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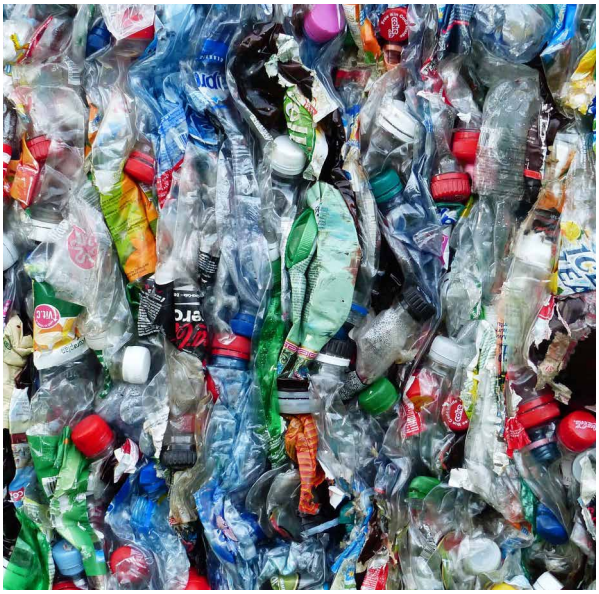
VdS

Sorting, reprocessing and storage of municipal waste and combustible secondary raw materials – information on fire protection









ASA BDE bvse VKU VERBAND KOMMUNALER UNTERNEHMEN e.V. GDV

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Summary

This publication contains information on the prevention of fires and their effects in recycling plants. For the purposes of this publication, recycling facilities are waste treatment plants in which municipal waste and combustible secondary raw materials are sorted, processed, and stored.

The Model Plastics Storage Guideline (MKLR), March 2023 edition, is integrated verbatim into this publication and labeled accordingly.

The recycling of batteries is not considered. However, the publication contains information for waste treatment plants in which batteries can occur as misdirected waste in the material flow.

This publication presents possible structural, technical fire protection and organisational protection measures, process-related prevention options and fire prevention measures for implementation in recycling plants. Which measures are implemented for the respective company should always be agreed on with the insurer.

There is no specific explanation of the general fire protection measures. These are described in detail, for example, in the GDV publication on loss prevention "Brandschutz im Betrieb" (VdS 2000).

The present publication was drawn up by the German Insurance Association "Gesamtverband der Deutschen Versicherungswirtschaft e. V." (GDV – www.gdv.de) in co-operation with:

- ASA (a German working group for material-specific waste treatment – www.asa-ev.de)
- BDE (a federal association of the German waste management, water and recycling industry – www.bde.de)
- bvse (a German association for secondary raw materials and waste management – www.bvse.de)
- VKU (an association of municipal companies – www.vku.de)

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Introduction

The present publication has no binding force. The insurers and operating parties may also agree other safety precautions in individual cases that do not correspond to the recommendations contained in this publication.

The publication shows possible structural, technical and organisational protection measures as well as measures of defensive fire protection for waste management facilities from the perspective of industrial fire insurers.

It is advisable to consult the insurer at an early stage when planning new buildings and conversions as well as when planning and implementing fire protection measures.

The recommendations always apply to plants to be newly constructed, taking into account the specific fire protection requirements. For existing plants it is recommended to adapt fire protection measures to these instructions in line with the conditions on the premises.

The recommendations shall not affect requirements by law and the authorities, e.g. the construction authority and the trade supervisory authorities or the employers' liability insurance associations and arrangements in particular insurance agreements. Complying with the recommendations does not exempt from adhering to applicable standards or other technical rules and regulations. The recommendations serve the explanation and are not exhaustive.

The recommendations are based on current fire protection knowledge. They contain information that serve the reduction of fire hazards and their effects. If there are fundamental changes in fire protection technology, the intention is to revise the recommendations by mutual agreement.

The associations ASA e. V., BDE e. V., bvse e. V. and VKU e. V. conducted a survey on fire incidents in the waste management industry in 2023. The results of the survey have been published in extract form by ASA e. V. in consultation with the participating associations in the journal for recycling and resource management "Müll und Abfall", issue 11/2023 published (DOI: https://doi.org/10.37307/j.1863-9763.2023.11.07). On the one hand, the article deals with the special challenges of the industry, such as inhomogeneous material flows, contamination, adhesions and impurities with an increased risk of fire and, on the other hand, it shows the historical development of fire incidents in the waste management industry. Industry-specific causes of fires such as lithium batteries or spontaneous ignition are also analysed on the basis of the survey.

The Model Plastics Storage Guideline MKLR, edition of March 2023, is integrated verbatim into the publication and printed in italics.

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1 Scope

This publication applies to waste treatment plants in which municipal waste and combustible secondary raw materials are sorted, reprocessed and stored and covers including but not limited to:

- the storage of combustible bulk materials in mono or mixed fractions or in compact form,
- the storage of used tyres,
- biological waste treatment,
- mechanical waste treatment and
- the interim storage of the reprocessed material.

The publication may also apply to waste treatment plants with commercial municipal waste and to waste transfer stations.

Furthermore, this publication applies to combustible secondary raw materials and used tyres in a total quantity of more than 200 m^3 in compact form or in bulk, in stationary or mobile containers. Even for quantities of material of up to 200 m^3 appropriate fire protection measures are required.

2 Definitions

A **waste treatment plant** is a facility for the storage and treatment of waste. These include plants for:

- thermal treatment,
- mechanical-biological, mechanical-physical or chemical-physical treatment,
- biological treatment,
- mechanical treatment and
- sorting

of municipal waste. **Sorting** comprises the basic processes of mechanical reprocessing of waste streams, the separation of materials according to physical or chemical-physical characteristics.

Depending on the materials and process technology, **reprocessing** comprises comminution, fractionation (sieving, classification, metal separation), cleaning, drying, grinding, melting, granulation and picking (e.g. baling).

Storing means the keeping for later use or for distribution to others.

Staging means the short-term storage for delivery or later use during operating hours for a maximum period of 24 hours. Designated staging areas shall be defined for this purpose. These shall not be arranged in aisles designed to be without any fire load ("aisles" in the following text). The staging areas shall be considered individually and agreed upon with the insurer.

A **storage area** is a building, an area or a room inside a building or an outdoor area with or without a roof that is intended to hold materials for storage. Outdoor storage is also deemed to be the case if the storage area is fitted with a weather protection roof and is fully open on at least two opposite sides.

Storage blocks are storage areas that are subdivided by aisles or fire-resistant partitions made of non-combustible building materials.

The **height of stored goods** is the distance between the floor and the top of the storage.

Municipal waste within the meaning of § 3 Paragraph 5a of the German Waste Avoidance, Recycling and Disposal Act (KrWG) is mixed and separately collected waste

1. from private households, in particular paper and cardboard, glass, metal, plastics, biowaste, wood, textiles, packaging, used electrical appliances and electronic equipment, used batteries and used accumulators as well as bulky waste, including mattresses and furniture and
2. from other sources, if this waste due to its nature and composition is comparable to waste from private households.

The fire loads of the respective waste streams highly depend on their composition.

(Combustible) secondary raw materials are obtained from wastes and municipal wastes and can consist of, e.g. plastics, paper, wood, textiles, used electrical appliances and a mixed fraction thereof. This also includes refuse-derived fuels.

Refuse-derived fuels / secondary fuels are various fractions with a high calorific value that are made available for energy recovery. They are produced e.g. from residual waste, process waste or household-type commercial waste.

A **mixed fraction** is composed of different materials.

Composting (rotting / biological drying) is a process for the aerobic decomposition of organic material. Various methods are used to carry out rotting, e.g. box composting or rotting halls.

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Fermentation is used for the anaerobic decomposition of the organic fraction contained in the waste. The biogas produced during the decomposition of organic matter contains methane, is combustible and can be used to harvest energy.

Combined heat and power plants (CHP) are often used to convert the biogas produced during fermentation into electrical energy and heat.

In order to minimise emissions from waste treatment processes, **exhaust air treatment** is required. In plants for the mechanical-biological or mechanical-physical treatment of municipal waste (MBT / MPS), thermal exhaust air purification processes such as regenerative thermal oxidation (RTO) are used, and for mechanical or biological treatment processes, e.g. biofilters or scrubbers are used. Dust emissions, particularly in the case of encapsulated units, are also treated with dust filters.

A **fire compartment** is a structurally separated volume in accordance with VdS 2234en (compartmentation) capable of maintaining its fire resistance capability for a specified minimum time.

The **intervention time** defines the period from the start of the emergency call in the control room to the arrival of the required fire fighters at the scene (see definition DIN 14011).

A **fire control matrix** is a detailed representation of the intended interaction of the technical systems and equipment derived from the safety-related control concept for the event of a fire.

Examples: Closing fire-resisting closures, disabling conveyor systems, disabling process systems, disabling ventilation systems and process air systems, alerting emergency services, alerting the fire brigade, depressurising hydraulic systems.

3 Fire protection concepts taking into account operational/corporate protection objectives

A fire protection concept that is deemed sufficient by the construction supervisory board does not always protect against major loss of property and longer business interruptions in the event of damage, which can even threaten the economic survival of a company.

These operational protection objectives are not sufficiently taken into account in the requirements by the construction supervisory board or other public law requirements. Normally, the building and operating licences are not sufficient for this.

Effective fire protection from a business and actuarial point of view can therefore only be achieved through a concept that is customised to the company and geared towards its protection objectives.

This publication provides information and describes measures to ensure that the company / plant fulfils these protection objectives.

