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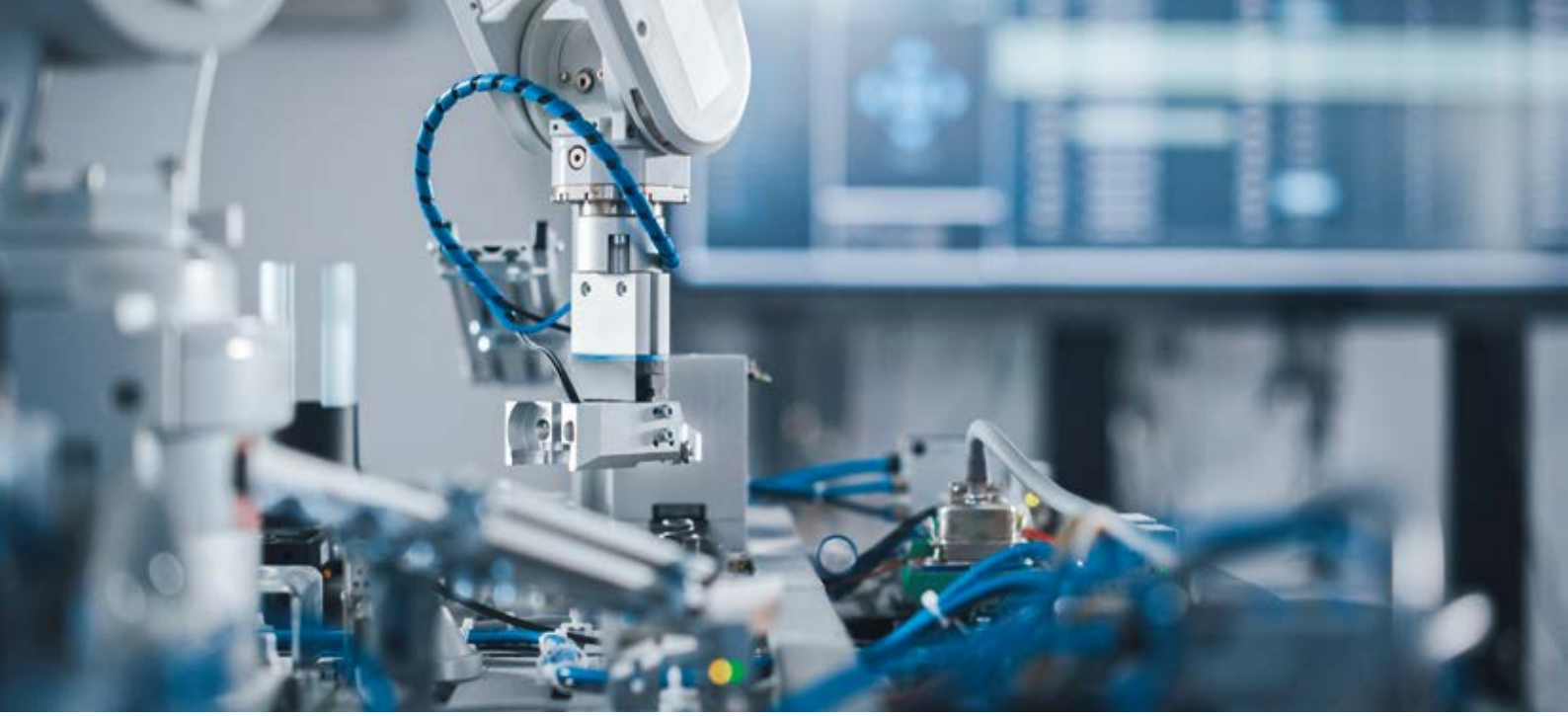


New developments – new rules – new products

Changes in society may require new laws – likewise, technical developments may entail the revision of technical rules, standards and regulations. New rules always require some accustoming, but they don't necessarily have to be bad. On the contrary: Often they create more clarity and better organization of conditions.

In any case, everyone should be well informed. And here's, where we would like to help you: In this issue of MRL News, we present a number of amended regulations. At the EU level, for example, the new Machinery Regulation is taking shape – we report on the state of things on page 3. The EU is responding to developments such as an ongoing digitalization and the increasing adoption of artificial intelligence. One positive consequence is the option of making operating instructions available to machine operators in digital form. Read more on page 4.

The EN ISO 13849-1 standard has equally been extensively revised, in particular the chapter containing the safety requirements for the software. An overview of the most important changes and additions can be found on page 12.

Besides that, the EN ISO 13849-1 standard is also interesting because it explicitly allows the exclusion of faults. However, this is subject to certain conditions which the designer must carefully consider. On page 14, we show an example of how this might work.

There are also new versions of the EN 1672-2 standard and the Regulation 10/2011/EU, which deal with the design of food processing machinery and the material selection for this area, respectively. And that is precisely why we have developed new products for the food industry – read more on page 8.

Not exactly new, but important to know: There are also safety-related rules and regulations for the maintenance of machines – and the most important rule is: "Expertise must be kept up to date." We will keep you up to date on the topic on page 6.

Occasionally, the designer not only has to observe new rules, but also consider how to comply with existing rules in the face of dramatic changes in the global economy. For example are the disrupted international supply chains leading to bottlenecks e.g. in electronic safety switchgear. On page 15, we show how machines and systems can be designed in a way that is safe and complies with standards, despite these circumstances.

Wishing you an informative read!

Yours sincerely

Editorial team

New Machinery Regulation published

42 months transition period after coming into force

The EU's new Machinery Regulation will replace the current Machinery Directive 2006/42/EC. Here's a summary of the most important changes.

On January 25, 2023, the preliminary final text of the EU Machinery Regulation (MR) passed the Committee of Permanent Representatives. Meanwhile, the text has been published. Thus, the legislative procedure is completed and the new Machinery Regulation will enter into force 20 days after publication in the Official Journal of the European Union. The release can probably be expected this May. The application of the MR will begin 42 months after the entry into force, which hence will be November or December 2026.

The following summary shows some of the major changes to the previous Machinery Directive:

Digital operating manual
Under the new MR, it is possible in the B2B sector to "supply" the operating instructions in digital form. For more information see the next page.

