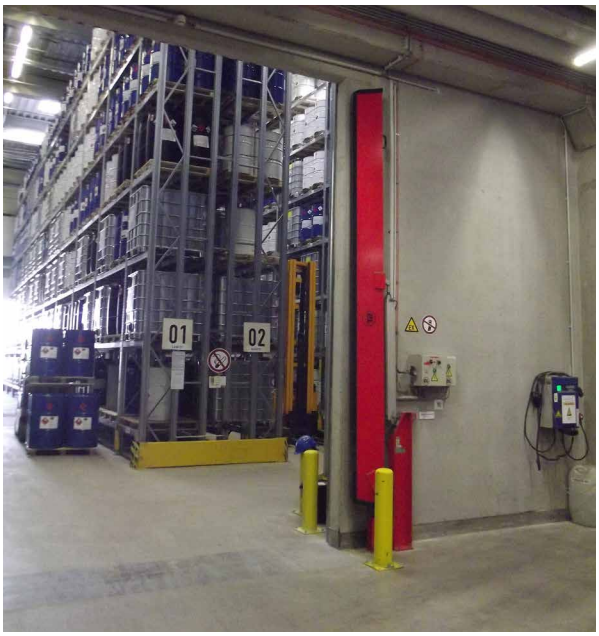
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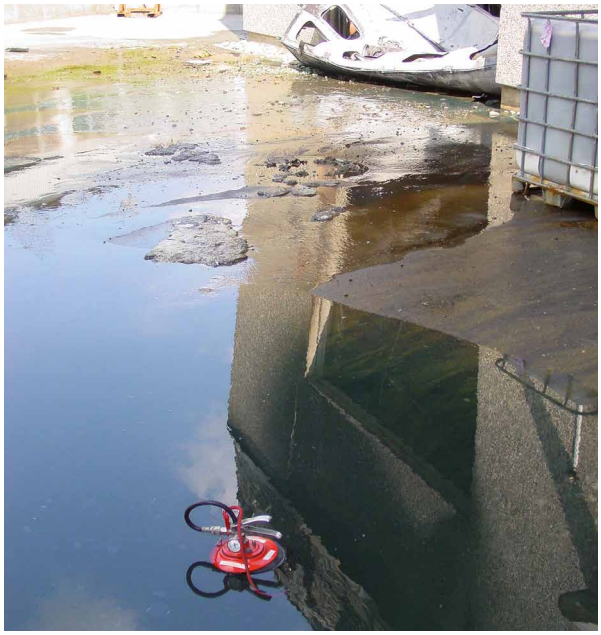
Publication by the German Insurers on loss prevention

VdS

Planning and Installation of Facilities for Retention of Extinguishing Water









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Planning and Installation of Facilities for Retention of Extinguishing Water

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Preface

In the case of fire, normally extinguishing water accumulates which has not volatilised and is extremely polluted. Polluted extinguishing water can cause considerable consequential loss when getting into the surface water or infiltrating in the ground, or even contaminate the groundwater or affect the clarification plant. Therefore, polluted extinguishing water must not be emitted to water or emerge in an uncontrolled manner if adverse effects on the properties of waterbodies cannot be excluded.

Often many operating parties of industrial or commercial plants are not aware of their basic risk of pollution (operating party's liability). Due to the general duty to take due care pursuant to Chapter 1 § 5 Paragraph 1 of WHG - the German Federal Water Act - anyone is obliged '...if taking actions implicating effects on waterbodies to take due care as the circumstances require to avoid adverse effects on the properties of waterbodies...' [literal translation].

If polluted extinguishing water causes considerable pollution of waterbodies, considerable harm to protected species, or considerable harm to protected habitats, the responsible party shall be liable pursuant to the German Environmental Damage Act (USchadG) of 10 May 2007. Pursuant to § 6 USchadG the responsible party must pay for the remedial measures required by the competent authority. If the extinguishing water contaminates the ground, there is an obligation to take remedial measures laid down in the German Federal Soil Protection Act (BBodSchG).

The operating party shall not be liable only for its operational risks following the pay-as-you-pollute principle but in particular cases can also be held responsible as proprietor for consequential loss due to the fire brigade action, e.g. due to the use of water-hazardous extinguishing agent.

The guideline on how to dimension facilities for retention of extinguishing water when storing water-hazardous substances (the German LöRüRL) implemented by the construction authority exclusively applies to storage plants and to substances classified in water endangering classes (WGKs). Consequently, this does not allow for the risk potential of material arising only during a fire (e.g. HCl and dioxin after PVC fires). For production plants, the LöRüRL does not even require preventive measures at all. In the case of damage this could cause high expenses for decontamination of the polluted ground and groundwater, since at the moment measures and/or rating bases for retention of extinguishing water beyond the basic requirements of several regulations (inter alia the AwSV - the German ordinance on installations handling materials hazardous to water) as well as of sublegislative normative acts are not required.

Measures aiming at avoidance of damages due to extinguishing water are required in all cases of possible emission of harmful substances together with the extinguishing water in the case of fire. Here, it does not matter whether the substances are contained in the operating supplies or only develop during fire.

The present guidelines point out how to identify risk potentials regarding possible damages by extinguishing water and how to minimise them with preventive technical and organisational measures.

For the installation and operation of facilities for retention of extinguishing water, first and foremost the provisions of statutes and by authorities are to be complied with. The present guidelines are one source of insight that can be taken as a basis to dimension the volume of extinguishing water to be retained irrespective of the mode of operation. Should the provisions of statutes and by authorities require other quantity limits and measures beyond, these shall be given priority.

The used technical terms are explained in the glossary (see Section 9).

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1 Application

1.1 Scope of Application

The guideline on how to dimension facilities for retention of extinguishing water when storing water-hazardous substances (the German LöRüRL) exclusively applies to the storage of water-hazardous substances from a particular quantity upward.

The scope of application of these guidelines covers all hazards / risks occurring in connection with production of contaminated extinguishing water in industrial and commercial plants and equipment irrespective of the type and quantity of the substances existing there. This applies to both, production and storage equipment (including handling equipment) not covered by the LöRüRL.

Measures aiming at avoidance of damages due to contaminated extinguishing water are required in all cases of possible emission of a dangerous quantity of harmful matters together with the extinguishing water in the case of fire. The necessity as well as kind and extent of the required measures result from the hazard and risk analysis.

Regarding the risk potential of material the application covers among other things:

- water-hazardous substances classified in water endangering classes (WGKs);
- water-hazardous substances not yet classified but classifiable due to their hazardous characteristics (to date: "R" phrases; in future: pursuant to the GHS "H" phrases);
- foodstuff and the like, which by definition cannot be classified in WGKs;
- operating supplies (raw material and consumables, intermediates, semi-finished and finished products, package, storage and transportation aids, waste) which themselves or the combustion products of which show harmful characteristics;
- building material (insulating material, sealing material, impregnation, e.g. for wood) which itself or the combustion product of which shows harmful characteristics;
- extinguishing agent.

In order to verify the possible hazard by resulting contaminated extinguishing water and - should this occasion arise - to be able to take the necessary preventive measures, a hazard and risk analysis (as defined by the present guidelines) covering the possible amount of contaminated extinguishing water during and after a fire is to be made. It is to be expected that even if directly recognisable hazards do not exist, the extinguishing water can be contaminated by building material and operating supplies, packages, etc. existing in the plant. Therefore, consideration of the risk potential of material also allows for the many substances that are not and cannot be classified harmful but do nevertheless produce harmful characteristics in the case of fire.

It has also to be taken into account that a fire brigade action can cause large quantities of polluted or contaminated extinguishing water; this inter alia caused by the use of water endangering foam compounds.

Please see the hazard and risk analysis in Section 3 to get a possible approach to the risk by extinguishing water.

1.2 Restriction of Application

In principle it is to be stated that a damage by extinguishing water is to be expected only after a fire event together with the emission of contaminated extinguishing water in large and hazardous quantities.

Retention of extinguishing water is not required if

- a fire can be definitely excluded. A fire occurs if combustible matters, working ignition sources, and sufficient concentration of oxygen come together.
- possible fires are not extinguished with water but always with special extinguishing agents without addition of water.
- the result of the hazard and risk analysis (see Section 3) of the risk potential of material is mostly "low" and partly "medium".

These guidelines do not apply to storage and/or handling of

- radioactive substances nor
- potentially explosive matters.

1.3 Structure of the Present Guidelines

First, a hazard and risk analysis is made to determine and assess risk indicators (inter alia risks of material and characteristics of operating supplies, building material, etc. during fire) (see Section 3).

If a fire causes an hazardous quantity of contaminated extinguishing water, the required retention volume of extinguishing water can be calculated as defined in Section 4.

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In order to avoid and control damages by contaminated extinguishing water, the organisational measures described in Section 5.2 should be considered first (in accordance with these guidelines).

Should the organisational measures be insufficient, technical and/or structural measures for retention of extinguishing water are to be provided (see Sections 5.3 and 5.4).

Section 6 describes the requirements for erection and installation and/or inspection, maintenance, and servicing of facilities for retention of extinguishing water.

Section 7 describes the measures to be taken in case of damage.

A definition of monitoring after fire and disposal of contaminated extinguishing water (including an analysis) is given in Section 8.

2 Risk Perception - Cases and Examples of Damage

For equipment in accordance with the German Federal Water Act (WHG), retention of contaminated extinguishing water is required as defined by the cause for concern principle of the water law (Chapter 3, § 62, Paragraph 1 of WHG) together with the applicable sublegislative rules and regulations as well as the requirements laid down in the German Federal Soil Protection Act (BBodSchG) and the German Law Concerning the Protection against Harmful Effects on the Environment through Air Pollution, Noise, Vibrations, and Similar Factors (BlmSchG) (inter alia § 22, Paragraph 1, Items 1 and 2). Consequently, extinguishing water that could have been contaminated by emerging, water endangering substances shall be retained and disposed of properly.

If according to the guidelines, retention of extinguishing water is not mandatory, it should be checked nevertheless whether a damage by contaminated extinguishing water occurring in the case of fire can be prevented or minimised. The basic requirement to take due care results already from the general duty to take due care laid down in § 5, Paragraph 1 WHG (see preface). The safety to be requested in this respect has to be adequate to the actual risk (principle of proportionality).

These guidelines aim at protection of waterbodies and ground against contaminated extinguishing water containing harmful substances or burnt material and being a possible result of every fire. But they also aim at prevention of consequential loss (e.g. due to business interruption, loss of property) caused by extinguishing water.This is the reason why the present guidelines contain several categories of requirements to delimit the risks.

A multitude of damages underlines the problems caused by emitted extinguishing water in the case of fire. Please find below some examples.

Exemplary damage 1

A major fire had occurred in a medium-sized, chemical firm that had not been within the scope of application of the LöRüRL because of the small amount of hazardous substances stored and used.

Due to the large amount of extinguishing water used to fight the fire, an increased concentration of toxic and corrosive substances had been emitted. The agricultural areas around being used by an agricultural establishment as hay field and cattle feeding area and a creek flowing past had been contaminated. Due to the concentrated load of harmful substances in the extinguishing water, the hay could not be used as animal foodstuff for several years. The oxygen depletion in the creek and in an adjacent trout farm caused by the contaminated extinguishing water resulted in an acute and extensive fish mortality. The noxious matters deposited on the ground of the creek and the pond made the fish stock unsuitable for consumption by humans for years.

As the polluter, the chemical firm had to pay for the contamination and the consequences. The total loss due to the environmental damage amounted to € 1.5 million - almost the same amount as the causal loss due to fire and business interruption amounting to a bit more than € 2.2 million.

Exemplary damage 2

A tyre warehouse by a recycling plant had been set on fire started by arson.

At the moment, the storage of old tyres and the preventive measures to be derived therefrom aiming at control of contaminated extinguishing water are not governed by the LöRüRL.

The more than 100 firefighters could not prevent that during this major fire not only harmful fire and decomposition products were emitted but also a large quantity of contaminated extinguishing water resulted due to pyrolysis oils produced by thermal decomposition of not yet burning tyres and the foam compound used to fight the fire. Through

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the surface water canalisation, a large amount of extinguishing water (more than 100 cubic metres) was supplied to the regional clarification plant.

The loss incurred by the clarification plant amounted to almost € 0.5 million.

Exemplary damage 3

In the mechanical production of a metal-working firm, a refrigerator had had a technical defect causing an initial fire. The fire spread to the roof and due to the combustible heat insulation as well as the bitumen roofing it rapidly built up on the entire roof surface. As a consequence of the fire, during which the roof of the workshop collapsed, the central tank of cutting oil (20 cubic metres, WKG 2) of the high-duty machining centres was damaged. The extinguishing water washed out the cutting oil which penetrated through defective expansion joints in the ground. As this was a plant for the production, treatment, and use, the LöRüRL did not apply despite of the existence of large amounts of water-hazardous substances.

Since the firm was located in the drinking water protection area III of the local water catchment, preventive rescue measures to prevent contamination of drinking water were required. An approved special firm was entrusted with cleaning of the soil on site.

The total expenses for decontamination of the ground amounted to € 250,000.

Exemplary damage 4

By night a fire had been started by arson in a refrigerated warehouse to rent. Due to the products stored there - butter, ice cream, meat, and foodstuff - the warehouse was not subject to the LöRüRL.

It "happened" that a security guard detected the fire when the flames spread out of the roof already and the entire cold store was on fire. The areas of walls and ceilings contained combustible insulating material made of polyurethane and partly of polystyrene and produced many heat leading to melting of the butter.

Liquid butter and ice cream emulsified in the extinguishing water and were transported by it into the environment (neighbouring basements of residential building, surface waterbodies, and canalisation).

Upon having cooled down, the emulsion solidified at the feed points and clogged up the canalisation and other things. It caused considerable damage to the pipes because the butanoic acid dissolved calcium hydroxide out of the concrete members.

Moreover, adjacent waterbodies were affected. The butanoic acid caused harm to the gills of fishes, caused sticking together of the birds' feathers, had to be sucked off the water surface, and had to be removed by digging from the riparian land.

All in all the loss of property amounted to approx. € 40 million and the loss caused by environmental damage amounted to approx. € 1.5 million.

Exemplary damage 5

In the waste paper storage of a company specialised in waste paper recycling, an initial fire had started by night for reasons as yet unexplained.

Due to the missing water endangerment by the stored matters this storage hall was not subject to the LöRüRL. Consequently, there did not exist any technical equipment nor had organisational measures be taken to retain extinguishing water.

During the fire fighting operations, the fire brigade used 5,000 l of foam compound as well as approx. 1,000 cubic metres of water. About half of the extinguishing water with foam compound penetrated through inlets in the bottom into the company sewerage system. At the instance of the environmental authority, the fire brigade put a stop to further flowing of extinguishing water into the public sewerage system.

Upon completion of fire fighting, one detected an old drainage shaft in the storage hall through the leaky cover of which an unknown quantity of extinguishing water or extinguishing water with foam compound, respectively, drained away in the ground. At the same time, one detected considerable damage of the company sewerage system when sucking away the retained residues of extinguishing agent, which gave rise to the suspicion that extinguishing agent drained away in the ground in the area of the property sewerage system, too.