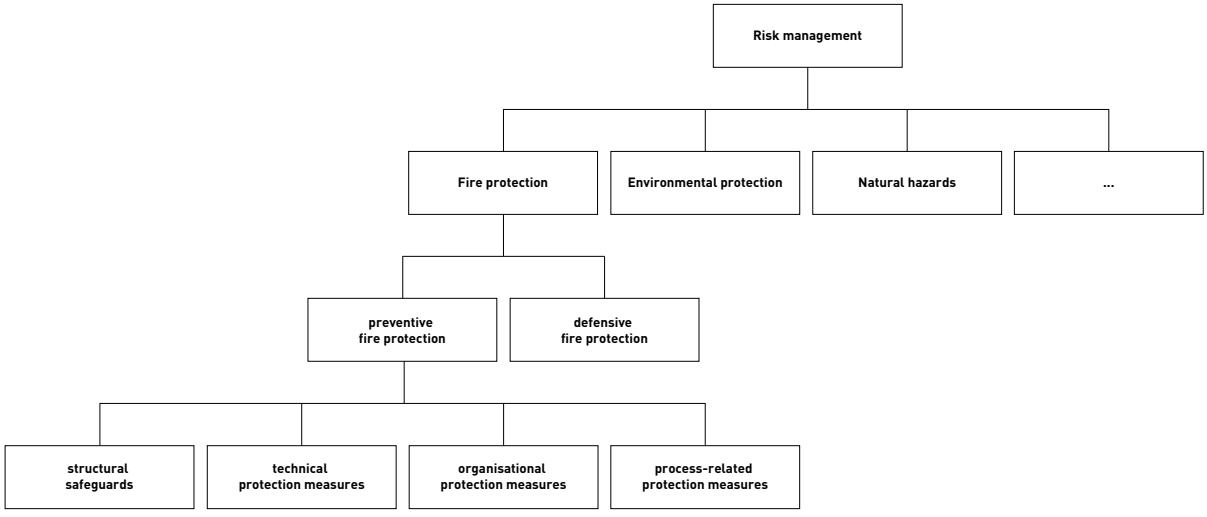


Figure 3-1: Fire protection as part of risk management and subdivision of fire protection measures

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Which measures are suitable and necessary for a particular plant depends on the type of recycling plant and the materials processed there and should always be agreed with the insurer.

Risk-adapted fire protection is essential for an effective risk management.

A fire protection concept is divided into preventive and defensive measures:

- Preventive fire protection consists of structural, technical and organisational measures to prevent the outbreak of fire and the spread of fire and smoke.
- Defensive fire protection is used to fight fires and avert dangers to people and assets.
- Also additional process-related measures are be taken into account.

Damage experience has shown that the protection objectives can only be achieved if the measures are harmonised accordingly. Please find a description of the possible measures below.

4 Preventive fire protection

Suitable fire protection measures should:

- prevent the development of fires,
- limit the spread of fire and smoke,
- detect and fight fires as early as possible in their development and
- avert hazards to people, environment and assets and
- prevent or minimise an interruption to the company's activities.

Here, structural (Clause 4.1), technical (Clause 4.2.) and organisational (Clause 4.3) measures of preventive fire protection and measures of defensive fire protection (Clause 5) as well as process-related measures (Clause 6) shall be combined as optimally as possible.

4.1 Structural fire protection

High fire loads and the burning behaviour of the building materials used favour the spread of fire, make fire fighting more difficult and thus lead to total losses in many cases. In order to counter this risk, non-combustible building and insulating materials should therefore be used for the construction of buildings wherever possible.

The effectiveness of structural fire protection measures is significantly influenced by

- the arrangement of the spatial or structural separations,
- the fire resistance capability of structural separations and framework as well as
- the fire behaviour of the building materials used.

The spread of a damaging fire can be effectively limited by structural or spatial separations. Therefore, for example:

- the use of combustible building materials (building material class DIN 4102-B) is to be restricted,
- components are to be designed with sufficient fire resistance time in accordance with DIN 4102 or DIN EN 13501,
- different operating areas are to be separated from each other – structurally or spatially,
- large areas are to be subdivided,
- rooms and facilities with special fire or explosion hazards are to be partitioned off in a fire-resistant manner.

The measures should be agreed with the insurer.

4.1.1 Legal requirements

The construction and operation of structures as well as changes to their use generally require authorisation from the construction supervisory board, particularly with regard to fire protection.

The type and scope of structural fire protection are to be determined in detail according to the local and in-plant conditions, in particular also according to the quantity and type of materials present, in consultation with the authorities having jurisdiction for fire protection (e.g. supervisory authority) and the fire insurer.

General fire protection requirements are contained in the German model building regulations (MBO) and their specific versions in the German Länder (LBOs – Federal Building Regulations). The provisions formulated there are primarily intended for personal protection and fire-fighting operations by the fire brigade. One fundamental requirement of the LBOs, for example, is the compartmentation in buildings. This is usually achieved by installing firewalls at intervals of no more than 40 metres. However, the LBOs also make it possible for the construction supervisory board to impose according to dutiful judgement special requirements or authorise

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simplifications for structures and rooms intended for commercial operations and classified as structures or rooms of special type and use (special construction).

The requirements for escape and rescue routes in terms of number, permissible length, fire protection separation and arrangement in the building can be found in the LBOs, the German Industrial Building Directive (IndBauRl) and the German Ordinance on Workplaces (ArbStättV).

In addition to the statutory and official building code requirements, which essentially relate to personal protection, the following information should be taken into account with regard to property protection.

4.1.2 Building materials, components

With regard to their combustibility and flammability, building materials are classified according to their fire behaviour at European level in accordance with DIN EN 13501 "Fire classification of construction products and building elements" and at national level in accordance with DIN 4102 "Fire behaviour of building materials and building components". According to DIN 4102 Part 1, these building material classes are divided into non-combustible (A) and combustible (B) building materials.

Fire resistance rating: Components get a fire resistance rating according to their fire resistance time. The classification is governed equally by the German standard DIN 4102-2: "Fire Behaviour of Building Materials and Building Components; Building Components; Definitions, Requirements and Tests" and the European standard DIN EN 13501-2: "Fire classification of construction products and building elements according to their fire behaviour – Part 2: Classification using data from fire resistance tests".

According to DIN 4102-2, the designation of the fire resistance rating contains the code letter F and a number that indicates the fire resistance time in minutes determined during the tests. Fire-resistant (F90 according to DIN 4102-2) means that the component shall ensure load-bearing capacity and/or room closure (prevention of fire and smoke spread) for a period of time of at least 90 minutes.

With sufficiently dimensioned cross sections, timber components – even though they are made of combustible material – have an equally high fire resistance capability as correspondingly dimensioned non-combustible components. This is due to the property of wood: when exposed to fire, the outer zones of the component char, forming a protective coating that significantly delays further burning due to its low thermal conductivity.

Non-combustible building materials should always be used.

For load-bearing components such as walls, pillars, columns and ceilings, non-combustible building materials should be used, which should also be fire-resistant.

A roof structure should be favoured in which a large-scale spread of fire is not to be expected. Here, a roof structure with non-combustible insulation has proven of value. Roof sealing should preferably be carried out with sealing sheets that are cold-bonded or mechanically fastened. In particular, building materials containing bitumen should not be used for roof sealing.

Note: Roof work with naked flame poses an increased fire risk. When laying bituminous roof sealing that is bonded with naked flame or liquid bitumen, the safety regulations for fire-hazardous tasks shall be observed.

In wall, ceiling and roof constructions, cavities are to be avoided and component surfaces are to be designed in such a way that dust deposits are largely prevented.

Fixtures and protective devices, for example against noise and dust propagation, should be made of non-combustible building materials.

4.1.3 Fire protection subdivisions

To prevent the spread of fire, operating areas such as delivery, sorting, reprocessing / drying and storage areas should be separated for fire protection purposes. The separations can be made structurally by means of complex partition walls or firewalls or spatially through a corresponding distance.

4.1.3.1 Separations of complexes

Operating areas with different operational hazards are assessed differently in the risk assessment for fire insurance. In the actuarial risk assessment, these operating areas can be assessed as independent danger zones if provided with structural and spatial separations of complexes and depending on the risk. This can result in a more favourable actuarial assessment for the entire plant.

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Spatial separation of complexes does exist if the distance:

- between buildings with a building height of 5 m to 20 m is at least equal to the height of the higher building,
- from outdoor storage areas of combustible materials is at least 20 m,
- between other buildings and/or storage facilities for non-combustible materials is at least 5 m,

provided that no combustible objects, e.g. vehicles, are parked or stored in the space between the buildings and the storage areas.

In the case of special risk conditions, e.g. special fire loads, high-rack storage systems, explosion hazard or buildings with a building height of more than 20 m, increased minimum distances may be required for the aisle without any fire load between the buildings, which are to be specified separately on an individual basis.

A **structural separation of complexes** can be achieved by installing complex partition walls. Complex partition walls meet higher requirements than firewalls. The arrangement and design of complex partition walls are described in leaflet VdS 2234en.

4.1.3.2 Fire compartments

A fire compartment is composed of one or several buildings, building sections or outdoor storage areas, which show no spatial or structural separation between each other but are separated spatially or structurally from other buildings, building sections or storage areas.

Spatial compartmentation exists if the distance between buildings or outdoor storage areas for non-combustible materials is at least 5 m, provided that no combustible materials or objects, such as vehicles, are parked or stored in the space between the buildings and the storage areas.

For a **spatial compartmentation**, the fire insurance requires a minimum distance of 20 m **between buildings and outdoor storage areas for combustible materials**. No combustible materials or objects such as vehicles may be parked or stored in the space in between.

A **structural compartmentation** is given if buildings, building sections or storage areas are separated by a firewall according to VdS 2234en.

Firewalls should be in accordance with VdS 2234en "Firewalls and complex partition walls, Leaflet for arrangement and construction". In part, these specifications differ from the building code requirements for firewalls, e.g. for roof and wall connections.

For further information on structural fire protection, see:

- VdS 0195 a technical guidance document by the fire insurance and insurance for business interruptions due to fire dealing with risks, protection objectives, protection concepts and safeguards
- VdS 2216en "Fire protection measures for roofs – Instructions for planning and construction"
- VdS 2234en "Firewalls and complex partition walls, Leaflet for arrangement and construction"

4.1.3.3 Separation of operating areas

The structural boundary of a fire compartment should be a firewall in accordance with VdS 2234en.

Fire protection subdivisions do not necessarily have to hinder operating procedures. Openings that are kept open for operational reasons can be protected against fire.

For rail-bound conveyor systems, fire-resisting closures can be provided that close automatically in the event of fire.

Fire-resisting closures can be kept open for operational reasons by a hold-open system generally approved by the construction supervisory board, which ensures that the closures close automatically in the event of a fire. These closures are to be closed at the end of work in accordance with the general safety regulations by the fire insurers for factories and industrial plants.

The following operating areas should form independent fire compartments that are spatially or structurally separated from each other and from other areas by firewalls:

- storage / bunkers,
- sorting plants,
- storage areas for finished products / production warehouse,
- administration.

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The drying plant should be separated from the reprocessing area with fire protection technology.

The exhaust air purification (in particular RTO facilities) should be operated in a separate fire compartment which is either spatially or structurally separated.

Within fire compartments, operating areas used for other purposes that pose a particular fire hazard are to be separated by fire-resistant walls and ceilings with fire-resistant fire-resisting closures.

Structural separations by firewalls and by walls and ceilings for rooms partitioned off in a fire-resistant manner are only effective if the openings and penetrations required for operational reasons are secured by fire-resistant fire-resisting closures. This applies to:

- doors or gates,
- visual connections (openings for glazing),
- rail-bound conveyor systems,
- pneumatic conveyor systems,
- ventilation pipes,
- electrical cables and wires,
- pipelines.

