Preventa™
Machine Safety Products

Catalog
2014

Chapter 7

International Safety Standards

Schneider Electric™

International safety standards

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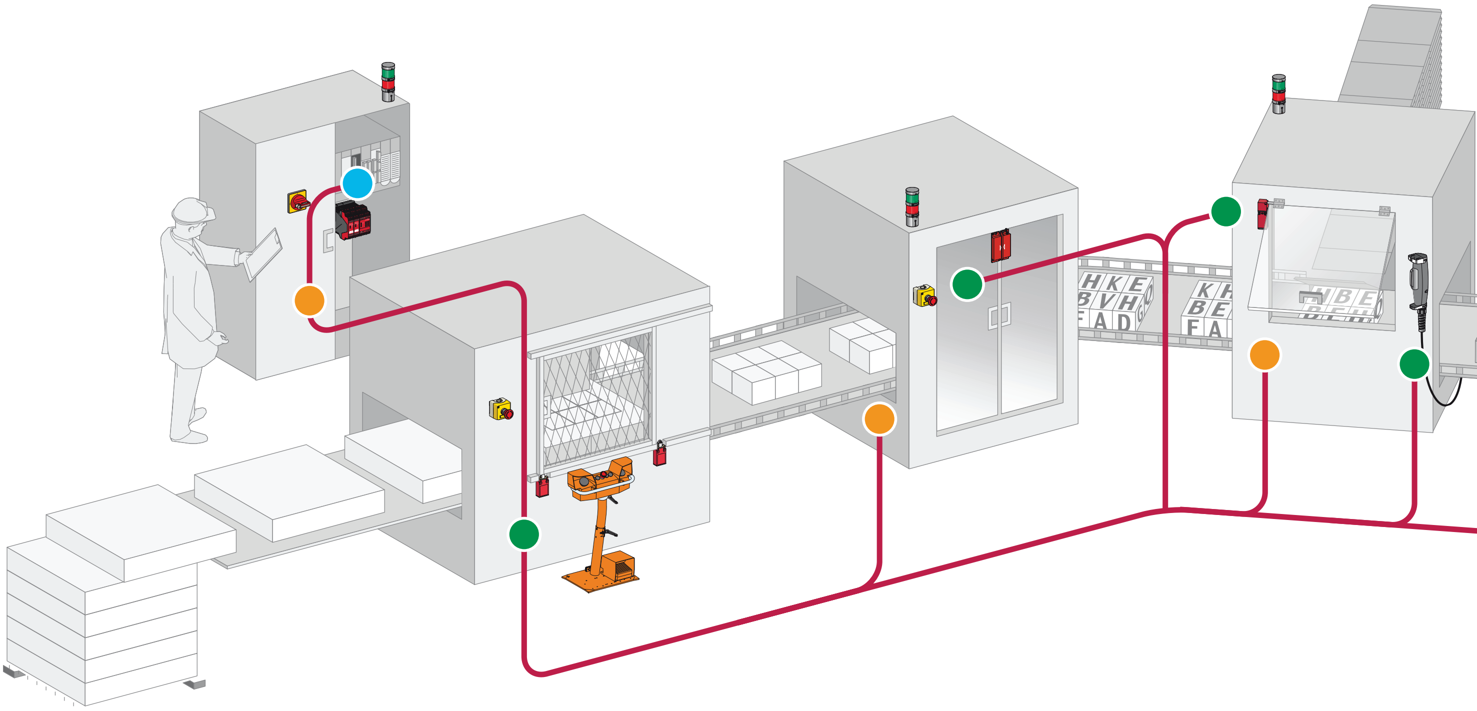


Safety-related signal transmission

Safety interlocks

Acquiring information…

- Safety interlock devices used as part of safeguarding systems to control access, under specific conditions of reduced risk.
- Light curtains to detect approach to dangerous and limited areas.
- Emergency stop buttons and cable pull switches for emergency shut down.

Monitoring and processing…

- Safety relay modules with specific safety functions – to monitor input signals from safety-related devices, and to interface with contactors and drives – by switching off output safety contacts.
- Safety Controller: configurable safety device capable of centralizing a range of safety monitoring functions.
- Safety PLCs: programmable electronic systems to carry out safety or non-safety related tasks for machinery and equipment.
- “As-interface safety at work”: safety field bus network certified to work with safety-related devices to provide safety functions.

Light curtains

Emergency stop

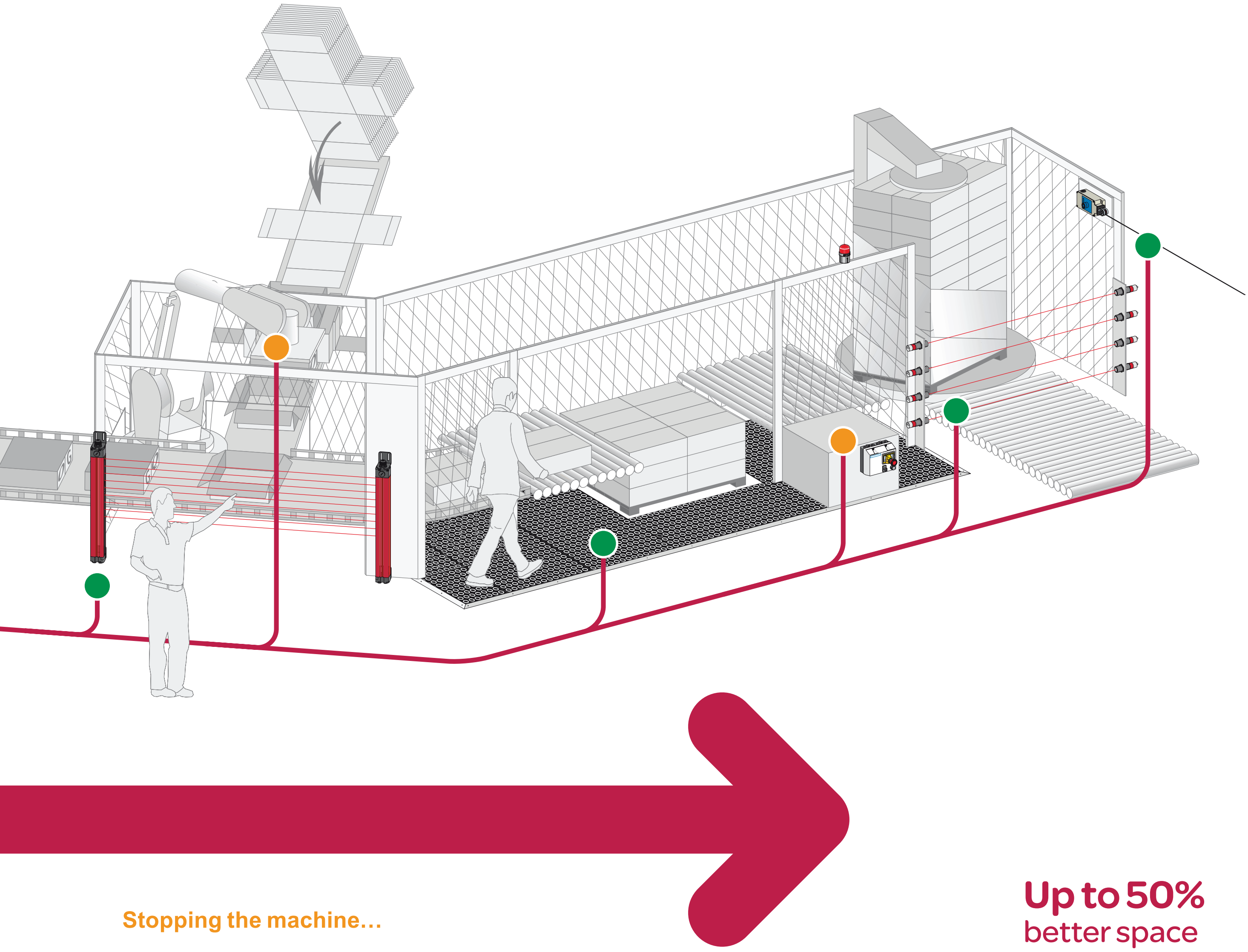
Cable pull switch

Safety relays

Safety Controller

Safety PLCs

As-interface safety at work



Stopping the machine…

- > Contactors to cut-off the electrical power supply to motors – with mechanically linked or mirrored auxiliary contacts – integrated for feedback loop diagnosis of safety relay modules, safety controllers, or safety PLCs.
- > Variable speed drives and servo drives with integrated safety functions…control stopping of dangerous movements.

Up to 50%
better space optimization

Compact components have smaller footprint

Save up to 30%
on installation time

Reduce installation time with quick and easy wiring

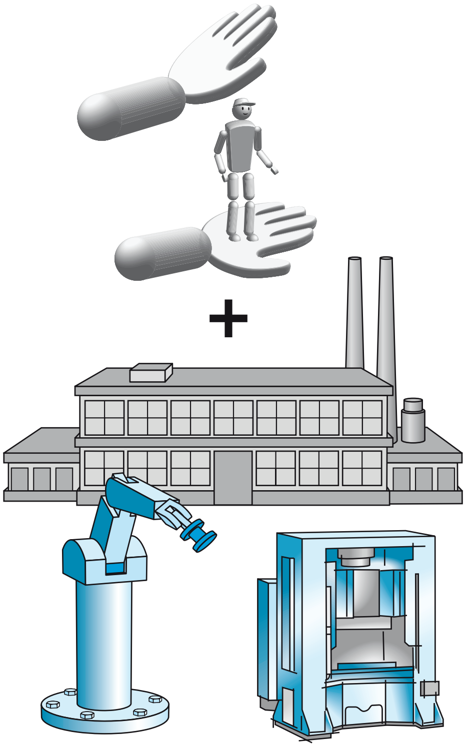
Variable speed drives

Servo drives

Contactors

International safety standards

Introduction - European legislation



Safety and process reliability

Introduction

Safety has become a key issue for businesses. Social developments in association with technological progress have had a profound impact on legislation and on regulations for the use of building electrical automation equipment.

Social issues

The safety-conscious nature of our western societies has led the legislature to increase the number of requirements and establish stricter rules, while the high cost of accidents has prompted companies to make efforts in the same direction.

Technological issues

■ Increasing levels of automation have led to new restrictions. In some case it is difficult, if not dangerous, to stop a machine suddenly and it is necessary to perform a safe shut down sequence before allowing personnel to enter into a production cell.

■ The increasingly widespread use of electronics and software has required a different approach to the solutions adopted; empirical rules are no longer enough. Selection includes a reliability calculation to determine the behavior of the system.

