

Logic units to ensure safety functions

On 29 December 2009, application of the new Machinery Directive, 2006/42/EC [1], becomes mandatory. The differences between the former and the new Machinery Directives are described in a number of publications, for example [2]. The present article deals solely with one amendment, which concerns "logic units to ensure safety functions". These products are now stated in Annex IV of the new Machinery Directive. This lists products which owing to their function are a source of particularly high hazards in the event of a fault. Accordingly, stricter requirements apply to the conformity assessment method. The affected components and the possible assessment methods are stated below.

1 What products are described as "logic units to ensure safety functions"?

Products are affected by this new provision when:

- a) they are safety components (see below) and are therefore governed by the Machinery Directive;

and

- b) they are "logic units to ensure safety functions" in accordance with Annex IV, No. 21 (see below).

Concerning a): safety component in accordance with the Machinery Directive

Article 1 of the Machinery Directive states its scope. The products considered here fall under c) safety components. In Sub-point c), Article 2 contains the definition of a safety component:

- c) "Safety component" means a component
 - which serves to fulfil a safety function
 - which is independently placed on the market
 - the failure and/or malfunction of which endangers the safety of persons, and
 - which is not necessary in order for the machinery to function, or for which normal components may be substituted in order for the machinery to function.

If the above definition is applied for example to a safety PLC¹, the following conclusion is reached: a safety PLC

- serves to fulfil a safety function
- is placed independently on the market, i.e. it is not supplied solely fitted to a machine
- endangers the safety of persons in the event of its failure and/or malfunction
- is not necessary for the machinery to function when used solely for the implementation of safety functions, or can be substituted by a conventional PLC for the purpose of the functioning of the machine, if non safety related functions are also performed.

Under the provisions of the Machinery Directive, a safety PLC is therefore classified as a safety component. As this example shows, the definition applies both to products which are employed solely for safety functions and to products which at the same time fulfil both safety functions and machine functions.

An additional aid for determining whether a component is a safety component can be found in Annex V of the Machinery Directive. This contains a non-exhaustive list of safety components. Point 4 states the logic units to ensure safety functions.

Concerning b): logic units to ensure safety functions

The background to the inclusion of these components in Annex IV is the growing use of functional safety products in machine controls. The Machinery Directive does not define "logic units to ensure safety functions". The guide to the Machinery Directive currently being drawn up by the European Commission will certainly be of assistance here. Unfortunately, at the present time (September 2009), Annex IV remains unedited; no draft paper is therefore available. The BGIA has however proposed the following text:

"Logic units to ensure safety functions" are devices, assemblies or components intended to be applied in safety-related parts of control systems to realise – solely or amongst others – safety functions and which generate the output signal(s) based on an internal logic operation with the input signal(s).

(German: "Logikeinheiten für Sicherheitsfunktionen" sind Geräte, Baugruppen oder Bauteile, die für die Verwendung in sicherheitsbezogenen Teilen von Steuerungen bestimmt sind, die - ausschließlich oder unter anderem - zur Realisierung von Sicherheitsfunktionen eingesetzt werden und die das Ausgangssignal auf Basis einer internen logischen Verknüpfung mit dem Eingangssignal/den Eingangssignalen erzeugen.)

¹ PLC = programmable logic controller

[Enclosure 2](#) gives an incomplete table of products which are typically employed for the implementation of safety functions. In addition, the table contains reasoned evaluations for each product of whether the conditions a) safety component and b) logic units are met.

2 What conformity assessment procedures are relevant?

Article 12 of the Machinery Directive, "Procedures for assessing the conformity of machinery", lists the various ways by which a product's conformity with the provisions of the directive can be demonstrated. For the "logic units to ensure safety functions" listed in Annex IV, Paragraph 3 and Paragraph 4 are relevant². The following conformity assessment procedures are possible:

- a) Conformity assessment by the manufacturer in accordance with Annex VIII (only where manufacture is fully in compliance with the listed standards³)
- b) EC type examination in accordance with Annex IX by a notified body and internal checks on the manufacture in accordance with Annex VIII, No. 3
- c) Full quality assurance in accordance with Annex X

