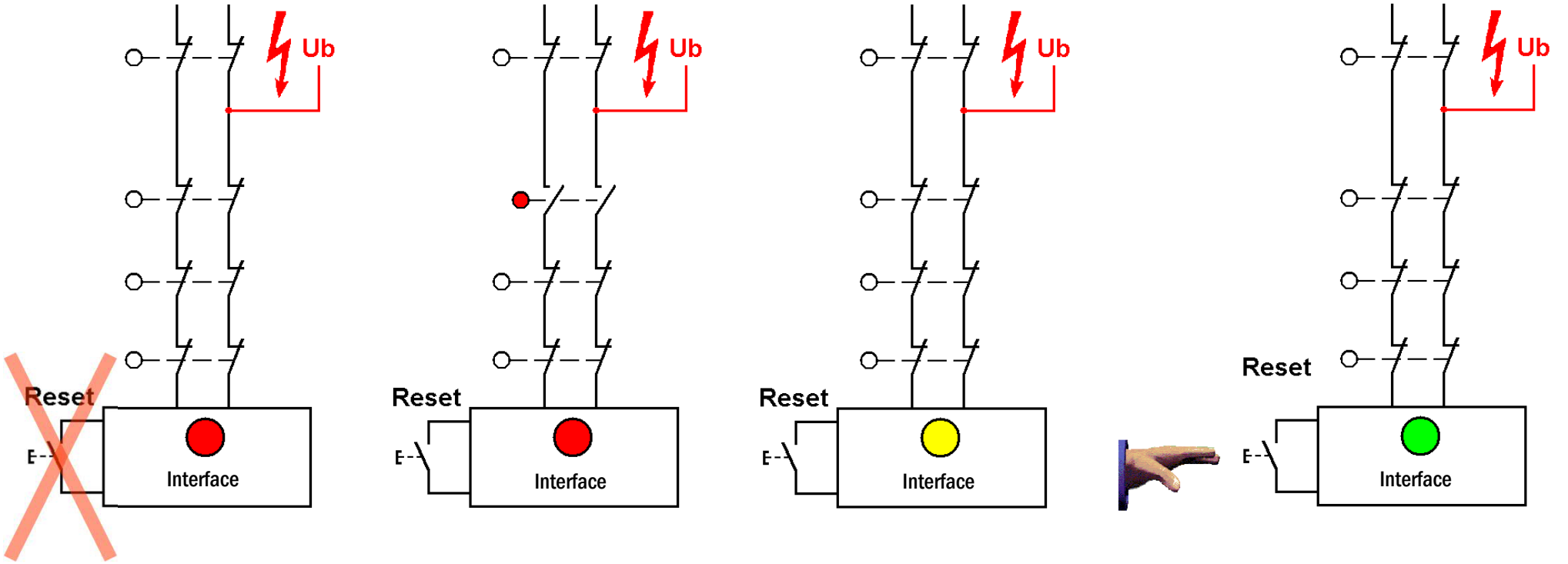
Activation

Activating the interlock leads to the switching off of the safety relay

Lockout

Signal change detected only on one input. Safety relay goes into lockout

SERIAL CONNECTION OF POTENTIAL FREE CONTACTS
PART 2 / 2



Service problem

The machine cannot be started due to the locked status of the safety device

Troubleshooting

During fault searching the operator opens other doors

Operator action

After closing the door the fault can be reset at the interface (input requirements are satisfied)

Danger

Although a channel is faulty, the safety relay allows a reset!
A second failure in the cable (now very likely) leads to the loss of the safety function

MAXIMUM ACHIEVABLE DC (SIMPLIFIED)

ISO TR 24119 > ISO DIS 14119:2022

Number of frequently used movable guards [a] [b]		Number of additional movable guards [c]	Maximum achievable DC [d]
0	+	2 to 4	Medium
		5 to 30	Low
		> 30	None
1	+	1	Medium
		2 to 4	Low
		≥ 5	None
>1	+	≥ 0	None

a) If the frequency is higher than once per hour.

b) If the number of operators capable of opening separate guards exceeds one then the number frequently used moveable guards shall be increased by one.

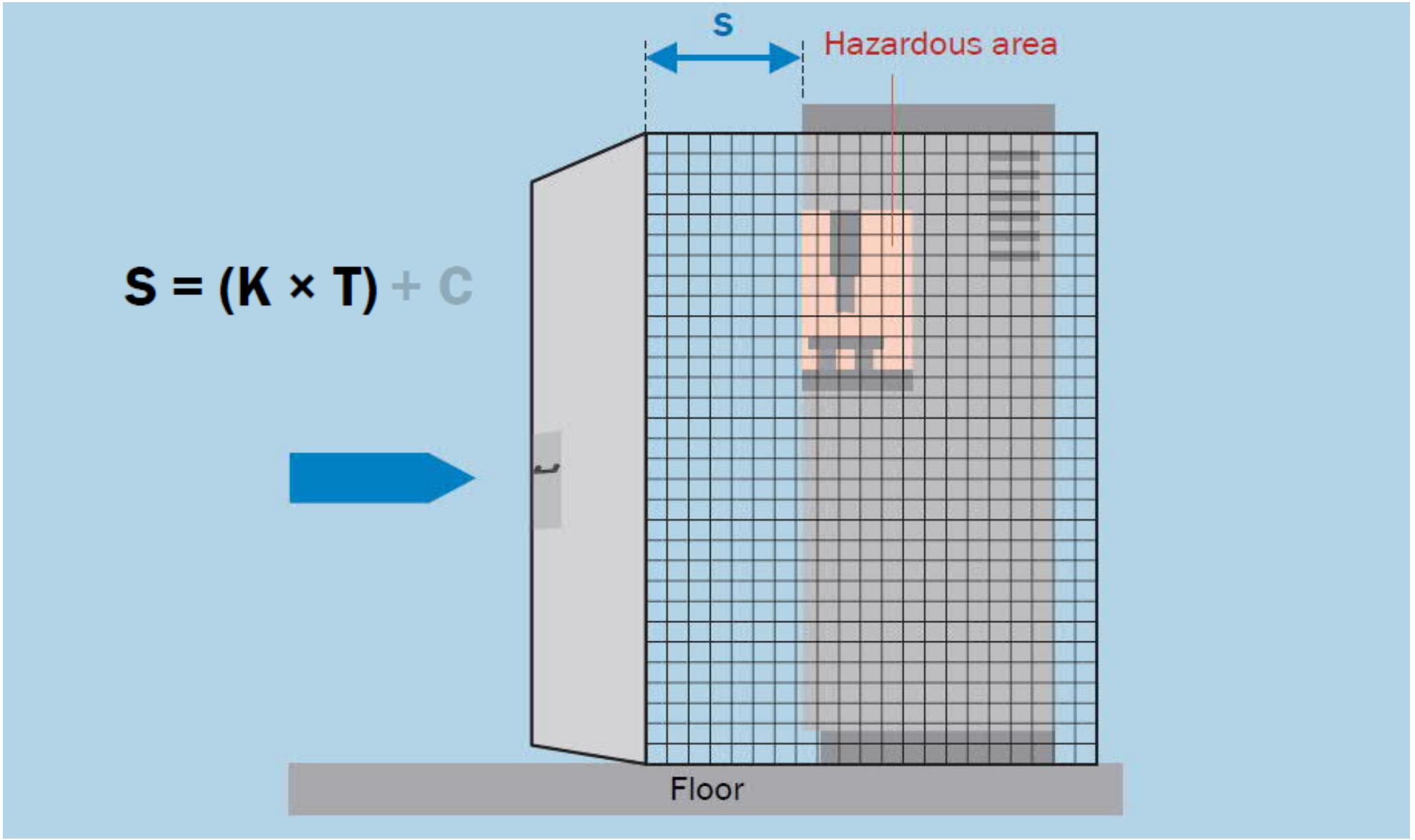
c) The number of additional movable guards my be reduced by one if one of the following conditions are met:

- When the m inimum distance between any of the guards is more than 5 m or
- When none of the additional movable guards is directly reachable

d) In any case, if it is foreseeable that fault masking will occur (e.g., multiple movable guards will be open at the same time as part of normal operation or srevice), then the DC is limited to none.

POSITIONING OF SAFEGUARDS

ISO 13855:2010

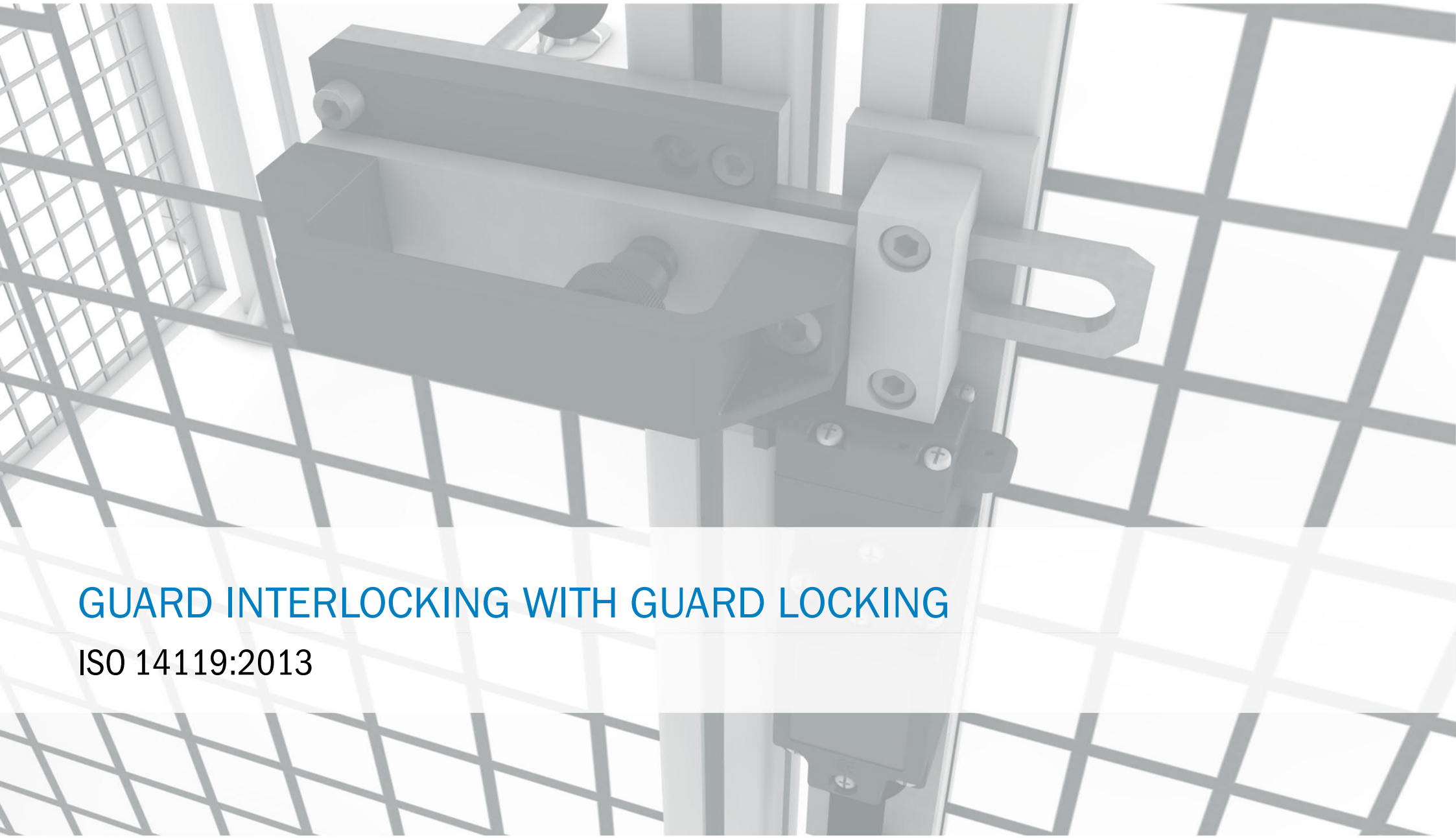


Guard interlocking

- Initiation of machine functions shall not be possible as long the guard is not closed (or in place)
- a stop command is given if the guard is opened while hazardous machine functions are operating

Guard interlocking with guard locking

- Initiation of machine functions shall not be possible as long the guard is not closed (or in place) & locked
- the guard remains closed and locked until the risk due to the hazardous machine functions “covered” by the guard has disappeared