In this context, the specification and design phase are crucial. Studies show that more than two-thirds of all incidents are due to bad design and inadequate specifications. At this stage it is therefore necessary to estimate potential risks and select the most appropriate solutions to reduce their consequences. Standards are available to assist and guide the designer.
Manufacturers of components and solutions help their customers by offering complete, ready-to-use functions which, when combined in accordance with the regulations, satisfy the customer's needs and meet legislative requirements.

In this chapter, we will present a simplified process. To make a choice, the customer will then be able to refer to the safety functions chapter and to the safety products chapters.

European legislation

European legislation requires that preventive action be taken to preserve and protect the quality of the environment and human health. To achieve these objectives, European Directives have been prepared which must be applied by plant operators and by manufacturers of equipment and machines. It also assigns responsibility for possible accidents.

■ Notwithstanding the constraints, machine safety has the following positive repercussions:
- prevention of industrial accidents,
- protection of workers and personnel by means of suitable safety measures that take into account the machine's application and the local environment.

■ This makes it possible to reduce direct and indirect related costs:
- by reducing physical harm,
- by reducing insurance premiums,
- by reducing production losses and possible delay penalties,
- by limiting damages and costs for maintenance.

■ Safe operation involves two principles: safety and reliability of the process:
- safety is the ability of a device to keep the risk incurred by persons within acceptable limits,
- reliability of operation is the ability of a system or device to perform its function at any moment in time and for a specified duration.

■ Safety must be taken into account right from the beginning of the design stage and kept in place throughout all stages of a machine's life cycle: transport, installation, commissioning, maintenance, dismantling.

Industrial accidents

An industrial accident occurs through work or in the workplace and causes minor to serious injury to a person using a machine, feeding it or carrying out special work on it (fitter, operator, and maintenance personnel).

Causes of accidents in the workplace

- Human-related factors (designers, users):
  - poor grasp of machine design,
  - over-familiarity with danger through habit and failure to take dangerous situations seriously,
  - underestimation of hazards, causing people to ignore safe working procedure,
  - loss of concentration on tasks to be performed (e.g. fatigue),
  - failure to comply with procedures,
  - stressful working conditions (noise, and/or work rates),
  - uncertainty of employment which can lead to inadequate training,
  - inadequate or bad maintenance, generating unsuspected hazards.

- Machine-related factors:
  - inadequate guards,
  - inherent machine hazards (e.g. reciprocal motion of a machine, unexpected starting or stopping),
  - machines not suited to the application or environment (e.g. sound alarms deadened by the noise of surrounding machinery).

- Plant-related factors:
  - movement of personnel from machine to machine (automated production line),
  - machinery from different manufacturers and using different technologies,
  - flow of materials or products between machines.

Consequences

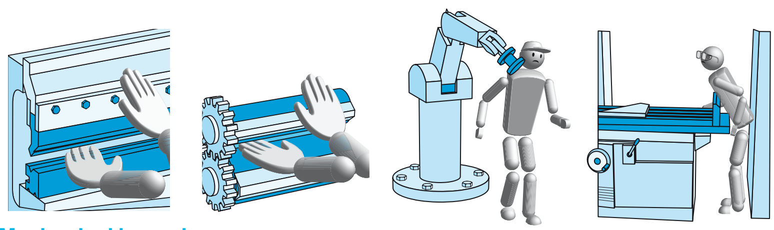
- Risk of varying degrees of physical injury to the user,
- stoppage of the machine involved,
- stoppage of similar machine installations for inspection, for example by health and safety inspectors,
- if necessary, modifications to make machinery safe,
- change of personnel and training new personnel for the job,
- damage to the company brand image.

Conclusion

Damages for physical injuries are equivalent to about 20 thousand million euro paid out each year in the European Union. Decisive action is required to reduce the number of accidents in the workplace. The first essentials are adequate company policies and efficient organization.
Reducing the number of industrial accidents and injuries depends on the safety of machines and equipment.

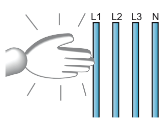
Types of potential hazard

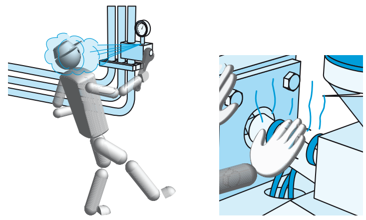
The potential hazards of a machine can be classified into three main groups, as illustrated below:



Mechanical hazards

Puncturing, cutting, shearing, fractures, severing	*Catching, entanglement, drawing in, trapping*	*Impact*	*Crushing*





Electrical hazards | **Physical and chemical hazards**

Electric shock, electrocution, burns	*Discharge of dangerous substances*	*Burns*

International safety standards

European legislation and the standards

European legislation and the standards

The main purpose of the Machinery Directive 2006/42/EC is to compel manufacturers to guarantee a minimum safety level for machinery and equipment sold within the European Union. This version has replaced the 98/37/EC version since January 2010.

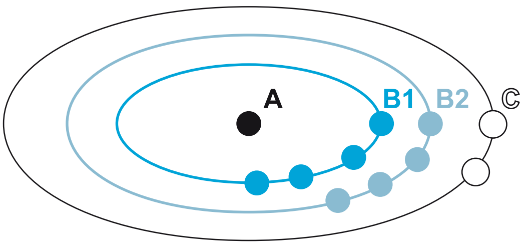
To allow free circulation of machinery within the European Union, the CE marking must be applied to the machine and an EC declaration of conformity is issued to the purchaser. This directive came into effect in January 1995 and has been enforced since January 1997 for all machines.

The user has obligations defined by the Use of Work Equipment directive 89/655/EEC which can in most cases be met by using machinery compliant with relevant standards.
These standards are complex. After a brief presentation of the structure of the standards system, we will provide the reader with a practical guide to the typical standards to be applied according to the selected control system design.

Standards

The harmonized European safety standards establish technical specifications which comply with the minimum safety requirements defined in the related directives. Compliance with all applicable harmonized European standards **can be assumed to ensure** compliance with the related directives. The main purpose is to guarantee a minimum safety level for machinery and equipment sold within the EU market and allow the free circulation of machinery within the European Union.

The 3 groups of European standards



- Type **A** standards
Basic safety standards which specify the basic concepts, design principles and general aspects valid for all types of machine: e.g. PrEN/ISO 12100.

- Type **B** standards
Standards relating to specific aspects of safety or to a particular device that can be used on a wide range of machines.

  - Type **B1** standards
  Standards relating to specific safety aspects of machines: e.g. EN/IEC 60204-1 Electrical equipment of machines.

  - Type **B2** standards
  Standards relating to specific products such as two-hand control stations (EN 574), guard switches (EN 1088/ISO 14119), and emergency stops (EN/ISO 13850).

- Type C standards
Standards relating to various families or groups of machines (e.g.: hydraulic presses EN 693, and robots) and giving detailed applicable requirements.

7

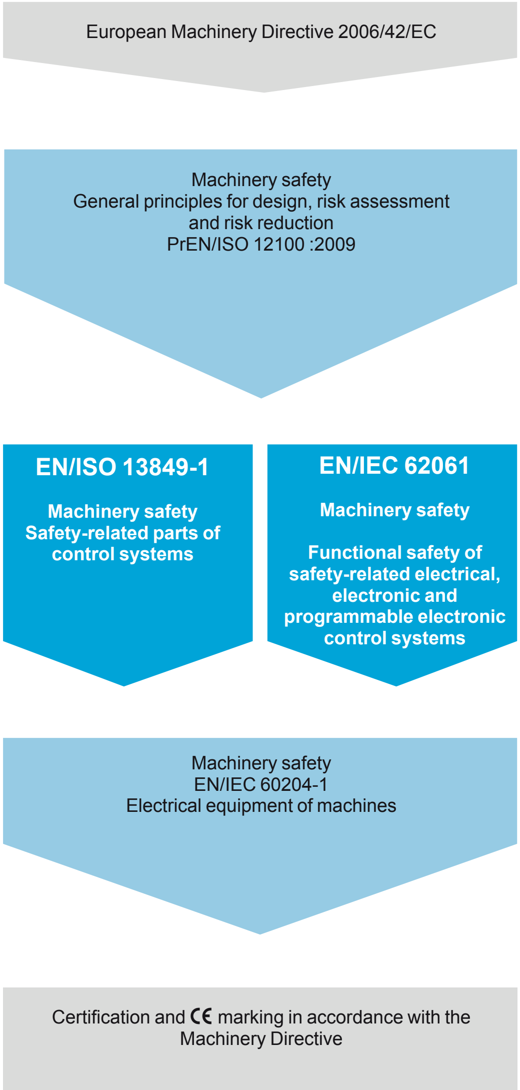
International safety standards

European legislation and the standards (continued)

European legislation and the standards (continued)

A selection of standards

Standards	Type	Subject
PrEN/ISO 12100	A	Machinery safety - General principles for design, risk assessment and risk reduction
EN 574	B	Two-hand control devices - Functional aspects and design principles
EN/ISO 13850	B	Emergency stop - Principles for design
EN/IEC 62061	B	Functional safety of safety-related electrical, electronic and electronic programmable control systems
EN/ISO 13849-1 (EN 954-1)	B	Machinery safety - Safety-related parts of control systems - Part 1 general principles for design
EN 349	B	Minimum gaps to avoid crushing parts of the human body
EN 294	B	Safety distances to prevent hazardous zones being reached by upper limbs
EN 811	B	Safety distances to prevent hazardous zones being reached by lower limbs
EN/IEC 60204-1	B	Machinery safety - Electrical equipment of machines - Part 1: general requirements
EN 999/ISO 13855	B	Positioning of protective equipment in respect of approach speeds of body parts
EN 1088/ISO 14119	B	Interlocking devices associated with guards - Principles for design and selection
EN/IEC 61496-1	B	Electro-sensitive protective equipment
EN/IEC 60947-5-1	B	Electromechanical control circuit devices
EN 842	B	Visual danger signals - General requirements, design and testing
EN 1037	B	Prevention of unexpected start-up
EN 953	B	General requirements for the design and construction of fixed and movable guards
EN 201	C	Machinery for plastics and rubber - Injection moulding machines - Safety requirements
EN 692	C	Mechanical presses - Safety requirements
EN 693	C	Hydraulic presses - Safety requirements
EN 289	C	Machinery for plastics and rubber - Presses - Safety requirements
EN 422	C	Blow moulding machines for producing hollow parts - Design and construction requirements
EN/ISO 10218-1	C	Manipulating industrial robots - Safety requirements
EN 415-4	C	Safety of packaging machines - Part 4: palletisers and depalletisers
EN 619	C	Safety and EMC requirements for equipment for mechanical handling of unit loads
EN 620	C	Safety and EMC requirements for fixed belt conveyors for bulk material
EN 746-3	C	Industrial thermo processing equipment - Part 3: safety requirements for the generation and use of atmosphere gases



Standards to be applied for the design of machines

Standards to be applied

The process

European Machinery Directive 2006/42/EC
Compliance with the following standards ensure compliance with the Machinery Directive (this new version of the Machinery Directive 2006/42/EC has replaced 98/37/EC since January 2010).