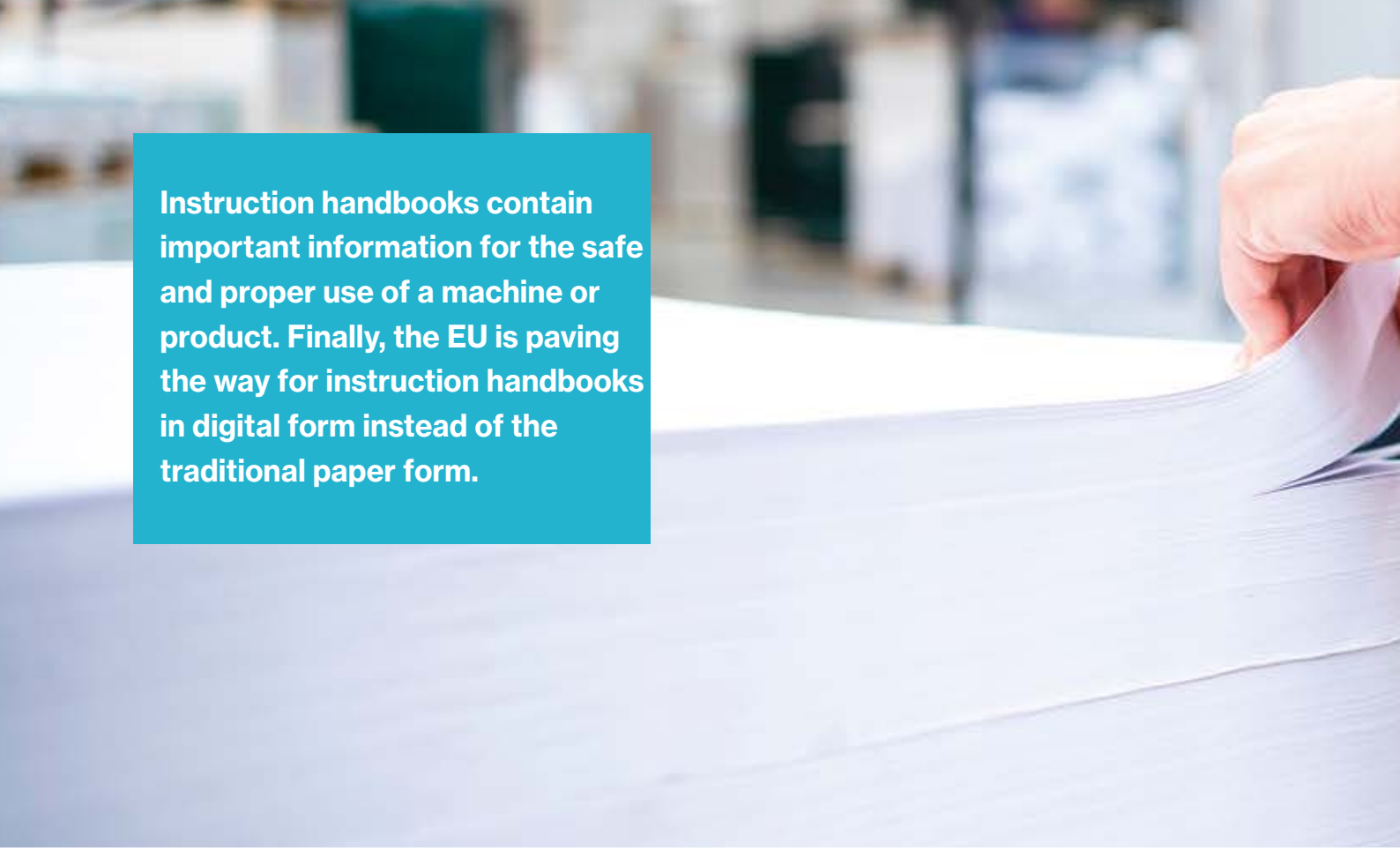
Third-party obligation – Annex IV becomes Annex I
The previous Annex IV of the Machinery Directive now becomes Annex I in the new Machinery Regulation. This is accompanied by a number of tighter rules, according to which six categories of machinery will be subject to mandatory third-party certification, without the application of a harmonized standard releasing the user from this testing obligation. Among other things, this owes to developments in artificial intelligence. After the separation of the AI Act from the Machinery Regulation, the term Artificial Intelligence no longer appears explicitly in the new Machinery Regulation. However, in the list of machinery categories subject to mandatory third-party certification the subject is not completely disregarded. Two of the mentioned categories are "Safety components with fully or partially self-evolving behavior using machine learning approaches ensuring safety functions" as well as "Machinery embedding systems with fully or partially self-evolving behavior using machine learning approaches ensuring safety functions that have not been placed independently on the market, in respect only to those systems."

In addition to the above mentioned, the six categories include "Removable mechanical transmission devices including their guards," "Guards for removable mechanical transmission devices," "Vehicle servicing lifts," and "Portable cartridge-operated fixing and other impact machinery." The machinery categories subject to mandatory third-party certification are found in "Part A" of Annex I. "Part B" of Annex I contains those machines which are only subject to third-party obligation if no harmonized standards are available or if these are not applied.

Substantial modification
The principle of "Substantial Modification" has now been adopted in the Machinery Regulation. In the past, the term only had been covered in the Blueguide for the Machinery Directive. Now it is made clear that a person who substantially modifies a machine must fulfill manufacturer obligations.

Sell-off deadline
Since there will be no transition period and the application of the Machinery Regulation will become mandatory by key date regulation, the question arises as to how this can be managed. The good news is that there is no sell-off date for products placed on the market under MD 2006/42/EC. However, it must be noted that it is not sufficient that the products are in your own warehouse by the deadline. While this does not fully answer the above question, it does give economic players some leeway. ■

Jörg Eisold
Head of Standards, Committees and Association Work



Instruction handbooks contain important information for the safe and proper use of a machine or product. Finally, the EU is paving the way for instruction handbooks in digital form instead of the traditional paper form.

New Machinery Regulation: an end to paper piles is at hand

Schmersal introduces digital operating instructions

The requirements for proper instruction handbooks are described in a special standard, EN ISO 20607 "Safety of machinery – Instruction handbook – General drafting principles." It states that the instruction handbook has to be provided in the official language or languages of the member state in which the machine is placed on the market and/or put into service.

The Machinery Directive itself does not specify the form of provision. Therefore, the guideline for the application of the Machinery Directive is often consulted, where under §255, it states: "...The general consensus is that all instructions relevant to health and safety must be provided in paper form, as it cannot be assumed that the user will have access to a reader for reading an instruction manual provided in electronic form or on a website..."

Hence, the production of multi-page operating manuals in various language versions has resulted in enormous paper piles, at considerable financial – and environmental – cost.

