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Electrical equipment of machines according to IEC 60 204-1

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Introduction to ISSA

14 International Prevention Sections

IEC 60 204-1 Electrical Equipement of Machines

Scope

DIN EN 60204-1 applies to:

the use of electrical and electronic equipment of machines which during the work activity is not used manually, including a group of machines matching together accurately and in a coordinated manner.

Excavator

Circular saw

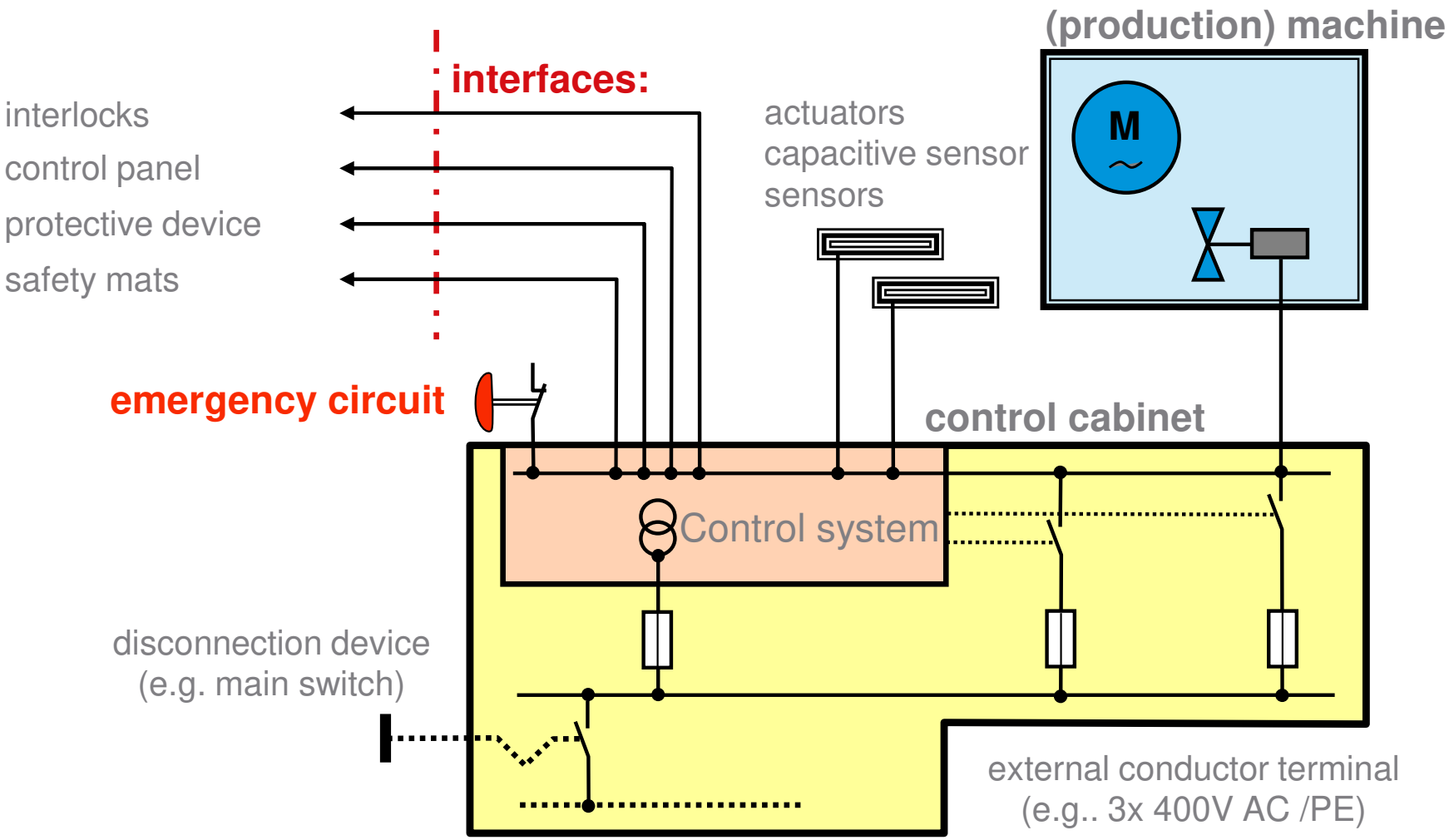
Machine for metalworking

Annex C

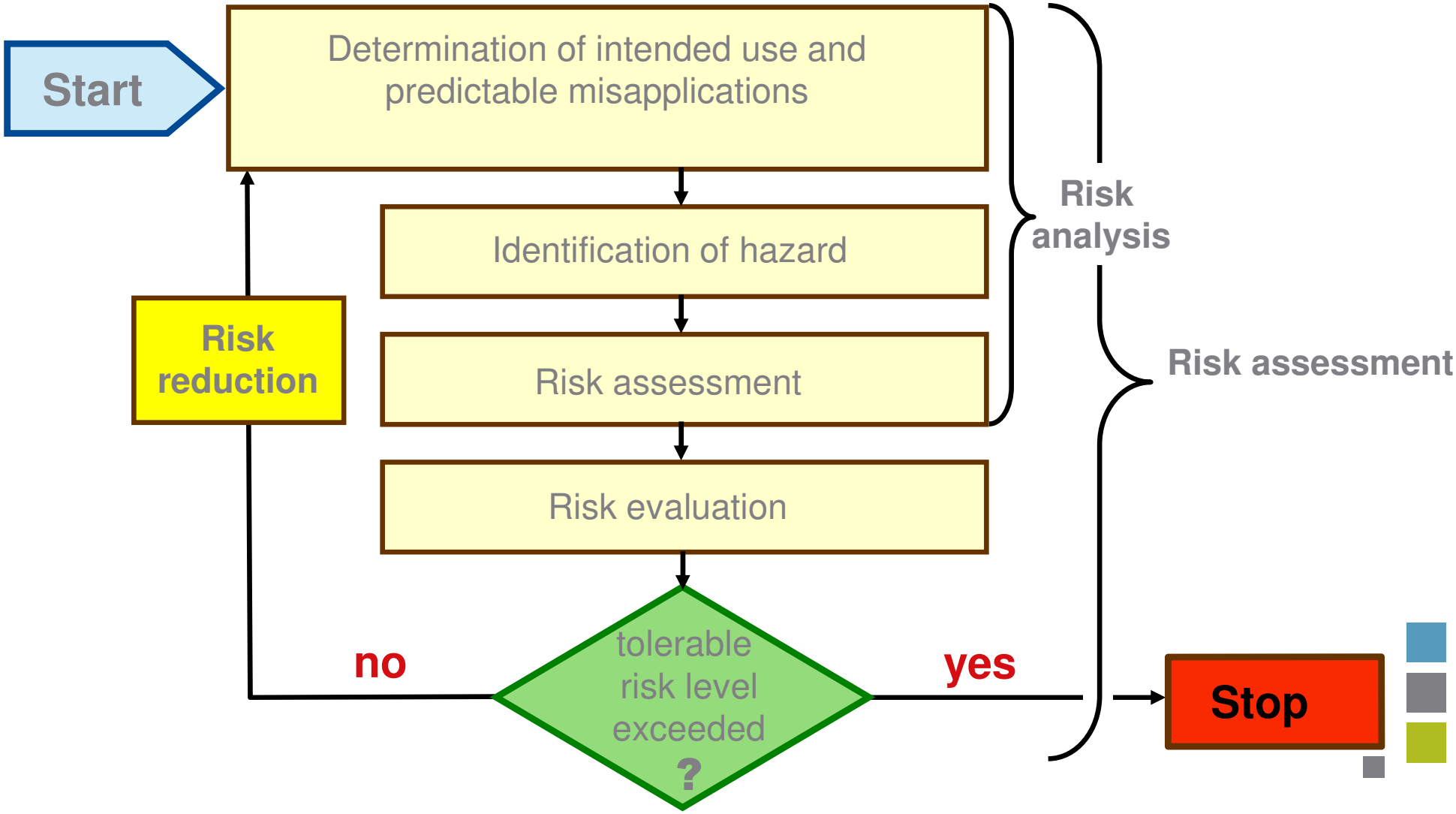
Examples of machines covered by IEC 60204-1

- Metal cutting machines and metal forming machine
- Plastics and rubber machinery
- Wood machinery
- Mobile machinery
- Textile machines
- Refrigeration and air-conditioning machines
- Food machinery
- Printing, paper and board machinery
- Inspecting/testing machinery
- Compressors
- Packaging machinery
- Laundry machines
- ……

Scope


(production) machine
interfaces:
interlocks
control panel
protective device
safety mats
actuators
capacitive sensor
sensors
M
emergency circuit
control cabinet
Control system
disconnection device
(e.g. main switch)
external conductor terminal
(e.g.. 3x 400V AC /PE)

General requirements – risk assessment



Examples of hazards from the electrical equipment :

hazards	paragraph
Protection against electric shock	6; 8; 11.4
fire hazard	7; 12
Malfunctions (of the energy supply, in control circuits, EMC influence)	5; 9; 10; 11
Failure of safety functions	8.2.3; 9.4.3.3
stored energy	7; 12
hot surfaces	16.2.2

4.2 Equipment selection

Electrical components and devices shall:

- be suitable for their intended use and
- correspond to the IEC standards that apply to them, if such standards exist and
- be used in accordance with the supplier's instructions.