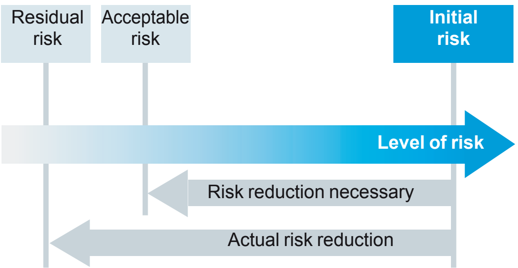
PrEN/ISO 12100 :2009: General principles for design, risk assessment and risk reduction.
See page 7/9.
The purpose of this standard is to provide designers with an overall framework and guidance to enable them to produce machines that are safe for their intended use.

Standards to be apply according to the design selected for the safety-related machine control system.
See page 7/12.

Remarks:
The use of one of these 2 standards gives presumption of conformity to the new 2006/42/EC directive.

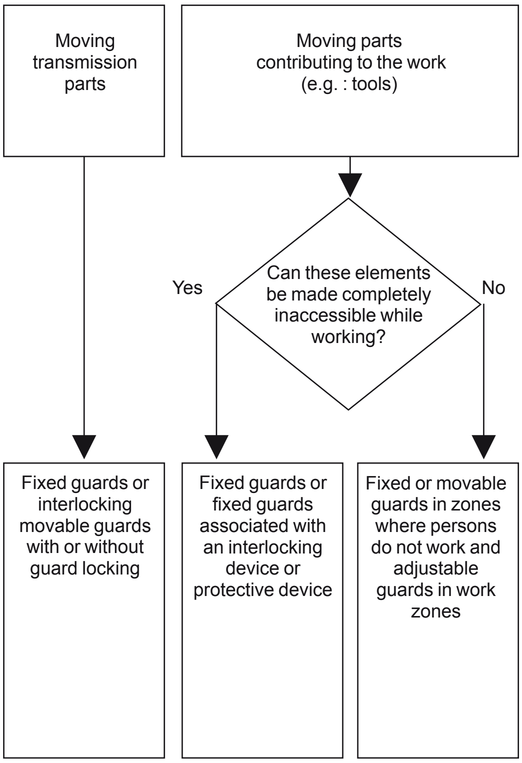
EN/IEC 60204-1: Electrical equipment of machines
Standard EN/IEC 60204-1 completes the safety standards by giving setting-up rules for each component of a machine's electrical functions.
It specifies, among other things:
- the type of connection terminals and disconnection and breaking devices,
- the type of electric shock protection,
- the type of control circuits,
- the type of conductors and wiring rules,
- the type of motor protection.

See page 7/23.



Achieved by design measures, safety-related systems and by external risk reduction devices

Reduction of risk to an acceptable level



Selection of the protection system (PrEN/ISO 12100 :2009)

Standards to be applied (continued)

Risk and safety

Safety is the absence of risks which could cause injury to or damage the health of persons. Functional safety is a part of safety that depends on the correct operation of safety functions.

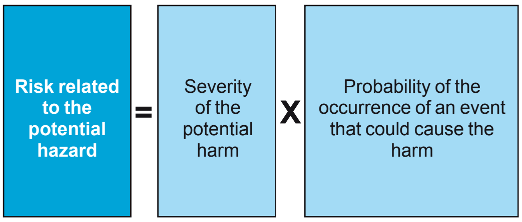
According to the requirements of standard PrEN/ISO 12100 :2009, the machine designer's job is to reduce all risks to a value lower than the acceptable risk.
For more details concerning the sources of accidents and risk prevention, the reader is referred on page 7/5.

This standard recognizes two sources of hazardous phenomena:
- moving transmission parts,
- moving parts contributing to the work.

It gives guidelines for the selection and installation of devices which can be used to protect persons and identifies those measures that are implemented by the machine designer and those dependent on its user.

The measures taken by the machine designer may be:
- inherent in the design,
- selection of guards and additional measures, including control systems,
- information for the user.

The measures taken by the user may be (non-exhaustive list):
- organization and procedures,
- personal protective equipment,
- training.



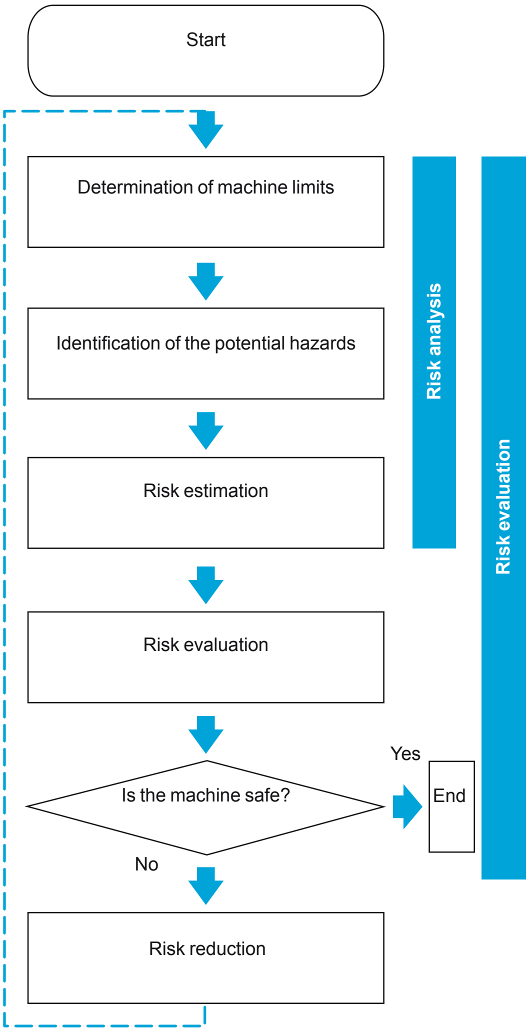
Definition of risk

Assessment of machinery related risk

European legislation

■ Machines are sources of potential risk and the Machinery Directive requires a risk assessment to ensure that any potential risk is reduced to less than the acceptable risk.

Standard PrEN/ISO 12100 :2009 defines risk as follows: risk is the severity multiplied by the possibility of occurrence. It defines an iterative process for achieving machine safety, which states that the risks for each potential hazard can be determined in four stages. This method provides the basis for the requisite risk reduction.



Logic steps for risk analysis

Risk assessment

Risk assessment consists of a series of logic steps which make it possible to systematically analyze and evaluate machinery-related risks.

Risk assessment is followed, whenever necessary, by a reduction of the risk. This definition taken from standard PrEN/ISO 12100 :2009 is based on an iterative process represented in the diagram opposite.

Determination of machine limits

Risk assessment starts by determining the limits of the machine at all stages of its life cycle:

- transport, assembly, installation,
- commissioning,
- use,
- de-commissioning, dismantling.

The use limitations must then be specified:

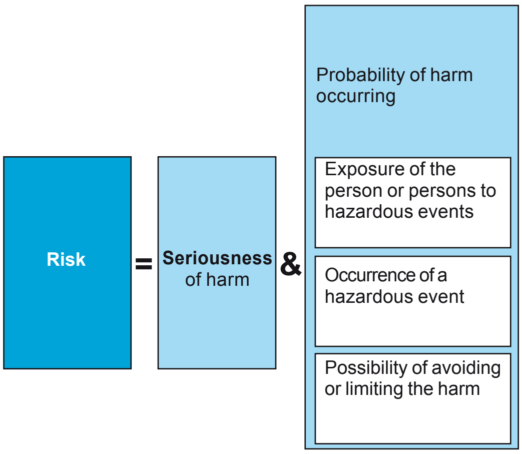
- operating modes,
- level of training required,
- space limits (amplitude, movement),
- time limits (life cycle, frequency of maintenance).

Identification of the potential hazard

If a potential hazard exists, a hazardous phenomenon will cause harm if measures are not taken. All the tasks associated with the machine’s life cycle must be identified, such as:

- assembly, transport and installation,
- adjustment, testing,
- learning, programming,
- tool changing,
- feeding, removal of product from the machine,
- starting, stopping,
- emergency stops, restarting after an unexpected stop,
- maintenance and cleaning.

International safety standards
Assessment of machinery related risk *(continued)*



Elements of the risk

Assessment of machinery related risk (continued)

Risk assessment (continued)

Risk estimation

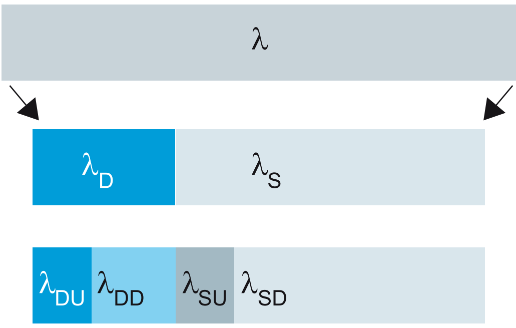
The risk is a function of the severity of the harm and the probability that this harm will occur.

■ The severity of the harm takes into account:
- the severity of injuries (slight, serious, death),
- the extent of the harm (number of persons).

■ The probability of the harm occurring takes into account:
- exposure to the hazard (nature of access, time spent in the hazardous zone, number of persons exposed, frequency of access),
- the occurrence of a hazardous event (accident history, comparison of risks),
- the possibility of avoiding or limiting the harm (experience, awareness of the risk).

Risk evaluation

On the basis of the risk assessment, the designer has to define the safety related control system. To achieve that, the designer will chose one of the two standards appropriate to the application:
- either standard EN/ISO 13849-1, which defines performance levels (**PL**),
- or standard EN/IEC 62061, which defines safety integrity levels (**SIL**).



λ rate of control system failures
λ_D rate of dangerous failures
λ_{DU} rate of undetected dangerous failures
λ_{DD} rate of detected dangerous failures
λ_S rate of safe failures
λ_{SU} rate of undetected safe failures
λ_{SD} rate of detected safe failures

Breakdown of the probability of failures

Risk reduction

The process of risk reduction for dangerous events starts by:
- intrinsic prevention (inherently safe design),
- definition of the appropriate protective means (guards, carters, fix fences),
- personal training.

If the selected preventive measure depends on a safety related control system, the designer has to perform an iterative process for the design of the safety relative control system.

■ The first stage is to define the necessary safety-related control functions:
- either through the choice of components,
- or by adapting the control system architecture. Redundancy (double circuit components), for example, significantly increases the reliability of the solution.

■ Once the limits of available technologies have been reached, it will not be possible to further reduce the rate of dangerous failures. To achieve the required level of safety, it will be necessary to use a diagnostic system that allows dangerous failures to be detected.

