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Information

**Machine Tool
Fire and Explosion
Prevention and Protection**

Imprint

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Mittelstraße 51
10117 Berlin
Tel.: 030 288763800
Fax: 030 288763808
E-Mail: info@dguv.de
Internet: www.dguv.de

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Machine Tool Fire and Explosion Prevention and Protection

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Foreword

In the metalworking industries, a great quantity of non water-miscible metalworking fluids is being used for the chip-forming machining of workpieces.

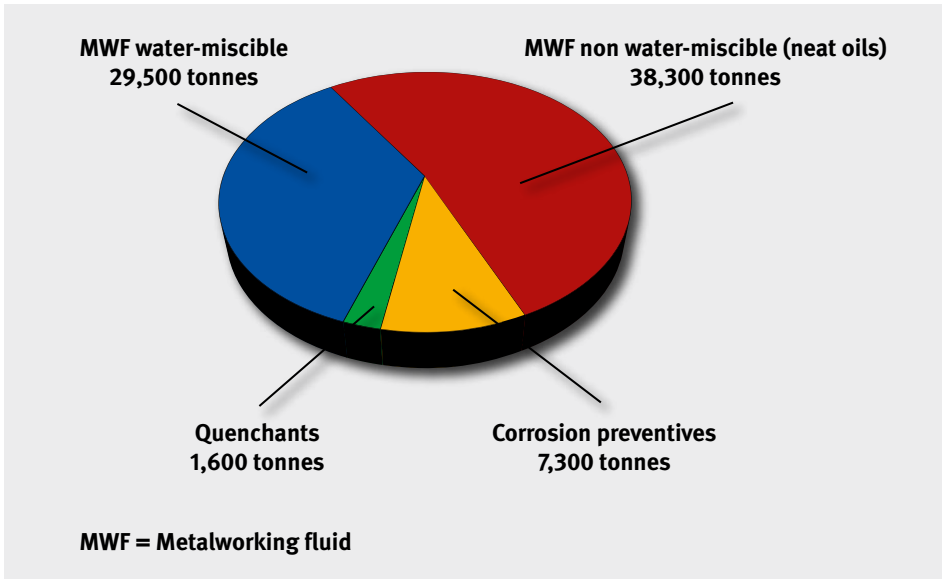


Figure 1 Metalworking oils in Germany 2006

Low-viscosity, flammable metalworking fluids are increasingly being used to achieve efficient and economic machining. This trend brings the topic of fire and explosion protection and prevention for machine tools to the fore.

Depending on type of machining, reactions of the oil/air mixture may occur in the interior of the machine tool, which if violent and followed by a fire can be the cause of accidents with severe material and fire damage. Besides injuries to persons, the consequences may be high losses due to production stoppages through to insolvency.

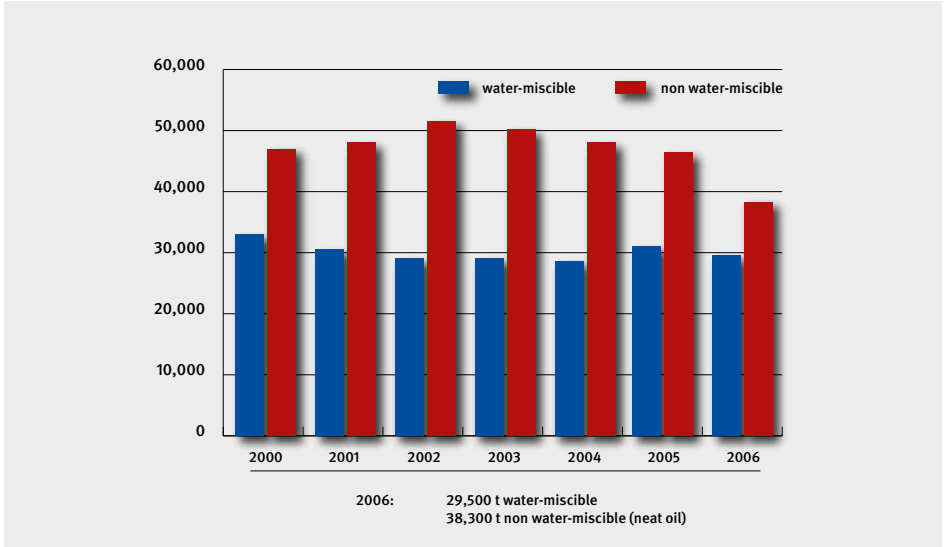


Figure 2 Trend in Germany

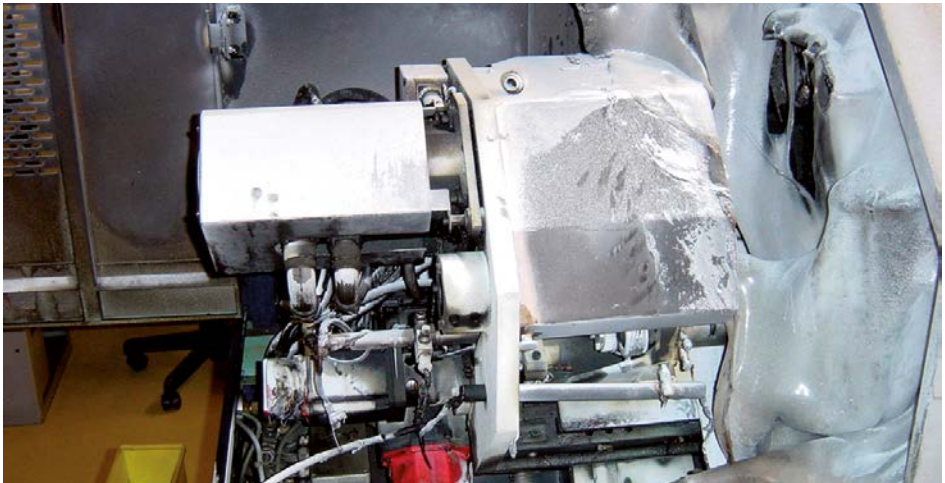


Figure 3 A machine tool fire ...



Figure 4 ... and its consequences

These guidelines describe measures against fire and explosion hazards during operation of machine tools with non water-miscible flammable metalworking fluids.

By definition, a flammable metalworking fluid is a non water-miscible metalworking fluid based on mineral oils, polyalphaolefins or fatty acid esters.

It is addressed to employers and assists them in the necessary negotiations with the manufacturer prior to the acquisition of a machine tool. The brochure provides information which the manufacturer may also take into account when placing a machine tool on the market in order to comply with the requirements of the Machinery Directive concerning fire and explosion protection and prevention (MD 2006/42/EC Annex 1 No. 1.5.6 and 1.5.7). At present, no specific standard for machine tools covering this topic is available.

Foreword

These guidelines contain information on the evaluation of hazards caused by fire and explosions. Checklists and sample operating instructions are available as assistance in the execution of the risk assessment at the workplace and the implementation of protective measures. The necessary measures may thus be determined in good time and expensive retro-fitting measures can be avoided. Fire and explosions are thus prevented or their effects minimized.

Protection goals going beyond personnel protection (e. g. protection of material assets, prevention of production disruptions, machine availability requirements, environmental protection) are not dealt with in these guidelines. Special protective measures for the machining of “critical“ light metals and their alloys (e. g. magnesium) are not dealt with in these guidelines. Information on this subject is given in “Umgang mit Magnesium” (BGR 204).

1 Legal basis: Duties of manufacturers and employers

The aim is to protect workers as comprehensively and efficiently as possible against fire and explosion hazards during use of machine tools. For this purpose, manufacturers and users (employers or businesses) of machine tools have the following obligations:

When using flammable metalworking fluids, the employer has the duty to determine in the framework of a **risk assessment at the workplace**, if a hazard caused by fire or explosions is possible. For this purpose, when purchasing the machine tool, he should firstly ensure that the machine is compatible with the metalworking fluids intended to be used.

The manufacturer takes this information into account when analyzing the risk for the identification and specification of the protection concept for the machine tool. In his instruction handbook, the manufacturer gives information on the intended use and on commissioning, setting, maintenance, servicing and start-and-stop procedures.

On the basis of the information given by the manufacturer, the employer then specifies the technical and organizational measures required in his company. The measures depend on the framework conditions of the overall system and on the conditions present in the company. As a general rule, the machine tool is connected to an extraction system already present in the factory. The responsibility for the safety concept of the resulting system lies principally with the employer. He may, however, take the manufacturer's advice and have him prepare the protection concept.

Legal basis: Duties of manufacturers and employers

	Manufacturing	Provision
Legal sources on the European level	2006/42/EC Machinery Directive, if applicable other Directives according to article 95 of the EEC treaty	Framework Directive on the protection of workers; other Directives, e. g. Directive for the use of work equipment
Implementation into national legislation	Produktsicherheitsgesetz (ProdSG) (Product Safety Act) especially ordinance (9th ProdSV)	<ul style="list-style-type: none"> • Arbeitsschutzgesetz (German Safety at Work Act) • Betriebssicherheitsverordnung (Ordinance on Industrial Safety and Health) • Gefahrstoffverordnung (Hazardous Substances Ordinance)
Addressees	Manufacturers, importers, dealers	Businesses (employers)
Subject	Safe products	Choice of safe work equipment suitable for the intended use

Table 1: Legal basis/overview

Fire and explosion risks are safely controlled when measures in accordance with the Machinery Directive MD 2006/42/EC Annex 1 No. 1.5.6 and 1.5.7 are implemented. Supplementary application of Directive 94/9 EC is principally not necessary, provided the machine is not operated in an explosive area.

2 Evaluation of hazards caused by fire or explosions

Within the framework of a study carried out by the Verein Deutscher Werkzeugmaschinenfabriken (VDW; Association of German machine tool manufacturers), about 150 fires involving the use of non water-miscible MWF were investigated in metalworking industries between 1987 and 1994. The causes for these fires are shown in the following Figure.

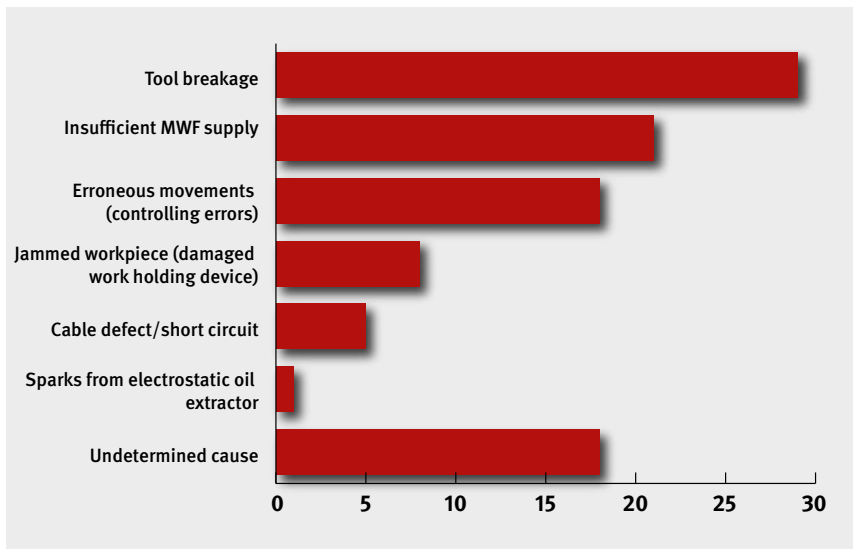


Figure 5 Causes of machine tool fires [1]

Most incidents were connected with the generation of incandescent chips, high-energy sparks or hot surfaces, which act as ignition sources. As a consequence of technical developments concerning feed and cutting speeds together with the trend towards low-viscosity metalworking fluids used at very high pressures, the fire risk has rather increased.

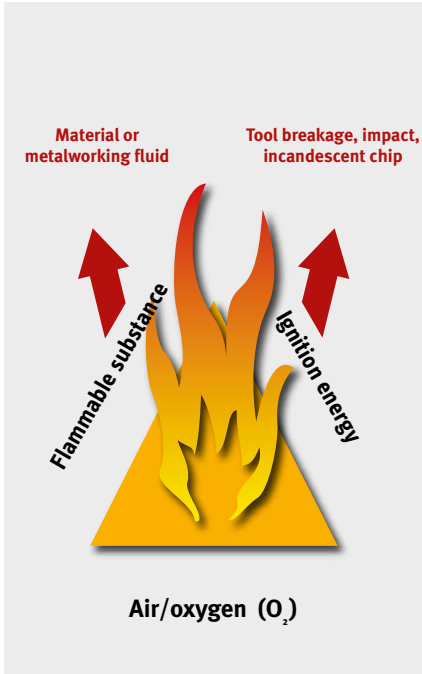


Figure 6 Preconditions for a fire



Figure 7 Reaction around grinding spindle

In the immediate vicinity of machining zone a reactive mixture of MWF and air is formed, which may be ignited by the above mentioned ignition sources. The resulting fire propagates very quickly through the whole interior of the machine tool. The pressure increase accompanying ignition is less important than in the case of an explosion inside a closed system. However, due to the pressure increase inside the machine, flame ejections may occur through gaps, pressed-open enclosure doors, feeding and chip-removal openings and pressure relief openings if no relevant provisions were taken.

