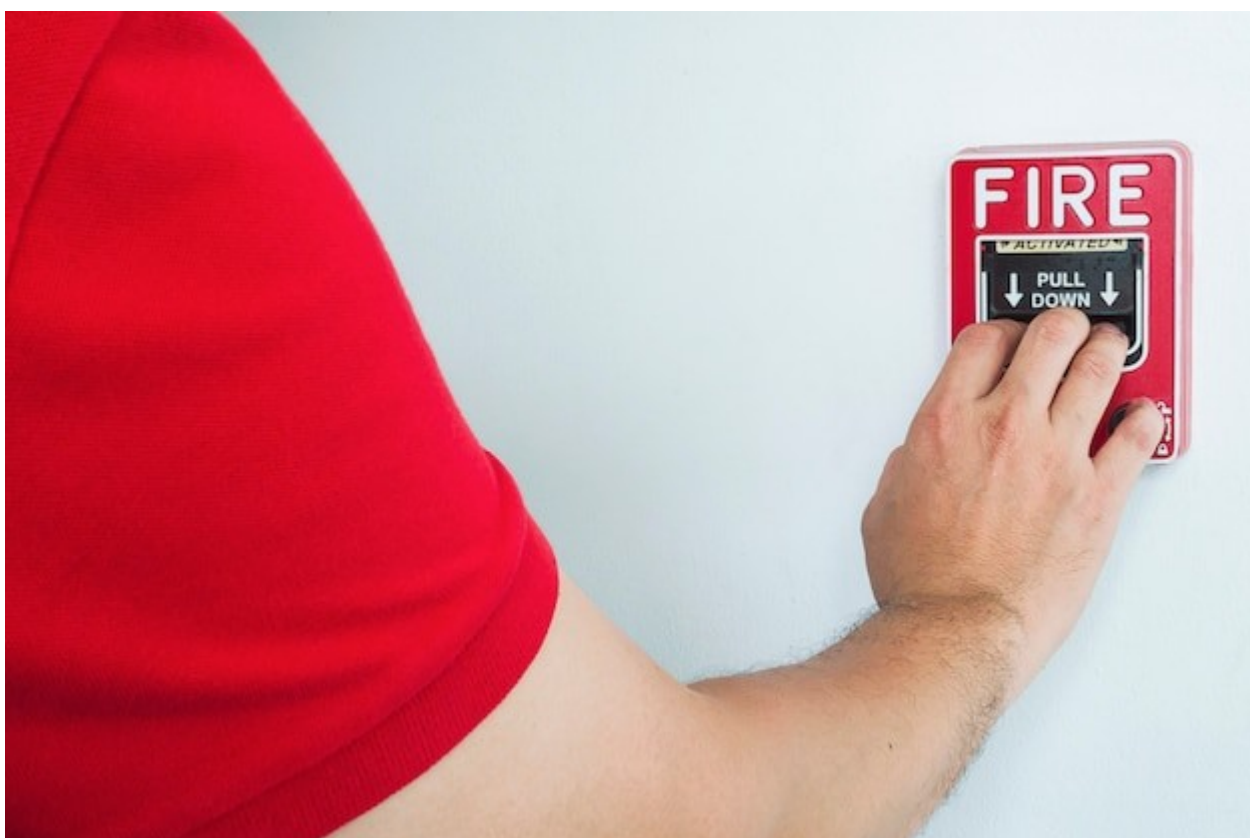




Guidance document for Selection of Fire Protection Systems

CFPA-E Guideline No 42:2024 F





The CFPA Europe develops and publishes common guidelines about fire safety, security, and natural hazards with the aim to achieve similar interpretation and to give examples of acceptable solutions, concepts, and models. The aim is to facilitate and support fire protection, security, and protection against natural hazards across Europe, and the whole world.

Today fire safety, security and protection against natural hazards form an integral part of a modern strategy for survival, sustainability, and competitiveness. Therefore, the market imposes new demands for quality.

These Guidelines are intended for all interested parties and the public. Interested parties includes plant owners, insurers, rescue services, consultants, safety companies and the like so that, in the course of their work, they may be able to help manage risk in society.

The Guidelines reflect best practice developed by the national members of CFPA Europe. Where these Guidelines and national requirements conflict, national requirements shall apply.

This Guideline has been compiled by the Fire Safety Commission and is adopted by the members of CFPA Europe.

More information: www.cfpa-e.eu



Zurich, June 2024
CFPA Europe

Elisabetta Carrea
Chairman

Cologne, June 2024
Fire Safety Commission

Hardy Rusch
Chairman

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Key words:

1 Introduction

Laying down protection and safety measures to suit the corresponding risks and with added consideration for economic factors, definitely requires an integral evaluation and decision process. Such a system is based on system-analytic safety methods, which considering risk acceptance and economic factors.

Determination of the protective and safety measures requires prior definition of the individual protection objectives. These have to provide for life safety, protection of property, and environmental protection.

For the technical protection measures, the existing guidelines for planning and installation should be observed. Selection takes place following the suitability of any selected measure to achieve the protection objective. The use of partial/local protection measures can make sense, especially if the matrix of ignition source and fire load is definitely not compatible. Also, sufficient separation (distance) of the protected facility from potential fire grounds should be taken into consideration. Structural separation of combinations of combustible material and ignition sources of a particular potential risk may reduce the overall risk for an area.

Escape routes shall be provided in all areas where life safety is a factor. These escape routes should not be put at risk by the fire, i.e. neither by heat nor smoke. The escape routes must be able to account for the numbers of people within the area of risk and must ensure that they can all leave the danger area in an adequately short time.

Technical fire protection in tall rooms shall allow for correct detection. Be aware, the corresponding fire characteristics which normal detection devices would recognise could be too weak to register when at a ceiling height greater than normal.

This guideline presents a general method of choosing protection measures, which are applicable to any risk. When implementing measures for a specific risk, a person shall comply with the corresponding technical guidelines applicable in the particular case. , e.g. fire protection systems. are normally the responsibility of those managing safety in companies. But this should also apply to designers, consultants, safety companies etc. so that, in the course of their work, they should be able to assist companies and organisations to minimize risks and possible fire damages in their businesses.

2 Scope

This guideline is applicable to any kind of fire related risk. For any fire related risk the required and appropriate equipment, policies, procedures and precautions can be taken to reduce the risk. That risk could be fire, explosion, smoke or any other where the corresponding rules and regulations apply.

3 Definitions

Comité Européen des Assurances (CEA): European Insurer Association, is called since 2012 „Insurance Europe“

Risk potential: Measure of the existing risk that jeopardises a protection objective

Risk: Product of the probability of occurrence of a fire event and the extent of loss to be expected

Risk acceptance: Measure of a risk that is acceptable to the operating party, the authority, or the insurer in view of the extent of loss to be expected

Protection measure: Measure to be taken to reduce the extent of loss

Safety measure: Measure to be taken to reduce the probability of loss occurrence

4 Procedure

Fire protection systems can reduce damage, providing they work in a reliable and effective manner. They are utilised to reduce the rate of increase of each risk once it has materialised. A proper procedure helps to identify risks in companies and then to mitigate those risks with appropriate protection measures.

4.1 General

The risk should be determined for the whole building or enterprise, so as to be able to define the priorities for the safety and protection measures. Further consideration of these measures should also take into account the financial implications, relative to the protection provided by them. Larger areas can be split into zones in which fires starting in one Zone would be unlikely to spread into another neighbouring zone, Zones can therefore be analysed separately, with a number of Zones making up an area or enterprise, with different risks and different safety and protection measures.

There are other reasons, why independent analysis of structurally or spatially separated areas is recommended for determining the risk by Zone. Examples of this are:

- Differing risk potentials, such as:
 - o Variety of distribution of fire load,
 - o highly flammable material present in some areas,
 - o variety of rate of Burn or combustibility of material in the different areas,
 - o variety of heat dissipation due to the quantity of material and the temperature of the combustion process.
 - o local ignition sources,
 - o ignition sources may be a temporary or permanent factor in the areas concerned.
 - o variety of distribution.
- a local concentration of material.
- A differing emphasis on business interruption (key processes),
 - o differing protection objectives ,life safety,
 - o protection of property,
 - o environmental protection.

Furthermore, any local area protection extinguishing systems may cover large areas, but should be considered as a protection system in each Zone that it covers. These Zones should be considered a Fire Compartment, and each should be evaluated

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individually. In this case, the loss expected according to Table 5-11, would be the worst case to be expected from all evaluations of the area being analysed.

The use of virtual sections as a basis for the evaluation requires verification of the actual sections for the effectiveness of their fire protection

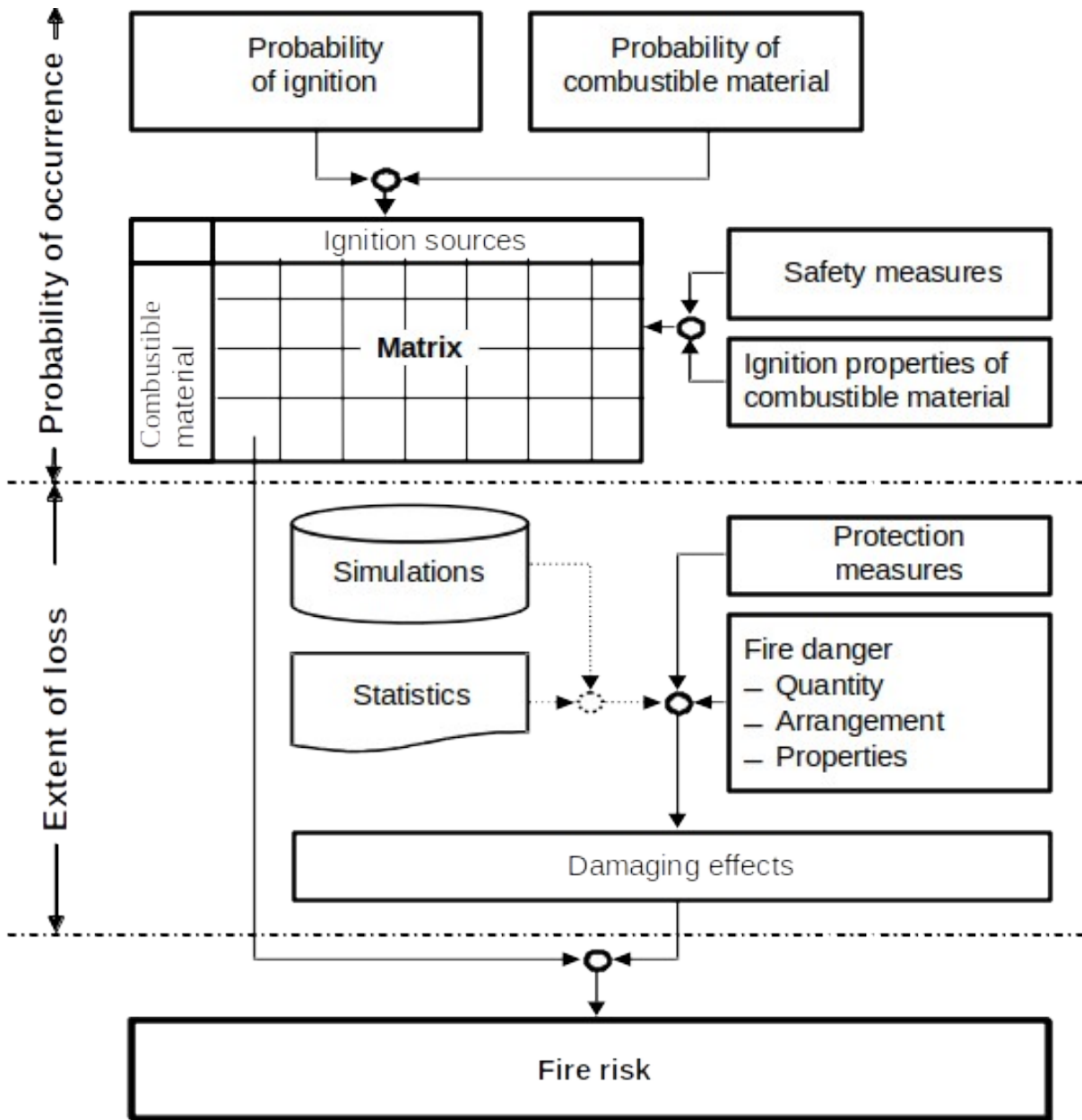


Figure 1: Connections in an analysis of the fire risk

Taking these connections together, the result is a well-structured means of processing the analysis of a fire risk. This process is shown in the flow chart in Figure 2.

