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Fachbereich Holz und Metall
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Fachbereich AKTUELL

FBHM-087E

Interface machine tool/fire suppression system Control requirements for fire suppression systems in metalworking

Expert Committee Maschinery, Robotics und Automation
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Translation of the German version

Non-water-miscible metalworking fluids which are based on mineral oil are frequently used for cooling and lubricating metalworking machine tools. As these metalworking fluids can pose a fire hazard, fire suppression systems are used [1]. Stationary fire suppression systems at machines which are required for the safety of persons are to be considered as safety components. This includes, for example, small suppression systems within the machine protection. The machinery itself and the fire suppression systems fall within the scope of the Machinery Directive 2006/42/ EC [2, 3].

Contents

Figure 1 – Fire suppression system integrated into a machine tool

1. Microprocessor-controlled fire suppression control system
2. Manual release
3. Visual and audible alarm
4. Optical sensor (UV or IR flame detectors)
5. Temperature sensor
6. Extinguishing agent tank with automatic activation
7. Flooding through CO_2 extinguishing nozzles
8. Flooding of individual extraction an filter system
9. Pressure relief device

If control-related measures are used to reduce risks, the corresponding safety functions have to be described and calculated. The DIN EN ISO 13849 series [4, 5] or DIN EN 62061 [6], for example, are applicable to control requirements.

This "Fachbereich AKTUELL" explains the basics of fire protection for machine tools and gives an example of a feasible implementation of safety functions and the determination of the achieved Performance Level (PL) according to DIN EN ISO 13849-1. The example is based on a practical application in the industrial series production of a machine tool.

> A glossary of terms and abbreviations is provided on page 16 of this publication.

1 Fire hazards on machine tools

In addition to a flashover and a typical fire inside the machine tool, the reignition is an unexpected third variant.

1.1 Flashover

During metal cutting with oil-based metal-working fluids (MWF), a flashover of the oil/aerosol/vapour/air mixture may occur (abrupt and almost complete reaction of the ignitable mixture) in the interior of the machine tool with subsequent fire.

Such violent reactions are mainly caused by tool breakage, malfunctions or dry running of tools. Glowing chips and hot surfaces act as ignition sources.

As a result of the flashover, very strong flames may escape from all openings of the machine, such as door labyrinths, workpiece feeders or openings in the area of the chip conveyor. Furthermore, smoke and possibly hazardous combustion gases may escape. For this reason, the operating personnel is exposed to a high risk of injury in such areas.

1.2 Fire in the interior of the machine

A flashover of the metalworking fluid/aerosol/vapour/air mixture, for example by a hot tool/chip or a hot surface, may lead to a subsequent fire in the interior of the machine. This can also be caused by a "high fire load" such as, for example, large quantities of oil-soaked chips or chip accumulations.

Furthermore, self-ignition in the chip container may occur, especially if it holds very high quantities of oil-soaked chip residues.

This is often caused by an exothermic reaction of metalworking fluid components with the metal surface of the chips, thus releasing heat. The oxidation of iron with rust formation has to be taken into account. The reaction is promoted by the formation of heat accumulation due to "covering" oily air-impermeable layers.

> **Consequences/impact:**
> The fire in the machine can spread and form hot surfaces, smoke, and possibly hazardous combustion gases. This can also lead to flame ejections at the machine openings. Although the flame ejections are less severe than in case of a flashover, they still pose a risk of injury to the operating personnel in these areas.

1.3 Reignition

An abrupt supply of air (e.g., by opening the door to the work area) and the hot surfaces can lead to violent flame reactions (reignition).

Reignition can occur if the following conditions are present:

- Ignition of MWF mixture with persistent fire / subsequent fire

- thus, formation of:
  - hot surfaces in the interior of the machine
  - toxic and possible explosive combustion gases (carbon monoxide: CO) due to oxygen shortage

> On machines equipped with a fire suppression system, reignitions may also occur, if the fire suppression system is not properly designed, if the fire is not detected or if the extinguishing agent bottle is empty on activation.

Reignition can be caused:

- if workroom doors are opened too early (e.g., for manual suppression in the interior) and if the machine has not sufficiently cooled down. This is a foreseeable misuse which is documented by accidents.
  The time until the door is opened depends on the design conditions in the interior of the machine and the risk assessment.
- if the machine is restarted too soon while surfaces are still hot and MWF spray mist is still present. The effect is intensified by air supply when the extraction system is activated.

As a result of the reignition, extremely violent / explosive flames may eject from openings in the machine, such as door gaps and workpiece feeds. Furthermore, smoke and possibly hazardous combustion gases can escape, which involves a risk of injury to the operating personnel in such areas.