International safety standards

Standard to be applied according to the design selected for the safety-related machine control system

Standard to be applied according to the design selected for the safety-related machine control system

Safety standards to be applied according to type of architecture selected

Based on the generic definition of the risk, the standards classify necessary safety levels in different discrete levels corresponding for each one to a probability of dangerous failure per hour:
- PL (Performance Level) for standard EN/ISO 13849-1,
- SIL (Safety Integrity Level) for standard EN/IEC 62061.

The table below gives **the relationship** between the performance level (PL) and the Safety Integrity Level (SIL).

PL	SIL	Probability of dangerous failures per hour 1/h
a	No correspondance	$\geq 10^{-5} \ldots < 10^{-4}$
b	1	$\geq 3 \times 10^{-6} \ldots < 10^{-5}$
c	1	$\geq 10^{-6} \ldots < 3 \times 10^{-6}$
d	2	$\geq 10^{-7} \ldots < 10^{-6}$
e	3	$\geq 10^{-8} \ldots < 10^{-7}$

In order to be able to select the applicable standard, a common table in both standards gives indications which are summarized in the table below:

	EN/ISO 13849-1	EN/IEC 62061
Technology used	**max. PL**	**max. SIL**
Non electric only, for example hydraulic	e	Not covered
Including some electromechanical, for example relays and/or non complex electronics	e *(1)*	3
Including complex electronics, for example programmable	d	3

(1) For designated architectures only.

For building specific complex sub-systems or for higher level requirements including software, standard EN/IEC 61508 relating to systems must be used.

International safety standards

Standard to be applied according to the design selected for the safety-related machine control system *(continued)*

Standard to be applied according to the design selected for the control system *(continued)*

Designing a safety-related control system taking into account the requirements of safety standards may seem rather complex. We will guide the reader through this process by presenting:
- the basis and development of the standards,
- the safety standards to be applied according to the type of architecture selected,
- machine equipment and wiring.

Basis and development of the standards

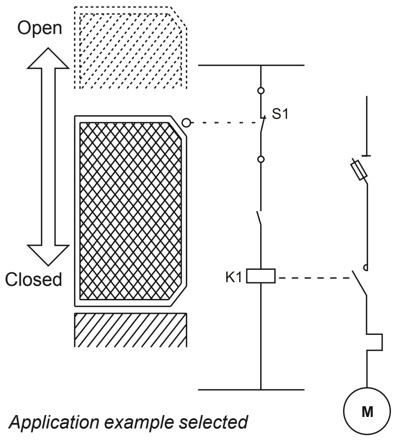
In a complex system, such as a refinery, it is no longer sufficient to consider only the sub-systems to ensure protection; failure of a sub-system could be catastrophic for persons and the environment.
The approach is therefore more global.Taking into account the whole safety life cycle, standard EN/IEC 61508 deals with safety-related control systems, and includes safety rules, technical specifications, management and training of personnel.

The use of more complex saftey-related control systems based on electronics and software highlights the weaknesses of standard EN 954-1:
- the reliability of components is not taken into account,
- insufficient requirements for programmable products,
- combining components with a category certification is not enough to "guarantee" the required level of risk reduction.

Based on experience gained with systems, the standards body has, in line with standard EN/IEC 61508, developed standard EN/IEC 62061 which applies the principles of functional safety to the design of safety-related control systems for machinery.
This standard offers two important advantages:
- it incorporates the new electronic and electronic programmable technologies to provide the safety functions,
- it is consistent with the basic standard EN/IEC 61508 and is therefore being specified more and more for machines by users.

At the same time, standard EN/ISO 13849-1, effective since 2006, has completely replaced the standard EN 954-1 since January 2010, which brings several improvements and, above all, is consistent with safety standards in general.

International safety standards
Standard EN/ISO 13849-1
Machinery safety - Safety-related parts of control systems (SRP/CS)



Application example selected

Standard EN/ISO 13849-1
Machinery safety - Safety-related parts of control systems

Standard EN/ISO 13849-1 is a development of standard EN 954-1. For clarity, only a simplified analysis of this new version will be presented here.

Field of application of the standard

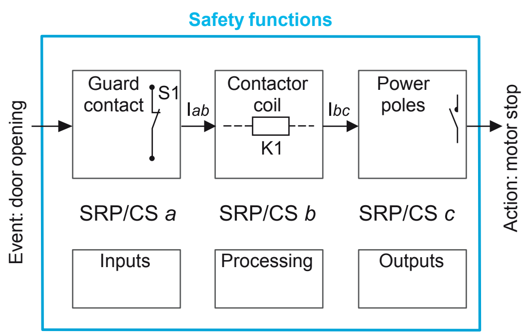
This standard gives safety requirements and advice relating to principles for the design and integration of safety-related parts of control systems (SRP/CS), including software design. For these parts, it specifies the characteristics, including the performance level, needed to achieve these safety functions. It applies to the SRP/CS of all types of machine, regardless of the technology and type of energy used (electric, hydraulic, pneumatic, and mechanical).

Process

Risk assessment as defined in standard PrEN/ISO 12100 :2009 (see page 7/8.) leads to decisions on risk reduction measures. If these measures depend on a control system, then PrEN/ISO 12100 :2009 can apply. It defines a 6-stage design process.

1 - Selection of the essential safety functions that SRP/CS must perform. For each safety function, specify the required characteristics.
2 - Determine the required performance level (PLr).
3 - Design and technical creation of safety functions: identify the parts that perform the safety function.
4 - Evaluate the performance level PL for each safety-related part.
5 - Check that the performance level PL achieved is greater than or equal to the required level (PLr).
6 - Check that all requirements are satisfied.

We will now illustrate these stages, taking as an example a safety function that stops operation of a machine motor when a safety guard is opened. The machine is potentially dangerous, there is a risk of the operator's arm being amputated if there is no guard.



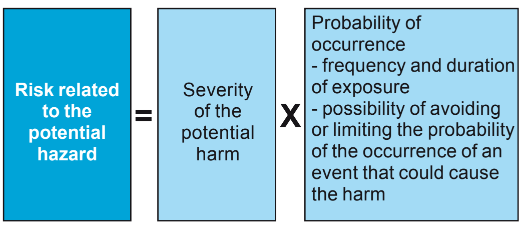
Representation of the safety function

Stage 1 - Selection of safety functions
The diagram opposite shows a safety function which consists of several parts:
- the input actuated by opening of the guard (SRP/CS*a*),
- the control logic, limited in this example to opening or closing of a contactor coil (SRP/CS*b*),
- the power output that controls the motor (SRP/CS*c*),
- the connections (I*ab*, I*bc*).

Stage 2 - Estimation of required performance level (PLr)
For our safety function, this is estimated using the risk graph.

The parameters to be considered are:
- □ **S** severity of the injury
- - **S1** slight injury, normally reversible,
- - **S2** Serious, normally irreversible, including death.
- □ **F** frequency and/or duration of exposure to the hazardous phenomenon.
- - **F1** rare to fairly frequent and/or short duration of exposure,
- - **F2** frequent to permanent and/or long duration of exposure.
- □ **P** possibility of avoiding the hazardous phenomena or limiting the harm.
- - **P1** possible under certain circumstances,
- - **P2** virtually impossible.

The result of the estimation (in blue on the drawing on the next page) gives a required performance level PLr = e.

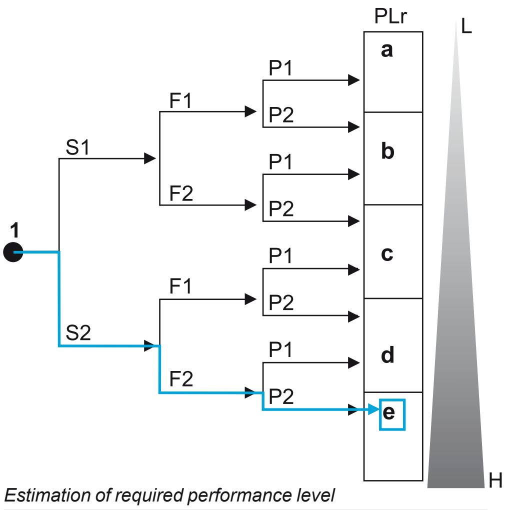


Risk analysis

International safety standards

Standard EN/ISO 13849-1

Machinery safety - Safety-related parts of control systems (SRP/CS) *(continued)*



Estimation of required performance level

1	Starting point for estimation
L	Low contribution to risk reduction
PLr	Performance Level required
H	High contribution to risk reduction
→	Estimation

Standard EN/ISO 13849-1
Machinery safety - Safety-related parts of control systems ***(continued)***

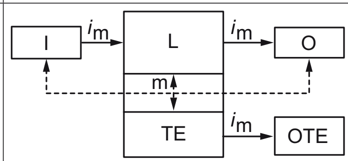
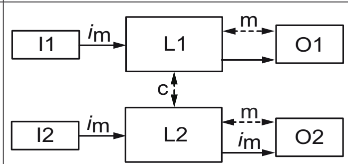
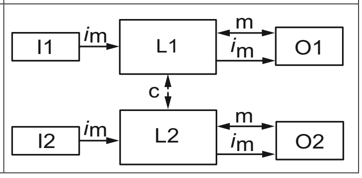
Process ***(continued)***

Stage 3 - Design and creation of the safety functions
At this point, we need to describe the PL calculation method.
The PL is defined in terms of the probability of a dangerous failure per hour:

PL	Probability of a dangerous failure per hour
a	$\geq 10^{-5} \ldots < 10^{-4}$
b	$\geq 3 \times 10^{-6} \ldots < 10^{-5}$
c	$\geq 10^{-6} \ldots < 3 \times 10^{-6}$
d	$\geq 10^{-7} \ldots < 10^{-6}$
e	$\geq 10^{-8} \ldots < 10^{-7}$

For a SRP/CS (or a combination of SRP/CS) designed according to the requirements of the article 6, PL could be estimated with the figure shown on page 7/16, after estimation of several factors such as :
- hardware and software system structure (categories),
- mechanism of failures, diagnostic coverage (DC),
- components reliability, Mean Time To dangerous Failure ($MTTF_d$),
- Common Cause Failure (CCF).

■ Categories (Cat.) and designated architectures
The table below summarizes system behavior in the event of a failure and the principles used to achieve the safety, for the 5 categories defined:

Cat.	System behavior	Designated architectures
B	A fault can lead to loss of the safety function	
1	As for category B but the probability of this occurence is lower than for the category B	
2	A fault can lead to loss of the safety function between two periodic inspections and loss of the safety function is detected by the control system at the next test.	
3	For a single fault, the safety function is always ensured. Only some faults will be detected. The accumulation of undetected faults can lead to loss of the safety function.	
4	When faults occur, the safety function is always ensured. Faults will be detected in time to prevent loss of the safety function	

Key:

*i*m	Interconnecting means
c	Cross monitoring
I, I1, I2	Input device, e.g. sensor
L, L1, L2	Logic
m	Monitoring
O, O1, O2	Output device, e.g. main contactor
TE	Test equipment
OTE	Output of TE

■ $MTTF_d$ (Mean Time To dangerous Failure)
The value of the $MTTF_d$ of each channel is given in 3 levels (see table below) and shall be taken into account for each channel (e.g. single channel, each channel of a redundant system) individually.