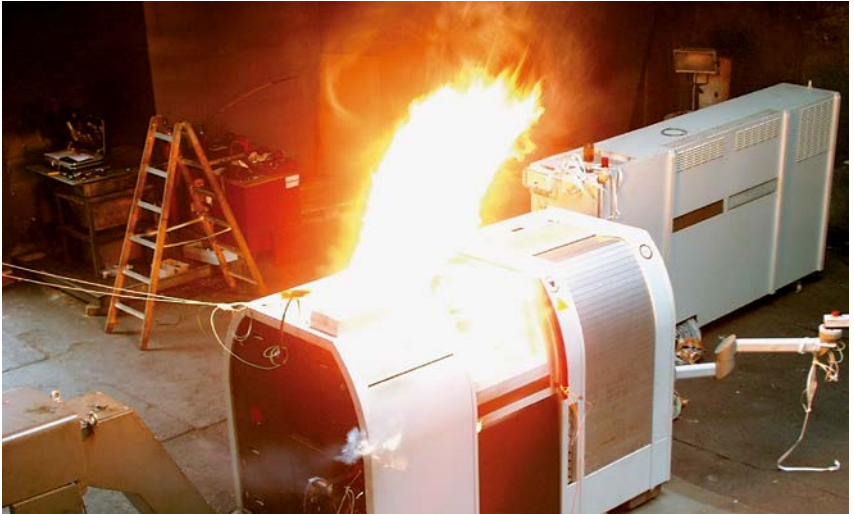


Figure 8 Ignition of an MWF/air mixture ...



Figure 9 ... with subsequent fire

In the framework of investigations on the ignitability of spray mists at the PTB Braunschweig [2] the following was determined for ignition sources:

- The ignition of MWF spray jets by electric sparks is possible at energies smaller than 10 Joules. Mechanical sparks may also provide a significant ignition hazard in the area around the cutting zone.
- Hot surfaces ($\geq 800\text{ °C}$) are very effective ignition sources. Hot surfaces are the main ignition sources of fires involving metalworking fluids in machine tools.



Figure 10 Flying sparks



Figure 11 Sparks during drilling

Often, the above mentioned ignition of the MWF/air mixture in the interior of the machine is followed by a subsequent fire. In case of flame ejections from openings and gaps, there is a risk that a machine fire flashes over to the surrounding area.

The risk assessment at the workplace should consider if a machine fire may propagate and flash over to other areas, which strongly depends on the “conditions” surrounding the machine. Liquid films and pools may also catch fire after ignition. The containment of such fires becomes easier as the viscosity and flashpoint of the MWF increases. The most frequent causes of the rapid propagation of a subsequent fire are oil pans filled to the rim and gratings with large surface areas, large-area MWF pools and other flammable materials (paper, cardboard, cleaning rags etc.).

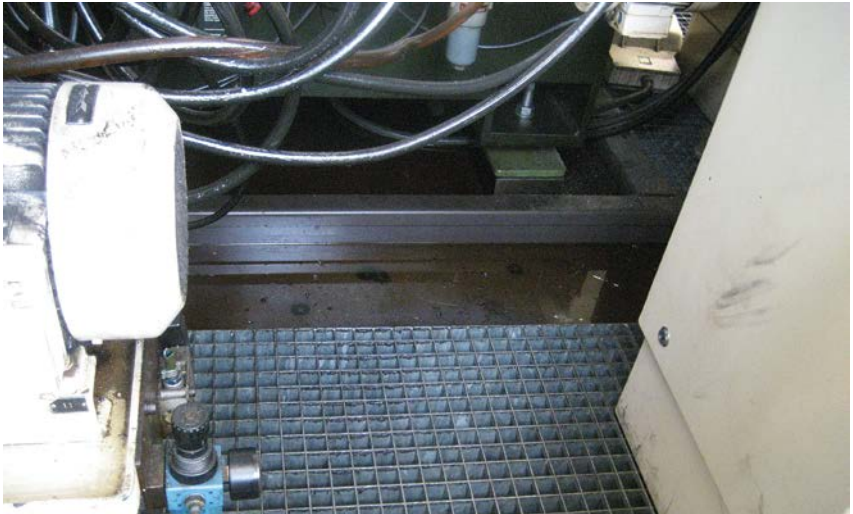


Figure 12 Oil-filled gratings with large surface areas



Figure 13 Machine tool in “oil bath”

3 Protective measures

“Everything under control”

When evaluating the work conditions according to § 5 of the German Safety at Work Act, the activities with dangerous substances, the use of machine tools, the work environment and the work space should be considered holistically.

The criterion for selecting a suitable machine tool is the health and safety of workers during its intended use. The requirements for the machine tool and the conditions for its provision should be specified on the basis of the hazard assessment.

See also: Technische Regel für Betriebssicherheit “Gefährdungsbeurteilung und sicherheitstechnische Bewertung” (TRBS 1111).

If these requirements are comprehensive, documentation (e. g. in the form of a specification) is reasonable, also with a view to the subsequent risk assessment at the workplace. In the specification, the conditions for production (use of certain materials, consideration of subsequent manufacturing units etc.) may, for example, be laid down.

On the basis of tests and investigations (PTB, IBEXU) a variety of protective measures were developed in the metalworking industries in order to minimize existing fire and explosion risks when using machine tools. The following chapters describe the protection concept and the sequence of the implementation of the measures for the execution of the risk assessment at the workplace (“The recurrent theme”):

Technical and engineering design measures

Priority measures are those which prevent fire or explosions, e. g.

- Choice of a metalworking fluid with a low hazard potential,
- Extraction of the oil mist from the work space,
- Prevention of oil pool formation,
- Prevention of ignition sources: cooling of the cutting zone by sufficient MWF flooding, process control.

As a fire or an explosion in the interior of the machine cannot be wholly excluded, the following measures, individually or possibly in combination, are, for example, suitable to minimize the consequences of a fire or an explosion:

- Installation of an automatic fire extinguishing system,
- Sufficient pressure resistance of the encapsulation,
- Labyrinths doors which resist flame propagation,
- Pressure relief valves if the pressure strength of the encapsulation is insufficient.

Specification of measures during risk assessment at the workplace

For the risk assessment at the workplace, the measures suitable for the relevant case are chosen from the above mentioned measures. After implementation, the employer should check, if:

- The measures are suitable and sufficiently effective,
- No new hazards have resulted from these measures.

If it is found that the measures are not sufficiently effective or that they cause new hazards, the process of risk assessment at the workplace should be repeated.

Information	Machine tool compatible with flammable MWF?	<ul style="list-style-type: none"> • Instructions for use • Intended use • Characteristics of machine tool
Flammable substance	MWF	<ul style="list-style-type: none"> • Low-emission MWF • MWF characteristics • Multifunction oil
Ignition sources, hot surfaces	MWF quantity MWF monitoring Tool monitoring	<ul style="list-style-type: none"> • MWF flow (VDI 3035) • Pressure/flow control • Frequency analysis
Technical and engineering measures	Requirements for machine	<ul style="list-style-type: none"> • Housing pressure/impact resistant • Door: labyrinth sealing
	Extraction system	<ul style="list-style-type: none"> • Suitable for use in areas with fire and explosion hazards • Volume flow monitored
	Pressure relief	<ul style="list-style-type: none"> • Dimensioning/place • Tested components
	Extinguishing system	<ul style="list-style-type: none"> • Manual/autom. extinguishing system • Suitable extinguishing agent
	Surrounding of machine tool	<ul style="list-style-type: none"> • Chip container • Oil pan • Flammable materials
Organizational measures	Instruction of workers	<ul style="list-style-type: none"> • CO₂ -backfire • Behaviour in case of fire • Operation extinguishing system
	Testing, maintenance	<ul style="list-style-type: none"> • Extinguishing system • Extraction system • Cleaning

Figure 14 „The recurring theme“: The process of risk assessment at the workplace

3.1 Selection of suitable metalworking fluids

Properties

During chip-forming machining, different emissions result from the metalworking fluid and machining process used. On one hand mechanical stresses on the metalworking fluid generate aerosols (particles of 0,5 to 50 µm of diameter), and on the other, thermal stresses on the metalworking fluid generate vapours or ultrafine aerosols [3].

Oil mists	Vapours
Oil particles between 0.1 and 50 µm Caused mechanically	Gaseous hydrocarbons Caused thermally
<ul style="list-style-type: none"> High MWF pressures and cutting speeds Impact of MWF on machine bed, tool and workpiece Nozzle shape and arrangement 	<ul style="list-style-type: none"> High feeds and cutting speeds Tool wear High MWF temperature High vaporization of MWF

Figure 15 Emissions during chip-forming machining

High mechanical and thermal loads at the cutting edge cause the metalworking fluids to atomize and vaporize. In the interior of the machine, a mixture of oil mist/ vapour and air is formed. The higher the thermal and mechanical stresses during the machining process, the higher the proportion of MWF vapours. The highest emissions have to be expected for machine tools with high cutting speeds and low-viscosity MWFs (e. g. during grinding).

By selecting low-emission metalworking fluids, MWF aerosols and vapours at the workplace can be reduced. Low-emission metalworking fluids are characterized by the following properties:

- Formulated with low-evaporation mineral oils or synthetic esters or special liquids, e.g. polyalphaolefins,
- Addition of anti-mist additives.


Tendency	Viscosity grade acc. to DIN ISO 3448	Viscosity at 40 °C acc. to DIN 51562	Flashpoint acc. to DIN EN ISO 2592 (CoC)	Evaporation losses at 250° acc. to DIN 51581-1, 2 (Noack procedure)	Examples of machining processes
 Decreasing fire and explosion hazard	ISO VG 5	4,14–5,06 mm ² /s	> 120 °C	< 85 %	Honing, reaming
	ISO VG 7	6,12–7,48 mm ² /s	> 145 °C	< 80 %	Grinding
	ISO VG 10	9–11 mm ² /s	> 155 °C	< 60 %	Deep hole drilling
	ISO VG 15	13,5–16,5 mm ² /s	> 190 °C	< 25 %	Turning, milling Drilling
	ISO VG 22	19,8–24,2 mm ² /s	> 200 °C	< 15 %	Threading
	ISO VG 32	28,8–35,2 mm ² /s	> 210 °C	< 13 %	Thread rolling
	ISO VG 46	41,4–50,6 mm ² /s	> 220 °C	< 11 %	Broaching

Table 2 Characteristics of non-water-miscible metalworking fluids

It is principally recommended to select the MWF with the lowest vaporization losses and the highest flash point at the viscosity required by the machining process, which should be as high as possible.

Example: Grinding with flammable MWF based on oil (non-water-miscible) MWF

Characteristics: – Flash point > 140 °C
 – Viscosity > 6 mm²/s at 40 °C
 – Vaporization losses at 250 °C < 80 %

Note:

With increasing viscosity, the filterability and the feed rate (flushing rate) of the oils in a given system decrease.

The formation of respiratory aerosols (particle size: 0,5 μm to 5 μm) can be reduced by using metalworking fluids with anti-mist additives. Anti-mist additives are especially effective in low-viscosity metalworking fluids such as grinding and honing oils.

The effect of the anti-mist additives may, however, “fade” with time due to mechanical and physical stresses (shearing at the machining point). Furthermore, certain anti-mist additives may lead to problems with the micro-filtration (10 μm filters, matt filters) of the MWF (e. g. obstruction, blocking of the filters). The suitability of the metalworking fluid for the process should therefore be agreed upon with the manufacturer.

If the MWF temperature is successfully monitored and the MWF is kept at room temperature by suitable measures, misting behavior can be significantly improved.

This can be achieved by:

- Sufficient quantities of MWF,
- Sufficient flooding of the cutting zone,
- Baffle plates for improved cooling,
- General cooling.

Investigations show that increasing the temperature of an MWF by 10 °C results in the doubling of aerosol formations.

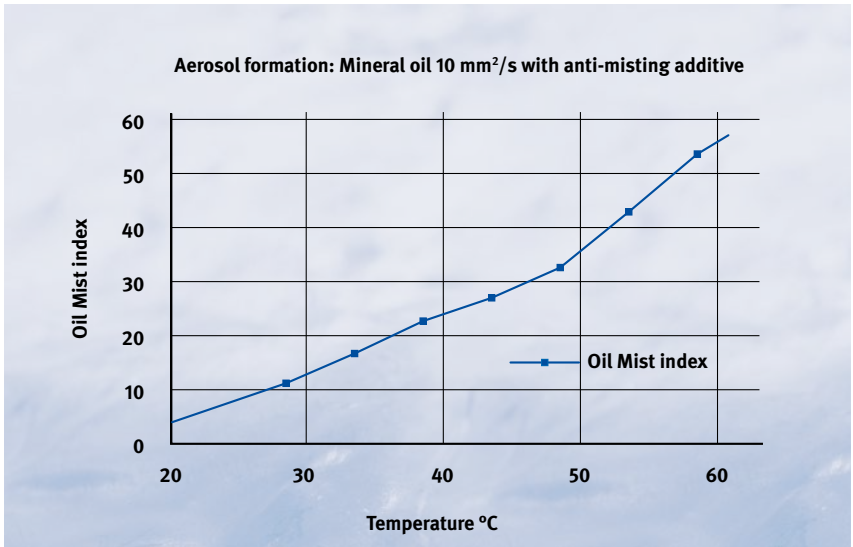


Figure 16 Temperature dependency of aerosol formation

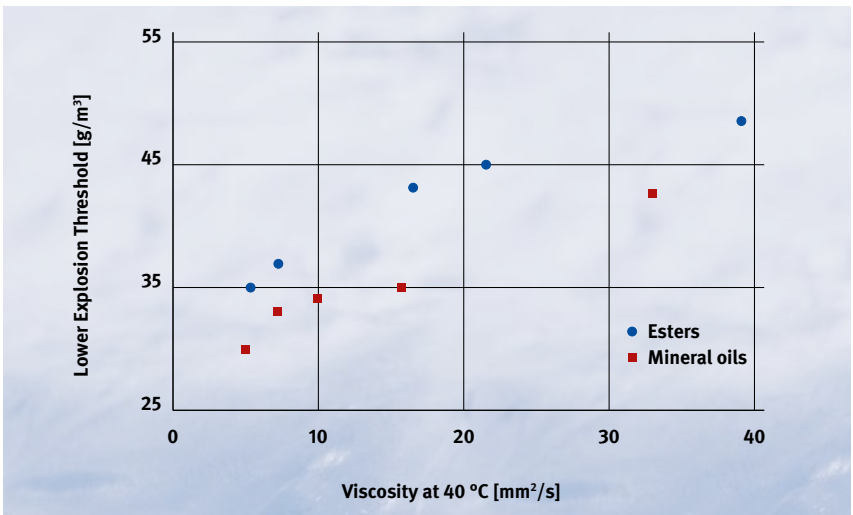


Figure 17 MWF - Lower explosion threshold; Influence of viscosity [6]

Besides the vaporization and misting behavior of the MWF, the following technical safety characteristics are relevant for the evaluation of the explosion risk:

- Lower explosion threshold in g/m^3 ,
- Maximum explosion pressure in bar (g),
- Maximum pressure increase, expressed by the K_p value in bar x m/s.