2 Fire prevention

Before providing the machine tool with a fire suppression system, fire prevention measures should be taken first. For this purpose, it is helpful to read the revised DIN EN ISO 19353 "Safety of machinery − Fire prevention and fire protection" [7]. Measures are also described in DGUV Information 209-026 "Brand- und Explosionsschutz an Werkzeugmaschinen" (English version: DGUV Information 209-027 Machine Tool Fire and Explosion Prevention and Protection).

These measures are shown as a "recurring theme“ in a flow chart and provide a guideline to machine manufacturers and users for creating a protection concept.

A machine tool with a complete enclosure (housing) for the machining of metallic materials (drilling, turning, polishing/grinding, milling) with non-water-miscible "flammable" metalworking fluids has been selected as an example. The measures for fire prevention and firefighting are described in a practical manner.

These measures which are detailed in the Annex E of the Standard consist of the selection of a suitable metalworking fluid (low evaporation and low atomization), the use of labyrinth sealings on workroom doors and the installation of extraction and fire suppression systems.

By deactivating the chip conveyor, which transports chips out of the machine interior, subsequent fires are avoided and/or limited.

3 Safety functions

Fire suppression systems are safety components according to the Machinery Directive, so that the corresponding requirements apply.

These fire suppression systems usually include fire suppression control systems which perform safety functions. Sensor signals are processed to detect a developing fire and to initiate the necessary measures:

- the introduction of the extinguishing agent,
- stopping the machining process,
- the interruption of the MWF supply and
- the deactivation of the extraction system, etc.

The integration of a fire suppression system into a machine tool is shown in Figure 1.

For the design of control technology of fire suppression systems, the standards DIN EN ISO 13849 or DIN EN 62061, are decisive. The safety functions should adequately reduce the risk caused by a fire or the introduction of extinguishing gas. Accordingly, high risks also place high demands on the design of the safety functions, while low risks help to implement the safety functions with less effort.

The Performance Level PL or the Safety Integrity Level SIL is used in machine protection as a yardstick for the "quality of the safety functions". The Performance Level (PLr; r = required) or the SIL required for a particular machine must be determined individually by means of a risk assessment.

Based on the analysis of the hazards described herein, the working group defined the safety functions listed in Table 1, which were also adopted in the international standard DIN EN ISO 19353 (but without indication of PLr, since PLr is machine-dependent).

Although most of these safety functions result from the aforementioned hazards, the question remains why the activation of the extinguishing process is not included? The answer: people who stay in front of the workroom door are largely protected when labyrinth sealings are used. Therefore, the extinguishing process itself is not in the foreground. However, it must be prevented that a fire spreads through the extraction system or the chip conveyor (SF3).

Table 1 − – Safety Functions including specification of the required performance levels

No.	Definition	Required Performance Level (PL_r)
SF 1	Prevention of **reignition** by keeping the workroom doors locked on fire detection	**c**
SF 2	Shut-down of metalworking fluid supply on fire detection	**b**
SF 3	Shut-down of the decentralised extraction system or seal-off from the central extraction system on fire detection	**b**
SF 4	Stopping of machining process on fire detection (including stopping of the chip conveyor, which could convey burning chips)	**b**
SF 5	If the workroom door is not locked and the manual reset is not activated (only for walkable machines), the activation of the fire suppression process with oxygen displacing gases is prevented	**d** (machine tool walkable) **c** (machine tool not walkable)
SF 6	The machine operation is only possible when workroom doors are locked and the fire suppression system is ready for operation (including sufficient quantity of extinguishing agent, extinguishing agent monitoring e.g. monitored by weighing device or loss monitoring)	**b**
SF 7	Alerting the responsible authorities in case of fire detection	**b**

Note: Table 1 was prepared on the basis of DIN EN ISO 19353 and provides adapted descriptions of the safety functions for better understanding

The fire should also be prevented from continuing due to the further supply of intake atmospheric oxygen. In this case, the operating personnel would be exposed to hazards due to hot surfaces, inhalation of combustion gases and, in the further course, due to burns after destruction of the enclosure.

There is still a high risk of possible reignition of a previously extinguished fire when oxygen is supplied on opening the workroom door. The fire suppression control system must therefore prevent the workroom door from being opened by the operating personnel in the event of a fire (SF1).

A further hazard is created by the use of the fire suppression system itself. With carbon dioxide, which is commonly used as extinguishing agent in practice, health hazards can be expected from a concentration of five percent by volume in air. From a concentration of more than eight percent by volume, there is a danger to life. This aspect must be taken into account, in particular for "walk-in machines" for which it is possible or necessary to enter the interior, e.g., for tool changes, maintenance and cleaning. The same applies to installations in "confined spaces". Fire suppression must therefore only be triggered when the workroom doors are locked (SF5).