Reliability levels of components	
Index	**Range**
Low	3 years $\leq MTTF_d <$ 10 years
Medium	10 years $\leq MTTF_d <$ 30 years
High	30 years $\leq MTTF_d <$ 100 years

A $MTTF_d$ of less than 3 years should never be found, because this would mean that after one year in operation, 30% of all those components in use would have failed to a dangerous state. The maximum value is limited to 100 years because devices dealing with a significant risk should not depend on the reliability of a single component. Additional measures such as redundancy and tests are required.

Standard EN/ISO 13849-1
Machinery safety - Safety-related parts of control systems *(continued)*

Process ***continued)***

Stage 3 - Design and creation of the safety functions ***(continued)***

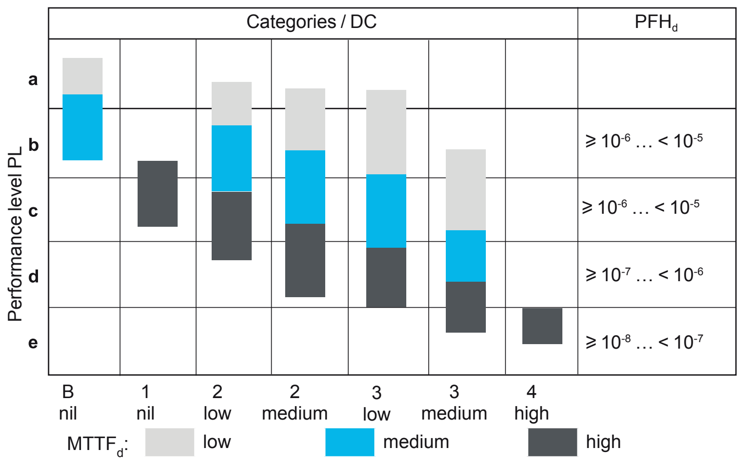
■ Diagnostic coverage: this term is expressed as a percentage and quantifies the ability to diagnose a dangerous failure.

For example, in the event of welding of a N/C contact in a relay, the state of the N/O contact could incorrectly indicate the opening of the circuit, unless the relay has mechanically linked N/O and N/C contacts, when the fault can be detected.

The standard recognizes four levels:

Diagnostic coverage	
Denotation	**Range**
Nil	DC < 60%
Low	60% ⩽ DC < 90%
Medium	90% ⩽ DC < 99%
High	99% ⩽ DC

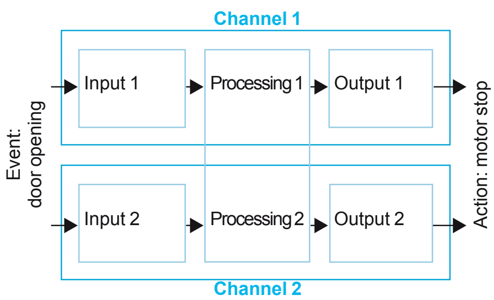
■ Relationship between Categories, DC and $MTTF_d$ of each channel and the PL



□ In our example, to reach the PL = e, the solution will therefore have to correspond to category 4 with redundant circuit; the function scheme is shown opposite with two channels in parallel,

□ a high diagnostic capability,

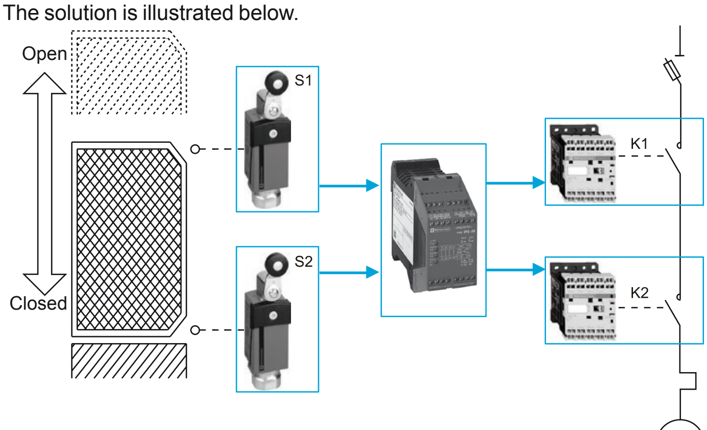
□ a high $MTTF_d$.



Functional diagram of the example

For our application, we could suggest a redundant relay scheme but it is nowadays easier to use safety function blocks.

The solution is illustrated below.



Application scheme of the example

The process suggested by the standard is iterative and a few estimations are therefore necessary in order to obtain the expected result. In view of the required performance level, we have chosen a solution with redundant circuit.

Standard EN/ISO 13849-1
Machinery safety - Safety-related parts of control systems *(continued)*

Process *(continued)*

Stage 4 - Evaluate the performance level PL for each safety-related part
Based on the information in the supplier's catalog and Annex E of the standard, we obtain the following values:

Example	B_{10} (number of operations) / % dangerous failure	$MTTF_d$	DC
SRP/CS_a: Safety limit switches	10.000.000 / 20% dangerous failure	7,102	99%
SRP/CS_b: XPS AK safety module	-	154.5	99,99%
SRP/CS_c: LCK contactor	1.000.000 / 73% dangerous failure	194	99%

For electromechanical products,
the $MTTF_d$ is calculated on the basis of the total number of operations that the product can perform, using $\mathbf{B_{10d}}$ values:
In our case, the machine operates for 220 days per year, 8 hours per day with a cycle of 90 s.
N = 220 x 8 x (3600 / 90) = 70,400 operations/year
$MTTF_d = B_{10d} / (0.1 \times N)$ and $B_{10d} = B_{10}$ / % dangerous failure.

For the safety switches,
the $MTTF_d$= (1 / 0.20 x 10 000 000) / (0.1) x 70,400 = 7,102 years
For the contactors,
the $MTTF_d$ = (1 / 0.73 x 1 000 000) / (0.1) x 70,400 = 194 years
The $MTTF_d$ for each channel will then be calculated using the formula:

$$\frac{1}{MTTF_d} = \frac{1}{MTTF_{da}} + \frac{1}{MTTF_{db}} + \frac{1}{MTTF_{dc}}$$

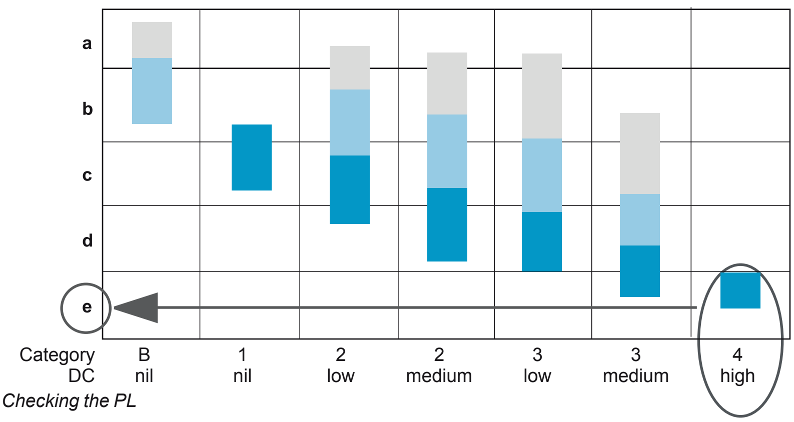
i.e. 85 years for each channel.
A similar formula is used to calculate the diagnostic capability

$$DC_{avg} = \frac{\frac{DC_a}{MTTF_{da}} + \frac{DC_b}{MTTF_{db}} + \frac{DC_c}{MTTF_{dc}}}{\frac{1}{MTTF_{da}} + \frac{1}{MTTF_{db}} + \frac{1}{MTTF_{dc}}}$$

The result of the calculation in our example gives a value of 99%

Stage 5 - Checking that required performance level is achieved
The result of the above calculations is summarized below:
- a redundant architecture: category 4,
- a mean time to failure > 30 years: high $MTTF_d$,
- a diagnostic capability of 99%: high DC.

Looking at this table, we confirm that **PL** level **e** is achieved:



Checking the PL

Stage 6 - Validation of the required performance level
The design of SRP/CS must be validated and must show that the combination of SRP/CS performing each safety function satisfies all the applicable requirements of EN/ISO 13849.

7

International safety standards
Standard EN/IEC 62061
Machinery safety - Safety-related electrical control systems (SRECS)

Standard EN/IEC 62061 Machinery safety - Safety-related electrical control systems (SRECS)

Functional Safety of safety-related electrical, electronic and electronic programmable control systems

Field of application of the standard

Safety-related electrical control systems in machines (**SRECS**) are playing an increasing role in ensuring the overall safety of machines and are more and more frequently using complex electronic technology.

This standard is specific to the machine sector within the framework of EN/IEC 61508. It gives rules for the integration of sub-systems designed in accordance with EN/ISO 13849. It does not specify the operating requirements of non-electrical control components in machines (for example: hydraulic, pneumatic).

Functional approach to safety

As with EN/ISO 13849-1, the process starts with analysis of the risks (PrEN/ISO 12100 :2009) in order to be able to determine the safety requirements. **A particular feature of this standard is that it prompts the user to make a functional analysis of the architecture, then split it into sub-functions and analyze their interactions before deciding on a hardware solution for them (the SRECS)**.

■ A functional safety plan must be drawn up and documented for each design project. It must include:
- □ a specification of the safety requirements for the safety functions (**SRCF**) that is in two parts:
  - a description of the functions and interfaces, operating modes, function priorities, and frequency of operation.
  - specification of the safety integrity requirements for each function, expressed in terms of **SIL** (Safety Integrity Level).

The table below gives the target maximum failure values for each level.

SIL	Probability of a dangerous failure per hour (PFHd)
3	$\geqslant 10^{-8}...< 10^{-7}$
2	$\geqslant 10^{-7}...< 10^{-6}$
1	$\geqslant 10^{-6}...< 10^{-5}$

- □ The structured and documented design process for electrical control systems (**SRECS**),
- □ the procedures and resources for recording and maintaining appropriate information,
- □ the process for management and modification of the configuration, taking into account organization and authorized personnel,
- □ the verification and validation plan.

