Guidance & Interpretation Document Fire Protection Systems according to Certification Scheme K21045

Approved by the Board of Experts Fire Safety

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2 Introduction

This Guidance & Interpretation document for the international standards for Inspection & Certification of Fire Protection Systems has been accepted by the Board of Experts Fire Safety (BoE FS), in which all relevant parties in the field of Fire Safety are represented. The Board of Experts also supervises the activities and where necessary requires this scope to be revised and additional interpretation is needed.

This interpretation document has been drafted to set two goals:

- To give **G**uidance in the context for the design, installation and operation of Fire Protection Systems and is marked with the letter “G”;
- To give additional or alternative **R**equirements on matters not clear defined in the standards or where the standards have not yet addressed the issue or development and is marked with the letter “R”.

Version	About	Date
1	First setup of the document – not published	2021/04/15
2	Update of items - published	2024/09/05

Table 1

3 Setup of the scheme K21045 “G”

3.1 Why Fire Protection Systems (FPS)?

The threats and hazards of fires are universal.

The risks for life safety, loss of property or impact on business continuity of processes / organisations can be most challenging.

Equation: *Risk of fire = (chance of fire – way of reduction) x (effect of fire – way of reduction).*

The most effective way to reduce / mitigate the threat of fire is to lower the chance of **ignition of fires**. The most direct way to achieve this is to eliminate all ignition sources. In practice this means elimination of open fire, electricity, and other heat sources. Another way is to eliminate all materials that are **easy to burn**. Practical implementation of this could start by using non-flammable and non-combustible materials only, such as metals and concrete.

However, a total elimination of ignition sources as well as a ban on flammable materials would face huge challenges. Reducing the chance of fire to zero is simply not possible. The risks of a fire breakout will always remain. And so, the next step in the equation focuses on reduction of the effects of the fire. An effective way to control fires is the creation of **fire compartments.** Each compartment installed with a proper resistance to fire and smoke will prevent the hazard from spreading to other compartments. This way of de-escalating the potential fire effects faces also practical implementation problems, however. And, even in situations where compartmentalization is possible, the fire and smoke resistance of the structure does not safeguard occupants and property residing within it.

Where so-called **passive (construction) fire protection systems** do protect structures and property against flame and smoke impingement or heat exposure, they do not attack the fire source. And this is where **active fire protection systems** come in.

Another effective way to control fires in conjunction with compartments with a proper resistance to fire and smoke is the use of **fire protection systems (FPS).** These FPS are covered by scheme K21045 and have one basic functionality in common. Grouped under the international definition as **active fire protection systems**, they are designed to de-escalate a fire’s effect from the initial fire ignition onwards by activation of a series of technical events. The systems are mostly focused on control on the effect of the fire and not on reducing the change of the fire. In other words, most of these systems do not contribute to a reduction or elimination of the chance of fire and they do not prevent fire breakout. They intervene after the first instance of fire breakout.

When regarding the FPS under the scheme’s scopes A to H more specifically, it shows that the several systems approach the fire differently. Some systems intend to focus on control and full extinction of a fire after full fire development. Some focus on fire control and loss mitigation with the intend that manual fire fighting (fire dept.) can take over after the first instances. The system in scope D is focusing on the reduction on the change of ignition of fires . Below is shown a matrix with all the systems in this scheme and there specific characteristics.

An additional way for the mitigation of thread of fires is the use of Smoke and Heat Control Systems (= S&HCS). This is arranged in certification scheme K21025.

3.2 Active media

The Fire protection Systems can be equipped with different active media that have different mechanisms for fire protection. Table 2 is list of all the different Fire Protection Systems within this scheme. If the system has a preventive- or repressive function is defined in this table. The goal(s) of the specific FPS and if the FPS needs short- or a long time supply of media in able to have a proper function. This time for function is based on the characteristics along with protection based on total flooding or surface application. With total flooding systems should the goal of the system be extinguishing and should shielded fires be extinguished.

S	FPS	T	Objective of the system	Active Medium	Basic Mechanism	Time
A	Watermist	R	Control of fires in surface application. Extinguishing of fires in total flooding application.	Water	Cooling by vaporization	LT ST
B	Automatic Sprinkler	R	Control of fires in surface application. Reduction of fires.	Water	Cooling Pre wetting	LT
C	Gas Extinguishing	R	Extinguishing of fires as total flooding application.	Several Gases	Chemical or low oxygen	ST
D	Oxygen reduction	P	Prevention of fires as total flooding application.	Nitrogen	Low oxygen	LT
E	Aerosol	R	Extinguishing of fires as total flooding application.	Aerosol	Chemical	ST
F	Powder	R	Extinguishing of fires as total flooding application. Reduction of fires in surface application.	Powder	Chemical	ST
G	Foam	R	Extinguishing of fires as total flooding application.	Foam	Low oxygen	ST
H	Water Spray Fixed	R	Control of fires in surface application.	Water	Cooling by vaporization	LT

Table 2; list of type of fire protection systems with characteristics.

Explanations:

S = scope of the FPS in the certification scheme

T = Type of system

R = Repression system reducing the effects of fires

P = Preventive system reducing the change of fires

LT = Long supply time of the medium

ST = Short supply time of the medium

3.3 TIC – Testing, Inspection and Certification

The scheme is designed to align the complete TIC chain for fire protection systems. The TIC (Testing; Inspection; Certification) scheme K21045 is arranged around following main processes.