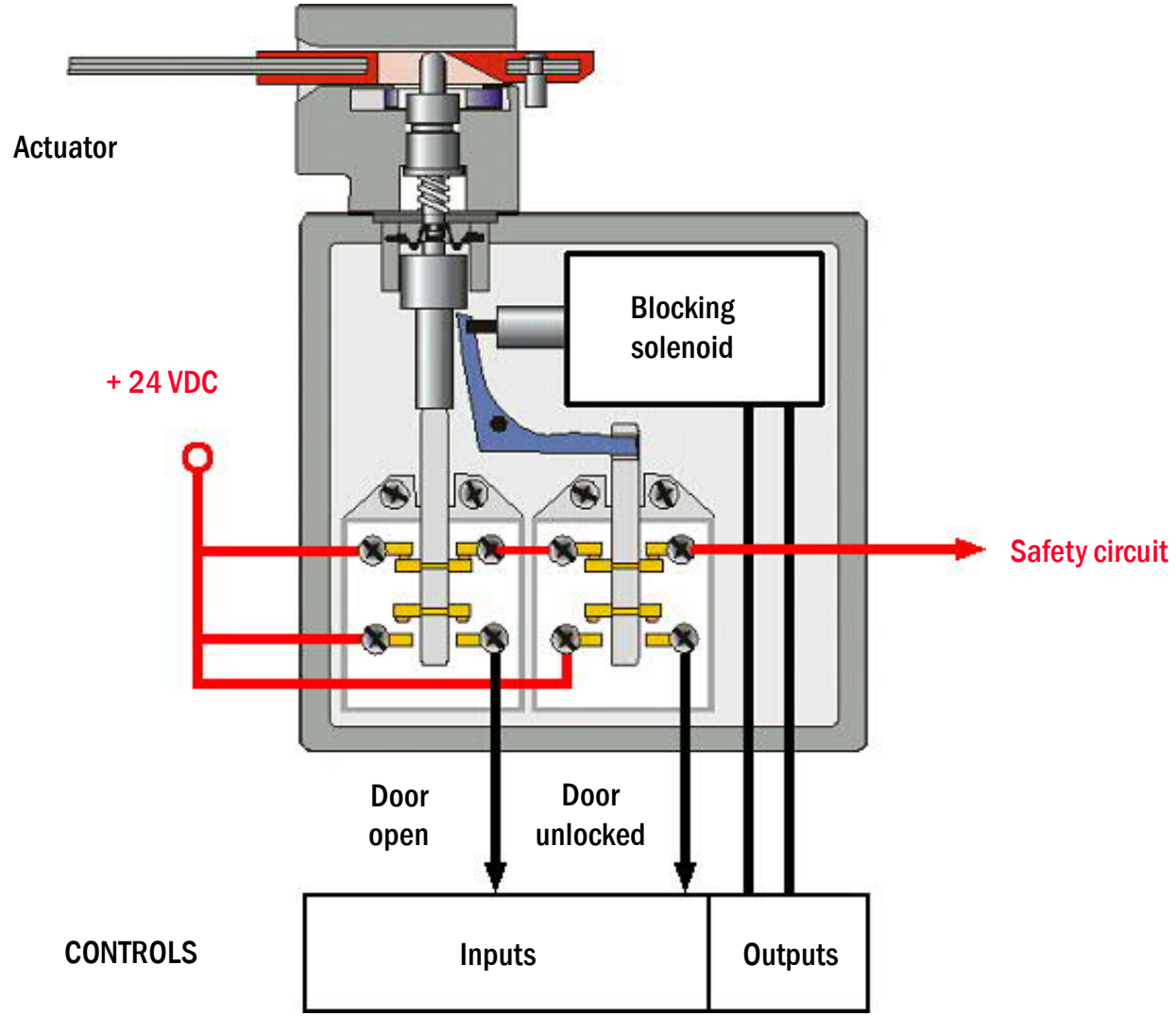


GUARD INTERLOCKING WITH GUARD LOCKING

ISO 14119:2013

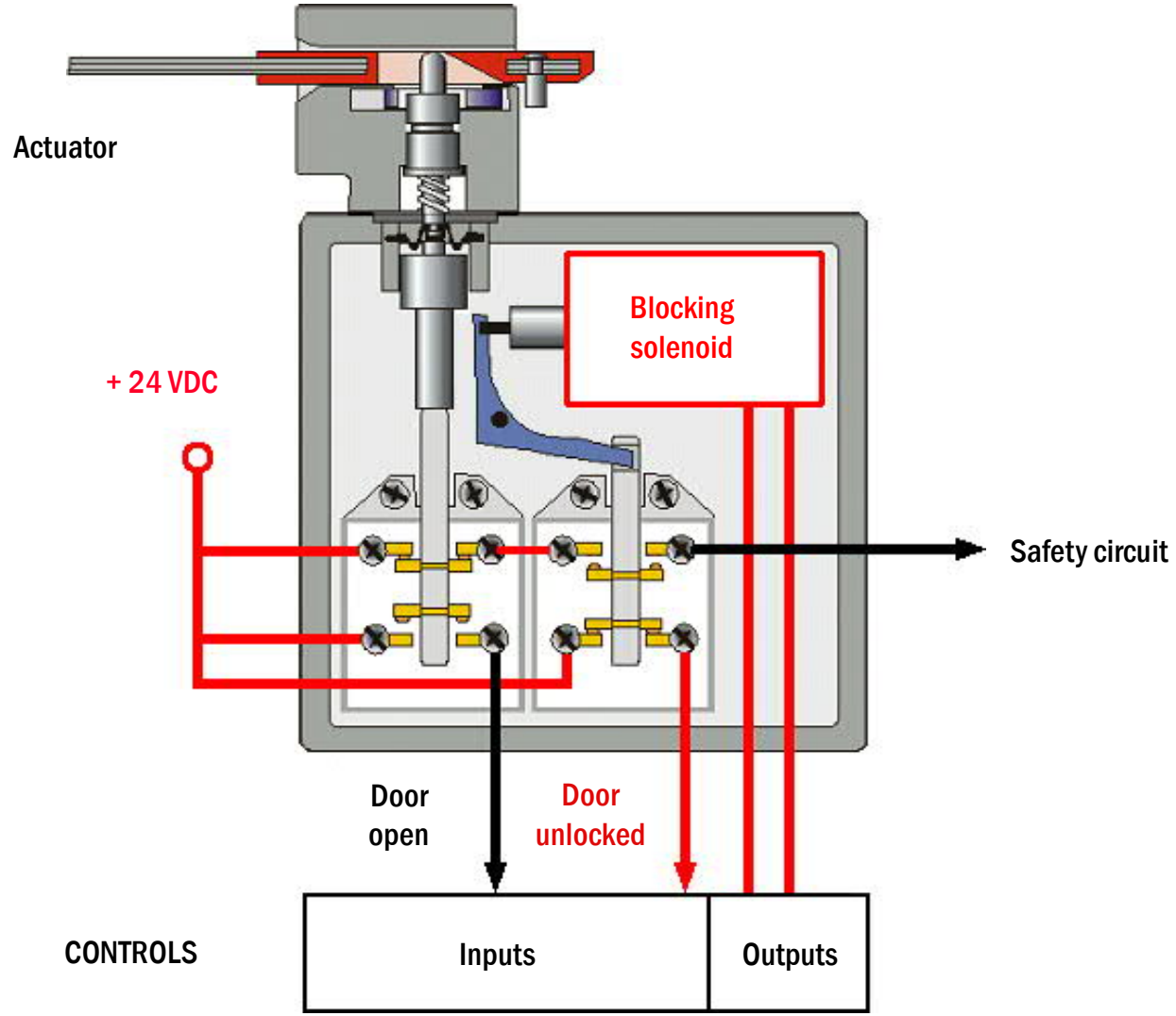
INTERLOCKING GUARD WITH GUARD LOCKING

DOOR CLOSED AND LOCKED



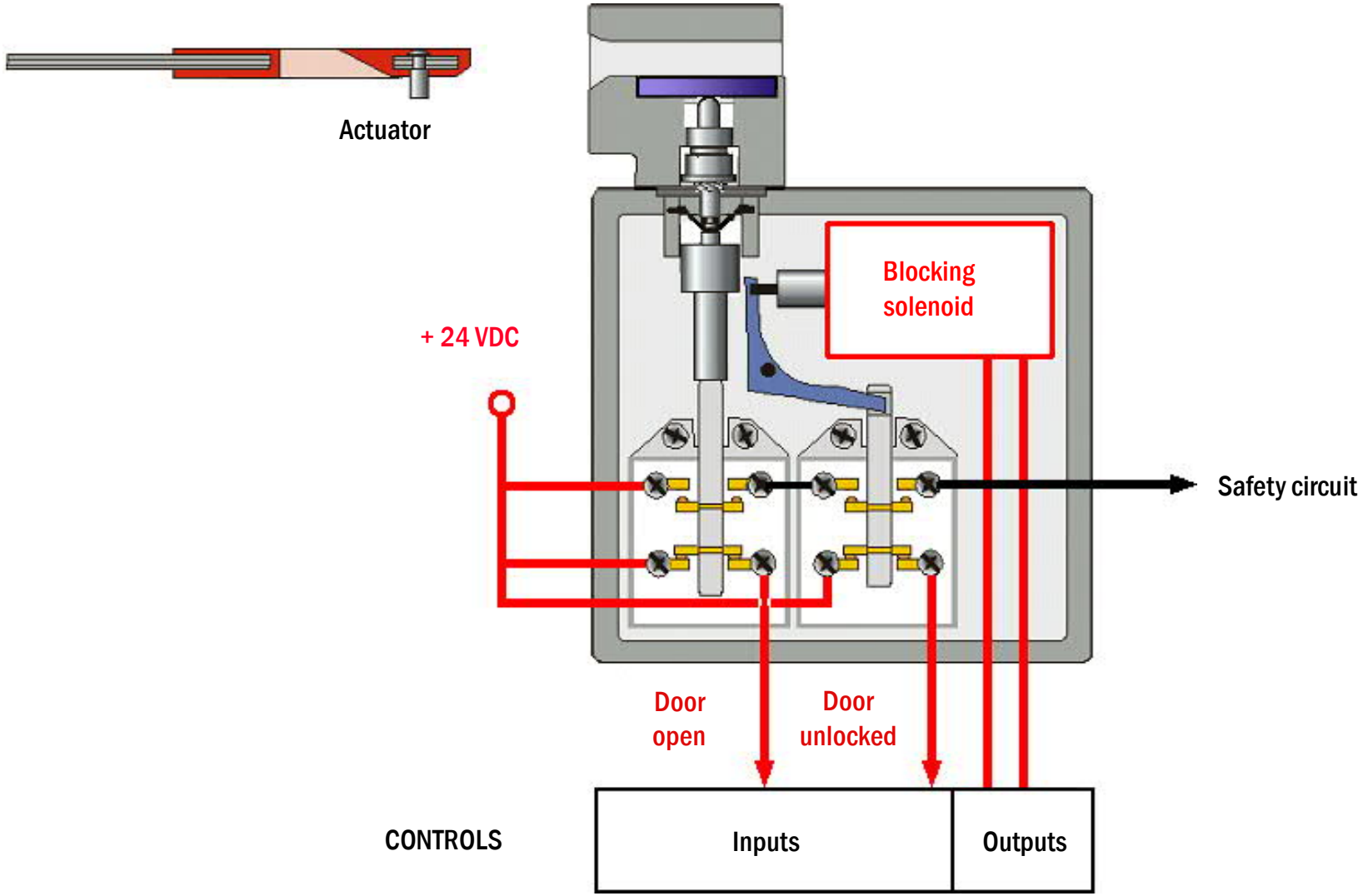
INTERLOCKING GUARD WITH GUARD LOCKING

DOOR CLOSED AND UNLOCKED



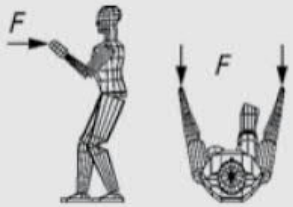
INTERLOCKING GUARD WITH GUARD LOCKING

DOOR OPEN AND UNLOCKED



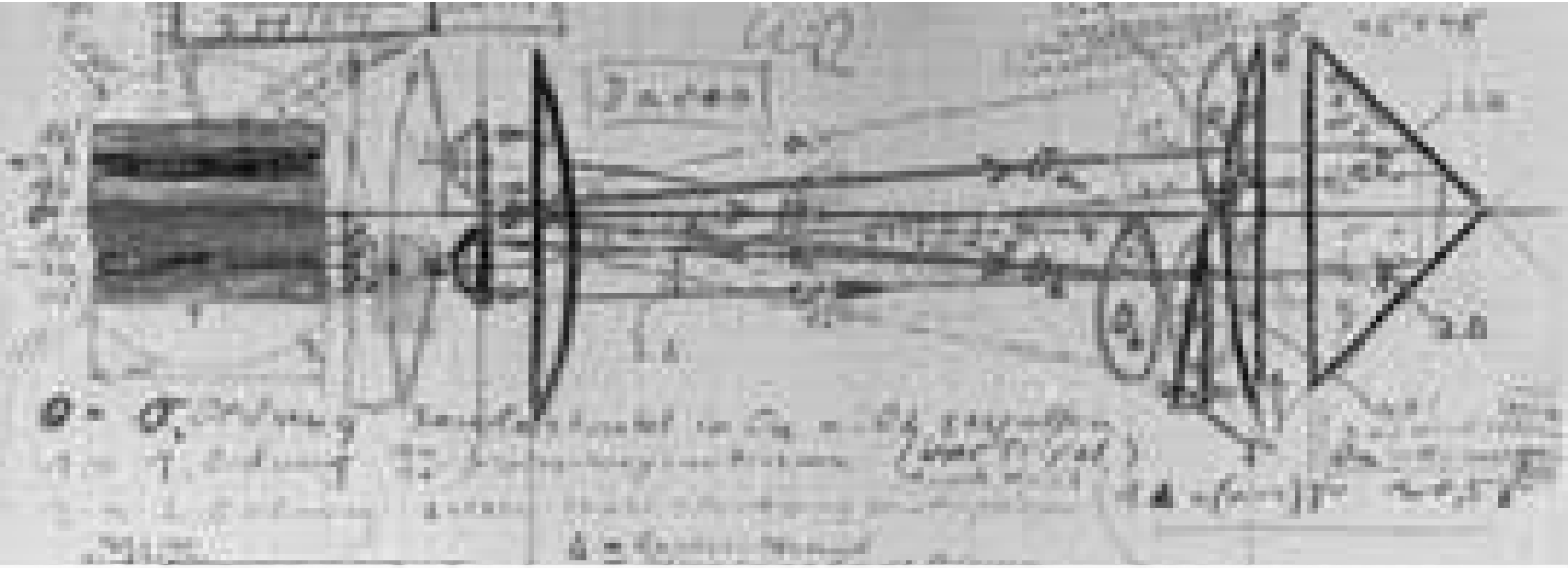
REQUIRED HOLDING FORCE FOR GUARDS

ANNEX I, ISO 14119:2013

Direction of force		Position	Application of force	Force (N)
	Horizontal, parallel to body symmetry plane, backward, pull	Standing upright, feet parallel or in step posture	Bi-manual, vertical grips	1100
	Horizontal, normal to body symmetry plane	Standing, feet parallel	Single-handed, vertical grips	700

REALIZATION
DESIGN STEPS FOR GUARDS

1.	Define the function	Covering / Distancing	(ISO 14120)
2.	Select type	Fixed or removable/movable	(ISO 12100)
3.	Select	Proper materials & Construction design considering required retention capabilities	(ISO 14120)
4.	Select interlocking	without / with interlocking considering systematic aspects of related components	(ISO 12100)
5.	Select	without / with guard locking	(ISO 13855)
6.	Determine	Dimensions & safety distance considering openings (e.g. mash width) height of hazard zone and heights of lower / upper edge of the guard	(ISO 13857)
	or	Minimum distance considering openings (e.g. mash width) height of hazard zone, heights of lower / upper edge, overall stopping time	(ISO 13855)



ELECTRO SENSITIVE PROTECTIVE EQUIPMENT

ESPE

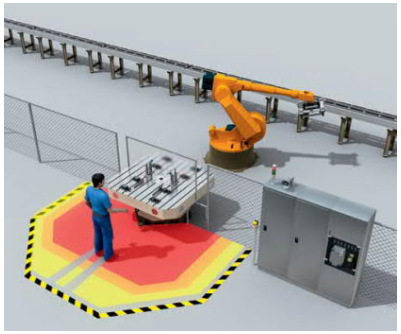
ELECTRO-SENSITIVE PROTECTIVE EQUIPMENT

AOPD, AOPDDR, VBPD, ...

WHAT SHOULD ESPE DETECT
SAFEGUARDING TYPE & DETECTION CAPABILITY

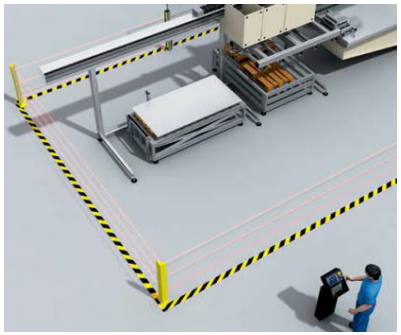
Point-of-operation protection

☑ Finger or hand detection



Hazardous area protection

☑ Detection of the presence of a person in the hazardous area



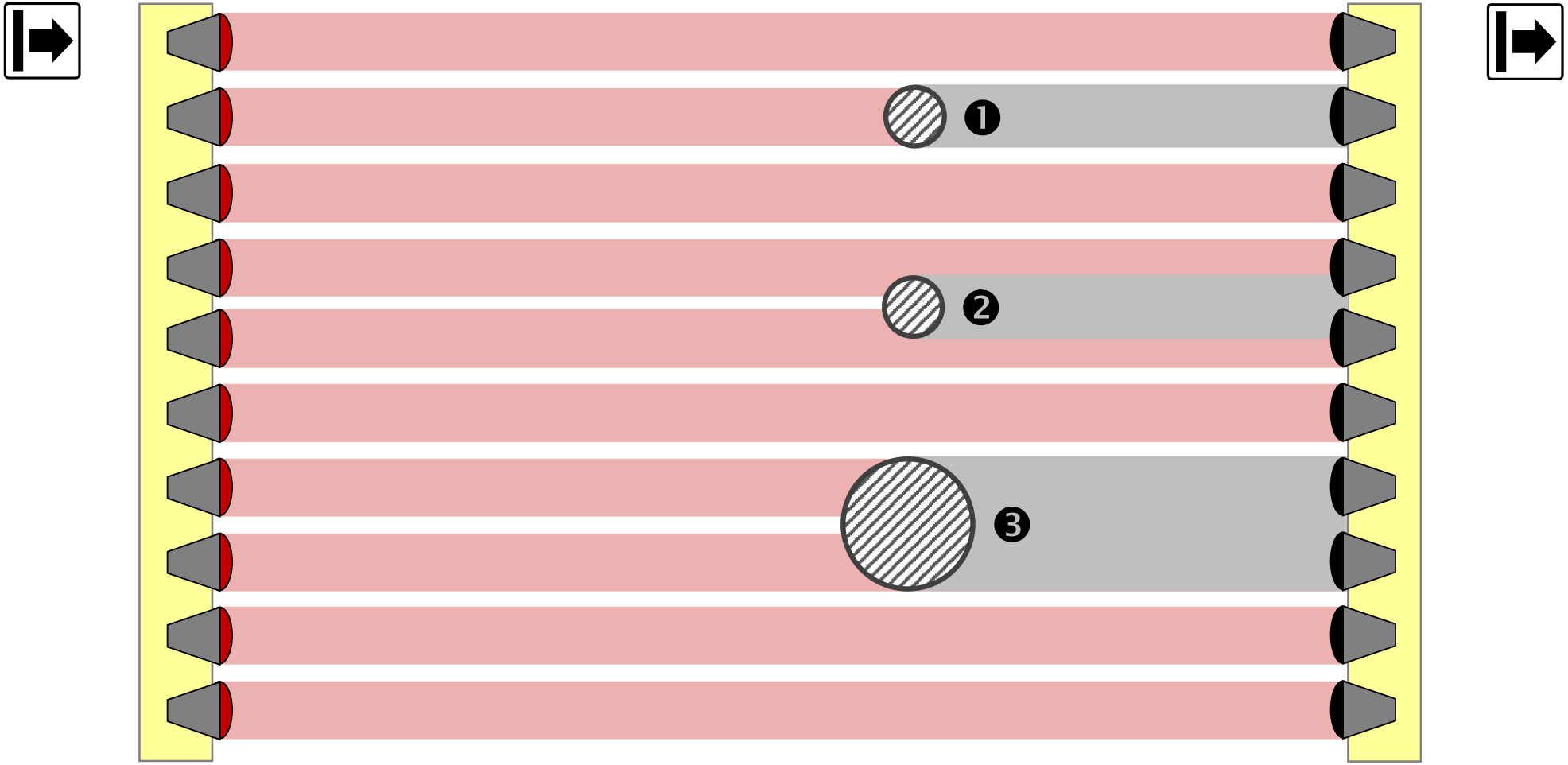
Access protection (perimeter guarding)

☑ Detection of a person on access to the hazardous area

POSITIONING OF AOPD
MOUNTING

DETECTION CAPABILITY

ACC. TO EFFECTIVE BEAM SECTION (ONLY FOR PARALLEL BEAMS)



❶	**Object detection**	test piece covers one beam section completely
❷	**Undefined object detection**	test piece covers only parts of the beam sections
❸	**Reliable object detection**	test piece covers two beam sections completely

ISO 13855 – MINIMUM DISTANCES

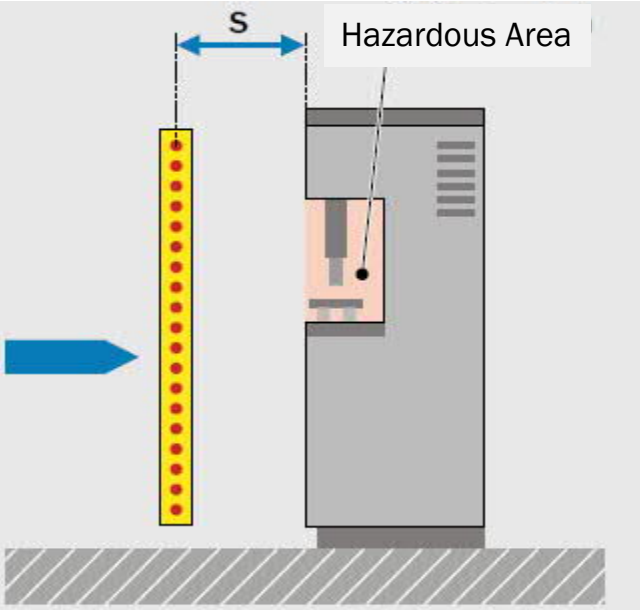
POINT OF OPERATION SAFEGUARDING – HAZARDOUS POINT PROTECTION

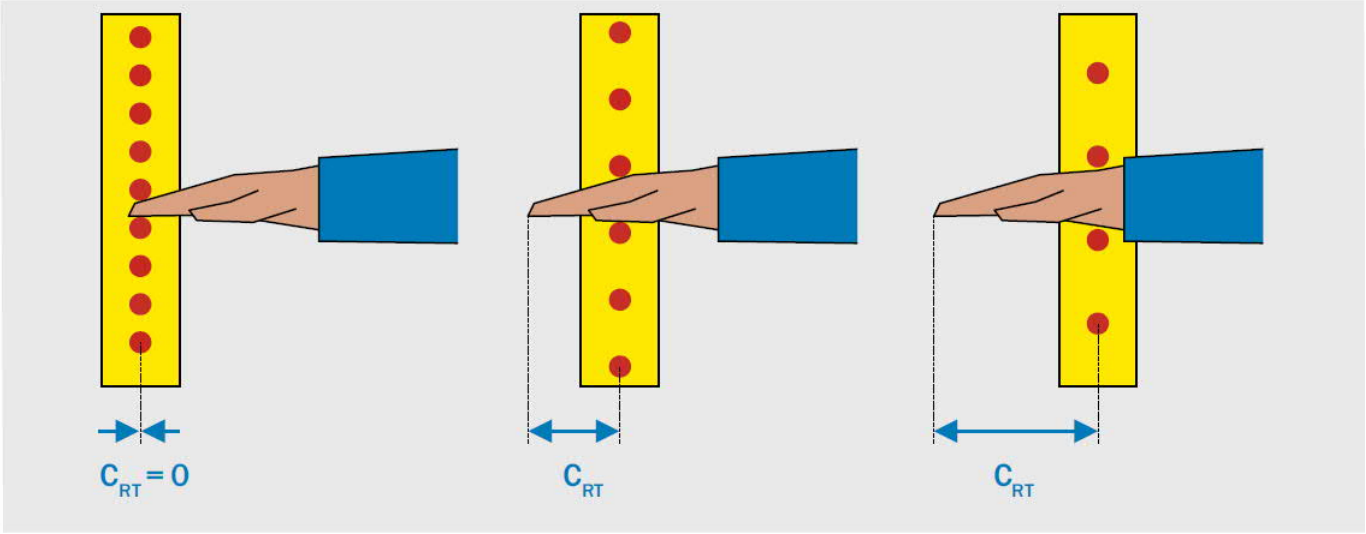
S = K x T + 8 x (d-14mm)

- S = Minimum / Safety distance [mm]
- K = Approach speed [2000 mm/s] for S ≤ 500mm
- K = Approach speed [1600 mm/s] for S > 500mm
- T = Response / stopping time [s]
- C = Additional distance [8 x (d-14mm)]
- d = Detection capability [mm]
- S always ≥ 100mm
- The formula is only valid for d ≤ 40mm & adults !
- Formula applies for any approach directions orthogonal to the detection plane [ß > 30°]