For MWF aerosols, the following values for the above characteristics are given in technical literature [4, 5, 6, 7]:

Lower explosion threshold	25 g/m^3 ... 60 g/m^3
Maximum explosion pressure	7,2 bar (g) ... 7,7 bar (g)
K_p value	75 bar x m/s ... 103 bar x m/s

The explosion pressures and K_p values are determined experimentally and are maximum values.

Use of multi-functional oils

In practice, mixtures of the metalworking fluid with other working substances may occur. As far as quantity is concerned, the most important tramp oil contamination of MWF circuits is caused by hydraulic oils. This may lead to a deterioration in the tribological properties of the MWF. The consequences are problems during machining, high tool wear through to tool breakage and machine damage.

The introduction of tramp oils and residues such as

- Machine cleaning and care products,
- Cleaning agents and solvents on workpieces,
- Tramp oils etc.,

into the metalworking fluid circuit of the machine tool should therefore be avoided as far as possible (information on MWF care see VDI 3397 Sheet 2, “Tätigkeiten mit Kühlschmierstoffen” BGR/GUV-R 143).

A possibility of reducing the above hazards is the use of compatible multi-functional oils (see VDI 3035). All lubricants used in the machine tool such as hydraulic oils, slideway oils, gear oils and spindle oils are matched to each other and fully compatible. Leakages then only have a very small influence on the metalworking fluid. Other advantages are increased process reliability and longer life of the metalworking fluid together with a reduction in servicing and maintenance expenditure.

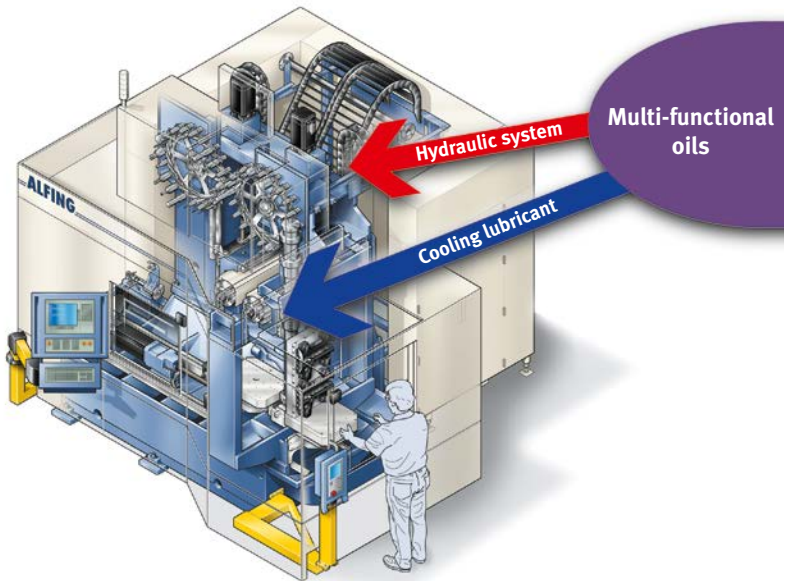


Figure 18 Multi-functional oils

3.2 Measures against hot surfaces and other sources of ignition

In most cases, machine fires during operation are started by an incandescent chip, a grinding spark or an overheated tool. Therefore, reliable and adequate cooling of the machining zone should be provided by the MWF.



Figure 19 Worn indexable cutting insert



Figure 20 Hot run drill as a source of ignition

Sufficient flushing quantities

The MWF circuit should be dimensioned (pipe cross-sections, storage tank, pumps etc.) so that a sufficient quantity of MWF is available to flood the cutting zone at all times and for every tool. The necessary quantity of MWF depends on the type of machine type and the machining process. For information on the design of the MWF circuit see VDI 3035, VDI 3397 Sheet 1. Measures for best possible flooding are e. g.:

- Cutting fluid flooding at low pressure (2 to 4 bar),
- Flushing (abrasive tools etc.) with 30 l/min at high pressure (up to 100 bar),
- Extinguishing of sparks with an additional MWF supply at the points of generation (e. g. lower nozzle during grinding).

The shape of the flushing nozzle (pressure, nozzle geometry and correct setting) is also relevant for the cooling effect and the degree of atomization. Flooding with large quantities and low pressures in the close vicinity of the tool is advantageous. By the installation of additional nozzles and their arrangement as “MWF rinsing curtains”, mist volumes can be further minimized. It is necessary to correctly adjust and direct the nozzles towards the workpiece/cutting zone area.

Monitoring of the MWF supply

The precondition for an optimum and safe process is ensuring sufficient MWF supply from the very start and during machining. The hazard of tool breakage is thus significantly reduced. For monitoring the MWF supply, switches for high and low pressure, flow control devices or monitoring of the pump motor currents are mainly used.

Generally, a monitoring and a functional test of the sensors (e. g. signal verification) should be carried out by the machine control system. In case of disruption or failure of the MWF supply, the control system induces a separation of tool and workpiece (emergency draw-back) and a shut-down of the machine drive.

Process and tool monitoring

A “hot running tool” or even a tool breakage are considered to be the most frequent causes of a machine fire. A “dull” worn-out drill often causes a sharp increase in temperature at the cutting point and thus may act as a source of ignition. Therefore, tools should be checked for their condition and be exchanged when their service life specified by the manufacturer has elapsed.

By means of process monitoring, the above situations affecting safety due to tool wear can be recognized and the machine stopped in time.

The following possibilities exist:

- Performance monitoring: Measurement of motor torque requirement at, for example the tool or workpiece spindle. Internal or separate device, easy handling, little susceptibility to malfunctions,
- Monitoring of the structure-borne noise: Measurement of the sound generated during machining. If a tool breaks, for example, the breakage signal clearly differs from the machining signal,
- Monitoring of the cutting force by sensors, e. g. piezo-quartz, elongation measuring tapes.

3.3 Technical and engineering design measures

3.3.1 Machine tool

Fire hazard

In order to avoid a fire or to limit its consequences, it is important to keep the “fire hazard” as low as possible. This is especially important in areas like the drive unit or on top of the machine, as these areas are generally not protected by extinguishing systems. Horizontal surfaces or areas with possible MWF pool formation or chip accumulation should be avoided. Slightly sloped machine tops facilitate the drain-off of cutting fluids.



Figure 21 Oil pool formation in the drive room

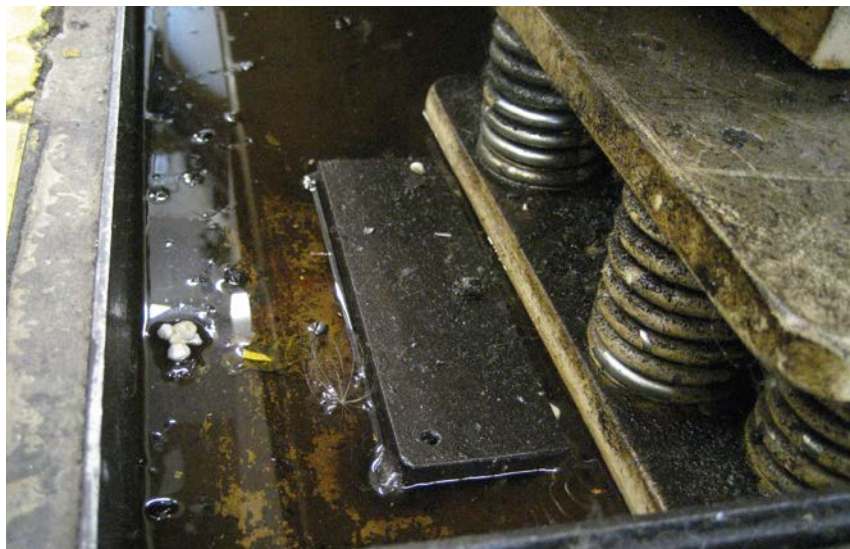


Figure 22 Machine tool in "oil bath"

Flame ejection from the machine

In case of an ignition of the MWF-air mixture and during fires, flames and hot gases may escape from the machine tool. The pressure increase in the interior of the machine causes flame ejections from door gaps, housing doors forced open, loading and unloading openings and pressure relief flaps. Flame ejections can also occur during flooding with extinguishing gas.



Figure 23 Flame ejection from a door labyrinth

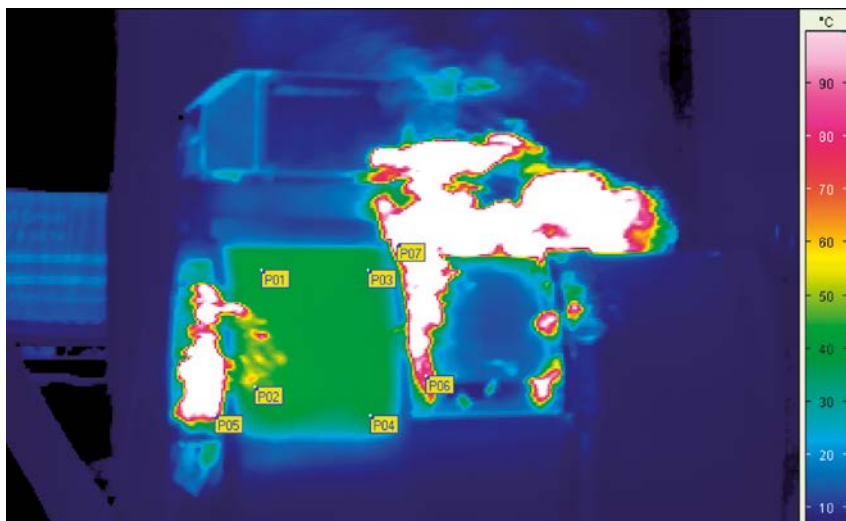


Figure 24 Temperatures during flame ejection from the door in the area of the machine operator

A hazard to the operator and the surrounding area by the ejection of flames and hot gases must be avoided. The following requirements are therefore specified for labyrinths in the area around the machine tool doors (see research reports VDW 3001/1 and VDW 3001/2):

- Flame propagation-inhibiting design: overlapping on both sides with several switch-backs and a maximum gap width of 2 mm. As to the fire hazard, the labyrinths should be so designed that no oil can accumulate,
- Reduction of the gap widths when the internal pressure increases (ignition of MWF mist) or when the door seals age. Construction of the doors so that they are forced into the machine housing and held in place along with a decrease in gap widths when the MWF ignites (see Figure 30),
- Design in a way that any ejection of flames or hot gases is not directed towards the area around the operator.



Figure 25 Detail of a sliding door designed for machining with emulsion



Figure 26 Detail of a sliding door with additional labyrinth for machining with neat oil

Furthermore the following should be taken into account:

- The safety distance at the doors in front of the labyrinth sealing is 30 cm (ejection area of hot gases with temperatures $> 60\text{ }^{\circ}\text{C}$).
- If parallel loading and machining is possible at the setting point of the pallet exchanger, the loading area should be separated from the working area with a flame retarding design
- Rubber or brush sealing is not recommended for technical fire protection reasons (Figure 28).
- Unavoidable openings such as workpiece openings should be carefully sealed, e.g. by flaps or sliders, which only release during a workpiece change.

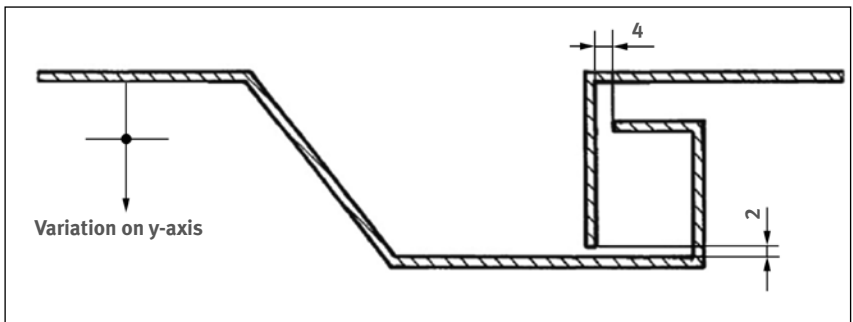


Figure 27 Door labyrinth resistant to the outbreak of flames (acc. to VDW 3001/1)



Figure 28 Door sealing not suitable for technical fire prevention and protection

Working area and enclosure

When an MWF-air mixture ignites, there is a danger of insufficiently pressure-resistant housing parts being ejected into the surrounding area, thus allowing the fire to propagate to adjacent machining areas.

The working area and encapsulation should have the following properties

- Pressure strength of the machining area encapsulation (doors, windows, telescopic covers and other covers) at least 0.1 bar,
- Design without large gaps, through which the combustion products may escape into the machine surroundings,
- Sealing-off of adjacent machine areas like handling area or drive unit,
- Doors should be secured against bursting open or off, for example, with circumferential wrap-arounds and/or locking bolts,
- Doors equipped with locking devices or interlocking controls,
- Transparent screens made of framed polycarbonate.