When it was known that the used foam compound had contained perfluorinated tensides, extensive examinations of ground and groundwater were effected. Decontamination of the soil in the area around the drainage shaft was required.

The resulting loss of property amounted to approx. € 350,000 plus € 250,000 of follow-up costs (demolition, clearance of debris, fire fighting costs, disposal of fire debris, and decontamination costs). € 70,000 thereof were incurred for analyses and

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decontamination of the soil as a consequence of the use of foam compound.

Exemplary damage 6

A fire had occurred in the warehouse of a medium-sized plastic converter company upon shrinking of film. Due to the fire load - above all synthetic materials (PE / PP), cardboard articles, film, pallets - the fire spread over the entire fire compartment. Upon abortive attempts by the fire brigade to fight the fire with water, a total of 20 square metres of foam compound of two factory fire services located in nearby industrial areas were used. After 7 hours the fire was put out.

The use of the foam compound (AFFF) caused that perfluorinated tensides (PFT) got into the extinguishing water.

The operating party of the clarification plant and its waste water specialist only got to know of the fire through warnings in the radio broadcasted to inform the people. As a consequence, the diluted foam concentrate flowed at the beginning through the sewerage system into the almost unprepared clarification plant.

The balancing basin in the plant could not hold the arriving quantity of extinguishing water and, therefore, a lot of foam was produced on all basins in the afternoon. Short-term drifting away of the foam into the nearby river and exceeding of the permissible discharge values for the clarification plant could not be avoided although supplementary coagulants and oxygen at high level were added immediately. Four days later, return to proper operation of the plant was announced. Due to heavy rains, the balancing basin could be entirely drained only another four days later. Thus, the coagulants were used over eleven days.

The total loss of property amounted to € 2.2 million, approx. € 200,000 of which for decontamination.

Conclusion: The above examples show that retaining of extinguishing water can become necessary also in cases of stored goods which are not classified to be water-endangering (e.g. plastics) or cannot be classified in water endangering classes (e.g. foodstuff), the combustion products of which nevertheless can show hazardous characteristics as defined in the present guidelines. Furthermore, the above cases show that a distinction between warehouses and production lines is not very reasonable as damages by extinguishing water are possible.

3 Hazard and Risk Analysis

The hazard and risk analysis below is required if pursuant to Section 1.2 the formation of contaminated extinguishing water cannot be excluded or is at least in doubt.

3.1 Determination of the Risk Potential of Material

Within the scope of the hazard and risk analysis it is first required to determine all matters regarding a possible contamination of extinguishing water after a fire. As to the possible combustion products, it is sufficient to give a quality assessment. Here, it is to be taken into consideration that a fire could cause production of substances which lead to further contamination of extinguishing water, such as

- combustion of PVC (liberates hydrochloric acid gas, HCl deposit) and/or
- fire fighting in case of burning synthetic material, tyres, or combustible liquids by means of water endangering foam compounds (e.g. fluorine tensides).

An as-is plan should be drawn up showing

- which pollutants are e.g. used as operating supplies,
- used a extinguishing agent and/or
- which pollutants could develop from a fire

and, therefore, could lead to contamination of the extinguishing water.

What matters (kind and quantity) are to be considered?

- Operating supplies (raw material and consumables, intermediates, semi-finished and finished products, matters / residuals / waste stored, provided, and available in production);
- package, storage and transportation aids;
- building material (insulating material, sealing material, impregnation, e.g. for wood).
  A classification of building material acc. to DIN 4102 Part 1 to be of low flammability is no criterion to exclude a fire danger as defined in the present guidelines.
- extinguishing agent (all extinguishing agents that could be used for the particular operational risk are to be taken into consideration);
- foodstuff and the like;
- matters the thermal decomposition of which could cause development of pyrolysis products contaminating the extinguishing water.

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What hazardous characteristics are to be determined?

- WGK classification (safety data sheet, VwVwS). Insofar as a substance shows no WGK classification, the WGK can be concluded from the R phrases (in future acc. to GHS: H phrases) and/or the classification criteria as defined in VwVwS.
- Harmful characteristics of other matters (see the list of examples in Annex A2, safety data sheet, or databases of substances, e.g. GESTIS-database on hazardous substances of the German Social Accident Insurance).

3.2. Determination of Combustion Properties

A determination of the combustion properties (see Annex A1, Part B of the matrix for hazard and risk analysis) is required if a risk potential of the material in accordance with Section 3.1. and/or Annex A1, Part A of the matrix for hazard and risk analysis has been determined. For an assessment of the combustion properties, you can use the following criteria:

- flash point of combustible liquids;
- calorific value, burning velocity of solids;
- quantity / fire load (pursuant to DIN 18230).

The data collected to comply with the Sections 3.1 and 3.2 should be documented and kept so a to be available. Each time when large and risk-relevant modifications are made, the data should be updated. In order to draw up corresponding documentation, you can use existing lists (e.g. the register of hazardous substances, warehouse lists).

3.3 Determination of Other Relevant Criteria

A determination of the other fire-relevant criteria (see Annex A1, Part C of the matrix for hazard and risk analysis) is required if a risk potential of the material in accordance with Section 3.1. and/or Annex A1, Part A of the matrix for hazard and risk analysis has been determined. In addition to the material properties, you have to determine the criteria below:

- company environment (protected water area, ecological system);
- extinguishing agent (foaming agent);
- drainage system (size, type of clarification plant / drainage ditch);
- infrastructure of fire protection (factory fire service, volunteer fire brigade, fire safety team, extinguishing systems, fire detection);
- structural requirements for retention of extinguishing water (e.g. basements, receiving rooms, waste water systems / lines).

3.4 Hazard and Risk Analysis / Assessment

The matrix given in Annex A1 for hazard and risk analysis is intended to deliver a rough assessment whether measures for retention of extinguishing water have to be taken.

First, the risk potential of material is to be assessed on the basis of Annex A1, Part A of the matrix for hazard and risk analysis. If the assessment results in a mostly "low" risk potential, normally no more measures for retention of extinguishing water are to be taken. If the assessment results in mostly "medium" and "high" risk potential of material, a second assessment of the combustion properties (Annex A1, Part B) and of other criteria (Annex A1, Part C) is required.

Therefore, measures for retention of extinguishing water should be taken if the total assessment reveals a risk potential that cannot be compensated by existing company-internal and/or organisational measures.

E.g. it is absolutely possible, that a dangerous quantity of critical substances does exist. However, the operating party of the clarification plant states that the sewage purification plant could cope with the expected quantity of contaminated extinguishing water.

For other examples of the hazard and risk analysis and application of the corresponding matrix, please see the Annexes A1.2 to A1.5.

Regular updates of the hazard and risk analysis in the course of intra-company modifications are recommended.

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4 Estimation of the Contaminated Extinguishing Water

The quantity of contaminated extinguishing water depends among other things on the kind and quantity of combustible matters, the fire detection, the type of fire brigade, as well as the infrastructure of fire protection. Therefore, as defined by the present guidelines the issues of water endangerment by substances and potential development of harmful substances during a fire do not have any direct effect on the quantity of contaminated extinguishing water used but are criteria for safety considerations regarding the size of fire compartments and are the basis for an assessment of the necessity to implement measures for retention of extinguishing water.

In literature, the quantities of extinguishing water stated for a medium-sized industrial fire range between 3,200 and 14,000 l/min. During such fire events, there could consequently result between 192 and 840 cubic metres of extinguishing water per hour and this normally for a time of 2 to 4 hours. About half of the used extinguishing water volatilises.

Estimation of the quantity of contaminated extinguishing water V in these guidelines is based on the equation below: The parameters taken into account are explained in the following.

In order to make application easier, we have drawn up a calculation sheet being enclosed with these guidelines.[1]

$$V = \{(A_{act} * SWL * BAF * BBF) + M \} / BSF$$

V [cub.m]: calculated retention volume for contaminated extinguishing water

A_{act} [sqm]: actual fire compartment area

SWL [cub.m/sqm]: specific water output

BAF: factor of fire compartment area (dimensionless)

BBF: factor of fire load (dimensionless)

M [cub.m]: quantity of all liquids for production, operation, and storage w or w/o WGK class in the respective fire compartment

BSF: factor of fire protection (dimensionless)

The design equation and the factors specified for its application are based on the experiences gained in fire events by the fire brigades, fire insurers, authorities, and experts.

For more information on the calculation and determination of individual factors, please refer to the Annex A3.

Should your calculation result in an extinguishing water volume of more than 1,000 cubic metres, it is strictly recommended to consider a limitation of fire compartment areas and the installation of permanently installed extinguishing systems. Often the particular reasons for an extremely high retention volume for extinguishing water are an inadequate fire protection standard (BS) for the corresponding risk and/or too large fire compartments.

[1] Download the calculation sheet from VdS Schadenverhütung, No. VdS 2557a - www.vds.de.

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<table>
<tr><th>Parameter</th><th>Designation</th><th>Explanation</th></tr>
<tr><td>V [cub.m]</td><td>Retention volume of extinguishing water</td><td>Calculated retention volume for contaminated extinguishing water.</td></tr>
<tr><td>A_{act} [sqm]</td><td>Fire area and/or (actual) fire compartment area</td><td>The estimation of the volume of extinguishing water to be retained V is based on a fire event on the maximum actually existing fire (compartment) area for storage and/or production.</td></tr>
<tr><td>$A_{perm.}$ [sqm]</td><td>Fire area and/or permissible (applicable to the risk) fire compartment area</td><td>The permissible fire compartment area $A_{perm.}$ is based in conformity with the German regulations of industrial construction upon consideration of the type of construction, the fire load density, and the fire protection standard.
(Please note: According to the possibilities of fire detection and fire fighting, a fire compartment area gets the relevant fire protection standard ranging from BS 1 to BS 4.)
In order to avoid above average retention volumes of extinguishing water, the actual fire compartment area should be largely the same as the permissible fire compartment area.</td></tr>
<tr><td>SWL [cub.m/sqm]</td><td>Specific water output</td><td>It is assumed that with the specified extinguishing time of 240 min a specific water output SWL of 0.24 cub.m/sqm is used within the fire compartment.</td></tr>
<tr><td>BAF</td><td>Dimensionless factor of fire compartment area</td><td>The analyses of loss events have shown that in case of very large fire compartment areas, the quantity of extinguishing water [l/sqm * min] actually required does not continue to increase linearly. This is taken into account by the dimensionless factor of fire compartment area BAF.
<table>
<tr><th>Fire compartment area [sqm]</th><th>Factor of fire compartment area BAF</th></tr>
<tr><td>up to 4,000</td><td>1.0</td></tr>
<tr><td>5,000</td><td>0.9</td></tr>
<tr><td>6,000</td><td>0.83</td></tr>
<tr><td>7,000</td><td>0.79</td></tr>
<tr><td>8,000</td><td>0.75</td></tr>
<tr><td>9,000</td><td>0.72</td></tr>
<tr><td>10,000</td><td>0.70</td></tr>
<tr><td>12,000</td><td>0.66</td></tr>
<tr><td>14,000</td><td>0.64</td></tr>
<tr><td>16,000</td><td>0.63</td></tr>
<tr><td>18,000</td><td>0.61</td></tr>
<tr><td>20,000</td><td>0.6</td></tr>
</table>
</td></tr>
</table>

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<table>
<tr><th>Parameter</th><th>Designation</th><th>Explanation</th></tr>
<tr><td>BBF</td><td>Dimensionless factor of fire load</td><td>The factor of fire load is calculated from the actually existing fire load q_R [kWh/sqm]. The table below can be taken for an estimation:
<table>
<tr><th>Factor of fire load BBF</th><th>Fire load q_R (kWh/sqm)</th><th>Comment</th></tr>
<tr><td>3.64</td><td>≥ 360</td><td>very high</td></tr>
<tr><td>1.67</td><td>250</td><td>high</td></tr>
<tr><td>1.03</td><td>160</td><td>increased</td></tr>
<tr><td>0.71</td><td>90</td><td>medium</td></tr>
<tr><td>0.53</td><td>40</td><td>low</td></tr>
<tr><td>0.42</td><td>≤ 10</td><td>very low</td></tr>
</table></td></tr>
<tr><td>q_R (kWh/sqm)</td><td>Fire load</td><td>The fire load in kWh per sqm results from addition of all combustible substances and materials existing in one fire compartment area.</td></tr>
<tr><td>M [cub.m]</td><td>Substance quantities</td><td>Substance quantity of all liquids for production, operation, and storage w or w/o WGK (1 t = 1 cub.m).</td></tr>
<tr><td>BSF</td><td>Dimensionless factor of fire protection</td><td>According to the possibilities of fire detection and fire fighting, a fire compartment area gets a fire protection standard ranging from BS 1 to BS 4. This can be taken to calculate the factor of fire protection:
<table>
<tr><th>Concept</th><th>Fire protection standard BS</th><th>Factor of fire protection BSF</th></tr>
<tr><td>Structural concept
No special fire call requirements</td><td>BS 1 = 1.0</td><td>0.93</td></tr>
<tr><td>Monitoring concept
Automatic fire detection and fire alarm system with automatic alarm transmission to a permanently manned location of the public fire service; attendance time of fire brigade less than 10 min!</td><td>BS 2 = 2.0</td><td>1.22</td></tr>
<tr><td>Monitoring concept with factory fire service
Automatic fire detection and fire alarm system with automatic alarm transmission to an always operationally factory fire service; attendance time of the factory fire service less than 3 - 5 min!</td><td>BS 3 = 3.0</td><td>1.93</td></tr>
<tr><td>Concept of extinguishing system
Automatic extinguishing system with automatic alarm transmission to a permanently manned location of the fire service</td><td>BS 4 = 4.0</td><td>3.64</td></tr>
</table></td></tr>
</table>

Table 1: Explanations and factors for an estimation of the contaminated extinguishing water in an equation and for determination of an adequate fire compartment area to meet the risk requirements (more information, see Annex A3).

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5 Measures and Equipment to Prevent and Control Damages by Contaminated Extinguishing Water

5.1 Basic Factors

An integral fire protection and safety concept is based on its components of structural, system, organisational, and defensive fire protection as well as - depending on the use / operation mode - on the components of equipment and process safety.

Retention of extinguishing water is one component of an integral fire protection and safety concept.

The necessity of retention of extinguishing water and the required quantity is decisively determined by the individual components of the fire protection and safety concept:

- For an equal storage density, the separation of small fire compartments and/or encasing / disconnection of the potentials (the substances) by means of fire-resistant containments leads to a reduced volume of extinguishing water.
- The use of non-combustible building materials reduces the fire load and the fire spread in the building and, consequently, the corresponding quantity of extinguishing water.
- If an adequate infrastructure of defensive fire protection equipment exists (intervention time, class of fire brigade, local knowledge), the installation of a fire detection and fire alarm system and the resulting early detection of a fire can have positive effects on the extent of fire, and the fire spread, and, thus, the required quantity of extinguishing water.
- By means of automatic (water) extinguishing systems the fire can be extinguished or its spread can be stopped already in the earliest stage of development and before arrival of the fire brigade. The quantity of extinguishing water required then for fire fighting by the fire brigade should be less than in case of a developed fire without extinguishing system.
- If using an extinguishing system working with the extinguishing agent gas or powder and/or a permanent inerting system, it can be almost ruled out that extinguishing water is required provided that there is not any risk of backdraught.
- The use of special extinguishing agents (e.g. foam compound with perfluorinated tensides) can cause contaminated extinguishing water irrespective of the hazard presented by the used agents.
- In the course of the organisational measures it can be verified whether replacement of water-endangering and/or combustible substance with uncritical substance would lead to a reduction in the measures for retention of extinguishing water or even a complete forgoing.