Main processes & output.	**How**
The process of manufacturing of **products** (components) of the fire protection systems **by the manufacturer of products** of the fire protection systems. These products shall comply with the requirements in the design standard of the applicable fire protection standard.	**Testing** of the functions and performances of the components of the fire protection systems by the accredited certification bodies or laboratories or; **Testing** of the functions and performances of the components of the fire protection systems witnessed by Kiwa. The **factory production control** of the **product** at the site of the manufacturer by Kiwa or an accredited certification bodies. This assessment is based on inspections in production and audits of the supporting quality system. The evaluation by Kiwa if the manufacturer is able to fulfill the requirements of the standard and the scheme. The output by Kiwa is a Kiwa report about the initial type testing, a Kiwa report about the assessment factory production control and a Kiwa product certificate.
The **process** of design and installation or providing of a fire protection system **by a fire protection system provider** (fire protection system integrator). These fire protection systems shall comply with the requirements in the design standard of the applicable fire protection standard and shall have an **operable state**.	This assessment is based on inspections of the fire protection system and audits of the supporting quality system. **Inspection** by the accredited inspection body arranged by Kiwa, that the fire protection system complies with the design standard and the basic design at the site of the system. The output is an inspection report by the accredited inspection body. **Audits** by Kiwa of the supporting quality system at the office of the provider. The output is Kiwa audit report. The evaluation by Kiwa if the system provider is able to fulfill the requirements of the standard and the scheme. The output by Kiwa is a process certificate.
The process of **service** in the context of maintenance **by a fire protection system service provider**. These fire protection systems shall comply with the requirements in the maintenance standard of the applicable fire protection standard or the maintenance part of the design standard of the applicable fire protection standard and shall have an **operable state**.	This assessment is based on inspections of the fire protection system and audits of the supporting quality system. A**udits** by Kiwa of the maintenance process of the service provider at the site of the system. The output by Kiwa is an audit report by Kiwa about the maintenance onsite. **Audits** by Kiwa of the supporting quality system at the office of the provider. The output is Kiwa audit report. The evaluation by Kiwa if the service provider is able to fulfill the requirements of the standard and the scheme. The output by Kiwa is a service certificate.

The process of the **operating** of the fire protection system **by the user in the context of the basic design of the fire protection system**.	**Inspection** by accredited inspection body Kiwa at the site of the fire protection system if the system is used and operated in the conditions according to the standard(s) and the basic design. The output is an inspection report and an inspection certificate by the accredited inspection body.

Table 3 – setup TIC scheme.

3.3.1 Testing of the COMPONENTS of the fire protection system

The first link in the chain in this scheme is the Testing part. In the Testing part are the critical components of the fire protection system tested according to the standards on their function, performance and reliability to operate under the defined environmental conditions. Within this testing part in information collected about the engineering rules for the design of the systems. These rules must be laid down in the Design, Installation and Operating Manual (DIOM) of the typical fire protection system.

Also is the quality control assessed of the manufacturer by performing factory production controls and so determining its expertise and the capacity to produce the components that are fulfilling their function, performance and reliability.

When the product of the manufacturer has passed the testing positively and assessing of the factory production control process is also positive, the certification engineer of Kiwa shall draft a report with a positive conclusion for certification of the product and manufacturer combination. This report with positive conclusion needs to be reviewed within Kiwa. After this may be decided by Kiwa to certify the product and manufacturer combination. From that moment s it allowed for the manufacturer to make use of the Kiwa certification mark in conjunction with this scheme by the manufacturer on its approved products.

3.3.2 Certification of the fire protection system – design & installation

The second link in the chain is the fire protection system itself with the conditions needed to design and install the system such that it is functional and has the proper performance. Some of these conditions such as the fire detection system are the responsibility of the system provider.

In this part is the expertise and the capacity of the provider designing and delivering the system assessed. In this stage is the knowledge and experience of staff within this provider essential to deliver a system according to the standard(s) and applicable the DIOM of the manufacturer. If the basic design is agreed with the authorities having jurisdiction and the applicable design standards.

This capacity of the provider is assessed based on audits of the quality system of the provider and sample inspections of the preformed work onsite.

The capacity of the provider to service / maintain the system is also part of this link in the total chain.

3.3.3 Inspection of the fire protection system – system intergration with the user(s)

The third link in the chain is the fire protection system itself with all the conditions needed to make the system functional and reaching the objectives of the fire protection system. Most of these conditions are the responsibility of the owner / user of the system. In this part is the system inspected in conjunction with its specific goal, performance and use. The inputs for this inspections are the results found during the testing and certification process.

3.3.4 Reports and certificates by Kiwa

In the table below are the reports and certificate specified in this TIC process.