POSITIONING OF SAFEGUARDS
ISO 13855:2010

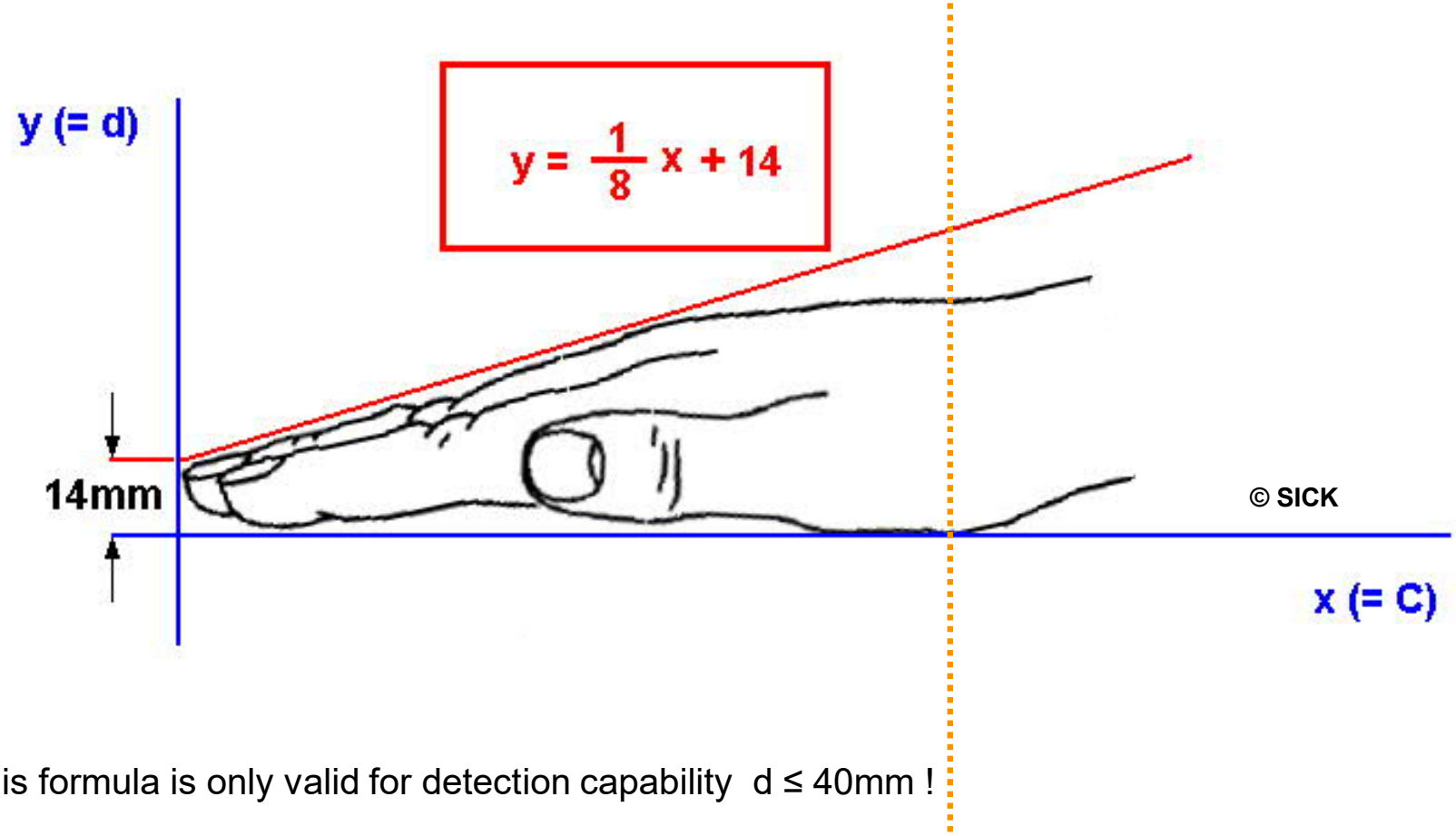
$$S = (K \times T) + C$$





C_{RT} = Resolution

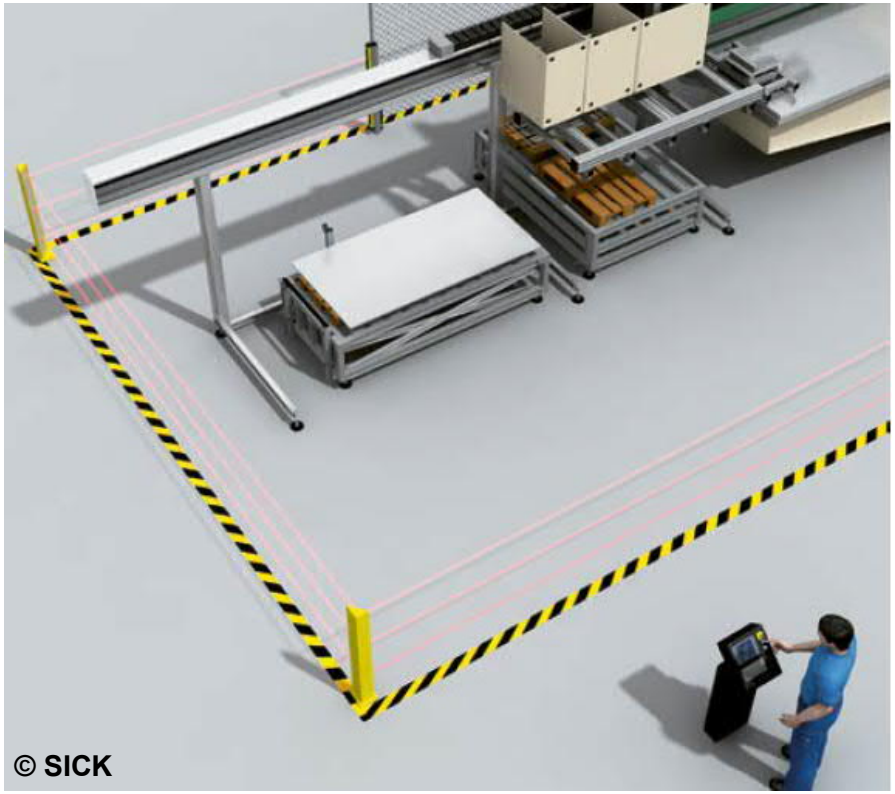
why C = 8 x (d-14mm) . . . ?



This formula is only valid for detection capability d ≤ 40mm !

ISO 13855 – MINIMUM DISTANCES

PERIMETER SAFEGUARDING – ACCESS PROTECTION



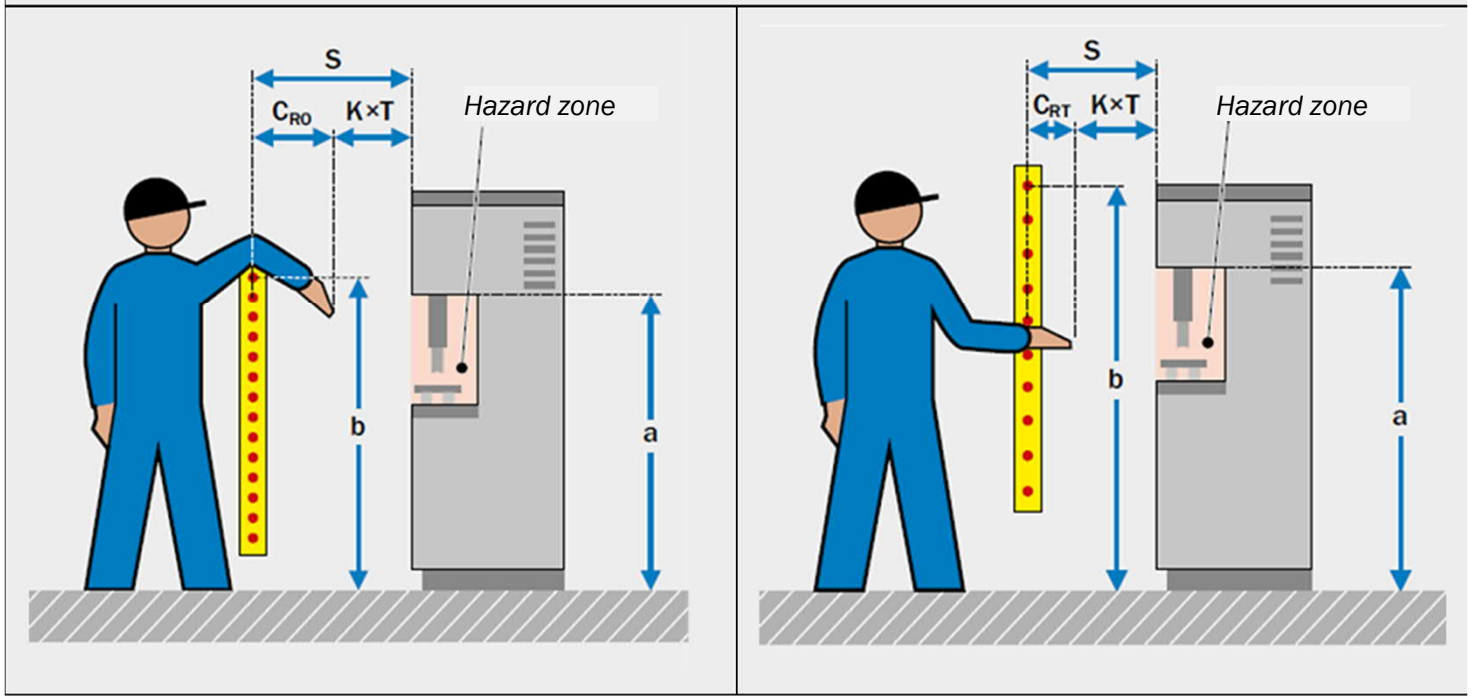
S = K x T + C

- S = Minimum / Safety distance [mm]
- K = Approach speed [1600 mm/s]
- T = Response / stopping time [s]
- C = Additional distance = 850 mm
  if reaching over the ESPE is not possible
- C = Additional distance see Table 1
  if reaching over the ESPE is possible
- C not less than 850 mm (length of the human arm)
- The formula is valid for devices with d > 40mm !
- Formula applies for any approach directions orthogonal to the detection plane [ß > 30°]

INTRUSION DISTANCE
REACHING THROUGH / REACHING OVER

C distance that a part of the body (usually a hand) can move past the safeguard towards the hazard zone prior to actuation of the safeguard

$$C = \max(C_{RO}, C_{RT})$$

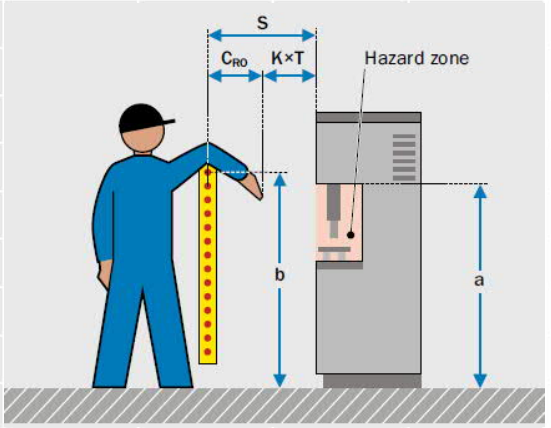


- If it is possible to access hazardous areas by reaching over the ESPE, then the height „b“ of the top edge of the detection field shall be selected according to the table so that :

$$C \geq C_{RO} \geq C_{RT}$$

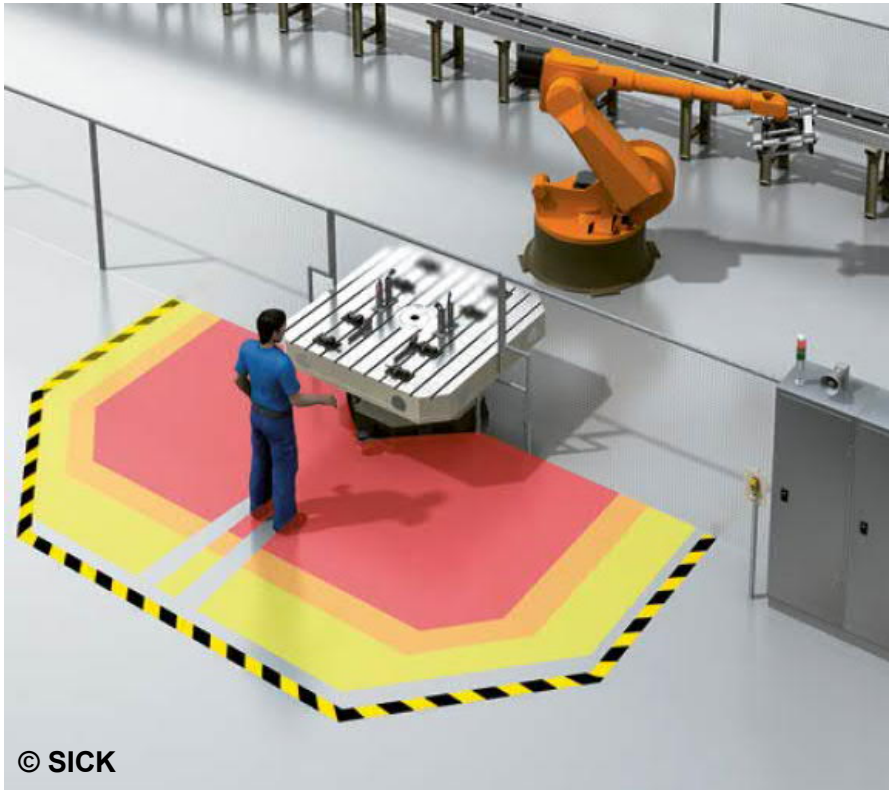
C_{RO} = Intrusion factor due to reaching over the detection field, C_{RT} = Intrusion factor due to reaching through the detection field

Height a of the hazard zone (mm)	Additional horizontal distance C to the hazard zone (mm)											© SICK
2600	0	0	0	0	0	0	0	0	0	0	0	0
2500	400	400	350	300	300	300	300	300	250	150	100	0
2400	550	550	550	500	450	450	400	400	300	250	100	0
2200	800	750	750	700	650	650	600	550	400	250	0	0
2000	950	950	850	850	800	750	700	550	400	0	0	0
1800	1100	1100	950	950	850	800	750	550	0	0	0	0
1600	1150	1150	1100	1000	900	850	750	450				
1400	1200	1200	1100	1000	900	850	650	0				
1200	1200	1200	1100	1000	850	800	0	0				
1000	1200	1150	1050	950	750	700	0	0				
800	1150	1050	950	800	500	450	0	0				
600	1050	950	750	550	0	0	0	0				
400	900	700	0	0	0	0	0	0				
200	600	0	0	0	0	0	0	0				
0	0	0	0	0	0	0	0	0				
	Height b of the top edge of the protective field (mm)											
	900	1000	1100	1200	1300	1400	1600	1800	2000	2200	2400	2600



ISO 13855 – MINIMUM DISTANCES

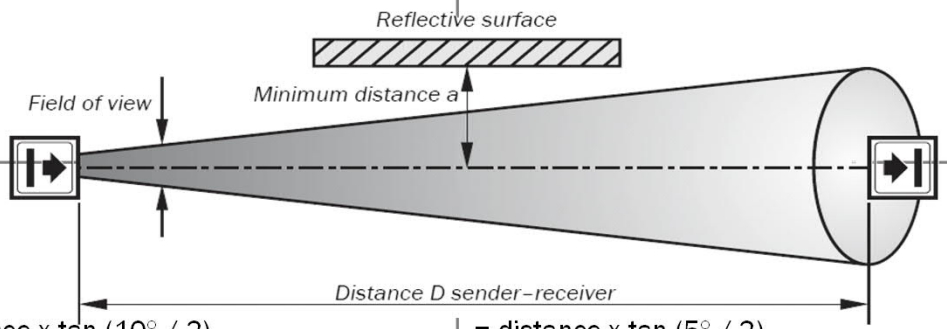
HAZARDOUS AREA PROTECTION



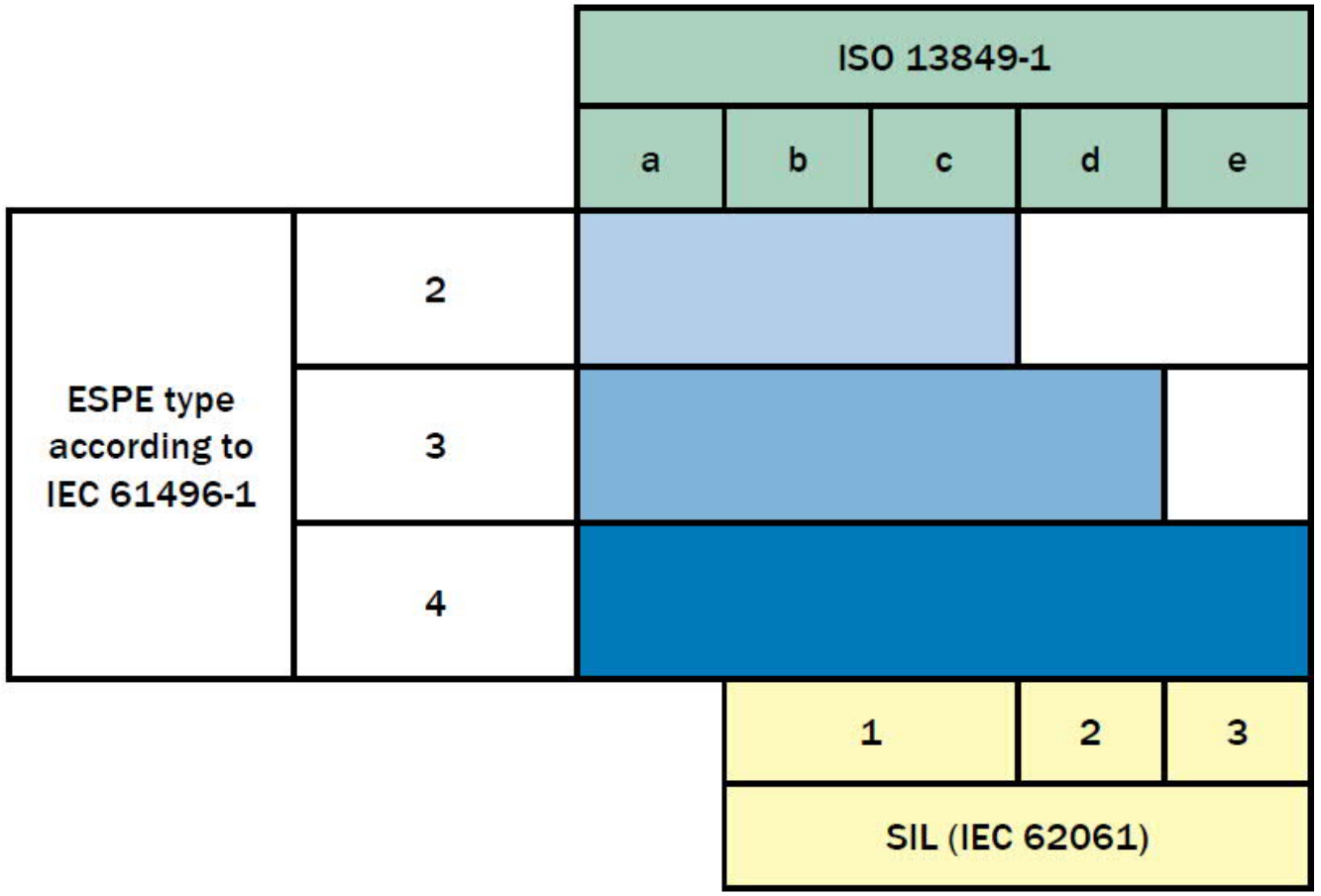
S = K x T + (1200- 0,4 x H)

- S = Minimum / Safety distance [mm]
- K = Approach speed [1600 mm/s]
- T = Response / stopping time [s]
- C = Additional distance [1200mm – 0,4H]
- H = Height of the edge of the detection zone furthest to the hazard zone but not less than 0 and not higher then 1000 mm
- d Detection capability [d ≤ (H/15) + 50mm]
- C not less than 850 mm (length of the human arm)
- The formula is only valid for devices with d ≤ 117mm !
- The formula applies for any approach directions parallel to the detection plane [ß ≤ 30°]

MAIN DIFFERENCE OF TYPE 2/4
ACC. TO IEC 61496-1:2013

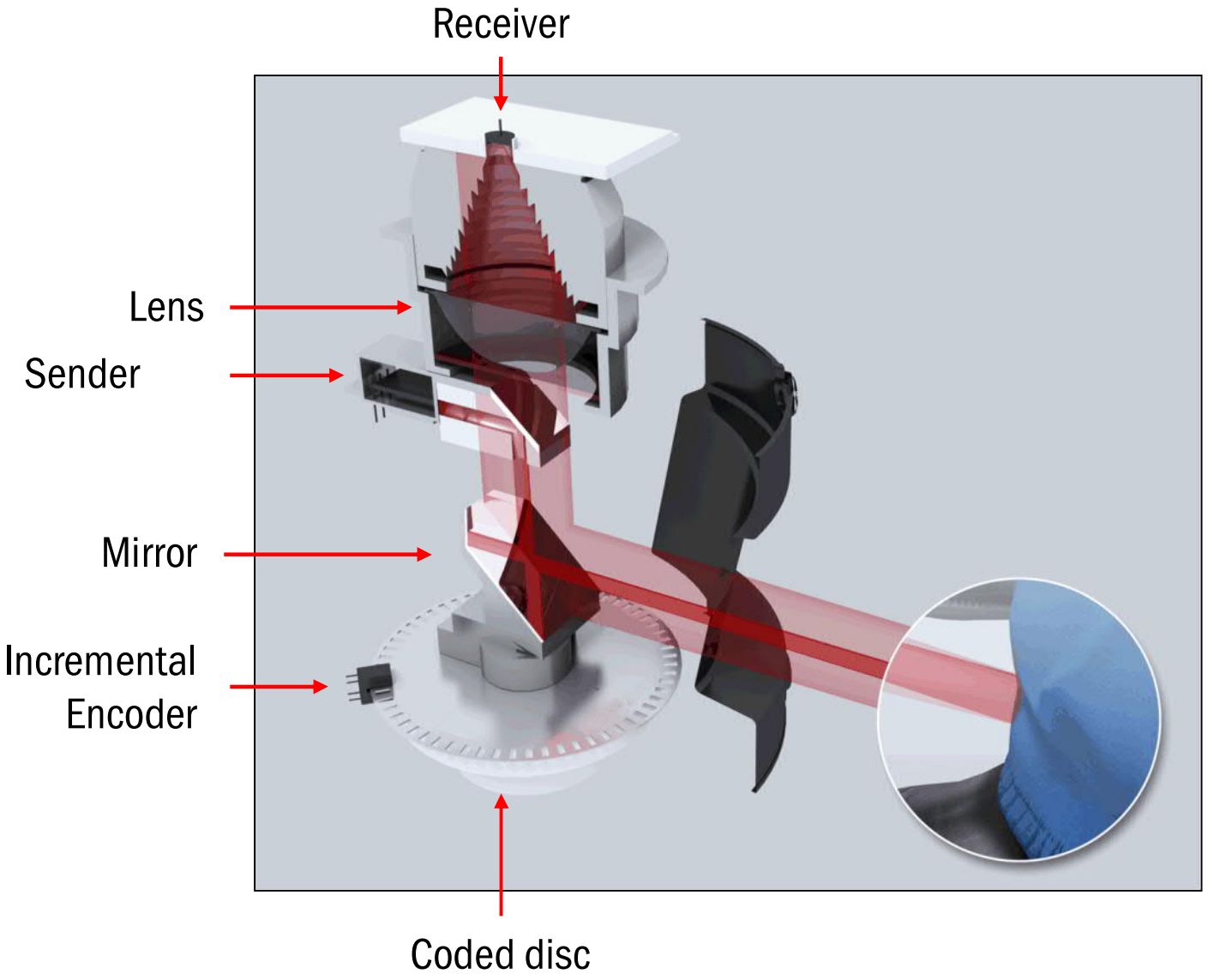
	Type 2	Type 4
Functional safety	Between the test intervals, the protective function may be lost during the occurrence of a failure.	The protective function is retained even during several failures.
EMC (electromagnetic compatibility)	Basic requirements	Increased requirements
Maximum field of view of the optics	10°	5°
Minimum distance ***a*** to reflective surfaces over a distance of ***D*** < 3 m	262 mm	131 mm
Minimum distance ***a*** to reflective surfaces over a distance of ***D*** > 3 m	 = distance x tan (10° / 2)	= distance x tan (5° / 2)
Several senders of the same design in a system	No special requirements (Beam coding is recommended)	No effect; however, if affected, OSSDs switch off.