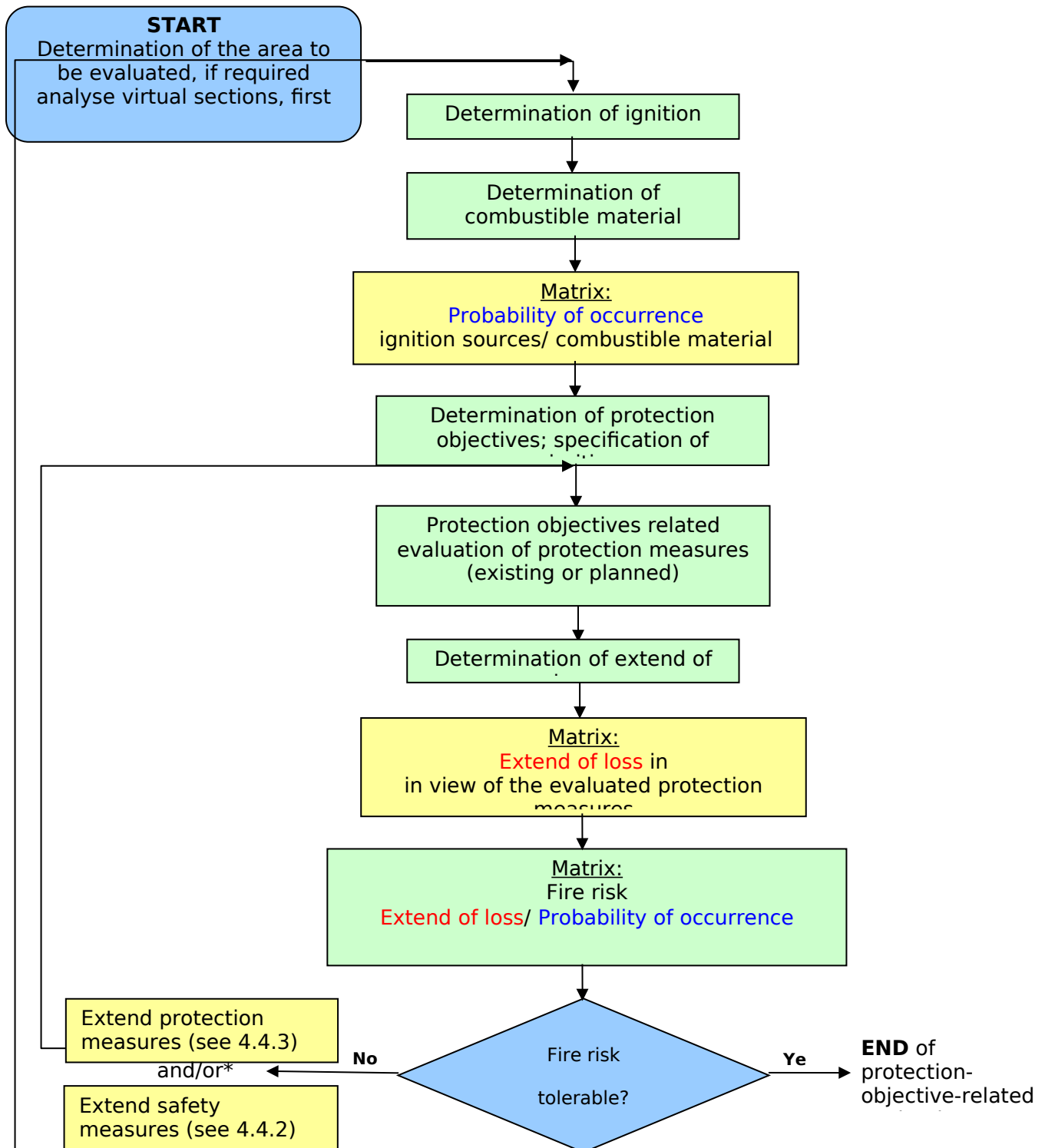


Figure 2: Overview of the process of determining fire risk.

*Note: Should the fire risk not be tolerable in spite of an extension of the protection measures, the safety measures should be extended with a re-evaluation

4.2 Determination of risk potential

The determination of risk potential is based on the degree of the simultaneous occurrence of ignition source and the presence and quality of combustible material. The probability of a fire can be determined (see Figure 1) by linking the probability of an effective ignition source with that of a combustible material. Taking into account particular operational safety measures or extremely adverse ignition properties of the combustible material. The probabilities are classified according to their frequency of occurrence (4 classes) and can be assigned to the risk as shown in the examples and descriptions below.

Ignition sources

The ignition sources in the area to be analysed shall be defined. Table 1 classifies different ignition sources, each related to its probability.

	Description of potential ignition sources	Examples
Permanently	These are operational ignition sources, which exist during normal operation of the machine (latently) and are not protected	Welding, open flame, hot surfaces (e.g. due to friction), hazardous chemical reactions
Often	Ignition sources that are due to the failure of insufficiently trained persons or due to frequent (almost regular) malfunctions during normal operation	Smoking, use of private electrical appliances on the premises, improper handling of work equipment, missing maintenance, electrical ignition source by insufficiently serviced equipment, arson in unprotected objects
Occasionally	Ignition sources that are due to malfunction of protected equipment during normal operation, e.g. due to human failure even by especially trained persons	Here, attention shall be paid to a potential "organisational blindness" - falling into daily routine", caused by technical malfunction, e.g. failure of a non-redundant coolant supply; arson in protected objects
Rarely	Rare malfunction; failure of automatic and safe separations and/or of redundant systems or of a fail-safe system*	Ignition sources that could occur during maintenance work for instance
* Note: A fail-safe system will automatically change into the safe process condition when deviating from the desired condition.		

Table 1: Probability of ignition sources

If two independent ignition sources are present which together lead to a hazard, the probability of occurrence shall be determined according to Table 2. If the probabilities of occurrence of three or more ignition sources are to be determined, the substances

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are to be linked in the order of their quantitative occurrence, starting with the smallest quantity of ignition source substance first. Combustible materials present in larger quantities can be defined according to their hazard potential.

Fault A	Fault B	Permanently	Often	Occasionally	Rarely
Permanently		Permanently	Often	Occasionally	Rarely
Often		Often	Often	Occasionally	Rarely
Occasionally		Occasionally	Occasionally	Rarely	Rarely
Rarely		Rarely	Rarely	Rarely	Rarely

Table 2: Combination of different probabilities of ignition sources

Combustible materials

Table 3 should be used to determine the occurrence probability of the combustible material. All combustible materials should be taken into account. The material property characterising ignitability is also subject to evaluation. This provides for an accurate definition of how effective any potential ignitions source is.

The evaluation should be based on the fact that the ignition source is able to ignite the combustible material.

	Description of potential combustible material	Examples
Permanently, long-term	The combustible material exists in a combustible condition during normal operation in the respective area	Warehouses, operational production with combustible materials
Often	The combustible material often is in the ignitable condition and/or is taken out of its enclosure	Transfer processes, time limited intermediate storage belonging to the operational sequence, failure of insufficiently trained persons
Occasionally	Due to a deviation from normal operation, the combustible material in the respective area can become ignitable, technical malfunction of unsafe enclosures, failure even of especially trained persons	Leakage of atmospheric containers, cleaning work
Rarely	In the respective area, the combustible material occurs only in case of rare malfunctions or rare maintenance work; a combustible material can occur in its ignitable condition only in case of a combination of several malfunctions; automatic and safe separations and/or redundant systems fail or a fail-safe system fails*	Leakage of double-wall containers, automatic shutdown procedures in case of deviation from the desired condition
* Note: A fail-safe system will automatically change into the safe process condition when deviating from the desired condition		

Table 3: Probabilities of occurrence of combustible materials

If two different combustible materials exist [Table 3], which would be considered a hazard when combined, their occurrence probability shall be determined by reference to Table 4. If the occurrence probabilities of three or more combustible materials are to be determined, the materials shall be linked in the order of their quantitative occurrence, starting with the smallest quantity. This means that any combustible materials present in larger quantities can be accurately evaluated according to their hazard potential.

In companies that possess a high technical and organisational safety standard the probability of human failure resulting from Table 1 and Table 3 can be further reduced by one degree (e.g. from often to occasionally). A higher safety standard can be reached, by any company maintaining standards, for example: by ensuring that transfers of highly flammable materials are carried out exclusively by trained and competent personnel.

Combustible material B	Permanently	Often	Occasionally	Rarely
Combustible				

material A				
Permanently	Permanently	Often	Occasionally	Rarely
Often	Often	Often	Occasionally	Rarely
Occasionally	Occasionally	Occasionally	Rarely	Rarely
Rarely	Rarely	Rarely	Rarely	Rarely

Table 4: Combination of different probabilities of combustible materials

Ignitability of material and the distribution of them should be evaluated to focus the analysis of structurally or spatially separated areas. (see Figure 1, fire danger). To this end, the classification system of the CEA (Comité Européen des Assurances), may be used. For examples of the ignitability of matters, refer to Table 5.

Matters of hazard code F1 (highly flammable), AF (self-ignitable), and HF (matters developing combustible gases upon contact with water) require special safety measures, which do not necessarily result from the evaluation of materials of hazard codes F2 through F5 proposed in the present guidance document. In this case the evaluation should be done particularly carefully.

For the assessment of the effectiveness of an ignition source , the actual condition of the respective material (such as heat, pressure, physical condition) should be taken into consideration.

Hazard codes	Solid material	Liquid	Gas
F1	Highly flammable and extremely speedy burning down (not included in CEA, fine dusts explode!)	Flash point < 21 °C, e.g.: alcohol (>70 %), methylated spirit, benzene, eau de Cologne, etc.	Combustible, e.g. natural gas, methane, hydrogen sulphide, etc.
F2	Ignitable and speedy burning down, e.g. wood wool (loose), shoe polish, etc.	Flash point 21 °C to 55 °C e.g. vinegar essence, white spirit, kerosene, xylene, etc.	
F3	Highly combustible, e.g. cotton, paper (loose), sulphur, steel wool (fine), cereals, etc.	Flash point > 55 °C to 100 °C, e.g. diesel fuel, formaldehyde solution (5 - 25 %), nitrobenzene, etc.	
F4	Moderately combustible, e.g. candles, butter, charcoal, paper (cramped), PU, PP, tyres, etc.	Flash point >100 °C, e.g. liver oil, glycerine, vegetable oils, ethylene alcohol, linseed oil, etc.	
F5	Not easily combustible (only with support fire), e.g. lindane, PVC (hard), soap, etc.	Not easily combustible (no flash point, only with support fire), e.g. chloroform, trichloroethylene, etc.	Not easily combustible, e.g. Halon 1211, Halon 1301, etc.
F6	Non-combustible, e.g. plaster, iron, quartz, etc.	Non-combustible, e.g. mercury, hydrochloric acid, etc.	
AF1	Self-ignitable even in small quantities (in contact with water, too), e.g. sodium, phosphorus (yellow or white), silanes (solid), etc.		
AF2	Self-ignitable only in large quantities or in special circumstances (in contact with water, too), e.g. linseed oil (finely distributed on organic substances), guano, malze grit, etc.		
HF	Matters that develop combustible gases upon contact with water (all hazard group 2, unless also self-ignitable (hazard code AF)), e.g. carbide, radium, etc.		