The mechanical containability and, if necessary, the exchange intervals of transparent screens (e.g. polycarbonate) should be considered. A sufficient overlap of the cladding panels on both sides should be provided for the framing (e.g. not en- chased in rubber). For more details see research reports VDW 0209 and VDW 0209/1, DIN EN ISO 23 125, DIN EN 12 417 and DIN EN 13 218.

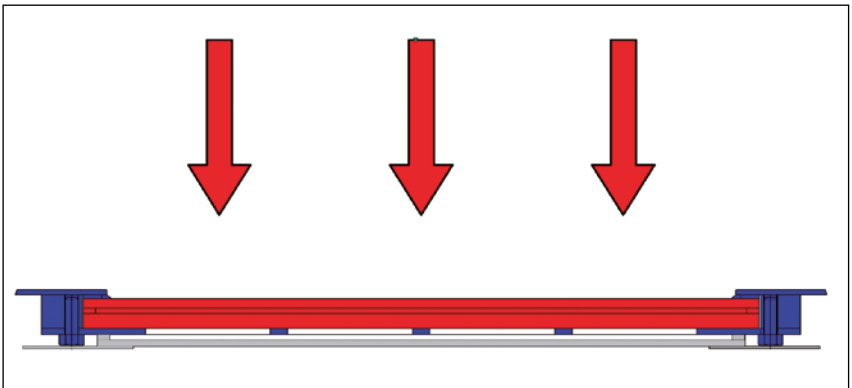


Figure 29 Mounting of transparent screens

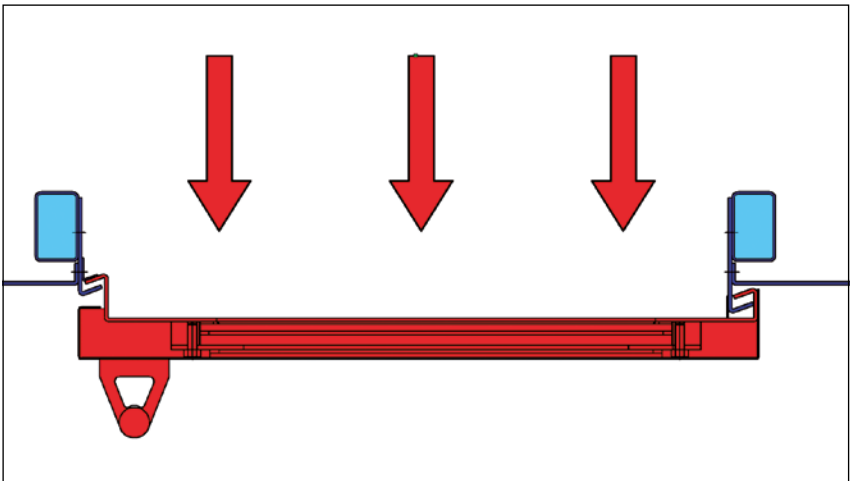


Figure 30 Door with wrap-around

Integration of controls into the overall concept

The optimum information exchange between the machine tool controls, the extraction unit and the automatic extinguishing system is the basis for the safe operation of the overall system. An example of the individual switch/control commands are shown in the flow chart.

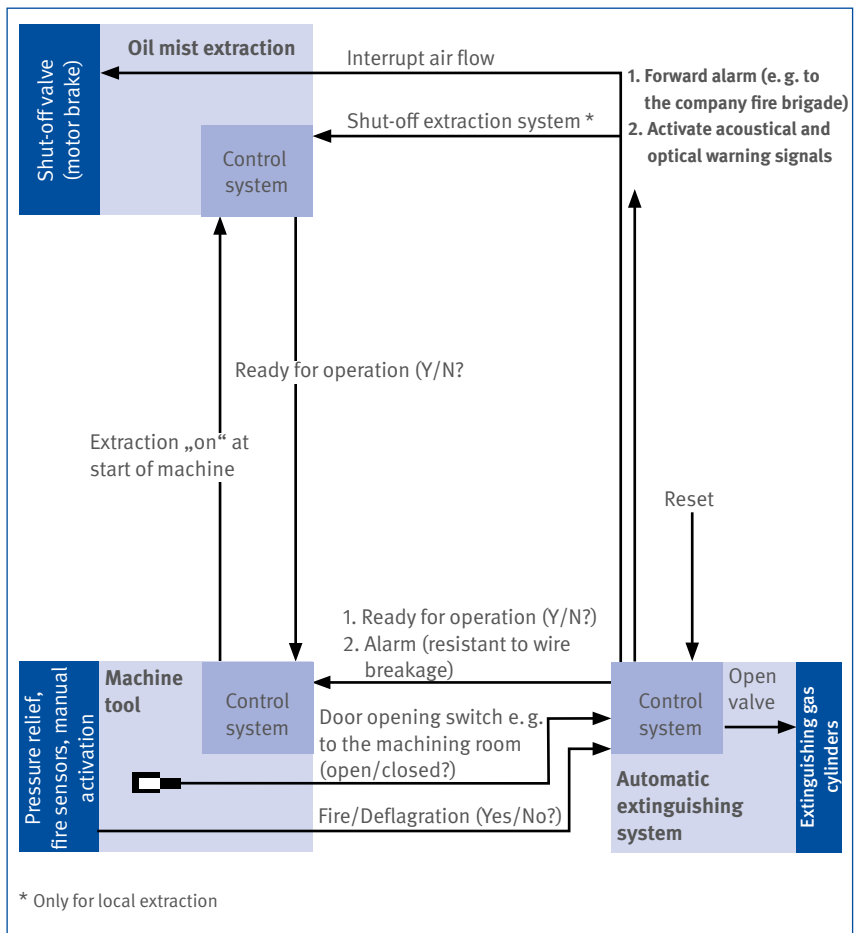


Figure 31 Switch/control commands between the machine tool, extraction system and automatic extinguishing system

It should only be possible to start the machine if

- The extraction and chip removal systems are ON,
- Door are locked and interlocked,
- The extinguishing system is ready to operate.

Indicated failures should be automatically notified and cleared without delay. Only then, may the system be started. When a fire is detected, the following machine control functions must be initiated:

- Stopping axes and drives as quickly as possible,
- Immediate halting of any metalworking fluid air purging,
- All covers must remain locked and interlocked shut,
- Shutting-down of the extraction system and closing of the exhaust air shut-off valve (this should stop the fresh air supply and prevent extraction of the extinguishing gas),
- Initiation of the extinguishing process (for extinguishing gas, e.g. CO₂, the possible time lag should be taken into account),
- Activation (optical and acoustic) of the alarm system,
- If applicable, isolation of the machining area (extinguishing area) and loading areas (for example, closing doors, blinds, etc.).

3.3.2 Extraction systems

During chip-forming operations in machine tools with defined and undefined cutting edge geometries using non water-miscible metalworking fluids (MWF), MWF mists and vapours are generated. In order to reduce enrichment of the flammable and possibly explosive MWF emissions inside the machine tool and in the immediate surroundings, they are captured, extracted and separated by extraction systems.

Separation systems for metalworking fluids

There are several filtration methods for the separation of metalworking fluids. The minimum requirements for the choice of the separator are the following:

- Observation of the pure gas values over the whole maintenance cycle,
- Low volume variation and observation of the minimum volume flow over the whole maintenance cycle,
- Safe observation of the pure gas values even during raw gas peaks,
- The safe discharge of the separated fluids/oils should be guaranteed.

Filtering separators

In filtering separators, the extracted air to be cleaned is passed through a porous medium, where the dispersed solid or aerosol particles are retained by various mechanisms.

There is a distinction between surface filters (see VDI 3677 Sheet 1) and depth filters (see VDI 3677 Part 2).

Electrostatic separators

The function of electrostatic separators is based on the physical principle of the deflection of electrostatically charged particles in an electrical field.

The solid and/or liquid particles contained in the extracted carrier gas (air) are unipolarly charged in the ionization zone. Separation takes place in the electrostatic field between charged plates in the downstream separation zone.

For further information on electrostatic separators see VDI Directive 3678 Sheet 2.

Inertia separators

In all inertia separators, the particles and aerosols are separated by means of inertia, gravitational or centrifugal force by aimed deflection from the gas flow. There is therefore a distinction between gravitational separators, deflection separators and centrifugal separators.

The most commonly used inertia separators for metalworking fluids are generally metal filters acting as pre-filters. They are especially used as pre-separator systems for non water-miscible metalworking fluids. For inertia separators, see also VDI 3676.

Design criteria of extraction systems with regard to fire and explosion prevention and protection

In general, systems for the extraction of flammable air impurities and explosive mixtures should be made of conductive or dischargeable electrostatic materials and should be earthed.

The precondition for the start of the machine is an operating extraction system maintaining the minimum volume flow/extracted air flow specified by the machine manufacturer (control e. g. by means of pressure or flow controls). If the required extraction rate is not achieved or in case of failure, the machine must be stopped. Delayed shutting-down may be incorporated into the control unit to allow machining cycles to end.



Figure 32 Pressure control



Figure 33 Flow monitors

Separators

- The separator should be designed so that no moving parts or electric equipment with surface temperatures above the ignition temperature of the extracted oil mists are on the intake gas side (ignition source free type).
- The extraction fan is on the air intake side.

- The extracted and cleaned air from the machine should be directed, if possible, into the open to minimize fire hazards inside the hall caused by residual emissions.
- As regards the machine tool, it should be checked if an ignition source can travel to the oil mist separator via the extraction ducts (e. g. hot chips). If this cannot be excluded, the oil mist separator must be integrated into the fire extinguishing concept of the machine tool.

Extraction capacity

In order to achieve the best possible degree of efficiency, the air should be extracted from a totally encapsulated machine tool. The optimum exchange of air inside the enclosure by appropriate supply air openings should also be ensured.

To avoid MWF aerosols and vapours escaping, low pressure must be maintained inside the enclosure. The air motion should always be directed towards the machining room and not vice versa. An air flow directed towards the machining room can, for example, be verified by misting tests.

- The reference value for the air flow velocity at enclosure openings into the machining room is 0.1 m/s [VDW 3001, Page 42].
- The extraction capacity should be individually adjustable via a throttle valve or a speed control at every extraction point.
- Depending on the machining process and the design of the machine tool, 100 to 300 air exchanges per hour in the machining area (m^3) of the machine tool are recommended.

Example:	Air exchanges x machining area	= extraction capacity
	300 h ⁻¹ air exchange x 1,5 m ³	
	work room	= 450 m ³ /h extraction capacity

Extraction point

The extraction point (connector) in the machine interior should be designed so that no coarser particles, metalworking fluid and chips can get into the extraction system and accumulate in the pipes. The optimum extraction of metalworking fluid emissions is achieved if the following criteria are taken into account or observed:

- Extraction point as far away as possible from the machining zone,
- Avoid lateral flows at the extraction point,
- Consideration of the arrangement of MWF nozzles, nozzle placing, main atomization direction and chip flight when selecting the extraction point,
- Installation of baffle plates or mechanical pre-separators. This avoids the introduction of MWF aerosols and chips into the extraction circuit,
- The air velocity at the extraction point should be as low as possible (≤ 8 m/s).

The desired flow rate (16 – 18 m/s) in the ducting can be achieved by reducing the duct cross-section after about the first meter.

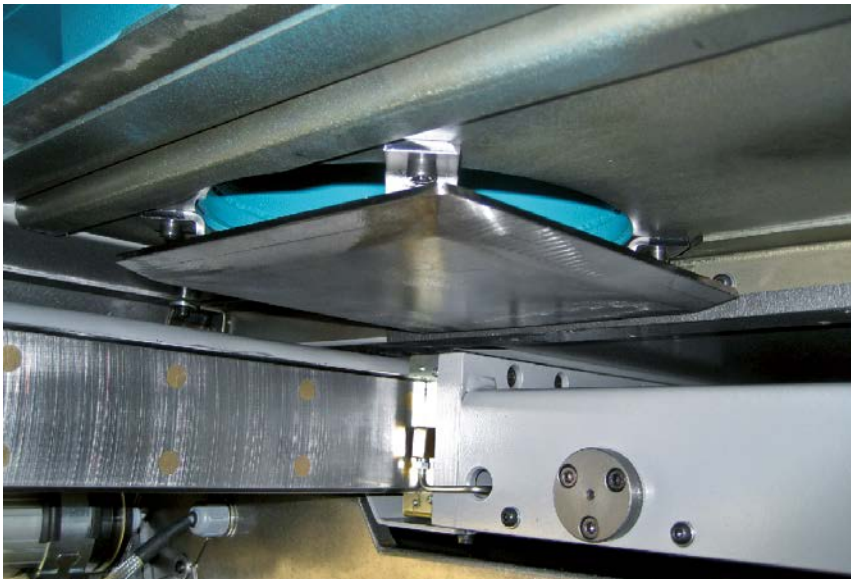


Figure 34 Baffle plate above extraction point



Figure 35 Clogged chip grating

Ducting

- Ducting should be non-inflammable and should not be electrostatically chargeable (ensure that ducting is earthed),
- No use of folded spiral-seam ducts,
- Ducting should be routed so that no introduced or condensed MWF can accumulate inside (avoid cavities and uneven ducting),
- Avoid flexible (corrugated) plastic pipes/hoses or the like if they are not compulsory for vibration isolation (if possible, fit vertically and keep as short as possible, only use electrostatically conductive materials; Figure 37).