Conformity assessment by the manufacturer under his own responsibility in accordance with (a) is possible only when manufacturing fully complies with the listed standards, i.e.:

- The product is manufactured in accordance with standards giving rise to a presumption of conformity
- **All** health and safety requirements relevant to the product set out in the above standards are observed

Annex I of the Machinery Directive describes the essential health and safety requirements. Almost all listed standards state, in their Annex ZB, the requirements of Annex I of the Machinery Directive which are covered by the standard concerned. Therefore, in order to determine whether the standards being applied cover all requirements, follow the following procedure:

² The Machinery Directive employs the term "machinery" as a generic term for a range of products (see Article 2). These also include the safety components.

³ When a standard is harmonized (Article 21) and has been published in the Official Journal of the EU (<http://ec.europa.eu/enterprise/newapproach/standardization/harmstds/reflist/machines.html>), it is described as a listed standard. Where the standard concerned is applied in full, a product is presumed to comply with the relevant "essential health and safety requirements relating to the design and construction of machinery".

- 1) Identify the requirements of Annex I relevant to your product.
- 2) Indicate which harmonized and listed type C standards⁴ cover these relevant requirements, i.e. give rise to a presumption of conformity for your product.⁵
- 3) If all relevant requirements are covered by listed standards and these standards are applied in full, the conformity assessment procedure stated under a) applies.
- 4) If not all relevant requirements are covered by listed standards or these standards are not applied in full, only the procedures stated in b) and c) are possible.

Full quality assurance

The conformity assessment procedure of full quality assurance is a new addition to the Machinery Directive. In contrast to a type examination, the objective is not that of evaluating individual products, but of demonstrating the competence of a manufacturer to develop and manufacture products stated in Annex IV. The demands placed upon the manufacturer are not inconsiderable, since the directive equates the result with an EC type examination by an independent, notified test body. As a notified test body, the BGIA has long offered product tests, and now also offers audits of the "full quality assurance" QA system.

3 Safety technology components

The table in [Enclosure 2](#) contains a list of products typically employed in safety functions of machine controls. The table describes whether a product is considered to be a safety component in accordance with the Machinery Directive and on what basis, and whether it must be regarded as being a "logic unit to ensure safety functions". Performance of one of the stated conformity assessment procedures may be necessary.

Several component descriptions in the table include the extension "for safety functions". In these cases it is necessary to distinguish them from product versions intended to be applied in conventional machine controls. Components are strictly intended to be applied in safety functions, if the manufacturer describes this application in the documentation and/or confirms at least one of the following product characteristics:

⁴ The current draft of the guide states more precisely the machinery directive and requires the application of type C standards (example: EN 61800-5-2, Adjustable speed electrical power drive systems – Part 5-2: Safety Requirements – Functional). Type A and type B standards, e. g. EN 60204 (Electrical equipment of machines) and EN 13849 (Functional safety) are not sufficient, although harmonized and listed.

⁵ Assistance in this task is available from the BGIA in the form of the table: "Machinery Directive 2006/42/EC – Annex I" in [Enclosure 1](#).

- The Category to EN 954-1/DIN EN ISO 13849-1
- The Performance Level (PL) to EN ISO 13849-1
- The Safety Integrity Level (SIL)
- PFH (probability of failure per hour)⁶.

These parameters are required only when the component is used for the implementation of safety functions.

The product documentation sometimes includes phrases like “applicable up to category .../PL ...”. This does neither confirm a product to fulfil a category or a PL nor to be a safety component according to the machinery directive. Nevertheless, it can be applied in safety functions; in this case it depends on the individual application, which safety relevant requirements are actually met (in combination with other components).