This is the only way to reliably prevent the spread of fire and smoke during the required fire resistance time of the structural separation. This is all the more important as small weak points and deficiencies can lead to considerable damage. Fire-resisting closures can be kept open for operational reasons by a hold-open system generally approved by the construction supervisory board, which ensures that the closures close automatically in the event of a fire. These closures are to be closed at the end of work in accordance with the general safety regulations of fire insurers (ASF) for factories and commercial facilities.

The closing area of doors and gates should be marked with labels and/or floor markings or secured by barriers.

It is recommended that all openings in a fire compartment are closed automatically when the FDAS (fire detection and fire alarm system) is triggered.

Conveying pipes and conveyance facilities shall not bridge fire compartments without protection. A case-by-case assessment is required here to determine suitable protection measures.

4.1.3.4 Separation of operating rooms, auxiliary and ancillary operations

Within an operating area, operating rooms as well as auxiliary and ancillary equipment are of key importance. In order to prevent the spread of fire, these shall be separated in a fire-resistant manner unless they represent independent fire compartments. Rooms are considered fire-resistant if they are separated by fire-resistant walls and ceilings made of non-combustible building materials.

Structural separations using fire-resistant partitions should be provided for e.g.:

- storage areas for combustible liquids and substances containing combustible liquids,
- filter installation rooms,
- firing and heating systems,
- compressed-air supply systems,
- electrical operating rooms,
- workshops,
- control systems,
- hydraulic systems,
- control rooms, especially if fire protection means, e.g. foam/water guns, are also controlled from there.

4.1.4 Photovoltaic systems (PV systems)

PV systems shall not bridge fire compartments.

When installing PV systems on roofs with combustible insulating materials, there is a risk of fire ignition and fire spreading across the entire fire compartment in the event of a technical defect.

Sufficient distances between PV systems and firewalls and SHEVS (smoke and heat exhaust ventilation systems) shall be ensured; see also VdS 3145 dealing with photovoltaic systems and VdS 6023 dealing with photovoltaic systems on roofs with combustible building materials and VdS 2234en "Firewalls and complex partition walls, Leaflet for arrangement and construction".

Inverters shall be mounted on non-combustible bases. Installation should be made in areas separated in a fire-resistant manner. A sufficient distance of at least 2.5 m from combustible materials should be maintained. A safe distance is to be maintained between inverters to ensure sufficient air flow. Here, a distance of 0.5 m has proven to be effective.

If a lightning protection system is present, the required separation intervals are to be observed and

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a lightning protection specialist shall be involved in the planning. The building insurer should be involved already in the planning phase.

4.1.5 Organisation of a storage area

The requirements for the storage of combustible matters are described below in accordance with the Model Plastics Storage Guideline MKLR.

Deviations from these requirements can be agreed with the insurer in individual cases. This applies in particular to substances that do not fall under the scope of the MKLR and show a different fire behaviour.

If automatic fire-fighting equipment is present, other fire-compartment areas and regulations applying to aisles may also be required.

It is advisable to store all matters in an organised manner. The stored goods should be stored separately taking into account the composition and type of materials. Mixed fractions should be stored separately.

The model guideline on fire protection for the storage of used tyres and plastic waste in waste disposal facilities (Model Plastics Storage Guideline MKLR, March 2023) is *printed in italics below (verbatim translation of the German original). The numbering [in square brackets] and the corresponding text are identical to the MKLR.* Any deviations from the plastic storage guidelines introduced by the construction supervisory board in the individual German Länder are to be checked on a case-by-case basis.

Additions from the point of view of property protection are printed in blue.

4.1.5.1 Storage of materials inside buildings

Materials inside buildings may only be stored on the ground floor. If they are not stored at ground level, special requirements may be imposed to enable effective extinguishing work. [MKLR 5.1]

The storage area is to be divided by firewalls into fire compartments of no more than 5,000 m². [MKLR 5.2]

The firewalls should be designed in accordance with VdS 2234en.

Each fire compartment is to be divided into storage areas of no more than 300 m² by zones without any fire load (aisles) of at least 10 m. [MKLR 5.3]

The following shall be present in a fire compartment:

- *stationary automatic fire extinguishing systems or openings for smoke extraction in conjunction with automatic fire detection and fire alarm systems if the fire compartment is larger than 800 m².*

The requirements for the openings for smoke extraction are met in particular if they comply with Clauses 5.7.1.2, 5.7.4.2 and 5.7.4.4 No. A 2.2.2.8 of the MVV TB (a German model administrative directive on technical building regulations, version of May 2019).

- *stationary automatic fire-extinguishing systems if the fire compartment is larger than 1,600 m². [MKLR 5.4]*

A suitable uncovered area of 400 m² shall be provided outdoors for the storage and extinguishing of burning materials. [MKLR 5.5]

4.1.5.2 Outdoor storage of materials

Outdoor storage of materials also includes storage within a storage section covered by a roof if:

- *the permissible height of the stored goods ends at least 2.5 m below the lower edge of the lowest part of the roof,*
- *the storage section is fully open on at least two opposite sides and*
- *the remaining sides of the storage section that are not fully open have a maximum length of 45 m. [MKLR 6.1]*

The distance of storage facilities for combustible materials from buildings shall be at least 20 m in accordance with VdS 2234en.

The storage area shall be divided into storage sections of no more than 2,000 m² by unroofed zones without any fire load (aisles) of at least 10 m or by fire-resistant walls made of non-combustible building materials.

The walls have to show the following heights:

- *for storage sections without roofs, at least 1 m above the permissible height of the stored goods;*
- *for storage sections with roofs made of non-combustible building materials in accordance with Clause 6.1 up to below the roof membrane;*

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- *for storage sections with roofs made of combustible building materials in accordance with Clause 6.1 at least 1 m above the roof. [MKLR 6.2]*

On the open sides of the storage area, stored materials shall fall below the wall depth by at least 1 m. This is to prevent the fire from spreading horizontally around the wall to the next section (see Fig. 4-1): Subdivision of storage sections into storage areas using walls: walls 1 m higher than the max. permissible height of stored goods and projecting horizontally 1 m above the storage goods level.

Each storage section shall be divided into storage areas of no more than 400 m² by zones without any fire load (aisles) of at least 10 m or by fire-resistant walls made of non-combustible building materials. The walls are to be built at least 1.0 m above the permissible height of the stored goods. [MKLR 6.3]

On the open sides of the storage area, stored materials shall fall below the wall depth by at least 1 m. This is to prevent the fire from spreading around the wall to the next section.



Figure 4-1: Subdivision of storage sections into storage areas using walls

Storage sections and storage areas must not exceed the following storage depths:

- *40 m if two opposite sides are freely accessible for fire fighting;*
- *20 m if only one side is accessible for fire fighting. [MKLR 6.4]*

Outdoor storage facilities shall maintain a distance of at least 10 m from the property boundaries or have fire-resistant walls made of non-combustible building materials without openings up to at least 1 m above the permissible height of the stored goods. [MKLR 6.5]

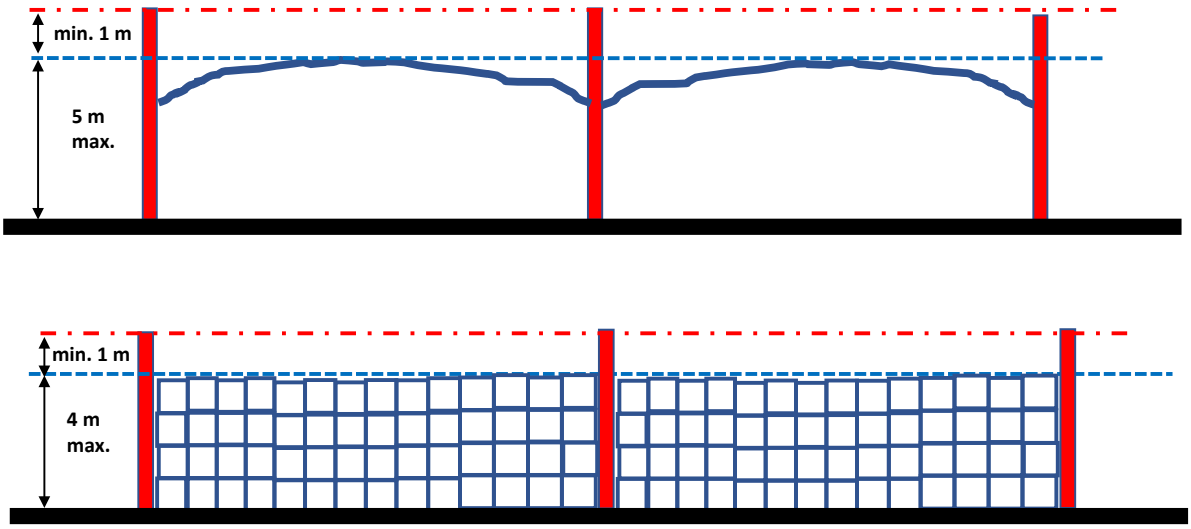


Figure 4-2: Requirements for bulk storage (above) and free-standing storage (below): maximum permissible storage height and partition walls which are higher by at least 1 m; in addition, the stored materials shall be at least 1 m less than the wall depth on the open sides of the warehouse

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A 10 m wide suitable aisle shall be provided along at least one edge of a storage area for the transfer and extinguishing of burning materials.

If this aisle coincides with a zone without any fire load in accordance with No. 6.3, a total width of 15 m is sufficient.

Instead of a suitable aisle, a suitable area in accordance with No. 5.5 may be provided. [MKLR 6.6]

4.1.5.3 Height of stored goods

The height of the stored goods must not exceed 5 m for bulk storage and 4 m for free-standing storage.

The permissible height of stored goods are to be clearly signposted [MKLR 7] or marked.

4.2 Fire protection systems

To minimise damage, it is important to ensure that fires are detected reliably and as early as possible so that effective fire-fighting measures can be initiated as quickly as possible. This is the only way to minimise major damage to property and the resulting business interruptions. The extent of damage is therefore directly related to the earliest possible detection and effective control of a developing event.

In the recycling industry, difficult ambient conditions are to be taken into account that make detection and control more difficult. In order to prevent frequent false alarms and false activations, these ambient conditions are to be taken into account when planning and designing the plant technology. This can prevent disabling and shutdown of fire protection systems and increase acceptance among the operating parties and fire brigades.

In addition to the established technologies that have been in use for decades, this clause also aims to highlight new solutions that are not yet fully reflected in the standards.