Table 5: Hazard codes according to CEA, examples of ignitability

Combination of both probabilities of existence results in a matrix, which assists in the evaluation of any combination of probabilities of the existence of combustible materials and ignition sources in a particular area. This makes it easier to determine the individual areas and the potential risk in determining the highest risk potential and therefore, the highest probability of occurring.

Combustible material	Permanently	Often	Occasionally	Rarely
Ignition source				
Permanently	Permanently	Often	Occasionally	Rarely
Often	Often	Often	Occasionally	Rarely
Occasionally	Occasionally	Occasionally	Rarely	Rarely
Rarely	Rarely	Rarely	Rarely	Rarely

Table 6: Probabilities of occurrence as a function of the probability of existence

The matrix of Table 6 should be used for each area to be evaluated, and this process should also be used for those areas with protection, detection or suppression equipment present.

NOTE: Also see Annex 1, clause 1.1

4.3 Protection objectives

The analysis of the potential extent of damage shall not only take into account the material damage, including business interruption, but also the potential loss of reputation, that the company may have enjoyed until the event. Damage that occurs in the immediate neighbourhood of the organisation particularly contributes to this (see Annex 2, clause 2.1, assessment of technical equipment in view of the protection objectives).

To begin with the individual protection objectives are derived from the potential extent of damage that can be estimated in advance. Damage to be avoided must be included in the protection objectives to be achieved. The protection objectives are therefore divided into: life safety, protection of property and environment.

Life safety

For life safety the groups of persons and the number of persons normally present in the area shall be considered:

- Persons not knowing the local area , e.g. hotel guests, customers, visitors of companies, etc..
- Persons knowing the place, e.g. operating personnel, pupils in local school, etc..

Protection of property

For the protection of property, all material damage resulting from the loss of buildings, facilities, stored goods/materials and business interruption should be considered. The analysis of business interruption should take into account any other operations/production areas that may be affected by a failure in the area of concern. Any loss of reputation or standing could result in a loss of customers and, consequently, cause considerable business damage, too.

In addition to purely material damage, non-material values should also be taken into account, such as the destruction of irretrievable cultural assets and the resulting loss of reputation.

Therefore, the following should all be considered:

- Business interruption,
- damage to buildings, loss of buildings,
- loss of furnishing and equipment, inventory, stored goods, data,
- damage to cultural assets.

Environmental protection

Regarding environmental protection the

- combustion residues/smoke,
- contaminated extinguishing water,
- properties of the extinguishing agent

should be analysed according to their potentially damaging effects in the company location and in the neighbourhood. This results in suggesting measures for clearing-up and disposal, which again cause material damage and perhaps even loss of reputation

Evaluation of the protection objectives

In a first step of evaluation, the protection objectives of the areas in question should all be evaluated. Having completed this evaluation, priorities can be assigned to the protection objectives, which help to clarify the importance of the overall protection concept. However, Life safety and the environmental protection measures required by law shall be fulfilled in all cases, regardless of the priorities.

Based on the previous explanations, an evaluation can be made according to Table 7

	Very high	High	Normal
Life safety	Many outsiders not knowing the place are present frequently (e.g. guests, customers)	Normally few outsiders are present (e.g. visitors in a company)	Normally few persons are rarely present (e.g. warehouse)
Protection of property	Cultural assets exist; extremely high concentration of values on little space; areas of high impact regarding business interruptions	High values homogeneously distributed over the entire area	Low concentration of values or low susceptibility to the impacts of fire in the respective area
Environmental protection	Sensitive neighbourhood (e.g. hospital, conservation area)	Special requirements due to past and/or potential damage or conflicts with neighbourhood or authorities	Objects to which the priorities “very high” and “high” to not apply

Table 7: Priorities of protection objectives (without consideration of specific fire loads)

In this example, the properties of the fire load are not taken into consideration for defining any priority of the protection objectives. Should such fire load properties exist and have any effect, they will be included in the evaluation.

Evaluations in connection with protection objectives of high priority shall override those with protection objectives of lower priority. Furthermore, the relevance analysis according to Table 8 should take account of the priorities.

4.4 Measures

Reduction of fire risk

Measures aiming at the reduction of the fire risk can

- as safety measures reduce the probability of occurrence of combustible material or ignition sources or
- as protection measures reduce the extent of loss

Safety measures

As safety measures, process-related changes are possible, e.g.:

- reduce the flammability of the material
- replace combustible material by non-combustible material,
- avoid effective ignition sources,
- improve the enclosure of ignition sources,
- reduce the opportunity to release combustible materials.

Since these measures require changes in operational techniques and/or operational sequences, correspondingly skilled experts should be involved.

If adequate effective safety measures regarding the ignition sources and combustible materials have been taken, the probability of the likely occurrence of a fire according to Table 6, can be reduced by one level. The most effective Safety measures in this case are machinery monitoring systems that have the ability to switch off machinery prior to any ignition.

Protection measures

Protection measures are based on the assumption that if a fire occurs these measures will reduce the damage. Protection measures can be:

- Extinguishing systems
- Detection systems together with the possibility of quick intervention
- Smoke and heat ventilation systems
- Structural measures taken to reduce the maximum area that can be affected by a fire
- Specific protection for specific hazards
- Specific adjustment of the system technology to the risks based on the size of each area

The suitability of a protection measure should be assessed on the basis of the probable fire scenario and on whether the protection objective is achieved by a particular protection measure. For details in this regard and for possible combinations of system types, refer to Annex 2. The following items should be considered:

1. Firefighting should start promptly

The suitability of the extinguishing agent is fundamentally important. It must be based on the anticipated fire development and the specific requirements of the protection objectives. The extinguishing agent should be evaluated as to whether any possible damage is considered tolerable in order to put out the fire.

2. Detection shall be suitable and prompt

Detection does not only cover the detection of fire it could also include monitoring of the machinery/plant to detect faulty operating conditions or larger than normal quantities of materials. A detection system should be appropriate for any area in which it is placed, to be able to detect promptly, reliably and accurately, and it should be as free as possible from the likelihood of false alarms. A single detection system alone is unlikely to be sufficient to implement an entire protection concept.

Whether an extinguishing system with an automatic alarm transmission to a fire service or a permanently manned location is required, or whether an alarm transmission to the fire service and another active system, for instance a semi-stationary extinguishing system is required shall be determined by this process, taking into account the defined protection objective, the anticipated fire development and the intervention time.

3. Other protection objectives examined and possible protection measures put in place.

In addition to the protection objectives defined within the scope of this risk analysis, further operational requirements shall be examined. The different protection measures shall be evaluated as to whether:

- other protection objectives are examined, i.e. whether for instance a smoke and heat exhaust ventilation system, which could affect the function of a protection measure, is required for life safety,
- measures to prevent intrusion are examined by the concepts of escape routes (locking vs. opening of the building)
- Any operational sequences that are significantly impaired.
- Any structural measures that are required for operating processes, (e.g. dome lights) which should meet the requirements of the protection measures.

4. Investments

It should be investigated as to whether any local protection measures can be used to achieve the protection objective (local application protection) or whether this has to be achieved on a step by step basis. Special attention should be given to facilities/areas of high-risk potential, of high values, of particular importance for life safety or for business interruption.

For extinguishing systems, fire detection and fire alarm systems, as well as smoke and heat exhaust ventilation systems, the instructions for planning and installation of these systems should be observed. These should also describe fields of operation and limits of application and, therefore help to rate the suitability of a system to achieve a protection objective.

The measures should be based on the risk potential and should aim at achieving the protection objectives. The possible measures for each combination of risk potential and protection objective should be prioritised. This ranking is based on the effectiveness and costs of the measure in question. The appropriate measure for the

whole area will be that of the highest priority for the combinations of risk potential and protection objectives.

If it is impossible for economic reasons to take measures for all risk potentials, those of the highest priority should be implemented first.

The flow chart in Figure 3 shows how to define measures. The evaluation shall be done for all protection objectives. A result will be the input variable “protection measures” of Table 11.

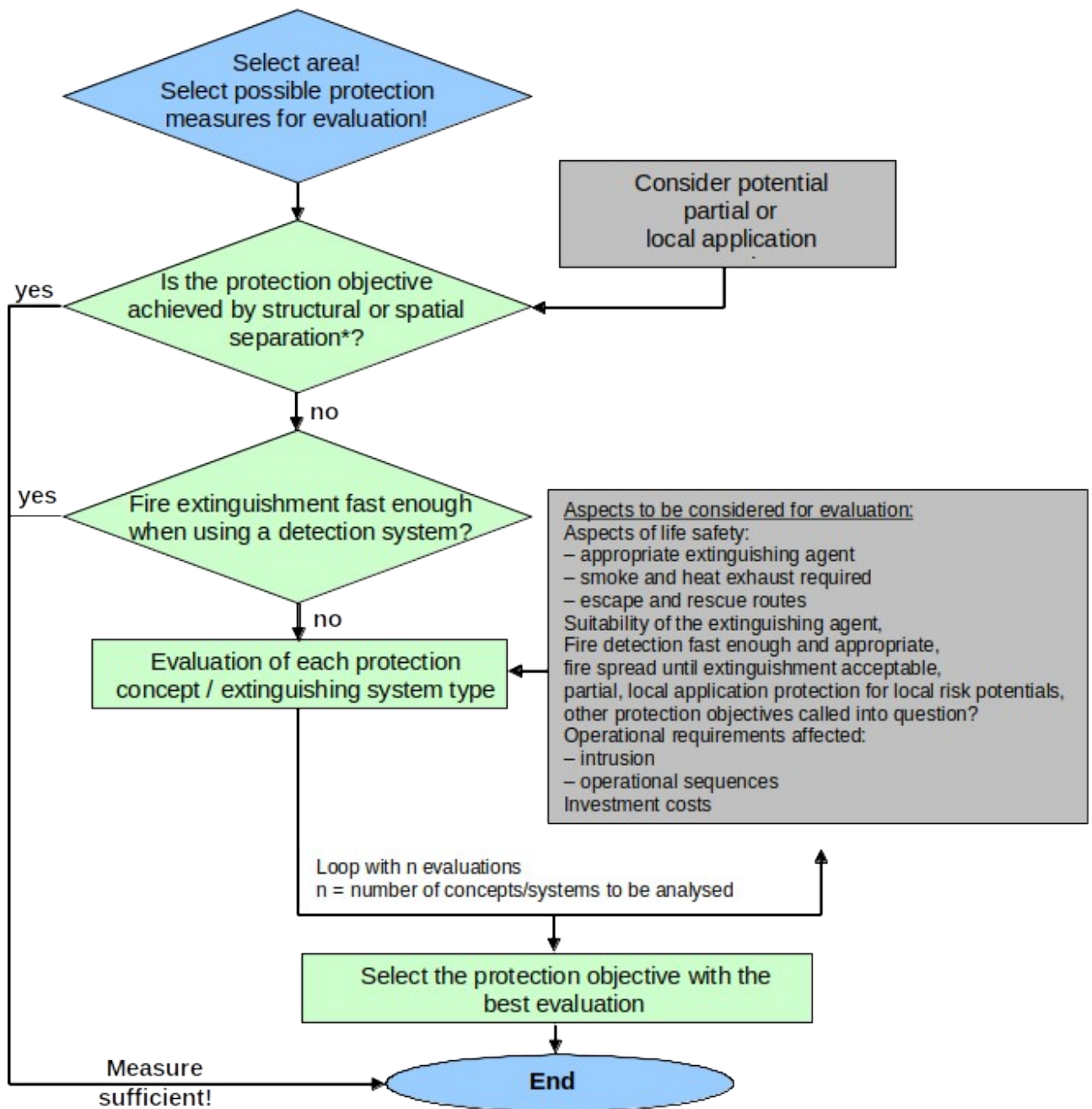


Figure 3: Example of how to specify the protection measures

* Note: "structural or spatial separations" means all types of separation of ignition sources from combustible material. They do not necessarily correspond to the conventional fire protection separation as defined by the assessment of the analysed areas.