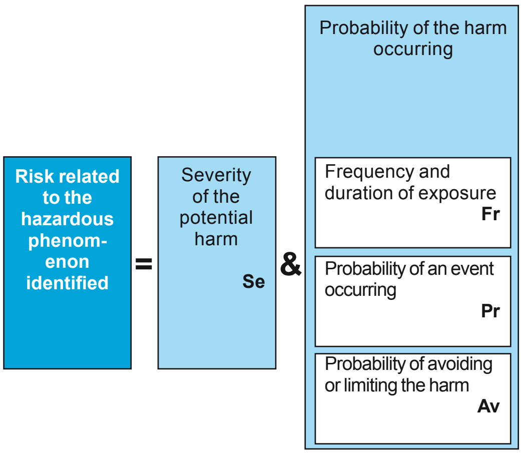
■ Functional safety
The decisive advantage of this approach is that of being able to offer a failure calculation method that incorporates all the parameters that can affect the reliability of electrical systems, whatever the technology used.
The method consists of assigning a SIL to each function, taking into account the following parameters:
- the probability of a dangerous failure of the components (**PFH**d),
- the type of architecture; with or without redundancy, with or without diagnostic device making it possible to avoid some of the dangerous failures,
- common cause failures (power cuts, overvoltage, and loss of communication network) (**CCF**),
- the probability of a dangerous transmission error where digital communication is used,
- electromagnetic interference (**EMC**).

International safety standards
Standard EN/IEC 62061
Machinery safety - Safety-related electrical control systems (SRECS) *(continued)*

Standard EN/IEC 62061
Machinery safety - Safety-related electrical control systems (SRECS) ***(continued)***

Process

Designing a system is split into 5 stages after having drawn up the functional safety plan:
1 - based on the safety requirements specification (**SRS**), assign a safety level (**SIL**) and identify the basic structure of the electrical control system (**SRECS**), describe each related function (**SRCF**),
2 - break down each function into a function block structure (**FB**),
3 - list the safety requirements for each function block and assign the function blocks to the sub-systems within the architecture,
4 - select the components for each sub-system,
5 - design the diagnostic function and check that the specified safety level (**SIL**) is achieved.
We will retain the previous example which consists of stopping the operation of a motor when the safety guard is opened. In the event of an incident, there is a risk of an harm being amputated or fracture of a limb.

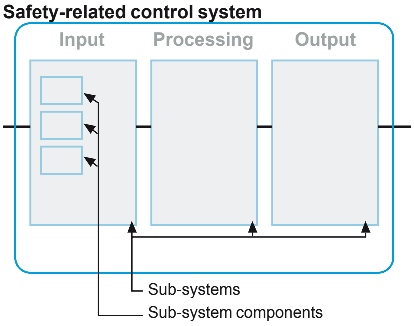


Risk assessment parameters

■ **Stage 1** - Assign a safety integrity level (**SIL**) and identify the structure of the **SRECS**
Based on the risk assessment performed in accordance with standard PrEN/ISO 12100 :2009, estimation of the required **SIL** is performed for each hazardous phenomenon and is broken down into parameters, see illustration opposite.

□ Severity **Se**
The severity of injuries or damage to health can be estimated by taking into account reversible injuries, irreversible injuries and death.
The classification is shown in the table below.

Consequence	Severity Se
Irreversible: death, loss of an eye or an arm	4
Irreversible: shattered limb, loss of a finger	3
Reversible: requires the attention of a medical practitioner	2
Reversible: requires first aid	1

SRECS
Safety-related control system


Stage 1*: Basic structure of the electrical control system*

□ Probability of the harm occurring
Each of the three parameters **Fr**, **Pr**, **Av** must be estimated separately using the most unfavourable case. It is strongly recommended that a task analysis model be used in order to ensure that estimation of the probability of the harm occurring is correctly taken into account.
- Frequency and duration of exposure **Fr**

The level of exposure is linked to the need to access the hazardous zone (normal operation and maintenance) and the type of access (manual feeding and adjustment). It must then be possible to estimate the average frequency of exposure and its duration.
The classification is shown in the table below:

Frequency of dangerous exposure	Fr
≤ 1 hour	5
>1 hour... ≤ 1 day	5
> 1 day... ≤ 2 weeks	4
2 weeks... ≤ 1 year	3
> 1 year	2

- Probability of occurrence of a hazardous event **Pr**.

Two basic concepts must be taken into account:
- the predictability of the dangerous components in the various parts of the machine in its various operating modes (normal, maintenance, troubleshooting), paying particular attention to unexpected restarting,
- behavior of the persons interacting with the machine, such as stress, fatigue, and inexperience.

Probability of occurrence of a dangerous event	Pr
Very high	5
Probable	4
Possible	3
Almost impossible	2
Negligible	1

International safety standards
Standard EN/IEC 62061
Machinery safety - Safety-related electrical control systems (SRECS) *(continued)*

Standard EN/IEC 62061
Machinery safety - Safety-related electrical control systems (SRECS) ***(continued)***

Process ***(continued)***

■ **Stage 1 -** ***(continued)***

- Probability of avoiding or limiting the harm **Av**.

This parameter is linked to the design of the machine. It takes into account the suddenness of the occurrence of the hazardous event, the nature of the dangerous component (cutting, temperature, electrical) and the possibility for a person to identify a hazardous phenomenon.

Probability of avoiding or limiting the harm	Av
Impossible	5
Almost impossible	3
Probable	1

□ Assignment of the **SIL**

Estimation is made with the help of the table below.
In our example, the degree of severity is 3 because there is a risk of a finger being amputated; this value is shown in the first column of the table.
All the other parameters must be added together in order to select one of the classes (vertical columns in the table below), which gives us:
Fr = 5 accessed several times a day
Pr = 4 hazardous event probable
Av = 3 probability of avoiding almost impossible
Therefore a class Cl = 5 + 4 + 3 = 12
A level of SIL 2 must be achieved by the safety-related electrical control system(s) (**SRECS**) on the machine.

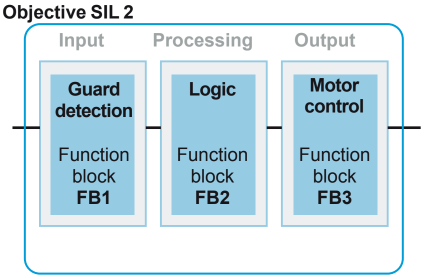
Estimation of the SIL

Se	Class Cl				
	3-4	5-7	8-10	11-13	14-15
4	SIL 2	SIL 2	SIL 2	SIL 3	SIL 3
3	-	-	SIL 1	SIL 2	SIL 3
2	-	-	-	SIL 1	SIL 2
1	-	-	-	-	SIL 1

□ Basic structure of the **SRECS**

Without going into detail about the hardware components to be used, the system is broken down into sub-systems. In our case, we find the 3 sub-systems that will perform the input, processing and output functions. The figure opposite illustrates this stage, using the terminology given in the standard.

SRECS
Objective SIL 2

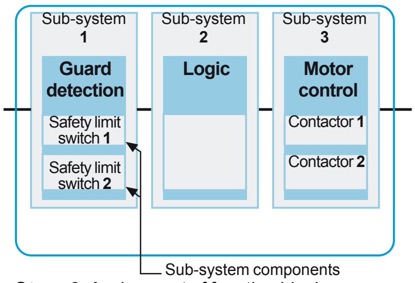


Stage 2*: Break down into function blocks*

■ **Stage 2** - Break down each function into a function block structure (**FB**)
A function block (**FB**) is the result of a detailed break down of a safety-related function.
The function block structure gives an initial concept of the SRECS architecture. The safety requirements of each block are deduced from the specification of the safety requirements of the system's function.

■ **Stage 3** - List the safety requirements for each function block and assign the function blocks to the sub-systems within the architecture

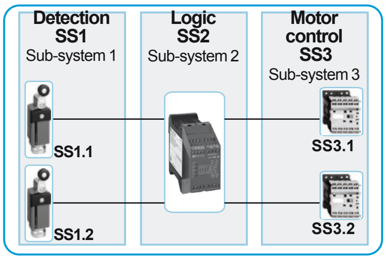
SRECS



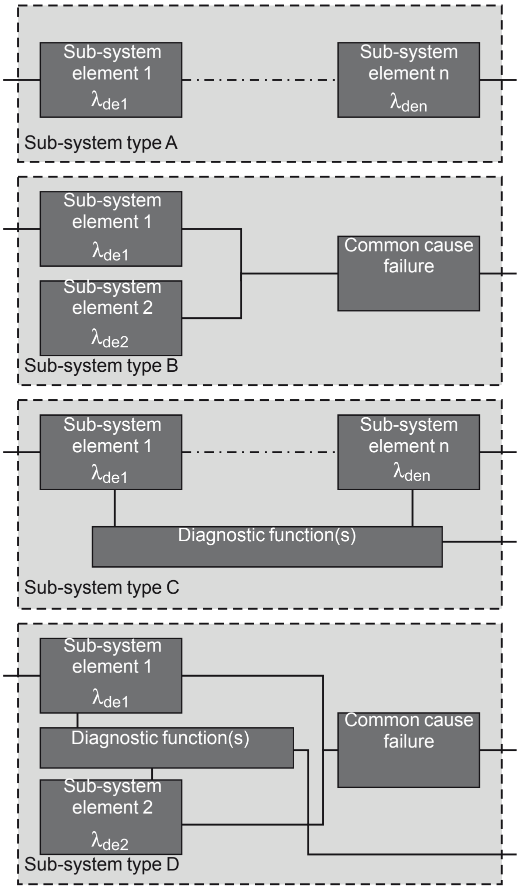
Stage 3*: Assignment of function blocks*

Each function block is assigned to a sub-system in the SRECS architecture. A failure of any sub-system will lead to the failure of the safety-related control function. More than one function block may be assigned to each sub-system. Each sub-system may include sub-system elements and, if necessary, diagnostic functions in order to ensure that anomalies can be detected and the appropriate action taken.
These diagnostic functions (D) are considered as separate functions; they may be performed within the sub-system, by another internal or external sub-system.

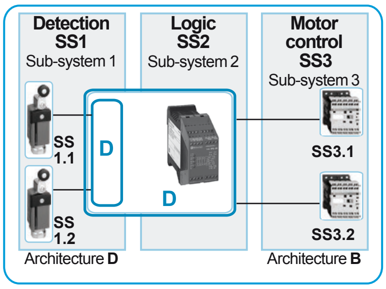
International safety standards
Standard EN/IEC 62061
Machinery safety - Safety-related electrical control systems (SRECS) *(continued)*



***Stage 4**: Component selection*



Types of sub-system architecture



***Stage 5**: Design of the diagnostic function*

Standard EN/IEC 62061
Machinery safety - Safety-related electrical control systems (SRECS) *(continued)*

Process *(continued)*

■ **Stage 4** - Select the components for each sub-system
The products shown in the illustration opposite are selected. If the sensors and contactors are the same as in the previous example, a safety module XPS AK will be chosen. In this example, we take a cycle of 450s which means the duty cycle **C** is 8 operations per hour.