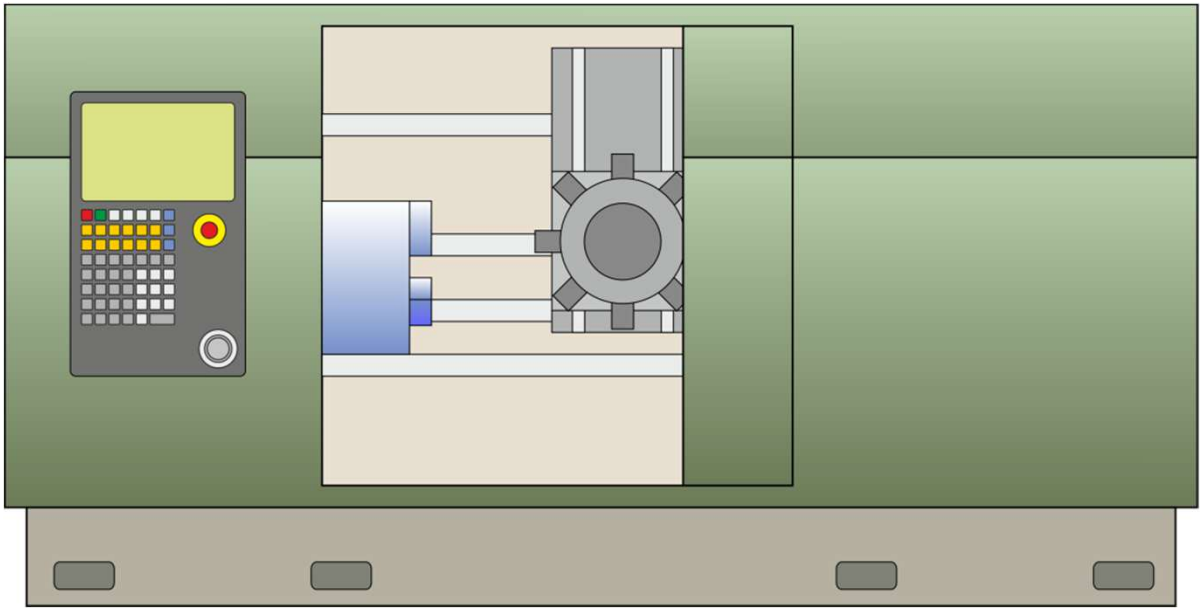
Physical environmental and operating conditions
– pollution –

Degree of pollution	Application in case of open insulation (clearances and creepage distances)
1	in air-conditioned, clean, dry rooms
2	in residential and commercial spaces
3	in industrial and business facilities
4	outdoor

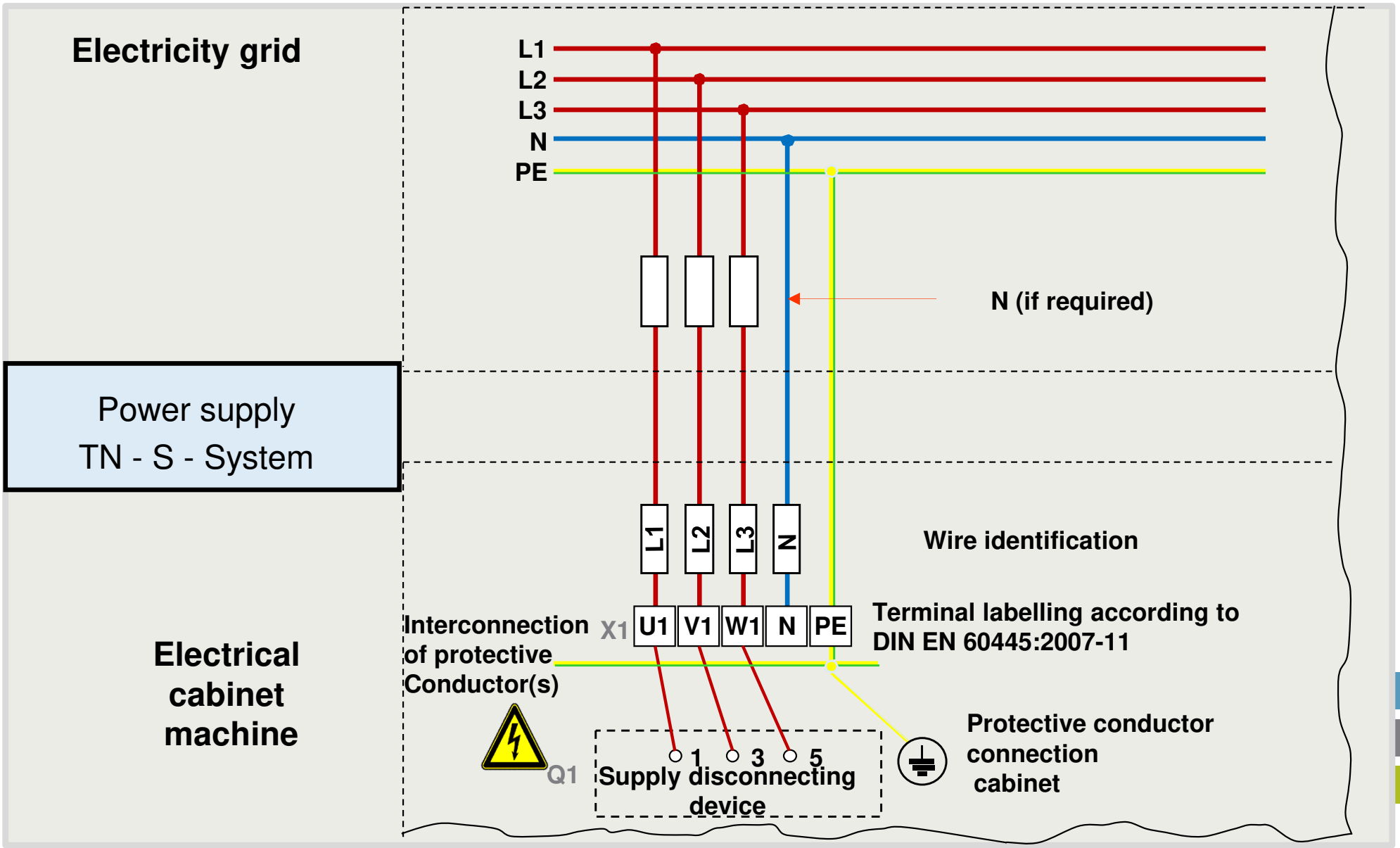
Electro**m**agnetic **c**ompatibility **(EMC)**	According to EN 60204-1

In addition, the equipment must have sufficient immunity to electromagnetic interference to operate properly in its intended environment

The electrical equipment shall not generate electromagnetic disturbances above levels that are appropriate for its intended operating environment.