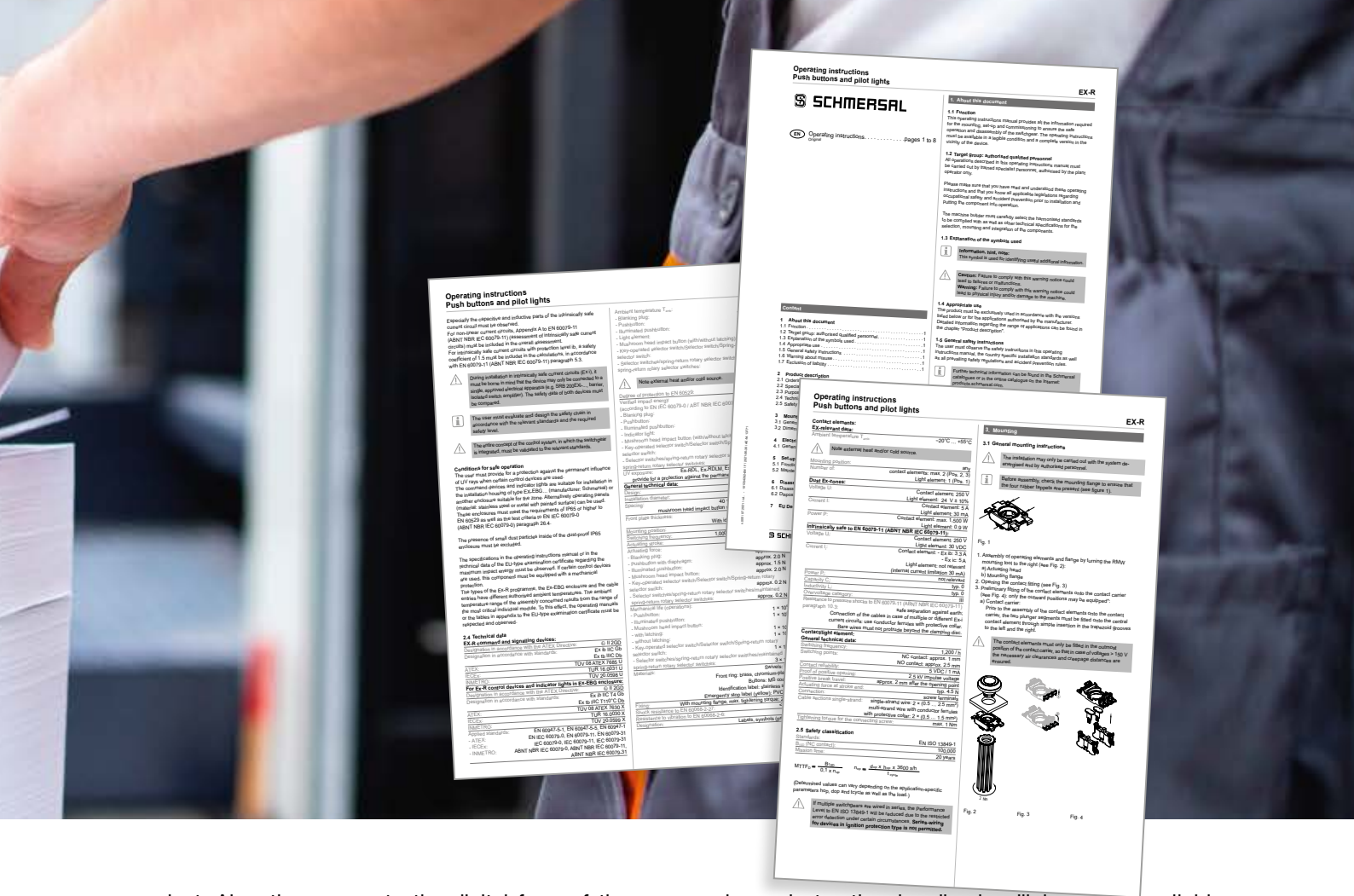
Savings of EUR 16.6 billion per year

Today, however, "readers for reading an instruction manual in electronic form" have long been part of everyday life and are in the pocket of almost every user. This has also been noticed by the EU Commission, who published the draft of a new Machinery Regulation (MR) in April 2021, in which – among many other points – the requirements for instruction handbooks have been reformulated.

The EU Commission has justified this decision with the "reduction of the administrative efforts and costs for the manufacturers: The regulations introduce administrative simplifications, such as allowing digital formats for instruction handbooks. This will help the industry to save up to EUR 16.6 billion per year."

Conditions for digital instruction handbooks according to MR

First of all, this is good news. But here too, there are some things to consider. For example, the instruction handbook must be provided to the customer upon request up to one month after the sale of the →



product. Also, the access to the digital form of the handbook must be made clear. For example, it would be possible to include an accompanying document with the product or to print a QR code on the product that will link to the corresponding digital documentation. As before, the instruction handbook still has to be provided in the respective official languages of the EU countries. In addition, it must be possible to provide the handbook versions being valid at the time of sale up to ten years after they have been placed on the market. Machines intended for consumers must be supplied with safety instructions in printed form.

Always up to date: Digital instruction handbooks in the Schmersal web shop

Apart from reduced costs, there is another significant advantage of the digital instruction handbook – and this refers primarily to the purchaser or user of the machines: After a change, the updated version of the instruction handbook is immediately available online. In addition, the digital version – unlike the paper version – cannot be lost or accidentally "misplaced."

Against this background, Schmersal has decided to set up a new digital system for providing instruction handbooks. The digital instruction handbooks for the safety switches and other components will be made available via the Schmersal web shop. In the newly created "Operation and assembly" tab, all the information contained in an instruction handbook will be available in various languages. It will be possible to print out this digital handbook or to generate and download it as a PDF document "on the fly" – just as required by the new Machinery Regulation.

The product will then only be accompanied by a printed info sheet with a QR code. Using this code, the users can navigate directly to the pertinent product series in the online catalog, where they will find all information – including the operating instructions – in their respective language.

First, the most important series will go online, such as the AZ16 safety switch and the AZM300 interlock. In the medium term, Schmersal will convert all instruction handbooks to "digital." ■

Uwe Franke
Head of Media and Databases,
Schmersal Group

The safety requirements for maintenance are high and defined in various rules and regulations. Expertise – and a qualification of specialists – are absolutely imperative.

Maintenance staff and their work require extremely high specialist knowledge. In this context, the specialist knowledge is described very precisely in the Ordinance on Industrial Safety and Health (German BetrSichV).

Safe maintenance on machines

“Expertise must be kept up to date”

Excerpt from §2 „Definitions“:

(5) An expert is a person who has the necessary expertise to perform a task specified in this Ordinance. The requirements for expertise depend on the respective type of task. Requirements include suitable professional training, work experience, or a recently carried-out relevant professional activity...

The authorities even go one step further and require: expertise shall be kept up to date by means of participation in training. Particularly in the area of machine and plant safety, requirements are set that are only partly represented in the course of a technical professional training.

According to §10 “Maintenance and modification of work equipment,” work equipment must comply with all applicable safety and health requirements and be maintained in a safe condition throughout its lifecycle. For this purpose, the employer must have maintenance work carried out safely on the basis of a risk assessment, which also requires expertise.

The new version of the Ordinance on Industrial Safety and Health from 2015 has reviewed the accident history since its first version from 2002 and describes especially the requirements for maintenance more clearly. As a supplement, there is a technical rule (TRBS) for operational safety. TRBS 1112 “Maintenance” describes the state of the art with regard to the requirements for maintenance and thus puts into concrete terms the requirements of the Ordinance on Industrial Safety and Health within its scope of application.

For example, the preparation of maintenance, the hazard assessment, the execution of maintenance work up to testing and the required inspection are described.

However, the requirements from the Ordinance on Industrial Safety and Health are primarily directed at the employer, who must ensure or create the conditions so that maintenance work is carried out safely and the work equipment can be permanently used safely.

These requirements increase year after year. For example, TRBS 1115 “Safety-related measuring and control equipment” was published in March 2021 and addresses for the first time the topic of functional safety of control systems. This shows quite clearly that the safety requirements for “legacy machines” are also increasing and that qualification of skilled personnel is absolutely necessary.

In the example of risk assessment according to §3 of the BetrSichV, the authorities are equally very clear: if the employer does not have the relevant knowledge himself, he must seek expert advice.

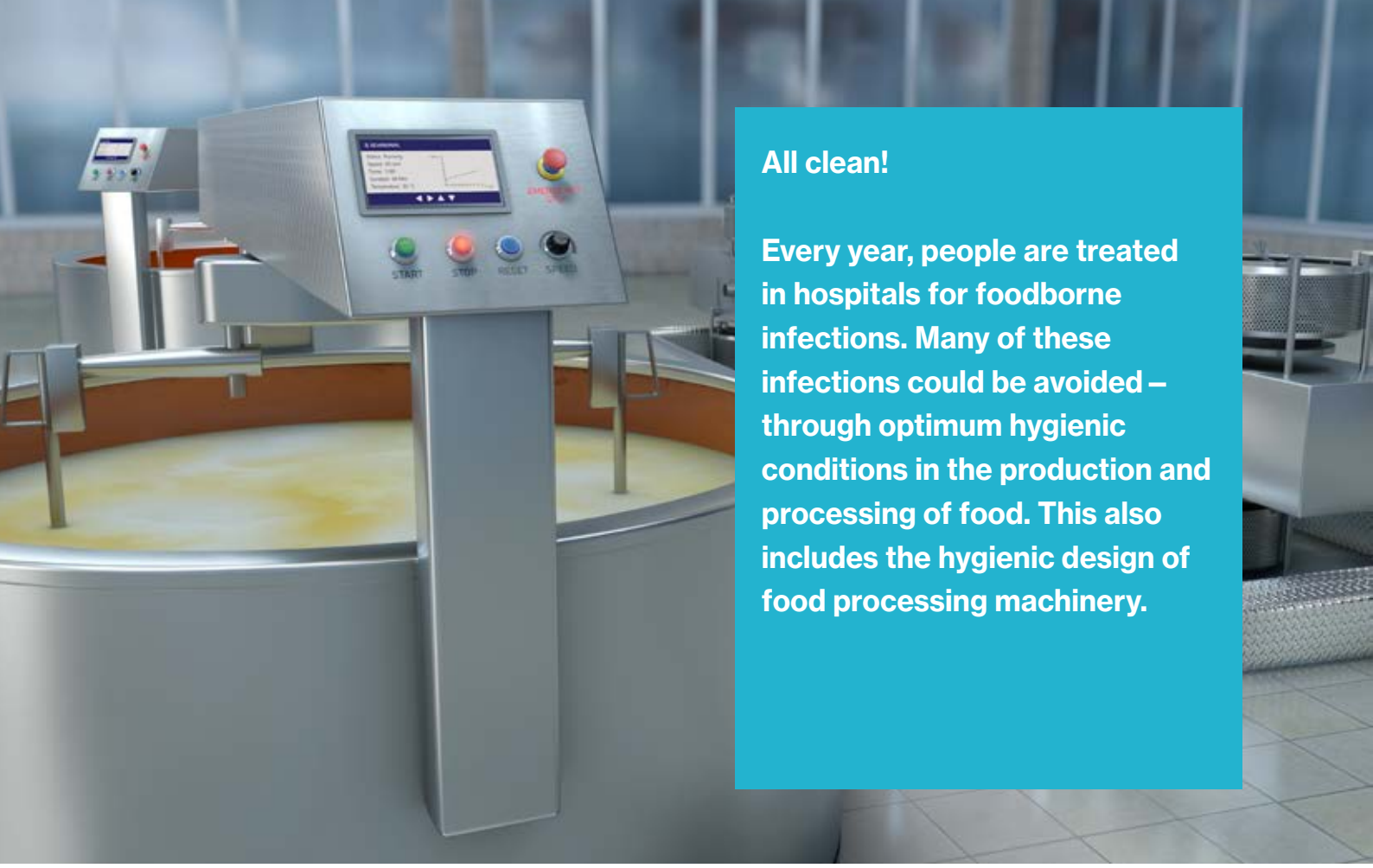
Expressions such as “may,” “possibly,” or “if applicable” cannot be found here. This shows that the accident history has led to clear requirements. And these requirements should be perceived as an opportunity so that machinery and equipment, and thus the provided work equipment, can always be operated safely and there are no risks of accidents.