Upon revision or modification of the fire protection and safety concept according to the above criteria, it is recommended to make a new hazard and risk analysis for an estimation of the quantity of extinguishing water pursuant to Section 4.

Damages by contaminated extinguishing water can be prevented by implementation of organisational and structural measures (see Sections 5.2 and 5.3) as well as by installation of technical equipment (see Section 5.4). First and foremost you should check whether organisational measures are enough.

5.2 Organisational Measures and Emergency Planning

A qualified organisation of safety measures covers the fields of prevention, support during the fire event, and monitoring after fire. In case of a damage or an accident it is the operating party's responsibility to determine the situation and to initiate emergency measures and countermeasures as required. For instance in case of major loss events, emergency management with contact to the authorities and aid agencies has to be established.

The criteria below - only a choice of possible criteria - should be verified. They are to be matched to the special requirements of the business and are subject to regular adjustments and updates.

- Inquiry of the competent water supply company or the competent water authority about the distance (if any) of the business from a drinking water collection area (sources, pump stations).
- Drawing up a plan of the sewerage system.
  In almost every case of damage (also in case of a fire!) an up-to-date plan of the sewerage system is required.
- Checking whether the sewerage system is for combined or separate waste water.

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- Checking the sewerage system for its suitability for retention of extinguishing water and for leakages.
- Checking the company sewage purification plant for its suitability to clarify contaminated extinguishing water - the risk of failure due to the loss event has to be considered.
- Checking how water is discharged:
  - direct discharge into surface waterbodies
  - discharge into clarification plant
  - stormwater overflow tank in main or secondary pipe
- Regularly checking the condition and the functionality of shut-off devices; immediate remedy of detected defects.
- Notifying employees and external personnel (especially forwarders, sub-contractors, service providers, etc.) of the hazardous situation and the safety precautions by information, training, and exercises.
- Checking whether mounting / installation / building of temporary shut-off devices / structures could create any volume for retention of extinguishing water (descent areas, deeper operating areas, thresholds, etc.).
- Defining and taking measures for retention of extinguishing water shall allow for possible adverse effects on in-house sequences as well as fire fighting (see Section 7).
- Drawing up a plan of action in collaboration with the public fire brigades in charge.
- Drawing up a plan of retention of extinguishing water with specification of location, type, and volume.
- In-house storage and provision of auxiliary equipment should be discussed and agreed with the competent fire department. Installation of mobile barriers and auxiliary equipment normally has to be carried out by in-house and trained personnel.
- Documentation of emergency measures.
- Definition of alerting procedures and pathes (competent authorities, aid agencies, and responsible persons in the company).
- Definition of an emergency organisation (crisis management, competences, responsibilities, etc.).
- Ensuring the access to auxiliary equipment and protection systems (list of the contact addresses required in case of emergency, expert institutes for examination, etc.).
- Drawing up an alarm and accident prevention plan (if required).
- Provision of communication means.
- Provision of auxiliaries to prevent pollution of bodies of water by leaking liquids as well as to protect the sewers against damaging substances.
- Clarifying the issues of provision and availability of technical equipment, such as
  - pumps with collecting tanks,
  - suction vehicles,
  - mobile collecting tanks, and/or
  - sealing materials (pads for drains, sealing of sewers, liquid-retention barriers).
- Clarifying the issue of external retention facilities and/or continuous removal of contaminated extinguishing water.
- Agreement with the disposal company on how to dispose of contaminated extinguishing water.

Any use of company equipment deviating from the original intention shall be agreed upon with the competent authorities and require prior authorisation to provide for legal security.

5.3 Structural Measures for Retention of Contaminated Extinguishing Water

For retention of extinguishing water preference should be given to self-acting, permanently installed, structural systems providing the required retention volume without any supplementary measures and being liquid-tight. Here, a central retention of extinguishing water should be preferred to a local retention of extinguishing water (in the building itself or at the point where the fire starts), e.g. to avoid hindrance to firefighters (also see the Sections 5.4, 5.5, and 6.1.1).

Structural measures for retention of extinguishing water are e.g.:

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- Retention basins for extinguishing water built to this purpose and connected to the building without pumps. Areas of particular hazards (e.g. galvanic equipment, chemical storage facilities) should be installed directly in catch-pots of sufficient dimensions.

- Final inspection shafts in rooms serving the retention of extinguishing water should be built so as to be fire-resistant (never of synthetic material).

- Indoor downpipes for rainwater in rooms serving the retention of extinguishing water should be avoided. Where required, they should be designed so as to be fire-proof at least up to the impounding height to be expected (e.g. poured into concrete)

- Building the floors of buildings as catch pit (upturns, doorsills, ramps, and intercepting gutters); this in addition to the retention volume required by law for retention of storage liquids has to be large enough to collect the extinguishing water occurring during a fire, too.

- Building of perhaps existing basements or other subsurface catch pits as retention volume for contaminated extinguishing water.

- Retention basins of sufficient dimensions of the sewage purification plant and/or the rain water retention basins.

- Liquid-tight open storage areas and shipment areas showing a slope being protected with a circumferential upturn against uncontrolled flowing out of liquid. This should be drained in a catch basin with emergency gate.

- Use of the existing sanitary sewer to drain the extinguishing water (barrages in the sewerage system) with corresponding gates.

- Empty tanks with corresponding admission system. Charge pumps have to be designed and dimensioned so as to allow for the required capacities; function and effectiveness are subject to regular tests.

- Catch-pots and trays to retain parts of the volume.

- Drains or pipes designed to drain the extinguishing water into retention rooms have to be designed so as to be fire-resistant. In the case of fire they must neither be disconnected nor blocked by debris.

- Safety containers with integrated retention of extinguishing water.

5.4 Technical Equipment for Retention of Contaminated Extinguishing Water

Retention of extinguishing water can be obtained by one or a combination of several of the technical and/or structural possibilities below. Generally, self-acting (e.g. structural solutions) and/or automatic (e.g. permanently installed barriers) retention systems shall be preferred.

We distinguish technical equipment for retention of extinguishing water

- that are self-acting,
- that are to be triggered manually, or
- that are to be installed manually.

Facilities for retention of extinguishing water can be installed permanently or provided as mobile facility.

5.4.1 Self-Acting Permanently Installed Facilities

Self-acting permanently installed facilities are

- permanently installed extinguishing water barriers fastened to their holders and being automatically triggered in case of fire by detection of fire characteristics, e.g. by smoke or heat, and then automatically moving into their shutting position;

- permanently installed facilities with pumps pumping the extinguishing water in the case of fire to the retention facility.

5.4.2 Permanently Installed Facilities to Be Triggered Manually

Permanently installed facilities to be triggered manually are permanently installed extinguishing water barriers fastened to their holders and being moved into their shutting position by manual triggering, i.e. by muscle power, backed-up energy (weight, spring), or auxiliary energy (e.g. electric, hydraulic, pneumatic).

5.4.3 Mobile Facilities to be Installed Manually

mobile facilities to be installed manually are:

- extinguishing water barriers being stored near the location of use and to be manually installed into local holders permanently mounted to this end;

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- covers on drain inlets;
- hoods and sealing pads (filled with water or sand);
- magnetic film;
- inflatable sealing pads (e.g. for drain inlets);
- mobile collecting tank (folding tank, container, etc.);
- multichamber hoses as liquid seal.

Seen from the point of view of safety engineering, the use of extinguishing water barriers to be installed manually can be recommended only upon supply of the proof that in case of fire an installation of the barriers is actually possible. In this respect, among other things the aspects of maintenance, functionality, responsibility, and accessibility (free of fire load) have to be clarified before.

However, it is absolutely required to install and maintain them in accordance with the technical state of the art, e.g. pursuant to VdS 2564-1 (Richtlinien für Löschwasser-Rückhalteanlagen, Bauteile und Systeme, Anforderungen und Prüfmethoden, Teil 1: Stationäre Löschwasserbarrieren / guidelines for facilities for retention of extinguishing water, components and systems, requirements and test methods, Part 1 dealing with permanently installed extinguishing water barriers).

For safety reasons, any other use of mobile extinguishing water barriers (e.g. multichamber hoses, covers on drains) cannot be recommended without restrictions.

Guaranteed and sufficient reliability in the case of fire requires:

- timely installation of the mobile equipement into shutting position.
- capabilities to install them so as to be functional. This requires permanent availability of especially trained personnel and possibly of technical equipment (e.g. compressor or pressure tank), and/or of sufficient space (mobile collecting tank) on site.
- that the multichamber hoses have been topped up with water prior to use. This requires permanent provision of appropriate water supply (continuous and sufficiently pressurised).

5.5 Comprehensive Aspects of the Installation of Facilities for Retention of Extinguishing Water

Prior to an installation of facilities for retention of extinguishing water in production and storage areas, it should be checked whether the extinguishing water impounding in case of fire could cause increased consequential damage to the building / equipment and/or losses due to business interruption. Therefore, preference should be given to an outdoor installation of the facility for retention of extinguishing water.

It is possible to build one central catch basin for several fire compartments in the same building or in adjacent buildings. Its volume is to be dimensioned so as to meet the requirements of that fire compartment for which the calculation shows the largest retention volume for required extinguishing water.

Taking the required volume of retained extinguishing water, the impounding areas provided, and possibly the required allowances for installations etc. into account, one can determine the required impounding height and the theoretical height of barriers.

Where possible, ramps at passages should be designed so as to provide for a sufficient retention volume for extinguishing water. The "ramp solution" may already be sufficient, especially together with automatic extinguishing equipment.

If the ramp solution does not provide for enough retention volume of the theoretical quantity of extinguishing water or if it cannot be realised for any other reason, "low barriers" should be provided, which do not hinder the firefighters. Consequently, the height of such barriers should be discussed and agreed with the fire departments. This provides for easy going beyond in case of danger.

If extinguishing water barriers are used, permanently installed solutions are to be selected where possible.

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6 Requirements for Facilities for Retention of Extinguishing Water

6.1 Basic Requirements

6.1.1 General

Please find below the general requirements for facilities for retention of extinguishing water (also see the AwSV - the German ordinance on installations handling materials hazardous to water). The special requirements for individual components are laid down in VdS 2564 (Richtlinien für Löschwasser-Rückhalteanlagen, Bauteile und Systeme, Anforderungen und Prüfmethoden / guidelines for facilities for retention of extinguishing water, components and systems, requirements and test methods).

The retention concept for extinguishing water shall be implemented in the plans of action of the company-internal protective measures to ensure that the required measures pass off smoothly (e.g. short-term use of extinguishing water barriers). For all measures that could be required in an emergency case, a sufficient number of correspondingly trained persons has to be available whose responsibilities have been defined before.

Furthermore, a retention concept for extinguishing water should cover the following main items:

- Description of the retention facilities (dimensions, structural design) including all components (slide valves, pumps, flaps, etc.).
- Determination of the maximum volume to be retained during the fire (extinguishing water, waste water, condensed water from other areas, released chemicals).
- In buildings and areas whereto the fire brigade requires free access even in case of retention of extinguishing water, the maximum impounding height of 30 cm must not be exceeded. Exceptions to this regulation are possible upon agreement with the locally competent authority for prevention of danger and the local fire service.
- Hydraulic proof for intake channels shall be furnished if this is required to prove drainage of the volume of contaminated extinguishing water, e.g. into a central retention basin.
- Drainage plan; it shall be prevented that contaminated extinguishing water gives further rise to spread of fire.
- Description of the safety equipment to be moved for the expected quantity of extinguishing water (type of control, operability, power supply, actions taken in case of failure, automatic check of functionality).
- Required, internal organisation for safe retention. Persons must never be put at risk by setting to work of the facilities for retention of extinguishing water. An accidental, automatic start-up without any warning in advance shall be excluded.
- Extent and type of self-monitoring.

6.1.2 Stability, Durability, and Tightness

Facilities for retention of extinguishing water shall be designed so as to be resistant to contaminated extinguishing water and tight. Components of facilities for retention of extinguishing water that could be exposed to fire, shall be designed so as to be resistant to the temperatures to be expected. Moreover, they shall prove sufficient durability and resistance to other physical and chemical attacks during fire.

The materials of the facilities have to be dimensioned so that they can stand any force acting on them. Per each 10 cm of water level, an additional pressure of approx. 1 kN/sqm is exerted on the ground. Depending on the planned impounding height of the retained extinguishing water, the resulting lateral forces exerted on the walls are to be taken into account, too.

Facilities for retention of extinguishing water and sealants have to be liquid-tight even under the thermal load existing during a fire and stand the impounded extinguishing water until this will be disposed of.

Should technical reasons absolutely require that pipelines and cables are guided through floors or walls of facilities for retention of extinguishing water, this has to be designed so as to be liquid-tight. Suitable sealants are to be installed that keep their tightness even under fire load.

By corresponding tests, the ageing resistance of perma-elastic sealants shall be proven for their duration of use. I.e. their creep strength related to time is to be ensured under the given storage conditions proving sufficient tightness required in case of use for the intended duration.

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6.1.3 Functional Safety

It has to be ensured that centrally triggered systems can be put into closed position at any time even in case of a power failure. Therefore, the trigger mechanisms are to be monitored according to the closed-circuit principle.

Two independent power sources are required to provide for power supply of automatically triggered systems. If using self-acting systems, which e.g. are operated pneumatically, hydraulically, or by gravitational force, the second independent power supply can be dispensed with.

The permanently manned location has to feature a possibility to activate semi-automatically triggered systems.

Installation and triggering of manually activated systems has to be ensured by easy manipulating within 60 seconds.

The effectiveness of retention facilities has to be ensured immediately upon detection of fire and prior to initiating fire-fighting operations.

All components have to be designed so as to exclude maloperation.

If connection to already existing fire protection systems is established (e.g. smoke and heat exhaust ventilation systems, fire detection and fire alarm systems, extinguishing systems), this has to comply with the state of the art, e.g. connection has to comply with the applicable guidelines and recommendations by VdS (see Section 10).

6.1.4 Operational Safety, Handling

Systems for retention of extinguishing water have to ensure life safety irrespective of their operating condition.

Automatically triggered systems have to be designed so as to be false-alarm proof. It has to be clearly recognisable whether they are ready for operation or out of order for a short time (e.g. during maintenance work). They have to be secured against accidental or thoughtless shut-down.

For barriers to be installed manually (see Section 5.4.3), a sufficient number of employees must always be available during the operation times and in the case of operational shut-downs of the system, to set the mobile retention system for extinguishing water to work.