How can we bring a machine in a safe state?


Electricity grid
L1
L2
L3
N
PE
N (if required)
Power supply
TN - S - System
L1
L2
L3
N
Wire identification
Electrical
cabinet
machine
Interconnection
of protective
Conductor(s)
X1
U1
V1
W1
N
PE
Terminal labelling according to
DIN EN 60445:2007-11
Q1
1
3
5
Supply disconnecting
device
Protective conductor
connection
cabinet

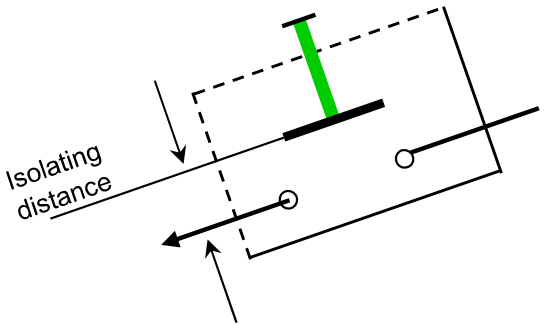
Supply Circuit Disconnecting Means – different types –

Switch disconnector → **According to EN 60947-3 (AC-23B or DC-23B)**

Disconnector → **With auxiliary contact and leading load disconnection**

Circuit-breakers → **According to EN 60947-2**

Connector system → **Load switching capacity is necessary or leading load disconnection**



Main switch – requirements

- manually operated main switch for each incoming source of supply
- if several main switches are used → protective interlock
- must disconnect all live conductors from the supply
- only one ON and one OFF position (marked with "0" and "I")

- must be provided with a means permitting it to be locked in the OFF position
- breaking capacity sufficient to interrupt the current of the largest motor when stalled together with the sum of the nominal running currents of all other loads
- manual operating means even for power-operated circuit-breakers
- handle located between 0.6m and 1.9m above the servicing level; preferably below 1.7m ■

Supply Circuit Disconnecting Means – excluded circuits

- Lighting circuits for illumination during maintenance
- Socket circuits for maintenance tools
- Undervoltage protection circuits
- Circuits compulsory for uninterrupted operation, e.g. heating systems, program memory modules
- Control current for locks




- **Usage of separate isolating devices**
- **Warning sign in the immediate area of supply circuit disconnecting means**
- **Warning sign in the immediate area of every excluded circuit**
- **Warning notice in technical documentation**
- **Separate cable routing or colour coding ■**

Installations to prevent an unexpected start-up

In the course of inspection, maintenance and repair work an appropriate switch-off device shall counteract an unintended start of hazardous movements.

- **Mains isolating device** (e.g. main switch)
- **Power Drive System (PDS) with a Safe Torque Off (STO) function**
- **Removal of fuses**
- **Separating tabs**

} only in closed electrical service location

⚠ The selection of a device will be dependent on the risk assessment, taking into account the intended use of the device, and the persons who are intended to operate them. ■

Concerning Control-circuits

STOP-function
- for shut-down of machines/-actuators-

Category 0

uncontrolled shut-down

Power supply will be disconnected immediately

Possible application of mechanical brakes (paragraph. 3.56)

Category 1

controlled shut-down

Power supply is maintained until complete stop

After complete stop power supply will be disconnected

Category 2

controlled shut-down

Power supply is maintained during standstill ■

Activity in case of emergency

Action in emergency situation needs or includes depending on the:

- Stopping in an emergency*)
- Starting in an emergency*)
- Power-off in an emergency*)
- Power-on in an emergency*)

*) decision according to risk assessment

Emergency stop

An emergency operation intended to stop a process or a movement that could become hazardous.

Emergency start

An emergency operation intended to start a process or a movement to remove or avoid a hazardous situation.

Emergency switching off

An emergency operation intended to switch off the supply of electrical energy to all or a part of an installation where a risk of electric shock or another risk of electrical origin is involved.

Emergency switching on

An emergency operation intended to switch on the supply of electrical energy to a part of an installation that is intended to be used for emergency situations.

STOP-categories

Determination of **stop-function** regarding **EMERGENCY STOP**
- for shut-down of machines/-actuators -

In consequence of the risk assessment of the machine:

Category 0 | **Category 1** | **Category 2**

Priority towards all functions in different operation modes

Specific requirements concerning properties:	
is permitted only if no other hazards can produce	to stop dangerous movements as fast as possible

Currently prohibited ! Exception see next slide

note:
Resetting may not initiate a restart!