In order to meet these comprehensive requirements, tec.nicum offers made-to-measure help for employers and maintenance staff. From training courses, the implementation of risk assessments, support in occupational health and safety, to the definition of safety functions and their calculation within the functional safety of control systems, tec.nicum offers a broad portfolio of services always tailored to the respective requirements.

And if desired, tec.nicum can also provide support for the retrofitting of machines and plants. With advice and active support! For example, turnkey projects with modifications are either accompanied or completely carried out as part of a general contractor contract. ■

Jürgen Heimann
Lecturer, omnicon engineering GmbH,
member of tec.nicum

Siegfried Wolf
Director tec.nicum



All clean!

Every year, people are treated in hospitals for foodborne infections. Many of these infections could be avoided – through optimum hygienic conditions in the production and processing of food. This also includes the hygienic design of food processing machinery.

Requirements and standards for hygienic food processing machinery

In the period from January to December 2020, 224 consumer warnings were published in Germany for the food and beverage category (source: www.produktwarnung.eu). Food infected with germs endangers the health of consumers, while recalls mean high financial damage and a considerable loss of reputation for manufacturers. Food safety is therefore a top concern, and the requirements and guidelines issued by the authorities for this area are correspondingly strict.

In order to avoid hygiene-related hazards, "hygienic design" is a key requirement in the design of machines for the production of food – and also of cosmetics and pharmaceutical products.

But what steps are required to ensure the hygienic design of food processing machinery? The answer can be found in a variety of different standards – here are some of the most important rules:

Basic Requirements: MRL 2006/42/EC, section 2.1

The basic set of regulations, also for food processing machinery, is the "Machinery Directive" 2006/42/EC (MD). In the MD, food processing machinery is considered a special case that, in addition to general safety requirements, must also meet requirements for cleanability, hygiene and disinfectability.

These requirements are described in section 2.1 of the MD 2006/42/EC **(extract):**

2.1. Foodstuffs machinery and machinery for cosmetics or pharmaceutical products

2.1.1. General

Machinery intended for use with foodstuffs or with cosmetics or pharmaceutical products must be designed and constructed in such a way as to avoid any risk of infection, sickness or contagion.

The following requirements must be observed:

a) (...)

b) All surfaces in contact with foodstuffs or cosmetics or pharmaceutical products, other than surfaces of disposable parts, must:

- be smooth and have neither ridges nor crevices which could harbor organic materials. The same applies to their joinings, →

- be designed and constructed in such a way as to reduce the projections, edges and recesses of assemblies to a minimum,
- be easily cleaned and disinfected, where necessary after removing easily dismantled parts; the inside surfaces must have curves with a radius sufficient to allow thorough cleaning;

Exact requirements: EN 1672-2

A more detailed specification of the requirements of the MD can be found in the standard DIN EN 1672-2 "Food processing machinery – Basic concepts – Part 2: hygiene and cleanability requirements."

DIN EN 1672-2 describes the requirements for hygiene and cleanability of food processing machinery. It is based on the globally consistent and well-known EHEDG Guidelines of the "European Hygienic Engineering and Design Group."

The standard goes into deep detail. Example: a defined minimum angle is specified for the front ring of an operator device, which forms the transition from the respective device to the front panel of the housing. This ensures that personnel can thoroughly clean the gaps on the front panel with a cloth and inspect the equipment from all sides for damage.

This standard is also helpful for the hygiene-related risk assessment of food processing machinery, the implementation and procedure of which are described in the standard.

Hygienic design of machines: DIN EN ISO 14159

Requirements for the hygienic design of machines are also laid down in EN ISO 14159 ("Safety of machinery – Hygiene requirements for the design of machinery"). For example, it must be ensured that there are no dead spots in which material residues can settle or biofilms can form. The surfaces and geometries of the machine must be designed to ensure that it can be cleaned easily. In addition, the standard describes strategies for the selection and verification of hygiene measures as well as test procedures. The examples of good and bad hygienic design features are also very informative. →

Various types of switchgear are available in the new H series.

Food grade materials: Regulation 10/2011/EU

If materials are in "food contact," they must comply with the relevant legislation and directives. One of the regulations to be taken into account is Regulation 10/2011/EU, which applies to all materials and items made of plastic or polymers. The regulation contains e.g. specifications for the execution of migration tests and information on Non-Intentionally Added Substances (NIAS).

Conclusion:

To meet food safety requirements, Hygienic Design and appropriate material selection for food processing machinery are an absolute necessity. This also applies to the safety components and controls installed on the machines. A large number of standards must be observed, but these also provide important assistance for hygienic design, as well as for the cleaning of food processing machinery.

→

The new H program has a modular design: The contact carriers are designed as individual contacts and can be combined.

The most important European regulations and standards at a glance

REGULATION (EC) NO 178/2002 OF THE EUROPEAN PARLIAMENT
defining the general principles and requirements of food legislation, establishing the European Food Safety Authority and laying down procedures for food safety

REGULATION (EC) NO. 1935/2004 OF THE EUROPEAN PARLIAMENT
on materials and articles intended to come into contact with foodstuffs and repealing Directives 80/590/EEC and 89/109/EEC

COMMISSION REGULATION (EC) NO 2023/2006
on good manufacturing practice for materials and items intended to come into contact with foodstuffs

EHEDG – EUROPEAN HYGIENIC ENGINEERING & DESIGN GROUP
Some sample excerpts of the content (in total, the EHEDG guidelines contain 38 documents):

- Criteria for the hygienic design of equipment
- Hygienic design of closed systems for the processing of liquid foodstuffs
- Hygienic packaging of food
- Hygienic design of equipment for open processing
- Construction materials for equipment in contact with foodstuffs
- Integration of hygienic and aseptic systems

The snap-on contact carrier enables uncomplicated disassembly with a screwdriver.

Standard-compliant: New series of operator devices for food processing machines

Schmersal has taken the new version of a food production standard as well as an EU regulation as an opportunity to also revise and reissue its proven N series of hygienic command and signaling devices.