In order to minimize hazards on walk-in machines due to accidental closing of the workroom door, a manual reset (acknowledgement) is required. Acknowledgement takes place outside the hazard zone before the machine movement can be started.

The SF6 safety function reports a ready-to-operate fire suppression system to the higher-level control system. The machine can only be started after having received a positive signal from all monitored components of the fire suppression control system. The ready-to-operate fire suppression system includes monitoring for a sufficient quantity of extinguishing agent, e.g., by means of a weighing device or shrink control.

Nowadays, the functions of machines are implemented by complex electronic control systems which, for example, start and stop motors or open and close valves. To fulfil its safety functions, the fire suppression control system must partially act on the same motors and valves. In this respect, there is an interface between the functional machine control system and the fire suppression control system. This interface is currently not standardized, so that an individual agreement between the machine manufacturer and the manufacturer of the fire suppression control system is required.

The components of safety-related control systems must be checked for their functionality depending on PLr. For electronic control systems, this is usually done automatically by means of self-tests and unnoticed by the machine user. However, this is not possible with the currently available sensors, as, for example, high temperatures or UV radiation are required for testing. Therefore, regular manual tests are necessary to ensure the functionality of the fire detection system.

4 Selection of sensors

Two types of sensors are usually used for fire suppression systems on machine tools.

- A. Temperature-sensors: detect heat
  Thermal fire detection elements (temperature sensors) react more slowly than optical sensors and are therefore also used in conjunction with optical sensors. Requirements for response sensitivity and differential behaviour are described in EN 54-5 [8] Class A1.
- B. Optical sensors: detect UV- or IR-radiation

UV-sensors:
The requirements for flame detectors for the detection of fires with rapid flame development and detection in the ultraviolet range are described in EN 54-10 [9].
Detection may be impaired by particles such as oil mist. The influence of oil mist on the response behaviour should be checked in the selection process. The oil mist of the combustible lubricant (aerosol/vapour/air mixture) in the interior of the machine is only partially permeable to UV radiation (depending on the density of the oil mist). UV sensors are therefore preferably used for dry machining and in areas without oil mist.

IR-sensors:
Requirements for IR sensors to detect fires with rapid flame development and detection in the infrared range are described in EN 54-10.
Only minor impairment of the particles (e.g., oil mist) on the detection of IR radiation. The oil mist of the flammable lubricant (aerosol/ vapour/air mixture) in the interior of the machine is permeable to IR radiation. IR sensors are therefore preferably used in areas with oil mist.
Optical sensors must be kept clean. This can be achieved, for example, by automatic detection of contamination and/or air flushing (sealing air) in conjunction with regular cleaning.