Figure 36 Accumulation of oil in the extraction ducting



Figure 37 Connecting piece for vibration isolation: vertical, earthed

Protective measures“Everything under control”

- The flow velocity should be < 8 m/s at machine connections and between 16 – 18 m/s in the supply lines.
- For the interior control of the ducting (oil deposits and chip accumulations) control/inspection hatches should be installed at required intervals.
- For the drainage of condensed oil along the extraction piping/ducting, drainage pipes with suitable siphons capable of being adapting to the pressure level should be fitted. The drainage pipes should be easy to check and to clean.
- Rapid-action shut-off valves or flame arresters should be installed in the piping/ ducting at interfaces outside the machine.



Figure 38
Inspection holes



Figure 39
Inspection holes 2

Rapid-action shut-off valves and flame arresters

Rapid-action shut-off valves are intended to reduce the risk of flames entering the piping and ducting and propagating to other areas. In case of fire, the rapid-action shut-off valve seals-off the machine tool from the extraction system and vice versa. In addition, the rapid-action shut-off valve also serves to disconnect the machine tool in case of a malfunction or shut-off of the extraction system. The shut-off valve actuation signal may either be generated by the machine tool or directly from the central fire alarm system.

If a fire occurs in the machine tool, the shut-off valve immediately closes in order to protect the piping, ducting and extraction system. In addition, the quantity of extinguishing agent, e.g. CO₂, necessary for the machine tool is thus significantly reduced.

Ideally, the activation is via the machine tool, as it is then also possible to disconnect the extraction for the machine tool in question in case of a malfunction without the necessity of disabling the whole central extraction system.

The rapid-action shut-off valves should be appropriate to the actual set up. The valve should have the following characteristics:

- Non-flammable material,
- Closing time: < 1,5 sec,
- Final position monitoring,
- Closed without electrical power or pressure.

The piping/ducting should be protected against flame propagation to other areas by, for example, the installation of reliable flame arresters.



Figure 40
Shut-off valve for ex-
tracted air

Local extraction

Electrostatic or mechanical filters:

- Start-up of the machine should only be possible with the extraction system working.
- In case of fire, interruption of extraction within 10 – 30 s after detection (immediate activation), for example, by means of a motor brake or an automatic shut-off valve (the time delay until interruption of the air flow is determined by the programmed quantity of extinguishing agent released in the case of automatic extinguishing systems).

Central extraction

- Connection to a central extraction system is only permitted if no explosive substances or mixtures, e. g. from other processes, are present (information in the operating instructions!). This measure, among others, is necessary in order to avoid the propagation of fires into surrounding piping/ducting.
- Every effort should be made (baffle plates, mechanical pre-separators etc.) to ensure that as little MWF as possible enters the extraction system from each machine.
- Start-up of the machine should only be possible with the extraction system working.

- In order to avoid fire propagation, an automatic shut-off device (e.g. shut-off valve for extracted air) should be installed. Activation is generally by the extinguishing system control unit in the case of centrally operated systems.
- Any malfunction in the extraction system must be signalled. In case of a breakdown, the relevant machine tools must be shut-down at the end of the machining cycle if extraction cannot be ensured. This is necessary, if in case of breakdown of the system, explosive mixtures form, which could ignite after escaping from the machine enclosure.
- A malfunction inside a machine tool must be signalled. The machine tool is then isolated from the extraction system by means of a shut-off valve. The rest of the extraction system can remain in operation.
- In the flow monitor of an individual machine indicates malfunction, the machine should be shut-down at the end of the machining cycle.
- The extracted air shut-off valve should be closed if machines are not running or if in emergency-stop mode.

3.3.3 Pressure relief devices

In case the machine's encapsulation is insufficiently pressure-resistant, a potential injury hazard exists to persons if housing parts blow-off or flames eject when a MWF mixture is ignited. In such cases, a pressure relief device should be fitted for such pressure peaks.

The pressure relief valve has the purpose of releasing excess pressure generated by the ignition of a mixture to the machine's surroundings. Flames and hot combustion gases resulting from ignition should be directed to safe areas.

The pressure relief valve is usually installed in the cover of the machine tool. It is intended to relieve pressure as quickly and directly as possible and thus reduce risk to machine operators.

As machine enclosures often only have low pressure resistances ($\ll 100$ mbar), the response pressure of relief devices fitted to machine tools should be less than 5 mbar. The device only opens briefly and shuts back closed. This should prevent the rekindling of flames by the introduction of air as well as avoiding flame propagation.

Protective measures“Everything under control”



Figure 41 Pressure relief valve open

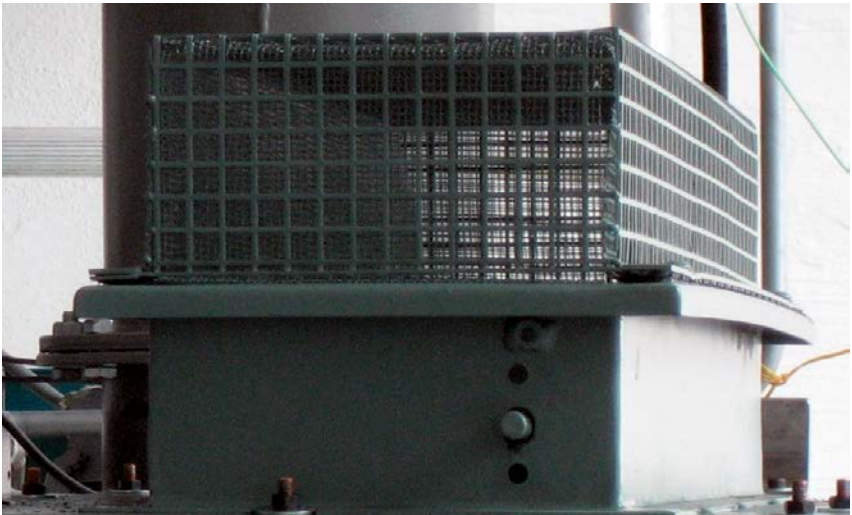


Figure 42 Pressure relief valve with wire cage, outside

When a MWF/air mixture ignites, long jets of flame may escape from the pressure relief device which pose a hazard to the surroundings of the machine. As a result, no flammable materials (wooden crates, insulation, etc) should be located above the pressure relief valve. A minimum distance to the hall ceiling should be maintained (details from the manufacturer of the pressure relief valve) in order to avoid the reflection of flames. Personnel should be instructed to keep the danger zones around and above the pressure relief device free.

Many pressure relief devices are also equipped with a wire mesh or fine wire gauze in order to hinder flames shooting out. However, such wire mesh guards affect the pressure relief process. In practice, such guards can represent an additional fire hazard if they are heavily wetted/polluted with oil and this also applies to the pressure relief device itself.

The possible danger of workpiece or tool parts being ejected through the pressure relief valve and the hazard of the pressure relief valve catching fire should also be taken into account during planning.



Figure 43 Flame ejection from a pressure relief valve



Figure 44 After-Fire subsequent to extinguishing

As a rule of thumb for dimensioning, the companies Total Walther GmbH, Cologne, and Deutsche Montan Technologie (DMT), Dortmund have, based on tests, determined that a minimum pressure relief area of 0.1 m^2 per m^3 of encapsulated volume is satisfactory. For higher strength enclosures, it may be reduced (e. g. $0,05 \text{ m}^2$ per m^3 enclosed volume) or replaced by alternative concepts (e. g. opening of the chip conveyor into safe areas).

A more detailed design including transfer to common pressure relief devices may be carried out according to research report VDW 3002.

3.3.4 Fire prevention and protection

3.3.4.1 Extinguishing agent

Extinguishing agents for fires of flammable metalworking fluids can be:

- Extinguishing gases, e. g. oxygen displacing gases like CO_2 , N_2 , inert gases and their mixtures,
- Water (using water atomizing technology, water misting technology),
- Foam,
- Powders of fire classes ABC or BC (oil fires correspond to fire class B).

Attention:

If carbon dioxide is used as the extinguishing agent, health hazards have to be anticipated at concentrations of 5 per cent by volume or more. Concentrations of more than 8 per cent by volume can pose a danger to life (see “Regeln für Sicherheit und Gesundheitsschutz bei der Arbeit – Einsatz von Feuerlöschanlagen mit sauerstoffverdrängenden Gasen” BGR 134).

Metal fires (e. g. Mg, Al, Ti) **cannot** be extinguished with extinguishing agents of fire classes A, B and C! At present, inert gases (e. g. argon) and powder extinguishing agents of fire class 4 exist for the fighting of metal fires. Suitability for the extinguishing of metal fires must be proven for all other extinguishing agents.

Some extinguishing agents (e. g. extinguishing powders) do not extinguish without leaving residues and may pollute machines and the surroundings.

Extinguishing of machine fires

If the operation of a machine tool involves a high risk of fire, integrated fire alarm and extinguishing systems must be installed (DIN EN 13 478). Here, the order should be as follows:

- Manual extinguishing system,
- Fire alarm system in combination with a manually operated extinguishing system,
- Fire alarm system in combination with an automatic extinguishing system.

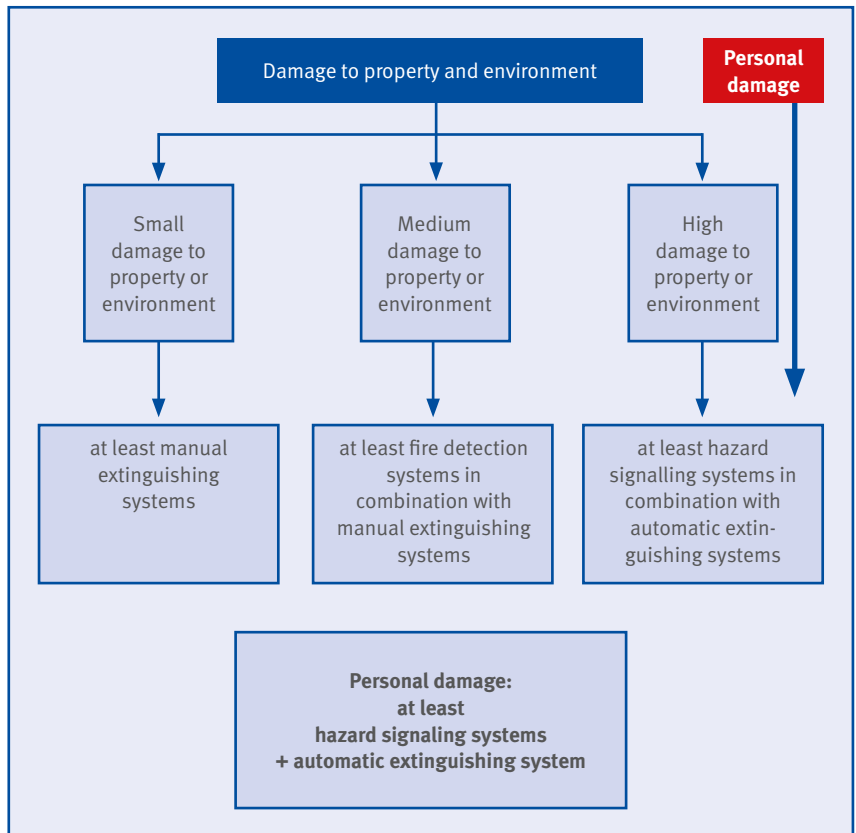


Figure 45 Choice of suitable extinguishing systems

In practice, the implementation ranges from a fixed fire extinguisher with corresponding piping to a fire alarm system coupled to an automatic extinguishing system.

The choice of the extinguishing method and the integrated fire alarm and extinguishing systems used for machine tools depends on the degree of potential hazard to persons, property and the environment.

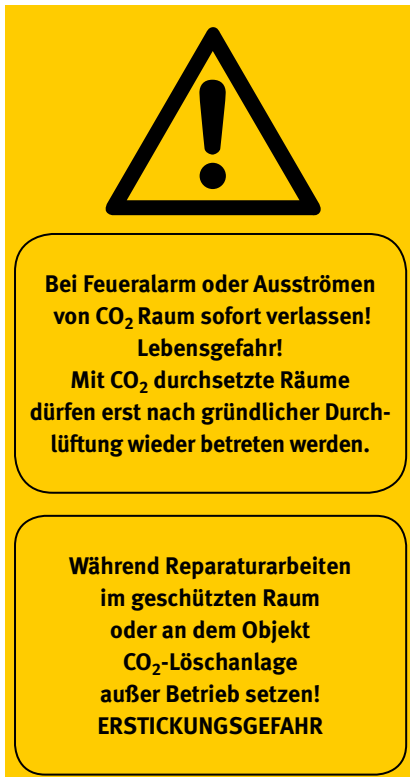


Figure 46 Warning notice for CO₂ extinguishing gas



Figure 47 MWF ignition during grinding with subsequent fire

The fast detection and the fast extinguishing of a fire by automatic fire extinguishing systems is essential, depending on the degree of risk of:

- Personal injury,
- Heavy damage to assets and the environment,
- Hazards of subsequent metal fire.



Figure 48 Extinguishing after fire detection

3.3.4.2 *Manual extinguishing*

For manual extinguishing, portable or mobile fire extinguishing devices are generally used. Suitable fire extinguishing devices must be available in sufficient number and size and in the vicinity of the machine tool (see “Ausrüstung von Arbeitsstätten mit Feuerlöschern” BGR/GUV-R 133).

Prior to the start of manual extinguishing it should be ensured that

- The local extraction system is disabled,
 - The metalworking fluid supply and the purging air supply is interrupted
- and
- The machine is in a safe state.

This can, for example, be realized by activating the machine’s central emergency stop.

If a fire is to be extinguished manually, machine doors must only be opened by specially instructed personnel or by the fire service.