ACHIEVABLE RELIABILITY
ACC. TO IEC 62046 & IEC 61496-1

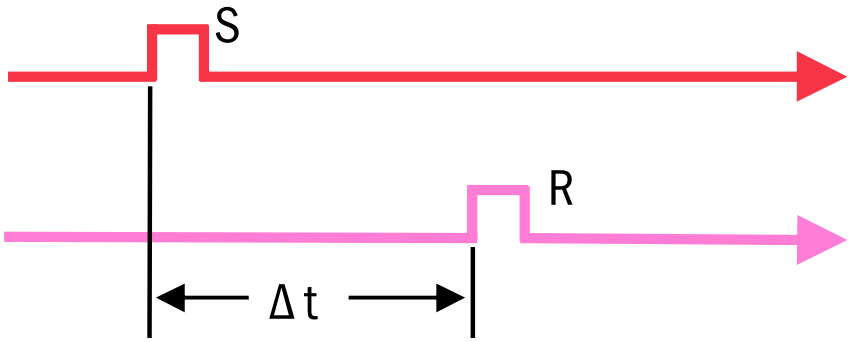


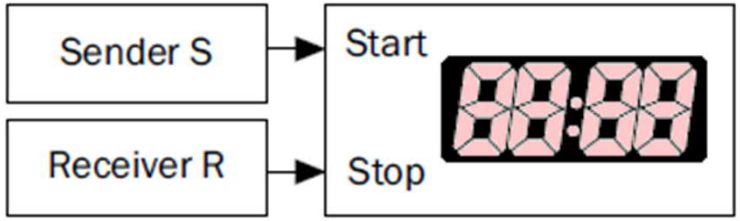
SAFETY LASER SCANNER (AOPDDR)

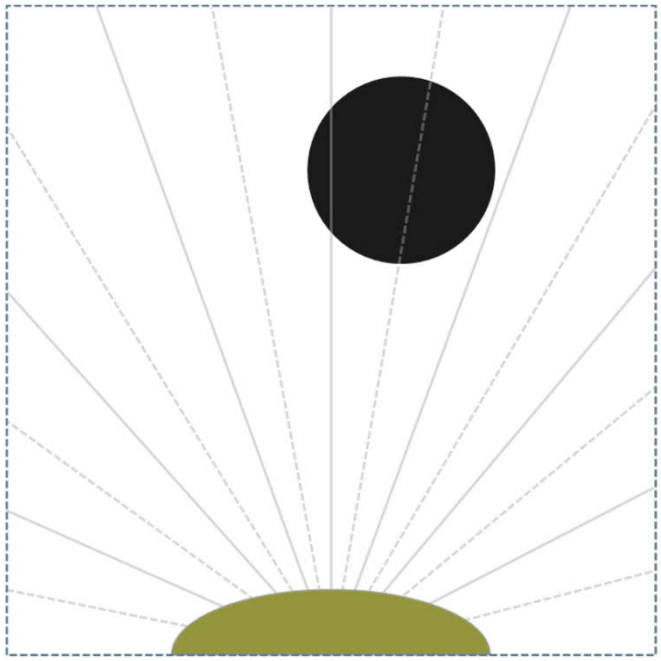
OPTICAL SCHEME



SAFETY LASER SCANNER (AOPDDR)
FUNCTIONAL PRINCIPLE – TIME OF FLIGHT MEASUREMENT

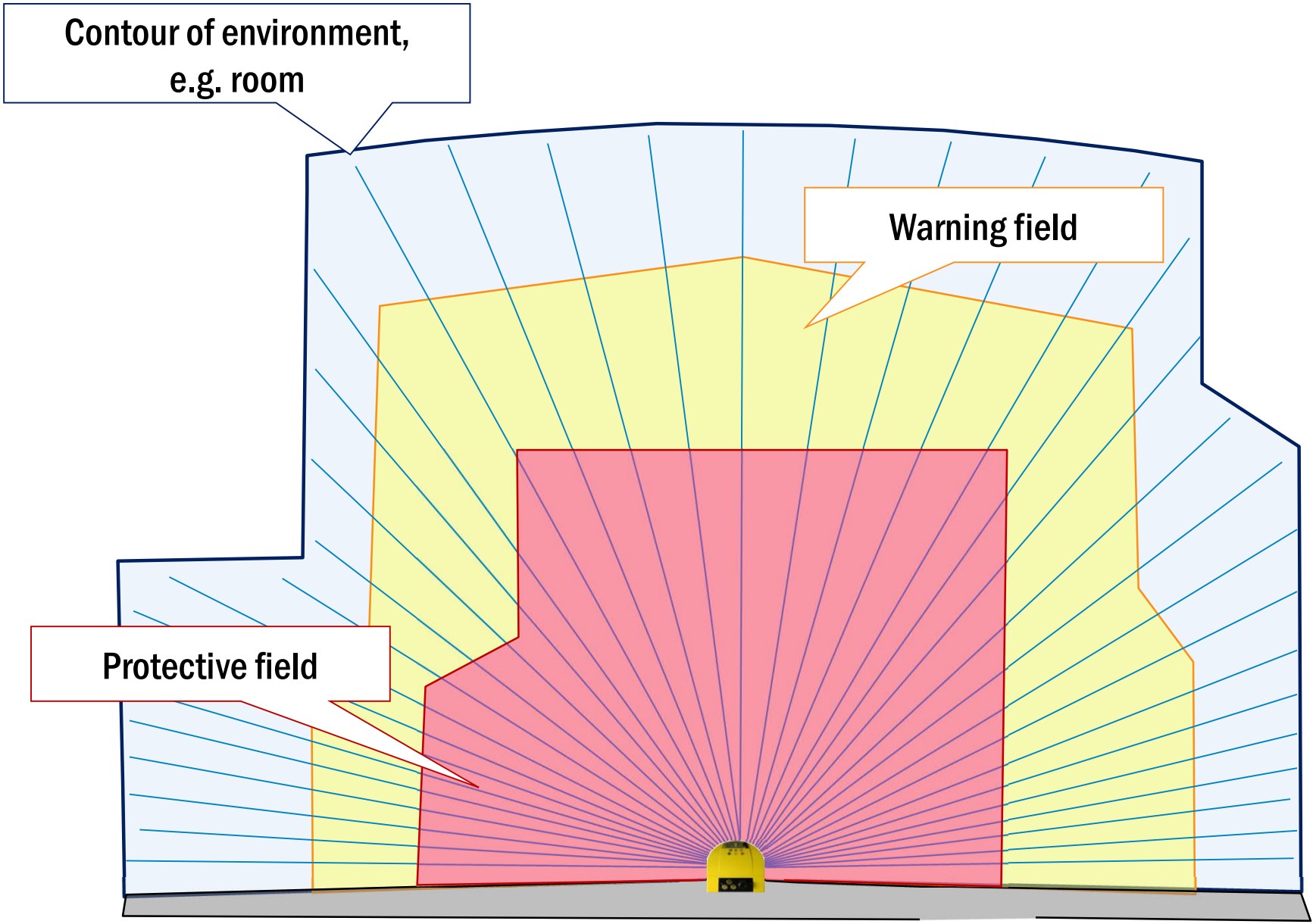




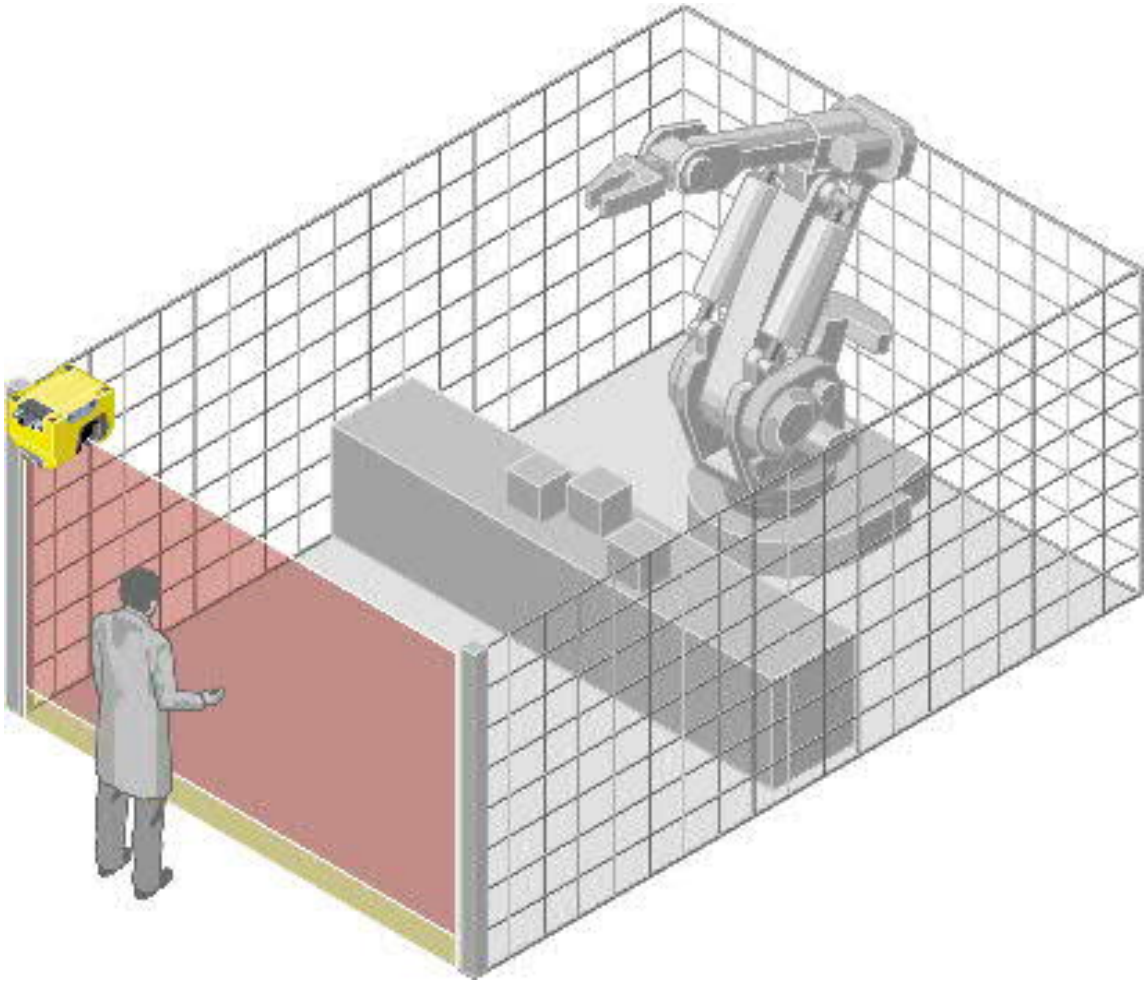


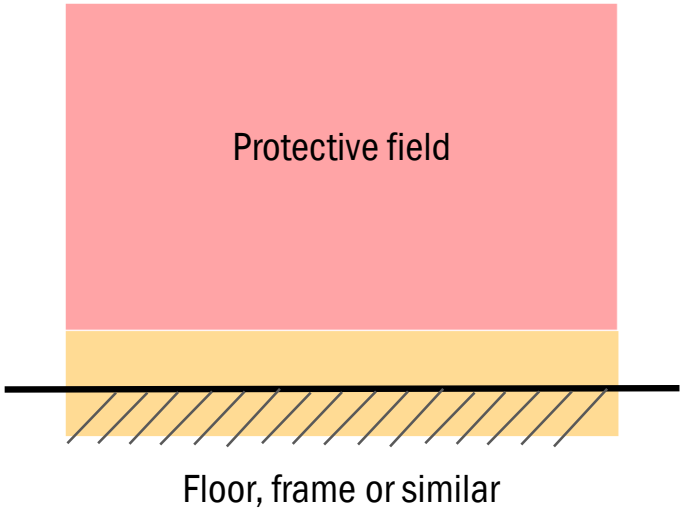
SAFETY LASER SCANNER (AOPDDR)

PROTECTIVE/WARNING FIELDS



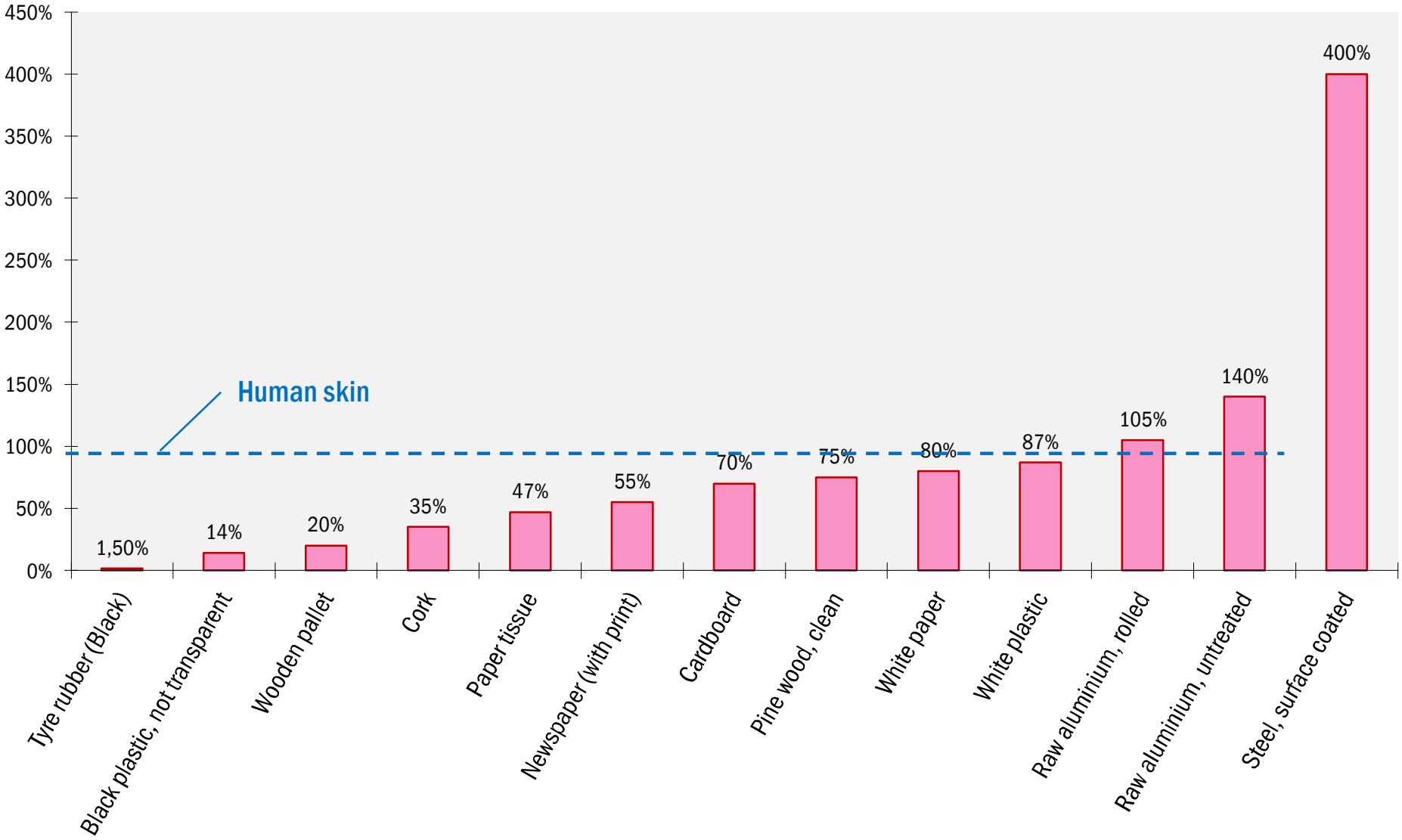
VERTICAL OPERATION
CONTOUR AS REFERENCE





SAFETY LASER SCANNER (AOPDDR)

DETECTION CAPABILITY AND RELATION TO OBJECT REFLECTANCE

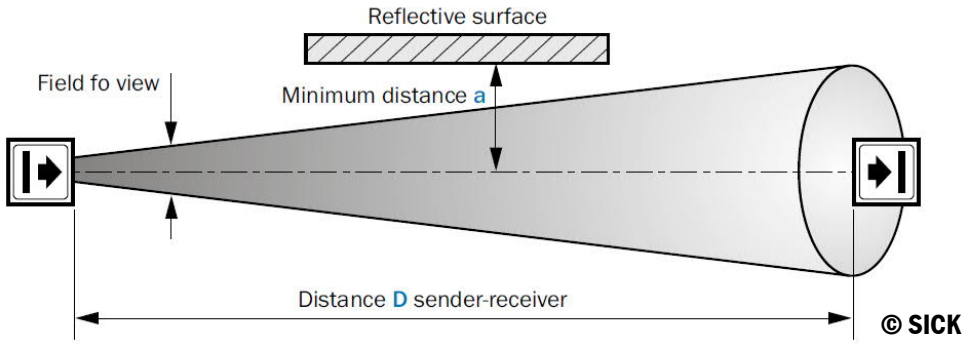


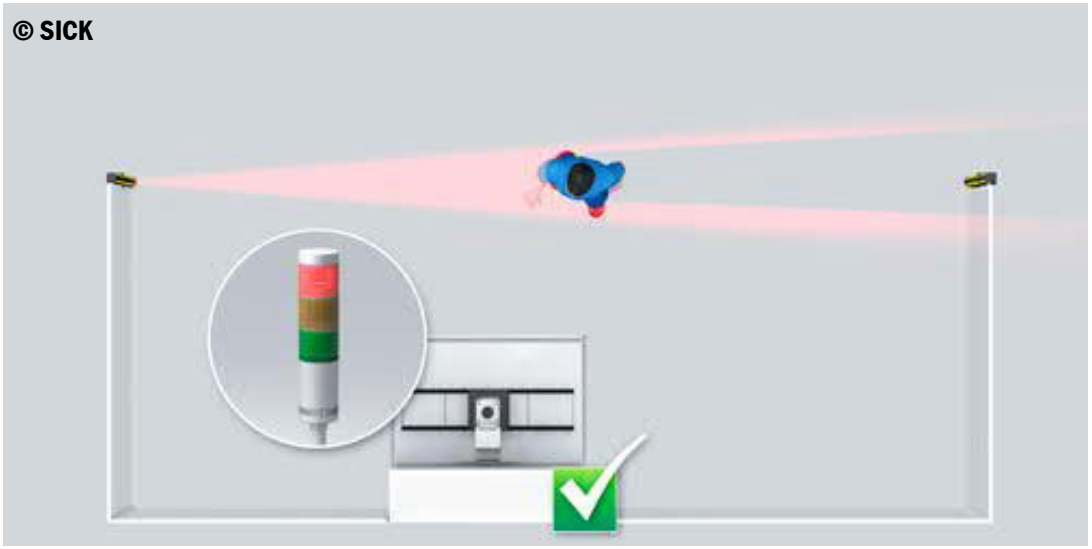
100% reference based on Kodak white material