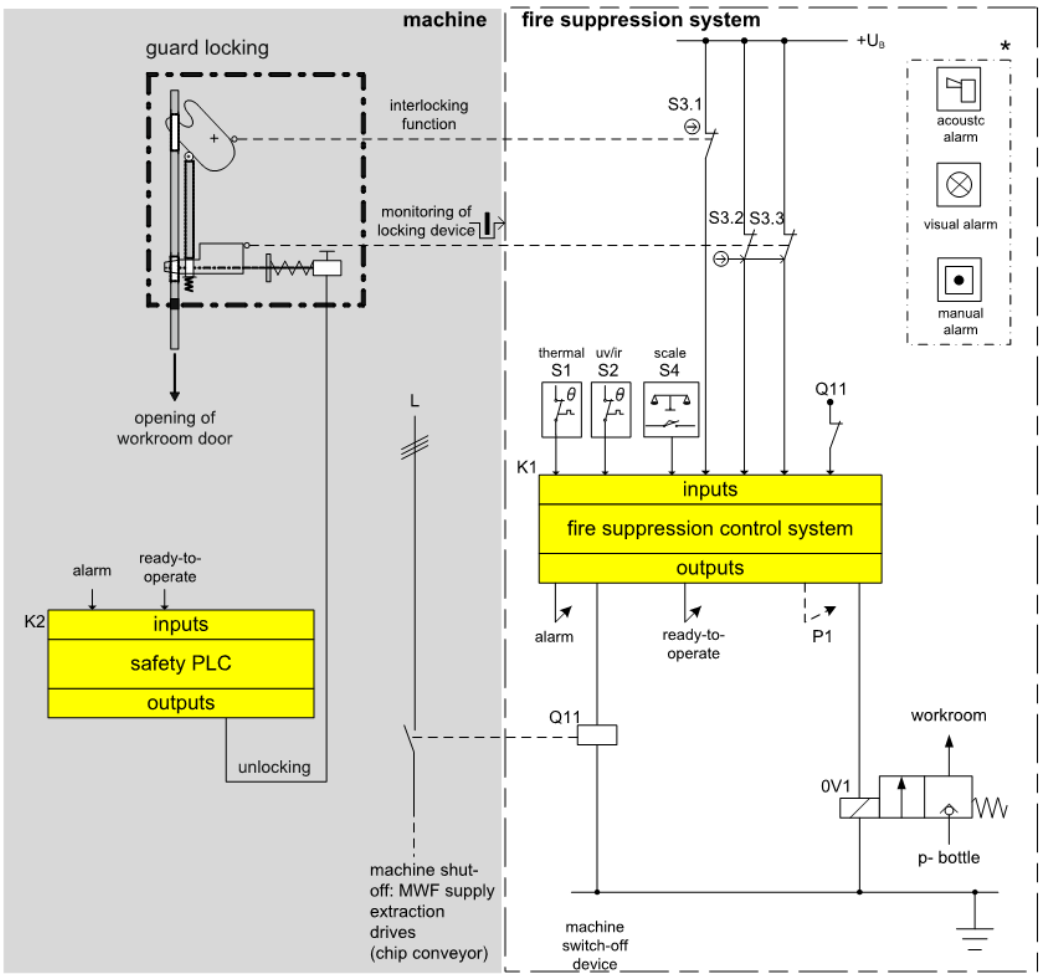

Figure 2 − Electrical schematic diagram of a fire suppression system at a non-walkable machine tool

The picture only shows that part which is required for personal protection. The components listed in the box (*) are not relevant for the safety functions

5 Sample calculation for safety functions

The example given in this chapter is based on an existing practical application. A detailed description of the steps for implementing the requirements for the interface machine tool/fire suppression system from chapter 1-4 is provided. Further examples are planned and will follow.

- The example shown (see Figure 2) is based on a fire suppression system on a machine tool for the machining of steel and cast iron (no magnesium machining). Separate requirements apply to the machining of magnesium.
- The protection concept is based on fire prevention as the primary objective. Therefore, measures for fire prevention (e.g., tool breakage detection, monitoring of the metalworking fluid supply) are implemented on a priority basis.
- The machine tool must only be started when the fire suppression control is ready for operation.
- The closing edges of the workroom door at the machine are designed as flameproof labyrinths. A machine operator standing in front of the workroom door is therefore protected against flame propagation.

5.1 Functional description

- The cutting machine tool shown as an example (see Figure 1) is used to machine workpieces of different diameters. The machine is fully enclosed and provided with a workroom door. The machine has four CNC-controlled axes, which enable precise machining. The machining process is cooled with non-water-miscible metalworking fluids based on mineral oil. The machine is connected to a central extraction system.
- The fire suppression control system K1 and the two fire detection sensors S1/S2 are used for fire detection in the interior of the machine. In the event of a fire, the sensors send a digital signal to the fire suppression control system, which passes on a message to the higher-level safety PLC K2. In the event of fire, the drives, the metalworking fluid supply and the extraction system are switched off by the fire suppression control system K1 via the main contactor Q11.
- The use of a thermal and an optical sensor provides diversity in the fire detection. Thus, the fire detection sensors are considered to be redundant according to category 3. To simplify matters, it is assumed in this case that even the slightly delayed fire detection by the thermal sensor (channel 1) is not relevant. The fire detections in channel 1 and channel 2 are assumed to be equivalent. This simplification is application-specific and must be reconsidered in each individual case as part of a risk assessment. If a delay in fire detection between the thermal and the optical sensor were unacceptable, other sensors might have to be used.
- The sensors are tested at least once a year by trained maintenance personnel. During this process, the correct functionality is checked and documented.

5.2 Description of safety functions

The safety functions listed in Table 1 are considered in more detail below.

- **SF1:** Prevention of a reignition by locking the workroom doors in case of fire detection.

  If a fire is detected, a reignition must be prevented by locking the workroom doors with guard locking. Preventing the unlocking of the guard locking is also part of this safety function, as is fire detection. Unlocking the guard locking is implemented by the machine tool's safety PLC K2.

  Sensors S1/S2 are used for fire detection. The fire suppression control system reports the states "Alarm" and "Ready for operation" to the safety PLC K2.

With an emergency release according to DIN EN ISO 14119 [10], direct access for the fire brigade can be ensured.

- **SF2:** Switching off the MWF supply on fire detection

  The metalworking fluid ("MWF") supply is switched off by a drop-out of the main contactor Q11.

- **SF3:** Switching off the extraction system on fire detection

  The extraction unit is switched off by a drop-out of the main contactor.