By opening machine doors, atmospheric oxygen can enter the machining area resulting in the hazard of

- Fanning the fire,
 - Backfiring
- and
- Flame ejections.

Another possibility is extinguishing through an extinguishing hole, which is easily opened (e. g. pushed open) in the case of fire. In practice, special holes through which fire-fighting lances can be held, have been proven of value. After the extinguishing holes or openings in the machining room door have been opened, the source of the fire can be extinguished by introducing an extinguishing lance or a fire extinguisher hose by the company fire service or by specially trained personnel.



Figure 49 Extinguishing hole with marking and information



Figure 50 Machine tool extinguishing hole

The extinguishing hole should be positioned so that the entire machining room can be flooded. Open extinguishing holes should not cause other hazards (e. g. ejection of workpieces, crushing or trapping hazards for personnel).

3.3.4.3 *Fixed fire extinguishing systems*

For the protection of machine tools, automatic extinguishing systems with gaseous extinguishing agents or water atomization technology are generally used. The aim is the extinguishing of the any burning metalworking fluids (oil fires). When a central extraction system is used, the use of an automatic fire extinguishing system is generally recommended because of the higher hazard potential.

In individual cases, when risks are low and where no unattended operation is possible, machine tools may also be equipped with manually activated fire extinguishing systems. It has to be ensured that a fire is detected as early as possible (e. g. by means of automatic fire detection) and that the fire extinguishing system is activated without delay.

An automatic extinguishing system for machine tools consists of, among others, the following components:

- Fire detection elements (in the machining room of the machine tool and at other places, where fire hazards exist, e. g. extraction system, chip conveyors),
- Fire alarm centre and/or control device (fire detection, alarming, monitoring and control of the extinguishing system, if applicable, control of equipment like machine shut-down, shut-off or closing of the extraction system – see Figure 51),
- Manual activation (at the control panel or in the vicinity of the machine)
- Extinguishing agent tank (including loss monitoring device) and distributor pipe circuit into the interior of the machine,
- Extinguishing nozzles (appropriate arrangement inside the machine, in order to uniformly distribute the extinguishing agent over the entire extinguishing area),
- Alarming devices, optical and acoustic (acoustic alarms must be at least 5 dB louder than the background noise),
- If applicable, interlocking option for the extinguishing system,

- If applicable, time switch (electrical, non-electrical),
- If applicable pressure relief device.

Extinguishing systems should conform to the state-of-the-art. Relevant information is e. g. contained in

- The standard series DIN EN 12 094 for gas extinguishing system components,
- The regulations (e. g. Regulation „Einsatz von Feuerlöschanlagen mit sauerstoffverdrängenden Gasen“ (BGR 134), Information „Sicherheitseinrichtungen beim Einsatz von Feuerlöschanlagen mit Löschgasen“ (BGI 888), Principle „Grundsätze für die Prüfung von Feuerlöschanlagen mit sauerstoffverdrängenden Gasen“ (BGG 920),
- VdS-Richtlinien für Planung und Einbau von Löschanlagen (z. B. VdS 2093).

Water mist systems must be specified for the relevant application. In addition, the efficiency and reliability should be verified by means of fire and extinguishing tests and corresponding component and system tests (see e. g. European Technical Specification DIN/CEN TS 14972 for water mist systems).

Design, planning and installation

When designing the extinguishing system, the parts of the machine tool which should be protected, e. g. the interior of the machine (with or without extraction) are specified with regard to the risk. The planning and project development of the fire detection and extinguishing system is carried out on the basis of these specifications.

For orientation and estimation of the quantity of extinguishing agent needed for automatic CO₂ extinguishing systems, a reference value of 5 kg CO₂ per m³ protection volume applies (extinguishing area).

The exact value should be determined for each machine/system in accordance with the Rules of Technology (e. g. VdS 2093).

Extinguishing agent losses, which can e.g. be reduced by rapid machine shut-downs, short extraction overruns and small openings in the machine enclosure should also be considered.

When calculating extinguishing agent quantities, the extraction system and its overrun should also be considered.

When gas extinguishing systems are used, there should be sufficient pressure release possibilities fitted to the machine to allow the pressure build-up after release of the extinguishing agent to be vented. Existing openings or pressure relief valves often suffice for explosion protection. However, this must be checked.

Design and construction criteria are e. g. published by “VdS Schadenverhütung GmbH” (testing and certification institution for the prevention of damage), (see www.vds.de).

The planning and installation of the fire extinguishing system should be done by a specialist company, if possible, in collaboration with the machine tool manufacturer.

Preconditions for operation

For a safe operation of machine tool extinguishing systems, the following should be taken into consideration:

- Electrical supply and control of the extinguishing system (including emergency electrical supply) should be independent from the machine tool,
- Interlocking option (blocking) of the extinguishing gas supply for personnel protection, e. g. during setting and maintenance work (non-electrical blocking device or electrical if an equivalent level of safety is ensured),
- Regular testing of the amount of extinguishing agent in the tank, e. g. by monitoring the extinguishing agent pressure and/or by an automatic weighing devices. Due to its physical properties, CO₂ cylinders cannot be monitored by testing the pressure.



Figure 51 Weighing device



Figure 52 Fire alarm centre with manual activation

Activation of extinguishing process

When evaluating the personnel hazards caused by extinguishing gases and the extinguishing gas concentration inside the machine and its surroundings, the specific ambient conditions always have to be taken into account (e.g. size of the machine, openings, size of the surrounding area, propagation of the extinguishing gas into the environment, if applicable, rooms below).

The above evaluation results in requirements for alarming and delay. The relevant regulations contain advice and specifications (see Regulation BGR 134 and the Information BGI 888).

For the safe activation of the machine tool extinguishing process, the following should be taken into consideration:

- When the extinguishing system activates, extraction flows and metalworking fluid supplies must be interrupted and the machine drive shut-down.
- The extinguishing system can be activated manually or automatically.
Caution: Effusion of the extinguishing agent may lead to flames escaping through openings and enclosure gaps.
- In the case of gas extinguishing systems, the time delay should be considered (personnel protection measures, interruption of extraction flows). For water mist systems, there is generally no delay.
- After every activation, the extinguishing agent tanks must be refilled (no multiple use possible as the containers are always completely emptied).

3.3.4.4 *Fire detection elements*

Fire detection elements are a key criterion for fire protection. They must guarantee the safe detection of fires in a fast and reliable way and activate the extinguishing process via the control system.

For automatic activation of the extinguishing system

- Thermal fire detection elements (e. g. thermo elements, bimetals)

and

- Optical fire detection elements (IR, UV) are available. Suitability should be tested for each individual case.

Thermal fire detection elements react slower than optical systems and are thus sometimes used in combination with optical sensors.

MWF mist is only partly permeable by UV radiation (depending on oil mist density). The use of UV sensors is preferable for dry machining and in areas free of MWF mists. The suitability of UV sensors should therefore be tested in each individual case.

Optical sensors must be kept clean. This is done, for example, by air purging. The functions “cable breakage” and “window malfunction” should also be monitored (the optical detector controls itself for vision).

Fire detection equipment must correspond to the state-of-the-art (e.g. DIN EN 12 094-9). For planning and installation, the manufacturer’s specifications and the rules of technology should be taken into account besides risk-specific aspects.

Special solutions must be specified for each application and their efficiency and reliability must be verified by fire tests and tests of the relevant components and systems.



Figure 53 Fire detection elements (optical sensor) with purging air

3.3.4.5 Extinguishing nozzles

The extinguishing nozzles must be compatible with corresponding extinguishing agent and application and be suitably arranged e.g. they should not be directed towards door labyrinths). Consultation with the manufacturer is recommended!

When using CO₂ extinguishing systems, the extinguishing agent is stored as a liquid in storage tanks (extinguishing gas cylinders). Gasification only occurs at the extinguishing nozzles and must be complete.

The other extinguishing gases mentioned are generally stored in a gaseous state.



Figure 54 Extinguishing nozzle in operation

3.3.4.6 Organisational measures for fire prevention and protection in the machine tool surroundings

In order to avoid propagation of a machine fire to its surroundings and personal injury during a fire or extinguishing, general rules of behaviour in case of fire and general rules of preventive fire protection must be observed (see also Information “Arbeitssicherheit durch vorbeugenden Brandschutz” BGI/GUV-I 560).

This includes:

- Reduction of combustible substances near to the machine (flammable materials, cardboard, oil),
- Provision of a sufficient number of manual fire extinguishers (BGR/GUV-R 133),
- Enforcing smoking prohibition,
- Keeping emergency exits, escape and rescue routes free,
- Behaviour in the case of fire: rescue chain, emergency calls, fire service.

Whether a machine fire can propagate and flash over to other areas is strongly dependent on the “conditions” surrounding the machine. The most frequent causes for the fast propagation of a subsequent fire are oil pans filled to the rim and gratings with large surfaces, large-area MWF pools and other flammable materials (paper, cardboard, cleaning rags etc.).



Figure 55 Oil-filled gratings with large surface areas

Protective measures“Everything under control”

To reduce fire hazards, there should be as few combustible materials in the immediate vicinity of a machine tool as possible. Packing materials or oil-soaked cleaning rags should, under no circumstances, be stored in the immediate vicinity. Regular emptying and cleaning of oil pans and gratings (provide drains, use oil extractors) and the disposal of cardboard boxes and oil-soaked rags significantly reduces fire hazards.

Attention:

Oil and grease on used cleaning materials wick and have large surface areas.

Under certain circumstances (temperature, pressure), MWF-soaked rags can self-ignite. Such “ignition sources” have repeatedly caused fires in chip containers, machine interiors and open waste containers. As a result, used and soiled cleaning materials should be kept in non-flammable, closed containers.



Figure 56 Source of ignition in the chip container



Figure 57 Fire hazard near to a machine

Furthermore, the chip containers should be emptied regularly in order to reduce the fire hazard and prevent possible self-ignition. If the chips are stored for several days and the volume of chips generates high internal loads, exothermic reactions may cause a heating process which could possibly lead to self-ignition.

Also cigarette ends and combustible materials (cleaning rags, cardboard boxes, paper cups) should not be thrown into chip containers. Furthermore, observance of a general ban on smoking is indispensable in these areas.

4 Use of machinery – Requirements of companies

The measures necessary for a new machine are not always necessary for machines which have been in operation for a longer period of time. However, also “established” machines need to be evaluated to determine whether supplementary measures are necessary according to Annex 1 of the BetrSichV (German Industrial Safety Regulations).

These may, for example, include:

- Use of low-emission metalworking fluids,
- Connection to an extraction system,
- Technical isolation of machine tool and extraction system with regard to fire protection,
- Training of workers.

The employer should take measures to ensure that the machine is tested for defects prior to use and that it operates as flawlessly as possible during use. Machine tools must only be operated by qualified, trained or appointed workers or under their supervision.

The protective measures specified by the manufacturer must be observed by the workers during use of the equipment; it is especially important to use the protective devices, and not to disable make. When defects are identified which could effect the safety workers, the machine tool should not be used. If such defects are found during operation, the machine must be shut-down.

The requirements for operation, marking, training of workers and regular testing and inspection also apply to automatic extinguishing systems fitted to machine tools. For extinguishing systems with gaseous extinguishing agents, e. g. CO₂, the relevant regulations, in particular, of the Berufsgenossenschaften must be observed (see also BGR 134, BGI 888). Information on maintaining the operational reliability of fire extinguishing systems is also contained in the relevant VdS Directives for planning and installation or in the VdS leaflets.

5 Instructions – Behaviour of workers in case of fire

The employer shall instruct the insured persons (employees) in accordance with the requirements of the German safety at work act and the accident prevention regulation “Grundsätze der Prävention” (Principles of prevention; BGV/GUV-V A1). These instructions inform workers of the hazards resulting from their activities and on the preventive measures. Instruction shall be carried out prior to the beginning of the job and be repeated at regular time intervals but at least once a year.

For activities at machine tools using flammable metalworking fluids, aspects concerning fire and explosion protection should also be addressed within the framework of the training. This includes the general rules of behaviour in case of fire and the general rules of preventive fire protection as e. g. behaviour in case of fire: rescue chain, emergency calls, fire service (compare BGI/GUV-I 560 and clause 3.3.4.6). In addition, the fire and explosion hazards during use of flammable metalworking fluids in machine tools described in detail in the following and suitable protective measures should be explained.

In principle, the instruction includes briefing on the function, operation and handling of installed safety devices, such as e. g. extinguishing systems. In this context, the worker should be informed that optical sensors of extinguishing systems may also respond to light flashes occurring during operation. In order to exclude faulty activation of extinguishing systems, the use of lighters and welding equipment in the vicinity of a machine tool equipped with the aforementioned sensors should be avoided.

If a fire happens in spite of the above-mentioned preventive measures, sudden flame ejections have to be expected especially around the area of machine tool openings (e. g. door gaps or pressure relief valves). This hazard also exists if the machine tool is equipped with an extinguishing system. The abrupt release of extinguishing gases (generally CO₂), may intensify flame ejections.

In addition, workers should be informed that the extinguishing gas released – especially in small and badly vented rooms – may cause an asphyxiation hazard besides generating fumes and smoke.



Figure 58 Warning sign for CO₂ extinguishing gas hazards

Generally, manual fire fighting should be carried out exclusively by the company fire service or by specially trained persons. It should only be carried out, if hazards are excluded. It is therefore worthwhile to inform the workers of the special hazards which can occur during the extinguishing of machine fires and the activation of extinguishing measures.

Thus, the hazard of an abrupt outbreak or backfire of unburned MWF when machine doors are opened, cannot be excluded. No oil-soiled or oil-soaked clothing should be worn in order to avoid clothing fires caused by escaping flames. Also fire-resistant textiles can catch fire, if they are wetted with flammable liquids (wicking).