The detailed risk-specific evaluation of protection measures to achieve the different protection objectives can be made with the assistance of Table 8.

Explanations to Table 8:

For an evaluation of the protection measures of the area in question, the protection objectives and the respective importance of individual aspects shall be taken into account. Therefore, in column "Relevance" the importance of the aspect in question for the protection objectives, i.e. 1 = irrelevant, 2 = neutral, and 3 = relevant are to be defined.

Lines 1, 7, 8, 13: The extinguishing agent is appropriate for fire-fighting; it does neither put life safety, property, or the environment at risk (e.g. NA + H₂O), nor does it cause any consequential loss (e.g. dry powder use causes damage to electrical systems/components).

Lines 2, 9, 14: Fire smoke is vented/reduced to a degree sufficient to achieve the protection objective.

Line 3: Usability of routes is maintained by a corresponding measure.

Lines 4, 10, 15: Detection allows for sufficiently prompt warning and/or taking action to achieve the protection objectives.

Lines 5, 11, 16: The measure required to achieve the corresponding protection objective allows minimum fire spread.

Line 6: The measure does not affect evacuation.

Line 12: Here local application protection, has to be considered e.g. of machines/components

Line 17: Achieving a protection objective should not adversely affect any measures taken to achieve a parallel protection objective.

Lines 18, 19: No mandatory criteria to be considered; hint at potential problems when taking necessary measures without any relevance for risk analysis.

General note:

E.g., the following symbols can be used for evaluation. They mean:

o = neutral aspect

+ = aspect realised by technical protection measure

- = aspect cannot be realised by this measure or measure does not exist

x = aspect not applicable

Aspects for protection objectives	⇒ Relevance ⇐	Protection measures, e.g.								
		Sprinkler	Water spray	Water mist	Gas	Foam	Powder	Aerosol	FDAS ¹⁾	SHEVS
Life safety										
1 Appropriate extinguishing agent										
2 Reduction/venting of smoke										
3 Escape/rescue routes										
4 Detection of fire fast enough										
5 Fire spread acceptable until extinguishment										
6 Evacuation (self-evacuation or by fire brigade) possible										
Protection of property										
7 Appropriate extinguishing agent										
8 Extinguishing agents do not put the goods to be protected at risk										
9 Reduction/venting of smoke										
10 Detection of fire fast enough										
11 Fire spread acceptable until extinguishment										
12 Sufficient local protection (e.g. for machines)										
Environmental protection										
13 Appropriate extinguishing agent										
14 Reduction/venting of smoke										
15 Detection of fire fast enough										
16 Fire spread acceptable until extinguishment										
General										
17 Other protection objectives called into question										
18 Operational requirements affected										
19 Investments										
<i>¹⁾ Note: With manual firefighting; the fire detection and fire alarm system shall be considered in view of a potential intervention</i>										

Table 8: Risk-specific evaluation of the protection measures in view of the protection objective

Conclusive evaluation and combination of protection measures:

The conclusive evaluation of protection measures taken in one area should be made separately for each protection objective. Upon subsequent application of Table 9, it should finally result in specification of the input variable “protection measures” of Table 11. It should be made column by column with reference to the system technology and the protection objective as described below:

- At least one aspect of relevance „3“ evaluated at (-):
⇒ protection measure with no or minor effect
- No aspect evaluated at (-) irrespective of the relevance:
⇒ protection measure with normal effect
- None of the aspects of relevance „2“ or „3“ evaluated at (-) and more than 50 % of the aspects of relevance “3” evaluated at (+):
⇒ protection measure with high effect
- All aspects of relevance „2“ or „3“ evaluated at (+) and all aspects of relevance “3” without (x):
⇒ protection measure with maximum effect

For the evaluation of protection measures of an area subject to analysis, any combination of measures (e.g. sprinkler system with SHEVS) to achieve a protection objective in consideration and avoidance of adverse effects is generally possible. (for possible adverse effects of protection measures see Annex 2.2.2). In this case, evaluation of the individual columns shall be combined logically, such as: “not applicable” (x) for SHEVS and “realised by technical protection measure” (+) for sprinklers results in the sum “realised by technical protection measure” (+).

Subsequent to the protection-objective-related individual evaluations of protection measures or combinations thereof (see Table 8) based on predefined aspects, the next step is the combination of this evaluation made for each protection objective. The safety measures of Table 5-8 evaluated as “maximum”, “high”, “normal”, or “minor” to achieve the different protection objectives shall be assigned to different topics in Table 9. The table based evaluation shall be made for existing measures first and then repeated – where required – with additional protection measures until this results in compliance with, or achievement of, the specified protection objectives.

If all evaluations of measures focused at compliance with the protection objectives that have been made and combined according to Table 8 can be assigned to the “green area” in Table 9, the protection measures and, consequently, the safety level of the analysed building area shall be evaluated at “maximum” taken as a whole.

If one protection objective is not evaluated so as to reach the “green area” but is in the “red area”, the protection measures shall be evaluated at “high” taken as a whole.

If the safety level of two protection objectives is in the “red area” and of one protection objective is in the “green area” of Table 9, the protection measures shall be evaluated at “normal” as a whole.

If no protection objective reaches the “green area of the table, the protection measures shall be evaluated at “minor” as a whole.

	Evaluated protection measures			
	Maximum effect, acc. to evaluation of Table 8	High effect acc. to evaluation of Table 8	Normal effect acc. to evaluation of Table 8	Minor effect acc. to evaluation of Table 8
Life safety				
Protection of property				
Environmental protection				

Table 9: Combination of evaluated protection measures of different protection objectives

As a result of such combination the input variable “protection measures” of Table 9 shall be used for Table 11.

For buildings and areas where life safety is no protection objective (e.g. high rack storage etc.) or where only one protection objective is to be evaluated, a modification of the evaluation model of Table 9 should be agreed.

4.5 Extent of loss

The extent of loss depends on the combustion properties, the distribution, and the quantity of combustible materials. The extent of loss is further affected by type, position, and use of the building or the area to be analysed. Industrial premises in close vicinity to residential buildings could require a different evaluation than industrial premises in the open countryside. First, potentially damaging effects of existing combustible material in the area to be analysed should be determined. Thereupon, Table 10 shall be used to evaluate the extent of possible loss. This could include individual protection objectives. To find out the actual risks, the evaluation at first should not allow for existing or planned protection measures according to clause 4.4.2 or any optimisation in this respect.

Note: In order to determine the extent of loss, the fire development and its damaging effects should be estimated. For example, the release of toxic and corrosive matters and the effect of heat radiation shall be taken into particular account. Doing so, the results of reputable simulation calculations, experience gained in fire tests, as well as statistical data may be used. Already existing protection measures as described in clause 4.4.2 shall be taken into account in a second step.

The identification of harmful combustion residues can be carried out using the classification system of the CEA.

The procedures to determine the extent of loss are given in detail in Annex 1, clause 1.2..

	Description	Examples
Maximum	<p>The fire event causes</p> <ul style="list-style-type: none"> - total loss of the respective area (building, equipment, data, customers, reputation), and - personal injury, and - environmental damage. 	<p>Large quantities of combustible materials¹ exist; arrangement and properties of combustible materials promote the fire development; the combustion residues of combustible materials are particularly harmful to humans, environment, and building; the building infrastructure as to fire protection could extremely hinder evacuation and fire fighting and causes environmental damage in case of fire.</p>
High	<p>The fire event causes</p> <ul style="list-style-type: none"> - loss of e.g. the building, the equipment, or - extreme loss of reputation, or - personal injury, or - environmental damage. <p>Conclusion:</p> <ul style="list-style-type: none"> - The fire event causes a long-term business interruption. - Decontamination of the building is just about possible. 	<p>Large quantities of combustible materials do not exist; arrangement and properties of combustible materials do not significantly promote the fire development; the quantity of harmful combustion residues of combustible materials is neither particularly high, nor particularly harmful to humans, environment, and building; the building infrastructure as to fire protection does neither extremely hinder evacuation or fire fighting, nor does it promote environmental damage.</p>
Normal	<p>The fire event causes</p> <ul style="list-style-type: none"> - partial damage within the respective area, e.g. to the building and/or the equipment, and - little loss of reputation, and - little personal injury and/or environmental damage. <p>Conclusion:</p> <ul style="list-style-type: none"> - The fire event causes short-term business interruption. - Decontamination of the building is possible without any problems. 	<p>A limited quantity of combustible materials exists; effective fire protection enclosures exist; combustion residues harmful to humans, environment, and building develop to a minor degree only; the infrastructure of the building in view of fire protection provides for controlled evacuation and effective fire fighting; the environmental damage is limited to e.g. an unavoidable degree of air pollution; infiltration of contaminated extinguishing water is prevented.</p>
Minor	<p>The fire event causes</p> <ul style="list-style-type: none"> - Minor damage which is scarcely noticeable in the normal course of operations, or - adverse effects within the respective area, e.g. damage to the building, or - to the equipment, to data bases, etc. <p>Conclusion:</p> <ul style="list-style-type: none"> - The fire event does not cause any considerable business interruption. - Decontamination of the building is not necessary. 	<p>Only very small quantities of combustible materials exist; harmful combustion residues develop to a minor degree at limited spots of ground; e.g., large structural measures prevent fire spread and/or combustion residues.</p>

¹⁾ *Note: Combustible materials are materials considered to be at least normally flammable (B2 according to DIN 4102). For materials of the hazard codes F1, AF, and HF according to CEA (cf. Table 5), particular safety measures shall be observed!*

Table 10: Evaluation of the anticipated extent of loss without protection measures

In the next step, the protection measures evaluated using Table 9 should be taken to achieve the specified protection objectives and are linked to the expected extent of loss according to Table 10.

This results in a matrix shown in Table 11, in which each combination of protection measures taken or planned, and the corresponding expected extent of loss, is converted into the extent of loss to be actually expected. This result shall be used in Table 12 as an input variable for the "extent of loss". Furthermore, it may be concluded as to the degree the protection measures will influence the extent of loss. If the result is an extent of loss evaluated at "minor", it can be assumed that there is optimal plant fire protection for the area under consideration.

Protection measures	Minor	Normal	High	Maximum
Extent of loss*				
Maximum	Maximum	High	Normal	Minor
High	High	High	Normal	Minor
Normal	Normal	Normal	Minor	Minor
Minor	Minor	Minor	Minor	Minor
* without protection measures				

Table 11: Anticipated extent of loss in view of the evaluated protection measures

The matrix shall be applied in conjunction with Table 6 for each area to be analysed (see clause 4.2) as well as to the local application procedure.

4.6 Determination of fire risk

As a final step, for the evaluation of the fire risk, the probability of occurrence of a fire event re-presented in Table 6 shall be linked with the expected extent of loss represented in Table 11. The resulting matrix can now be used to evaluate the risk of each combination of input parameters for each area subject to analysis with effective fire protection separation. Therefore it is easy to determine resulting and/or existing main risks and, therefore, unsafe areas relating to fire protection.