For systems to be activated manually, rapid triggering is to be guaranteed. Mobile barriers have to be designed so that they can be installed rapidly, at minimum effort, and without any risk of confusion. Dimensions and weights have to be so that a barrier can be installed by maximum 2 persons without any other means (criteria, see VdS 2564)

All components of the facility for retention of extinguishing water are to be protected against external impact and always be kept in working order.

6.1.5 Explosion Protection

In explosion endangered areas, the provisions regarding explosion protection have to be observed (see Section 10).

If extinguishing water can mix with ignitable liquids or if ignitable gas can be emitted, the requirements for explosion protection (e.g. technical ventilation and air extraction) are to be met. Should a corresponding risk potential exist, it is strictly forbidden to use underground parts of the building, property sewerage systems (e.g. company-owned drainage systems), or other unprotected drains and shafts for retention and drainage of contaminated extinguishing water. Use of such systems requires a corresponding proof of suitability proving safe and reliable control of the risk potential. Otherwise, preference shall be given to an outdoor facility for retention of extinguishing water.

Among other things the systems have to be secured against electrostatic charging, which could lead to hazardous discharging. Furthermore, the systems are to be protected against the development of compensating currents, which could be the source of ignitable sparks.

6.2 Erection and Installation of Facilities for Retention of Extinguishing Water

Please find below the requirements for selected components relevant to planning and installation of facilities for retention of extinguishing water (see Section 5.1).

All parts of a facility for retention of extinguishing water and its triggering devices are to be installed so that they will not be damaged by operational activities. Installation is to be carried out so that accessibility for maintenance purposes and in the case of danger / fire is ensured at any time.

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6.2.1 Extinguishing Water Barriers

Extinguishing water barriers in passageways and gateways are to be installed inside so that the firefighters are still able to open all gates and doors in case of fire.

Floors and containment walls of building areas intended to retain extinguishing water are to be checked to detect cracks, dilatation joints, openings, penetrations, etc. in the area where water will pile up. They have to be designed so as to be resistant to media, impermeable to water, and possibly fire-resistant and/or have to be subjected to rehabilitation or repair.

The extinguishing water barriers to be installed manually into permanently installed devices have to be held available near the corresponding passageway or gateway so as to be easily accessible.

In times where no operating personnel is on site, the extinguishing water barriers to be activated manually are to be installed as a precaution.

The location where extinguishing water barriers are stored has to be protected and clearly marked. It has to be ensured that removal and handling of mobile extinguishing water barriers does not involve any risk.

The barriers have to be stored in a way to be protected against any damage (e.g. bumpers) and so that seals do not rest on or lie on.

6.2.2 Pipelines and Sewer Systems

Should - in particular for existing systems - parts of the property sewerage system or other pipelines be used for discharging of extinguishing water into collecting facilities, tightness of the corresponding section of the sewer / pipeline shall be proven. The operating party shall ensure for that part of the sewerage system / pipework used for drainage of extinguishing water or being part of the retention facility that this in the emergency case can be blocked immediately and tightly off the rest of the sewerage system or the pipework without causing at the points of discharge dangerous backing-up in the connected systems.

If the section of the sewerage system used to drain extinguishing water into a retention facility also serves the drainage of operational waste water, this shall be taken into account for the design and dimensioning of connected volumes of retention.

The inlet into the pipeline or the sewer has to be designed so that burnt material or other coarse debris cannot block the inlet pipe nor get into the pipe. Immersion tubes or inlet structures with coarse screens can be installed to this end.

Drainage of extinguishing water that could be mixed up with combustible liquids, through sections of the property sewerage system into corresponding retention facilities is allowed only if appropriate measures have been taken to ensure that no explosive atmosphere can result in the used sections of sewers.

6.2.3 Shut-off Devices

Shut-off devices installed in drains for contaminated extinguishing water always have to be closed and locked so that they are opened only when extinguishing water flows through. Depending on the company fire protection concept, the shut-off device has to open automatically or be opened manually from a safe location as soon as extinguishing water piles up. Shut-off devices are to be marked according to DIN 4066 and to be included in the ground plans for fire brigade use acc. to DIN 14095, Part 1.

The shut-off devices of buried pipes have to be marked with easily accessible, visible indicating devices. Detachable connections and fittings are to be arranged in tight inspection shafts subject to monitoring.

If the sewerage system is used to retain extinguishing water, the barrages have to be provided with sampling ports in the area of the shut-off gates.

6.2.4 Delivery Facilities

If a delivery facility is used to feed the extinguishing water into the facility for retention of extinguishing water, e.g. a pump, an inlet structure featuring a coarse screen, a settling chamber, and an inlet chamber is to be provided. The delivery facility is to be fixed in place or the operating party shall ensure that well-educated personnel receiving regular training are able to install a mobile device promptly. Its functionality, triggering, and power supply shall be guaranteed even in the case of fire. The delivery devices are to be designed so as to ensure the required output even under unfavourable conditions.

For the operation of delivery devices, reliable power supply shall be guaranteed even in the case of fire.

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Depending on the used concept, the delivery devices can be triggered manually or automatically. During the use of delivery devices, the facility for retention of extinguishing water must never be overfilled. An automatic warning must be transmitted by an appropriate fill level monitoring device so that further actions can be taken.

6.2.5 Catch Pits and Retention Basins

It is generally recommended to remove the extinguishing water into basins or tanks being located outside the production and storage areas. Here, it is quite reasonable to use extinguishing water barriers as supplementary means. These should absolutely be used for combustible liquids to remove them rapidly from the seat of fire (also see Sections 5.3 and 5.4). See to it that the drains keep their functionality even in case of fire and do not become blocked up.

Burnt material and extinguishing water should not penetrate into the adjacent fire compartments unless these are intended to retain extinguishing water and are correspondingly designed.

The mandatory catch pits (e.g. for water hazardous substances) can also be used to retain extinguishing water. In such cases, they must be dimensioned not only for the mandatory volume for leaking substances but additionally for the volume of extinguishing water and/or extinguishing foam. Normally, they have to show 30 cm more in height for retention of extinguishing water.

Facilities for retention of extinguishing water must be used as catch pit for retention of perhaps stored liquids running out only if they also comply with the statutory requirements for catch pits (e.g. regarding material quality, tightness).

For the retention of extinguishing water containing combustible liquids that cannot be mixed with water, a permanent foam system shall be installed in the catch pit to prevent spread of fire.

Catch pits and retention basins for extinguishing water are to be arranged or equipped so that overfilling will be detected in good time and further actions can be taken.

6.2.6 Tanks

The use of fixed and mobile tanks for retention of extinguishing water requires observance of the requirements specified in the rules and regulations of the building law, the water law, and the dangerous goods law applicable in Germany.

The tanks are to be equipped with devices for ventilation and air extraction designed for maximum volume flows during feeding and discharging.

For a retention of combustible liquids that can produce an explosive atmosphere or of substances that can liberate combustible gases, the air extraction devices are to be designed so as to be protected against explosion and are to be equipped with a flashback arrester. Possible permanent gas extraction devices must not be brought together with corresponding company installations. The entire permanent gas extraction system has to be designed so as to be protected against explosion. Always observe the guidelines for explosion protection!

6.2.7 Triggering in Case of Fire

If triggering of the automatic facility for retention of extinguishing water in the case of fire is effected from the control and indicating equipment, the fire detection unit has to meet the requirements for automatic fire detection and alarm systems, e.g. pursuant to VdS 2095.

Suitable detection to cause triggering of the closing mechanisms is based on the fire characteristics: smoke, heat, or flames.

Automatic triggering should be made via two lines / 2-detector dependency to largely exclude unintentional releases.

6.2.8 Floor Design

The floor of the rooms for retention of extinguishing water and areas where extinguishing water is applied shall be designed so as to be stable and liquid-tight.

The floor is to be secured with circumferential gutters or upturns so that the leaking liquid or extinguishing water cannot flow away in an uncontrolled manner. If it is not intended to retain the extinguishing water in the storage or production area itself, a directional descent perhaps equipped with drains is required. The drains are to be dimensioned so as to take the quantity of extinguishing water to be expected; and they have to drain off the contaminated extinguishing water into the facilities for retention of extinguishing water without any backing-up.

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6.3 Inspection and Servicing

6.3.1 Approval and Documents

Upon handing over to the operating party, the installer shall prove the functionality of the facility for retention of extinguishing water. At the moment of approval inspection, the operating party shall be provided with the documents below:

- documentation of the constructional and technical design;
- installation certificate;
- operating instructions;
- inspection and maintenance instructions.

Locations of installation and triggering devices for the facilities for retention of extinguishing water are to be marked in the ground plans for fire brigade use.

6.3.2 Installation Certificate

The installation certificate to be issued by the installer has to show at least the data below:

- name and address of the operating party;
- name and address of the installer;
- date of installation;
- location of the facility for retention of extinguishing water (designation of storage, building, or area);
- type of construction, model;
- dimensions and volume;
- confirmation of operability (date, signature / stamp of operating party and of installer).

6.3.3 Operating and Maintenance Instructions

For all technical facilities for retention of extinguishing water, comprehensible operating and maintenance instructions have to be delivered. The maintenance and inspection intervals have to be specified there.

6.3.4 Training

The personnel shall be instructed and trained how the systems to be activated manually work and how to use them. Instruction and training shall be repeated regularly, at least yearly. The employees shall confirm in writing their attendance.

6.3.5 Inspection and Maintenance

Automatically triggered systems together with the approved fire detection and fire alarm systems are subject to regular inspection observing the defined intervals and to be incorporated into the maintenance and servicing schedules. Retention of extinguishing water is subject to inspection by an expert following the ordinance on installation handling materials hazardous to water (the German VAwS) every 5 years (in accordance with TRwS 779 - the German technical rules and regulations for installations handling materials hazardous to water).

Facilities for retention of extinguishing water to be started manually are subject to at least monthly inspection to prove their functionality and ensure their operability in case of emergency. The inspections shall be carried out as laid down in the maintenance instructions by the manufacturer and/or the installer. The responsibility for observance of the inspection and maintenance intervals lies with the operating party.

The facility for retention of extinguishing water has to be inspected regularly for its proper constructional condition, too. Here, a visual inspection of the surface of all parts and areas exposed to extinguishing water in case of emergency satisfies the requirements. Should defects be detected, e.g. separation in the area of joints or due to settlements, further inspections become necessary. Connections, seals, and other wear parts are to be exchanged / replaced as recommended by the manufacturer.

The inspection and maintenance works are to be logged in an operations diary. All defects are to be removed immediately.

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7 Measures to be Taken in Case of Damage

In order to avoid further damage during and upon emission of contaminated extinguishing water, the measures below should be taken.

Immediate measures:

- Shutdown and - if required - emptying of affected production equipment, tanks, storage containers, etc.;
- Safeguarding and closing-down of the sources of damage;
- Prevention of propagation of the accident, e.g. by barriers, mobile tanks, absorption and/or coating with binders;
- Notification of the competent authorities and the insurer.

Further measures:

- Involvement of an expert examination institute;
- Arranging for sampling and examinations;
- Safeguarding and fencing off of the accident area to keep off unauthorised persons;
- Assessment of the danger (e.g. possible spread of pollution, endangerment of ground and ground water, of surface waterbodies, of water supply, of the sewerage system and/or the local clarification plant, and fire or explosion hazard);
- Removal of localised and easily accessible pollutions;
- Keeping rain water away of polluted ground, e.g. by covering the ground with plastic film.

Measures after disposal of extinguishing water:

- Cleaning the sewerage system used for retention;
- Function test of the used technical equipment;
- Analysis of the accident; check of the safety and emergency concept as well as amendment if necessary.

8 Analysis and Disposal of Polluted Extinguishing Water

Fire in industrial plants can entail large quantities of extinguishing water of varying degree of pollution. By way of example we can distinguish between

- **non-polluted or low-polluted extinguishing water** (values falling short of the limit values laid down in the indirect discharger statute), which can be drained safely into the public sewerage system because the local clarification plant can treat such water - with regard to quality and quantity - without prior notification and special measures.

- **low- to moderately polluted extinguishing water** (values do not considerably exceed the limit values laid down in the indirect discharger statute), which can be drained into the public sewerage system to be disposed of there; however, prior notification to the competent water authority and the operating party of the sewerage system and of the clarification plant for reconcilement is recommended.

- **considerably polluted extinguishing water**, which can cause damage to the biological purification stage of the local clarification plant due to the composition of the water, and must never be drained into the public clarification plant without prior reconcilement with the competent water authority and the operating party of the clarification plant, and could require preliminary purification / preliminary treatment on site.

- **heavily polluted extinguishing water**, a preliminary purification / preliminary treatment of which is mandatory due to its composition; this shall be effected on site or in suitable treatment plants - company-owned waste-water treatment plants, suitable waste-water treatment plants of neighbours, treatment plants of disposal companies or of the municipality, etc.

A pollutant analysis shall be made to assess the degree of harmfulness of the contaminated extinguishing water and to define the adequate type of disposal. Even in case of low-polluted extinguishing water, it is strictly recommended to reconcile with the competent authorities, the operating party of the sewerage system, the operating party of the clarification plant, and the insurer. If required, the competent water authority shall issue a permit to discharge.

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Generally, simple analytical procedures, such as a determination of the total parameters, does already deliver sufficient information regarding proper disposal of contaminated extinguishing water.

In order to get a quick on site analysis, e.g. determination of the pH-value, the electric conductivity, the coefficient by absorption spectroscopy amounting to 245 nm, the chemical oxygen demand COD, and the GL-value showing toxicity based on a luminescent bacteria test turned out to be appropriate.

In order to get sufficient characteristics of extinguishing water, the additional determination of AOW (adsorbable organic halogen), TOC (total organic carbon), and BOD_5 (biochemical oxygen demand) could be required.

9 Glossary

9.1 Definitions

Burning velocity
The burning rate gives the maximum speed of propagation of the combustion zone for solids. Similar to the combustion factor, the burning velocity presents a criterion of fire behaviour.

The burning velocity also describes the stationary combustion of an explosive. It is specified in [mm/s] or [m/s].

Building material class (BSK - Baustoffklasse)
Pursuant to the German standard DIN 4102, the building material classes A and B are distinguished here. Building material of class A are non-combustible building products, whereas building material of class B are combustible building products.

More and more the national classification pursuant to DIN 4102-1 is being replaced with the European classification pursuant to DIN EN 13501-1. This standard defines a greater variety of classes and combinations. It classifies not only the reaction to fire behaviour but also additional requirements (smoke development, burning droplets / burning particles). A comparison of the classifications is given in Annex D of the publication by the GDV [German Insurance Association] called "Brandschutz im Betrieb" (VdS 2000) dealing with fire protection in companies.

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 separation of fire compartments
is given if the distance (free of any fire load) between buildings or outdoor storage areas for non-combustible matters is at least 5 m. For outdoor storage areas for combustible matters, a minimum distance of 20 m is required.

Structural separation of fire compartments
is given if buildings, building sections, or storage areas are separated by a fire break wall according to this leaflet. The requirements for the fire break walls as defined e.g. in the German standard DIN 4102 as well as the publication by the GDV [German Insurance Association] "Firewalls and complex partition walls" (VdS 2234) are to be observed.

Fire compartment area
This is the area being formed by spatial or structural subdivision in accordance with the requirements for separation of fire compartments (see fire compartments).