Components for the Fire Protection System assessed by Kiwa		
Product certification	Report	Certificate
Initial	Kiwa report about the initial type testing of the components. Kiwa report about the factory production control.	Kiwa Product certificate
Surveillance	Kiwa report about the factory production control.	Decision to continue the certificate
Design and integration of the Fire Protection System by the system integrator provider onsite assessed by Kiwa		
Process certification	Report	Certificate
Initial	Inspection reports about the fire protection systems by the accredited inspection body. Kiwa audit report about the quality control of the FP system integrator provider.	Kiwa Process certificate
Surveillance	Inspection reports about the fire protection systems by the accredited inspection body. Kiwa audit report about the quality control of the FP system integrator provider.	Decision to continue the certificate
Maintenance of the Fire Protection System by the maintenance provider onsite assessed by Kiwa		
Service certification	Report	Certificate
Initial	Kiwa audit reports about the maintenance of the fire protection systems by the FPS service provider. Kiwa audit report about the quality control of the FPS service provider.	Kiwa Service certificate
Surveillance	Kiwa audit reports about the maintenance of the fire protection systems by the FPS service provider. Kiwa audit report about the quality control of the FPS service provider.	Decision to continue the certificate
Operating of the Fire Protection System by the user onsite assessed by Kiwa		
Inspection certification	Report	Certificate
Initial and periodic	Inspection report by the accredited inspection body Kiwa about the operating of the user of the fire protection system	Kiwa Inspection certificate

Table 4 – reports and certificates

4 Principles and goals “G”

The principles and goals / objectives behind the need of a fire protection system are:

- Life safety for staff and visitors (occupancies) (fulfilling requirements within ISO19600):
- Loss prevention of investments / goods (fulfilling requirements within ISO19600):
- Business continuity processes (fulfilling requirements within ISO22301):

The engineering of the fire detection system is not the same for every goal. For the goal “**Business continuity**” is early warning of phenomes giving information about processes that could to the rise of fires important. This information should be used to check the protected area by staff onsite of the phenomes and take action when needed. This to prevent the occurrence of fire. In the case that no staff is present onsite is the fire protection system ready to repress a growing fire when needed. The function of the system based on the availably of the delivery of the active media is here an issue.

The goal “**Life safety**” is mostly used when the construction requirements are not enough to fulfil the fire safety requirements. Authorities having jurisdiction are mostly requiring a fire protection system in these cases. In these cases is the reliability of the fire protection set on higher level than normal. The function of the system based on the availably of the delivery of the active media is here an issue. These situations have more stringent requirements for matters directly related to personal safety, such as a smaller fire (less smoke development) and making escaping easier (for example by an acoustic alarm, doors open automatically, always secure escape routes).

The goal “**Loss prevention**” is mostly used when the insurance company requires additional risk reducing instruments. As repressive instrument is the fire protection system a popular possibility. The awareness and the behaviour in the protected premises of the people active in this building is also an issue and is during the inspection by Kiwa part of the assessment. This can also be an issue for the goals “Business continuity” and “Life safety”.

Note: Societal security - Business continuity management systems - Requirements (ISO22301:2012). Compliance management systems – Guidelines (ISO 19600:2014).

5 Availability of a Fire Protection System “G”

The Fire Protection System (FPS) is there to create more safety and continuity for people, process and property on site. Therefore is the business continuity or availability of the fire protection system itself an important criteria.

5.1 Components / elements of a Fire Protection System – Product Certification

Because of this should the readiness of the system or availability be high. The system is assembled based on several elements / components with a good performance on the MTBF (= Mean Time Between Failures).

To establish reliable systems demands these elements / components in the systems to fulfil the requirements of type testing with the scope “Environmental”. This means that the elements are tested according to several cruel severe environmental conditions to imitate the expected live conditions of these elements in a short test period. When needed are the components also tested on their behavior during fire.

After these environmental type testing, all the components/elements are functionally tested to check if they fulfill the requirements of product certification.

5.2 Systems engineering & installation of a Fire Protection System – Process Certification

To ensure good uptime and system availability onsite, the system design should focus on the following the six essential highlights allowing the fire protection to perform within its function:

- Supply control / reduction / extinguishing medium;
- Supply energy and backup energy of the FPS;
- Density / concentration of the control / reduction / extinguishing medium;
- Obstructions to the proper operation of the system;
- Quality of the protected compartment / area;
    - Fire resistance of the walls, ceilings, floors, doors, piping, cables, etc. ;
    - Pressure resistance or appendages for over / under pressure by the fire and / or FPS;
    - Closing / opening of doors etc.;
- Activation of the FPS;
    - Method of activation;
    - Detection of fire phenomena;
    - Groups / zones arrangements;
- Communication around the FPS;
    - Transmission of alarm and faults of the FPS to other systems and internal / external organizations;
    - Inputs form other systems or users in the FPS;
    - Organizational control of the users / owner of the FPS.

5.3 System maintenance of a Fire Protection System – Service Certification

To arrange a good uptime and system availability onsite should in the servicing of the system be focusing on the following highlights:

- The elements that are important for system design engineering;
- The servicing / maintenance requirements in the applicable standard for the system that should be easy;
- The requirements in the DIOM (Design-, Installation- and Operations Manual) of the supplier / manufacturer.