Furthermore, particularly metallic machine parts and surfaces should not be touched after a fire because they may be extremely hot and electrocution hazards caused by charred cables cannot be excluded.

6 Testing and inspection

Tests have the purpose of the timely detection and repair of damage as well as ensuring safe operation. Machine tools must be tested for safety

- Prior to initial commissioning,
- Recurrently,
- After maintenance work which may affect safety,

with regard to correct assembly and safe function by competent persons. Information about tests on machine tools and protection devices and check lists are given in “Maschinen der Zerspanung” (BGI 5003). A supplementary inspection by competent persons is especially required after fires.

For the testing of working equipment, the precise proceedings for the identification of test type, test scope and test time limit and the qualification of the person to be appointed to carry out the test are described in the TRBS 1201. Requirements for the qualification of the competent person are given in TRBS 1203.

The employer must record the test results. The records shall be kept for an appropriate period of time but at least until the next test. The required mandatory tests with regard to fire and explosion hazards include:

Extinguishing systems in accordance with BGR 134 and BGI 888

Depending on the regulation, the following extinguishing systems tests are required with regard to safe functioning (asset protection) and personal protection:

Approval test

Depending the potential degree of hazards to personnel, an approval test must be carried out within 6 months of commissioning after installation or major alterations to the system. In addition, preparation of a test report detailing observance of the requirements or an approval protocol is required (see BGR 134 No. 6.2).

Routine tests

The correct functioning of the extinguishing system should be carried out at least once a year or as needed (e. g. after fire damage). In practice, the test is generally carried out within the framework of servicing and maintenance work by the installing company.

A test by independent third parties/experts (also replaces tests by competent persons) is required at least every 2 years. Tests by competent persons and by experts are possible every alternate year.

The results of the tests must be recorded in a test book or a test report and stored for at least 4 years.

The documents of the approval test must be stored over the whole operation period of the extinguishing system.

Ventilation systems in accordance with “Arbeitsplatzlüftung – Lufttechnische Maßnahmen” (BGR 121)

Ventilation systems must be tested for correct installation, functioning and assembly

- Prior to initial commissioning,
- At routine intervals, but at least once a year,
- Following major alterations

by a competent person according to the company safety ordinance. The test results should be recorded in a test book or test report (see also §§ 3 and 10 of the BetrSichV).

Note:

The testing prior to initial commissioning (approval test) includes tests for completeness and proper function as well as a functional measurement in line with DIN EN 12599 “Ventilation for buildings - Test procedures and measuring methods for handing over installed ventilation and air conditioning systems: German version EN 12599:2000“.

Testing at routine intervals comprises functional measurements along with the inspection of the individual system parts according to VDMA 24176 “Inspektion von lufttechnischen und anderen technischen Ausrüstungen in Gebäuden”.

Major changes are, for example

- Exchange of non-equivalent system components,
- Modifications to air gaps, measuring components and line ducting,
- Extension or down-sizing of the system.

Annex 1

Legal basis – Requirements for placing on the market

1. General

Requirements for machines are uniformly regulated in the single European market. Within the concept of the “New Approach”, new machines may fall under the scope of several EU Directives and their configuration must then comply with all the relevant EU Directives.

A product may only be placed on the market, if it complies with the regulations of all applicable directives and if a conformity assessment was carried out in accordance with all applicable directives. The manufacturer identifies the directive under which a product falls in based on a risk analysis of the product and, if applicable, an analysis of the application intended by him – or by the client. That means that the intended use of a machine has a decisive influence on the directives to be considered for the conformity assessment which can be adopted into national legislation by a ProdSG (Product Safety Act) ordinance.

If two or more directives apply to the same product or the same hazard, the application of other directives may be omitted after a procedure including a risk analysis of the product with regard to the intended use defined by the manufacturer is performed. In the case of machine tools, the manufacturer may, for example, omit the application of Directive 94/9/EC. In this particular case, the explosion risk is sufficiently covered by the measures specified in the Machinery Directive.

Depending on the intended use of the machine, different case configurations are possible.

The future user of a machine and/or the client of the machine manufacturer, must observe the safety regulations valid in the Federal Republic of Germany when installing and using the machine. With regard to the health and safety of workers, these are the national and BG regulations for the protection of worker’s health and safety; added to these are regulations from other areas of legislation such as the requirements for fire protection contained in the law on buildings (e. g. with regard to requirements for extraction systems) and for environmental protection.

Last but not least, requirements from the area of property insurance, e. g. for fire protection, may also exist.

2. Requirements of the Machinery Directive 2006/42/EC

For machine tools, the Directive 2006/42/EC, also called “Machinery Directive” should be used which is being implemented into national law by the 9th ordinance to the “Produktsicherheitsgesetz” (9. ProdSV) (Product Safety Act).

Annex I, clauses 1.5.6 and 1.5.7 of the Directive 2006/42/EC state that machines shall be designed and constructed in a way to exclude any risk of fire and avoid any explosion hazard. In Annex I under 1.1.2 b, the Machinery Directive requires the safe design of machines; applying the principle of intrinsic safety. For this purpose, the necessary protective measures must be taken. In addition, it is required to stipulate the hazards which cannot be avoided in the instruction handbook.

The standards DIN EN 13 478 “Safety of machinery – Fire prevention and protection” and DIN EN 1127-1 “Explosive atmospheres – Explosion prevention and protection – Part 1: Basic concepts and methodology” may provide assistance – but only in a very generalized manner however – in the area of fire prevention and protection and provide guidelines for explosion prevention and protection for machines.

If in the interior of machine enclosures, the formation of a hazardous explosive atmosphere cannot be safely avoided, constructive measures must be taken, which limit the effects of a possible explosion to a harmless level. These include pressure relief devices.

3. Applications of Directive 94/9/EC

While assessing his product for risk, a manufacturer should also identify if it might be subject to the Directive 94/9/EC (also called “ATEX 95”). The Directive 94/9/EC regulates the technical safety requirements for equipment, components and protection systems intended for use in explosive areas as well as associated safety and control devices. The Directive was implemented into national legislation by the 11th ordinance for the “Produktsicherheitsgesetz” (Product Safety Act) – of December 2011.

However, if an explosive mixture is only present within the machine and its encapsulation and not, for example, in a connected extraction duct, then the whole machine is not subject to the Directive 94/9/EC (see also section 4.1.2.3 of “Application guidelines for Directive 94/9/EC”, Date: May 2007 (<http://ec.europa.eu/enterprise/atex/guide.htm>)).

4. Other applicable regulations

Other applicable regulations include, where appropriate, the Low Voltage Directive, the EMC Directive or the Pressure Equipment Directive, which are not further dealt with in these procedural guidelines.

Annex 2

Check lists

Extraction system	Yes	No
Extraction system suitable for neat oil machining? (Instructions for use/technical documentation) e. g.: <ul style="list-style-type: none"> • Design free of ignition sources • Arc-free fan drive on the intake side • System and ducting earthed 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Air flow monitored (pressure, flow controls)? <ul style="list-style-type: none"> • Extraction starts when machine starts • Flow too low: signal indication, machine tool failure indication 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Extraction capacity adjusted via throttle valve/speed control	<input type="checkbox"/>	<input type="checkbox"/>
Extraction system integrated into extinguishing concept: <ul style="list-style-type: none"> • Provide sufficient quantity of extinguishing agent in extraction system and separator • If applicable, extinguishing nozzle and fire detection in separator • Consider fan overrun 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Ducting: <ul style="list-style-type: none"> • Slightly inclined without depressions (if applicable, provide MWF drain) • Provide inspection holes/control openings • Regular inspection for deposits, if necessary, cleaning? 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
For ducting system: Prevention of fire propagation, e. g. by means of <ul style="list-style-type: none"> • Flame arresters (in pipes and in the machining area) • Shut-off valves (at the machine tool) 	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
Effective pre-separation at the machine outlet, e. g. by means of baffle plates, pre-separators	<input type="checkbox"/>	<input type="checkbox"/>
Regular maintenance of system and ducting: Maintenance schedule (Instruction handbook)	<input type="checkbox"/>	<input type="checkbox"/>
In case of fire: Interruption/extraction by means of <ul style="list-style-type: none"> • Fan motor-brake (reduction of overrun) • Automatic shut-off valve 	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
Pressure relief device	Yes	No
Route flames and hot gases into safe areas	<input type="checkbox"/>	<input type="checkbox"/>
Installation in the cover areas	<input type="checkbox"/>	<input type="checkbox"/>
Provide pressure relief area: ~ 0.1 m ² /m ³ work room (see VDW 3002)	<input type="checkbox"/>	<input type="checkbox"/>
Reliable opening at minimal excess pressure (<< 5 mbar)	<input type="checkbox"/>	<input type="checkbox"/>

Check lists

Reliable closing subsequent to pressure relief	<input type="checkbox"/>	<input type="checkbox"/>
Suitability as protective device verified by the manufacturer (e. g. test)	<input type="checkbox"/>	<input type="checkbox"/>
No flammable materials (wooden crates, insulation materials) in the danger zone around the pressure relief device	<input type="checkbox"/>	<input type="checkbox"/>
Danger zone warning signs around the pressure relief device	<input type="checkbox"/>	<input type="checkbox"/>
Metalworking fluids	Yes	No
Low-emission metalworking fluid used?	<input type="checkbox"/>	<input type="checkbox"/>
1: Observe characteristics, e. g. in the safety data sheet, product information	<input type="checkbox"/>	<input type="checkbox"/>
Example: For MWF with a viscosity of 4.1 [mm/min at 40 °C] <ul style="list-style-type: none"> • Flash point > 120 °C (see Table 1) • Noack evaporation losses [250 °C] < 85 % (see Table 1) 	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
2: MWF with anti-mist additives (consider filterability)	<input type="checkbox"/>	<input type="checkbox"/>
MWF compatible with hydraulic oils, slideway oils (multi-functional oil)?	<input type="checkbox"/>	<input type="checkbox"/>
Sufficient quantity of MWF (MWF circuit, storage tank) during machining (see VDI 3035)?	<input type="checkbox"/>	<input type="checkbox"/>
No drag-in of large quantities of: <ul style="list-style-type: none"> • Cleaning agents and solvents (on workpiece/part) into the MWF circuit • Hydraulic oil into the MWF circuit 	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
MWF supply: <ul style="list-style-type: none"> • Monitored? (pressure or flow controls) • Sufficient cooling quantity, MWF nozzles? • MWF nozzles arranged in the best possible way? 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Avoid considerable temperature increase of the MWF <ul style="list-style-type: none"> • Increase of MWF temperature by 10 °C = doubling of misting • MWF temperature monitored? • Possibility of cooling: e. g. baffle plates, MWF container used sufficiently large? 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Extinguishing system	Yes	No
Use suitable extinguishing agent (consider fire class)	<input type="checkbox"/>	<input type="checkbox"/>
Attention: <ul style="list-style-type: none"> • For extinguishing gases, e. g. carbon dioxide (CO₂) consider danger to personnel (see BGR 134, BGI 888) • For metal fires (magnesium, aluminium, titanium): only use suitable extinguishing agents, e. g. fire class D! 	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>

Extinguishing system (continued)	Yes	No
<ul style="list-style-type: none"> For powder extinguishers: considerable material damage in the interior of the machine tool possible 	<input type="checkbox"/>	<input type="checkbox"/>
<p>Provide a sufficient quantity of extinguishing agent:</p> <ul style="list-style-type: none"> Also consider extraction system, chip conveyer, holes Consider flow-off losses (e. g. overrun, extraction ...) 	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
<p>Extinguishing system:</p> <ul style="list-style-type: none"> Planning and installation: By a specialist company, possibly in agreement with the manufacturer Components, planning and installation: consider the state-of-the-art (e. g. VdS Directives..) Planning and installation: Demand approval test and approval protocol Positioning: No adverse effects by pressure or flame propagation Electrical supply and control system independent of machine tool Interlocking of the extinguishing gas supply during setting and maintenance work (non-electrical or electrical shut-off devices, see BGR 134, BGI 888) Regular checking of extinguishing agent tanks fill-levels: e. g. pressure controls, weighing devices Gas extinguishing system: Provide sufficient pressure relief options Considerable material and environmental damage, personnel injuries: Automatic extinguishing systems! 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
<p>Fire detection and extinguishing:</p> <ul style="list-style-type: none"> Use optical and/or thermal fire detection elements Fire detection elements: Consider the state-of-the-art (e. g. VdS Directives) Optical sensors: <ul style="list-style-type: none"> – consider suitability (e. g. MWF mist) – keep clean (e. g. by air purging) Thermal sensors: <ul style="list-style-type: none"> – fire detection slower than with optical sensors Extinguishing nozzles: <ul style="list-style-type: none"> – suitable for the relevant extinguishing agent – consider arrangement: if possible, do not direct towards door labyrinths 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
<p>Extinguishing hole and machining area door in case of fire:</p> <ul style="list-style-type: none"> Only to be opened by fire service and specially instructed persons 	<input type="checkbox"/>	<input type="checkbox"/>
<p>Regular testing of the extinguishing system (see BGR 134)</p>	<input type="checkbox"/>	<input type="checkbox"/>