Combustion residues
These are substances that are produced only by exposition to fire (e.g. smouldering fire, incomplete combustion, reaction in the gas phase).

Fire hazard
A fire hazard describes the possibility of adverse effects on personal, material, or environmental safety due to the formation or spread of fire and related consequences, such as heat or smoke.

Fire hazard class
Fire hazard classes as defined in the present guidelines serve a classification of substances regarding their combustibility. For a classification of the fire-related hazard inherent in a substance, we distinguish 3 classes (F1 to F3) (see Annex A2.2).

Fire decomposition products
Thermal decomposition product of existing matters at complete and/or incomplete combustion.

Dioxins
Polychlorinated dibenzo-p-dioxins and furans (PCDD / PCDF) are two groups of chemically similar structured chlorinated organic compounds. In everyday language and in some publications, they are brought together under the general heading "dioxins".

Dioxins result as by-products from the production of organochlorine chemicals or during combustion.

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The most toxic single compound of the dioxins - the so-called "Seveso dioxin" (2,3,7,8-tetrachloro-dibenzodioxin, in short 2,3,7,8-TCDD) - is often called the most toxic substance ever produced by humans. The acute toxicity of the other polychlorinated dibenzo dioxins and dibenzo furans is specified comparatively to 2,3,7,8-TCDD. Already a small amount of polychlorinated dioxins and furans may promote development of cancer out of damaged cells.

Being durable organic pollutants, they are hardly decomposed in the environment - traces of polychlorinated dioxins and furans can be found everywhere. They accumulate in living organisms being transported through the food chain. The human being mainly takes in dioxins together with food of animal origin (fish, meat, eggs, dairy products).

Flash point
The flash point is the lowest temperature, at which a liquid under specified testing conditions and subject to normal pressure emits such a quantity of combustible gas or combustible vapour that it immediately causes a flame as soon as it comes into contact with an active ignition source.

Threatening quantity
This is that quantity of contaminated extinguishing water, an emission of which causes adverse changes of the characteristics of waterbodies entailing corresponding consequences of loss (cf. § 62 WHG (the German Federal Water Act)

Hazard and risk analysis
The hazard and risk analysis as defined by the present guidelines goes beyond the generally known risk assessment and, consequently, beyond mere protection of personnel. It considers in the case to be analysed especially the danger to property and environment that could be caused by contaminated extinguishing water.

Hazardous matters / harmful matters
Hazardous matters are substances, substance mixtures, and goods that as a consequence of a fire put human and environment at a particular risk. This includes but is not limited to all matters being classified to be water-endangering.

But hazardous matters as defined by the present guidelines are also any combustible and potentially explosive matters that themselves or the products of combustion of which

- are toxic to fauna or flora (toxic matters) or
- can endanger water, air, or ground (ecotoxic matters).

Hazardous / harmful characteristics
Hazardous / harmful characteristics as defined by the present guidelines are

- water endangerment,
- combustibility,
- explosion hazard,
- toxicity, as well as
- ecotoxicity

because all these put human, flora, fauna, and environment at risk in case of fire.

Hazardous substances / pollutants
Hazardous substances are pursuant to § 3, Paragraph 1 GefStoffV [German Hazardous Material Ordinance] those substances, preparations, and products specified in § 19, Paragraph 2, ChemG [German Chemical Act], namely

- hazardous substances and preparations pursuant to § 3a as well as substances and preparations of other chronically deleterious properties,
- potentially explosive substances, preparations, and products,
- substances, preparations, and products that can develop into or liberate during production or use substances or preparations as defined under a) and b), as well as
- substances, preparations, and products with the potential to spread pathogens as known from experience.

Moreover, hazardous substances as defined in the present guidelines can be substances or substance mixtures (pure substance, product, residual substance, residue, waste) that can cause adverse changes when entering the ecosystems, or when being absorbed by living organisms, or to physical assets.

GL value
This is the toxicity determined by way of the luminescent bacteria test of a sample.

The determination of the GL value is a way to determine the toxicity of a sample in compliance with the German standard DIN. The GL value is the dilution level G of a sample at which a water sample causes less than 20 % inhibition. The dilution level G is the dilution factor of the sample to be tested. Thus, one portion of undiluted sample plus one portion of bacteria suspension results in a dilution to be tested of 1:2. This corresponds to a G value G2. A dilution of 1:2 of the sample gets the G value G4 and so on. The level of the GL value is the measure for toxicity of a sample in the luminescent bacteria test.

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Plant for the production, treatment, and use
Plant for the production, treatment, or use of water endangering matters

Calorific value
The calorific value is the maximum useful heat quantity resulting from combustion of a defined quantity of combustible material which does not cause condensation of the water vapour existing in the exhaust gas.

Methods of storage
The following methods of storage and construction models of the storage equipment are distinguished:

- block storage: mixed cargo, block-type with or without pallets, piled up in racks;
- rack storage: cargo warehouse with racks;
- high-rack storage: racking storage with top of the storage above 7.5 m;
- bulk storage: storage in bulk;
- storage tanks; storage in stationary tanks;
- barrel storage / containment shelving: storage in mobile containers

Storage types
- Warehouse in buildings:
  bordered by façades and roof / ceiling
- Outdoor storage area:
  - roofed storage area:
    bordered only by roof
  - membrane containment:
    fabric buildings or inflatable structures;
  - outdoor storage:
    storage area without any weather protection.

Storage sections
One storage section is that part of the storage that is separated

- in buildings from other rooms by walls and ceilings;
- outdoor by an adequate distance or by walls.

Storage, filling, and transshipment facility
Facility for storage, filling, and transshipment of water hazardous substances.

Extinguishing water
As defined by the present guidelines, this is water taken out of the public drinking water supply, surface waterbodies, extinguishing water basins, etc. to be used in the case of fire as extinguishing or cooling medium.

Extinguishing water barrier
Barriers that serve the prevention of uncontrolled discharge of contaminated extinguishing water through openings in structural works (e.g. doors, gates). We distinguish between:

- **Permanently installed extinguishing water barriers**
  Extinguishing water barriers, which are permanently installed at the location of use.

- **Self-acting permanently installed barriers**
  Permanently installed extinguishing water barriers, which are automatically triggered in case of fire by detection of fire characteristics, e.g. by smoke or heat, and then automatically moving into their shutting position.

- **Permanently installed barriers to be triggered manually**
  Permanently installed extinguishing water barriers fastened to their holders and being moved into their shutting position by manual triggering, i.e. by muscle power, backed-up energy (weight, spring), or auxiliary energy (e.g. electric, hydraulic, pneumatic).

- **Permanently installed barriers to be installed manually**
  Permanently installed extinguishing water barriers being stored near the location of use and to be manually installed into local holders permanently mounted to this end.

Retention of extinguishing water
All appropriate measures to avoid uncontrolled discharge of the extinguishing water used to fight a fire, to collect it, and to retain it for a limited period of time.

Local retention of extinguishing water means retention effected just at the location or in the building where the water piles up. Central retention of extinguishing water means retention in a catch pit and/or retention basin located outside of the operating facilities.

Facilities for retention of extinguishing water
Open or closed basins, pits, or other areas and rooms serving a different purpose, including the safety-relevant equipment, such as extinguishing water barriers as well as tanks and other facilities, e.g. parts of a sewerage system designed and appropriate to collect contaminated extinguishing water until proper disposal of it.

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Facilities for retention of extinguishing water can be classified according to their mode of functioning as follows:

- **Self-acting facilities**
  Structural measures that ensure retention of extinguishing water without the need to take further measures.

- **Automatically triggered facilities**
  The systems will be automatically triggered upon detection of a fire characteristic, e.g. smoke or heat, and will retain the extinguishing water and/or ensure transportation into a corresponding retention basin.

- **Facilities to be activated manually**
  In the emergency case, these systems have to be triggered manually or be put manually into a position to prevent any discharge of extinguishing water or ensure transportation into a retention basin.

Contamination of extinguishing water
Pollution of ground, ground water, and/or waterbodies caused by extinguishing water.

Damage by extinguishing water
Damages to the environment, buildings, or other material assets caused by extinguishing water.

Ecotoxic matters
Ecotoxic matters as defined by the present guidelines are substances, substance mixtures, and articles that themselves or the products of combustion of which involve a risk for the environment and can cause damage to water, air, or ground.

In addition to matters of water-endangering potential, ecotoxic matters as defined here are matters that can pollute the air, such as

- compressed toxic gases presenting an imminent danger that adversely affect the fire fighting operations.

- Matters that in the case of fire can liberate a significant amount of toxic products that are hardly degradable and, consequently, contaminate the environment making extensive decontamination measures necessary.

- Matters that in the case of fire can liberate a significant amount of toxic substances that contaminate the environment making simple and local decontamination measures necessary.

Pyrolysis
Pyrolysis (Greek: pyr = fire, lysis = dissolution) is the designation for thermal cracking of organic compounds under lack of oxygen.

Pyrolysis oil
Pyrolysis oil is a dark-brown liquid being the result of pyrolysis of biomass at a temperature of approx. 500 °C. Pyrolysis oil is composed of a multitude of oxo-components, such as carboxylic acids, phenols, aldehydes, and ketones. Here, several hundreds of combinations can be proven, being partly monomeric or polymeric lignin components.

R and S phrases
(in future acc. to GHS H and P phrases)
R and S phrases (Risk and Safety) are codified warning information to characterise the hazardous characteristics of hazardous substances, thus elements and compounds as well as the hazardous preparations of them. Together with the indication of risk from hazardous substances and the corresponding symbols of danger, they are the most important aids to identify hazardous substances as required in the EU.

The R phrases form the basis for classification of a hazardous substance. Having specified them, you can derive the required indications of risk with the symbols of dangers as well as the required S phrases.

The Globally Harmonizes System for Classification and Labelling of Chemicals (GHS) replaces this identification of hazardous substances more and more and for substances it has become legally binding already. For mixtures (called "preparations" above), a transition period until 1st June 2015 shall apply; until then an identification using the symbols of danger and the R / S phrases will still be valid. Substances and mixtures classified according to the GHS, are identified by the GHS danger pictograms as well as H and P phrases.

The H phrases (Hazard statements) describe hazards presented by chemical substances or preparations. The P phrases (Precautionary statements) present the precautions to be taken when handling them.

Impounding height
Impounding height is the calculated height of retained extinguishing water possibly piling up on the ground surface of a building. This does not allow for installations and volume-displacing stored goods, production means, etc.

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Storage blocks and aisles
Storage blocks are linked ground areas occupied by stored goods separated by aisles, traffic routes, or separations from other storage blocks.

Water endangering class (WGK - Wassergefährdungsklasse)
Classification into water endangering classes (WGK) is given on the safety data sheet or the VwVwS (see Section 10). Insofar as a substance shows no WGK classification, the WGK class can be concluded from the H phrases (R phrases in the past) (also see Annex A2.1).

Factory fire service
Factory fire services as defined in the present guidelines are fire brigades approved pursuant to the provisions of Land law in Germany. Regarding structure, equipment, and training, they shall meet the requirements for public fire brigades. More detailed information is given in the VdS guidelines dealing with in-plant fire protection (VdS 2000) and the VdS leaflet dealing with the factory and works fire brigades (VdS 2034).

9.2 Abbreviations Used

ABS - acrylonitrile butadiene styrene

AOX - adsorbable organic halogen

BBodschG - Bundes-Bodenschutzgesetz
(German Federal Soil Protection Act)

BetrSichV - Betriebssicherheitsverordnung
(German Ordinance on Industrial Safety and Health)

BOD_5 - Biologischer Sauerstoffbedarf
(biochemical oxygen demand)

CEA - Comité Européen des Assurances -
European insurance and reinsurance federation (today: Insurance Europe)

CSB - Chemischer Sauerstoffbedarf
(chemical oxygen demand)

DIN - Deutsches Institut für Normung
(German Institute for Standardization)

EU - European Union

F1, F2, F3 - fire hazard classes

GDV - Gesamtverband der Deutschen Versicherungswirtschaft
(German Insurance Association)

GefStoffV - Gefahrstoffverordnung
(German Hazardous Material Ordinance)

GHS - Globally Harmonized System of Classification and Labelling of Chemicals

HCl - hydrochloric acid

S1, S2, S3, S4 - safety categories

LöRüRL - Löschwasser-Rückhalte-Richtlinie
(German guideline for retention of extinguishing water)

PA - polyamide

PAH - polynuclear aromatic hydrocarbons

PE - polyethylene

PETP - polyethylene terephthalate (plastic)

PF - phenolic formaldehyde resin (bakelite)

PMMA - polymethylmethacrylate (plastic)

POM - polyoxymethylene (plastic)

PP - polypropylene

PS - polystyrene

PTFE - polytetrafluoroethylene (teflon)

PU - polyurethane

PVC - polyvinyl chloride

RI - risk indicator

SI - silicon

TOC - Total Organic Carbon

TRwS - Technische Regel wassergefährdender Stoffe
(German technical rules and regulations for water hazardous substances)

UP - unsaturated polyester resins

USchadG - Umweltschadengesetz
(German Environmental Damage Act)

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VwVwS - Verwaltungsvorschrift wassergefährdende Stoffe
(German administrative regulation on substances hazardous to water)

WHG - Wasserhaushaltsgesetz
(German Federal Water Act)

WGK - Wassergefährdungsklasse
(water endangering class)

10 Laws, Ordinances, Technical Rules and Regulations, and Literature

10.1 Laws and Ordinances

Please note: To the list below applies that laws and ordinances can only define a framework whereas the realisation often requires rules and regulations by the German Länder.