5.4 System Application Inspection of a Fire Protection Site – Inspection Certification

A fire protection system can only function in a proper way if the conditions needed to let the system function are arranged. This is not always the responsibility of the supplier of the system or the supplier of the maintenance of the system. This is the responsibility of the user / owner of the system. In this inspection by- or for Kiwa is an assessment method were shall be checked if the fire protection system meet the requirements and conditions of the design standard(s) of the fire protection system and the conditions required in the basic design of the system in conjunction with the required conditions for the construction of the building compartment(s) and the organization applying the fire protection system. These conditions can be for example a fire detection system of a closed compartment with or without a certain fire resistance. The conditions are about the construction, installation and organization (CIO) related to the fire protection system and specified in the design standard that are applicable. The requirements on the organization using the system within the property are key within this assessment.

This inspection has the goal to define if the conditions are still within the settings of the requirements. It has to give the proper feedback if the conditions together with the system are still in such a way that the availability of the fire protection system itself is still within the criteria.

6 Construction requirements of compartments for a FPS “G”

6.1 Resistance against fire

If the shell of the protected compartment needs to have a fire resistance for example according to EN 13501-2 “Fire classification of construction products and building elements - Part 2: Classification using data from fire resistance tests, excluding ventilation services” with a minimum of 30 minutes (for example). The standard mentions the following fire scenario’s:

- The standard temperature/time curve (post flash-over fire);
- The slow heating curve (smoldering fire);
- The ‘semi-natural’ fire;
- The external fire exposure curve;
- Constant temperature attack.

The minimal requirement that is applicable is E – Integrity for the wall, ceiling, floor and doors. National building regulations or the design of the building can obtain more performance characteristics such as R - Loadbearing capacity, I – Insulation, W – Radiation, etc. Do not forget to check them with the architect and/or local building authorities.

Reinforced concrete of minimal 10 cm shall fulfil this E30 characteristic.

<u>Additional fire resistance products</u>

Penetration seals have to fulfill the standard EN1366-3 “Fire resistance tests for service installations; Part 3: Penetration seals“ and certified according to the ETAG 26 series ”Guideline for European Technical Approvals for Fire Stopping and Fire Sealing Products”. The ETAG guidelines are replaced by EAD’s;
EAD 350141-00-1106; Linear Joint and Gap Seals;
EAD 350454-00-1104; Penetration Seals.

Fire protective Products have to be certified according to the ETAG 18 series. The ETAG guidelines are replaced by EAD’s;
EAD 350402-00-1106; Reactive coatings for fire protection of steel elements.
EAD 350142-00-1106; Fire Protective Board, Slab and Mat Products and Kits.
EAD 350140-00-1106; Renderings and kits based on Renderings intended to fire resisting applications.

Fire dampers in Heating, Ventilation and Air Condition systems have to fulfill the standard EN1366-2 “Fire resistance tests for service installations - Part 2: Fire dampers” and a classification according to EN13501-3 “Fire classification of construction products and building elements - Part 3: Classification using data from fire resistance tests on products and elements used in building service installations: fire resisting ducts and fire dampers”.

Important is the installation instruction of the products. These installation instructions of the manufacturer shall be obeyed to guarantee the same performance as during the initial type tests of these products. These products are to be installed in the shell of the compartment or on the shell depending the instruction of the manufacturer. The side of the shell is depending what needs protecting. Be aware that fire dampers are mostly tested mounted in the fire resistant wall.

7 Fire detection for a FPS “G”

A proper fire detection is essential to start a fire protection system in time and is an essential part of the fire protection system. It is essential to do this in time to be able to control or extinguishing the fire by the fire protection system.

The essence behind this is that the initial type testing for fire protection systems are mostly carried out with a standard model fire. This standard model fire (fire scenario) is engineered in such a way that it is determining the minimal density / concentration of the fire protection system with its typical functional media and setup of the system, that is needed for the extinguishing or control of fire.

One of the critical features in such a fire scenario is the pre-burn time of the fire scenario. The pre-burn time in the fire scenario is the time that is given to the fire to grow. After the pre-burn time is then the fire protection system activated. It is for the planning and the engineering of the fire detection system important to incorporate this pre-burn time.

When the fire detection system is not engineered based on this information is it possible that the fire protection system shall not perform as has been determined in the initial type testing of the fire protection system. The engineer of the fire detection system has also to incorporate the delay time for the activating of the fire detection system and for volume protection the maximum filling time of the fire protection system.

Fires these days in buildings are often occurring by burning solid isolation materials made of plastics and / or polymers. These isolation materials start to burn because of high heat radiation created by electrical failures or overload in circuits and / or -components.

Fires are typically started as a result of one of the following situations, or a combination.

- Faults with electrical equipment and/or circuits in combination with combustible materials.
- Wrong handling and/or behaviour by persons.
- Hazardous processes.
- Improper handling of flammable and ignitable commodities.

Examples of these are the use of open fire within closed compartments and also open areas next to or on top of buildings. This mostly in combination with the presence of easy burnable material.

In Europa are these fires mostly classified according to EN2 “Classification of fires” as an A – fire.

The electrical equipment and circuits should be electrical protected by means of an electrical fuse. Based on the situation in the equipment / circuit shall this fuse function direct or indirect. This indirect process can take its time with overload situations just under the limit.

Note. Fires are mainly be caused by problems with electrical installations in combination with combustible construction materials or by human action. Storage and processing of good flammable products create an extra dimension.