New technologies with proven effectiveness and reliability can offer opportunities to improve the protection of assets. Further information on this can be found in Clause 4.2.6.

4.2.1 Fire detection

Loss prevention measures, which are described in other chapters, can reduce the probability of a fire but never completely rule out the outbreak of a fire. The earlier a fire can be detected and reported, the more effective measures can be taken to limit, contain and extinguish it, thereby reducing damage to property and business interruptions. The outbreak of fire should be detected at an early stage by an automatic fire detection system and reported to a permanently manned location.

In addition to early detection, it is important to minimise interfering factors that can lead to frequent false alarms. In many cases, these two factors are contradictory, i.e. the sensitivity of the fire detection technology is reduced in order to suppress interference. However, with the help of the best available technology in the right place and combinations of system interactions, considerable improvements can also be achieved in recycling plants, as described below.

Particular challenges include dust pollution, effluvia, outgassing and emissions (e.g. nitrogen oxides, sulphur dioxides) as well as horizontal air movements, partially open buildings, dew point undershoots and difficult thermal conditions.

Fire detection alone does not minimise damage. Measures are to be taken quickly to prevent the fire from spreading, contain it and finally extinguish it.

The technologies are described below, together with information on possible areas of application in recycling plants.

4.2.1.1 Smoke detector (detection of the fire characteristic “smoke”)

Smoke detectors (point-type smoke detectors) use various physical effects to detect fire smoke. The most common smoke detectors are optical smoke detectors. These work according to the scattered-light method, with which smoke particles can be detected.

Light-beam smoke detectors (linear optical smoke detectors) work according to the transmitted-light principle. They consist of a transmitting/receiving unit and a reflector if required.

Aspirating smoke detector (ASD): Aspirating smoke detectors (also known as aspirating smoke detector systems) feed the smoke to themselves through pipework. The pipework with one or more inlet openings is connected to an evaluating processor unit that draws in room air via a fan. Air samples are therefore constantly drawn in from the monitored area. The air drawn in is contin-

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uously monitored for smoke in the measuring chamber of the evaluating processor unit.

4.2.1.2 Heat detector (detection of the fire characteristic "temperature")

Maximum temperature detectors react when a preset temperature is reached.

Rate-of-rise detectors react to a rise in temperature within a period of time. They are used where a rapid rise in temperature is to be expected or where there are large fluctuations in the operating temperature. Fires that start slowly are not detected, so a maximum temperature detector is always to be integrated.

Linear heat detectors are sensor cable detectors that detect increases in temperature. They can consist of electrical cables, fibre optic cables or air-filled pipes.

Note: The effectiveness of heat detectors can be limited if – depending on the positioning of the detector – the heat is recognised only with a delay.

Sprinkler (automatic): Nozzle with a temperature-sensitive sealing element (fusible link, glass body) that opens when exposed to heat. The actuation of a sprinkler also works as a fire call.

4.2.1.3 Flame detectors / spark detectors

Flame detectors detect flames using infrared radiation (IR), ultraviolet radiation (UV) and/or flickering frequency and are particularly suitable for use in areas where naked flame is to be expected immediately at the start of a fire and where virtually no smoke results, e.g. storage areas for combustible liquids. Flame detectors react to one or more wavelength ranges.

Spark detectors react extremely sensitive and with a very short delay to infrared radiation and transmit an electrical signal to the control and indicating equipment. The spark detection system detects sparks and smouldering nests in good time. Alarms, suitable control processes (e.g. machine shutdown) and spark extinguishing and/or spark separation can then be initiated immediately and automatically.

4.2.1.4 Special fire detectors

Multi-sensor fire detectors are detectors that work with several sensors or sensor principles. For example, you can combine and analyse the detection systems of a smoke detector and a heat detector. They have a higher level of security against false alarms.

Video-based fire detection systems use artificial intelligence (AI) and algorithms to detect smoke based on colour schemes and movements. These systems continuously monitor rooms and areas visually in order to detect fires at an early stage. Restrictions on use may include vapours (including mist) and smoke, direct sunlight on the material and a lack of ambient light.

Infrared cameras detect temperature increases on surfaces. The monitoring area depends on the resolution of the camera. The surface monitored by a camera can be enlarged using a pan-and-tilt-head device.

Fire gas detectors / gas sensor units are based on the detection of one or more fire gases. These include carbon monoxide, various hydrocarbons, hydrogen and nitrogen oxides. By analysing the combination, substance-specific smouldering fires can be detected at a very early stage. These detectors are "sensitive" in their application and require highly customised planning and design. In particular, the expected fire gases have to match the detector type and these fire gases have to be channelled to the detector in a safe manner.

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Table 1: Compilation of detector types, response characteristics and operating environment

Characteristic	Types of alarm devices	Response characteristics	Operating environment	Typical areas of application in recycling plants	Notes
Smoke	Point-type smoke detectors	Smoke at the detector	(Heated) indoor rooms, normal ambient conditions, no increased dust content, no dew point undershooting	Administration, technical operating rooms	Smoke has to rise to the ceiling, which is often a challenge in storage areas in recycling plants (e.g. cross ventilation, great heights) and can lead to considerable delays in automatic fire detection.
Smoke	Linear smoke detectors	Smoke detection due to / through opacification of a light beam	Do not mount on vibrating or deforming components. The receiver is to be installed away from light and heat. Operational work processes must not take place in the detection area.	Monitoring of large halls	Difficult in open halls due to air humidity, exhaust fumes from vehicles, flying birds, etc.
Smoke	Aspirating smoke detector (ASD)	Active smoke evacuation	Inside buildings	Object monitoring inside buildings is also possible in halls and in hard-to-reach places (e.g. transformers).	See also point-type smoke detectors. Can be used in areas subject to dust and/or moisture (in combination with filter and/or separator devices upstream of the evaluating processor unit). Blow-out devices can be used in dusty environments.
Smoke	Smoke detectors to monitor ventilation pipes	Smoke or fire gas supply via inlet pipe / sensor tube / extraction device in the duct	Special fire detectors on the pure gas side of dust extraction systems	Air recirculation inside buildings	-

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Characteristic	Types of alarm devices	Response characteristics	Operating environment	Typical areas of application in recycling plants	Notes
Smoke / flames	Video-based fire detection	Visible, analysable flame or smoke	Halls and also outdoor areas to a limited extent	Storage and processing areas without effluvia	Minimum illuminance shall be provided. Combination with IR technology should be tested.
Radiation	Flame detector	Light detection in the UV/IR range, combined with flickering frequency of the flame if required	The field of vision toward the flame must not be covered.	High and open halls, conveyor belts	Often used in combination with smoke detectors; here, one fire characteristic shall already be evaluated as a fire alarm. Burning material shall have a sufficient tendency to form flames.
Heat / light	Spark detector	IR radiation from glowing, smouldering particles		Pneumatic conveying pipes, suction lines, drop chutes	These IR detectors must not be exposed to direct sunlight or reflections in the monitoring area. Particularly useful with downstream spark extinguishing system. For effective detection, the materials shall be sufficiently loosened so that sparks / glowing particles become visible.
Radiation / heat	Hot spot detector	Heat radiation from hot surfaces	Conveyor belts	Object monitoring	Observe the field of vision and conveyor speeds
Radiation / heat	IR camera device	Heat radiation from hot surfaces		Outdoor and indoor areas, storage and processing areas, conveyor belts	Sources of error (e.g. hotspots due to vehicle exhaust fumes) shall be "dubbed out", observe resolution. Use fixed or in swivelling, tilting operation. Hot smoke may not be detected.

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Characteristic	Types of alarm devices	Response characteristics	Operating environment	Typical areas of application in recycling plants	Notes
Heat	Static detector	Maximum temperature at the detector	In general, all areas in which high temperatures are generated in the event of a fire, would be possible.		Robust technology, greater delays are to be expected due to low sensitivity; therefore, only very limited use, limited ceiling heights.
Heat	Rate-of-rise detector	Measurement of temperature differences	Areas with rapid temperature rises in the event of fire		Possibly delayed triggering, limited ceiling heights.
Heat	Linear detector	Temperature measurement over a defined distance	Areas with high levels of soiling	Power and media ducts, cable routes, tunnels	Possibly delayed triggering, limited ceiling heights.
Gases	Gas sensors	Detection of fire gases	Areas with high dust exposure, expected smouldering fire	Areas with defined burning material, e.g. rotting, bunkers or silos	Gases shall reach the detector. Gas sensors shall be adapted to the respective burning material.
Heat / smoke	Multi-sensor fire detector	Smoke and/or heat and/or CO in combination		Plant rooms	Increased reliability but generally similar to the smoke detector principle (smoke is the dominant characteristic). Reduced probability of false alarms thanks to multi-criteria detection. Configuration shall be based on the sensor with the smallest monitoring area and installation height; as a rule, the heat sensor is to be used.

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4.2.2 Fire fighting

Early fire detection and alerting are the basic prerequisites but are not effective on their own. Appropriate measures are to be taken to minimise damage.

Fire-fighting equipment shall always be provided for this purpose. This can be divided into different categories:

- **automatic fire-fighting equipment,** where effective measures are usually taken immediately,
- **manual fire fighting**, in which the chain of alerting, arrival, reconnaissance, preparation of measures (extinguishing water supply) shall be taken into account,
- **auxiliary means / combinations** of both, such as semi-stationary or manually triggered devices.

The protection objectives that can be achieved with the respective equipment depend, among other things, on the point when fire fighting can still be effective.

In the case of slow-onset events, under favourable conditions an intervention can still be successful after several minutes, sometimes even hours. However, from the point of view of the protection of assets, unfavourable developments shall be assumed that require intervention as soon as possible, often even immediately.

As with fire detection, there also is a large number of established technologies available for fire fighting, which all are fully covered by standards. These and new technologies are described below, which – provided they are sufficiently effective and reliable – are good alternatives to minimise property damage and business interruptions.

4.2.2.1 Sprinkler and deluge systems / foam extinguishing systems

Sprinkler systems are stationary water extinguishing systems with fixed pipes that are sealed with sprinklers. If the trigger temperature is exceeded, the sealing element of the sprinkler nozzle triggers.

Water spray systems are fire-extinguishing systems with stationary pipework, which contrary to sprinkler systems provide open nozzles. When triggered, all extinguishing nozzles in a flooding zone are activated simultaneously. Water spray systems are used where a rapid spread of fire is to be expected in the event of a fire.

The **addition of foam concentrates** can improve fire fighting for certain combustible materials. Foam concentrates can also be used in sprinkler and water spray systems. Some foam compounds require special nozzles so that the compound can be applied in accordance with the requirements. A proportioning unit is usually required for the system.