4 Literature

- [1] Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery and amending Directive 95/16/EC (recast) with Corrigendum to Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery and amending Directive 95/16/EC of 9 June 2006. OJ EU L 157
http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_157/l_15720060609en00240086.pdf
http://eur-lex.europa.eu/LexUriServ/site/en/oj/2007/l_076/l_07620070316en00350035.pdf
- [2] Bamberg, U.; Boy, S.: The New Machinery Directive. KAN Report 40. KAN Kommission Arbeitsschutz und Normung, Sankt Augustin 2008
http://www.kan.de/uploads/tx_kekandocs/Beri40e.pdf

⁶ Important: the PFH should not be confused with the $MTTF_d$ (mean time to dangerous failure) or $B10_d$ value (number of cycles until 10% of the components fail dangerously) of a component. It is possible to specify $MTTF_d$ and $B10_d$ values for products primarily not intended to be applied in safety functions.

Components for safety functions

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Premises/notes for the application of this table:

- a A condition is that the component serves the purpose of assuring a safety function, is placed separately on the market, and that its failure or malfunction presents a hazard to persons.
- b The classification of a component as a "logic unit to ensure safety functions" constitutes an estimation on the part of the BGIA which has been agreed with further European test bodies. No responsibility is assumed for correctness.
- c Components are strictly intended to be applied in safety functions, if the manufacturer confirms at least one of the following product characteristics: Category, Performance Level (PL), Probability of dangerous failure per hour (PFH), Safety Integrity Level (SIL). The intended application of components can not be clearly derived from a statement of MTTF/MTTFd or B10/B10d.

No.	Component	Safety component in accordance with the Machinery Directive 2006/42/EC ^a ?		Logic unit to ensure safety functions ^b in accordance with the Machinery Directive; annex IV; point 21?		Application of art. 12/(3)(4) ?
1	Position switch with positive opening operation according to EN 60947-5-1, annex K	Yes	With regard to the machine function, can be substituted by a position switch without positive opening operation.	No	Does not perform logic operations for the control of safety functions.	No
2	Proximity switch for safety functions ^c ; as well referred to as PDF-X according to EN 60947-5-3	Yes	With regard to the machine function, can be substituted by a conventional proximity switch.	Yes	Performs logic operations for generation of the output signal, and is intended for use within safety functions.	Yes
3	Mechanical guard locking to EN 1088 (for protection of persons)	Yes	With regard to the machine function, can be substituted by guard locking without personal protection function.	No	Does not perform logic operations for the control of safety functions.	No
4	Electromagnetic guard locking for safety functions ^c according to Draft ISO 14119 (for protection of persons)	Yes	With regard to the machine function, can be substituted by guard locking without personal protection function.	Yes	Performs logic operations for generation of the output signal, and is intended for use within safety functions.	Yes
5	Trapped-key interlocking system for safety functions ^c ; in the form of a complete system only, not of discrete components	Yes	Is not required for functioning of the machine.	Yes	Performs logic operations for generation of the output signal, and is intended for use within safety functions.	Yes
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No.	Component	Safety component in accordance with the Machinery Directive 2006/42/EC ^a ?		Logic unit to ensure safety functions ^b in accordance with the Machinery Directive; annex IV; point 21?		Application of art. 12/(3)(4) ?
7	Position measuring system for safety functions ^c , e.g. rotary encoder, length measuring device	Yes	With regard to the machine function, can be substituted by a conventional position sensor.	Yes	Performs logic operations for generation of the output signal, and is intended for use within safety functions.	Yes
8	Protective device designed to detect the present of persons – electro-sensitive protective equipment, laser scanner, pressure-sensitive mat, pressure-sensitive edge, bumper, camera system	Yes	Is listed in Annex IV, Point 19.	No	Explicitly listed in annex IV, point 19	Yes
9	Protective devices for indirect detection of the presence of persons, for example by the use of RFID transponders	Yes	Is not required for functioning of the machine.	Yes	Performs logic operations for generation of the output signal, and is intended for use within safety functions.	Yes
10	Protective device for the detection and deactivation of possible hazards (not a warning system only), such as the detection of hazards presented by laser radiation by activ laser guards	Yes	Is not required for functioning of the machine.	Yes	Performs logic operations for generation of the output signal, and is intended for use within safety functions.	Yes
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12	Emergency stop device	Yes	Is stated in Annex V, Point 10.	No	Does not perform logic operations for the control of safety functions.	No
13	Control device for enabling devices (enabling control)	Yes	Is not required for functioning of the machine.	No	Does not perform logic operations for the control of safety functions.	No
14	Safety switchgear ^c , for example for the monitoring of speed, protective doors, emergency-stop, two-hand control, enabling device; note: may be part of a portable control station	Yes	Is not required for functioning of the machine.	Yes	Performs logic operations for generation of the output signal, and is intended for use within safety functions.	Yes
15	Safety PLC ^c	Yes	With regard to the machine function, can be substituted by a conventional PLC.	Yes	Performs logic operations for generation of the output signal, and is intended for use within safety functions.	Yes