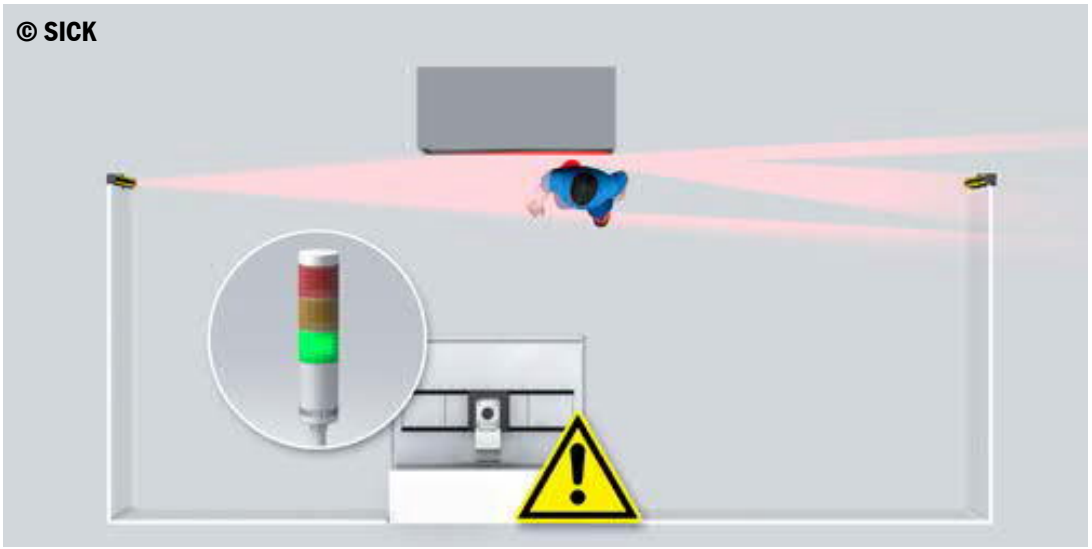
SYSTEMATIC ASPECTS – LOSS OF EFFECTIVENESS

BEAM DEFLECTION DUE TO NEAR REFLECTIVE SURFACES

- Reflective surfaces present within the transmitting / receiving beam path, or deposited or attached there, can cause reflections and thus lead to a hindrance not being detected.
- For this reason a minimum distance „a“ must be maintained between reflective objects and the optical axis (the straight-line between sender and receiver).
- The distance „a“ depends on the distance between sender and receiver and the effective aperture angle α
- The effective aperture angle α = ± 2,5° for Type 4 devices and α = ± 5° for Type 2 devices

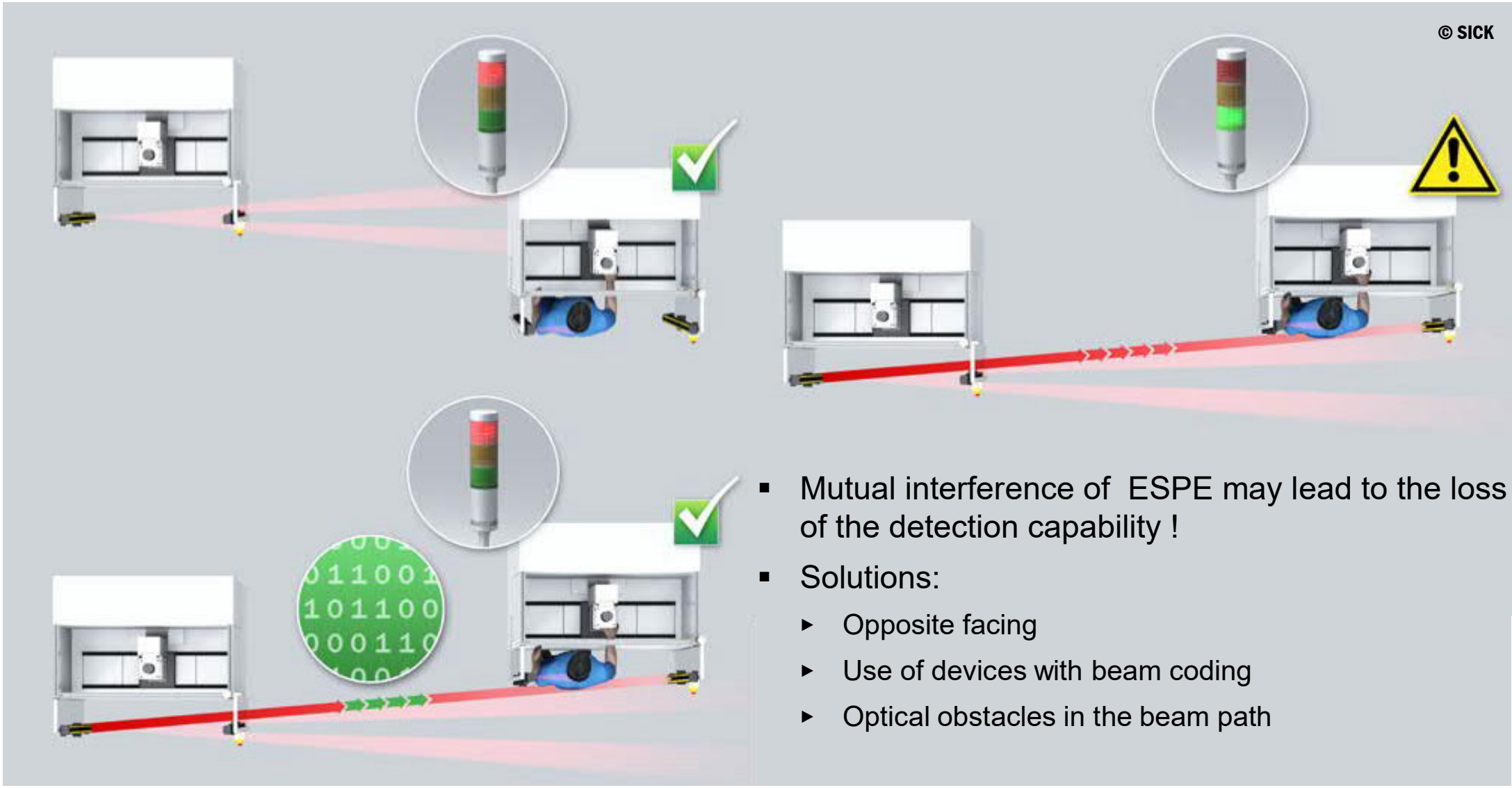






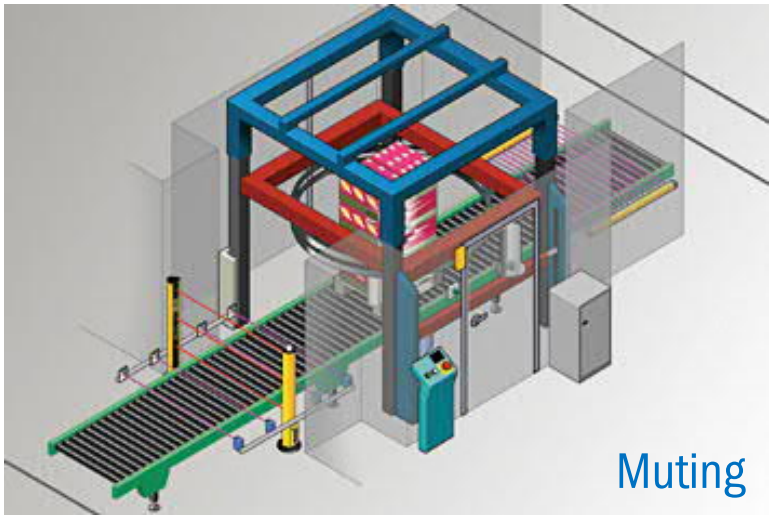
SYSTEMATIC ASPECTS – LOSS OF EFFECTIVENESS

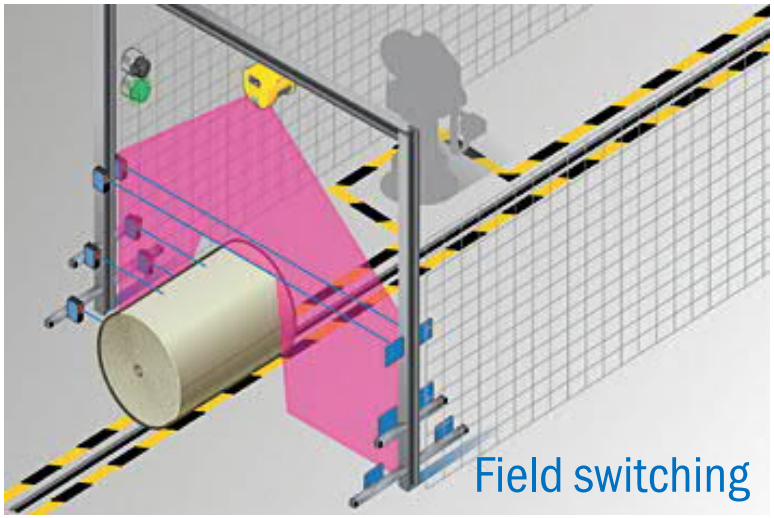
MUTUAL INTERFERENCES

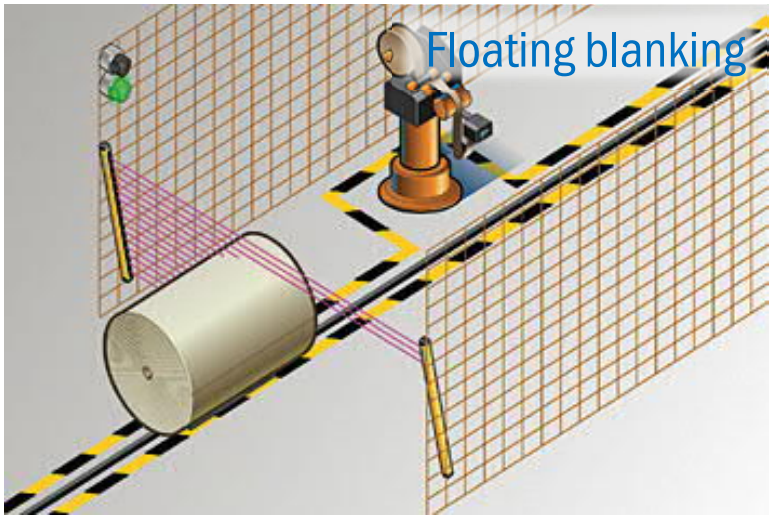


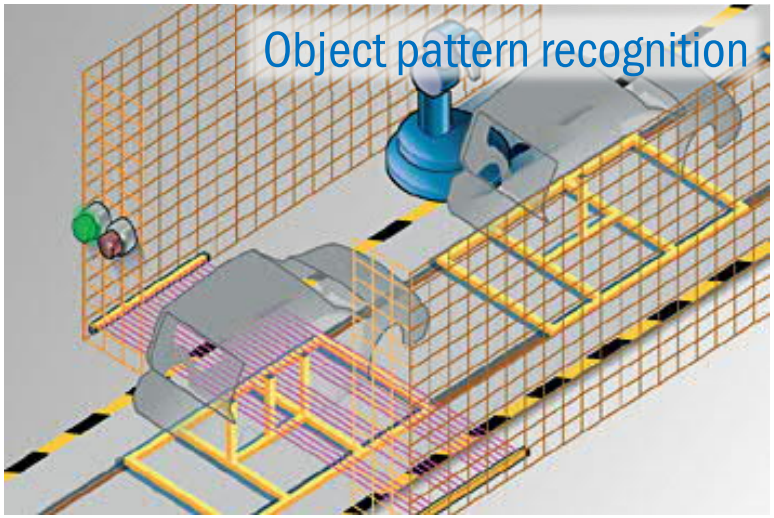
- Mutual interference of ESPE may lead to the loss of the detection capability !
- Solutions:
  - Opposite facing
  - Use of devices with beam coding
  - Optical obstacles in the beam path

ALLOWING MATERIAL PASSAGE
SUITABLE SOLUTIONS

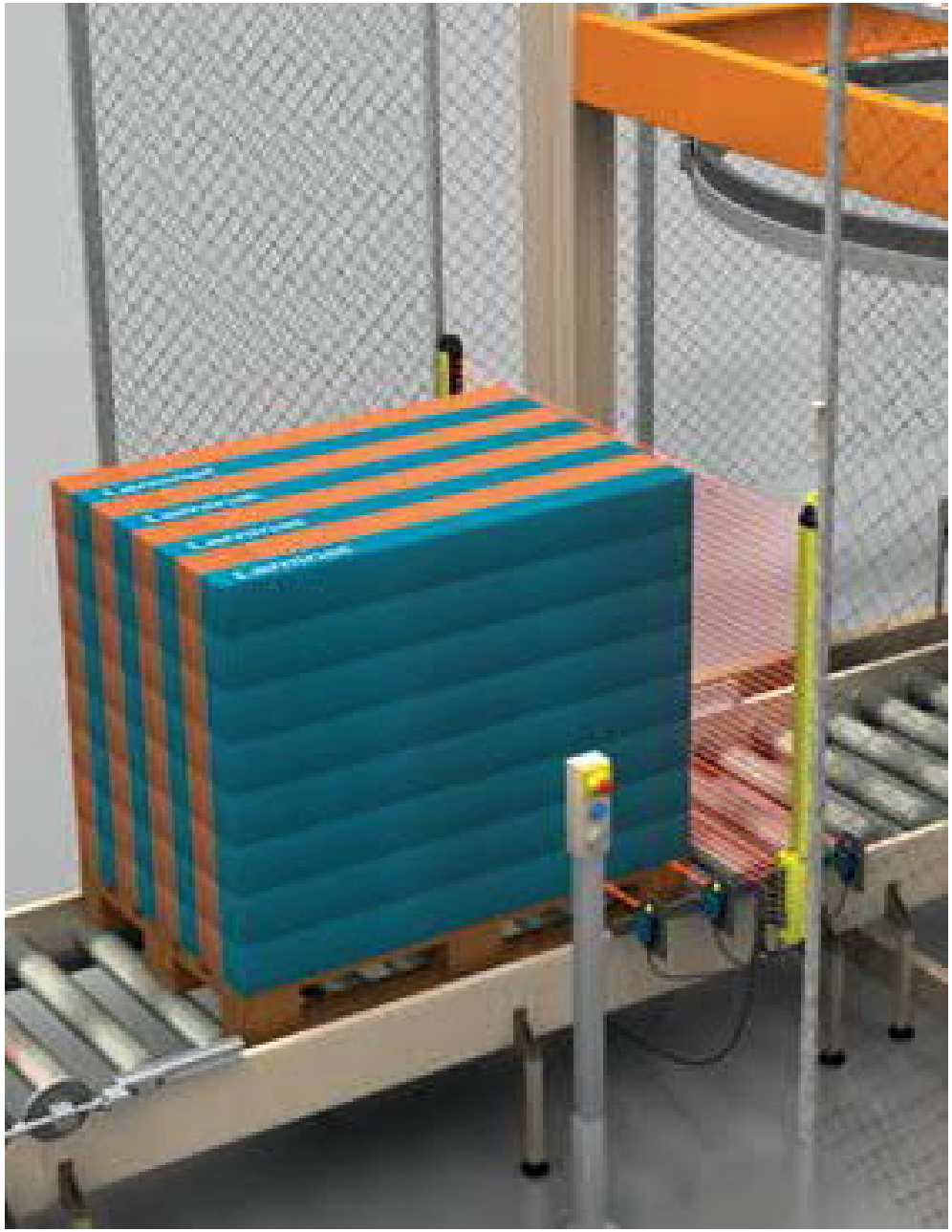








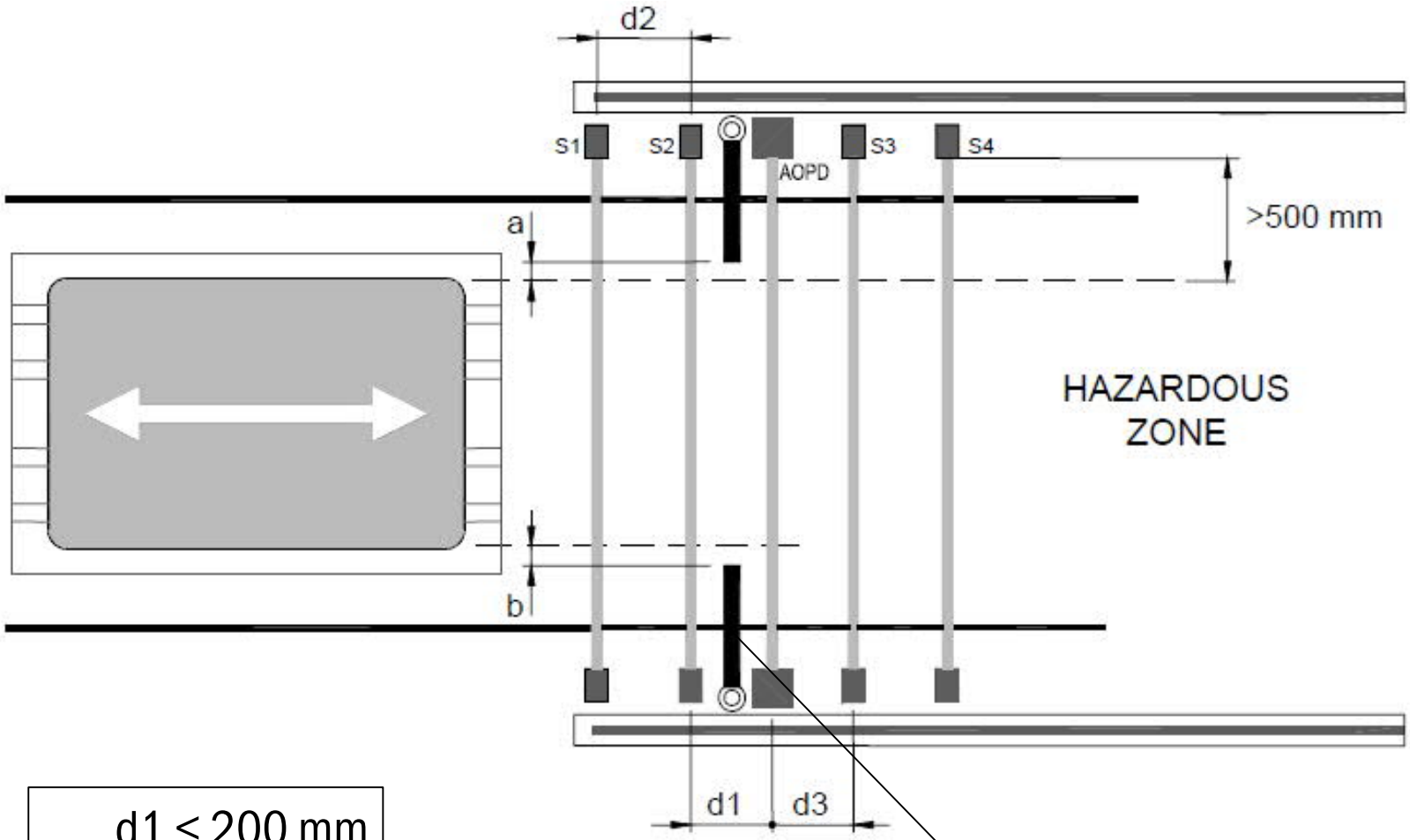
MUTING FUNCTION
REQUIREMENTS



- During muting, a safe state must be ensured by other means, therefore it shall not be possible to access the hazard zone
- Muting shall be automatic, i.e. not manual
- Muting shall not be dependent on a single electrical signal
- Muting shall not be entirely dependent on software signals
- An invalid combination or sequence of muting signals shall not allow any muting state, and it shall be ensured that the protective function is retained
- The muting status shall end immediately after the material has passed through