Foam extinguishing systems can generate different types of foam. High-, medium- and low-expansion foams are available for the various risks. If foam compounds are used, further environmental requirements may have to be met.

High-expansion foam extinguishing systems generate foams with high expansion ratios in a short time; so rooms can be flooded within a short time and smother a possible fire. High-expansion foams can only be produced and introduced using high-expansion foam generators. High-expansion foams can be used to fight fire of solid materials and/or non-polar liquids. Life safety measures are to be observed.

Low- and medium-expansion foam extinguishing systems are deployed with foam-generating components and produce a solid, stable foam that can smother a fire and ideally flows smoothly over the material.

4.2.2.2 Spark extinguishing systems

A **spark extinguishing system** consists of spark detection and spark extinguishing. Spark extinguishing systems shall detect and extinguish in good time sparks that are generated during the production and/or conveying of combustible dusts, chips or fibres or that can be introduced into pneumatic conveying systems, so that a fire or explosion in the downstream system is counteracted.

4.2.2.3 Gas extinguishing systems

Gas extinguishing systems are extinguishing systems with gaseous extinguishing media such as carbon dioxide, nitrogen, argon and approved gas mixtures. The extinguishing principle is based on a reduction of the oxygen which the fire is in need of. Gas extinguishing systems extinguish without residue. Life safety measures in accordance with official regulations are to be observed. Gas extinguishing systems are mostly used as volume protection systems. They can only be partially used

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as object protection extinguishing systems. To achieve the required extinguishing concentration and to reach the hold time, the protected rooms shall be sealed and openings shall close automatically. To prevent damage due to pressure build-up caused by the inflowing extinguishing gas, an appropriately dimensioned pressure relief is to be provided.

4.2.2.4 Aerosol extinguishing systems

Aerosol extinguishing systems extinguish by dispersing liquid or solid substances (aerosol particles). Aerosols have a chemical and physical effect on the fire. The particles applied can work best in a closed facility. Life safety measures may be required.

4.2.2.5 Water mist systems

The function of **water mist systems** is mainly based on the use of very small water drops (as a rule <1 mm in diameter). As the specific surface area is relatively larger, the heat will be absorbed rapidly and the tiniest water drops will evaporate. A distinction is made between high-pressure water mist systems (HPWM, from 15 bar) and low-pressure water mist systems (up to 15 bar).

4.2.2.6 Special extinguishing systems

Monitor extinguishing systems deliver a defined quantity of extinguishing water to a seat of fire in a targeted manner or alternately cover a defined flooding zone. Extinguishing monitors can be used as stationary extinguishing systems and attached to the ceiling or wall. Automatic and/or manual use is possible.

Turbine extinguishing systems are based on the principle of extinguishing monitors but are additionally equipped with a blade wheel for compression and another nozzle ring. Thanks to this design, the throw range of extinguishing turbines can be increased. If designed accordingly, the fanning of the extinguishing jet can be used for better distribution of the extinguishing water. Static requirements may have to be observed due to size and weight.

4.2.3 Manual fire-fighting units

Manual fire-fighting units shall be provided.

This includes e.g. the following equipment:

- fire extinguishers,
- extinguishing water pipes and fire extinguisher hose connector mechanisms (fire hose stations),
- semi-stationary extinguishing equipment,
- dry risers,
- above/below-ground hydrants as well as extinguishing water extraction and suction points for the fire brigade,
- additional facilities for the fire brigade.

Wall hydrants should be provided in recycling plants in all storage and production areas where fire loads, especially loose bulk material, are present. Due to the existing fire loads, the installation of type F wall hydrants is recommended.

Extinguishing water pipes, dry risers and semi-stationary equipment are used to shorten the time until the manual fire fighting by fire brigades becomes effective or to make fire fighting possible in the first place.

Above- and below-ground hydrants or other suitable extinguishing water extraction points shall be provided at sufficient distances. These are to be kept clear and labelled at all times. The distances between the tapping points are to be agreed with the fire protection authority and should not exceed 100 m.

For initial fire fighting, supplementary options and methods of manual fire fighting can also be used in certain areas (e.g. containers with sand or other inert materials, containers with water).

For further information, see also ASR A2.2 dealing with measures against fire.

4.2.4 Supplementary facilities for the fire brigade

If, for tactical reasons, additional facilities are required for the local fire brigade to ensure defensive fire protection, these shall be made available on a case-by-case basis in consultation between the operator and the local authority (responsible body for defensive fire protection).

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4.2. 5 Smoke and heat exhaust ventilation systems (SHEVS)

It shall be possible to dissipate smoke and heat from an area affected by fire. Smoke and heat dissipation measures should also be considered for the early stage of fire to enable or secure targeted fire fighting.

Regardless of the dissipation of smoke and heat during the fire, it shall also be possible to dissipate flue gases **after a fire** in order to prevent further damage to buildings and equipment, e.g. through corrosion and the deposition of smoke particles.

Smoke and heat exhaust ventilation systems are to be assigned to smoke compartments, and **air inlet openings** shall be taken into account.

4.2.6 Use of fire detection and fire-fighting equipment for which finalised directives and standards are not yet available

Full standards and design guidelines are available for most fire detection and fire-fighting equipment.

Some of the fire detection and fire-fighting systems mentioned in this publication are not yet fully reflected in directives and (European) standards or do not yet comply with the generally recognised codes of practice, but they can still make a valuable contribution to the prevention of property damage.

The following points shall be taken into account in order to use these techniques:

- Fire detection or fire-fighting systems should be certified by independent bodies (e.g. laboratories accredited to DIN EN ISO / IEC 17025).
- If, for example, certification is not possible due to a lack of standardised test bases, the usability of the systems is to be assessed on an individual basis. The design of the systems shall be recognisable and comprehensible for the respective application.
- As soon as standards or guidelines or more recent findings are available, the equipment is to be reviewed and adapted to the current state of the art.
- The monitored areas (fire detection) and protection zones (fire-fighting equipment) are to be compiled in a concept for the fire protection systems.

For the recognition of new extinguishing techniques, for example, there is the procedure according to the guideline VdS 2562en "Procedure for the approval of new extinguishing techniques". This procedure makes it possible to provide proof of the extinguishing effectiveness and reliability of new extinguishing techniques for which existing guidelines cannot be applied or can be applied in part only.

It is also possible to obtain VdS approval of new protection concepts through the procedural guideline VdS 3115en "Procedure for the Approval of New Protection Concepts for Extinguishing Systems".

The procedures also give the insurer the opportunity to evaluate new extinguishing techniques and protection concepts.

4.3 Organisational fire protection

The organisational fire protection measures help to minimise the probability that operational disruptions or resulting loss occur.

Fire safety officers

A fire safety officer should be appointed to fulfil the extensive fire protection tasks.

The training and necessary activities of a fire safety officer are described in detail in the joint publication by DGUV, vfdb and VdS dealing with the tasks, qualification, training and appointment of fire safety officers.

For more information, see the corresponding VdS 3111.

New builds and conversions, changes of use or processes

The fire safety officer should be involved in all modifications right from the planning phase.

Regular inspections

Regular tours of inspection should be carried out, in which the fire protection measures are checked and documented. Keeping fire safety checklists has proven to be helpful for these inspections.

A customised checklist should be drawn up for the plant, which also contains daily, weekly and monthly inspections.

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For fire safety checklists, see also the appendices in VdS 2000 dealing with fire protection in companies and VdS 3110 containing supplementary information for fire safety officers.

A key issue here is to check the compliance with storage regulations as well.

Documentation

The implementation of essential fire protection measures and their results in the company are to be documented, e.g.:

- cleaning instructions,
- fire precautions checks,
- permits,
- instruction and training,
- maintenance and defects book,
- inspection of electrical systems,
- inspection of fire protection systems and fire protection equipment,
- all fire incidents, even if they can be extinguished immediately, and their causes,
- explosion protection measures and revision inspection.

Tidiness and cleanliness

The plant shall be maintained and operated in a proper condition. The equipment should be cleaned and dust deposits be removed regularly. Spillages and other accumulations of material are to be removed daily. The equipment should be emptied at the end of business hours.

Inspection of electrical systems

Proper planning and installation, regular inspection and maintenance of electrical systems can significantly reduce the risk of fire.

The systems are to be inspected regularly in accordance with the VDE regulations, the regulations for accident prevention by the Employers' Liability Insurance Association and the safety regulations agreed with the insurer. See also:

- VdS 2871 dealing with guidelines for the inspection of electrical systems; inspection guidelines according to Clause SK 3602; instructions for the recognised electrical expert
- DGUV Regulation 3 – Electrical systems and equipment

In addition, by professionally recording and analysing thermographic images in electrical systems, weak points or damage can be detected at an early stage, thus reducing the risk of fire and accidents. See also:

- VdS 2858 dealing with thermography in electrical installations; a contribution to loss prevention and operational safety
- VdS 2859 dealing with the approval by VdS of thermography experts, procedure guidelines

Note: Electrical systems should be planned and installed in such a way that the system components not required outside of operating hours can be de-energised.

Fire-hazardous tasks

Fire-hazardous tasks such as welding, abrasive cutting, soldering and flame cutting in connection with repair, assembly and disassembly work outside the workshop area as well as roof work with flames are a recurring cause of fire.

It is not only the immediate vicinity of the workplace that is at risk. Welding, cutting and grinding sparks, for example, can ignite combustible materials even at distances of 10 m or more. For this reason, fire work outside workplaces permanently set up for this purpose should always be prohibited in the plant.

If such work is unavoidable, a written permit shall be issued by the site manager or the authorised representative (permit for fire-hazardous tasks). This obliges the personnel carrying out the work (own and external) to take and observe all necessary precautionary measures.

For further information see:

- VdS 2008en "Hot work, Guidelines for fire protection"
- VdS 2036 – permit for fire-hazardous tasks
- VdS 2047 dealing with the safety regulations for fire-hazardous tasks

Smoking and naked flame

Smoking and the use of naked flame are prohibited in production and storage areas – both, inside buildings and outdoors. Employees and visitors are to be instructed accordingly. The prohibition shall be clearly and visibly marked with a prohibition sign.

Smoking areas should be set up to prevent secret smoking. They are to be clearly labelled as such and suitably equipped.

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Fire precaution regulation

An essential part of organisational fire protection is regulated in the fire precaution regulation. The fire precaution regulation consists of three parts:

- A (notice "Reaction to fire"),
- B (for persons not fulfilling special fire protection tasks) and
- C (for persons fulfilling special fire protection tasks).

DIN 14096 governs the content and presentation.