- **SF4:** Interrupt machining process if a fire is detected (including stopping the chip conveyor, which could convey burning chips)

  The machining process is switched off by a drop-out of the main contactor Q11.

> A hazard from ejected parts due to dry running may need to be taken into account.

- **SF5:** If the workroom door is not locked with a guard locking device and manual reset function[1] is not yet performed, the activation of the extinguishing process is prevented by oxygen displacing gases.

  In this example, the machine is considered to be not walkable. Therefore, a PL_r=c must be fulfilled.

  If the workroom door is not locked with guard locking, the activation of the solenoid valve 0V1 is interrupted by the fire suppression control K1.

> The use of a mechanical blocking device (e.g. a monitored ball valve in conjunction with a blocking device for inserting locks) is a measure equivalent to SF5.

- **SF6:** The machine can only be operated when workroom doors are locked and the fire suppression system is ready for operation (including a sufficient quantity of extinguishing agent, extinguishing agent monitoring by weighing device).

  The fire suppression control systemK1 forwards the signal "ready for operation" to the higher-level machine control.

  As a condition for the "Ready for operation" signal, a sufficient quantity of extinguishing agent must be available (weighing device S4) and, in the case of automatic detection, the detection system, including visual monitoring of the optical detectors, must operate without any faults. The workroom door must be locked with guard locking (locking mechanism contacts S3.2, S3.3).

- **SF7:** Alerting the responsible authorities in case of fire detection

  This function does not result from the essential safety requirements of the Machinery Directive. However, requirements may arise from an operational safety point of view. For this reason, an interface for further signal processing during operation is provided to signal a fire.

  The alarm is signalled by K1 via a potential-free contact P1.

5.3 Design characteristics

- Basic and well-tried safety principles according to DIN EN ISO 13849-2 as well as the requirements of category B according to DIN EN ISO 13849-1 are complied with. Protective circuits (e.g., contact protection, oversizing) are provided.
- Fault exclusion for line short circuits in accordance with DIN EN ISO 13849-2, Table D.4 is additionally possible, provided the conditions specified in the table are met.
- The guard locking S3 meets the require-ments of DIN EN 14119]. The spring of the guard locking is a proven spring in accordance with DIN EN ISO 13849-2, Annex A.3. In addition, the spring is

[1] Only for walkable machines

permanently safe in accordance with DIN EN 13906-1 [11]. The safety requirements for the spring force-actuated guard locking are included in test principle GS-ET-19, clause 5.5.1 [12]. The protection against unintentional closing of the guard locking ensures by design that the locking mechanism contacts cannot be in the locked position (guard locking position) when the workroom door is open.
The locking mechanism contacts are monitored by two positive opening contacts S3.2, S3.3 according to DIN EN 60947-5-1, Annex K [13]. The spring of the guard locking keeps the locking mechanism contacts in the closed position in the event of a power failure (closed-circuit principle). The guard locking mechanism is part of safety function 1, as it ensures that the workroom door remains locked ("guard locking function").

- The interlocking function is carried out via contact S3.1. The separate actuator (type 2) is mounted on the workroom door. The switching position of contact S3.1 is read and monitored in the fire suppression control system. The electrical contact S3.1 has positive opening and meets the requirements according to DIN EN 60947-5-1, Annex K.
- S1 is a thermosensor and serves as a channel for fire detection in the machine tool.
- The UV/IR sensor S2 serves as a second channel for fire detection in the machine tool. It is a sensor which is suitable for industrial use.
- The fire suppression control K1 fulfils category 3 and PL c according to the manufacturer's specifications. It has an internal 2-channel design. Occurring internal faults are partially detected and the safe state is initiated.
- According to the manufacturer's specifications, the safety PLC (SSPS) K2 fulfils category 3 and PL d. The SSPS has an internal 2-channel structure. Occurring internal errors are detected and the safe state is initiated.
- The main contactor Q11 has mirror contacts according to DIN EN 60947-4-1, Annex F [14]. The contact position is read back into the fire suppression control K1 and checked for plausibility. In case of failure, the safe state is initiated (disconnection of the power supply of the machine).
- S4 represents a weighing device which is used for monitoring the extinguishing agent. It is an electromechanical component which is suitable for industrial use. It meets the requirements of category B according to DIN EN ISO 13849-1.
- The parameterization of the fire suppression control is carried out according to the requirements in section 4.6.4 of DIN EN ISO 13849-1.
- The gas cylinder valve 0V1 is an electromagnetically operated 2/2-way valve in seat-type design. The valve is suitable for use in fire suppression systems with oxygen displacing gas (CO_2).