POSITIONING OF MUTING SENSORS

APPLICATION EXAMPLE WITH FOUR THROUGH BEAM PHOTO CELLS



d1 < 200 mm

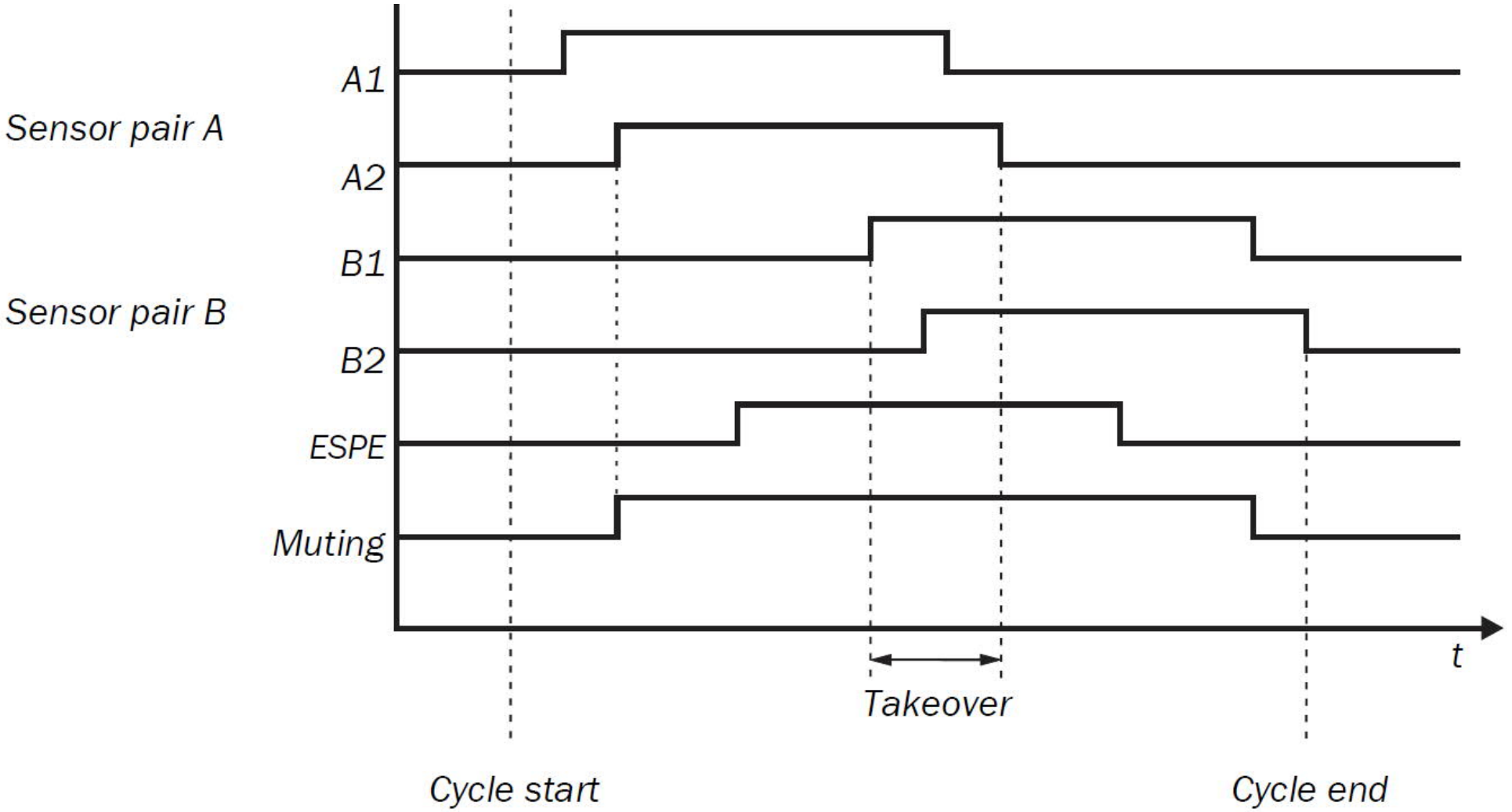
d2 > 250 mm

$\overline{S1\text{-}S4} \geq 500$ mm

optional:
additional swinging doors

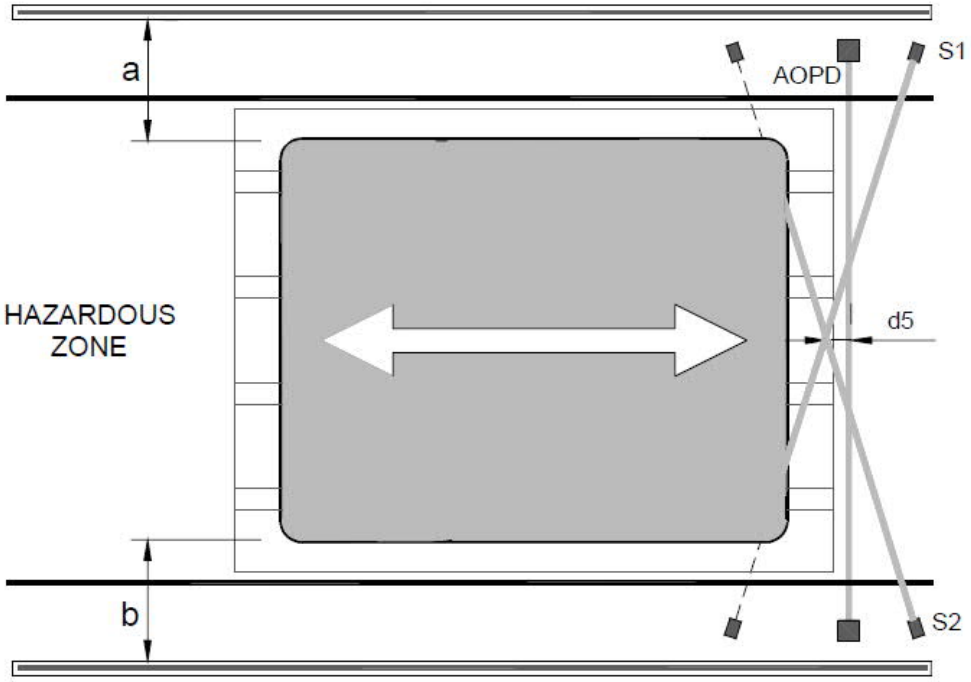
SEQUENCE/TIMING DIAGRAM

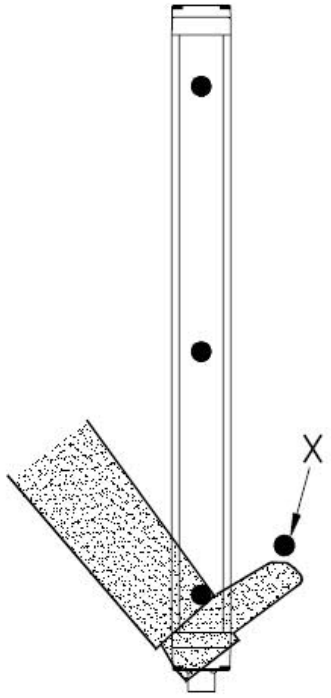
EXAMPLE OF VALID MUTING SEQUENCE



POSITIONING OF THE MUTING SENSORS

APPLICATION EXAMPLE WITH TWO REFLEX PHOTO CELLS

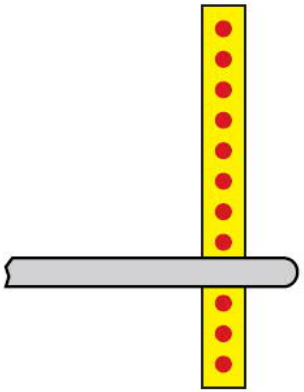
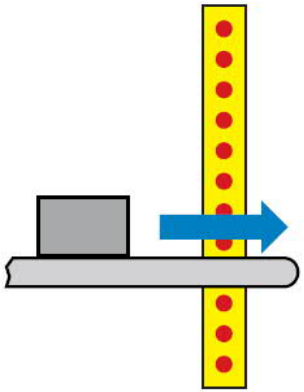
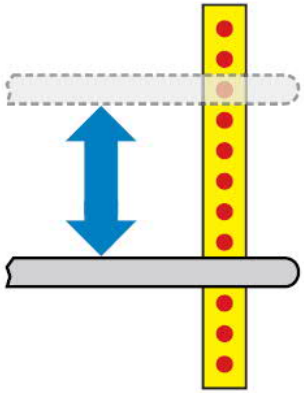
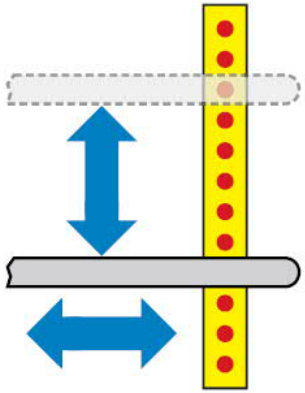


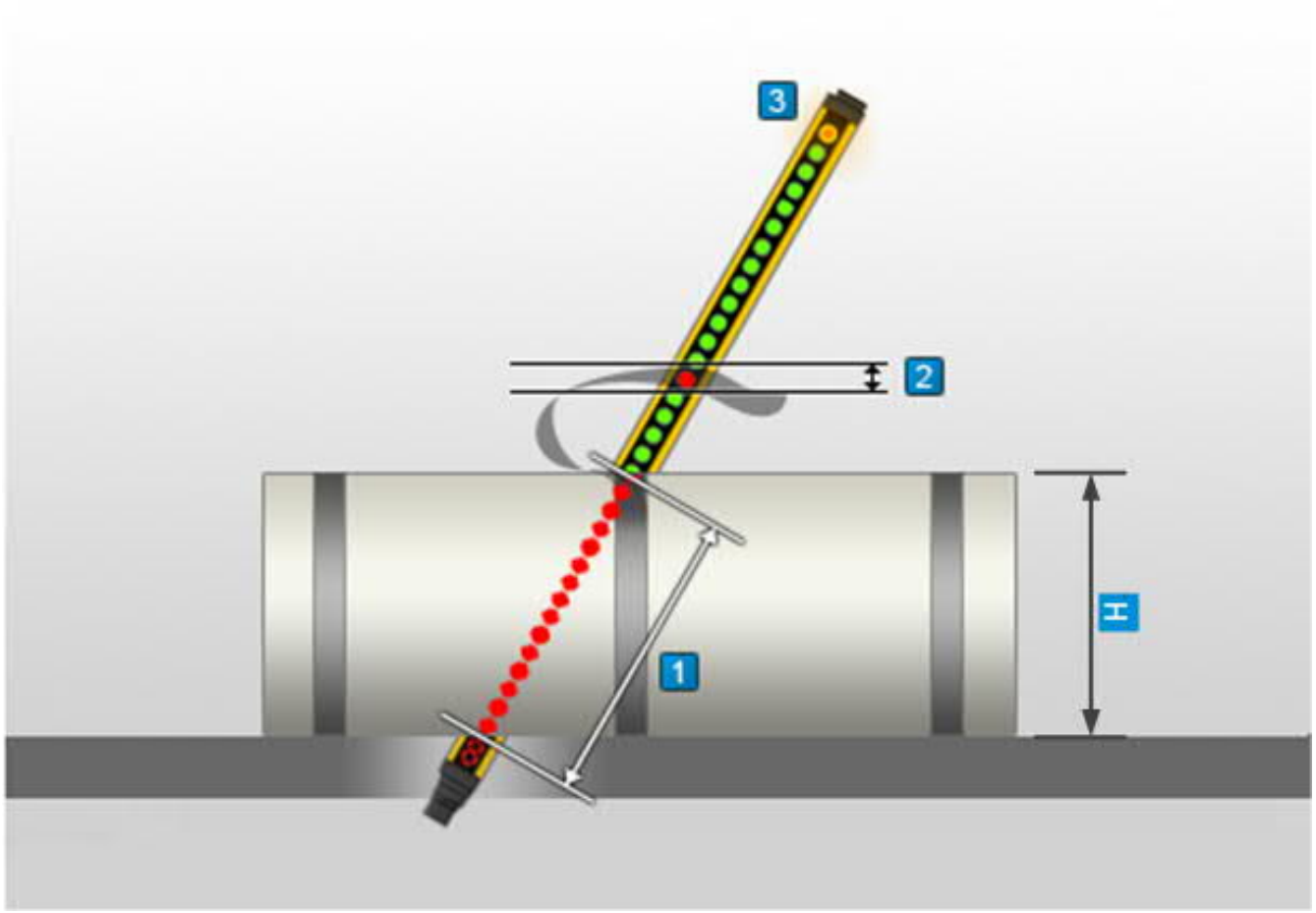


d5 ≤ 200 mm & if possible ~ 0mm

ADDITIONAL SWINGING DOORS
PREVENTION OF CRUSHING OR SHEARING RISKS

BLANKING FUNCTION
CLAUSE 6.1.3.3, IEC 62046:2018

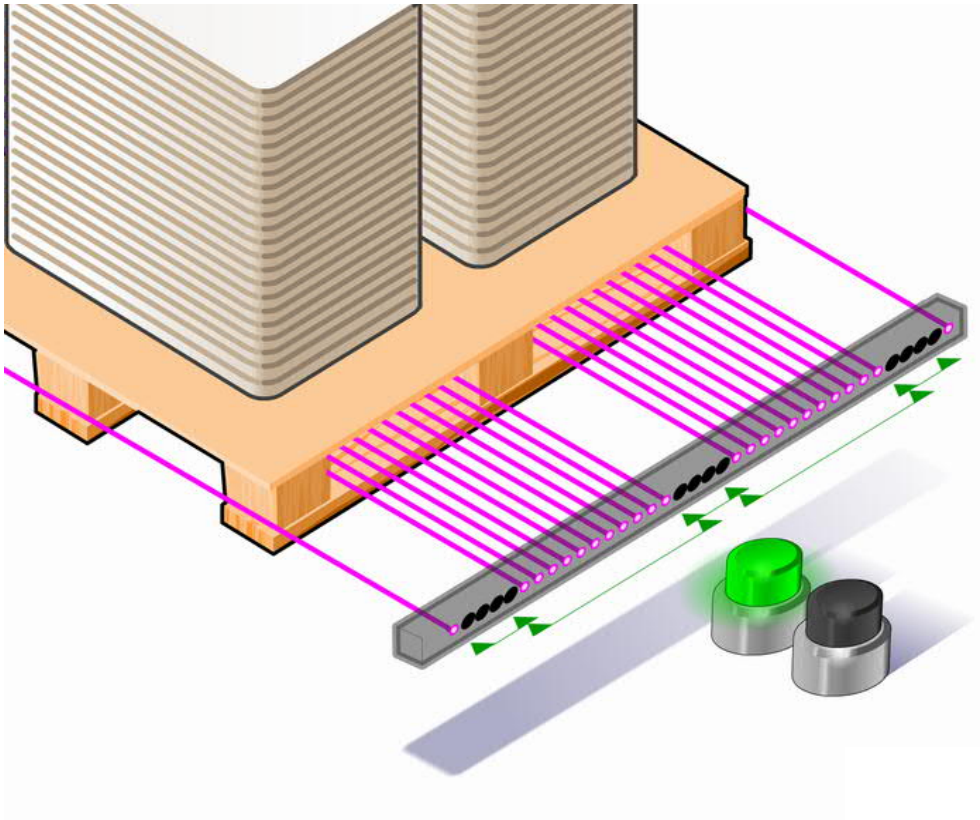
Fixed blanking		Floating blanking	
Fixed blanking	Fixed blanking with increased size tolerance	Floating blanking with complete object monitoring	Floating blanking with partial object monitoring
An object of *fixed* size *must* be at a specific point in the protective field.	From the operator side, an object of *limited* size *is allowed to* move through the protective field.	An object of fixed size *must* be within a specific area of the protective field. The object is allowed to move.	An object of fixed size *is allowed* in a specific area in the protective field. The object is allowed to move.
			

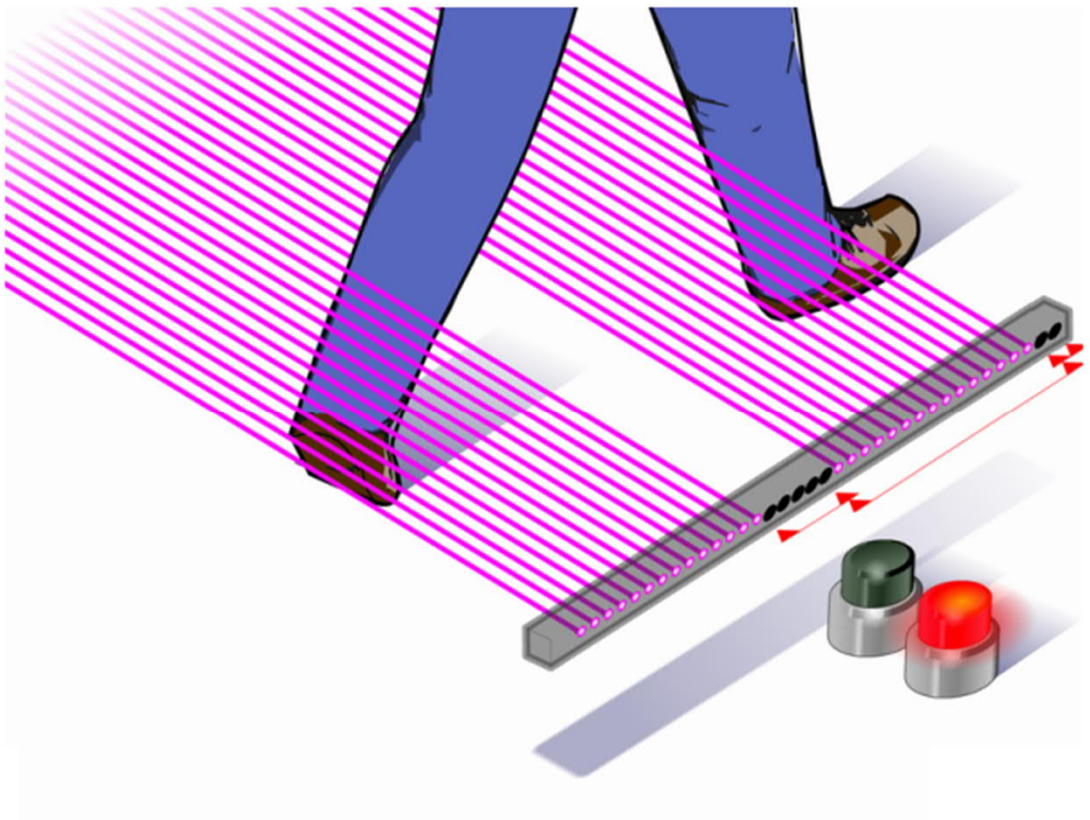


1. **Max. object size** [H ≤ 1.500 mm]
2. Reduced resolution
3. **Synchronization beam**