Probability of occurrence	Permanantly	Often	Occasionally	Rarely
Extend of loss				
Maximum	not acceptable		high	acceptable
High	not acceptable		high	acceptable
Normal	high	high	acceptable	Akzeptabel
Minor	acceptable	acceptable	acceptable	Akzeptabel

Table 12: Evaluation of the fire risk with consideration of the protection measures

Annex 1: Probability and extent of loss

Annex 1.1 Probabilities

The specialist literature below gives more detailed information on the probability of ignition sources and combustible materials:

- Lees, F. P., 1980, Loss prevention in the process industries, Butterworth-Heinemann, Oxford
- Gesellschaft für Reaktorsicherheit (GRS), Juni 1989, Deutsche Risikostudie Kernkraftwerke Phase B. – GRS-A-1600, Köln

Annex 1.2 Extent of loss

Annex 1.2.1 Combustion residues

For a determination of the possible extent of loss, the heat that can be released by the fire and the possible combustion residues should be examined. To this end, e.g. the classification system by CEA (Comité Européen des Assurances) may be applied:

- Fu matter of any hazard category that emits thick smoke when on fire and thereby impedes rescue and extinguishing measures or causes considerable damage by soot
- Ra radioactive substances of any hazard category
- T very toxic and toxic substances
- HT human-toxic substances; substances developing toxic, corrosive, or very offensive gases in combination with water
- C corrosive substances
- PN water-hazardous substances
- PN1 severely hazardous to water
- PN2 hazardous to water
- PN3 low hazardous to water
- Z ecotoxic substances; air-hazardous
- Z1 compressed gases presenting an immediate threat and impeding fire-fighting.
or
substances releasing significant amounts of toxic and hardly degradable products in the case of fire and being able to contaminate the environment to a degree that extensive decontamination measures become necessary.

- Z2 substances releasing significant amounts of toxic substances in the case of fire and contaminating the environment to a degree that simple decontamination measures to a limited extent become necessary.

Using the listed hazard codes, the "Substances and Goods" catalogue can be used to determine which additional hazards are present in the area under consideration.

Annex 2: Protection measures - Basics

Annex 2.1 Evaluation of technical equipment in view of the protection objectives

Annex 2.1.1 Overview

The following tables show in what way a particular system technology may contribute to achieving a protection objective. The precondition is that the system is used according to the marginal conditions specified in clause Annex 1.2.

The three basic protection objectives, as laid down in clause 4.3, life safety, protection of property and environmental protection should be distinguished.

	Extinguishing systems	Smoke and heat exhaust ventilation systems	Fire detection and fire alarm systems
Damage by fire/heat	Water extinguishing systems: Reduction of the heat released by fire Gas extinguishing system: Reduction of the duration of heat radiation	Dissipation of fire heat	
Rescue routes	Limitation of fire spread which could prevent the fire from spreading to areas important for life safety	Creation of a smokefree layer on escape routes	Audible and visible signalling devices support self-evacuation
Fire fighting	Confinement of the fire and support of the firefighting activities by the fire brigade by means of the extinguishing	Smoke-free layer allows firefighting by the fire brigade	Early alerting of the fire brigade and support of fire localisation

	system		
Release of hazardous substances	Extinguishing the fire reduces the period of time during which persons are put at risk by hazardous fire gases	Exhaustion of fire gases reduces the risk of direct exposure of persons to hazardous substances	

Table 13: Life safety

	Extinguishing systems	Smoke and heat exhaust ventilation systems	Fire detection and fire alarm systems
Damage by fire heat	Limitation of fire spread and heat release	Dissipation of the fire heat and indirect contribution by enabling the fire brigade to take action	Limitation of fire spread by supplementary control of fire-resisting closures
Damage by smoke	Limitation of the fire duration	Fire gases are drawn off	See above

Table 14: Protection of property

	Extinguishing systems	Smoke and heat exhaust ventilation systems	Fire detection and fire alarm systems
Combustion residues	Limitation of fire spread and fire duration		Alerting of emergency services/help to start actions

Table 15: Environmental protection

Furthermore, possible damage due to incorrectly selected extinguishing agents or lack of extinguishing water retention are to be considered.

Annex 2.1.2 Combination of system types

For any combination of different systems, the question of mutual effects arises.

The combination of a sprinkler or water spray system with a natural smoke exhaust is considered to be positive providing that particular requirements regarding the layout are met. The layout shall be designed so that the smoke outlet does not cause an aisle effect for the sprinkler release and that no false alarms are caused at the boundaries of groups by the release of the water spray system or by the smoke detectors.

When combining a sprinkler system with powered smoke exhaust, there is a need to prevent an aisle effect.

For a water spray system combined with a powered smoke exhaust, triggering of the smoke exhaust should be realised via the water spray valve station.

The use of ESFR sprinklers requires a more precise consideration. With the sensitive ESFR technology, an adverse effect on the system by the smoke exhaust cannot be excluded. A combination is only possible under strict marginal conditions. Release of the natural smoke exhaust via smoke detectors in combination with ESFR sprinklers is out of the question. In the case of a powered smoke exhaust, release should take place after the ESFR sprinklers. The same applies to the natural smoke exhaust with release via thermocouples. A release of the SHEVS via manual call points is a reasonable combination specifically with regard to firefighting by the fire service.

Even more critical than the combination of ESFR technology with SHEVS is the combination of a water mist system with a smoke exhaust. This involves the risk that the air flow deviates the small and consequently lightweight drops. Only in case of manual triggering of the SHEVS a combination is a reasonable assistance to the firefighting by the fire service.

Further notes offers e.g. the leaflet VdS 2815en - Interaction of water extinguishing systems and smoke and heat exhaust ventilation systems (SHEVS).

Note: Smoke and heat exhaust ventilation systems should never open automatically in rooms with gas and aerosol extinguishing systems. They should only be controlled manually. In case of fire the manual triggering device shall be operated only by authorised persons and shall be protected against activation by unauthorised persons.

	Sprinkler	ESFR	Water spray	Water mist
MRA Automatic triggering	Combination possible ^{1, 2}	Combination not admitted	Combination possible ³	Effectiveness to be proven by fire tests
MRA Manual triggering	Combination possible ²	Combination possible ² triggering only by fire brigade ⁴	Combination possible	Combination possible ² triggering only by fire brigade ⁴
NRA triggering by smoke detectors	Combination possible ¹	Combination not admitted	Combination possible ³	Effectiveness to be proven by fire tests
NRA triggering by thermos-elements	Combination possible	Combination possible coordinate the triggering parameters ⁵	Combination possible	Effectiveness to be proven by fire tests
NRA manual triggering	Combination possible	combination possible ² triggering only by fire brigade	Combination possible	Combination possible ² triggering only by fire brigade ⁴
1 Position the sprinklers no more than 15 cm below the ceiling or use sprinklers with the response sensitivity "fast" 2 Sprinkler must have a minimum distance of 0.5 m from extraction openings of MRA. 3 The detection must be in accordance FDAS regulations. Smoke extraction and extinguishing area must be identical, triggering of the MRA via the SP alarm valve station, detailed case-by-case consideration necessary if the total effective area of the extinguishing system is composed of several group effective areas or different extinguishing systems are present in the same area, e.g. sprinkler and deluge extinguishing system				

4 e.g. by key switch
5 e.g. automatic smoke and heat exhaust ventilation systems may be used, if their triggering temperature is at least one level higher and the RTI of the triggering element is at least one level slower than that of the sprinklers.

Table 16: Combination of fire protection system types

Annex 3: Example of a fire-risk analysis

The example below analyses the fire risk in a company.

Several buildings, which are partly connected, belong to a plastics processing company. The layout in Figure 4 shows the ground plan of the premises.

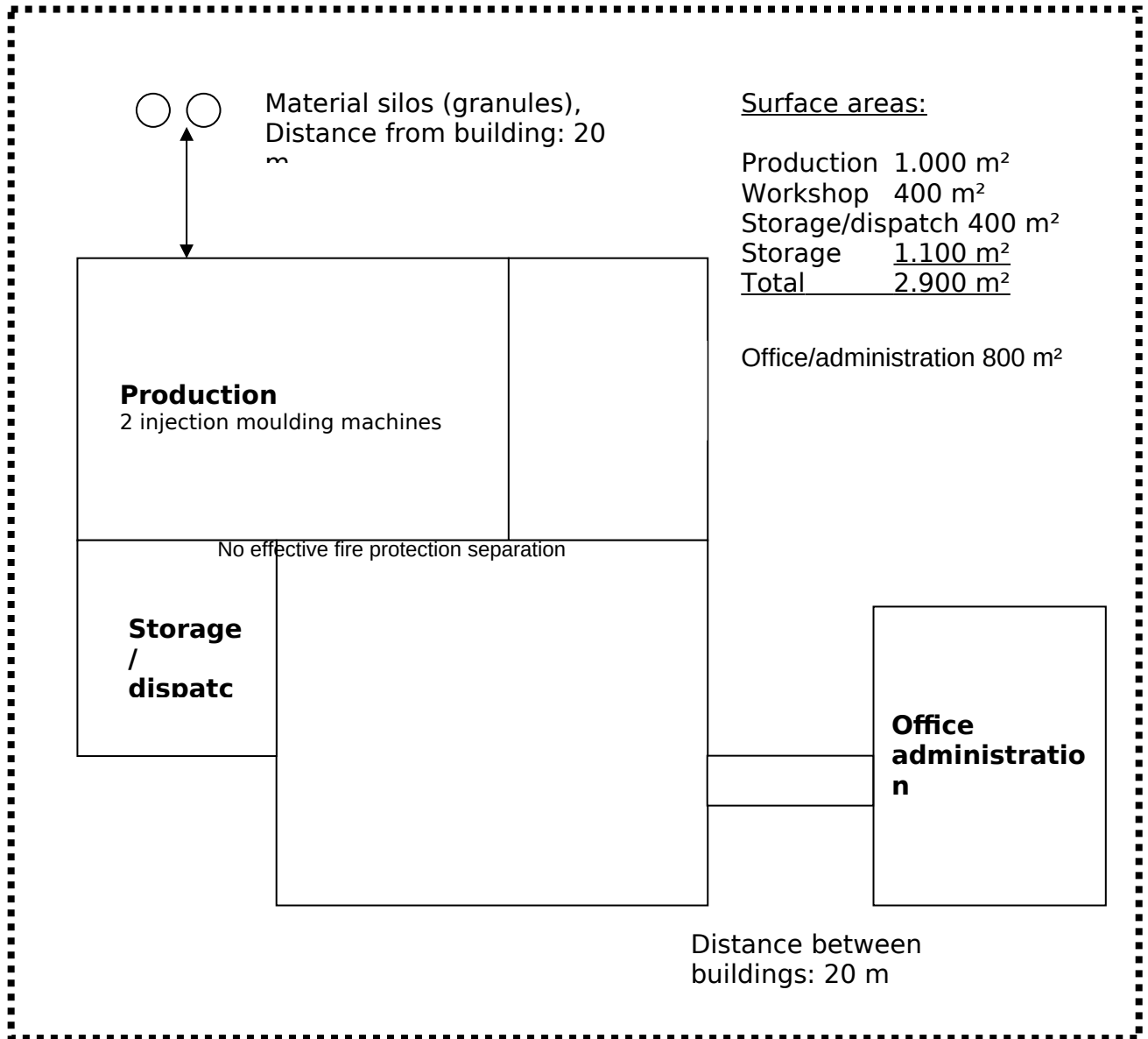


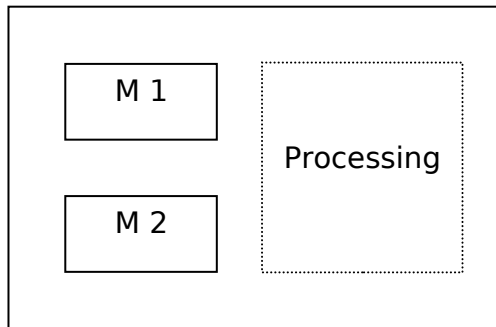
Figure 4: Block plan

Object description:

In the production area, there are two injection-moulding machines processing synthetic material of a value of € 5 million each as well as stocks on hand of a value of € 1 million. The value of the production building is € 1.5 million. The value of both

injection-moulding machines is based on the fact that these are special designs with a long replacement period as the production processes are specialist.