5.4 Test of sensors

- The sensors are tested for positioning, cleanliness and function as part of annual maintenance. Due to the wide range of applications, this may only be carried out by trained specialist personnel.
- The test identifies errors in the individual fire detection sensors to a high degree (DC = 99 %). Depending on the sensor type (thermal/optical), different test procedures are carried out. The degree of diagnostic coverage (DC) is verified by means of an FMEA of the possible failures and the manual tests.
- In practice, a combined test is carried out during maintenance to check the entire safety function including the sensors.
- The thermosensor S1 is heated with a heat source while the workroom door is closed. The activation of the test alarm triggers the solenoid valve 0V1, followed by the corresponding display on the fire suppression control unit (red=alarm, yellow=fault). The correct function of the thermosensor S1 can be concluded from the display.

- The UV/IR sensor S2 is triggered with the working room door open, but the 0V1 solenoid valve must not switch. When the optical sensor is triggered, a red LED in the viewing window indicates the triggering. This signals the functionality of the sensor. After triggering, there is also a corresponding display on the fire suppression control (red=alarm, yellow=fault).
- Thus, the entire chain from fire detection to the solenoid valve on the gas cylinder is tested.
- For the optical sensors (UV/IR), a special testing device is used to test all relevant parameters. The special test equipment is only used during production to determine the function and measured values. After installation or during maintenance, only the pure function is tested without the complete test fixture.
- If the described test procedure is carried out correctly, it can be assumed that the sensor is fully functional and ready for use after a test has been performed.
- By selecting suitable measures, impermissible contamination of the optical sensors must be prevented.

5.5 Remarks

- After a fire, the function of the fire suppression control and the sensors must be checked and replaced, if necessary.
- If a safety function fails, the machine must take the safe state (usually: shutdown and prevent further operation).
- The risk of fire can be reduced from the beginning by
  - ensured MWF supply (flood lubrication)
  - avoiding the use of blunt tools

5.6 Calculation of failure probability

Sufficient measures against common cause failures (65 points): disconnection (15 points), protection against overvoltage, etc. (15 points) and environmental conditions (25 points + 10 points).

Table 2 shows all essential values for calculating the performance level of the safety functions according to Figure 3 with the aid of the SISTEMA software (see Figure 4).

A fault exclusion is assumed for the mechanics of guard locking S3, since the following conditions are fulfilled:

- Application in accordance with the operating instructions, in particular installation instructions and technical data (e.g., actuation radius, actuation speed)
- Prevention of self-loosening.
- The static forces acting on the guard locking are lower than the locking force specified in the data sheet.
- No dynamic forces occur since the release solenoid is energized only when the workroom door is closed. See DGUV Information 203-079 "Auswahl und Anbringung von Verriegelungseinrichtungen" [15].
- No use as mechanical end stop, non-releasable fixing of the actuator, regular maintenance, positive locking after installation.
- Sufficient mechanical strength of all carrier and functional elements.
- Damage that could result from foreseeable external influences (e.g., ingress of dirt, dust and mechanical vibration) is kept away by the type of mounting or is not to be expected due to the operating conditions.

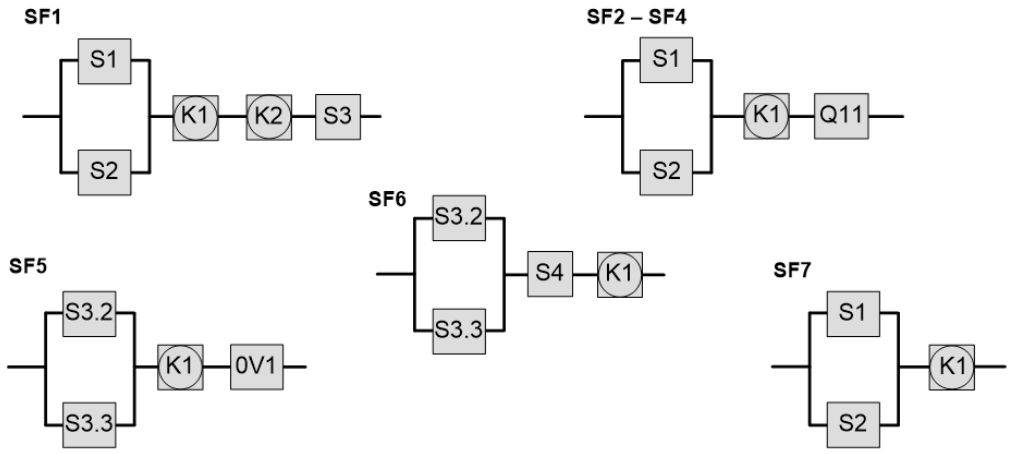

Figure 3 − Safety-related block diagrams of all seven safety functions SF1 to SF7

Table 2 – Values for the calculation of the calculation of the failure probabiltiy of the components in Figure3