As the safety integrity level required for the entire system is SIL 2, each of the components must achieve this level.
The manufacturer's catalog gives the following values:
Safety limit switches 1 and 2: B_{10} = 10 000 000 operations, the proportion of dangerous failures is 20%, lifetime is 10 years.

- Safety module: $PFH_d = 7.389\ 10^{-9}$
- Contactors 1 and 2: B_{10} = 1 000 000 operations, the proportion of dangerous failures = 73%, lifetime is 20 years.

■ **Stage 5** - Design the diagnostic function
The SIL of the sub-system depends not only on the components, but also on the architecture selected. For our example, we will choose architectures B and D of the standard.
In our architecture, the safety module performs diagnostics not only on itself, but also on the safety limit switches.

We have three sub-systems for which the safety levels must be determined:

- ◻ SS1: two redundant safety limit switches in a sub-system with a type D architecture,
- ◻ SS2: a SIL 3 safety module (obtained on the basis of the PFH provided by the manufacturer),
- ◻ SS3: two redundant contactors built in accordance with a type B architecture.

The calculation method is quite complex, so we will only give the final result. This method takes into account the following parameters:

- **B_{10}**: number of operations at which 10% of the population fail
- **C**: Duty cycle (number of operations per hour)
- λ_D: rate of dangerous failures ($\lambda_D = \lambda$ x portion of dangerous failures in %)
- β: common cause failure coefficient, which is 10 % here and 10% is the worst case: see Annex F.
- **T1**: Proof Test Interval or life time whichever is smaller, as provided by the supplier
- **T2**: diagnostic test interval
- **DC**: Diagnostic coverage rate = λ_{DD}/λ_D, ratio between the rate of detected failures and the rate of dangerous failures.

We obtain:

- for SS1 $PFH_d = 1.6\ E^{-9}$
- for SS3 $PFH_d = 1.06\ E^{-7}$

The total probability of dangerous failures per hour is:

- $\mathbf{PFH_{DSRECS} = PFH_{DSS1} + PFH_{DSS2} + PFH_{DSS3}}$
- $\mathbf{PFH_{DSRECS}} = 1.6\ 10^{-9} + 7.38\ 10^{-9} + 1.06\ E^{-7} = 1.15\ E^{-7}$

Which corresponds to the expected result (table below) of a SIL = 2 .
Comment: A level of SIL 3 could have been achieved by using mirror contacts to create a feedback loop on the contactors, i.e. a sub-system architecture type D.

Checking the required SIL

SIL	Probability of dangerous failures per hour (PFHd)
3	$\geqslant 10^{-8} ... < 10^{-7}$
2	$\mathbf{\geqslant 10^{-7} ... < 10^{-6}}$
1	$\geqslant 10^{-6} ... < 10^{-5}$

International safety standards
Certification and CE marking

Certification and CE marking

There are 6 stages in the process for certification and afmounting of the CE marking on machines:
1 - apply all the relevant directives,
2 - conform to the essential health and safety requirements,
3 - draw up the technical documentation,
4 - if applicable proceed with the conformity examination,
5 - draw up the Declaration of Conformity,
6- affix the CE marking.

The Machinery Directive

The Machinery Directive is an example of the “New approach” for the harmonization of products in terms of technical specifications and standards. It is based on:
- essential health and safety requirements which must be complied with before the machine is put on the market,
- a voluntary harmonization process of standards undertaken by the European Standards Committee (CEN) and the European committee for electro-technical standardisation (CENELEC).
- conformity of evaluation procedures adapted to the types of risk and associated with machine types,
- the CE marking, affixed by the manufacturer to indicate that the machine conforms to the applicable directives; machines bearing this marking can circulate freely within the European Union.

The directive has considerably simplified the multiple national legislations which were in force and has therefore removed many barriers which made trading difficult in the European Union. This has also made it possible to reduce the social cost of accidents. The directives do not apply to pre-existing machines within the EU unless they are substantially modified.
A list of the machines requiring special attestation procedures can be found in the Machinery Directive Annex 4.

The essential requirements

Annex I of the Machinery Directive groups together the essential health and safety requirements, for putting machines and safety components on the market and into service in Europe.
It follows that:
- if all the requirements of the directive are complied with, no member state of the European Union can oppose circulation of this product.
- if the requirements of the directive are not complied with, putting the product on the market may be prohibited or withdrawal of the product from the market may be required.

In the European Union, this concerns not only manufacturers or their distributors, but also importers and resellers who import these machines or put them into service. Second-hand machines within the EU are not covered, but used machines that have been modified or refurbished can be considered to be new machines.

The harmonized standards

The simplest way to demonstrate conformity with the directives is to conform to the European Harmonized Standards. When, for a product listed in Annex 4 of the Machinery Directive, there is no harmonized standard, or the existing standards are not relevant to cover the essential health and safety requirements, or if the manufacturer considers that these standards are not applicable to their product, they can apply for approval by an outside Notified Body.

These bodies are approved by the Member States after having shown that they have the recognized expertise to give such an opinion (TÜV, BGIA, INRS, and BSI Product Services.

Although the Notified Body has a certain number of responsibilities under the Directive, it is always the manufacturer or their representative who remain responsible for conformity of the product.

Certification and CE marking *(continued)*

Declaration of conformity

In accordance with Article 1 of the Machinery Directive, the manufacturer or their authorized representative established in the European Union must draw up a European Declaration of Conformity for each machine (or safety component). This is in order to certify that the machine or safety component conforms to the Directive.
Before putting a product on the market, the manufacturer or their representative must be able to prepare a technical file.

CE marking

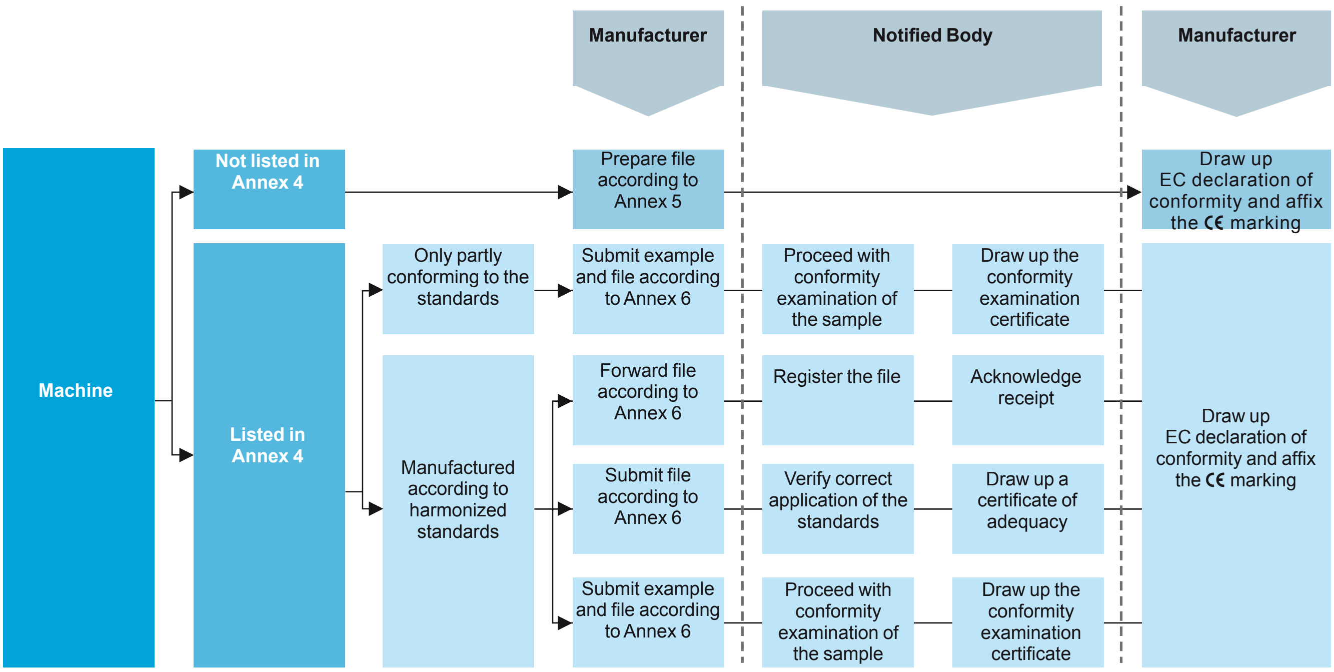
Finally, the CE mark must be affixed to the machine by the manufacturer or their authorized representative in the European Union. This marking has been obligatory since 1st January 1995 and can only be affixed if the machine conforms to all the applicable directives, such as:

- the Machinery Directive 2006/42/EC,
- the Electromagnetic Compatibility (EMC) directive 2004/108/EC,
- the Low Voltage Directive 2006/95/EC.

There are other directives such as the protection of persons, lifts, and medical equipment, which may also be applicable.

The CE marking is the machine's passport in the European Union, which allows it to be marketed in all countries within the Union without taking into account regulations in each individual country.

CE marking procedure



7

International safety standards

Relays and contactors for use in safety control Circuits with Preventa™ safety relays

Category (architecture) requirements for relays and contactors

The overall category (architecture) of a safety circuit depends on the components used in the circuit and the method of wiring. The actual maximum category possible for the safety control circuit may be reduced based on the components chosen. The relays or contactors used in a safety circuit, as well as how they are wired, can significantly affect the overall category. Relays and contactors used in the safety circuits must use linked contacts. While there are many relays and contactors available with linked contacts, a majority of them are suitable for use only in category 3 safety circuits – they are not suitable for category 4 circuits (per EN/ISO 13849-1). It is recommended that customers use relays and contactors suitable for use in category 4 circuits as these devices can be used in any safety circuit and eliminate any concern about the devices suitability for the safety circuit desired, whether Category 3 or 4.

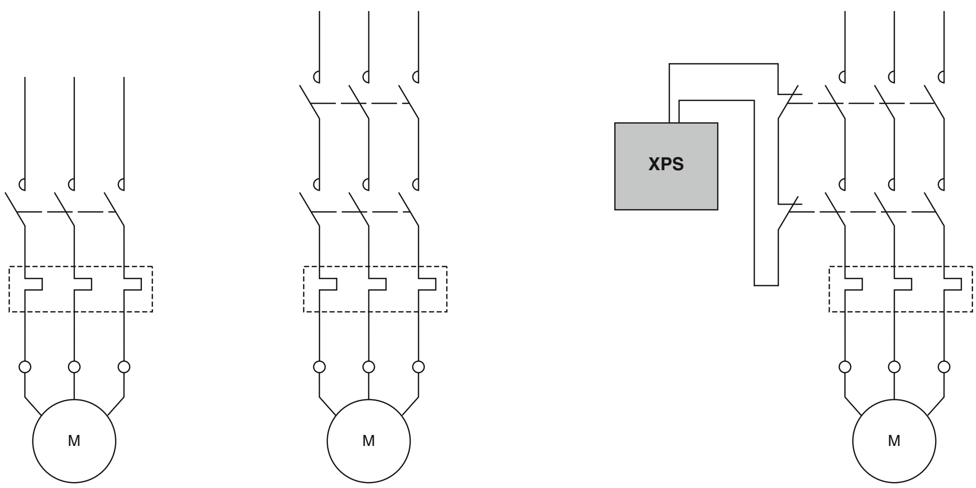
All of the relays and contactors referenced on these pages are suitable for category 4 safety circuits.