Figure 5 shows the production area of 1000 m² from Figure 4 in detail.



Not far from both injection, moulding machines M1 and M2 there is the processing area.

Fire spread between both machines and/or between the machines and the processing area cannot be excluded!

Figure 5: Production zone

In the workshop (400 m²), there are the tools for the injection moulding machines, which are manufactured by the company itself. These tools are of importance, as, in case of loss, a new manufacture of them would take several months, which in view of the market situation is a serious danger. Thus, there is a considerable risk of business interruption.

Due to the invested knowledge, manufacture of tools generally should not be outsourced. The building value of the workshop is approx. 0.5 million €; the estimated value of equipment and tools is extraordinarily high.

The warehouse (storage = 1100 m²) contains goods and raw materials worth 2 million €; the equipment (racks and material-handling vehicles) also costs 1 million € and the building costs 1,5 million €.

The area storage/dispatch (400 m²) contains mainly goods of a total value amounting to 0.5 million € and equipment of 0.5 million €. The building costs amount to 0.5 million €.

The office and administration building (800 m²) is worth 1 million € and the equipment/furniture 0.5 million €.

The material silos (granules) contain raw material, which can be topped up within a short time.

Existing fire protection systems:

The buildings on the premises are fitted with an overall fire detection and fire alarm system; however, for the time being they are not equipped with an automatic extinguishing system. A SHEVS is installed in the storage area.

General proceeding:

For the fire risk analysis below, we evaluate as an example the fire protection system for the plant area of 2900 m² (production, warehouse, dispatch area, and workshop), which is structurally and spatially separated from the office and administration building and the material silos. This area does not provide effective fire compartments in relation to fire protection.

The distance of the silos from the building is more than 20 m and, consequently, they are not included in the fire risk analysis of the building. Should production depend crucially on a trouble-free operation of the silos, we recommend a separate analysis of these areas that are vital for The maintenance of plant operation. Further appropriate protection measures may be required.

Note: The evaluation of the office and administration area made in parallel should be a second, independent example in this respect. Potential more serious risks, e.g. due to the existence of IT-rooms or the like, are not given here.

Determination of risk potential

The probability of occurrence of a fire and, therefore, the risk potential is estimated for the plant area to be analysed taking the probability of ignition sources and the combustible material as a basis.

Determination of the probability of ignition sources according to Table 1

We distinguish between ignition sources required in the plant (hot machines, chemical reactions, electrical ignition sources, burners, etc.) and those existing due to technical or human failure. The probability of ignition sources is classified according to its frequency; i.e. "permanently", "often", "occasionally", and "rarely".

For the example plant, we specify as follows:

- In the production area, there are ignition sources (hot machines, M1 and M2) that are required (see Figure 5); the ignition sources in the processing area are enclosed.
- In the warehouse, there may be ignition sources because of technical/human failure. In particular this could be the case because of arson, non-observance of precautions, e.g. during welding, or because of non-observance of prohibitions (smoking ban). The material handling equipment in the warehouse could catch fire, e.g. due to technical defects and overheating, etc.
- The above applies analogously to the storage/ dispatch area.
- In the workshop, ignition sources that are required (hot work) exist.

Separate evaluation of the office building:

- In the offices, potential ignition sources exist occasionally only.

The probability of ignition sources are shown in the following survey:

Survey 1	<i>Separate assessment</i>				
	Production zone	Warehouse	Storage/ dispatch	Workshop	<i>Office</i>
Probability of ignition sources	permanently	often	often	permanently	<i>occasionally</i>

A closer investigation into the production area and its machines leads to a more detailed classification of the ignition sources, which should be analysed in a second evaluation:

Survey 2	Production zone	compared to:	M 1	M 2	Processing
Probability of ignition sources	permanently (of survey 1)		permanently	permanently	occasionally

It also arises from Survey 2 that the machines installed in the production area involve a particularly high risk of ignition sources. You can respond to this risk, e.g. by means of effective local application protection. This could be completed in virtual zones.

Combination of the different probabilities of ignition sources in the plant area of Survey 1 (permanently, often, often, and permanently) is done according to Table 2 with the following result:

In total, the probability of ignition sources in the overall plant area is "often".

Note 1: For a combination of the probabilities you need to consider the largest areas first, followed by the smaller ones.

Note 2: The analysis shows that a structural distribution into closed-off areas (fire compartments) as to fire protection would make sense, e.g. compartment 1: warehouse and storage/dispatch (in total 1500 m²), compartment 2: production area with workshop (in total 1400 m²). This is the only way to respond adequately to the different risk potentials in both areas.

Then, the result of the probabilities of ignition sources, which would have to be treated separately, would be "often" in compartment 1 and "permanently" in compartment 2.

This intermediate result should at least be considered for the final result . However, the example will be continued without the required compartmentation, as no real compartments do exist.

Determination of the probability of combustible materials according to Table 3

The fire loads determined above are classified according to their probability in "permanently/long-term", "often", "occasionally", and "rarely" depending on their ignitable condition as follows:

- In the production area there are fire loads, such as synthetic materials, etc. in an ignitable condition that are required. Machine oils are always enclosed.
- In the areas warehouse and storage/dispatch there often are fire loads (finished goods, packaging materials, furniture/equipment) in an ignitable condition.
- In the workshop there often are fire loads (e.g. machine oils) in an ignitable condition when being used, i.e. they are required.

Separated evaluation of the office building:

- - In the office building there are permanent fire loads.

The probability of combustible materials in ignitable condition is shown in the following Survey 3:

	<i>Separate assessment</i>				
Survey 3	Production area	Warehouse	Storage/dispatch	Workshop	<i>Office</i>

Probability of combustible material	permanently , long-term	often	often	permanently , long-term	<i>permanently</i>
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Combination of the different probabilities of combustible materials in the analysed area (permanently, often, often, and permanently) is done according to Table 4 with the following result:

In total, the probability in the production and storage area is "often" (cf. notes on the result of Survey 2).

Determination of the probability of fires as a function of the probability of combustible materials and ignition sources according to Table 6

The probability of a fire in the production and storage area results from a combination of the results of Surveys 1 and 3:

Probability: often + often = often

If an independent analysis of the compartments 1 and 2 (production + workshop and storage/ dispatch + warehouse, cf. Note on Survey 2) is required as explained above, deviating probabilities of an ignition result from the combination of the respective probabilities according to the following survey:

Survey 4	Production	Workshop	Warehouse	Storage/ Dispatch
Probability of ignition due to probability of ignition source + combustible material according to Survey 1 and 3	permanently + permanently = permanently	permanently + permanently = permanently	often + often = often	often + often = often
	Fire compartment 1: Production and workshop		Fire compartment 2: warehouse and storage/dispatch	
Probability of an ignition	permanently + permanently = permanently		often + often = often	

If, furthermore, the production area - as a part of compartment 1 - is examined even closer, the resulting probability of an ignition is as shown in Survey 5.

Survey 5	Production on the whole	M 1	M 2	Processing

Probability of ignition in production area with permanent probability of combustible material according to Table 3	permanently acc. to survey 4	permanentl	permanentl	occasionall
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We can state for the office building:

Probability: occasionally + permanently = occasionally

Conclusion of the probabilities

In the production area and workshop there is the highest probability that an ignition takes place. The less hazardous area in our example is the storage area.

As an effective fire protection separation is missing, and as this deficiency has been accepted (evaluation of the overall object is continued instead of restarting evaluation with a structural fire protection separation between the compartments 1 and 2, which has been accepted to be required), the result does not reflect the actual risk potential. The same applies to the production area where imaginary separations should be taken as a basis because the actions could be taken in reality, e.g. by local application protection.

Important note: The manner of proceeding above shows that it is important in each evaluation that potential deficiencies recognised, are integrated in the running evaluation. In these cases, the evaluation should be restarted whilst taking the new knowledge into account.

Consequently, further evaluation of the example is based on an effective fire protection separation between the compartments 1 and 2 as shown in subsequent Figure 6 (e.g. fire break wall according to national legislation). Therefore, corresponding structural measures should be taken into account.

A result of Survey 5 would also be the implementation of local application protection for both machines in the production area.

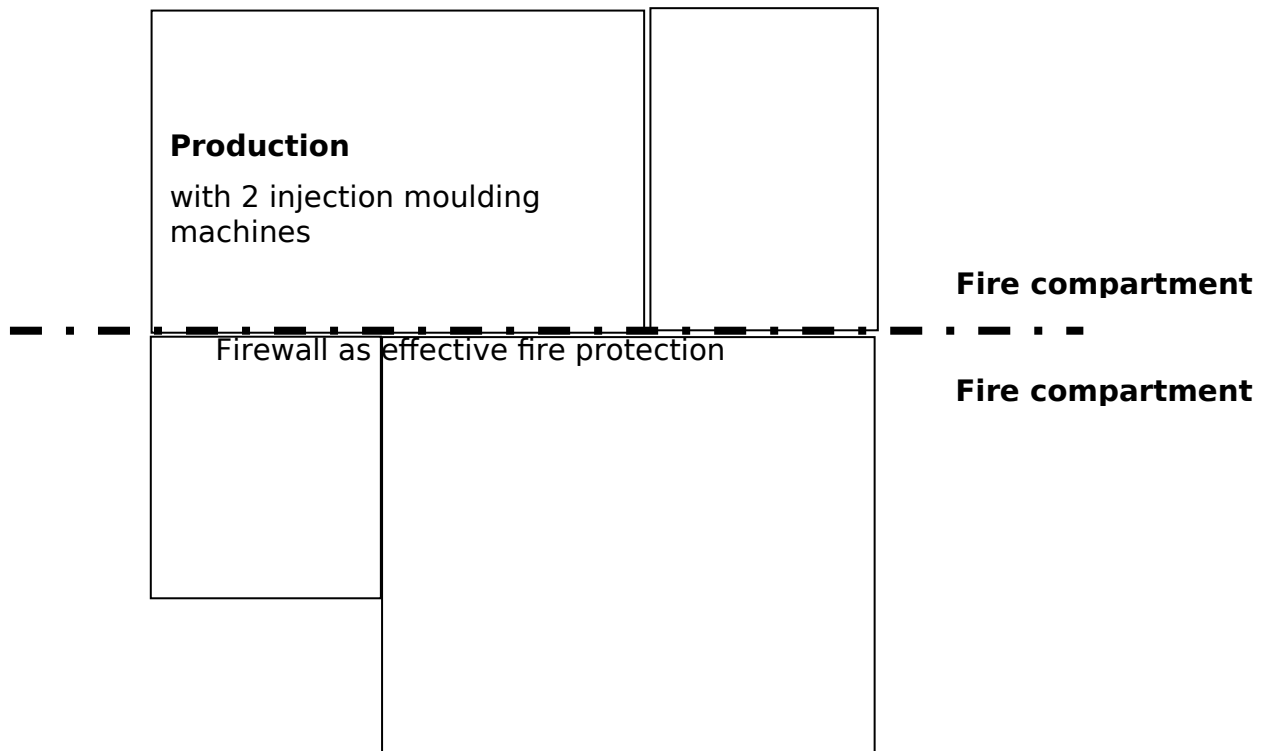


Figure 6: Compartmentation

The probability of a fire in the office building determined in the present example is "occasionally". Regarding the fire loads and ignition sources, this office building is of normal use.