The new edition of the standard DIN EN 1672-2 became necessary in order to adapt the harmonized European standard EN 1672-2:2009 to the updated Machinery Safety Directive 2006/42/EC.

The Regulation 10/2011/EU was also revised: Regulation (EU) 2020/1245 of 2 September 2020 published amendments and corrections to Regulation (EU) 10/2011 on plastic materials and items intended to come into contact with food in the Official Journal of the European Union.

Schmersal's new hygienic H Series now complies with this new edition of the standard or regulation. The requirements of DIN EN ISO 14159 ("Safety of machinery – Hygiene requirements for the design of machinery") were also taken into account.

The characteristic features of the H series command and signaling devices include gap-free transitions between sealing elements and surfaces and the absence of protruding parts. The command elements are easy to clean and so well sealed that they can withstand regular cleaning, e.g. with high-pressure cleaners and aggressive cleaning agents.

The new H series not only meets the requirements of the standards and the "Hygienic Design" principle, but it is also fully modular. Thanks to snap-on contact carriers and individual contacts which can be combined – also in a piggyback system –, this concept enables very easy and rapid installation as well as maximum flexibility and the ideal preconditions for pre-wiring.

A total of 147 different devices are available, including 26 mushroom pushbuttons, 24 selector switches with two or three positions and four potentiometer-rotary switches. Designers of a food-processing machine can freely decide which type of command device from the H series they wish to use for the design of the HMI. With its wide range of different hygienic switchgear devices, the H series is unique to the market. ■

Anton Ivanov
Industry Manager for Food, Beverage, Medical and Packaging,
Schmersal Group

Major changes in the new ISO 13849
A standard continues to evolve

Now valid for seven years, the revision of EN ISO 13849-1 is a significant evolution of this safety standard for machinery and plant engineering.

Several points in the new EN ISO 13849-1 standard now contain references to the IEC 61508 standards series on functional safety. In addition, there is a stronger focus on the topic of “subsystems” throughout the standard.

Structural changes of the standard

In some sections, the structure of EN ISO 13849-1 has been fundamentally revised and changed. A significant change is that the normative Chapter 4, “Validation”, from the former Part 2 of the standard has been incorporated as Chapter 10 in Part 1 of the new edition.

In addition, there will be no Part 2 in the standard. Rather, the remainder of the old Part 2, including the annexes on the various technologies, will be transferred to a “Technical Report” ISO TR 13849-2.

Furthermore, the chapters in Part 1 have been reorganized, expanded and revised. →

ISO/FDIS 13849-1:2022 (E)
1 Scope
2 Normative references
3 Terms, definitions and abbreviations
4 Overview
5 Specification of the safety functions
6 Design considerations
7 Software safety requirements
8 Verification (PL ≥ PL_r)
9 Ergonomic aspects of design
10 Validation
11 Maintainability of SRP/CS
12 Technical documentation
13 Information for use

EN ISO 13849-2:2012
1 Scope
2 Normative references
3 Terms, definitions and abbreviations
4 Validation of safety requirements
… Analysis … Testing … Specification
… Safety function …
… PL … Category …
… Validation technical documents
Annex A: mechanical systems
Annex B: pneumatic systems
Annex C: hydraulic systems
Annex D: electrical systems
Annex E: Example of validation

Integration of Part 2 of the old standard into the new EN ISO 13849-1

Contents: ISO/FDIS 13849-1:2022 (E)	
1 Scope	
2 Normative references	
3 Terms, definitions and abbreviations	
4 Overview	Edit
5 Specification of the safety functions	Edit
6 Design considerations	Edit
7 Software safety requirements	New
8 Verification (PL ≥ PL_r)	
9 Ergonomic aspects of design	
10 Validation	New
11 Maintainability of SRP/CS	
12 Technical documentation	
13 Information for use	

Annex A:	Graph for determining of PL_r	Edit
Annex B:	Block method	
Annex C:	Calculation or evaluating $MTTF_D$	
Annex D:	Simplified method for $MTTF_D$	
Annex E:	Estimates DC	Edit
Annex F:	Estimates CCF	Edit
Annex G:	Systematic failure	Edit
Annex H:	Combination of Subsystems	
Annex I:	Examples	
Annex J:	Example SRESW realisation	
Annex K:	Numerical representation of PFH_D	
Annex L:	EMC	New
Annex M:	Additional information for SRS	
Annex N:	Software requirements	New
Annex O:	VDMA 66413 Types of device	New

New: Added chapter / Edit: Revised chapter

The image shows the new structure of ISO/FDIS 13849-1:2022(E) with the changes.

Overview of the content changes

These are the major changes and additions to the content in the order of the table of contents:

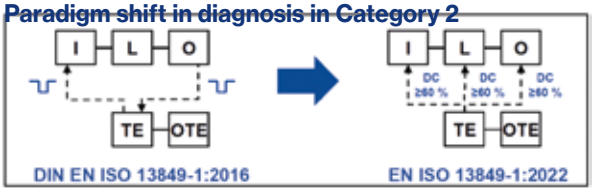
Chapter 4 “Overview” describes the risk assessment and mitigation process, the design process of an SRP/CS (safety-related part of a control system), and the implementation of safety functions using subsystems.

A revision of those parts specifying the safety requirements and determining the required performance level is contained in Chapter 5, “Specification of the Safety Function.” Particular mention should be made here of the new chapter 5.5, which describes in detail the breakdown of safety functions into sub-functions. In addition, the requirements for specific safety functions, such as “manual reset function” in the subsections of Chapter 5.2.2, have been adapted and revised in line with practical requirements.

Regarding the design aspects in Chapter 6, the requirements for “proven components” for Category 1 systems are now described in detail in the separate Section 6.1.11.

In Category 2, there is a paradigm shift regarding the test functions for 1-channel safety functions. Testing of the safety function at appropriate intervals is replaced by testing of all parts of the function channel, i.e. testing of input, logic and output by a test facility with sufficient diagnostic coverage (DC).

Paradigm shift in diagnosis in Category 2



The chapter on Category 2 also details the test rate and test channel requirements.

In the description of Category 4, the new remark 1 indicates that based on an analysis, e.g. FMEA, undetected faults with very low probability need not be considered in the fault accumulation if this is sufficiently documented and verified.

The old Chapter 4.6 containing the safety requirements for the software has been extensively revised and can now be found as Chapter 7 “Software Requirements.” In particular, the simplified V model for the SW lifecycle has been revised. Also, new sections on the requirements of safety-related application software and embedded software have been added.

In Annex A for the determination of the required Performance Level (PLr), a determination guide for the P parameter, which describes the possibility of avoiding the hazard or limiting the damage, has been added. Annex E contains changes to the DC tables for estimating the diagnostic coverage. Further, common cause failure (CCF) measures are described in more detail in Annex F, and examples are given in Annexx I. A new section in Annex G “Systematic Failure” covers the functional safety management.

Special mention should also be made of the new Annex L, which deals with EMC requirements for machinery and equipment. This informative annex is intended as a guideline for machinery and plant engineering and is to support an EMC-compliant design.

Also newly included: Annex N on the avoidance of systematic failure by software design, with an example of software validation, and Annex O with the definition of the safety-related values of parts or components, in analogy to the device types from the VDMA 66413 database.

What’s next?