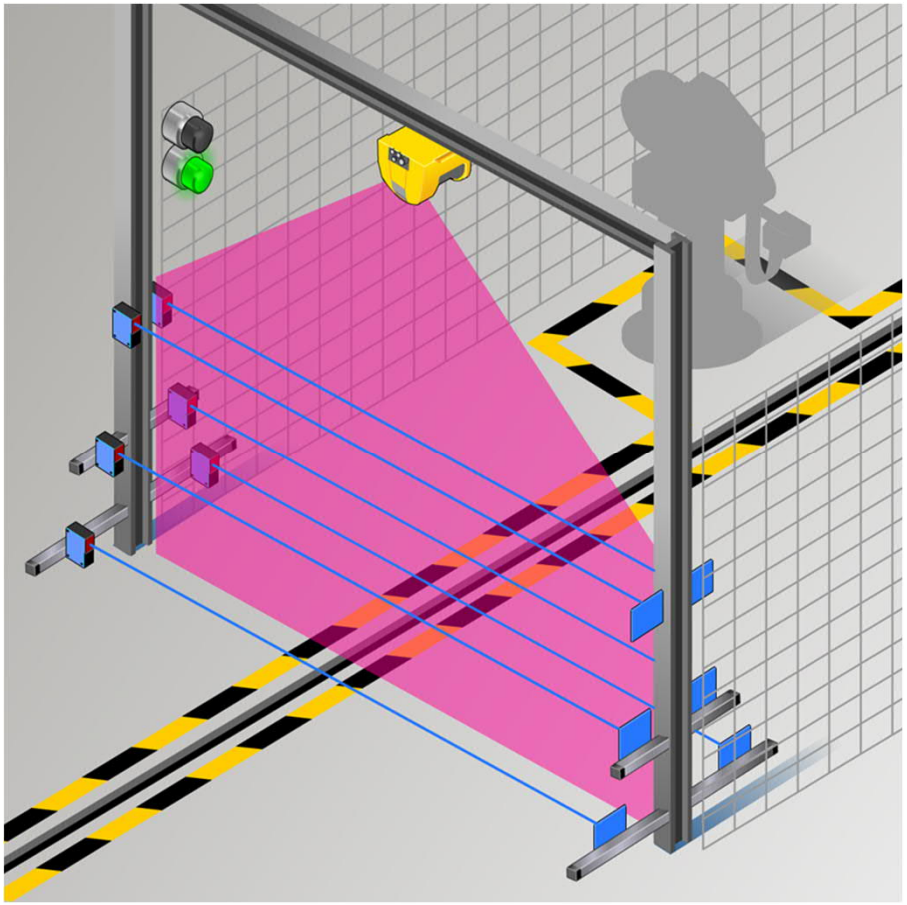
OBJECT PATTERN RECOGNITION

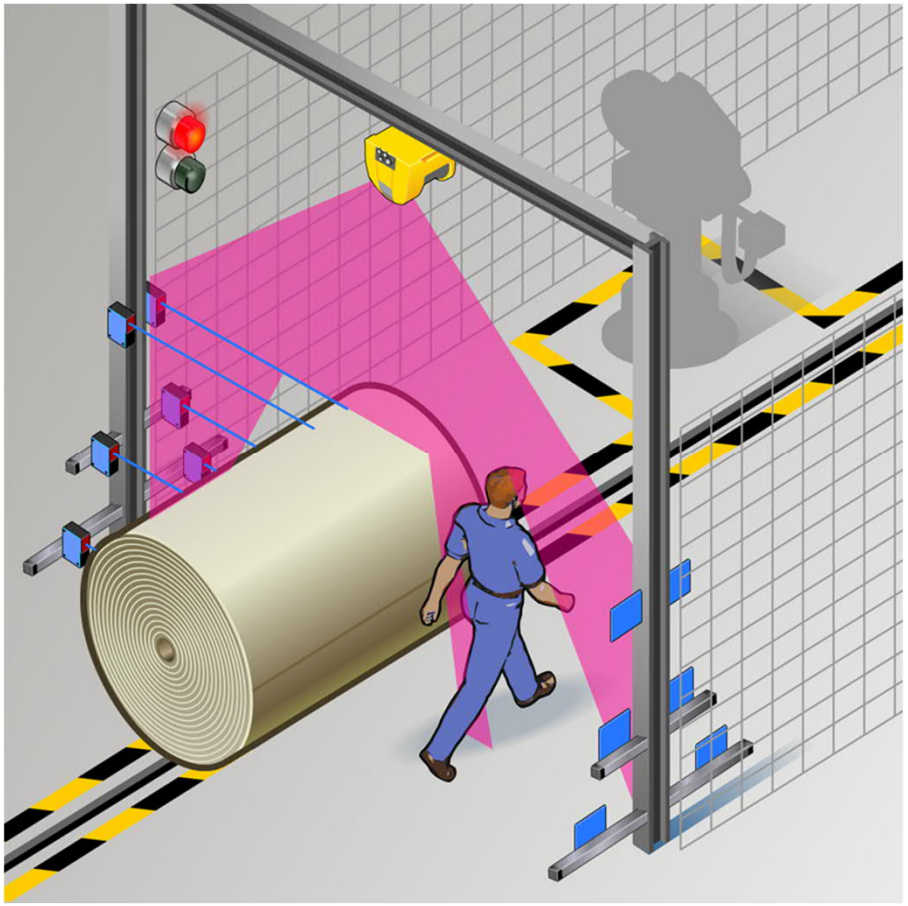
SELF-TEACH DYNAMIC BLANKING



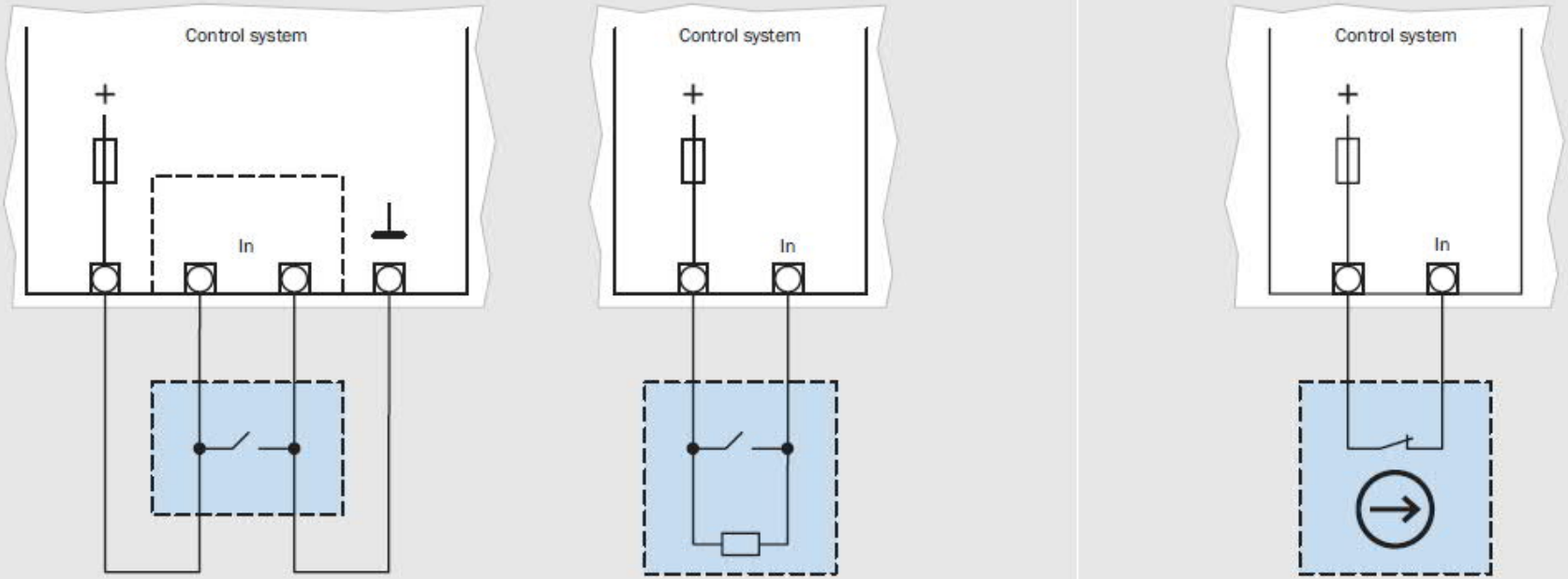


VERTICAL SAFEGUARDING
MUTING ALTERNATIVE





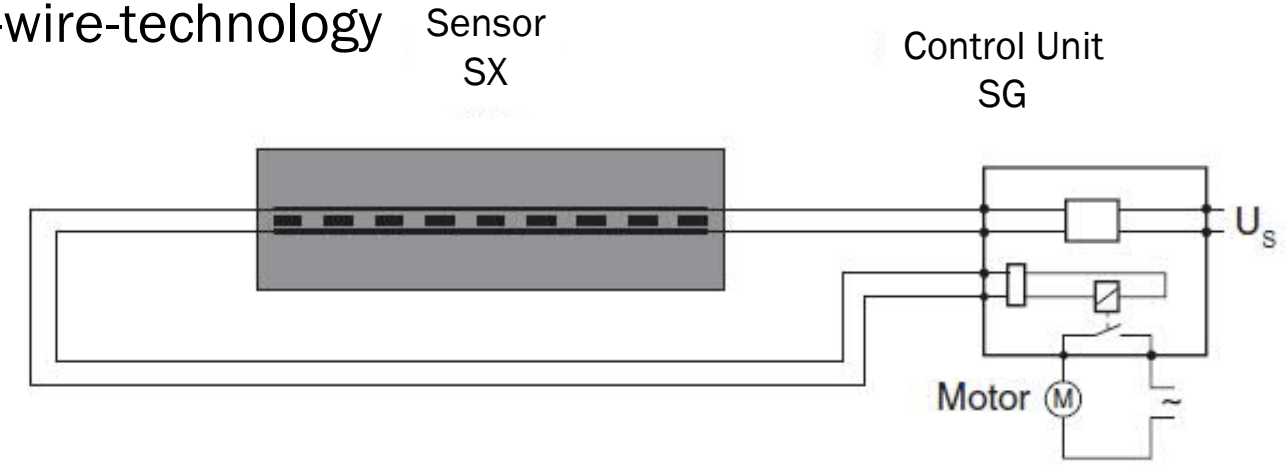
Short circuiting designs (energize to trip principle)		Positive opening contact design
4-wire version	Resistance version	(de-energize to trip principle)



The detection of children with body weights less than 20 kg is not addressed in the product standards for pressure-sensitive mats and floors

OPERATION PRINCIPLE
NORMALLY OPEN CONTACT

4-wire-technology



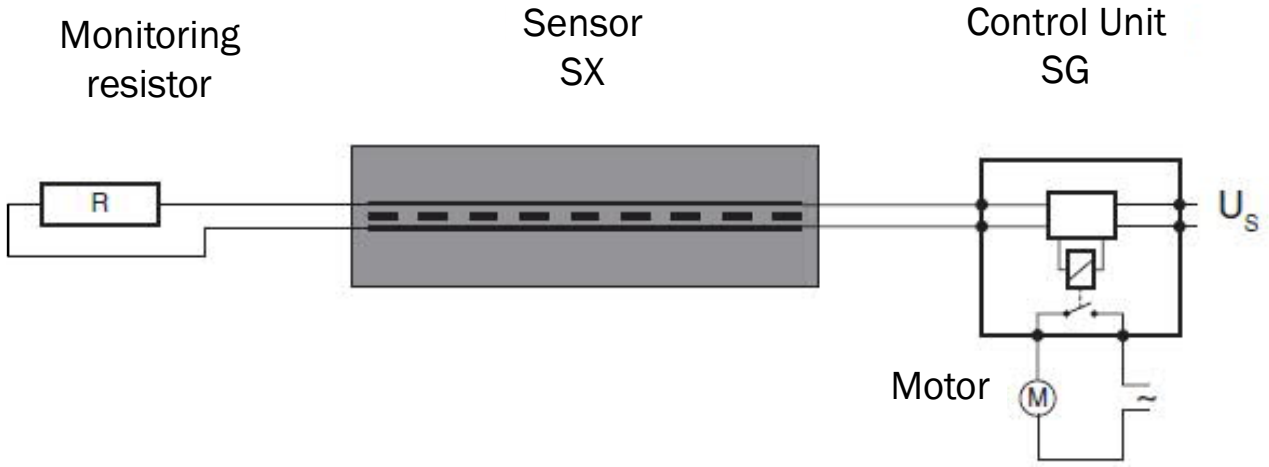
Note: SX stands for

SM = Safety Mat

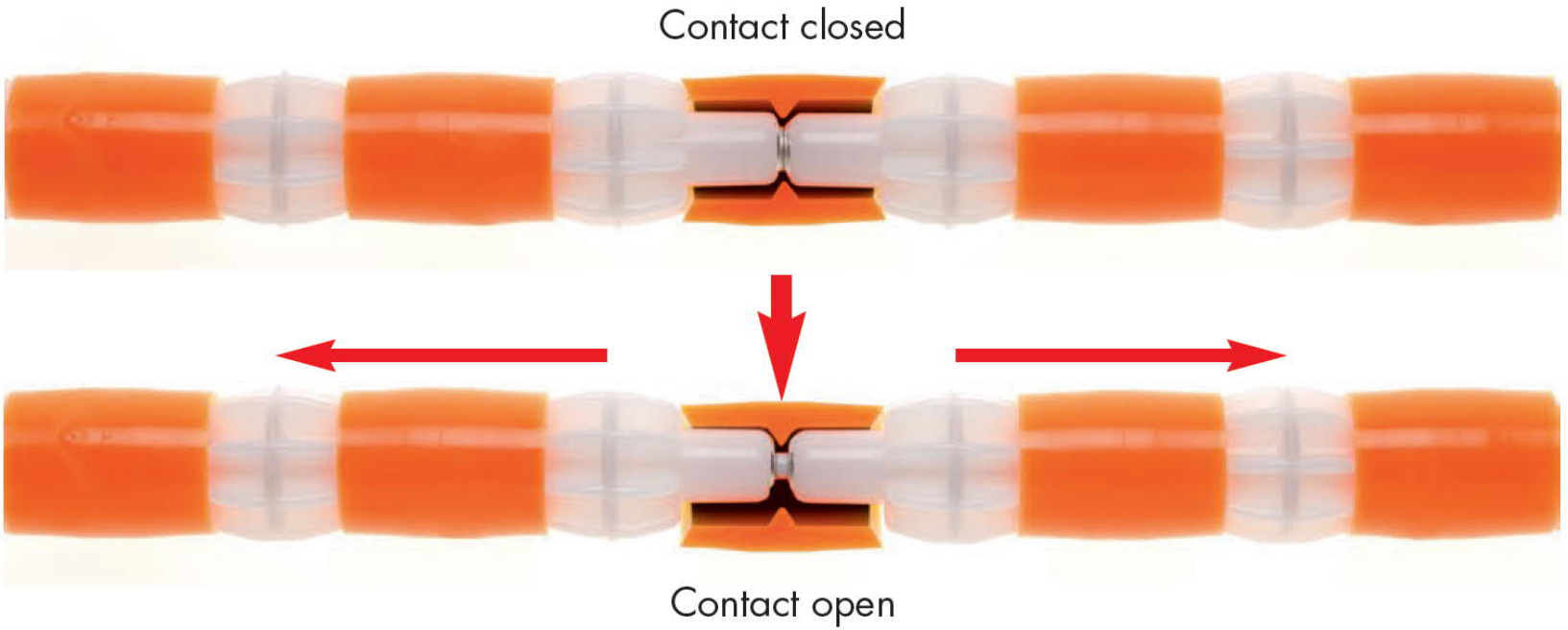
SL = Safety Edge

SB = Safety Bumper

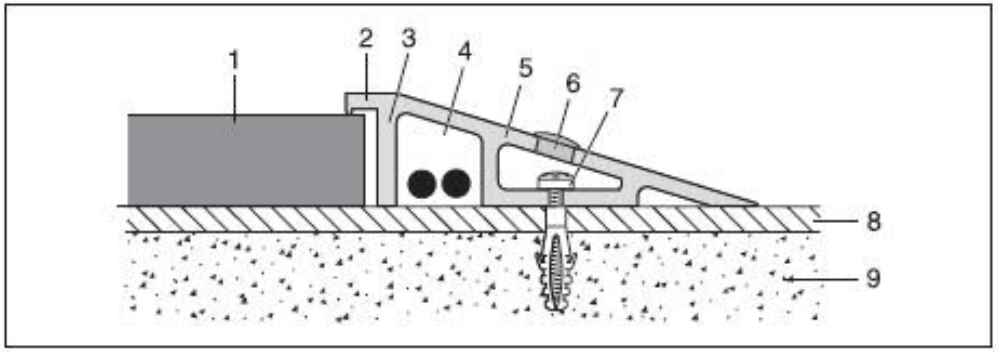
2-wire-technology



OPERATION PRINCIPLE
NORMALLY CLOSED CONTACT



POSITIONING OF PRESSURE-SENSITIVE MATS
IF NO TYPE-C STANDARD EXISTS



1 Safety Mat
2 Cover ridge
3 Stop ridge
4 Cable conduit
5 Ramp Edge
6 Sealing
7 Fixing screw
8 Plant floor
9 Screed

$$S = K \times T + (1.200\ mm - 0{,}4 \cdot h)$$

$$S > 750\ mm$$

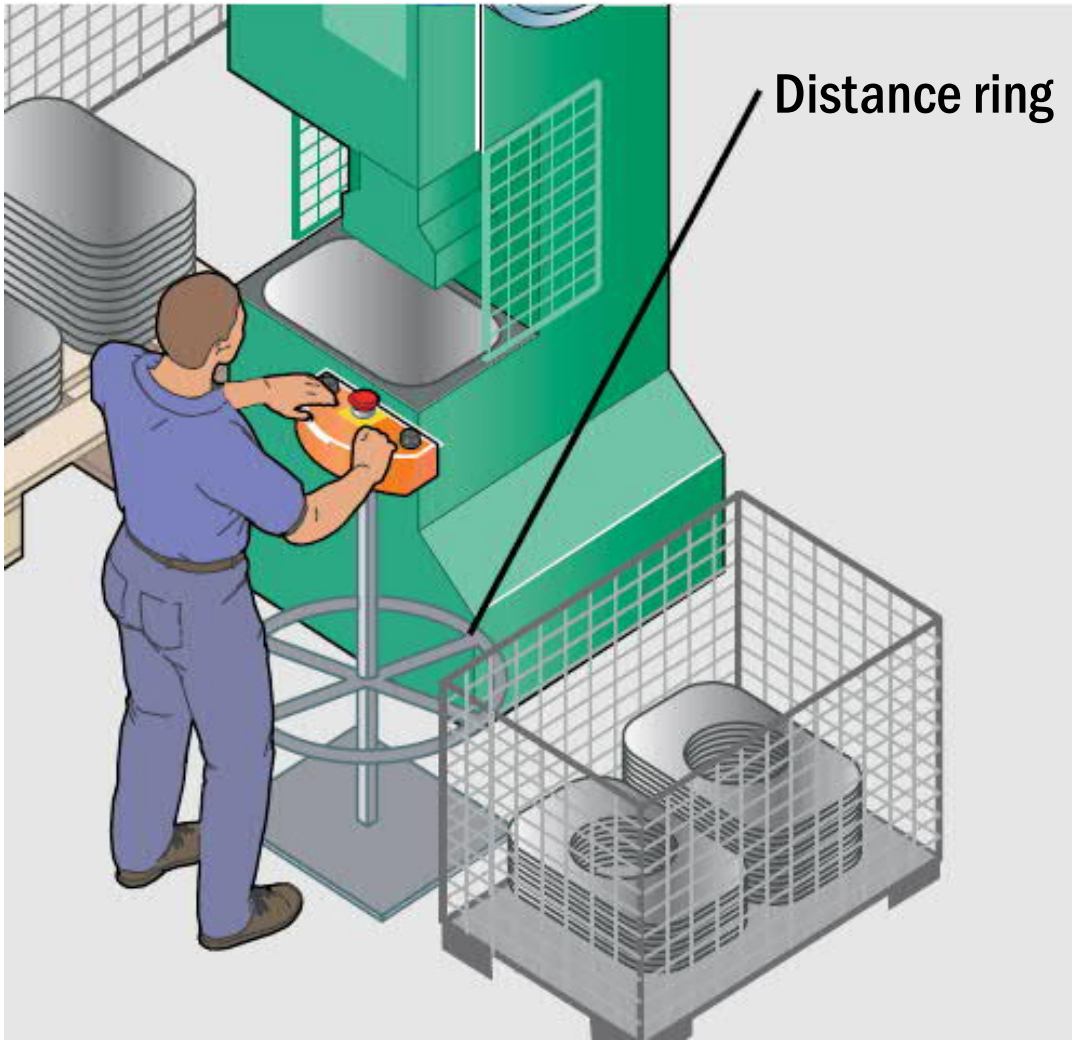
where

$$K = 1.600\ mm/s$$

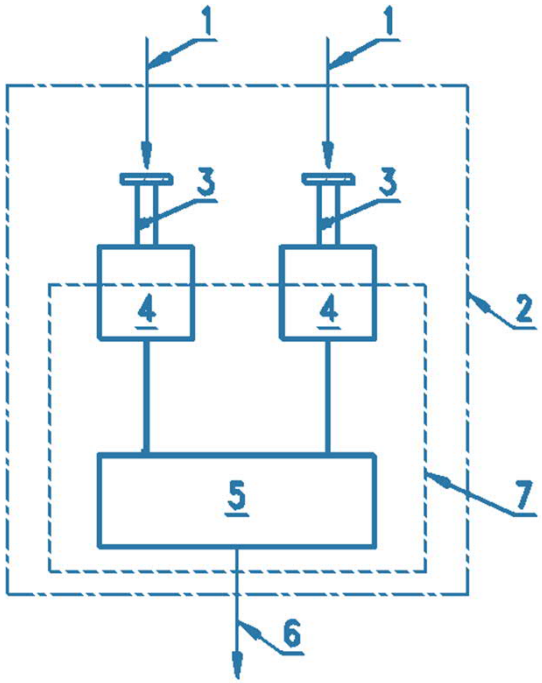
TWO-HAND CONTROLS
ISO 13851:2019

The following basic principles apply:

- It shall be ensured that both hands are used
- Releasing one of the two control actuating devices shall stop the dangerous movement
- Inadvertent actuation shall be prevented
- It shall not be possible to easily defeat the device
- It shall not be possible to take two-hand controls into the hazard zone



TWO-HAND CONTROL DEVICE
CLAUSE 5, ISO 13851:2019



Key

1 Input signal

2 two-hand control device

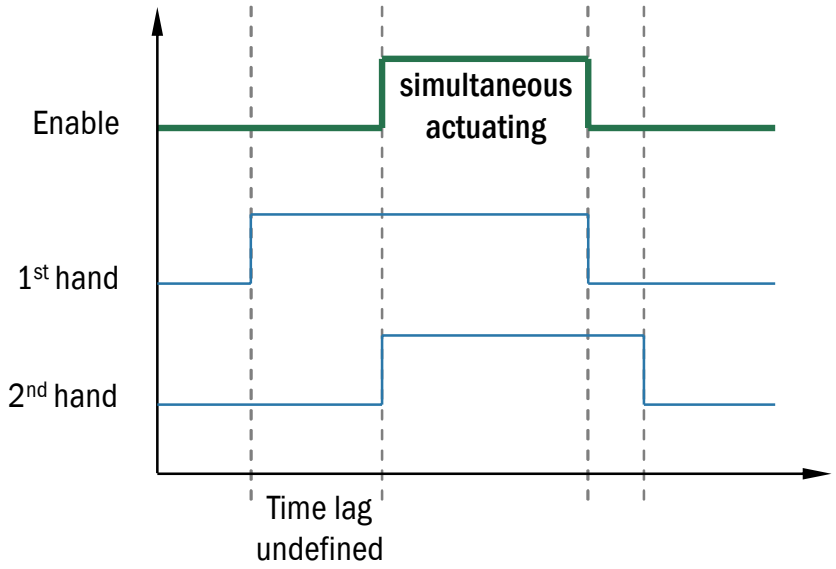
3 Control actualting device

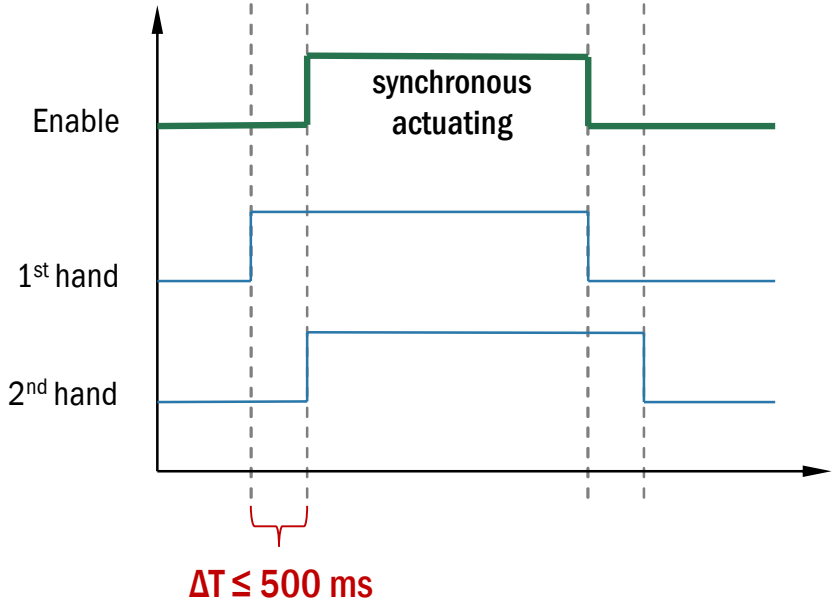
4 Signal converter(s)

5 Signal processor(s)

6 Output signal

7 Logic unit



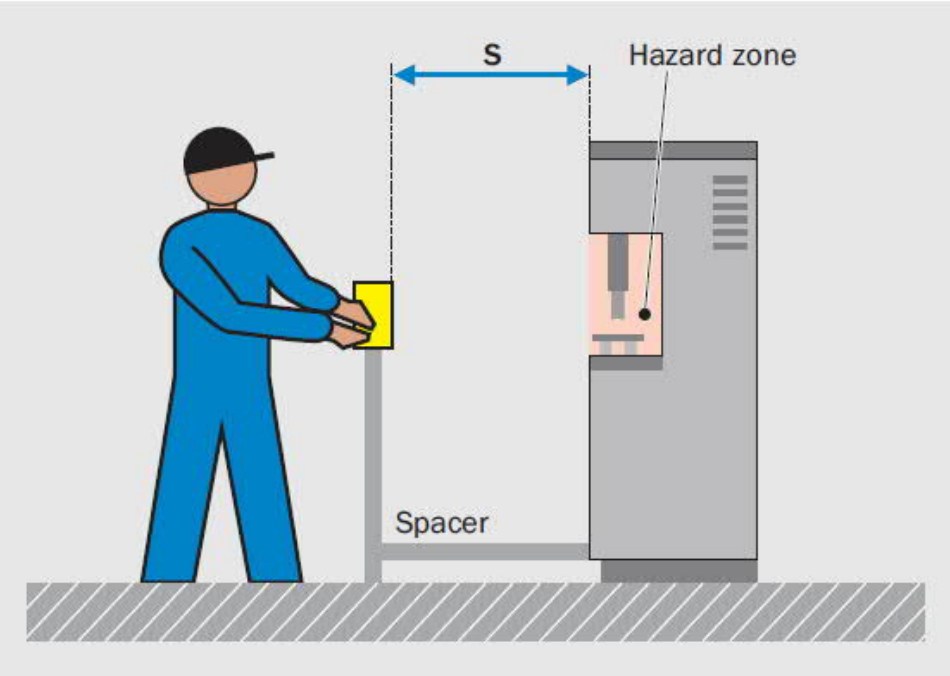


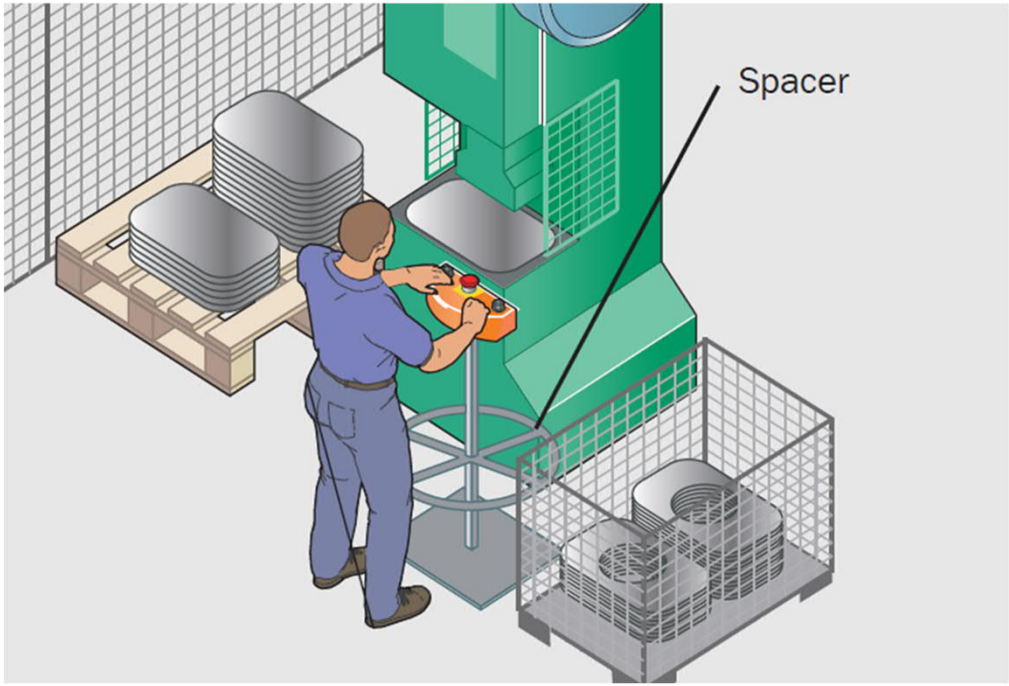
MINIMUM SAFETY REQUIREMENTS

TABLE 1, ISO 13851:2019

Requirements	Type				
	I	II	III		
			A	B	C
Use of both hands (simultaneous actuation)	●	●	●	●	●
Relationship between input signals and output signal	●	●	●	●	●
Cessation of the output signal	●	●	●	●	●
Revention of accidental operation	●	●	●	●	●
Prevention of defeat	●	●	●	●	●
Re-initiation of the output signal	○	●	●	●	●
Synchronous actuation			●	●	●
Use of category 1 (see ISO 13849-1)	●		●		
Use of category 3 (see ISO 13849-1)		●		●	
Use of category 4 (see ISO 13849-1)					●

MINIMUM DISTANCES
FOR TWO-HAND CONTROLS





$$S = K \times T + C$$

$$C = 250\ mm$$

where

$$K = 1.600\ mm/s$$

C = 0 mm if control actuators are shrouded

SUSPENSION OF SAFETY FUNCTIONS

CLAUSE 6.2.11.9, ISO 12100:2010

Where, for setting, teaching, process changeover, fault-finding, cleaning or maintenance of machinery, a guard has to be displaced or removed and/or a protective device has to be disabled [...], the safety of the operator shall be achieved using a specific control mode which **simultaneously**:

a) disables all other control modes,

b) permits operation of the hazardous elements only by continuous actuation of an enabling device, a two-hand control device or a hold-to-run control device,

c) permits operation of the hazardous elements only in **reduced risk conditions** (for example, reduced speed, reduced power/force, step-by-step, for example, with a limited movement control device), **and**

d) prevents any operation of hazardous functions by voluntary or involuntary action on the machine's sensors

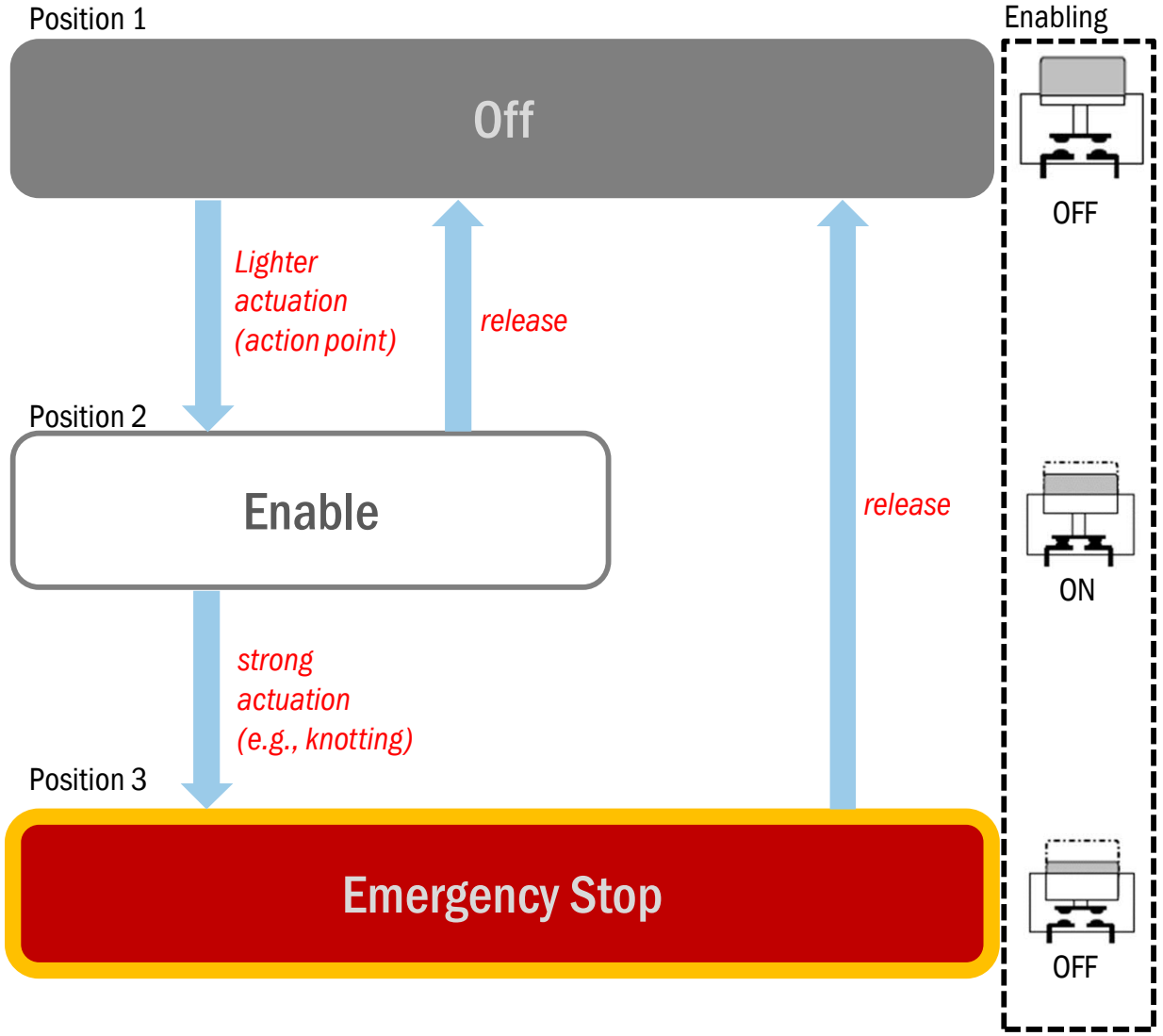
ENABLING CONTROL FUNCTION

CLAUSE 9.2.3.9, IEC 60204-1:2020

- **Manually activated** control function interlock
- When activated allows a machine operation to be initiated by a **separate** start control
- When de-activated initiates a stop function and prevents initiation of machine operation
- It shall not be possible to defeat the enabling function by simple means

THREE-POSITION ENABLING DEVICE

FIGURE C.1, ISO 10218-1:2011



EMERGENCY OPERATIONS
CLAUSE 9.2.5.4 IEC 60204-1:2006

Emergency stop

: Stopping hazardous motion as quickly as possible

: Stop category 0, 1

: Often by mushroom-type pushbuttons

: Handles, wires, ropes, bars may be used

Emergency switching off

: Switching off electrical energy (e.g. direct contact)

: Stop category 0

: Often by main switches

: Pushbuttons, wires, ropes, bars may be used

: Switching off the incoming supply electromechanically **only**

EMERGENCY STOP FUNCTION

ANNEX 1.2.4.3., DIRECTIVE 2006/42/EC [MD]

- Machinery must be fitted with one or more emergency stop devices to enable actual or impending danger to be averted.

- The emergency stop function must be available and operational at all times, regardless of the operating mode.

- Emergency stop devices must be a back-up to other safeguarding measures and not a substitute for them.

EMERGENCY STOP DEVICE

CLAUSE 4, ISO 13850:2006

- The emergency stop device shall be designed to be easily actuated by the operator and others who could need to actuate it.
- An emergency stop device shall be located at each operator control station [...]
- It shall be positioned such that it is readily accessible [...]
- Measures against inadvertent actuation should not impair its accessibility.
- The actuator of the emergency stop device shall be colored **RED**. [...] the background shall be colored **YELLOW.**

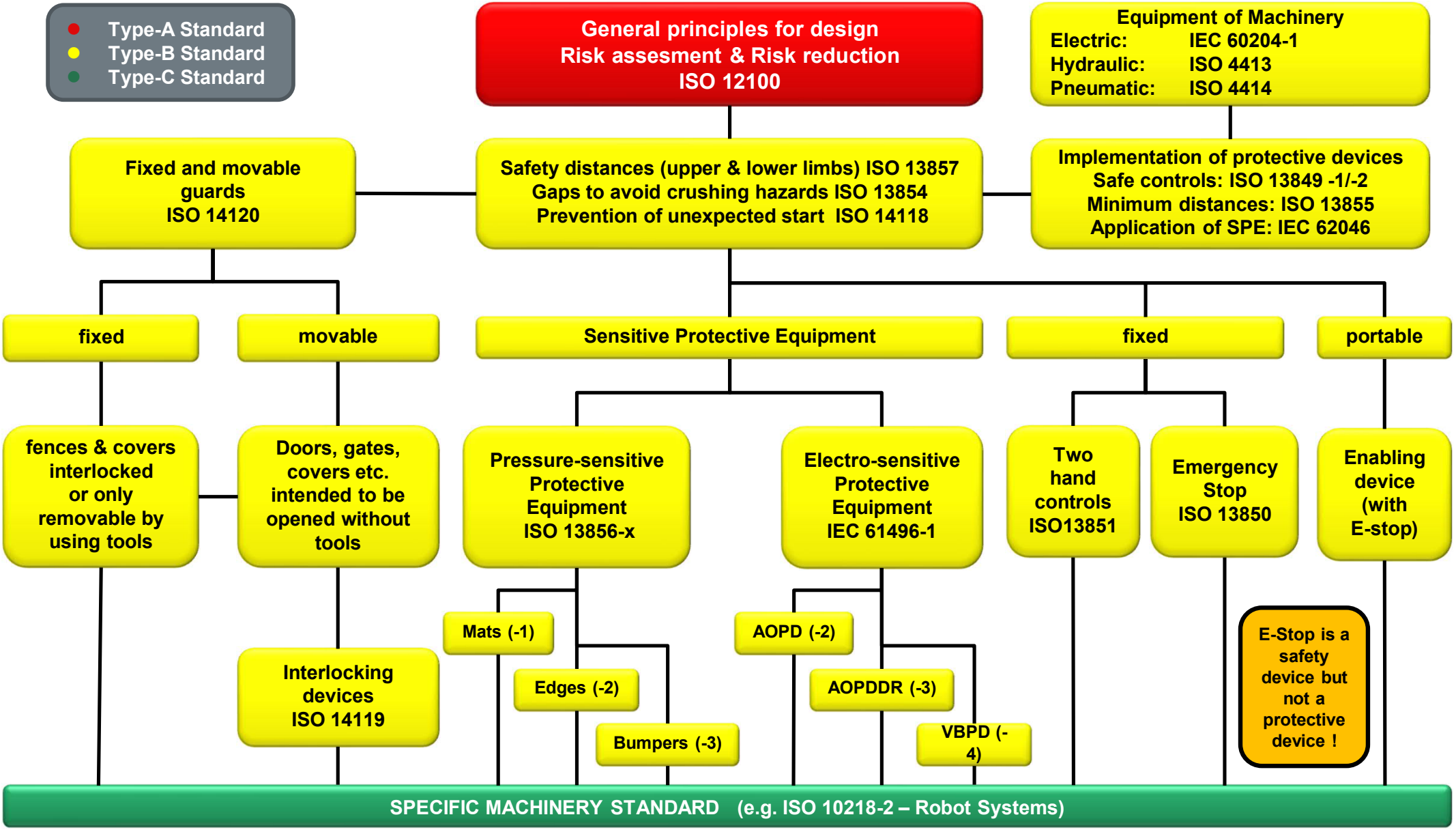
EMERGENCY STOP FUNCTIONS ...
... ON PORTABLE OPERATOR CONTROL STATIONS

- Confusion between active and inactive emergency stop devices shall be avoided by means that can include appropriate design and information for use.

  For example, if a charging station for the portable operator control station is provided near a machine, and the emergency stop function is inactive when it is placed in the charging station, the emergency stop device should be made inaccessible.

TECHNOLOGY OF SAFEGUARDING

SEPARATE FROM DANGER BY MEANS OF SPACE OR TIME



THANK YOU FOR YOUR KIND ATTENTION

SICK
Sensor Intelligence.

Otto Görnemann
Research & Development
Tel.: +49 7681 202 5420
Otto.Goernemann@sick.de