Determination of the priorities of protection objectives

The analysis of the possible extent of loss and the resulting priorities shall take into consideration and examine not only the (groups of) persons at risk but also the economic loss (including business interruption, loss of customers, etc.) and the environmental damage (cf. clause 4.2)

Life safety

In our example, only a few persons are employed – no outsiders and, thus, no one not knowing the place are present. This is why the protection objective of life safety in this area gets the priority "normal".

In the office building, normally a few outsiders are present; here the protection objective priority is "high".

Protection of property

The example company manufactures plastic products. Manufacturing absolutely requires the presence of machines in the production area and the injection moulding tools manufactured and possibly stored in the workshop. When lost, a replacement of machines and tools takes a long time. Manufacturing of tools is not outsourced; they are developed and manufactured internally in order to keep company confidentiality. Protection of property in this example is protection against material loss and loss due to threatening business interruptions as well as other associated disadvantages.

Therefore, the priority for the protection of property is considered to be very high in compartment 1 (production and workshop area), especially regarding business interruption (due to long delivery times of new machines), the threat of loss of reputation (customers moving to competitors due to supply difficulties), and the loss of expensive development products (tools).

In compartment 2 (warehouse and storage/dispatch), the protection objective "property" has "high" priority (stored goods, handling equipment, etc.).

The office building shows a evenly distributed concentration of values; consequently, the priority for the protection of property is considered to be "high".

Environmental protection

The danger for the environment in both fire compartments is increased because of the fire loads (plastic materials); consequently, the protection objective priority is considered to be "high".

For the office building, the protection objective "environmental protection" is considered to be "normal".

Summary of protection objective priorities

The following survey lists the protection objective priorities defined above:

Survey 6	Compartment 1		Compartment 2		Office building
	Production	Workshop	Storage/dispatch	Warehouse	
Life safety	normal	normal	normal	normal	high
Protection of property	very high	very high	high	high	high
Environmental protection	high	high	high	high	normal

Comparing Survey 6 with the probabilities defined above, we find again that especially the production and workshop areas require particular protection. In these areas, the protection objective priorities with regard to achieving them are increased, too. Thus, a ranking can be derived per compartment from the analysed sections as shown in as follows:

Survey 7	Section	Probability of ignition	Protection objective life safety	Protection objective protection of property	Protection objective environmental protection
1. Production	1	permanently	normal	very high	high
2. Workshop		permanently	normal	very high	high
1. Warehouse	2	occasionally	normal	high	high
2. Storage/dispatch		occasionally	normal	high	high
1. Office building	3	occasionally	high	high	normal

Note: Priorities are defined e.g. in order to deduct and develop appropriate protection concepts. They have no immediate influence on the evaluation of the fire risk of an object.

Measures

The measures taken to reduce the risk of loss, if taken as safety measures, can reduce the probability, and if taken as protection measures reduce the extent of loss (cf. clause 4.3).

Subsequently – if not done before – measures leading to achieve the protection objective specified before shall be discussed and examined as to their applicability. The evaluation of the fire risk in the example company takes into account the compartmentation that has not yet been implemented. It shall demonstrate the fire risk of both fire compartments for the present infrastructure of systems (FDAS but no extinguishing system) and evaluate this. A reduction in risk shall be proven after selection and subsequent re-evaluation of an effective protection concept, taking into account the selected protection concepts. This step shall be repeated until the defined protection objectives are achieved.

Safety measures

As safety measures, [changes in the process technology] are possible in the example company, it may be agreed with the operator that replacement of the hazardous matters with less ignitable ones is impossible. The existing ignition sources, above all in the workshop and production area, cannot be enclosed thoroughly. Thus, the corresponding risk cannot be reduced.

So, in our example the protection objectives cannot be achieved by means of safety measures. Additional protection measures should be taken to protect against the detected risks.

Protection measures

In the example company, there are a variety of possible and reasonable protection measures.

- Structural fire protection
 - o In the example company, a fire break wall between the areas production/workshop and warehouse with the adjacent storage/dispatch area would make sense to minimise the detected fire risk. This separation not yet implemented will be taken into account for further evaluation of protection measures.
 - o An appropriate spatial separation between this area and the office building and the material silos was considered and implemented early in the planning stage.

Note: Storage of the important injection moulding tools outside the workshop does not reduce the probability of ignition but has an important effect on the protection objectives.

- Fire protection systems
 - o It is of utmost importance to protect the main risks – the injection moulding equipment (areas M1 and M2 in the production area). They involve an increased risk of ignition and, moreover, in view of the effects of a business interruption their integration into the operating sequence is particularly sensitive. Therefore, we would propose to combine the fire detection and fire alarm system with an appropriate extinguishing equipment/device (fast, safe, adequate fire characteristic) instead of local application protection. In doing so, even the spreading of fires that are not caused by a machine itself can be fought effectively.

Note: From an economic point of view, it should be examined nevertheless whether local protection measures, e.g. the aforementioned local application protection for both machines would equally achieve the protection objective.

- o In order to reduce the risk at focal risk points, appropriate extinguishing systems should be installed. Their selection shall be mainly based on the adequate extinguishing agent (fire load: synthetic material).
 - o Moreover, fire compartment 1 shall be equipped with smoke and heat exhausts. The exhausts shall ensure life safety, keep the attack routes for fire brigades free from smoke, and protect the stored goods as well as the machines against smoke damage.
 - o Installation of fire protection equipment shall allow for operational sequences and necessities.
- Operational/organisational fire protection
 - o A number of operational/organisational measures can achieve the protection objectives. They should be examined and - where required - agreed with the competent authorities.

As a basic rule: If it is impossible for economic reasons to realise all measures for all risk potentials, the protection objective of the highest priority should be taken into consideration first. In our example, this is the protection of property in the workshop and production area.

Example risk-specific evaluation of protection measures with reference to the protection objective according to Table 8 for the fire compartment 1

As stated the company is equipped with an overall FDAS but not with an automatic extinguishing system. A SHEVS has been installed already in the warehouse but not in the fire compartment 1.

As an example, the fire compartment 1 is evaluated based on Table 8 as to all existing and additionally potential protection objectives. Thus, the non-existence of an appropriate measure can cause a negative evaluation depending on its suitability. The measures suitable to achieve all protection objectives and to minimise the risk, will be selected and evaluated. This is to be established by a new overall evaluation.

Note: For the relevance and meaning of symbols, please see clause 4.4, Table 8.

Aspects for protection objectives	Relevance ↓	Protection measures, e.g.:						
		Sprinkler	Water spary	Gas	Foam	Powder	FDAS ¹⁾	SHEVS
Life safety								
1 Appropriate extinguishing agent	2	o	o	-	o	-	x	x
2 Reduction/venting of smoke	3	-	x	x	x	x	x	-
3 Escape/rescue routes	3	-	-	-	-	-	+	-
4 Detection of fire early enough	3	o	o	o	o	o	+	o
5 Fire spread until extinguishment acceptable	2	-	-	-	-	-	+	o
6 Evacuation (self-evacuation or by fire brigade) possible	3	o	o	x	x	x	o	-
Protection of property								
7 Appropriate extinguishing agent	3	-	-	-	-	-	x	x
8 Extinguishing agents do not put the goods to be protected at risk	3	-	-	-	-	-	x	x
9 Reduction/venting of smoke	2	-/+	x	x	x	x	x	-/+
10 Detection of fire early enough	3	+	+	+	+	+	+	x
11 Fire spread until extinguishment acceptable	3	-	-	-	-	-	-	x
12 Sufficient local protection (e.g. for machines)	3	x	x	-	-	x	x	-
Environmental protection								
13 Appropriate extinguishing agent	3	o	o	o	o	o	x	x
14 Reduction/venting of smoke	3	+/-	-	-	-	-	x	-
15 Detection of fire early enough	2	+	+	+	+	+	+	x
16 Fire spread until extinguishment acceptable	3	-	-	-	-	-	-	x
General								
17 Other protection objections called into question	3	o	o	o	o	o	x	x
18 Operational requirements affected	-	-	-	-	-	-	-	-
19 Investments	-	-	-	-	-	-	-	-

Without any relevance for risk

¹⁾ FDAS exists as protection measure; this is taken into consideration in view of possible interventions

Table 17: Aspects of protection objectives

Explanations of Table 17 and result of the risk analysis

The relevance of individual aspects can vary when considering different protection objectives. For example, whether an extinguishing agent is suitable has more relevance to the protection objective 'property' than to the protection objective 'life safety' in our example. In this case, the few persons familiar with the place are able to leave the risk area very quickly in the event of fire. The suitability of the extinguishing agent is almost irrelevant or neutral for this purpose. The suitability of the extinguishing agent is of the utmost relevance to the machines because they are exposed to the fire for a longer period of time and cannot be "evacuated".

In conclusion, no protection objective in fire compartment 1 – not even in combination with the existing FDAS – can be sufficiently achieved as the fire protection systems are insufficient.

Result of the analysis according to clause 4.3.2 is that the existing FDAS is considered to be a normal protection measure to achieve the protection objective 'life safety'. As to the protection objective 'property', the FDAS as the only system is not more than "minor" protection measure. The same applies to the protection objective 'environment'. According to Table 18, no protection objective has been evaluated by a green field. Thus, the input variable "protection measures" of Table 11 is "minor" in total.

	Evaluated protection measures			
	Maximum effect, acc. to evaluation of Table 12	High effect acc. to evaluation of Table 12	Normal effect acc. to evaluation of Table 12	Minor effect acc. to evaluation of Table 12
Life safety			x	
Protection of property				x
Environmental protection				x

Table 18: Example of an evaluation of protection measures

Evaluation of the anticipated extent of loss according to Table 10

The anticipated extent of loss – the last missing input variable for Table 11 – can be evaluated at "high" in total according to the descriptions made in Table 10 as to the existing fire protection infrastructure of the building.

Evaluation of the anticipated extent of loss according to Table 11

A protection measure evaluated at "minor" and an extent of loss evaluated at "high" lead to a "high" extent of loss to be expected (as to the evaluated protection measures).

Determination of the actual fire risk according to Table 12

In the present example, the matrix in Table 12 shows for fire compartment 1 the actual fire risk below:

Probability of occurrence = **permanently** (see Survey 4),

Extent of loss = **high** (see result according to Table 11)

Fire risk = *not acceptable*

Notes: For the production area within the fire compartment 1 it was determined amongst other things that the existing protection measures are not sufficient to achieve the relevant protection objectives. Consequently, measures beyond the existing ones (e.g. an extinguishing system etc.) should be taken into consideration. Due to the different probabilities of ignition in the area with injection moulding equipment and the processing area, even local application of protection of the injection moulding equipment can considerably reduce the risk.

The analysis of fire compartment 2 (warehouse, storage/dispatch), which is not presented herein, shows that the high fire loads as well as the fact, that the company is located in a mixed-use zone, also require protection by an extinguishing system to achieve the protection objectives. Without an extinguishing system and in case of fire, e.g. the loss of reputation – in particular in the neighbourhood – would be very high. e.g. By not storing the injection moulding tools in the workshop, the protection objectives would change there so that protection of the workshop would get a lower priority.

Conclusion:

With the specified manner of proceeding, it is relatively easy to evaluate the fire risk per compartment. It is evident that fire compartments should be created; however, each fire compartment will require its own protection concepts. By gradually installing fire protection systems in individual areas until the relevant protection objectives are achieved and by repeated evaluations the fire risk will finally be reduced.