To have an proper, reliable and swift reaction should the detection principle be focussing on the thread of fire in the specific expected fire scenario. This based on the possible ignition sources and availability of burnable materials / fluids / gases. The (wrong) behaviour of people is also an element to assess in the choosing of a detection system / principle.

For reliability reasons should following detection criteria be considered: Two detector dependence and two physical fire phenomes. This should arrange that only real fire are activating the fire detection system and this setup can also be seen as a good verification method of the fire.

For a swift reaction should following detection criteria can be used: Two physical fire phenomes based on the expected fire scenarios.

Input **Fire Source**	**Output** **Fire Phenomes**	**Type of detector**	**Height**	**Reaction**
Solid (isolation) materials made of plastics and / or polymers	CO combinations. Flakes of material or dry aerosols. Heat.	CO. Tyndale / smoke.	Limited. Limited.	Proportional. Proportional.
Solid wood materials	CO combinations. Flakes of material or dry aerosols. Heat.	CO. Tyndale / smoke.	Limited. Limited.	Proportional. Proportional.
Fluids of carbon combinations / alcohol combinations	CO combinations. High heat. Flames.	CO. Heat. Flame.	Limited. Limited. -	
Other material combinations				

Table 5 – detection options

8 Alarmtransmission and alarm handeling for fire protection systems “G”

The standard “EN54-21 - Fire detection and fire alarm systems - Part 21: Alarm transmission and fault warning routing equipment” is mandatory to use within the EU for the manufacturing of elements for the alarm transmission systems between the supervised premises with the fire protection system and the alarm chain to the alarm receiving centre. The EN54-21 directs to the “EN50136-1- Alarm systems - Alarm transmission systems and equipment - Part 1: General requirements for alarm transmission systems” for the design, function and performance of these systems. The EN50136-1 directs to the “EN50518 - Monitoring and alarm receiving centre”. This standard describes that Alarm management equipment and resources shall provide the following performance. The time ΔTOP shall comply with the performance criteria contractually agreed with each client, but at least as follows: for hold-up, fire, fixed firefighting systems, people monitoring and for other alarms agreed to be of highest priority level conditions: 30 s for 80 % of alarms received and 60 s for 98,5 % of alarms received. The urgency and importance of these alarms is expressed with this performance requirement. Below is an example made of possible actions for the alarm receiving centre.

Alarm receiving of fire detection & - extinguishing.

1	About	Protocol
1	Fire Alarm Manual	• Inform Fire Brigade • Inform Client
2	Fire Alarm Automatic	• Inform Client
3	Fire Alarm automatic with verification of detection	• Inform Fire Brigade • Inform Client
4	Fire Extinguishing with verification of detection	• Inform Fire Brigade • Inform Client
5	Fault in system	• Inform Technical Support

Table 6 – escalation process by incidents

9 Gas extinghuising systems “R”

9.1 Pneumatic pressure testing

The standard EN15004-1 in chapter 8.2.3.12 contains requirements about the pneumatic pressure testing. The report of this test shall contain at least the following information:

- Project number and name;
- The type of installation;
- The scope of the protection (sections, drawing);
- The room (s) in which the test was performed (drawing);
- The date of the test;
- The manometer and test equipment used (photos);
- Description of the procedure, duration of the test, the place where pressure was applied (photo or drawing);
- Initial and final pressure of the system;
- The result of the test: passed;
- The statement that the system is unchanged after the test;
- Signed for approval by the technician who performed the test and the project manager responsible for the delivery;
- Initialling by the customer as a sign that he has seen the report.

9.2 System functional operational test

The standard EN15004-1 in chapter 8.2.7 contains requirements about the system functional operational testing. The report of this test shall contain at least the following information:

- Project number and name;
- The type of installation;
- The scope of the protection (sections, drawing);
- The room (s) in which the test was performed (drawing);
- The date of the test;
- The test method and equipment used (photos). End-to-end is minimal with the exhaust of gas for a minimal time;
- Description of the test procedure;
- The result of the test: passed;
- The statement that the system is unchanged after the test;
- Signed for approval by the technician who performed the test and the project manager responsible for the delivery;
- Initialling by the customer as a sign that he has seen the report.

10 Testing of Fire Protection Systems “G”

10.1 Performance-based design insights

Prescriptive (rule-based) and performance-based design of fire and life safety systems have practical applications, depending on a building’s use.

Additionally, both designs have benefits and drawbacks to keep in mind when determining which type to implement.

All building and fire protection system designs must adhere to a set of criteria that are specific to the goals and objectives of a project. There are multiple NFPA committees that revise prescriptive codes and standards, like NFPA 13: Standard for the Installation of Sprinkler Systems, every few years. In fact, there are currently five technical committees focused just on NFPA 13. The revisions to the codes and standards reflect advancements in industry knowledge and lessons learned from real-world fire events.

For example, the Station Nightclub Fire of 2003 prompted the National Institute of Standards and Technology to recommend a revision to model code that all existing nightclubs with an occupancy of over 100 people must be retrofitted with a sprinkler system and all new nightclubs must be built with a sprinkler system. Over the decades, dozens of fire events have contributed to the criteria of prescriptive fire codes, at the cost of life and property.

NFPA 13 states that “Nothing in this standard is intended to prevent the use of systems, methods or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability and safety over those prescribed by in this standard.”