Emergency Stop

The emergency stop shall function either as a stop category 0 or as a stop category 1. The choice of the stop category of the emergency stop depends on the results of a risk assessment of the machine

New: Exception: In some cases, to avoid creating additional risks, it can be necessary to perform a controlled stop and maintain the power to machine actuators even after stopping is achieved. The stopped condition shall be monitored and upon detection of failure of the stopped condition, power shall be removed without creating a hazardous situation.

EN ISO 13850:2015 "EMERGENCY STOP"

Paragraph 4. 1. 3.

EMERGENCY-STOP function has to be implemented in such a way that the decision to activate the EMERGENCY-STOP button does not need further reflections, especially with regard to resulting consequences.

(concerning the area that shall be switched off, deceleration rate etc.) ■

2006/42/EG – requirements for control systems

1.2.4.3. Stop in an emergency :

- The EMERGENCY STOP function must be available and operational at all times, regardless of the operating mode.
- EMERGENCY STOP command devices has to complement other protective measures, but must not replace them.

Consequence

Emergency stop is not a substitute for safety functions

Emergency is dependent of will

Safety functions are independent of will

What kind of requirements must be met by the control systems of machines?

Requirements of control systems

Machinery directive -annex I / number 1.2.1:
Safety and reliability of control systems

"Control systems must be designed and constructed in such a way as to prevent hazardous situations"

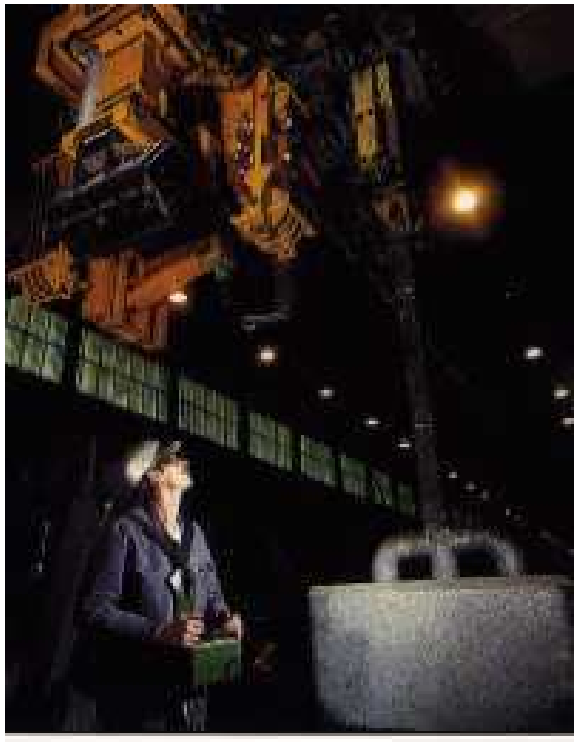
They have to be designed and constructed in such a way that

- they can withstand the intended normal operating conditions and external impacts
- a fault in the hardware or the software of the control system does not lead to hazardous situations
- errors in the control system logic do not lead to hazardous situations
- reasonably foreseeable human error during operation does not lead to hazardous situation

implementation:

- *specifications in the C standards (having priority)*
- *DIN EN ISO 13849-1 / -2*
- *DIN EN 62061*
- *DIN EN 61508*
- *individual responsibility*

Cableless control system (CCS)



Operating restrictions of control

- only for the associated machine
- only for predetermined functions
- spatially delimited if necessary

Unequivocally stop-function on the operator panel

- operating unit shall not be marked as EMERGENCY SHUT-OFF

Automatic stop of machine when:

- a stop signal is received
- a system fault is detected
- no valid signal has been detected within a predetermined period

Use of error detection procedures during data transmission

When using several operator panels only one shall be released (exception: stop-function) ■