For further information, see also VdS 2000 dealing with fire protection in companies, here the clause on the fire precaution regulation.

DIN 14096 dealing with the fire precaution regulation – rules for drawing up and posting – is a summarising regulation for the behaviour of persons inside a building or plant in the event of a fire and for measures to prevent fires.

Contents of DIN 14096 [verbatim translation of the original German text]:

- The fire precaution regulation Part A consists of a notice with keyword-like instructions or notes and supplementary graphic safety signs for fire prevention and the reaction to fire.
- The fire precaution regulation Part B (for persons not fulfilling special fire protection tasks) is aimed at persons (e.g. residents, employees) who are present in a building not only temporarily.
- The fire precaution regulation Part C (for persons fulfilling special fire protection tasks) is aimed at persons who have been assigned special fire protection tasks in addition to their general duties (e.g. fire safety officers, safety engineers).



Figure 4-3: Sample for notice regarding the fire precaution regulation Part A

Fire fighting by employees

Employees are to be instructed at appropriate intervals about the fire hazards and protection measures relating to their workplaces.

The employees should receive regular training – once per year if possible – on functions and handling of the fire-fighting equipment as well as proper behaviour at the outbreak of fire.

The aim should be to train 100% of the operating personnel in the production and storage areas as fire safety assistants.

For further information see:

- DGUV 205-023 dealing with fire safety assistants – training and qualification
- Guidelines for workplaces ASR 2.2 dealing with measures against fires (there the section for fire protection assistants stating instructions and training for employees)
- VdS 2213 dealing with in-plant fire protection training
- VdS 3462 dealing with wall hydrants for initial fire fighting in companies

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Shutdown of fire protection systems

Fire protection systems may be taken out of operation only in consultation with the persons in charge of this in the company.

In accordance with the individual agreements, the insurer shall be notified of the shutdown of fire protection systems.

Suitable alternative measures shall be defined for the duration of the shutdown.

For further information, see e.g. leaflet by the German Fire Protection Association (vfdb) 14-05 dealing with the measures to be taken in the event of a failure of technical fire protection equipment.

Lithium batteries

Lithium batteries mainly end up in municipal waste and combustible secondary raw materials as a result of false disposal by consumers. The batteries are an additional source of ignition in the recycling process. They can self-ignite due to defects, ageing or deep discharge or catch fire due to mechanical or thermal stress, for example. Depending on the size and type of battery, severe fire incidents combined with a very rapid spread of fire are possible. The risks involved here result in especially high demands on fire protection.

In order to meet these demands in principle, operating instructions are to be drawn up for areas in which lithium batteries are found. These operating instructions shall specify how batteries found in recycling centres are to be handled. This includes operating instructions for lithium batteries for all plant sections, in particular delivery, reprocessing technology and storage areas.

Undamaged lithium batteries should be sorted out manually, e.g. with a shovel, and placed in a suitable safe intermediate container or taken directly into the open air.

Instructions shall also be provided for the removal of conspicuous, damaged or burning lithium batteries, e.g. by means of a wheel loader to a specified, suitable storage area outside. Of course, this means that only some of the batteries can be detected and removed. Basically, these operating instructions raise awareness of how to handle lithium batteries and show ways of handling them quickly. All operating instructions shall also take personal protection into account.

Further information on lithium batteries can be found in the publications VdS 3103en "Lithium Batteries", VdS 3856en "Sprinkler Protection Of Lithium Batteries" and DGUV Information 205-041 dealing with fire protection when handling lithium batteries.

4.3.1 Localisation of temperature anomalies

Regular (manual) temperature measurements allow fire hazards to be recognised at an early stage. Hand-held thermal imaging cameras are suitable for this purpose. These instruments allow a targeted identification of potential seats of fire during delivery and storage.

Temperature probes (temperature measuring rods) can be used to measure the temperature in bulks in deep-seated areas or other places that are difficult to access. This allows precise and continuous measurement. The temperature curve can be monitored by recording. By networking several devices, comprehensive monitoring is possible.

In waste treatment plants with complex structures, in which conventional fire detection systems are influenced by disruptive factors such as shading, the temperature measuring devices are a useful addition. This method can offer a significant time advantage in fire detection.

Actions regarding temperature measurement should be determined according to the operating conditions (environment, materials, susceptibility to fire) and in consultation between the operating party and the insurer. The results of the measurements should be documented in the operating log.

4.3.2 Cooperation with the fire brigade

Ground plan for fire brigade use

Ground plans for fire brigade use shall be drawn up in agreement with the authority responsible for fire protection and made available to the local fire brigade. [MKLR 9][1]

A ground plan for fire brigade use in accordance with DIN 14095 dealing with ground plans for fire

[1] Verbatim translation of the text from the model guideline on fire protection for the storage of used tyres and plastic waste in waste disposal facilities (Model guideline of the German Länder on fire protection for storage of secondary plastic materials, model plastic storage guideline MKLR) – March 2023. The [numbering in square brackets] is identical to the MKLR. Any deviations from the plastic storage guidelines introduced by the construction supervisory board in the individual German Länder are to be checked on a case-by-case basis.

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brigade use for structures shall be drawn up for each major part of the plant.

These plans shall be regularly reviewed and, if necessary, adapted to changing circumstances.

Storage plan

A storage plan should be drawn up that contains information on the distribution of the storage area and the type and quantity of the stored substances. The plan is to be constantly updated and kept outside the storage area in an accessible place at all times. In the event of a fire, the storage plan is to be handed over to the fire brigade's officer in charge. Details are to be agreed with the fire brigade.

Regular inspections / fire drills

Together with the fire brigade, regular inspections and fire drills should be carried out.

4.4 Process engineering and fire protection measures

Automation has increased steadily in the recycling industry and a wide range of technologies are being used in the processes. These can contribute to the prevention of fire damage by means of process-related measures.

This publication therefore presents additional process-related measures that have an indirect impact on potential fire hazards, such as the selection of materials (non-sparking, non-combustible, of low flammability) for the equipment in use, provided that the required process technology allows this.

In addition, process-related measures are mentioned that enable an assessment of the situation by monitoring process parameters and can actively minimise fire risks by preventing expected problems, such as overheating, through condition-based maintenance and servicing measures.

The possible process-related monitoring parameters include, for example, temperature, pressure, filling level, power consumption and speed.

If deviations in any parameters are detected, the system components shall be controlled, e.g. by reducing the output, shutdown, cooling or running empty.

The aim of monitoring and control is to bring affected units or system components into a non-critical state in terms of fire protection before a fire breaks out.

In addition, it is suggested that the use of process-related equipment to support fire fighting should also be considered, e.g. the use of existing exposure protection systems or cooling systems.

The process-related measures are listed in tabular form in Clause 6 "Overview of fire protection measures". The table describes fire hazards and protection measures typical for the equipment or process.

5 Defensive fire protection

The requirements for the areas for the fire brigade and the extinguishing water supply apply in principle to all combustible materials. They are described below on the basis of the model plastic storage guideline (MKLR). Deviations from these requirements can be agreed with the insurer in individual cases, in particular for matters that are not governed by the MKLR.

5.1 Fire brigades

The efficiency of the local fire brigade should always be taken into account when drawing up fire protection concepts with a view to the operational/ corporate protection objectives. It depends, among other things, on functional strength, intervention time, degree of accessibility, vehicles, equipment, personal protective equipment and qualification.

5.2 Areas for the fire brigade

Suitable access roads as well as set-up and movement areas for the fire brigade shall be created on the property in agreement with the authority responsible for fire protection. Set-up areas are to be provided on at least two opposite sides for outdoor storage areas of 2,000 m² or more and for structures of 5,000 m² or more. Distances to external building walls in accordance with the model guideline on areas for the fire brigade apply to the boundaries of storage areas as well. [MKLR 4][2]

Bypasses are to be provided for outdoor storage areas of 2,000 m² or more and for structures of 5,000 m² or more.

[2,3] Verbatim translation of the text from the model guideline on fire protection for the storage of used tyres and plastic waste in waste disposal facilities (Model guideline of the German Länder on fire protection for storage of secondary plastic materials, model plastic storage guideline MKLR) – March 2023. The [numbering in square brackets] is identical to the MKLR. Any deviations from the plastic storage guidelines introduced by the construction supervisory board in the individual German Länder are to be checked on a case-by-case basis.

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5.3 Extinguishing water supply for the fire brigade

A sufficient quantity of extinguishing water can be provided either from the public area with tapping points within a radius of approx. 300 m, from an extinguishing water reserve on the company premises or through a combination of both.

Regarding the extinguishing water supply, a distinction is made between basic protection and local application.

For areas that show only low fire load, a reduced quantity of extinguishing water may also be sufficient in deviation from the following explanations.

The water supply of existing extinguishing systems shall be ensured regardless of the following requirements.

5.3.1 Basic protection

To limit the spread of fire beyond a storage area, an extinguishing water volume of at least 192 m³/h shall be available over a period of two hours. In consultation with the authority responsible for fire protection and the fire insurer, a larger quantity of extinguishing water and a greater pumping capacity may be required if necessary. For storage areas with an automatic fire extinguishing system, the amount of extinguishing water for fire fighting by the fire brigade can be reduced in consultation with the fire protection authority and the fire insurer. [MKLR 8][3]

5.3.2 Property-specific dimensioning of the extinguishing water demand (local application)

From the point of view of asset protection, the basic protection mentioned above is sufficient, provided that the storage and production areas are protected with automatic fire extinguishing systems in accordance with Clause 6 "Overview of fire protection measures".

For unprotected areas, additional local application is recommended in accordance with the results of the study on fire incidents in waste treatment plants by LANUV NRW [verbatim translation of the original German text]: An additional extinguishing water volume of 768 m³ (384 m³/h for two hours) is recommended for the storage of combustible secondary raw materials with an area of 800 m² or more.

6 Overview of fire protection measures

The following table describes typical main risks and fire protection measures with reference to the respective plant section.

The table provides guidance for the selection of possible measures in recycling plants. The table is not exhaustive; instead of the systems listed as examples, other suitable systems may also be used.

The measures shown in standard font are to be interpreted as basic protection, the notes printed in *blue italics* are to be understood as *extended protection measures*.

Here, too, measures should be determined on the basis of an individual risk analysis in consultation with the insurer.

Technical measures for fire detection and fire fighting shall be effective and reliable.

Notes on the table:

- Emergency stop switches are not explicitly listed in the table. It is assumed that they are present on the equipment accordingly and that they put the equipment into a safe state in the event of hazard. Any new hazards that may arise shall be taken into account for a shutdown.
- Plant sections in which potentially explosive atmospheres are typically possible are marked in the table with the warning sign. 