Check lists

Instruction	Yes	No
Function and handling of the machine tool and the extinguishing system in case of fire	<input type="checkbox"/>	<input type="checkbox"/>
Optical sensors: Avoid light flashes (lighters, welding)	<input type="checkbox"/>	<input type="checkbox"/>
Special hazards (NEVER!): <ul style="list-style-type: none"> • Opening of the machine door in the event of a fire in the interior: Hazard of backfire • Wearing oil soaked clothing: Fire hazard (wicking) in case of backfire 	<input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
In the case of fires or explosions (BGI/GUV-I 560): <ul style="list-style-type: none"> • When the alarm activates: Leave the danger zone immediately • Use escape and rescue routes • Search for help: Fire service, emergency telephone numbers 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Hazards during ignition of the MWF mixture: <ul style="list-style-type: none"> • Violent flame ejections at pressure relief devices/ subsequent fires possible • Flame ejection at machine tool door gaps and openings • Extinguishing agent CO₂ : Hazard of suffocation (above 5 % CO₂ volume in air) • During extinguishing process: Ejection of flames in the door area • Hazard of suffocation in confined spaces due to fire smoke and fumes • Do not touch machine components subsequent to fire: Possibly live (electric shock) and hot (burns) 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Reduce fire hazard – Preventive measures: <ul style="list-style-type: none"> • Regular emptying of chip container to avoid self-ignition • Regular emptying of machine tool oil pans (extract oil) • No combustible materials (cardboard/carton/oil-soaked rags) in the vicinity of the machine tool • General smoking prohibition: No cigarette ends in chip containers/oil pans 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Machine tool	Yes	No
Machine tool suitable for neat oil machining (non water-miscible MWF)?	<input type="checkbox"/>	<input type="checkbox"/>
Oil machining dealt with in the “Technical documentation”?	<input type="checkbox"/>	<input type="checkbox"/>
Extinguishing system present?	<input type="checkbox"/>	<input type="checkbox"/>
Extraction system present?	<input type="checkbox"/>	<input type="checkbox"/>
Extinguishing system deactivated when machining room door open?	<input type="checkbox"/>	<input type="checkbox"/>
Machining room door stays interlocked during machining and emergency stop?	<input type="checkbox"/>	<input type="checkbox"/>

Machining room door non-interlockable when the machine is open and switched-off?	<input type="checkbox"/>	<input type="checkbox"/>
No oil pool formation in the machining area, drive room or handling area?	<input type="checkbox"/>	<input type="checkbox"/>
No oil pool formation in the area outside the machine (oil pan regularly emptied)?	<input type="checkbox"/>	<input type="checkbox"/>
Sufficient pressure resistance of guarding?	<input type="checkbox"/>	<input type="checkbox"/>
Pressure relief device present?	<input type="checkbox"/>	<input type="checkbox"/>
Door labyrinths resistant to outbreak of flames?	<input type="checkbox"/>	<input type="checkbox"/>
Other openings (e.g. loading and unloading openings, gaps) in the operating area covered?	<input type="checkbox"/>	<input type="checkbox"/>
If applicable, extinguishing hole present?	<input type="checkbox"/>	<input type="checkbox"/>
Transparent screens made of polycarbonate undamaged (see DIN EN ISO 23 125,VDW 0209)?	<input type="checkbox"/>	<input type="checkbox"/>
Transparent screens positively fitted (not with rubber edging)?	<input type="checkbox"/>	<input type="checkbox"/>
Alarm device present?	Optical	<input type="checkbox"/>
	Acoustic	<input type="checkbox"/>
Marking: Information signs, CO ₂ hazard warnings, extinguishing system?	<input type="checkbox"/>	<input type="checkbox"/>
Machine tool: Control system (example)	Yes	No
Start of machine:		
• Extraction system on/chip removal on	<input type="checkbox"/>	<input type="checkbox"/>
• Door interlocked (with guard locking)	<input type="checkbox"/>	<input type="checkbox"/>
• Extinguishing system ready to operate (optical and thermal sensors, activation)	<input type="checkbox"/>	<input type="checkbox"/>
• MWF supply monitored	<input type="checkbox"/>	<input type="checkbox"/>
Extinguishing process:		
• For CO ₂ : If applicable, activation delay set (BGR 134)	<input type="checkbox"/>	<input type="checkbox"/>
• Extraction system off	<input type="checkbox"/>	<input type="checkbox"/>
• MWF supply off	<input type="checkbox"/>	<input type="checkbox"/>
• Extinguishing system ready to operate	<input type="checkbox"/>	<input type="checkbox"/>
• Doors interlocked (with guard locking)	<input type="checkbox"/>	<input type="checkbox"/>
• Alarm device (optical/acoustic) active	<input type="checkbox"/>	<input type="checkbox"/>
• Machine drive off	<input type="checkbox"/>	<input type="checkbox"/>
Opening of the door:		
• Extinguishing system inactive	<input type="checkbox"/>	<input type="checkbox"/>
• MWF supply off	<input type="checkbox"/>	<input type="checkbox"/>
• Machining process safely stopped	<input type="checkbox"/>	<input type="checkbox"/>
• Extraction system: If applicable, keep in mind short overrun!	<input type="checkbox"/>	<input type="checkbox"/>

Annex 3

Operating instructions

Company:
Insert name of company here

Operating instructions acc. to GefStoffV § 14

Number: 7.3.24

SCOPE

Handling of non water-miscible metal working fluids (MWF) for mechanical machining

Department: _____ Workplace: _____

NAME OF HAZARDOUS SUBSTANCE

Product name: _____

HAZARDS FOR MAN AND ENVIRONMENT



- Intensive skin contact leads to destruction of the acid mantle, degreasing, dehydration and irritation of the skin as pre-stage to skin diseases.
- Even minor skin injuries, e.g. by metal particles, increase the risk of a skin disease when in contact with MWF.
- Skin contact may cause allergic reactions to constituents of MWF.
- Blowing compressed air on skin or clothing wetted with MWF damages the skin.
- Inhalation of MWF vapour may cause irritation of the respiratory tract.
- During use of MWF, formation of flammable or explosive vapour/mist air mixtures (aerosols) is possible (see safety data sheet).

PROTECTIVE MEASURES AND RULES OF BEHAVIOUR



- Prior to start of work, breaks and after end of work protective measures in accordance with the skin protection plan shall be carried out.
- Switch on extraction system prior to start of work.
- Avoid skin contact as far as possible, i.e.:
 - Do not clean skin with MWF,
 - Change moist clothing immediately, wash/clean before using it again,
 - Use splash guard or splash protecting apron or rubber apron,
 - Use clean textile or paper towels for drying the skin,
 - Do not put polluted rags in your clothes.
- Do not eat, drink, smoke at the workplace and do not keep food there.
- Do not throw food, beverage residues, cigarette ends and other waste into the MWF.
- Avoid skin contact during cleaning with solvents or wear protective gloves.

BEHAVIOUR DURING FAILURE AND IN CASE OF DANGER

Emergency call:



- Inform responsible superiors in case of breakdown of the extraction system or other malfunctions.
- Inform responsible superiors if special odours, discolorations, flocking or foaming of the MWF occur.
- Take up spilled MWF e.g. with paper towels or bonding agents.
- Inform responsible superiors in case of leakage of significant quantities of MWF.

BEHAVIOUR IN CASE OF ACCIDENTS – FIRST AID

Emergency call:



- Inform first-aiders and responsible superiors.
- Have even minor injuries treated by the first-aid.
- Notify the responsible superior of skin reactions (e.g. redness, rough skin, itching, burning, blisters, danders, fissures).

MAINTENANCE, DISPOSAL

- MWF to be disposed of should only be collected in the containers or systems provided and specially marked.
- Rags, towels and binding agents soaked with MWF should only be collected in non-flammable, closable, specially marked containers.
- Person responsible for disposal: _____

Date: _____ Signature: _____

Operating instructions according to GefStoffV § 14

Workplace, work area, activity:

Signature: _____

Date: _____

NAME OF HAZARDOUS SUBSTANCE

**Carbon dioxide = CO₂
in fixed fire extinguishing systems**

HAZARDS FOR MAN AND ENVIRONMENT

Danger to life by suffocation, if more than 8 % carbon dioxide in the breathable air

PROTECTIVE MEASURES AND RULES OF BEHAVIOUR

- Leave hazardous areas without delay in case of accoustic extinguishing alarm.
- Go to gathering places.
- If maintenance work has to be carried out in hazardous areas, which may lead to unintended activation of the extinguishing system, the extinguishing system shall be blocked by an appointed person.

BEHAVIOUR IN CASE OF EMERGENCY

Emergency call:



- Rooms flooded with CO₂ shall only be entered again, if approved by the appointed person or the fire brigade after thorough testing.
- Flooded rooms shall be aired before entering them again. It shall be ensured that persons in adjacent rooms are not endangered.
- In case of emergency only use self contained breathing apparatus.

FIRST AID

Emergency call:



- Bring injured person into fresh air after inhalation.
- In case of unconsciousness always call emergency physician.

PROPER DISPOSAL

Flooded rooms shall be ventilated into the open in a way not to endanger persons in adjacent rooms.

Annex 4

Directives, Regulations, Information

In the following, the pertinent regulations, rules and information which are to be observed are listed:

1 Acts, Ordinances and Technical Regulations

Reference:

Book shops and Internet, e. g. www.gesetze-im-internet.de

- Arbeitsschutzgesetz (ArbSchG) (English version: Occupational Health and Safety Act),
- Gefahrstoffverordnung (GefStoffV) (English version: Hazardous Substances Ordinance),
- Produktsicherheitsgesetz (ProdSG) (English version: Product Safety Act),
- 9. ProdSV – Maschinenrichtlinie (Machinery Directive 2006/42/EC),
- 11. ProdSV – Expositionsschutzrichtlinie 94/9/EC.

Betriebssicherheitsverordnung (BetrSichV) (Ordinance on Industrial Safety and Health with relevant Technical Rules for company safety (TRBS), especially)

- TRBS 1111: Gefährdungsbeurteilung und sicherheitstechnische Bewertung,
- TRBS 1201: Technische Regeln für Betriebssicherheit; Prüfungen von Arbeitsmitteln und überwachungsbedürftigen Anlagen,
- TRBS 1203: Technische Regeln für Betriebssicherheit; Befähigte Personen – Allgemeine Anforderungen, Gefahrstoffverordnung.

2 **Regulations and Information for occupational Health and Safety and Principles**

Reference:

To be obtained from your responsible insurer

For addresses see www.dguv.de/publikationen

Accident prevention regulations:

- Grundsätze der Prävention (BGV/GUV-V A1).

Regulations:

- Arbeitsplatzlüftung – Lufttechnische Maßnahmen (BGR 121),
- Regeln für die Ausrüstung von Arbeitsstätten mit Feuerlöschern (BGR/GUV-R 133),
- Einsatz von Feuerlöschanlagen mit sauerstoffverdrängenden Gasen (BGR 134),
- Tätigkeiten mit Kühlschmierstoffen (BGR/GUV-R 143),
- Umgang mit Magnesium (BGR 204).

Information sheets:

- Arbeitssicherheit durch vorbeugenden Brandschutz (BGI/GUV-I 560),
- Sicherheitseinrichtungen beim Einsatz von Feuerlöschanlagen mit Löschgasen (BGI 888).
- Maschinen der Zerspanung (BGI 5003).

Principles:

- Grundsätze für die Prüfung von Feuerlöschanlagen mit sauerstoffverdrängenden Gasen (BGG 920).

3 Standards, Directives and Research Reports

Reference:

Beuth Verlag GmbH, Burggrafenstraße 6, 10787 Berlin/Germany

www.beuth.de

bzw.

VDE-Verlag GmbH, Bismarckstraße 33, 10625 Berlin/Germany

www.vde.com

- DIN EN ISO 2592: Mineralölerzeugnisse; Bestimmung des Flamm- und Brennpunktes; Verfahren mit offenem Tiegel nach Cleveland (English version: Petroleum products: Determination of flash and fire points – Cleveland open cup method),
- DIN ISO 3448: Flüssige Industrie-Schmierstoffe; ISO-Viskositätsklassifikation (English version: Industrial liquid lubricants; ISO viscosity classification),
- DIN EN 1127-1: Explosionsfähige Atmosphären; Explosionsschutz; Teil 1: Grundlagen und Methodik (English version: Explosive atmospheres – Explosion prevention and protection – Part 1: Basic concepts and methodology),
- DIN EN 12094: Ortsfeste Brandbekämpfungsanlagen; Bauteile für Löschanlagen mit gasförmigen Löschmitteln; Teil 9: Anforderungen und Prüfverfahren für spezielle Branderkennungselemente; Deutsche Fassung EN 12094-9:2003 (English version: Fixed fire-fighting systems – Components for gas extinguishing systems – Part 9: Requirements and test methods for special fire detectors),
- DIN EN ISO 23125: Werkzeugmaschinen - Sicherheit - Drehmaschinen (English version: Machine tools – safety - turning machines),
- DIN EN 12417: Werkzeugmaschinen; Sicherheit; Bearbeitungszentren; Deutsche Fassung EN 12417:2001+A2:2009 (English version: Machine tools – Safety – Machining centres),
- DIN EN 13218: Werkzeugmaschinen; Sicherheit; Ortsfeste Schleifmaschinen; Deutsche Fassung EN 13218:2002+A1:2008+AC:2010 (English version: Machine tools – Safety – Stationary grinding machines),

- DIN EN 13478: Sicherheit von Maschinen; Brandschutz (English version: Safety of machinery – Fire prevention and protection),
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Figure 27

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- DEKRA EXAM, Bochum,
- Physikalisch-Technische Bundesanstalt (PTB), Braunschweig,
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- Kraft & Bauer Brandschutzsysteme, Holzgerlingen,
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**Deutsche Gesetzliche
Unfallversicherung e.V. (DGUV)**

Mittelstraße 51
10117 Berlin
Tel.: 030 288763800
Fax: 030 288763808
E-Mail: info@dguv.de
Internet: www.dguv.de