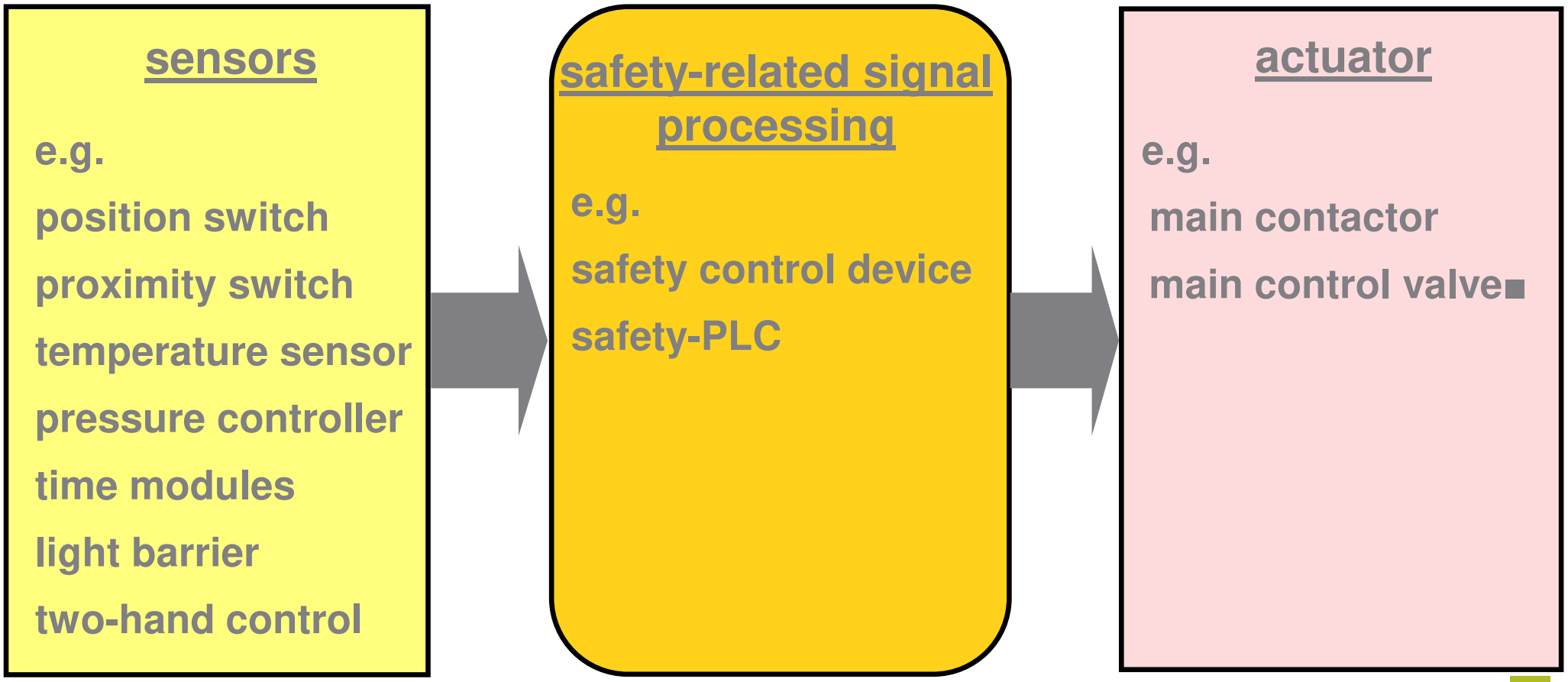
New: Monitoring the effectiveness of a wireless control system for controlling a machine (IEC 204-1, clause 9.2.4.2)

The effectiveness of a wireless control system (CCS) for controlling a machine must be automatically monitored, either permanently or at appropriate intervals. The effectiveness must be clearly indicated (e.g. by a signal lamp, indication on a display, etc.).

9.2.4.3: Control limitation (new)

Measures (e.g. coded transmission) must be provided to ensure that the machine does not respond to signals other than from the intended wireless control. ■

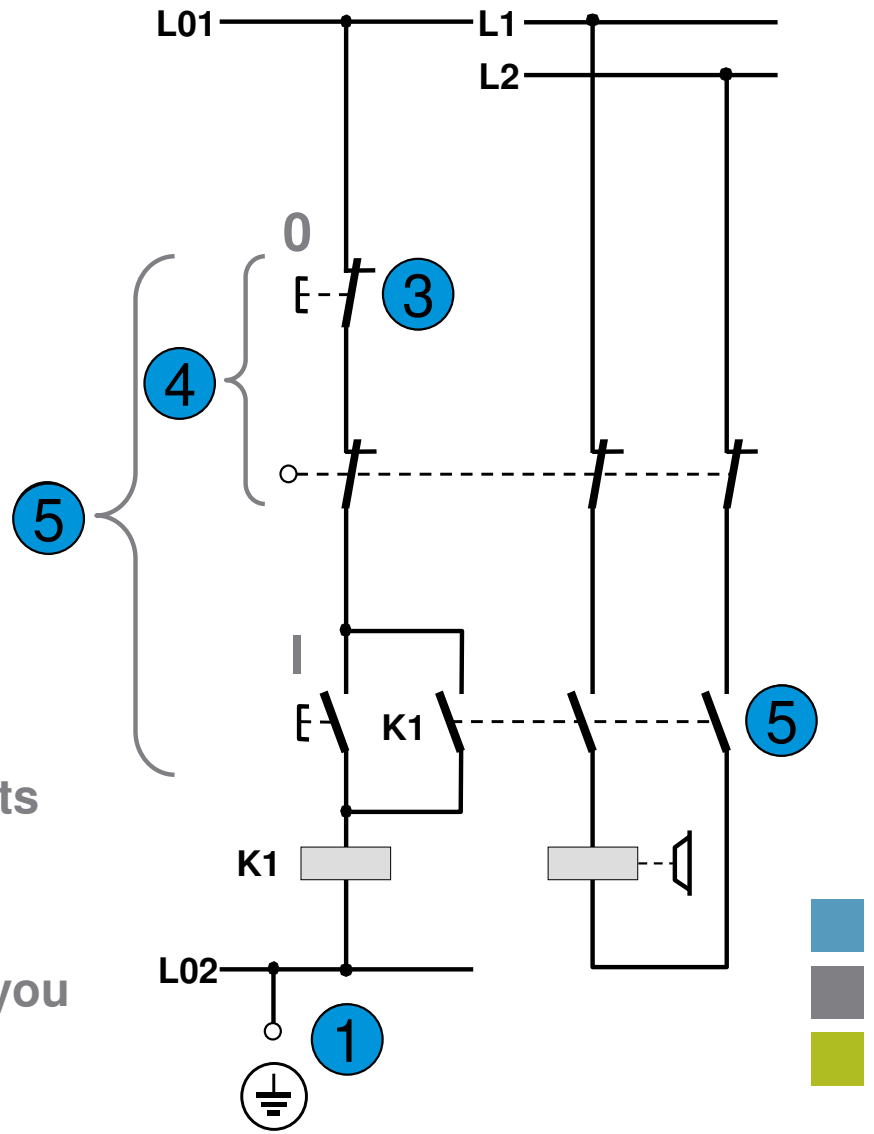
Requirements of safety related parts of control



Control circuits

Use proven switching technologies and components!