**Annex 4: Example of a PERFORMANCE SPECIFICATION - FIRE
DETECTION AND ALARM SYSTEM**

(Source: Brandskyddsföreningen Sverige)

1. General

<input type="checkbox"/> New facility	<input type="checkbox"/> Modification/extension	Reference number or similar:	Regulations/addition:
The next carried out with requirements set forth:		Description:	Floor:
<input type="checkbox"/> Building codes			
<input type="checkbox"/> Insurance requirements			
<input type="checkbox"/> Own ambition			
<input type="checkbox"/> Health and safety requirements			
Name and address of the establishment:		Facility owner and address:	

2. Surveillance area

<input type="checkbox"/> Class A – Monitoring of the entire building	Description:
<input type="checkbox"/> Class B – Full fire coil monitoring	Description:
<input type="checkbox"/> Class C – Limited monitoring of escape and communication routes	Description:
<input type="checkbox"/> Class D – Limited monitoring of certain spaces	Description:
<input type="checkbox"/> Class E – Manual activation only	Description:

3. Manual activation

<input type="checkbox"/> All persons must be able to activate the fire alarm manually	Description of the location of alarm buttons:
<input type="checkbox"/> Only designated personnel shall be able to activate the fire alarm manually	

4. Activation of fire alarms from other fire protection systems

<input type="checkbox"/> Gas extinguishing system	Description:
<input type="checkbox"/> Water sprinkler system	Description:
<input type="checkbox"/> Other types of fire protection systems	Description of the type of system:

5. Specific risks

<input type="checkbox"/> Spaces with electrical and electronics installations with high airspeed or high air circulation	Description:
<input type="checkbox"/> High storage warehouse	Description:
<input type="checkbox"/> Facade monitoring	Description:
<input type="checkbox"/> Other risks to consider	Description:

6. Alarm signaling

See Annex No:

<input type="checkbox"/> Alarm for internal intervention	Where and how should the alarm signal be emitted:
<input type="checkbox"/> Alarm for attention	Where and how should the alarm signal be emitted:
<input type="checkbox"/> Evacuation alarms	Coverage area:
<input type="checkbox"/> Several coverage areas exist and are listed in appendix:	
Signal type:	
<input type="checkbox"/> Siren <input type="checkbox"/> Alarm Clock <input type="checkbox"/> Optical <input type="checkbox"/> Spoken Message (see separate design specification according to SBF 502)	

7. Selection of evacuation alarms

See Annex No:

<input type="checkbox"/> Alarms must be given throughout the building / facility at the same time	
<input type="checkbox"/> Alarms should be selected as follows	Description:

8. Delay of alarm transmission

In what parts:
Within what times of the day:
Response time:
Survive time:
Location of alarm control unit:

9. Prerequisite for power supply for backup operation

<input type="checkbox"/> 24 hours of operation in normal mode according to 6.5.5
<input type="checkbox"/> 5 hours of operation in normal mode according to 6.5.6 a)
<input type="checkbox"/> 2 hours of operation in normal mode according to 6.5.6 b)

10. Control and activation of other fire protection systems

Type of control output (option 1 applies unless otherwise specifically stated) Option 1 – Control output without indication requirement Option 2 – Control output with indication in central equipment that control signal has been activated Option 3 – Control output with indication in central equipment that the controlfunction has received the control signal (receipt)	Equipment for receipt from controlled function is available in: <input type="checkbox"/> Controlled function <input type="checkbox"/> Central control unit
--	--

<input type="checkbox"/> Gas extinguishing system	<input type="checkbox"/> Control output option 2	<input type="checkbox"/> Control output option 3
<input type="checkbox"/> Type 1 – Automatic activation via separate control and delay device		
<input type="checkbox"/> Type 2 – Automatic activation with integrated control and delay device		

<input type="checkbox"/> Water sprinkler system	<input type="checkbox"/> Control output option 2	<input type="checkbox"/> Control output option 3
<input type="checkbox"/> Automatic activation via separate control unit		
<input type="checkbox"/> Automatic activation directly from the fire alarm system		

<input type="checkbox"/> Other types of extinguishing systems	<input type="checkbox"/> Control output option 2	<input type="checkbox"/> Control output option 3
Type of system:		
<input type="checkbox"/> Automatic activation via separate control unit		
<input type="checkbox"/> Automatic activation directly from the fire detection and alarm system		

<input type="checkbox"/> Fire gas ventilation	<input type="checkbox"/> Control output option 2	<input type="checkbox"/> Control output option 3
Description:		

<input type="checkbox"/> Ventilation control	<input type="checkbox"/> Control output option 2	<input type="checkbox"/> Control output option 3
<input type="checkbox"/> Several ventilation systems to be controlled are available and are listed in appendix:		
System:	Feature description:	

<input type="checkbox"/> Fire doors	<input type="checkbox"/> Control output option 2	<input type="checkbox"/> Control output option 3
Description:		

<input type="checkbox"/> Elevators <input type="checkbox"/> Control output option 2 <input type="checkbox"/> Control output option 3 <input type="checkbox"/> Several lifts to be controlled are available and listed in appendix:		
Receiver IP No-	Reference-	Alternative plan-
Other:		
Other: <input type="checkbox"/> Fire curtain/lift shutter <input type="checkbox"/> Emergency lighting <input type="checkbox"/> Electric end plate <input type="checkbox"/> Music system <input type="checkbox"/> Escalators <input type="checkbox"/> Other governance	<input type="checkbox"/> Control output option 2 <input type="checkbox"/> Control output option 2 <input type="checkbox"/> Control output option 2 <input type="checkbox"/> Control output option 2 <input type="checkbox"/> Control output option 2 <input type="checkbox"/> Control output option 2	<input type="checkbox"/> Control output option 3 <input type="checkbox"/> Control output option 3 <input type="checkbox"/> Control output option 3 <input type="checkbox"/> Control output option 3 <input type="checkbox"/> Control output option 3 <input type="checkbox"/> Control output option 3
Description:		
Other information controls:		

11. Alarm transmission

Alarm transmission takes place via: <input type="checkbox"/> Fixed alarm network <input type="checkbox"/> Radio/Mobile Transfer <input type="checkbox"/> IP networks	Fire alarm signal receiver and contact details: Measure:	Receiver of error signal and contact details: Measure:
---	---	---

12. Care and maintenance

Specific care and maintenance requirements beyond the minimum requirements

Description:

13. Admitted deviations

The plant is carried out according to SBF 110 with the following admitted deviations

Description:

14. Other information

Description:

15. Signing of the performance specification

Specification has been drawn up by (name and company):	Enterprise:
Signature:	Place and date:

ACCOUNTING COVERAGE AREAS

Coverage area:
Rinnal tone: <input type="checkbox"/> Evacuation alarm <input type="checkbox"/> Spot <input type="checkbox"/> Alarm Clock <input type="checkbox"/> Optical <input type="checkbox"/> Spoken message (see separate performance specification according to SBF 502)
Coverage area:
Rinnal tone: <input type="checkbox"/> Evacuation alarm <input type="checkbox"/> Spot <input type="checkbox"/> Alarm Clock <input type="checkbox"/> Optical <input type="checkbox"/> Spoken message (see separate performance specification according to SBF 502)
Coverage area:
Rinnal tone: <input type="checkbox"/> Evacuation alarm <input type="checkbox"/> Spot <input type="checkbox"/> Alarm Clock <input type="checkbox"/> Optical <input type="checkbox"/> Spoken message (see separate performance specification according to SBF 502)
Coverage area:
Rinnal tone: <input type="checkbox"/> Evacuation alarm <input type="checkbox"/> Spot <input type="checkbox"/> Alarm Clock <input type="checkbox"/> Optical <input type="checkbox"/> Spoken message (see separate performance specification according to SBF 502)

Control of ventilation systems

System:	Feature description:

Control of elevators

Controlled elevator No:	Stopping-floor:	Alternative stopping-floor:

European guidelines

Fire (<https://cfpa-e.eu/category-guidelines/fire-prevention-and-protection/>)

- Guideline No 1 F - Internal fire protection control
- Guideline No 2 F - Panic & emergency exit devices
- Guideline No 3 F - Certification of thermographers
- Guideline No 4 F - Introduction to qualitative fire risk assessment
- Guideline No 5 F - Guidance signs, emergency lighting and general lighting
- Guideline No 6 F - Fire safety in care homes
- Guideline No 7 F - Safety distance between waste containers and buildings
- Guideline No 8 F - withdrawn*
- Guideline No 9 F - Fire safety in restaurants
- Guideline No 10 F - Smoke alarms in the home
- Guideline No 11 F - Recommended numbers of fire protection trained staff
- Guideline No 12 F - Fire safety basics for hot work operatives
- Guideline No 13 F - Fire protection documentation
- Guideline No 14 F - Fire protection in information technology facilities
- Guideline No 15 F - Fire safety in guest harbours and marinas
- Guideline No 16 F - Fire protection in offices
- Guideline No 17 F - Fire safety in farm buildings
- Guideline No 18 F - Fire protection on chemical manufacturing sites
- Guideline No 19 F - Fire safety engineering concerning evacuation from buildings
- Guideline No 20 F - Fire safety in camping sites
- Guideline No 21 F - Fire prevention on construction sites
- Guideline No 22 F - Wind turbines – Fire protection guideline
- Guideline No 23 F - Securing the operational readiness of fire control system
- Guideline No 24 F - Fire safe homes
- Guideline No 25 F - Emergency plan
- Guideline No 26 F - withdrawn*
- Guideline No 27 F - Fire safety in apartment buildings
- Guideline No 28 F - Fire safety in laboratories
- Guideline No 29 F - Protection of paintings: transports, exhibition and storage
- Guideline No 30 F - Managing fire safety in historic buildings
- Guideline No 31 F - Protection against self-ignition and explosions in handling and storage of silage and fodder in farms
- Guideline No 32 F - Treatment and storage of waste and combustible secondary raw materials
- Guideline No 33 F - Evacuation of people with disabilities
- Guideline No 34 F - Fire safety measures with emergency power supply
- Guideline No 35 F - Fire safety in warehouses
- Guideline No 36 F - Fire prevention in large tents
- Guideline No 37 F - Photovoltaic systems: recommendations on loss prevention
- Guideline No 38 F - Fire safety recommendations for short-term rental accommodations
- Guideline No 37 F - Fire protection in schools
- Guideline No 38 F - Fire safety recommendations for short-term rental accommodations
- Guideline No 39 F - Fire protection in schools
- Guideline No 40 F - Procedure to certify CFPA-E Fire Safety Specialists in Building Design

Guideline No 41 F - Safety instructions for the use and charging of small and medium size lithium ion powered devices

Natural hazards (<https://cfpa-e.eu/category-guidelines/natural-hazards/>)

- Guideline No 1 N - Protection against flood
- Guideline No 2 N - Business resilience - An introduction to protecting your business
- Guideline No 3 N - Protection of buildings against wind damage
- Guideline No 4 N - Lighting protection
- Guideline No 5 N - Managing heavy snow loads on roofs
- Guideline No 6 N - Forest fires
- Guideline No 7 N - Demountable / Mobile flood protection systems
- Guideline No 8 N - Ensuring supplies of firefighting water in extreme weather conditions
- Guideline No 9 N - Protection against hail damage

Security (<https://cfpa-e.eu/category-guidelines/security/>)

- Guideline No 1 S - Arson document
- Guideline No 2 S - Protection of empty buildings
- Guideline No 3 S - Security systems for empty buildings
- Guideline No 4 S - Guidance on keyholder selections and duties
- Guideline No 5 S - Security guidelines for museums and showrooms
- Guideline No 6 S - Security guidelines emergency exit doors in non-residential premises
- Guideline No 7 S - Developing evacuation and salvage plans for works of art and heritage buildings
- Guideline No 8 S - Security in schools
- Guideline No 9 S - Recommendation for the control of metal theft
- Guideline No 10 S - Protection of business intelligence
- Guideline No 11 S - Cyber security for small and medium-sized enterprises
- Guideline No 12 S - Security Guidelines for Businesses



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