This guidance has been in the standard since the 1983 edition was issued. It continues to state that technical documentation proving equivalency shall be submitted to the authority having jurisdiction (AHJ) that approves the use of performance-based design. Furthermore, NFPA 13 section 1.7 allows for new technology and alternate arrangements if the level of safety is not lowered. This section is very important as it shows that NFPA recognizes that there are multiple ways of achieving life Prescriptive criteria.

Examples of prescriptive criteria included in recent editions of NFPA 13 include:

- ESFR Sprinklers for Palletised, Solid-Piled or Rack Storage of Class I Through Class IV and Group A Plastic Commodities.
- Protection of Exposed Expanded Group A Plastics.
- General Requirements for Ceiling and In-Rack Sprinklers Protecting Rack Storage.
- Control Mode Density/Area Sprinkler Protection Criteria for Palletised, Solid-Piled, Bin Box, Shelf or Back-to-Back Shelf Storage of Class I Through Class IV Commodities.

The standard is full of criteria for several different water-based suppression applications, varying building uses and commodity arrays. Selection of the appropriate criteria requires the design professional to obtain specific knowledge of many items, including but not limited to: commodity classification and volume, storage layout, interior finish types, aisle widths and ceiling heights.

A significant limitation of prescriptive criteria is that it requires the facilities to be built and operated within the very specific requirements enforced by NFPA 13. This includes operational factors such as fixture types, product types, storage methods, aisles, storage, and ceiling heights, etc. That way, the associated design densities, water flows, sprinkler and pipe sizes and pipe and sprinkler arrangements of the sprinkler system are effective.

If one variable is not within the intent of the regulations of the criteria listed in the standard, then other options, prescriptive or performance-based, must be researched. and property protection, so long as the highest level of safety is maintained.

10.2 Performance-based design process

Performance-based approaches date back to the 1970s when the United States General Service Administration developed goal-oriented approaches to building fire safety. In 1985, British Regulations published a performance-based document. Following Britain over the next 10 years, New Zealand, Australia, Japan, and the Nordic Region all published their own performance-based design documents.

Later, NFPA 101: Life Safety Code was amended to allow for performance-based equivalencies in 2000 and the United States International Code Council amended International Building Code to include a performance option in the year 2003.

Performance-based suppression criteria are based on goals and objectives identified by the stakeholders of a project. These goals give the stakeholders specific objectives that must be met for an acceptable outcome. Examples might include:

10.2.1 Atmospheric temperature

If the temperature in a room exceeds 315°C for a specified period, the structural integrity of the building is compromised, and the test fails. Heavy timber is another construction type being used in buildings; it would be of use to know when atmosphere in a room reaches 65°C, because that is when pyrolysis of mass timber begins.

Furthermore, if the temperature in a room gets too hot and the interior finish ignites, perhaps the building loses its one-of-a-kind historical feature. In turn, the fire test would be considered failed, and the stakeholder would know that the fire protection design needs to be modified to prevent that design fire scenario.

10.2.2 Fire spread

If a fire jumps from the storage bay where ignition occurred to another bay before the suppression systems can control it, the test might be considered a failure because the sprinkler system wasn’t robust enough to control the fire before additional property became involved. The stakeholder would know what sprinkler configuration is truly necessary, based on the proposed use of the space.

10.2.3 Egress

If the prescriptive requirements related to building egress, such as number of exits, distance to an exit, or hallway widths of a building cannot be met due to a retrofit or change in occupancy, then performance-based criteria might include a modelled fire in this space and a subsequent egress model to prove that the building can be fully egressed before the conditions become untenable.

These are a few examples of performance-based criteria that are tailored to the goals and objectives of the stakeholder and the expertise of the fire protection engineers.

The Society of Fire Protection Engineers provides a two-phase process of using performance-based design.

10.3 Performance-based design process

Phase 1

- Determine scope of project.
- Define the goals of the project.
- Identify the project's objectives.
- Establish performance criteria.
- Create fire scenarios and trial designs.
- Evaluate in design brief.

Phase 2

- Determine if the design meets performance criteria.
- If it does not, repeat Phase 1.
- If it does, select final design.
- Create design documents.
- Building use effect on design

A building's use and construction type are the driving factors for fire protection requirements. Every building has a related risk depending on what its purpose. In addition to several specific uses, NFPA 13 has a quantified risk based on varying occupancy and hazard classifications.

10.4 Specific design process test protocols

Performance requirements / specifications for testing are laid down in standards like NFPA 750 & EN14972-1.

NFPA 750 sets performance objects for testing shall be defined such as;

1. Fire extinguishment
2. Fire suppression
3. Fire control
4. Temperature control
5. Exposure protection

The scope or listing of fire protection systems or devices shall be based on a comprehensive evaluation designed to include fire test protocols, system components, and the contents of the manufacturer's design and installation manual.

The fire test protocols shall be designed to address performance objectives of the application specified in the listing and the application parameters.

Application parameters shall be the features that define an application.

Application parameters shall include compartment variables (such as height, volume, obstructions, and ventilation), fire hazard (fuel type and configuration), and occupancy, with consideration of performance objectives specific to the application.