1. Earth the control circuit
2. Set all switching functions on the non-grounded side
3. Switch off by de-energizing which provides wire-breakage
4. Use switches with positive opening contacts
   (Note: do not confuse with forced guidance)
5. Switch all active conductors to the device you want to control ■



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Requirements concerning control systems

Reliable component?

- has been used widely and successfully in similar applications in the past

or

- has been produced and verified according to manufacturing principles which reveal adequacy and reliability regarding safety-related application

The classification as reliable component always depends on its application! ■

Requirements regarding control systems

Reliable safety principles?

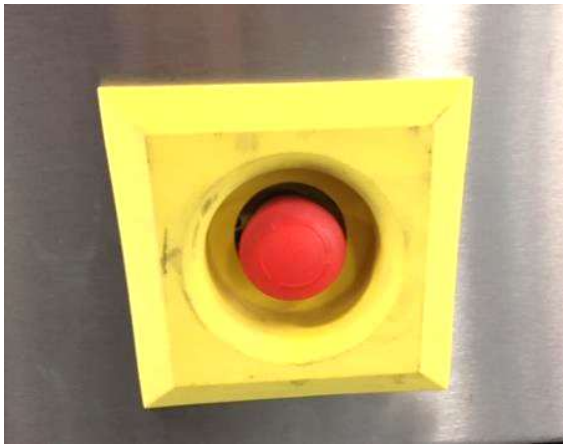
- Error prevention
- Oversizing
- Use of components with defined failure behaviour
- Inevitable mechanical impact/operation
- Force-actuated contacts
- Utilization of redundancy
- Utilization of diversity
- Error detection ■

Operator interface – location and mounting

Actuating means shall be located and assembled in such a way that...

- they are readily accessible for service and maintenance (at least 0.6m above the servicing level),
- the operator is not placed in a hazardous situation when operating them,
- the possibility of damage is minimal,
- the possibility of inadvertent operation is minimized,
- the operator is able to identify the target operating mode immediately or on the basis of a response,
- their movements are in line with the target operating mode,
- they withstand mechanical, chemical and thermal effects. ■

Protection against inadvertent operation



Hardware solution ?

Incorrect!!!

Real example 1

Fatal accident at a guillotine cutter

General information

- A employee had been working as a machine operator on cutting lines for about 20 years.
- The scene of the accident was the unloading station of the cutting line.
- Course of events: Presumably, the operator went under the base plate to rectify the fault at the unloading device. The base plate (750kg) fell down and he got trapped. He was fatally injured. ■

Scene of the accident – unloading station
secured with pallets after the accident

Course of events

- A mechanical defect that had already occurred once in the previous week and that had not been repaired permanently and safely led to another blockage of the base plate.
- The employee entered the area below the base plate without securing it. By triggering the light barriers in front of the stroke area the drive was switched off.
- The monitoring of the movement of the base plate did not work properly on the day of the accident. Normally, the base plate is immediately lifted again when it hits the ground/makes contact with an object. By this, the carrying chains will be tightened again, thus restoring them to a safe condition. The cable control sensor used for this purpose, which triggers an emergency stop, showed a defect. This allowed the carrying chains to move further downwards than specified.
- The base plate got stuck to the back plate of the machine. Without securing the base plate, the employee crawled under the base plate to release it. The plate gave way and was able to continue moving due to the untensioned carrying chain. ■

Accident cause: The plate at the back wall was bent!