Bundes-Bodenschutzgesetz (BBodschG) - German Federal Soil Protection Act - act on protection against harmful changes to soil and on rehabilitation of contaminated sites

Chemikaliengesetz (ChemG) - German Chemical Act - act on protection against hazardous substances

Kreislaufwirtschaftsgesetz (KrWG) - German Waste Avoidance, Recycling and Disposal Act - act on recycling economy and maintenance of ecologically benign waste management

Wasserhaushaltsgesetz (WHG) - German Federal Water Act - act on managing water resources

Abfallverzeichnis-Verordnung (AVV) - German Waste Catalogue Ordinance - ordinance on the European waste catalogue

Arbeitsstättenverordnung (ArbStättV) - German Workplace Ordinance - ordinance on workplaces

Betriebssicherheitsverordnung (BetrSichV) - German Ordinance on Industrial Safety and Health - ordinance on safety and health at the provision of equipment and the corresponding use during work, on safety during operation of equipment subject to monitoring, and on the organisation of occupational health and safety

Biostoffverordnung (BioStoffV) - German Biological Agents Ordinance - ordinance on safety and health protection when working with biological agents

Gefahrstoffverordnung (GefStoffV) - German Hazardous Materials Ordinance - ordinance on protection against hazardous materials

Nachweisverordnung (NachwV) - German ordinance on waste disposal and recovery records

Bundesanzeiger Verlagsgesellschaft m.b.H.,
Postfach 13 20,
D-53003 Bonn
Internet: www.bundesanzeiger.de

10.2 Technical Rules and Regulations

Technische Regeln für Betriebssicherheit (TRBS) - Technical regulations for operational safety

TRBS 1111 - risk assessment and safety assessment

TRBS 1151 - hazards at the interface man - work equipment; ergonomic and human factors

TRBS 1201 - check of work equipment and equipment subject to monitoring

TRBS 1203 - competent persons

TRBS 2111 - mechanical danger - general requirements

TRBS 2152 - dangerous explosive atmosphere - general

TRBS 2152
- **Part 1** - dangerous explosive atmosphere - assessment of explosion hazard
- **Part 2** - avoidance and reduction of explosive atmosphere
- **Part 3** - dangerous explosive atmosphere - avoidance of ignition of dangerously explosive atmosphere

TRBS 2210 - hazard by interaction

Internet: www.baua.de

Technische Regeln für Gefahrstoffe (TRGS) und für biologische Arbeitsstoffe (TRBA) - Technical regulations for hazardous substances (TRGS) and for biological agents (TRBA)

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TRGS 001 - general, structure, application, and taking effect of TRGS

TRGS 002 - outline of the TRGS at present

TRGS 003 - generally approved safety and hygienic rules

TRGS 401 - hazard by skin contact for determination, assessment, measures

TRGS 500 - safeguards

TRGS 510 - storage of hazardous substances in mobile containers

TRGS 524 - safeguards for activities in contaminated areas

TRGS 555 - operating instructions and information of the personnel

TRGS 900 - limit values at workplaces

TRGS 903 - biological limit values

TRGS 905 - list of carcinogenic, mutagenic, or reproductively toxic substances

TRGS 906 - list of carcinogenic activities or procedures pursuant to § 3, Paragraph 2, Item 3 GefStoffV (German Hazardous Materials Ordinance)

Supplement to TRGS 905 and 906 - list of carcinogenic, mutagenic, or reproductively toxic substances, activities, and procedures pursuant to Annex I of the Directive 67/548/EEC, TRGS 905 and TRGS 906

TRBA 400 - how to proceed in risk assessment of activities with biological agents

TRBA 500 - general hygiene measures: minimum requirements

Internet: www.baua.de

Technische Regeln wassergefährdender Stoffe (TRwS) - Technical rules and regulations for water hazardous substances

TRwS 779 (sheet DWA-A 779) - general technical rules and regulations

DWA - Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e. V.,
Theodor-Heuss-Allee 17,
D-53773 Hennef
Internet: www.dwa.de

10.3 Publications of GDV / VdS

VdS 2000 - Brandschutz im Betrieb (deals with in-plant fire protection)

VdS 2034 - Werk- und Betriebsfeuerwehren (deals with the factory and works fire brigades)

VdS 2095 - "Automatic Fire Detection and Fire Alarm Systems, Planning and Installation"

VdS 2217 - Umgang mit kalten Brandstellen (presents how to handle cold fire grounds - example of an information leaflet for owners of a dwelling, tenants, property managers, as well as for trade and industrial establishments)

VdS 2234 - "Firewalls and complex partition walls, Leaflet for arrangement and design"

VdS 2357 - Richtlinien zur Brandschadensanierung (presents guidelines for fire loss restoration)

VdS 2516 - Kunststoffe (deals with synthetic materials: information on their characteristics, fire behaviour, fire hazards; leaflet)

VdS 2564 - Löschwasser-Rückhalteanlagen (deals with facilities for retention of extinguishing water, Part 1 deals with permanently installed extinguishing water barriers; guidelines for requirements and test methods for components and systems)

VdS Schadenverhütung, Verlag,
Amsterdamer Straße 174, D-50735 Köln
Internet: www.vds-industrial.de

10.4 Standards, Regulations, and Recommendations

General administrative regulation on closer determination of substances hazardous to water and their classification according to their inherent hazard - VwVwS

Catalogue of substances hazardous to water (work group of German Länder dealing with water), of water endangering classes (WGK), German Federal Ministry of the Interior in Bonn / Germany

LöRüRL - Löschwasser-Rückhalte-Richtlinie (guideline on how to dimension facilities for retention of extinguishing water when storing water-hazardous substances)

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Concept of joint storage of chemicals by the Verband der chemischen Industrie [German chemical industry association], Frankfurt 1993

DIN ATV 18299 - "German construction contract procedures (VOB) - Part C: General technical specifications in construction contracts (ATV) - General rules applying to all types of construction work"

DIN 4066 - deals with information signs for the fire brigade

DIN 14095 - "Ground plans for components for buildings for fire brigade use"

LAGA PN 98 - presents a guideline for procedures for physical, chemical, and biological testing in connection with the recovery / disposal of waste

Internet: www.beuth.de
Internet: www.baua.de

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Annexes

A Matrix for Hazard and Risk Analysis

A 1.1 Matrix for Hazard and Risk Analysis - Master

Master	Risk indicators RI		
Criterion	**RI 1 - low**	**RI 2 - medium**	**RI 3 - high**
A Risk potential of material			
Water endangerment operating supplies	WGK 1 equivalent and/or detrimental to health: quantity > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 10 t or toxic > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 100 t or very toxic > 1 t or toxic > 10 t
Water endangerment products of combustion (operating supplies / building materials)	WGK 1 equivalent and/or detrimental to health: quantity > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 10 t or toxic > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 100 t or very toxic > 1 t or toxic > 10 t
Water endangerment extinguishing agent	WGK 1 equivalent and/or detrimental to health: quantity > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 10 t or toxic > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 100 t or very toxic > 1 t or toxic > 10 t
Other hazardous properties corresponding to Annex A 2.3 of combustion products, production articles, and stored goods / stocks (For the quantity limits see Table 3 of Annex A2.3)	less hazardous	hazardous	very hazardous
B Combustion Properties			
Combustibility / quantity of operating supplies and consumables (see Annex A2.2)	not easily combustible (F3) > 0.1 t/sqm "F1 equivalent"	ignitable (F2) > 1 t/sqm "F1 equivalent"	easily ignitable (F1) > 10 t/sqm "F1 equivalent"
Combustibility / quantity building materials (see Annex A2.2)	not easily flammable (B1) > 1 t "F1 equivalent"	flammable (B2) > 10 t "F1 equivalent"	easily flammable (B3) > 100 t "F1 equivalent"
Fire load of operating supplies, consumables, and building materials	low > 30 kWh/sqm	medium 30 kWh/sqm - 200 kWh/sqm	high > 200 kWh/sqm

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Master	Risk indicators RI		
Criterion	**RI 1 - low**	**RI 2 - medium**	**RI 3 - high**
C other criteria			
Fire compartments	< 1,600 sqm	1,600 to 6,400 sqm	> 6,400 sqm
Ambient conditions	commercial and industrial areas	residential areas, bird sanctuaries pursuant to Natura-2000-RL [German directive for special protected areas]	protected water areas / zones 1 to 3; special protected areas for flora, fauna, and habitat pursuant to Natura-2000-RL
Size, type of clarification plant	sewage purification plant copes with contaminated extinguishing water	sewage purification plant copes with contaminated extinguishing water upon reconcilement and taking additional measures	Sewage purification plant normally cannot cope with contaminated extinguishing water
Fire protection infrastructure (e.g. fire protection standard, see Section 4, Table 1)	BS 4	BS 3	BS 2
Structural requirements (basement, outdoor area...)	external, tight retention possibilities do exist	liquid-tight ground areas	not liquid-tight ground areas
prior damages, near-accidents, and minor events in connection with discharge of contaminated extinguishing water	none	negligible effects	serious effects

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A 1.2 Application of the Matrix for Hazard and Risk Analysis - Example 1

Example 1	Risk indicators RI		
Criterion	**RI 1 - low**	**RI 2 - medium**	**RI 3 - high**
A Risk potential of material			
Water endangerment operating supplies	WGK 1 equivalent and/or detrimental to health: quantity > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 10 t or toxic > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 100 t or very toxic > 1 t or toxic > 10 t
Water endangerment products of combustion (operating supplies / building materials)	WGK 1 equivalent and/or detrimental to health: quantity > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 10 t or toxic > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 100 t or very toxic > 1 t or toxic > 10 t
Water endangerment extinguishing agent	WGK 1 equivalent and/or detrimental to health: quantity > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 10 t or toxic > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 100 t or very toxic > 1 t or toxic > 10 t
Other hazardous properties corresponding to Annex A 2.3 of combustion products, production articles, and stored goods / stocks (For the quantity limits see Table 3 of Annex A2.3)	less hazardous	hazardous	very hazardous
B Combustion Properties			
Combustibility / quantity of operating supplies and consumables (see Annex A2.2)	not easily combustible (F3) > 0.1 t/sqm "F1 equivalent"	ignitable (F2) > 1 t/sqm "F1 equivalent"	easily ignitable (F1) > 10 t/sqm "F1 equivalent"
Combustibility / quantity building materials (see Annex A2.2)	not easily flammable (B1) > 1 t "F1 equivalent"	flammable (B2) > 10 t "F1 equivalent"	easily flammable (B3) > 100 t "F1 equivalent"
Fire load of operating supplies, consumables, and building materials	low > 30 kWh/sqm	medium 30 kWh/sqm - 200 kWh/sqm	high > 200 kWh/sqm

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Example 1	Risk indicators RI		
Criterion	**RI 1 - low**	**RI 2 - medium**	**RI 3 - high**
C other criteria			
Fire compartments	< 1,600 sqm	1,600 to 6,400 sqm	> 6,400 sqm
Ambient conditions	commercial and industrial areas	residential areas, bird sanctuaries pursuant to Natura-2000-RL [German directive for special protected areas]	protected water areas / zones 1 to 3; special protected areas for flora, fauna, and habitat pursuant to Natura-2000-RL
Size, type of clarification plant	sewage purification plant copes with contaminated extinguishing water	sewage purification plant copes with contaminated extinguishing water upon reconcilement and taking additional measures	Sewage purification plant normally cannot cope with contaminated extinguishing water
Fire protection infrastructure (e.g. fire protection standard, see Section 4, Table 1)	BS 4	BS 3	BS 2
Structural requirements (basement, outdoor area...)	external, tight retention possibilities do exist	liquid-tight ground areas	not liquid-tight ground areas
prior damages, near-accidents, and minor events in connection with discharge of contaminated extinguishing water	none	negligible effects	serious effects

Example 1:

In this example dangerous quantities of critical substances actually do exist. However, the operating party of the clarification plant states that the sewage purification plant could cope with the expected quantity of contaminated extinguishing water. Consequently, own volumes of retention would not be required on the operating premises. Certainly, safe draining of contaminated extinguishing water must also be ensured on the operating premises by taking constructional, technical, and above all organisational measures.

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A 1.3 Application of the Matrix for Hazard and Risk Analysis - Example 2

Example 2	Risk indicators RI		
Criterion	**RI 1 - low**	**RI 2 - medium**	**RI 3 - high**
A Risk potential of material			
Water endangerment operating supplies	WGK 1 equivalent and/or detrimental to health: quantity > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 10 t or toxic > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 100 t or very toxic > 1 t or toxic > 10 t
Water endangerment products of combustion (operating supplies / building materials)	WGK 1 equivalent and/or detrimental to health: quantity > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 10 t or toxic > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 100 t or very toxic > 1 t or toxic > 10 t
Water endangerment extinguishing agent	WGK 1 equivalent and/or detrimental to health: quantity > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 10 t or toxic > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 100 t or very toxic > 1 t or toxic > 10 t
Other hazardous properties corresponding to Annex A 2.3 of combustion products, production articles, and stored goods / stocks (For the quantity limits see Table 3 of Annex A2.3)	less hazardous	hazardous	very hazardous
B Combustion Properties			
Combustibility / quantity of operating supplies and consumables (see Annex A2.2)	not easily combustible (F3) > 0.1 t/sqm "F1 equivalent"	ignitable (F2) > 1 t/sqm "F1 equivalent"	easily ignitable (F1) > 10 t/sqm "F1 equivalent"
Combustibility / quantity building materials (see Annex A2.2)	not easily flammable (B1) > 1 t "F1 equivalent"	flammable (B2) > 10 t "F1 equivalent"	easily flammable (B3) > 100 t "F1 equivalent"
Fire load of operating supplies, consumables, and building materials	low > 30 kWh/sqm	medium 30 kWh/sqm - 200 kWh/sqm	high > 200 kWh/sqm

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Example 2	Risk indicators RI		
Criterion	**RI 1 - low**	**RI 2 - medium**	**RI 3 - high**
C other criteria			
Fire compartments	< 1,600 sqm	1,600 to 6,400 sqm	> 6,400 sqm
Ambient conditions	commercial and industrial areas	residential areas, bird sanctuaries pursuant to Natura-2000-RL [German directive for special protected areas]	protected water areas / zones 1 to 3; special protected areas for flora, fauna, and habitat pursuant to Natura-2000-RL
Size, type of clarification plant	sewage purification plant copes with contaminated extinguishing water	sewage purification plant copes with contaminated extinguishing water upon reconcilement and taking additional measures	Sewage purification plant normally cannot cope with contaminated extinguishing water
Fire protection infrastructure (e.g. fire protection standard, see Section 4, Table 1)	BS 4	BS 3	BS 2
Structural requirements (basement, outdoor area...)	external, tight retention possibilities do exist	liquid-tight ground areas	not liquid-tight ground area
prior damages, near-accidents, and minor events in connection with discharge of contaminated extinguishing water	none	negligible effects	serious effects

Example 2:

By analogy to example 1, dangerous quantities of critical substances do exist, too. In this example, the operating party of the clarification plant states upon request that the sewage purification plant could cope with the expected quantity of contaminated extinguishing water. However, this establishment has not met the structural requirements for retention of extinguishing water because there are no liquid-tight ground areas. Therefore, the operating party shall make improvements or opt for an alternative for retention of extinguishing water.