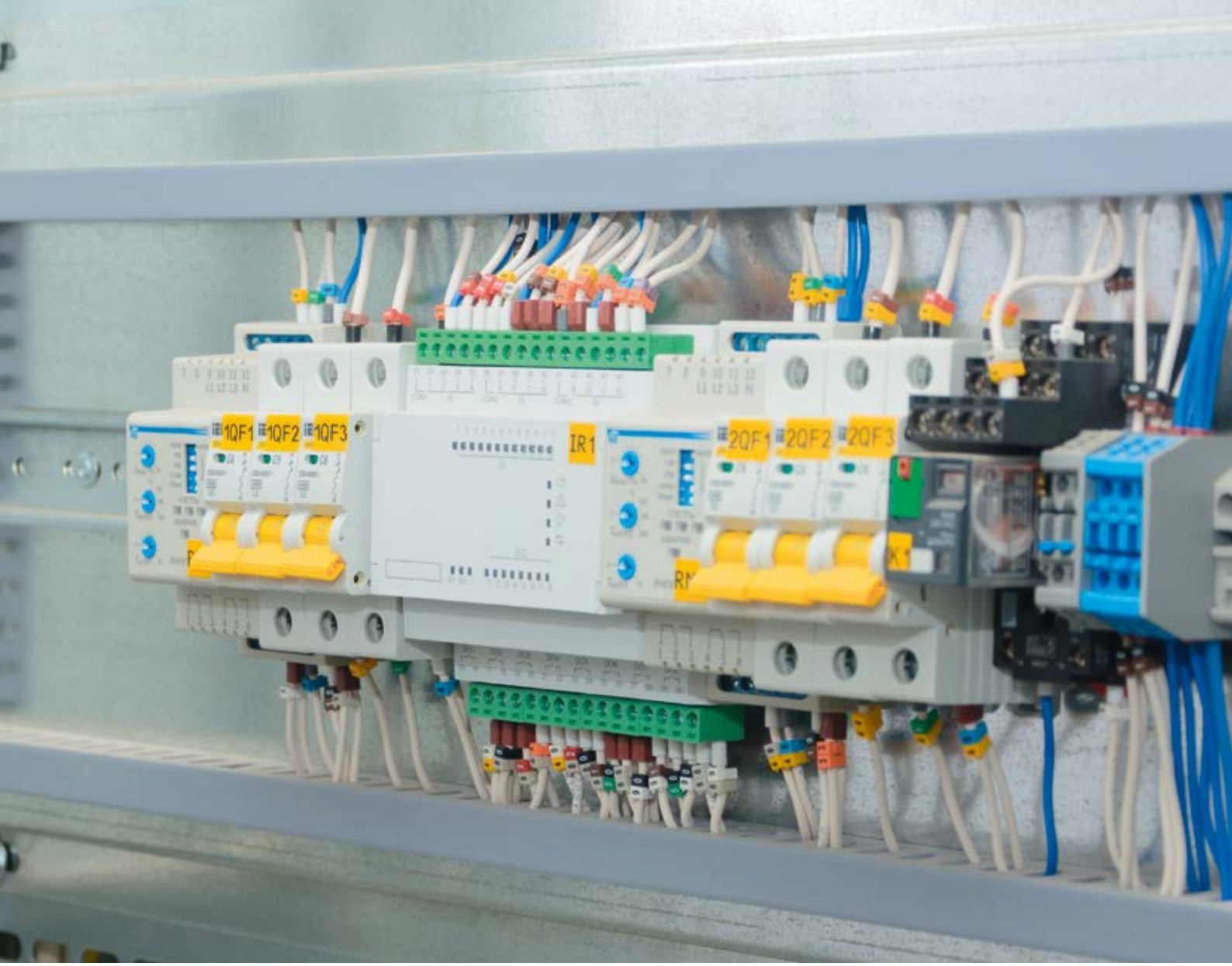
The explanations show that there are extensive changes in the standard work for the safety of machinery and equipment. A draft of the new standard is already available in German and English as prEN ISO 13849-1:2021(E) from DIN Beuth Verlag.

The draft standard for Part 1 is currently undergoing final international coordination.

Publication of the new EN ISO 13849-1 is planned for mid-2023 at the latest.

The “Technical Report” ISO TR 13849-2, with the informative annexes on the various technologies from the old Part 2 of the standard is still in the early stages of content coordination and will probably be completed by the end of 2024. ■

Udo Weber
Product Manager,
Schmersal Group

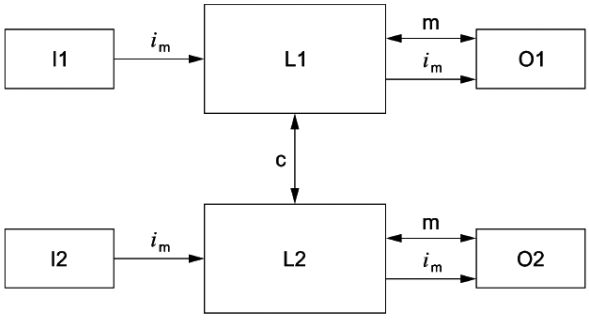


Fault exclusions in the control cabinet

In which cases may safety outputs claim category 4 / PLe in single-channel use?

In addition to functionality and safety, the designer must also pay attention to cost when developing a machine so it becomes competitive. Against this background, it is of interest that the EN ISO 13849-1 standard explicitly allows the exclusion of faults, which then need not be considered further. However, fault exclusion is subject to very specific conditions which the designer must carefully consider. Here is an example of how it might work...

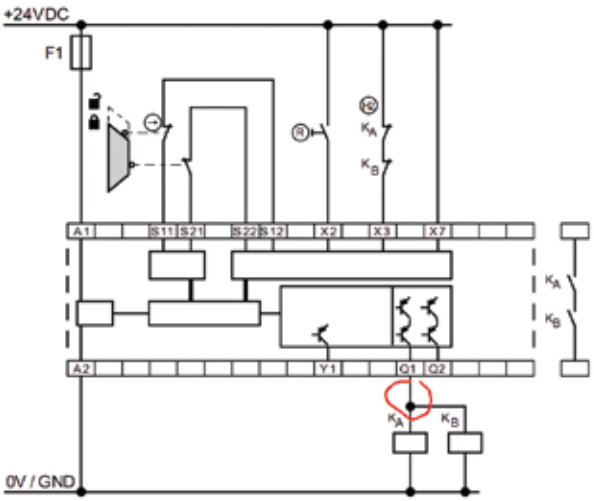
Modern safety logics usually provide a variety of safety outputs. Generally, they are intended for safety functions up to category 4 / PLe in accordance with EN ISO 13849-1(*1). Here we find traditional relay contacts as well as semiconductor outputs to be used in pairs, either both positive switching or both positive-negative switching, which implement the two-channel architecture the standard requires for Category 4. →



Required architecture of Category 4 according to EN ISO 13849-1

For some outputs, however, category 4 / PLe can often also be claimed even for single-channel use.

The following figure shows an example of such a wiring:



Adapted wiring example SRB-E-201ST

Quite obviously, such a structure is not consistently two-channel. How can a solution like this still meet category 4? The following consideration is limited to the logic and actuation technology of the safety function. Of course, a complete evaluation of the achievable performance level and applicable category always requires the inclusion of the associated input circuitry.

If you look at the circuit above, you can see that both the internal output circuit of the safety logic and the actuator circuitry – in this case two power contactors – have two channels, i.e. are redundant. It is only the wiring that is designed as single-channel. In the safety logic, faults in the two semiconductor outputs are detected via test pulses, i.e. the interrupting capacity is tested cyclically at short time intervals. Faults of the contactors, welded contacts being primarily regarded as dangerous, are detected via the feedback circuit using force-guided relays.

If all faults of the single-channel line are excluded (e.g. short circuit to 24V), you hence get a system which fulfills the requirements of Category 4. A fault is detected immediately and does cause a failure of the safety function, since a second interrupting element is always present.

Is fault exclusion permissible?

According to the EN ISO 13849 series of standards, which is authoritative for the user, a fault is the inability to perform the required (safety) function. Ultimately it is the fault resistance, which is assessed and quantified by the pfhD value. At the same time, however, the standard explicitly permits the exclusion of errors (EN ISO 13849-1, section 7.3). It thus no longer contributes to the calculation and need not be considered further. But if a fault is excluded, the standard usually requires a precise justification based on the improbability of its occurrence or on general technical experience.