Fire control shall be measured using three basic approaches:

1. A reduction in the thermal exposure to the structure, where the primary objective is to maintain the structural integrity of the building (e.g., prevent flashover)
2. A reduction in the threat to occupants, where the primary objective is to minimize the loss of life
3. A reduction in a fire-related characteristic, such as heat release rate, fire growth rate, or spread to adjacent objects

Fire suppression is the sharp reduction in the heat release rate of a fire and the prevention of its regrowth by a sufficient application of media.

Fire extinguishment is the complete suppression of a fire until there are no burning combustibles.

Application Parameters

- Compartment variables shall include both the geometry of the compartment and the ventilation conditions in the compartment.
- The compartment geometry (floor area, compartment volume, ceiling height, and aspect ratio) shall be considered when designing such parameters as nozzle locations, system flow rate, and total water use needs of the system.
- Ventilation considerations shall include both natural and forced ventilation parameters.
- Natural Ventilation. The number, size, and location of the openings in the space (e.g., door, windows) shall be addressed in the design and installation of the system. In some cases, special precautions shall be given to minimize the effects of these openings, including, but not limited to, automatic door closures and water mist curtains.
- Forced Ventilation. The magnitude of the forced ventilation in the compartment shall be addressed in the design and installation of the FPS. In some cases, consideration shall be given to shutting down the forced ventilation prior to FPS activation.

Annex A 14972-1 defines following steps

The following standards is used in drafting this specific certification programs and the performance-based design process: Annex A of EN 14972-1 of 2020 - Fixed firefighting systems - Water mist systems - Part 1: Design, installation, inspection and maintenance.

a.	fuel	Class A material according to EN2: 1. bottom coverage like xxx; 2. wood construction xxx; 3. isolation material xxx; 4. cables for armatures and the armatures itself; 5. stored materials
b.	arrangements	According to standard xxx
c.	size	According to standard xxx
d.	obstructions	According to standard xxx
e.	ignition	Electrical is most obvious. *For this test a n-heptane catalysator in a can with a minimum pre-burn standard for testing of total flooding systems*

Table 7

The performance objectives to be set:

	Objective	Select	Extra information
a.	structural integrity	Building Y/N Other Y/N	
b.	damage to sensitive equipment or systems	Y / N	
c.	smoke damage	Y / N	• *Life stock* • *Electronics* • *Humans*
d.	water damage	Y / N	
e.	visibility	Y / N	
f.	tenability	Y / N	
g.	flash-over prevention	Y / N	

Table 8

The defined set of test fires include:
a) the anticipated worst-case fires with respect to possible consequences;
b) fires of greatest challenge to the tested FPS with respect to the particular application.

For example SCP02, -03, -05 & -07 have all parameters covered.
This reversed engineering approach defines a design process whereby a test protocol is drafted based on a specific risk / thread scenario for a typical location. The performance of the tests are based on the performance objectives and application parameters.

The standard EN15276-1 defines “Performance Based Characteristics”. This means that the components and fire extinguishing media of the system shall been tested for the situation or circumstances in which it is meant to be used. This is the input for the type approval of the components of the product certificate.

10.5 Fire classifications

Fire classes according to EN2

A	Fires of solid substances, mainly of an organic nature, which burn with the formation of embers. *In addition to the generally known substances such as wood, paper, etc., also plastics, rubber in combination with textiles, e.g. car tyres, etc. Substances which only for embers, e.g. artificially degassed, also belong here.*
B	Fires of liquid substances or substances that become liquid. *This includes not only liquid substances but also substances that melt when heated (semi-solid substances), which burn like a liquid, i.e. where only the vapours can burn.*
C	Fires of gases, e.g. methane, propane, hydrogen, acetylene, natural gas. *These are only substances which are already present as gas in containers of any kind (steel cylinders, pipelines, boilers, etc.). Gases escaping or formed from other substances, e.g. during degassing of wood, are not included here.*
D	Fires of metals, e.g. aluminium, magnesium, lithium, sodium, potassium and their alloys.
E	*Until 1978, fire class E in DIN 14406 described the suitability of a fire extinguisher for low-voltage installations up to 1,000 volts. With the 1978 edition of DIN 14406, however, fire class E was abolished and replaced by a danger notice. This notice is printed on the extinguisher's operating diagram and is located directly below the fire*

	class symbols. As a rule, all fire extinguishers (including water and foam fire extinguishers) can be used safely up to a voltage of 1,000 volts at a minimum distance of 1 metre.
F	Fires of cooking oils and fats. *Fires of cooking oils / fats (vegetable or animal oils and fats) in deep-frying and fat-baking equipment and other kitchen equipment and appliances.*

Table 9

Fire classes according to NFPA

A	Ordinary Combustibles
B	Flammable Liquids & Gases
C	Electrical Equipment
D	Combustible Metals
K	Cooking Oils & Fats

Table 10

Fire classes general

Ordinary combustibles / solid substances	A
Flammable Liquids	B (EU & AU)
Flammable Gases	B (US) / C (EU & AU)
Metal	D
Electrical	C (US) / E (AU) / Unclassified (EU)
Cooking oils and fats (kitchen fires)	F (EU & AU) / K (US)

Table 11

There are five occupancy types or risk groups per NFPA 13:

- Light hazard.
- Ordinary hazard group 1.
- Ordinary hazard group 2.
- Extra hazard group 1.
- Extra hazard group 2.