The wiring of the safety circuit also affects the overall safety level of the installation. The following needs to be considered when designing a safety circuit:

To meet the requirements of Category 3 per EN/ISO 13849-1 (this standard deals with safety related parts of control systems), the output devices must be redundant - meaning there must be two relays or contactors in series controlling the load which can cause a hazardous movement. Using only one relay or contactor will reduce the control system to a maximum Category 2.

To meet the requirements of Category 4 per EN/ISO 13849-1, the requirements for Category 3 need to be met, plus one of the N.C. auxiliary contacts from each of the two relays or contactors in series must be wired in series in the feedback loop. Without both of these N.C. contacts wired in series in the feedback loop, the control system is reduced to a maximum Category 3. The auxiliary contacts of the relays or contactors also need to be linked contacts in conjunction with the power contacts of the relay or contactor to be suitable for Category 4. Even if there are two relays or contactors wired in series and a feedback loop is wired to the safety relay, if the contacts in the feedback loop are not linked contacts with the contacts wired to the load, the maximum category of the safety circuit is now reduced to a maximum Category 3.

The TeSys IEC contactors and 8501 Type X relays shown on the next few pages are suitable for use in safety circuits to category 4 per EN/ISO 13849-1 in the configurations listed. This is a brief listing and many more devices that meet category 4 are available. The TeSys contactors should be your first choice in any application, as they can be used for both standard control and safety related applications - for no additional cost.



Maximum Category 2 only | **Meets Category 3 requirements for output portion of circuit** | **Meets Category 4 requirements for output portion of circuit**

International safety standards

Relays and contactors for use in safety control Circuits with Preventa™ safety relays *(continued)*

TeSys IEC contactors for category 4 safety circuits per EN/ISO 13849-1

Below is a listing of just some of the devices suitable for category 4 safety circuits, many more devices are available. Contact us for additional devices for your application.

Devices with mirrored auxiliary contacts:

- TeSys™ K contactors
- TeSys D contactors (up to 65 amps)
- TeSys F contactors
- TeSys N contactors

Devices with mechanically linked contact pairs:

- TeSys D contactors
- TeSys N (Sizes 00-2 only)

Examples of TeSys D devices

All TeSys D contactors (including AC and standard DC) have mechanically-linked power contacts and are suitable for use in safety circuits through Category 3 per EN/ISO 13849-1. When used with LADN•• auxiliary contacts, the combination of contactor and auxiliary contacts below meet the requirements of IEC 60947-5-1 and are suitable for use in safety circuits through Category 4 per EN/ISO 13849-1:

LC1D•••• plus LADN••
LC2D•••• plus LADN••

On contactors up to 32 A, the use of the internal auxiliary N.C. contact on the devices below also meet IEC 60947-5-1 and are suitable for use in safety circuits through Category 4 per EN/ISO 13849-1:

LC1D••••••
LC2D••••••

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International safety standards

Relays and contactors for use in safety control Circuits with Preventa™ safety relays *(continued)*

TeSys IEC relays for category 4 safety circuits per EN/ISO 13849-1

Below is a listing of just some of the devices suitable for category 4 safety circuits, many more devices are available. Contact us for additional devices for your application.

TeSys D Relays
TeSys D 10 amp 600 volt industrial control relays are available in fixed contact arrangements up to 9 poles. Two or four pole adder decks in a combination of N.O. and N.C. contacts can be snapped on to the basic five pole relay. TeSys D relays are built to a design specification of 30,000,000 mechanical operations.

TeSys D

The contacts of the relays below meet IEC 60947-5-1 and are suitable for use in safety circuits through Category 4 per EN/ISO 13849-1:

CADN32••
CADN50••

These relays can also be used with the following auxiliary contact blocks and all of the resulting contacts also meet the requirements of IEC 60947-5-1 and are suitable for use in safety circuits through Category 4 per EN/ISO 13849-1:

LADN••

International safety standards

Relays and contactors for use in safety control Circuits with Preventa™ safety relays *(continued)*

NEMA type relays for category 4 safety circuits per EN/ISO13849-1

Type X Relays

Class 8501 Type X relays combine a rugged, heavy duty design with modular construction for greater flexibility. They are ideal for those applications where long life, high reliability and ease of maintenance are important. The Type X family offers a complete line of relays and accessories for all control applications. The basic relay has room for up to 4 convertible contact cartridges. It can be expanded to 6 or 8 poles by installing an adder deck. A 10 or 12 pole relay can be built by adding a second adder deck.

All Type X relays and adder blocks have mechanically-linked power contacts. When a Type X relay is used with any of the adder blocks, the combination of relay and additional contacts meet the requirements of IEC 60947-5-1:

Type X AC Relays

AC control relays below meet the requirements of IEC 60947-5-1 and are suitable for use in safety circuits through Category 4 per EN/ISO 13849-1:

XO00••	XO60••
XO20••	XO80••
XO30••	XO1000••
XO40••	XO1200••

AC Master relays meet IEC 60947-5-1 and are suitable for use in safety circuits through Category 4 per EN/ISO 13849-1:

XMO20••	XMO60••
XMO40••	

The above Type X relays can be used with either the 8501 Type XB20 or XB40 adder decks and meet the requirements of IEC 60947-5-1. Logic reed contact blocks can be mounted to the above relays, but the contacts from these auxiliary logic reed contact blocks do not meet the requirements of IEC 60947-5-1

Type X DC Relays

DC control relays below meet the requirements of IEC 60947-5-1 and are suitable for use in safety circuits through Category 4 per EN/ISO 13849-1:

XDO00••	XDO60••
XDO20••	XOD80••
XDO40••	

DC utility relays below meet IEC 60947-5-1 and are suitable for use in safety circuits through Category 4 per EN/ISO 13849-1:

XUDO40••	XUDO1200••
XUDO04••	XUDO0012••
XUDO80••	

NOTE: The catalog numbers of the 8501 Type X shown above are basic offerings and include all normally open contacts. Since this product line is extremely flexible, the possible contact configurations from normally open (N.O.) and normally closed (N.C.) are far too long for this document. Refer to the catalog or Digest for a complete listing of N.O./N.C. combinations and ordering information. However, each of the contact cartridges are easily field convertible to N.C..

Overlapping contacts are available on many of the relays above by ordering Forms 1591, 1592, 1593, and 1594. Overlapping contacts are not suitable for use in safety circuits and therefore these forms should not be used where safety is concerned.

The •• indicate positions for voltage codes. Refer to the Square D Digest for complete catalog numbers.

Additional information on EU safety standards

There are many sources of information on the EU, EU standards, and directives, below is a partial list of these sources. This information has been taken from literature, personal contacts, and from the internet. While we believe this information to be correct, there may have been changes in phone numbers and addresses from when we acquired this information. If you need any additional information regarding the EU, directives or standards, please contact any of the sources listed below:

American National Standards Institute (ANSI)

(for IEC/CENELEC/CEN /ISO Standards)
1899 L Street, NW, 11th floor, Washington, DC 20036
Phone: 202-293-8020
Fax: 202-293-9287
http://web.ansi.org

American Society for Quality

600 North Plankinton Ave, Milwaukee, WI 53203
Phone: 800-248-1946
http://www.asq.org

British American Chamber of Commerce

Orlando Fashion Square Mall, 3201 E. Colonial Drive, Suite A-20, Orlando, FL 32803
Phone: 407-266-7251
http://www.britishamericanchamberorlando.com

Compliance Engineering

11444 W. Olympic Blvd., Los Angeles, CA 90064
Phone: 310-445-4200
Fax: 310-445-4299
http://www.ce-mag.com

Delegation of the European Commission

2175 K Street, Washington DC 20037
Phone: 202-862-9500
Fax: 202-429-1766
http://www.euintheus.org

European Committee for Standardization (CEN)

Avenue Marnix 17, B-1000, Brussels
Phone: 32-2-550-08-11
Fax: 32-2-550-08-19
https://www.ce.eu

Additional information on EU safety standards *(continued)*

European Telecommunication Standards Institute (ETSI)
650 route de Lucioles, F-06291 Sophia-Antipolis Cedex, France
Phone: 33-92-94-42-00
Fax: 33-93-65-47-16
http://www.etsi.org

Global Engineering Documents
15 Inverness Way East, Englewood, Colorado 80112
Phone: 800-854-7179
Fax: 303-397-2740
http://global.ihs.com

Information Handling Services (IHS)
321 Iverness Way East, Englewood, CO 80150
http://www.ihs.com

International Electrotechnical Commission (IEC)
rue de Varembe 3, PO Box 131, CH-1211 Geneva 20, Switzerland
Phone: 41-22-919-0211
Fax: 41-22-919-0330
http://www.iec.ch

International Standards Organization (ISO)
ISO 1, ch. de la Voie-Creuse, Case postale 56, 1, CH-1211 Geneva 20, Switzerland
Phone: 41-22-749-0111
Fax: 41-22-733-3430
http://www.iso.ch

National Center for Standards and Certification Information
NCSCI
Global Standards and Information Group
National Institute of Standards and Technology
100 Bureau Drive, Stop 2100, Gaithersburg, MD 20899-2100
Phone: 301-975-4040
Fax: 301-926-1559
http://ts.nist.gov/standards/information/index.cfm

Underwriters Laboratories Inc.
333 Pfingsten Road, Northbrook IL 60062-2096
Phone: 847-272-8800
http://www.ul.com

Techstreet Inc.
Phone: 800-699-9277
http://www.techstreet.com

University of Wisconsin (Seminars on EU compliance)
University of Wisconsin, Engineering Professional Development
432 North Lake Street, Madison, WI 53706
Phone: 800-462-0876
http://epdwww.engr.wisc.edu

Additional information on EU safety standards *(continued)*

Internet sites:

CORDIS

Information on EU research and development programs
http://cordis.europa.eu/

EUROPA

The main server for all institutions
http://europa.eu.int

EUROPARL

Information on the European Parliament’s activities
http://www.europarl.europa.eu/

EUROPEAN ENVIRONMENT AGENCY

Information on the mission, products and services, and organization and staff of the EEA
http://www.eea.europa.eu


XCS
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Knightdale, NC 27545

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