"Allowed" fault exclusions

In the second part of the EN ISO 13849(*2) series of standards, Annexes A-D list a large number of possible faults for various technologies. Guidance is also provided here as to the circumstances under which fault exclusion may be justified. For the case discussed here, Table D.4 in Annex D.2 is particularly relevant. It states that a short circuit between any two conductors within a shared installation area can be excluded. However, this assumes that the installation area is designed professionally, i.e. in compliance with the relevant standards and regulations, and that all nominal values are observed. Hence a requirement that is generally easy to comply with. ■

Conclusion

Even with single-channel wiring, Category 4 with Performance Level PLe is basically possible, provided that some constraints are observed. Primarily, this refers to the wiring within a closed installation area such as a control cabinet. Fault exclusions are also possible in general. Here, however, it is the sole responsibility of the designer to evaluate whether the potential savings justify the increased risk, especially with regard to liability and associated recourse claims.

(*1) DIN EN ISO 13849-1: Safety of machinery – Safety-related parts of control systems – **Part 1: General principles for design**

(*2) DIN EN ISO 13849-2: Safety of machinery – safety-related parts of control systems – **Part 2: Validation**

Christian Lumpe
Product Manager Controls, Schmersal Group

There are various reasons for a longer-term shortage of microchips: disrupted supply chains for electronic components, increased demand for consumer electronics, lost production capacity.

This also has an impact on machine safety: Especially in electronic safety switchgear we observe bottlenecks. The designer has to do some rethinking – but there are viable alternative solutions.

Semiconductor shortage and the selection of safety switchgear

Supply bottlenecks call for alternatives

There are some good reasons for the ongoing trend towards electronic safety switchgear: They enable higher tamper protection, greater flexibility, better adaptation to individual requirements, as well as improved connectivity and greater transparency, e.g. in the detection and diagnosis of faults.

Many machine builders therefore prefer RFID-based safety sensors when it comes to position monitoring of safety gates, for example the RFID sensors of the Schmersal RSS series.

With this safety sensor design, a (safe) RFID sensor communicates with an associated target. This occurs without wear and allows a high safety rating (PLe according to EN 13849). Thus, a high coding can be reached while the sensors offer some important additional functions. For example, they can detect any safety gate misalignment and immediately issue a corresponding alarm. Another advantage is self-monitoring, e.g. for cross-fault.

High coding can be implemented with the RSS260 electronic safety sensor.

These advantages are due to the fact that the RSS series safety sensors are equipped with their own microcontroller for safety evaluation. However, exactly these microcontrollers are only available in limited quantities. Switchgear manufacturers are therefore unable to produce the quantities requested by customers, and certain product groups may no longer be available at all.

Magnetic safety sensors such as the BNS40 do not operate without wear.

Mechanical engineers and designers therefore have to rethink their strategy. Luckily, alternatives are available such as the proven electromechanical switchgear and magnetic switches. Like RFID sensors, the latter operate contactless. Unlike electronic safety switchgear, where the safety characteristics are specified by the manufacturer, these alternative solutions require the calculation of the safety characteristics for each application. Since both electromechanical switchgear and magnetic switches – unlike RFID sensors – do not operate without wear, the safety characteristics for these switches depend on the number of actuations. Also, it must be considered that in series connection a fault masking can occur. Another disadvantage of magnetic switches compared to RFID sensors: they do not allow individual coding. →

When selecting alternatives to an RFID sensor, the designer should first ask himself the following questions:

- What coding is necessary? How high is the tampering risk in this application?
- Should the switch act contactless? For example, is it a dust-contaminated environment?
- How many switching cycles? For example, is the safety gate or flap opened every five minutes or only every five hours?
- Which structural design is required? Can an RFID sensor simply be replaced with another switch type of the same structural design? (For example: the RSS16 has exactly the same dimensions as the electromechanical AZ16 – as does the BNS16 safety magnetic sensor. Here, the designation "16" refers to the same structural design.)

After these preliminary considerations, the designer must calculate the safety characteristics of the electromechanical or magnetic alternative solutions. A calculation that is not required for RFID sensors because they operate wear-free.

This calculation takes into account various parameters such as wear and probability of failure.

Another important factor to consider is the number of actuations. According to the Technical Report ISO/TR 24119, "frequent actuation" is when a protective device or switchgear is actuated more than once per hour. The diagnostic coverage would thus amount to zero. However, the number of protective devices that may be opened or closed with different frequencies must also be taken into account here.

A sample calculation of the safety characteristics makes it clear how differently the mentioned influencing factors affect the switch types. It was assumed that three switchgears are connected in series and the number of operations per year is 12,672. In addition, it is assumed that only one of the devices is actuated once every 1000 sec, whereas the other two devices are actuated only seldom (e.g., because only one flap is used for insertion and removal and the others are used only occasionally for maintenance work).

In this example, it can be seen that the electromechanical switch achieves an acceptable PLd with a low diagnostic coverage (DC) and a high MTTFD, while the magnetic switch achieves no DC and the PLc is not satisfactory for a safety application.

The comparison once again illustrates the advantages of RFID sensors: They can be easily connected in series, so the wiring effort is low, no fault masking occurs, and the safety outputs of each sensor monitor themselves.

There are significant limitations in the alternative solutions, particularly in the case of series connection: With magnetic switches, there is no positive opening, fault masking tends to be expected, and no or only a low diagnostic coverage (DC) is achieved. These restrictions can be compensated to a limited extent (e.g. by additional evaluation logics).

Calculations of safety parameters

Electro-mechanical & magnetic

- $B10_D$ specified by manfucturer
- $MTTF_D = B10_D / (0{,}1 * n_{op})$
  mit $n_{op} = d_{op} * h_{op} * 3600\ s/h / t_{cycle}$
  n_{op}: No. of operations $[\frac{1}{a}]$
  d_{op}: No. of operating days per year $[\frac{d}{a}]$
  h_{op}: No. of operating hours per day $[\frac{h}{d}]$
  t_{cycle}: Cycle time [s]
- $PFH_d = \frac{1}{MTTF_D}\ [\frac{1}{h}]$
- PL calculates from PFH_D Value and Safety Category
  see EN ISO 13849-1: 2015, Table 7

Electronic

- PFH_d specified by manufacturer
- $B10_D$ doesn't apply
- $MTTF_D = 1 / PFH\ [a]$
- PL directly specified by manufacturer

Fig. 1: While the Performance Level for the RFID sensor is specified directly by the manufacturer, the PL for the alternative solution must be calculated using the PFH value (Probability of Failure per Hour) and the safety category (according to EN ISO 13849-1:2015, Table 7)