- In general, risk assessments shall be carried out and explosion protection measures shall be defined in an explosion protection concept.
- Generally applicable organisational measures (see Clause 4.3) apply in principle and – for reasons of readability – are not listed repeatedly.

4 (Technical report 68, LANUV 2016)

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Storage areas		Fire protection measures				Note
Plant section	**Main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
Delivery, outgoing storage flat/deep bunker (open, covered, closed)	Smouldering fires, introduced fires, deep-seated fires, lithium batteries	Compartmentation acc. to VdS 2234	Automatic fire detection and fire alarm system (FDAS), e.g.: ■ IR camera device ■ aspirating smoke detectors Video-based fire detection Automatic water extinguishing system covering the entire area, e.g.: ■ sprinklers ■ water spray system ■ extinguishing monitors Smoke and heat exhaust Type F wall hydrants	*Temperature sensors/ rods* *Water curtain /sprinkling to bind dust, provided this is compatible with the production process*	Emergency planning for this operational area (including the reaction to fire, fire fighting, evacuation) Sorting / checking the material to be stored Regular inspection of the storage sections (e.g. distances, heights, open spaces, temperatures, etc.) Mobile thermal imaging camera No parking of motor vehicles and machines Regular repositioning Emptying the bunker / warehouse at the end of business hours	If extinguishing systems can only be triggered manually, operators shall be present at all times or the bunker / storage facility shall be emptied.

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Mechanical treatment		Fire protection measures				Note
Plant section	**Hazards / main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
Total plant / hall: Reprocessing and sorting plant	Ignition sources (introduced or effective due to process engineering) in connection with high fire loads Technical defects	Separate fire compartment	Automatic FDAS, e.g.: ■ aspirating smoke detectors ■ smoke detectors Smoke and heat extraction *Automatic water extinguishing system covering the entire area, e.g.:* ■ *sprinklers* ■ *water spray system* *provided that the extinguishing agent does not lead to undesirable chemical reactions in the recycling material*	Access to **all** facilities for regular maintenance and manual fire fighting *Access via permanently installed platforms / maintenance routes*	Daily cleaning Emptying at the end of business hours (reduction of fire load) Documentation of servicing	-
Conveyor belt / conveyor system / chain conveyor	Glowing embers, hot runners on rollers or chains Overheated drives Skewing Burning belt Combustible deposits in the environment	Non-combustible building materials for enclosures	After comminution, screening, mechanical stress or in case of enclosures: Automatic FDAS, e.g.: ■ flame detector ■ spark detector ■ IR camera device ■ hot spot detectors and automatic water extinguishing system, e.g. water spray	Belts of low flammability Speed and skewing monitoring *Temperature monitoring of roller bearings* Monitoring of load pick-up Motor protection switch / overload protection Fire control matrix (including organised disabling procedures)	Daily cleaning Emptying outside business hours (reduction of fire load)	-

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Mechanical treatment		Fire protection measures				Note
Plant section	**Hazards / main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
Screening / drum screen	Static charging Hot-running, defective batteries	-	Automatic FDAS, e.g.: ■ flame detector ■ IR camera device Automatic water extinguishing system, e.g.: ■ water spray systems ■ water mist system ■ extinguishing monitor (permanently installed) *) Extended coverage sprinklers on both sides in the drum screen	Monitoring of load pick-up Motor protection switch / overload protection Speed monitoring	Daily cleaning Emptying outside business hours (reduction of fire load)	-
Pneumatic conveying lines	Ignition source entrainment and static charging, explosion hazard	No bridging of fire compartments or suitable protection measures (e.g. bulkheads)	*Spark extinguishing systems*	Electrically interconnected and included in equipotential bonding *For fans / ventilators: Monitoring of operating parameters such as speed, overload, vibrations*	Clean regularly	If necessary, decouple for explosion protection and equip with appropriate protection measures (inerting, pressure-proof construction, etc.)

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Mechanical treatment		Fire protection measures				Note
Plant section	**Hazards / main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
Air separator	Possible ignition of an existing ignition source	-	*Automatic FDAS, e.g. spark/glow detection before entry featuring automatic shutdown of the air separator (monitoring can be integrated into an existing FDAS)* *Manual/automatic flooding device of the air separator*	*Temperature monitoring*	Clean regularly	-
Bulky waste cutter	Crushing of flammable materials (lithium batteries, gas containers, etc.)	-	Automatic FDAS, e.g.: ■ flame detector ■ IR camera device Automatic water extinguishing system*), e.g.: ■ water spray system ■ foam systems Above the feed hopper as well as up- and downstream the cutter	Automatic stop of fire detection or discharge into a secured area *Monitoring of the drive (pressure, temperature, load/ power consumption ...)*	Regular cleaning Emptying outside business hours (reduction of fire load)	*) Manual activation of the extinguishing system is possible if operators are constantly present and can activate the system immediately.

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Mechanical treatment		Fire protection measures				Note
Plant section	**Hazards / main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
Shredder / disintegrator / bag ripper	Fire and explosion hazards due to comminution processes; crushing / squeezing of flammable materials (lithium batteries, gas containers, aerosol cans, etc.) Hot running of the drives, sparking	Structural or spatial separation of storage areas exposed to fire	At the entry and discharge area: Automatic FDAS, e.g.: ■ flame detector ■ IR camera device Automatic*) water extinguishing system, e.g. spray water at the feed hopper	Automatic stop of fire detection or discharge into a secured area *Low-speed engine (up to 100 rpm)* *Monitoring of the drive (pressure, temperature, load/ power consumption ...)*	-	EX Check whether measures for explosion protection are necessary; explosion protection document. *) Manual activation of the extinguishing system is possible if operators are constantly present and can activate the extinguishing system immediately. Protection measures shall be defined for other conveyor systems depending on their size, accessibility, importance for the production flow, etc. (e.g. automatic FDAS, automatic water extinguishing system).

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Mechanical treatment		Fire protection measures				Note
Plant section	**Hazards / main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
Grinders (e.g. hammer mills)	Fire/explosion hazards due to comminution processes	-	At the discharge area: Automatic FDAS, e.g. spark detection system *Spark extinguishing system* *Type F wall hydrant* *Manual/automatic water extinguishing system, e.g. water spray system, provided that the extinguishing agent does not lead to undesirable chemical reactions in the recycling material*	Automatic stop of fire detection or discharge into a secured area Suitable magnetic separator upstream *Non-ferrous metal separator* Storage temperature monitoring Grinding chamber temperature monitoring Automatic level control	-	Fine grinding: EX

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Mechanical treatment		Fire protection measures				Note
Plant section	**Hazards / main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
Physical drying for combustible materials (e.g. drum dryer)	Ignition of the material to be dried due to heating / drying	-	In the exhaust air and discharge area: Automatic FDAS, e.g. spark detection system Manual / *automatic* water extinguishing system, e.g.: ■ water spray system ■ spark extinguishing system	Indirect heating: Exhaust air temperature monitoring Monitoring of the drive (load monitor / contactor) In case of fire detection: ■ Automatic stop or discharge into a secured area ■ Redundant safety temperature limiting ■ Redundant volumetric flow control Individual protection measures shall be defined for direct heating.	Emptying of the drying system at the end business hours	EX Preferably indirect heating Note VdS 6053 dealing with fire protection in drying systems (in preparation)

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Mechanical treatment		Fire protection measures				Note
Plant section	**Hazards / main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
Baler Metal/can press	Ignition of hydraulic oil, heating due to pressure For can presses, also ignition of contents from pressurised gas tanks, e.g. aerosol cans	Structural or spatial separation of the presses from storage areas exposed to fire	Automatic FDAS, e.g.: ■ flame detector ■ IR camera device ■ heat detector Manual/*automatic* water extinguishing system e.g.: ■ water spray system ■ sprinklers ■ water mist system	If safety devices are triggered, transfer to safe operating state and/or automatic disabling Fire control matrix Monitoring of pressure, temperature; monitoring of the drive (load monitor / contactor)	No additional fire loads in the immediate vicinity of the press	Also see hydraulic systems.
Pelleter with pellet cooler	Ignition of the material due to pressure and friction	Structural or spatial separation of the presses from storage areas exposed to fire	Automatic FDAS, e.g.: ■ spark detection in the discharge of the press or entry into the cooler ■ spark detection in the exhaust air Manual/*automatic* water extinguishing system, e.g. water spray system Extinguishing equipment for internal flooding of the pellet cooler	Monitoring operating parameters (pressure, temperature, monitoring of the drive (load monitor / contactor)	-	EX

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Mechanical treatment		Fire protection measures				Note
Plant section	**Hazards / main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
NF separator Fe separator	-	-	Automatic FDAS, e.g.: ■ IR detection ■ Spark detection/ *extinction* before entry	Automatic shut-off on fire detection or discharge into a secured area. For NF separators: Upstream connection of Fe separator	-	Protection of belt systems such as conveyor systems (see above) If necessary, also monitoring of the discharge fraction by fixed IR camera device
NIR sorting system	-	-	Automatic FDAS, e.g. IR detection system Spark detection/*extinction* before entry	Automatic shut-off on fire detection or discharge into a secured area *Upstream connection of Fe and NE separators* Selection of luminaires with regard to heat radiation when the system is at standstill and/or automatic turn-off of the luminaires	-	Protection of belt systems such as conveyor systems (see above)

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Biological treatment		Fire protection measures				Note
Plant section	**Main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
Fermenter / digestion plant	Anaerobic digestion	Spatial or structural fire compartmentation between the individual plant sections Distances, e.g. between gas storage tanks and adjacent equipment, facilities and buildings	Gas warning system	-	-	EX For distances, see also TRAS 120 dealing with the safety requirements for anaerobic digestion plants

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Biological treatment		Fire protection measures				Note
Plant section	**Main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
Rotting / biological drying	Self-ignition through biological processes	Spatial or fire-resistant separation from adjacent areas	Automatic FDAS in the exhaust air and in the media duct, e.g.: ■ heat detectors ■ fire gas detection (e.g. CO) Openings / *flooding devices* for manual fire fighting in consultation with the fire brigade If existing process irrigation equipment is also to be used for fire fighting, a sufficient water supply and effective design density shall be ensured. *Semi-stationary fire-fighting equipment*	Temperature monitoring of the exhaust air Inspection openings in the exhaust air ducts Process control system and temperature probes with connection	Regular cleaning of the exhaust air duct Possibility of manual emptying (e.g. using a wheel loader) in the case of fire Documented regular manual temperature measurement	-

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Biological treatment		Fire protection measures				Note
Plant section	**Main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
RTO facilities	-	Structural or spatial separation	-	System featuring a start-up burner: flame monitoring with interlock Redundant temperature monitoring		EX

Physical treatment		Fire protection measures				Note
Plant section	**Main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
Filtering installations	Introduction of hot particles, static charge, self-ignition process	Structural or spatial separation *Installation outside of buildings*	Spark detection and spark extinguishing system before entering the filter Automatic FDAS in the filter, e.g.: ■ heat detector ■ smoke detector (on the pure gas side) Manual/*automatic* extinguishing system in the filter, e.g.: ■ water spray system ■ sprinklers ■ gas	Inspection openings from at least two sides Disabling in case of fire – automatic or from a safe location Exhaust air fan on the pure gas side *Filter media made of materials of low flammability*	-	EX VdS 3445 dealing with fire protection in dust extraction systems, leaflet on loss prevention

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Physical treatment		Fire protection measures				Note
Plant section	**Main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
Silos	Self-ignition or introduced ignition sources	*Built with non-combustible materials* *Outdoor installation*	Automatic FDAS, e.g.: ■ heat detector, *fire gas detection (e.g. CO)* ■ inerting/extinguishing equipment *Nozzle rings*	Cooling of storage product to below 50 °C Silo vehicles are to be earthed during loading and unloading	Determination of the safety-related characteristic values regarding self-ignition behaviour Operating instructions for inerting in case of fire and evacuation concept	EX VdS 2154 dealing with the inerting of silos in case of fire Silos made of woven fabric inside buildings should be analysed individually.