Com-ponent	Remarks	Manufacturer's specifications [H]	Values
K1	**Fire suppression control system**	Cat. 3, PL c	PFH_D = 2,5*10^{-6} /hour
K2	**Safety PLC**	Cat. 3, PL c	PFH_D = 3,2*10^{-7} /hour
S3	**Guard locking mechanism (for the „guard locking function")**	Fault exclusion	PFH_D = 0 /hour
S3.1, S3.2, S3.3	**Monitoring of door position / interlocking** (S3.1) **Monitoring of locking device (locking mechanism contacts)** (S3.2 and S3.3) For the electrical **contacts with** positive opening (S3.1 – S3.3) of the guard locking device, a fault exclusion is assumed. For the mechanical part, the manufacturer indicates the B_{10D} value. 365 working days, 8 hours per day and a cycle time of 5 minutes result in the following n_{op} value as well as $MTTF_D$ value.	B_{10D} = 1.000.000 cycles	n_{op} = 35040 cycles/year $MTTF_D$ = 285,39 years
S1	**Thermal sensor** The specified DC value is achieved by annual manual testing on site.	$MTTF_D$ = 45.662 years	DC = 99 %
S2	**UV/IR-Sensor** The specified DC value is achieved by annual manual testing on site	$MTTF_D$ = 1779 years	DC = 99 %
	Weighing device With electromechanical position switch There are no manufacturer's specifications available for the mechanical part. For this purpose, the MTTFD value is taken from DIN EN ISO 13849-1 Table C.1 [N].		Cat. B $MTTF_D$ = 150 years [N]
S4	Associated **position switch**	B_{10D} = 1.300.000 cycles	n_{op} = 35040 cycles/year $MTTF_D$ = 371 years
Q11	**Power contactor**	B_{10D} = 1.000.000 cycles	n_{op} = 35040 cycles/year $MTTF_D$ = 285 years
0V1	**Gas cylinder valve** In this example, a fault exclusion for the automatic change of the output switching position (without input signal) and "leakage" according to Table C.3 of DIN EN ISO 13849-2 is used. A prerequisite is that the conditions listed in this table are fulfilled.	Fault exclusion	PFH_D = 0 /hour