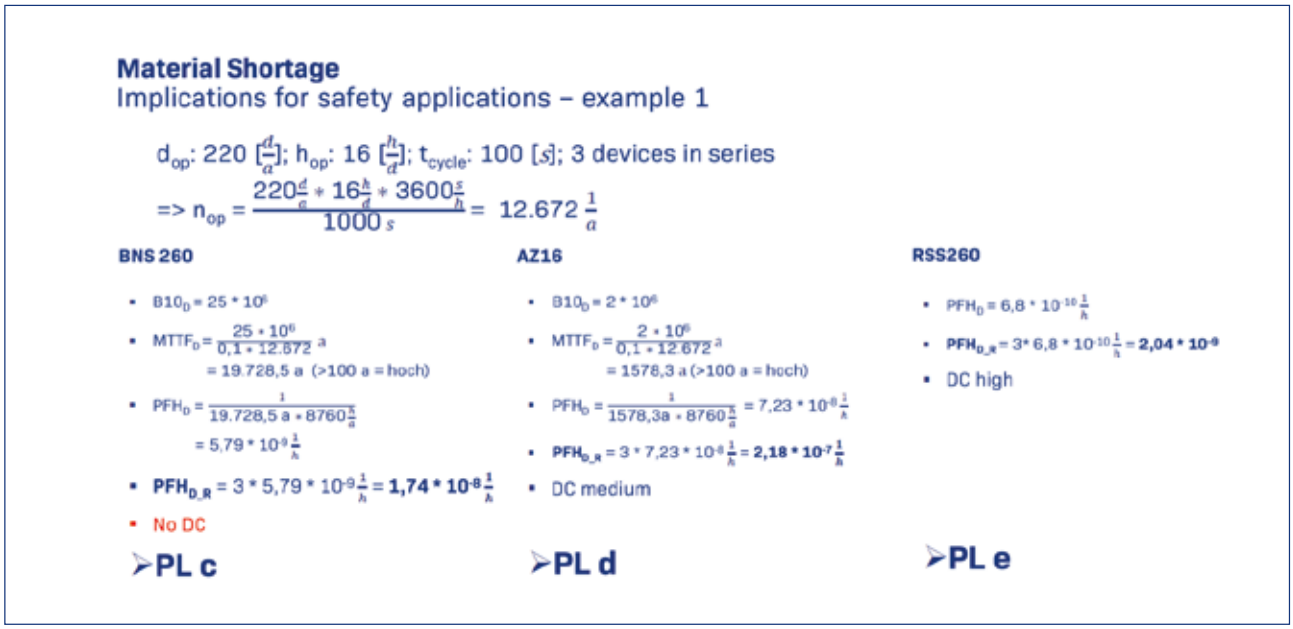


Fig. 2: The example calculation shows that magnetic switches are less suitable as an alternative solution for a series connection, at least adjustments would have to be made here in the evaluation (e.g. cross-fault monitoring).

In principle, this also applies to the electromechanical switchgear in a series connection. However, positive opening of the contacts is the rule here, i.e. the probability of fault masking is lower, a medium diagnostic coverage level is achieved and the series connection does not limit the performance level, so PLd is possible.

The second example for calculating the safety characteristics is based on an application in which eight RFID sensors of the RSS260 series are installed. Coding is not required for this application, evaluation is performed via the SRB-E-204ST safety relay module.

The BNS16 magnetic safety sensor has exactly the same dimensions as the AZ16 electromechanical and the RSS16 RFID safety sensor.

To be able to achieve Performance Level PLd in this application with the BNS260 magnetic switch – as a replacement for the RSS260 RFID safety sensor, – parallel wiring is required instead of a series connection. Furthermore, a cross-fault monitoring and a monitoring of the synchronism is required, which can be realized via the input expansion SRB-E-204PE, used in addition to the SRB-E-204ST.

PL_r d possible, PL_{max}-Parallel = PL d*

* with PFH_D $5,79 * 10^{-8}\,\frac{1}{h}$

In a nutshell: using parallel wiring and just one additional module, in this example PLd can also be achieved with a magnetic switch. ■

Conclusion:

There are viable alternatives

In general, as the comparison of the switches' structural designs shows, a changeover is possible. There may be some limitations, which however can be compensated. So neither the mechanical engineer nor the purchaser have to panic. Alternatives to electronic safety switches with microcontrollers – often even in the same structural design – are available. Thus, it is possible to react flexibly to limited component availability by using different approaches.

Webinar on material shortage

You can access a detailed webinar on this topic at any time in our webinar archive:
https://www.gotostage.com/channel/9c310ffcddef-4b15ba85943d0fe8e1c1

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Seminar topics	Wuppertal	Ulm	Wettenberg	Bremen	Online	Inhouse
Law						
Machinery Directive 2006/42/EC – CE conformity evaluation procedure	17.11.2023	on request		10.10.2023	17.03.2023	on request
Legal aspects of machine safety for purchasers, designers, project coordinators **(half-day seminar)**	27.10.2023	on request	on request	11.10.2023	23.06.2023	on request
Basics of occupational health and safety for managers	14.11.2023	07.07.2023	on request	on request	29.09.2023	on request

Seminar topics	Wuppertal	Ulm	Wettenberg	Lübeck	Online	Inhouse
Legal aspects of machine safety for managers **(half-day seminar)**	26.10.2023	on request	on request	12.10.2023	22.06.2023	on request

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Seminar program 2023 (continuation from page 21)

Seminar topics	Wuppertal	Ulm	Wettenberg	Lübeck	Online	Inhouse
Standards – Regulations						
Risk assessment for infection prevention	Dates on request: **mdahm@tecnicum.com** or **jruda@tecnicum.com**					
Risk assessment and operating instructions	15.11.2023	03.07.2023	13.11.2023	20.06.2023	17.02.2023	on request
Validation according to EN ISO 13849-2 **(half-day seminar)**	16.06.2023	24.11.2023	on request	21.06.2023	24.02.2023	on request
Basics of the Ordinance on Industrial Safety and Health (German BetrSichV)	16.11.2023	04.07.2023	25.01.2023	on request	15.05.2023	on request
Risk assessment for machinery and equipment	26.01.2023	05.07.2023	on request	on request	30.01.2023	on request
Technical documentation of machines and equipment	on request	06.07.2023	23.01.2023	on request	15.09.2023	on request
New construction, conversion, retrofitting – from manufacturer to owner/operator? **(half-day seminar)**	25.09.2023	on request	on request	22.06.2023	on request	on request

Seminar topics	Wuppertal	Ulm	Hamburg	Lübeck	Online	Inhouse
Application of EN ISO 13849-1; getting started with SISTEMA	14.06.2023	22.11.2023	07.11.2023	14.03.2023	10.02.2023	on request
Practical workshop working with SISTEMA	14.06.2023	23.11.2023	08.11.2023	15.03.2023		on request

Seminar topics	Wuppertal	Kirkel	Wettenberg	Lübeck	Inhouse
Qualification as TÜV certified “Machinery CE Certified Expert® – MCEExpert”		04.12.2023 – 08.12.2023	08.05.2023 – 12.05.2023	09.10.2023 – 13.10.2023	on request

Seminar program 2023 (continuation from page 22)

Seminar topics	Wuppertal	Ulm	Wettenberg	Lübeck	Online	Inhouse
Application						
Basics of safety engineering – separating and non-separating protective devices	07.09.2023	on request	25.05.2023	13.10.2023	on request	on request
Electromagnetic compatibility EMC / EMEC in practice	Dates on request: **mdahm@tecnicum.com** or **jruda@tecnicum.com**					
Safe fluid power – safe implementation of EN ISO 13849-1	Dates on request: **mdahm@tecnicum.com** or **jruda@tecnicum.com**					
Fire protection in mechanical engineering	13.06.2023	21.11.2023	on request	on request	08.09.2023	on request
Automated guided vehicles and their integration into the production environment	23.05.2023	on request	12.09.2023	on request	07.03.2023	on request
Safety in integrated robotic manufacturing plants	25.05.2023	on request	13.09.2023	on request	08.03.2023	on request
Human-robot collaboration	26.05.2023	on request	14.09.2023	on request	09.03.2023	on request

Seminar topics	Wuppertal	Ulm	Wettenberg	Bremen	Online	Inhouse
Explosion protection (compact seminar)	09.11.2023	on request	23.05.2023	05.10.2023	01.02.2023	on request

Seminar topics	Wuppertal	Kirkel	Wettenberg	Lübeck	Online	Inhouse
Safety-oriented design of battery production plants	24.05.2023	11.09.2023	on request	on request	10.03.2023	on request

Products	Wuppertal	Ulm	Wettenberg	Bremen	Online	Inhouse
Basic workshop Safety control PSC1	on request	on request	26.09.2023	on request		on request
Expert workshop Safety Control PSC1	on request	on request	27.09.2023	on request		on request
Basics and inspection of opto-electronic protective devices according to BetrSichV **(seminar objective: Competent Person)**			**Mühldorf** 26.10.2023			

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