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Other sections		Fire protection measures				Note
Plant section	**Main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
Technical operating rooms	Increased risk of fire due to technical defect	Fire-resistant separation	Automatic FDAS, e.g. smoke detectors	-	Free of fire loads not required for operation	-
Electrical operating rooms	Increased risk of fire due to technical defect	Fire-resistant separation	Automatic FDAS, e.g.: ■ smoke detectors ■ aspirating smoke detectors *Automatic extinguishing system, e.g. gas extinguishing system, depending on availability requirements*	Positive pressure ventilation in dusty areas	Regular cleaning Free of fire loads not required for operation	Protection of all final circuits by RCD max. 300 mA. Regular inspection of the electrical equipment in accordance with DGUV / VDE. E-revision by recognised experts in accordance with inspection guidelines (VdS 2871). VdS 2033 dealing with electrical installations in operating sites at risk of fire and equivalent risks. De-energise electrical equipment that are not required at the end of business hours.

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Other sections		Fire protection measures				Note
Plant section	**Main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
Free-mounted switching and control systems which are **not** separated in a fire-resistant manner (e.g. in production)	Increased risk of fire due to technical defect	-	Use of closed controllers with FDAS monitoring inside: ■ smoke detectors ■ aspirating smoke detectors Automatic extinguishing system, e.g. gas extinguishing system, depending on the requirement regarding availability	Positive pressure ventilation or sufficiently dust-tight design in areas exposed to dust	Regular cleaning	See "Electrical operating rooms" in this table
Illumination	Increased risk of fire due to defects / errors / increased operating temperature	-	-	IP suitability according to VDE specifications	Regular (visual) inspection of the luminaires for defects	VdS 2005 dealing with luminaires. Use encapsulated lights. Take into account the ambient conditions when selecting the luminaries (e.g. corrosion resistance, humidity).

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Other sections		Fire protection measures				Note
Plant section	**Main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
Hydraulic systems	Leakage / spraying of ignitable hydraulic fluid	Collection tray Distance to fire loads or splash guards *Fire-resistant separation or outdoor installation (e.g. in containers)*	Automatic FDAS, e.g.: ■ flame detector ■ IR camera device ■ heat detectors Manual/*automatic* water extinguishing system, e.g.: ■ water spray system ■ sprinklers ■ water mist system	Monitoring of pressure, temperature, fill level If safety devices are triggered, transfer to safe operating state and/or automatic disabling Fire control matrix *Hydraulic hoses with burst protection*	Regular replacement of hydraulic hoses	
Warehouse for equipment and machinery materials	Small quantities of combustible, (highly) flammable liquids	Fire-resistant separation Collection trays	Automatic FDAS, e.g.: ■ smoke detectors ■ aspirating smoke detectors ■ heat detectors *Automatic extinguishing system, e.g. sprinklers*	Avoid ignition sources	Free from other fire loads *Storage in cabinets for hazardous materials*	EX Register of equipment and machinery materials / register of hazardous substances
Ventilation systems	Smoke propagation	Fire dampers for the event of penetration through fire protection separations	Automatic FDAS, e.g. ventilation duct detectors Activation of fire dampers with triggering through the characteristic “smoke”	Disabling in case of fire – automatic or from a safe location (e.g. control centre) Fire control matrix	Regular cleaning	VdS 2298 dealing with fire protection in ventilation systems. For dust accumulation: see filter systems.

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Other sections		Fire protection measures				Note
Plant section	**Main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
Fans	Fan overheating, imbalances, sparking	-	-	Motor protection switch *Automatic lubrication system for bearings* *Monitoring of bearing temperature and vibration* *Material selection (spark prevention)*	Regular inspection and maintenance of the bearings and fan blades (dirt, imbalance) *Day-by-day visual inspections*	-
Industrial trucks	Potential ignition source	Refuelling only outdoors at specially equipped points Charging only at suitable stations	-	Spark catcher for diesel-powered industrial trucks	Parking of industrial trucks only in suitable and marked parking spaces with sufficient distance to combustible components and combustible materials A distance of at least 5 m should be maintained from storage areas. *Fire extinguisher on the industrial truck (attached to the industrial truck in accordance with the manufacturer's specifications)*	For the design of charging stations, see VdS 2259 dealing with battery charging facilities for electrically powered industrial trucks and mobile machinery

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Other sections		Fire protection measures				Note
Plant section	**Main risks**	**Structural**	**Technical**	**Process-related**	**Organisational**	
Radiant heaters (dark radiators, bright radiators)	Fire hazard due to high operating and surface temperatures	-	*Use only in areas that are protected by automatic fire protection systems*	Overheating protection Stop valve for fuel supply at a safe location incl. marking Constructions to prevent (dust) deposits Sufficient safety distance between the installation and combustible materials	No objects must be placed on heat sources or hot pipework. Operation only during business hours To be kept free of fire loads Dust deposits to be avoided Regular inspection and cleaning, especially before the heating period starts	Direct heating, for example with gas-fired IR radiators, should be avoided. No use of radiant heaters: ■ in operating sites at risk of fire (VdS 2033); ■ above combustible materials/stored goods. Use only above workplaces. Mobile heaters must not be used.
Combined heat and power plant	Combustible materials and hot surfaces	Fire-resistant separation *Separate fire compartment*	Automatic FDAS, e.g.: ■ smoke detectors ■ aspirating smoke detectors Gas warning system with connection	-	Approval of the CHP unit for biogas by the manufacturer Free of fire loads not required for operation	-

7 Explosion protection

The need for explosion protection measures is determined object- and equipment-related in the risk assessment and the explosion protection document in accordance with § 6 of the German Ordinance on Industrial Safety and Health. It may be necessary to involve an expert (qualified person) to prepare the explosion protection document. During sorting, reprocessing and storage of combustible secondary raw materials, the occurrence or deposition of explosive dusts, e.g. due to abrasion, is always to be expected.

In operating areas with high dust generation, operating equipment and structures should be designed in such a way that sloping surfaces and covers prevent dust deposits.

Regular cleaning is advisable to remove dust deposits on building members or operating equipment that may occur despite extraction systems and exhaust air purification. The cleaning process shall ensure that dust is not stirred up. The cleaning intervals shall ensure that dust deposits are prevented.

For further information see:

- Guideline by the German Social Accident Insurance DGUV Rule 113-001 (former Employers' Liability Association rule BGR 104) a guideline for explosion protection (EX-RL)
- DGUV Information 213-106 regarding the explosion protection document

8 Environmental protection

8.1 Extinguishing water retention with stationary and mobile measures

Secondary raw materials from solid substances are generally not classified as hazardous to water. In the event of a fire, hazardous fire by-products can be produced that lead to contamination of the extinguishing water.

As a rule, measures shall be taken that allow the extinguishing water to be chemically characterised first. Only then a decision can be made on how to deal with the extinguishing water. This means that, as a rule, preparatory measures are required to retain extinguishing water.

The term **retention of extinguishing water** should be understood to mean all measures that are suitable for preventing the extinguishing water produced during fire fighting from flowing off or being discharged in an uncontrolled manner.

Facilities for retention of extinguishing water are open or closed basins, pits or rooms or containers with a comparable function and the corresponding equipment intended and suitable for holding extinguishing water until it can be disposed of properly.

Facilities for retention of extinguishing water are at least required to be self-acting and feature a sufficiently liquid-tight lining if possible. Fire-fighting measures must not be hindered by this. Furthermore, contaminated extinguishing water must not contribute to the spread of fire when being discharged. The retention concept for extinguishing water shall be implemented in the plans of action of the in-plant protection measures to ensure that the required measures pass off smoothly in the emergency case.

Sufficient retention of extinguishing water can be achieved with both, stationary and mobile measures. Recommendations or requirements for the retention of extinguishing water can also result from the fire protection concept.

Further information:

- AwSV German ordinance on installations handling water-hazardous substances
- Guideline on how to dimension facilities for retention of extinguishing water when storing water-hazardous substances (LöRüRL) by ARGEBAU
- VdS 2557en "Planning and Installation of Facilities for Retention of Extinguishing Water"
- VdS 2564-1 dealing with guidelines for facilities for retention of extinguishing water, Part 1: Stationary extinguishing water barriers; components and systems, requirements and test methods

8.2 Extinguishing water disposal

It is recommended that a concept for the disposal of extinguishing water is defined as a precautionary measure with the operating parties of the sewage treatment plants and the responsible authorities. Consultation with the operating parties of the sewage treatment plant is required every time before discharging any extinguishing water, especially if special extinguishing agents or foam additives have been used.

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8.3 Fire residues

Fire residues are to be collected and disposed of in consultation with the supervisory authorities in accordance with the applicable regulations. Further information can be found, for example, in the guidelines for fire loss restoration (VdS 2357en).

8.4 Fire gases

In view of the circumstances in the plant and the potential risks to the surrounding area in the event of a fire, it is generally advisable to draw up in advance an emergency plan with the relevant parties (e.g. fire brigade / police). Every fire produces fire gases from organic materials (e.g. wood, textiles or plastics). These always may contain toxic substances, regardless of whether they are "natural" or synthetic materials.

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