No.	Component	Safety component in accordance with the Machinery Directive 2006/42/EC ^a ?		Logic unit to ensure safety functions ^b in accordance with the Machinery Directive; annex IV; point 21?		Application of art. 12/(3)(4) ?
16	Relay/contactor relay with mechanically linked contacts	Yes	With regard to the machine function, can be substituted by a relay/contactor relay without mechanically linked contacts.	No	Does not perform logic operations for the control of safety functions.	No
17	Contactor with mirror contacts	Yes	With regard to the machine function, can be substituted by a contactor without mirror contacts.	No	Does not perform logic operations for the control of safety functions.	No
18	Contactor monitoring module	Yes	Is not required for functioning of the machine.	Yes	Performs logic operations for generation of the output signal, and is intended for use within safety functions.	Yes
19	Power Drive System with integrated safety functions (PDS(SR)) ^c , e. g. frequency inverter, servo converter	Yes	With regard to the machine function, can be substituted by a PDS without integrated safety functions.	Yes	Performs logic operations for generation of the output signal, and is intended for use within safety functions.	Yes
20	Time delay element for safety functions ^c	Yes	With regard to the machine function, can be substituted by a time delay element without Category, PL, SIL or PFH.	Yes	Performs logic operations for generation of the output signal, and is intended for use within safety functions.	Yes
21	Undervoltage release for a mains disconnecting device, intended for use in safety functions (for example to provide protection against restarting following power restoration)	Yes	Is not required for functioning of the machine.	No	Does not perform logic operations for the control of safety functions.	No
22	Braking unit, for example for woodworking machines	Yes	Is not required for functioning of the machine.	Yes	Performs logic operations for generation of the output signal, and is intended for use within safety functions.	Yes

No.	Component	Safety component in accordance with the Machinery Directive 2006/42/EC ^a ?		Logic unit to ensure safety functions ^b in accordance with the Machinery Directive; annex IV; point 21?		Application of art. 12/(3)(4) ?
23	Component for the logical processing of safety-related signals of Safety Bus Systems ^c ; excluding components to be applied in "black channels" according to EN 61784-3 (black channel: communication channel without available evidence of design or validation according to IEC 61508)	Yes	With regard to the machine function, can be substituted by a conventional bus system.	Yes	Performs logic operations for generation of the output signal, and is intended for use within safety functions.	Yes
24	Brake assembly for the protection of persons, e. g. to keep up gravity loaded axis	Yes	Is not required for functioning of the machine.	No	Does not perform logic operations for the control of safety functions.	No
25	Bank of valves with self-contained logic combination of safety relevant signals, for example a safety valve block for presses	Yes	With regard to the machine function, can be substituted by conventional valves.	Yes	Performs logic operations for generation of the output signal, and is intended for use within safety functions.	Yes
26	Valves with additional means for failure detection intended for the control of dangerous movements on machinery	Yes	Is stated in Annex V, Point 5.	No	Does not perform logic operations for the control of safety functions.	No
27	Equipment for protection against overpressure, e.g. pressure valve	Yes	Is not required for functioning of the machine.	No	Does not perform logic operations for the control of safety functions.	No
28	Equipment for stopping of movement, e.g. resettable check valve	Yes	Is not required for functioning of the machine.	No	Does not perform logic operations for the control of safety functions.	No
29	Contact expansion module; enhancement to safety switchgear (s. no. 14); for time delay s. no. 20	Yes	With regard to the machine function, can be substituted by conventional relais/contactors.	No	Does not perform logic operations for the control of safety functions.	No