Monitoring of the base plate's movement – cable control switch/carrying chains

loose carrying chain after stop on pallet stack and reversing movement

Real example 2

Fatal accident at a plastic injection machine

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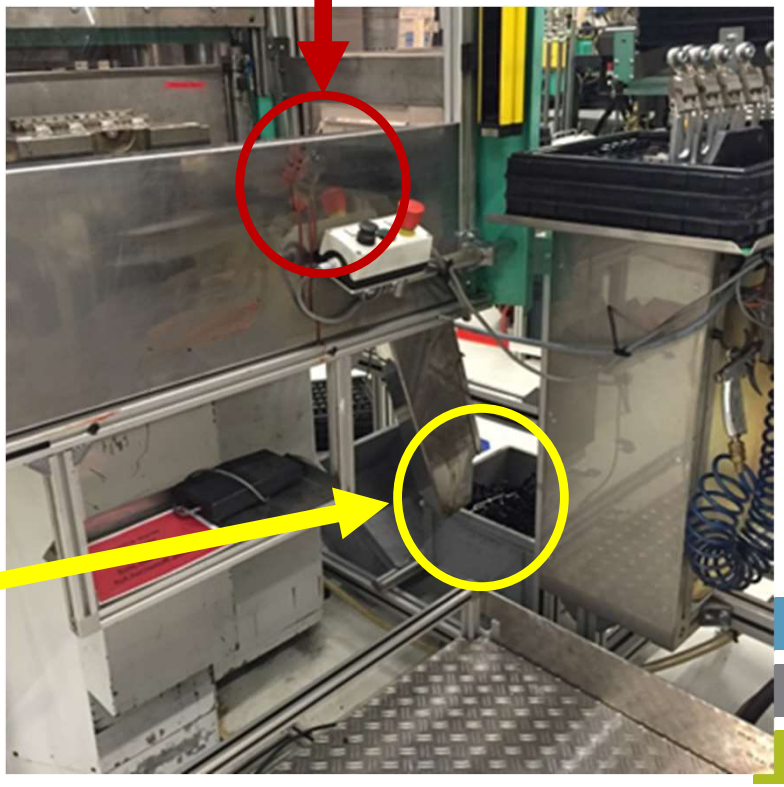
General information

- A employee had been working as a machine operator on cutting lines for many years.
- There was another worker who had been working as a holiday help on a plastic injection machine
- The scene of the accident was the mobile lifting platform on the plastic injection machine, which was subsequently added to this machine.
- Course of events: The cause of the accident was an improperly laid connection cable (loosely under the platform) of a multi-socket strip. ■

plastic injection machine

Electrically adjustable platform

The fatally injured S. laid with his head above this machine panel.



The injured vacation worker B laid with his head on this metal slide.

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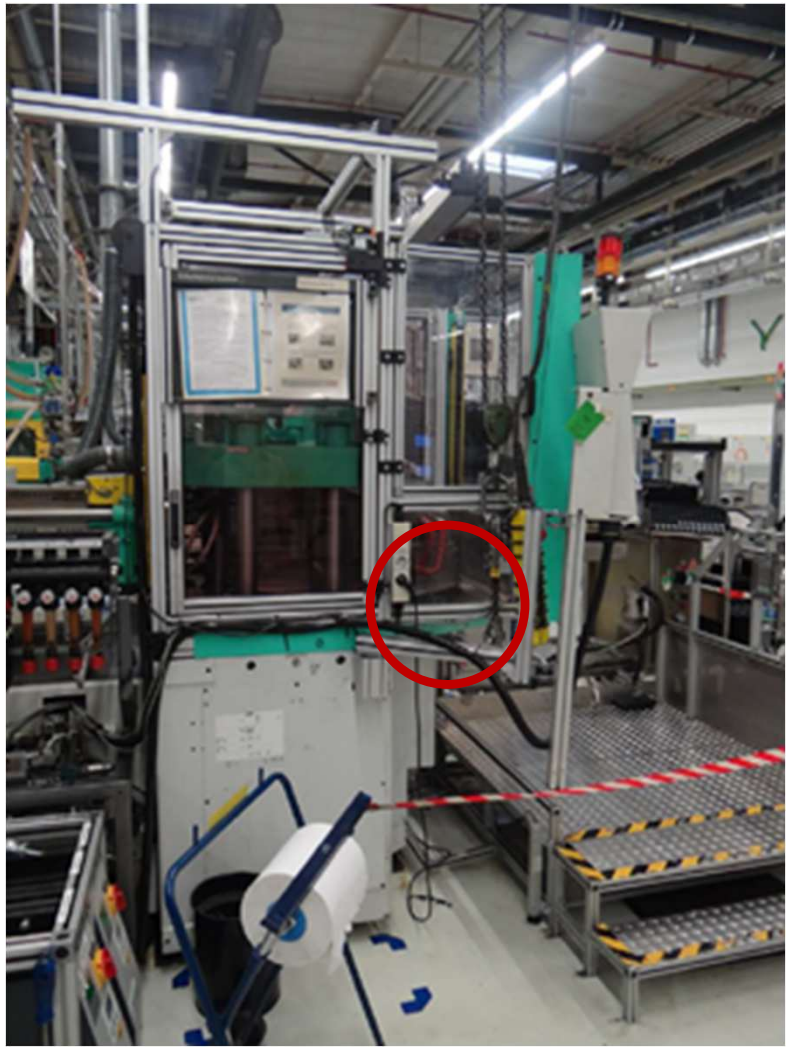

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Cause of Accident

The cause of the accident was an improperly laid connection cable (loosely under the platform) of a multi-socket strip.

This cable was plugged into a socket mounted on the plastic injection molding machine. This, in turn, was not secured with a 30 mA residual current protection and was connected directly to the machine's control cabinet and secured with an automatic 16 A circuit breaker.

Furthermore, the motorized mobile lifting platform was not integrated into the protective conductor system with low resistance.

15.1 Socket-outlets

All unearthed conductors connected to the socket-outlet shall be protected against overcurrent and, when required, against overload in accordance with 7.2 and 7.3 separately from the protection of other circuits.

New requirement of the standard!!!

Circuits supplying socket-outlets with a current rating not exceeding 20 A shall be provided with residual current protection (RCD) with a rated operating current not exceeding 30 mA. ■

Many thanks for your attention!