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A 1.4 Application of the Matrix for Hazard and Risk Analysis - Example 3

Example 3	Risk indicators RI		
Criterion	**RI 1 - low**	**RI 2 - medium**	**RI 3 - high**
A Risk potential of material			
Water endangerment operating supplies	WGK 1 equivalent and/or detrimental to health: quantity > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 10 t or toxic > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 100 t or very toxic > 1 t or toxic > 10 t
Water endangerment products of combustion (operating supplies / building materials)	WGK 1 equivalent and/or detrimental to health: quantity > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 10 t or toxic > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 100 t or very toxic > 1 t or toxic > 10 t
Water endangerment extinguishing agent	WGK 1 equivalent and/or detrimental to health: quantity > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 10 t or toxic > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 100 t or very toxic > 1 t or toxic > 10 t
Other hazardous properties corresponding to Annex A 2.3 of combustion products, production articles, and stored goods / stocks (For the quantity limits see Table 3 of Annex A2.3)	less hazardous	hazardous	very hazardous
B Combustion Properties			
Combustibility / quantity of operating supplies and consumables (see Annex A2.2)	not easily combustible (F3) > 0.1 t/sqm "F1 equivalent"	ignitable (F2) > 1 t/sqm "F1 equivalent"	easily ignitable (F1) > 10 t/sqm "F1 equivalent"
Combustibility / quantity building materials (see Annex A2.2)	not easily flammable (B1) > 1 t "F1 equivalent"	flammable (B2) > 10 t "F1 equivalent"	easily flammable (B3) > 100 t "F1 equivalent"
Fire load of operating supplies, consumables, and building materials	low > 30 kWh/sqm	medium 30 kWh/sqm - 200 kWh/sqm	high > 200 kWh/sqm

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Example 3	Risk indicators RI		
Criterion	**RI 1 - low**	**RI 2 - medium**	**RI 3 - high**
C other criteria			
Fire compartments	< 1,600 sqm	1,600 to 6,400 sqm	> 6,400 sqm
Ambient conditions	commercial and industrial areas	residential areas, bird sanctuaries pursuant to Natura-2000-RL [German directive for special protected areas]	protected water areas / zones 1 to 3; special protected areas for flora, fauna, and habitat pursuant to Natura-2000-RL
Size, type of clarification plant	sewage purification plant copes with contaminated extinguishing water	sewage purification plant copes with contaminated extinguishing water upon reconcilement and taking additional measures	sewage purification plant normally cannot cope with
Fire protection infrastructure (e.g. fire protection standard, see Section 4, Table 1)	BS 4	BS 3	BS 2
Structural requirements (basement, outdoor area...)	external, tight retention possibilities do exist	liquid-tight ground areas	not liquid-tight ground areas
prior damages, near-accidents, and minor events in connection with discharge of contaminated extinguishing water	none	negligible effects	serious effects

Example 3:

By analogy to the examples 1 and 2, dangerous quantities of critical substances do exist, too. However, the operating party of the clarification plant states upon request that the sewage purification plant could not cope with the expected quantity of contaminated extinguishing water. But this establishment has met the structural requirements for retention of extinguishing water because there are liquid-tight ground areas. Thus, the operating party could for instance consider the use of barriers or upturns for the building entrances (see the examples in Annex 5 for advantages and disadvantages).

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A 1.5 Application of the Matrix for Hazard and Risk Analysis - Example 4

Example 4	Risk indicators RI		
Criterion	**RI 1 - low**	**RI 2 - medium**	**RI 3 - high**
A Risk potential of material			
Water endangerment, operating supplies	WGK 1 equivalent and/or detrimental to health: quantity > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 10 t or toxic > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 100 t or very toxic > 1 t or toxic > 10 t
Water endangerment products of combustion (operating supplies / building materials)	WGK 1 equivalent and/or detrimental to health: quantity > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 10 t or toxic > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 100 t or very toxic > 1 t or toxic > 10 t
Water endangerment extinguishing agent	WGK 1 equivalent and/or detrimental to health: quantity > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 10 t or toxic > 1 t	WGK 1 equivalent and/or detrimental to health: quantity > 100 t or very toxic > 1 t or toxic > 10 t
Other hazardous properties corresponding to Annex A 2.3 of combustion products, production articles, and stored goods / stocks (For the quantity limits see Table 3 of Annex A2.3)	less hazardous	hazardous	very hazardous
B Combustion Properties			
Combustibility / quantity of operating supplies and consumables (see Annex A2.2)	not easily combustible (F3) > 0.1 t/sqm "F1 equivalent"	ignitable (F2) > 1 t/sqm "F1 equivalent"	easily ignitable (F1) > 10 t/sqm "F1 equivalent"
Combustibility / quantity building materials (see Annex A2.2)	not easily flammable (B1) > 1 t "F1 equivalent"	flammable (B2) > 10 t "F1 equivalent"	easily flammable (B3) > 100 t "F1 equivalent"
Fire load of operating supplies, consumables, and building materials	low > 30 kWh/sqm	medium 30 kWh/sqm - 200 kWh/sqm	high > 200 kWh/sqm

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Example 4	Risk indicators RI		
Criterion	**RI 1 - low**	**RI 2 - medium**	**RI 3 - high**
C other criteria			
Fire compartments	< 1,600 sqm	1,600 to 6,400 sqm	> 6,400 sqm
Ambient conditions	commercial and industrial areas	residential areas, bird sanctuaries pursuant to Natura-2000-RL [German directive for special protected areas]	protected water areas / zones 1 to 3; special protected areas for flora, fauna, and habitat pursuant to Natura-2000-RL
Size, type of clarification plant	sewage purification plant copes with contaminated extinguishing water	sewage purification plant copes with contaminated extinguishing water upon reconcilement and taking additional measures	sewage purification plant normally cannot cope with
Fire protection infrastructure (e.g. fire protection standard, see Section 4, Table 1)	BS 4	BS 3	BS 2
Structural requirements (basement, outdoor area...)	external, tight retention possibilities do exist	liquid-tight ground areas	not liquid-tight ground area
prior damages, near-accidents, and minor events in connection with discharge of contaminated extinguishing water	none	negligible effects	serious effects

Example 4:

By analogy to example 3, dangerous quantities of critical substances do exist, too. In this example, the operating party of the clarification plant states as well upon request that the sewage purification plant could not cope with the expected quantity of contaminated extinguishing water. But contrary to example 3, this establishment has not met the structural requirements for retention of extinguishing water by liquid-tight ground areas. Thus, retention of extinguishing water inside the building has to be ruled out.

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A 2 Risks of Material

A 2.1 Water Endangering Classes (WGK)

Classification into water endangering classes (WGK) is given on the safety data sheet or the VwVwS. Insofar as a substance shows no WGK classification, the WGK class can be concluded from the H phrases (R phrases in the past).

Should classification into different WGKs have been made, conversion is as follows:

1 t of substance of class WGK 3 corresponds to 10 t of substance of class WGK 2

1 t of substance of class WGK 2 corresponds to 10 t of substance of class WGK 1

1 t of substance of class WGK 3 corresponds to 100 t of substance of class WGK 1

A 2.2 Determination of Fire Hazard Classes (F1 to F3)

For the event of "fire", the material property "combustibility" is a significant characteristic. Combustibility is a complex characteristic, which mainly describes ignitability and spread of fire in the beginning of a fire. The combustibility of stored matters and their packagings, of storage and transportation devices (e.g. pallets), as well as of the construction components of a warehouse has an effect on the development of fire and, consequently, on the consumption of extinguishing water, thus also on the quantity of extinguishing water to be expected or used, respectively.

Fire hazard classes as defined in the present guidelines serve a classification of substances regarding their combustibility. For a classification of the fire-related hazard inherent in a substance, we distinguish the fire hazard classes according to Table 2.

If substances of different combustibility exist, the conversion factors below shall apply:

1 t of substance of class F1 corresponds to 3 t of substance of class F2

The converted quantities of substances are to be summed up. Here, substances of class F3 (non-combustible) are to be ignored.

	Fire hazard classes		
	F1	**F2**	**F3**
	extremley ignitable (R12), easily ignitable (R11), and rapidly burning down	ignitable (R10) easily to medium combustible, flammable	not easily combustible (only with supplementary firing equipment) or non-combustible, respectively
Examples (package)	foam plastics	cardboard, wood, synthetic material (PE, PP, PVC, etc.)	glass, metal, stone
examples (goods, stored goods)	acetone, petrol, alcohol, kerosene, red phosphorus	sulphur, carbon, heating oil, tyres, lube oil	concrete, cement, hydrochloric acid
Liquids	flash point < 55°C	flash point > 55°C	not easily combustible (only with supplementary firing equipment) or non-combustible, respectively
Building material classified into building material class (BSK) pursuant to DIN 4102 and/or DIN EN 13501-1 (see explanations in Section 9.1).	easily flammable BSK B3	flammable and not easily flammable, BSK B1 and B2	non-combustible, BSK A1 and A2

Table 2: Definition of fire hazard classes F1 to F3

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A 2.3 Collection of Examples for Selected (Other) Hazardous Substances and Possible Consequences

This lists those substances to which no danger criterion according to the GefStoffV [German Hazardous Material Ordinance] can be assigned or which by definition cannot be classified into water endangering classes (WGK) ("other" hazardous substances).

List of "other" harmful characteristics:

- Substances that become hazardous substances only because of the combustion process (e.g. synthetic materials).
- Substances that - when being on fire - require special extinguishing agents hazardous to water (e.g. synthetic materials on fire, tyres on fire).
- Substances to which no hazardous characteristic can be assigned (e.g. foodstuff).
- "Critical" building material that already contains hazardous substances or that liberate hazardous substances when being on fire.

Operating supplies	Possible consequences	Quantity limit [t] per fire compartment		
		low	medium	high
Foodstuff e.g. butter, honey, milk, frozen food, such as ice cream.	Blockage of sewers, damage to building material, overcharge of biological purification stage of the clarification plant, increased oxygen-depletion in waterbodies.	10 t	500 t	1000 t
Rubber products, e.g. tyres.	Liberation of pyrolysis oil, Use of water-endangering special extinguishing agent required.	5 t	25 t	50 t
Aliphatic plastics that contain only carbon, hydrogen, and oxygen, e.g. polyethylene, polypropylene.	Use of water-endangering special extinguishing agent required.	25 t	100 t	500 t
Plastics with halogens, nitrogen, sulphur, and/or aromatic components, e.g. polyvinyl chloride, polyamide, polystyrene.	Liberation of hydrochloric acid, hydrocyanic acid, hydrogen sulfide, perhaps dioxins / furans, use of water-endangering special extinguishing agent required.	10 t	50 t	200 t

Building materials	Possible consequences	low	medium	high
"Critical" building material, such as insulating material, wood preservatives, coatings. **Examples:**	Liberation of hazardous substances already contained in the building material or which can occur during a fire.			
PUR	Production of hydrocynic acid	10 t	50 t	200 t
PS	Production of PAH	10 t	50 t	200 t
PVC	Liberation of sulphuric acid; perhaps dioxins / furans	10 t	50 t	200 t
Coated, impregnated wooden building material.	Liberation of impregnating agents containing heavy metals; pollution of open water			

Table 3: Quantity limits of operating supplies and building material, which during a fire can liberate hazardous substances and/or lead to hazardous characteristics.

Please note: The quantity limits specified in this table are recommended values to evaluate the risk potential as defined in the present guidelines.

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A 2.4 Combustion Residues

Synthetic material (abbreviation)	CO, CO_2 (toxic / combustible)	HCl, HF (corrosive / toxic)	HCN (toxic / combustible)	PAH (toxic / combustible)	PHDD/ PHDF (toxic)	Highly sooty
PE	#					
PP	#					
PS	#			(#)		#
PVC (hard and soft)	#	##		(#)	(#)	
PU	#		##	(#)		
PA	#		##			
PC	#					
PTFE	#	##				
POM	#					
ABS	#		##			#
PETP	#			(#)		
PMMA	#					
PF	#					
UP	#					
SI	#					
Buna	#			(#)		#
Chlorinated rubber	#	##			(#)	

CO = carbon monoxide

CO_2 = carbon dioxide

HCl = hydrochloric acid

HF = hydrogen fluoride

HCN = hydrocyanic acid, hydrogen cyanide

PAH = polynuclear aromatic hydrocarbons

PCDD = polychlorinated dibenzo dioxins

PCDF = polychlorinated dibenzo furans

(#) Production of small quantity of the hazardous substance possible

Production of the hazardous substance highly probable

Production of large quantity of the hazardous substance to be expected

Table 4: Possible production of toxic or environmentally hazardous combustion residues from synthetic material (without additional material).

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A 3 Estimation of the Contaminated Extinguishing Water

Estimation of the quantity of contaminated extinguishing water V in these guidelines is based on the equation stated in Section 4: The parameters to be taken into account here are explained in Section 4 and below.

$$V = \{(A_{act} * SWL * BAF * BBF) + M \} / BSF$$

V [cub.m]:	calculated retention volume for contaminated extinguishing water
A_{act} [sqm]:	actual fire compartment area
SWL [cub.m/sqm]:	specific water output
BAF:	factor of fire compartment area (dimensionless)
BBF:	factor of fire load (dimensionless)
M [cub.m]:	quantity of all liquids for production, operation, and storage w or w/o WGK class in the respective fire compartment
BSF:	factor of fire protection (dimensionless)

V - calculated retention volume for contaminated extinguishing water
If the hazard and risk analysis results in the requirement of a retention of extinguishing water, the volume has to be determined with the above equation; however, the minimum retention volume of extinguishing water to be considered is 100 cubic metres.

A_{act} - actual fire compartment area
The actual fire compartment area corresponds to the respective fire compartment / fire-fighting area for which the quantity of contaminated extinguishing water is to be estimated.

The retention volume for the extinguishing water required in the establishment results from the estimation of the maximum quantity of contaminated extinguishing water expected for the worst case of the actual compartment area.

The fire compartment area is the sum of the entire used area aboveground and underground in square metres in one fire compartment. Horizontal separations of fire compartments between storeys above and under ground level can be considered in exceptional cases, only, provided that fire spread can be excluded certainly.

SWL - specific water output
It is assumed that with the specified extinguishing time a specific water output SWL is used within the fire compartment.

The specific water output SWL for the assumed extinguishing time of 240 min is:

SWL [cub.m/sqm] = 1.0 (l/sqm * min) * t * (1.0 cub.m/ 1000 l) = 0.24 cub.m/sqm (t = 240 min)

t - extinguishing time
For calculation of the contaminated extinguishing water to be retained, an extinguishing time of 240 min is assumed. This is based on the assumption that within this extinguishing time perhaps additionally occurring quantities of extinguishing water can be retained by mobile facilities for retention of extinguishing water or by other ones not belonging to the plant.

BAF - factor of fire compartment area
The analyses of loss events have shown that the quantity of extinguishing water [l/sqm * min] actually required decreases with an increasing fire compartment area. This is taken into account by the dimensionless factor of fire compartment area BAF, which can be calculated with the following equation:

$$BAF = 0.25 + (2500 / A_{act}) * (0.8 + A_{act} / 10000)$$

Fire compartment area [sqm]	Factor of fire compartment area BAF
up to 4,000	1.0
5,000	0.90
6,000	0.83
7,000	0.79
8,000	0.75
9,000	0.72
10,000	0.70
12,000	0.66
14,000	0.64
16,000	0.63
18,000	0.61
20,000	0.60

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Specification of the factor of fire compartment area is to be based on the actual fire compartment area A_{act}.

BBF - factor of fire load
For a "fire" event, the fire load is an important characteristic to be included in the assessment basis. In the present guidelines, the fire load is included in the dimensionless factor of fire load BBF resulting from the class of fire load BBK of the fire load q_R.

The following table shows exemplary fire load factors for very high down to very low fire load densities.

Factor of fire load BBF	Class of fire load BBK	Fire load q_R (kWh/sqm)	Comment
3.64	1	≥ 360	very high
1.67	2	250	high
1.03	3	160	increased
0.71	4	90	medium
0.53	5	40	low
0.42	6	≤ 10	very low

Table 5: Fire load factors for very high down to very low fire load density

If there are concrete fire load values q_R for individual fire compartments, the class of fire load BBK can be calculated with the following equation.

$BBK = 7 - (\sqrt{0.1\ sqm/kWh * q_R})$
q_R = fire load in kWh/sqm

Then the factor of fire load is calculated as follows:

$BBF = 4 / (BBK + 0.1 * BBK^2)$

If a fire load calculation does not exist, the class of fire load BBK can be determined by approximation allowing for the factor of utilisation of space RAF and the proportion of combustible matters (AbS)

q_R (kWh/sqm) = 600 kWh/sqm * RAF * AbS

The minimum fire load density is 15 kWh/sqm

q_R – fire load
The fire load in kWh per sqm results from addition of all combustible substances and materials existing in one fire compartment area.