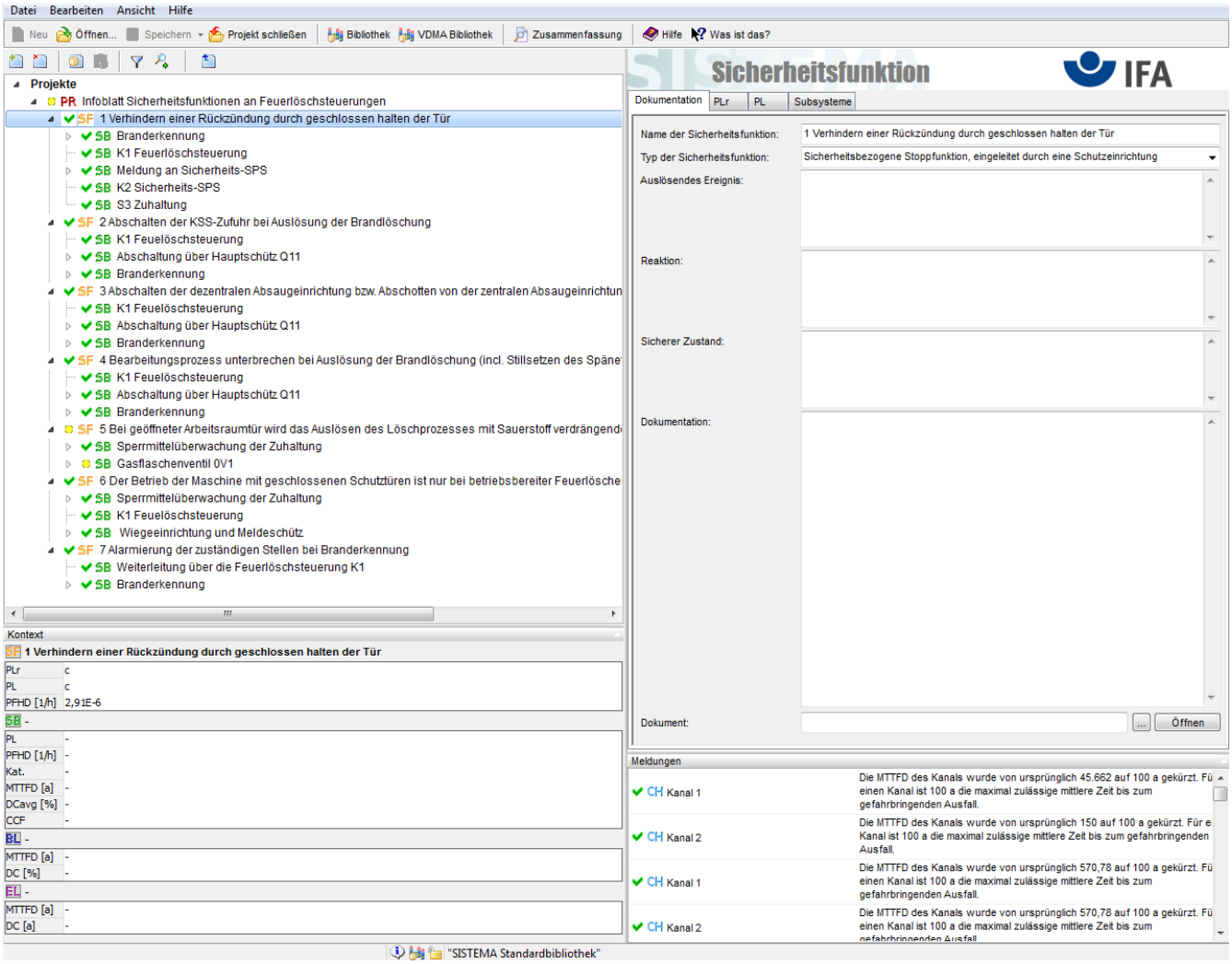

Figure 4: Safety-related block diagram of the seven safety functions SF1 to SF7

6 Results of the calculation

Table 3 shows the results of the calculation using the SISTEMA software (see Figure 4).

Table 3 − Results of PFH-calculation. All required PL's are achieved (compare Table 1).

Safety-function (SF)	PFH_D / hour	Performance Level (PL)
SF1	$2,9*10^{-6}$	c
SF2	$3,7*10^{-6}$	b
SF3	$3,7*10^{-6}$	b
SF4	$3,7*10^{-6}$	b
SF5	$2,6*10^{-6}$	c
SF6	$6,8*10^{-6}$	b
SF7	$2,6*10^{-6}$	c

7 Summary and limits of application

This “Fachbereich AKTUELL” is based on expert knowledge gathered by the expert committee woodworking and metalworking, subcommittee machinery, robotics and automation of Deutsche Gesetzliche Unfall-versicherung (DGUV) and experience from practical application in the field of control and safety-related components in conjunction with fire suppression systems for machine tools.

The present “Fachbereich AKTUELL” has been developed by the section “machine tools” (in the subcommittee machinery, robotics and automation) in cooperation with the „Institut für Arbeitsschutz (IFA) of Deutsche Gesetzliche Unfallversicherung (DGUV).

It is particularly intended as information to the manufacturer’s designers and users by means of practical examples with regard to control systems on machine tools and automatic fire suppression systems.

Special regulations for other applications (e.g., for mining) have to be considered

The provisions according to individual laws and regulations remain unaffected by this “Fach-bereich AKTUELL”. The requirements of the legal regulations apply in full.

In order to get complete information, it is necessary to consult the relevant regulation texts and the current standards.

The expert committee woodworking and metalworking is composed of representatives of the German Social Accident Insurance Institutions, federal authorities, social partners, manufacturers and users.

This “Fachbereich AKTUELL” replaces the version of the same title, issued as DGUV Information FBHM-087 as of 07/2018. An updating has become necessary due to editorial amendments.

This “Fachbereich AKTUELL” is the English translation of the German issue “FBHM-087” of 27.10.2022.

Further “Fachbereich AKTUELL” or information sheets of the expert committee woodworking and metalworking (Fachbereich Holz und Metall) are available for download on the internet [16].

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List of tables:

Glossary

Abbreviation or term	Description
[H]	Manufacturer's value
[N]	Value from DIN EN ISO 13849-1 Annex C, Tab. C.1
[G]	Estimated value
PFH_D	Average probability of dangerous failure per hour
PL	Performance Level
$MTTF_D$	Mean time to dangerous failure ($MTTF_D$) /
n_{op}	Number of operations per year
B_{10D}	Number of operations in which 10% of the components failed dangerously
DC	Diagnostic coverage
UV	Ultraviolet radiation
IR	Infrared radiation
KSS	Metalworking fluid
Fire suppresion control system	Microprocessor-controlled suppression system control. Processes logical links
Fire suppression system	A suppression system consisting of detectors, fire suppression control system, alarms, extinguishing agent containers, if necessary with weighing devices, extinguishing nozzles, extraction and flaps
Fire detection element	Detectors or sensors which are capable of detecting a fire. This is typically achieved by detecting optical or thermal radiation.

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