As a guideline, Table 6 gives a list of the average fire loads for a choice of operating modes. These values are empiric knowledge gained with standardised operating modes. Therefore, take into consideration that there can be considerable deviations from such average values if the application deviates from the standard.

Operating mode	Fire load (kWh/sqm)
Bookbindery	280
Chemical industry	> 360
Printing plant	120
Manufacture of electrical equipment	130
Paints and varnish industry	480
Fodder production	450
Electroplating equipment	360
Foundries	25
Glass production	60
Production of rubberware	160
Production of batteries	120
Wood processing	180
Timber window manufacture	260
Coffee production	120
Production of candles	380
Car body pressing	50
Cold stores	450
Production of plastics	400
Recycling of plastics	450
Paint shop	110
PCB production	360
Metal processing	30
Waste bunker	300
Food processing	200
Oil / fat production	300
Paper / card board production	240
Plastic foam production	660
Particle-board production	210
Spirits production	200
Confectionery packing	240
Textile production	150
Brickworks	50

Table 6: Fire loads of a choice of operating modes in kWh/sqm

RAF – factor of utilisation of space
The factor of utilisation of space RAF allows by approximation for the different coverage densities with fire loads for a choice of operating modes.

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Factor of utilisation of space depending on the operating mode		Comment
High rack storage	1.0	> 7.5 m top of the storage
Rack storage	0.85	up to 7.5 m top of the storage
Storage warehouse / consignment store	0.7	
Production with compact coverage	0.5	
Production with little coverage	0.2	

Table 7: Factor of utilisation of space depending on the operating mode

AbS - Percentage of combustible matters
Factor AbS is the percentage of combustible matters in relation to the total quantity of substances.

Percentage of combustible matters	Factor	Comment
Percentage of combustible matters > 75 %	1.0	total
Percentage of combustible matters > 50 %	0.7	high
Percentage of combustible matters > 30 %	0.5	increased
Percentage of combustible matters > 10 %	0.3	medium
Percentage of combustible matters < 10 %	0.1	small

Table 8: Percentage of combustible matters.

M - Quantity of all liquids for production, operation, and storage
In the present guidelines, the quantity of substances of all liquids for production, operation, and storage in the respective fire compartment are included by addition in the volume of contaminated extinguishing water. Here shall apply the approximation: 1 t = 1 cub.m This is independent of a perhaps existing WGK since only the increase in retaining volume is decisive for any discharge.

If storage tanks do exist in fire compartments, these have to be taken into account for an estimation of the required volume of extinguishing water. For storage tanks above 100 cub.m, 100 % of the largest tank volume and 10 % of the rest are to be included into the quantity of contaminated extinguishing water.

BSF - factor of fire protection
The dimensionless factor of fire protection BSF is determined by the standard of fire protection applying to the fire compartment. It is taken for granted that the protective measures, such as

- public fire brigade,
- small extinguishing equipment (e.g. hand fire extinguisher, wall hydrants),
- alarm device (telephone, pushbutton),
- instructed personnel,
- sufficiently dimensioned extinguishing water supply

always do exist.

According to the possibilities of fire detection and fire fighting, a fire compartment area gets a fire protection standard ranging from BS 1 to BS 4. This can be taken to calculate the factor of fire protection as follows:

$$BSF = 0.85 * 1.4^{0.27 * BS * BS}$$

The four fire protection standards BS 1 to BS 4 result in the following factors of fire protection (BSF):

Concept	Fire protection standard BS	Factor of fire protection BSF
Structural concept No special fire call requirements	BS 1 = 1.0	0.93
Monitoring concept Automatic fire detection and fire alarm system with automatic alarm transmission to a permanently manned location of the public fire service; attendance time of fire brigade less than 10 min!	BS 2 = 2.0	1.22
Monitoring concept with factory fire service Automatic fire detection and fire alarm system with automatic alarm transmission to an always operationally factory fire service; attendance time of the factory fire service less than 3 - 5 min!	BS 3 = 3.0	1.93
Concept of extinguishing system Automatic extinguishing system with automatic alarm transmission to a permanently manned location of the fire service	BS 4 = 4.0	3.64

Table 9: Definition of fire protection standards

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A 4 Design Examples of Facilities for Retention of Extinguishing Water

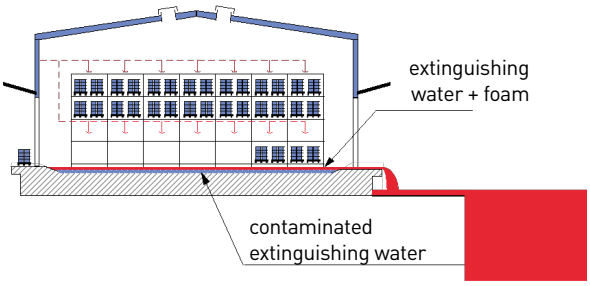
The present compilation shows examples for planning and installation of facilities for retention of extinguishing water.

Commentaries on each example with the most important advantages and disadvantages are given.

For reasons of clarity, the figures do not show fire protection facilities in detail.

This compilation makes no claim to be complete; it rather should be a suggestion to the operating party and the planner and present the user the best-selling retention systems.

Example A 4.1:
Retention of extinguishing water outside the building at a central location showing a natural slope



Advantages:
Hindrance to the firefighters by impounding extinguishing water can be excluded to a large extent.

Purification and cleanup work can be started immediately when the fire ground has cooled down. Proper reprocessing or disposal of contaminated extinguishing water has no effect on the downtime of the operating site.

Consequential damage by retained extinguishing water on the operating site is largely avoided.

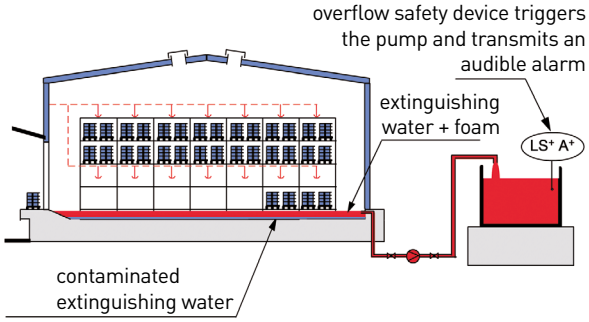
A central facility for retention of extinguishing water can be used independent of the fire compartment by all operational areas / facilities. Dimensioning of the volume of extinguishing water to be retained shall be based on the largest volume required for a fire compartment.

Thanks to the natural slope used to discharge the contaminated extinguishing water, a technologically elaborate pump system susceptible to faults can be omitted.

Disadvantages:
In order to drain off the extinguishing water, a permanently installed and appropriate pipework leading into a collecting basin / tank of sufficient dimension is to be provided. See to it that the drains keep their functionality even in case of fire and do not become blocked up.

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Example A 4.2:
Facility for retention of extinguishing water outside the building at a central location featuring a pump system



Advantages:
Hindrance to the firefighters by impounding extinguishing water can be excluded to a large extent.

Purification and cleanup work can be started immediately when the fire ground has cooled down. Proper reprocessing or disposal of contaminated extinguishing water has no effect on the downtime of the operating site.

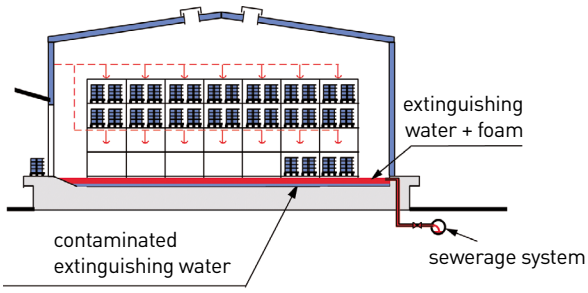
Consequential damage by retained extinguishing water on the operating site is largely avoided.

A central facility for retention of extinguishing water can be used independent of the fire compartment by all operational areas / facilities. Dimensioning of the volume of extinguishing water to be retained shall be based on the largest volume required for a fire compartment.

Disadvantages:
In order to drain off the extinguishing water, a permanently installed and appropriate pipework leading into a collecting basin / tank of sufficient dimension is to be provided.

Required pump systems have to be connected to reliable power supply.

Example A 4.3:
Facility for retention of extinguishing water outside the building (use of company-internal drainage system)



Advantages:
Hindrance to the firefighters by impounding extinguishing water can be excluded to a large extent.

Consequential damage by retained extinguishing water on the operating site is largely avoided.

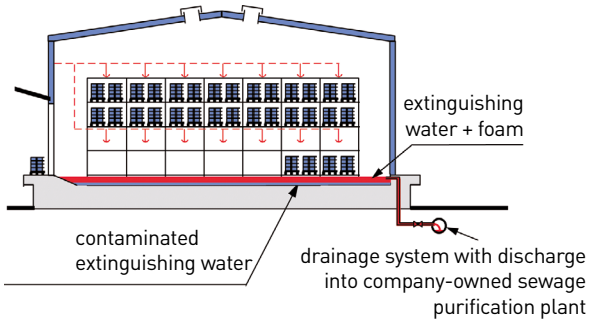
Disadvantages:
Elaborate purification and cleanup work of the drainage system are required. High requirements for durability and tightness of the sewer system. The tightness of older sewer systems not subject to monitoring cannot always be ensured.

The misuse of the sewer system could cause long-term operational outages even of the sections not affected by the fire.

Discharging of combustible liquids of the combustibility classes F1 and F2 involves an increased explosion hazard (take EX-protection measures).

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Example A 4.4:
Facility for retention of extinguishing water outside the building (use of company-internal drainage system for discharge into the company-owned sewage purification plant)



Advantages:
Hindrance to the firefighters by impounding extinguishing water can be excluded to a large extent.

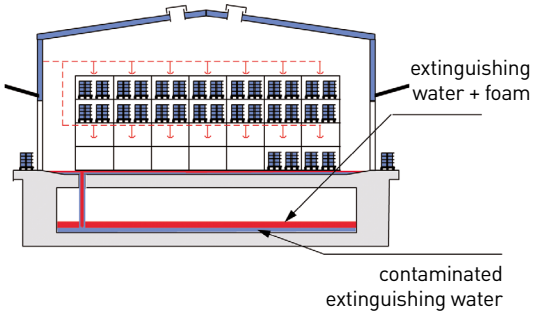
Purification and cleanup work can be started immediately when the fire ground has cooled down. Proper reprocessing or disposal of contaminated extinguishing water has no effect on the downtime of the operating site.

Consequential damage by retained extinguishing water on the operating site is largely avoided.

Disadvantages:
Purification and cleanup work of the drainage system are required. High requirements for durability and tightness of the sewer system. The tightness of older sewer systems not subject to monitoring cannot always be ensured. Observance of the requirements for sewage purification plants as defined in the German technical rules and regulations for water hazardous substances (TRwS) is mandatory.

Discharging of combustible liquids of the combustibility classes F1 and F2 involves an increased explosion hazard (take EX-protection measures).

Example A 4.5:
Facility for retention of extinguishing water in the basement under the building



Advantages:
Hindrance to the firefighters by impounding extinguishing water can be excluded to a large extent.

Purification and cleanup work can be started immediately upon cooling down of the fire ground provided that there is no hazard presented by the retained extinguishing water and the leaked liquids. Proper reprocessing or disposal of contaminated extinguishing water has no direct effect on the downtime of the operating site.

Consequential damage by retained extinguishing water on the operating site are largely avoided.

Disadvantages:
Underground rooms for retention of extinguishing water must not be used for equipment being of importance for the business.

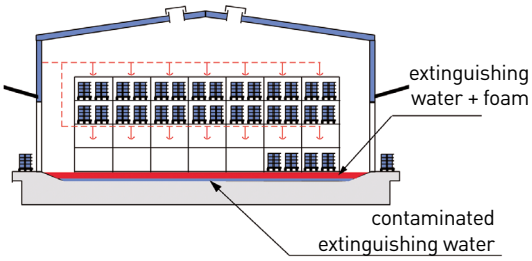
There are high requirements for the static construction and tightness of the basement to be met so as to prevent liberation of extinguishing water and damage to the building. Liberation of hazardous substances (e.g. by levitating tanks) must be avoided.

For a discharge of combustible liquids and substances that can produce combustible gases in contact with water, sufficient ventilation has to be provided and an automatic foam system is to be installed in the basement. Additional fire spread in the rooms in the basement shall be prevented. In case of toxic substances, appropriate measures to protect persons are to be taken.

Discharging of combustible liquids of the combustibility classes F1 and F2 involves an increased explosion hazard (take EX-protection measures).

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Example A 4.6:
Facility for retention of extinguishing water in the extended catch pit inside the building (by upturns)



Advantages:
Simple constructional realisation.

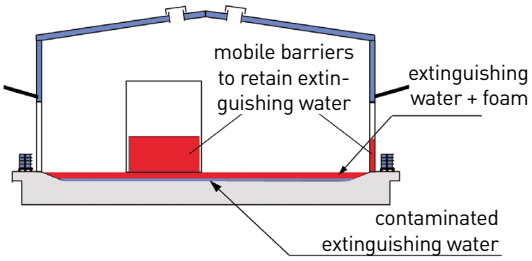
The retaining volume can be enlarged on the short term, e.g. by installing barricades or barriers in gateways and passageways, provided that floor and walls are sufficiently tight and media-proof.

Disadvantages:
The required upturns / thresholds can impair operational procedures.

In case of initial and partial fires, the collected extinguishing water hinders the firefighters in fighting the fire inside the building. Depending on the impounding height of the extinguishing water or foam, this can be so that an advance into the building becomes dangerous. Compartmentation of the retention of extinguishing water according to the storage sections or collecting the extinguishing water in a drainage systems may reduce this risk.

Rebuilding or repair of the operating site and the equipment can be started only when the extinguishing water will be pumped off. Depending on the possibilities in the establishment to provide for intermediate storage of the extinguishing water elsewhere or to properly reprocess or dispose of it on the spot, the period of downtime can be much longer.

Example A 4.7:
Facility for retention of extinguishing water in the extended catch pit inside the building (by barriers)



Advantages:
The retaining volume can be enlarged on the short term and without problems, e.g. by installing barricades or barriers in gateways and passageways, provided that floor and walls are sufficiently tight and media-proof.

Disadvantages:
In the case of fire, it is not ensured that the barriers actually are / can be installed / operated.

In case of initial and partial fires, the collected extinguishing water hinders the firefighters in fighting the fire inside the building. Depending on the impounding height of the extinguishing water or foam, this can be so that an advance into the building becomes dangerous. Compartmentation of the retention of extinguishing water according to the storage sections or collecting the extinguishing water in a drainage systems may reduce this risk.

Rebuilding or repair of the operating site and the equipment can be started only when the extinguishing water will be pumped off. Depending on the possibilities in the establishment to provide for intermediate storage of the extinguishing water elsewhere or to properly reprocess or dispose of it on the spot, the period of downtime can be much longer.

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