The differences between each group are the quantified risk based on the use of the space, especially for storage, manufacturing or processing of product, as well as the quantity and volume of contents in the space, content combustibility, content heat release rate, presence of flammable or combustible liquids and intended storage heights. The use of the space is a requisite for the types of items and activities within it.

Furthermore, if the building will be used for storage, the commodity will need to be classified as class I, II, III, IV and plastics. Plastics are classified into group A, B or C. Group A is subcategorized into expanded or nonexpanded. Expanded group A plastics are “airy” plastics, such as packing peanuts or foam. Nonexpanded plastics are any other type of plastic in which the density is not reduced by air, like plastic totes for example.

Each classification has requirements in relation to what material the commodity is stored on or in, how many layers of commodity there are within the storage box, if there is extra material within the box for packing and the volume of each material in proportion to the entire package. Commodity can also be classified as exposed or nonexposed; exposed commodity is stored within packaging that absorbs water while nonexposed would be storage-wrapped in plastic so water (or any fire suppressant that would otherwise extinguish the fuel source) cannot drip in.

Whether prescriptive or performance-based, this sort of specific information is necessary to ensure appropriate protection of the hazard. Ultimately, the purpose of commodity classifications is to choose the sprinkler system best suited for the types of contents and the challenges with the method of storage. For more information on commodity classifications, read "Commodity Classifications in NFPA 13" by Brian O'Connor.

By quantifying the occupancy and commodity type, fire protection engineers can identify a potential fire scenario because they know how hot and fast specific contents burn based on historical data from general lab testing. Then, they can determine what sprinkler design components will be necessary. The design components of a sprinkler system affected by the use of the building (occupancy and commodity type) are the number of required sprinklers, sprinkler spacing, water supply requirements and potential need for a pump or a water storage tank, sprinkler density discharge, pipe sizes and system hydraulics.

10.6 Benefits & Drawbacks of Prescriptive versus Performance-based Design

A prescriptive approach and a performance-based design approach both have advantages and disadvantages. Some are listed below. Performance-based design of fire protection systems has both benefits and drawbacks. Many items here are referenced in "Performance-Based Fire Safety Design" by Morgan J. Hurley and Eric R. Rosenbaum.

Performance-based design	
Benefits	Drawbacks
- Testing and designs are specific to each project and fire scenario. - Construction cost savings, especially for retrofit projects where part of the existing system can be salvaged as part of the new design. - Multiple scenarios can be tested to create flexibility in design options, unlike prescriptive where only one arrangement and design is permanent. - Could lessen other fire protection requirements (i.e., allows for larger compartments or reduced fire resistance ratings than prescriptive, increased egress time for occupants). - Accounts for realistic hydraulic characteristics that aren't addressed in code due to simplification assumptions. - Revolutionizes the fire protection industry's understanding of fire behavior.	- Costly upfront. - Requires extra time; could take time to conduct testing and get prior approval from authority having jurisdiction. - Validation and verification of experiment uncertainties; ways to offset uncertainty in performance testing are conducting sensitivity analyses and applying realistic safety factors. - Requires extra planning of test materials, lab time, test construction and team meetings.

Table 12

Prescriptive design	
Benefits	Drawbacks
- Formally accepted and recognized throughout the United States or jurisdiction of application. - Manufacturers and suppliers have products required by code in constant production. - Codes reference formally published fire tests by American Society for Testing and Materials and United Laboratories.	- Revisions are made on a three-year cycle so fire protection for new technology isn't represented until long after it's being used in the real world. - Only protects for fire scenarios that have already happened. - Suppresses innovation by specifying materials and methods that closely resemble but are often not exact representations of a scenario. - Assumes hydraulic simplifications that aren't always representative of real-world water and fire behavior. - Installation of prescriptive system could cost the end user significantly more to install and maintain. - Unique construction type, building use, commodity type and architectural features are not represented in the code.

Table 13

Performance-based approaches are well suited for retrofit projects because fire tests could be designed to use existing pipe sizes or sprinkler types. If part of a building's existing system is proven to be sufficient, the owner(s) can save significant spend in construction costs that would have otherwise been spent gutting and replacing an entire sprinkler system to match exactly what NFPA 13 prescriptions require. Appropriately designed performance-based systems can also provide significantly more flexibility in building use and suppression system life cycle maintenance costs for the owner.

Practical applications for performance-based design

Our world is continually evolving with new technologies and materials that currently fall outside the parameters of codes and standards in the fire protection environment. While professionals at NFPA and other regulatory agencies struggle to keep up with our evolving world, performance-based solutions function brilliantly to bridge the gap to fire safety. Additionally, user flexibility, life cycle costs, construction spend and generally improved levels of fire safety might make sense for new and future projects that are underrepresented in our current guidelines.

Examples include:

- Automatic storage retrieval systems.
- Electric vehicle charging areas.
- Car stackers.
- Lithium-ion electric bicycles sold in retail establishments.
- Green building materials not yet listed in code.
- Unique interior finishes and historical buildings.
- Unique occupancy combinations in buildings. Retrofitting an existing space to protect new products, processing or manufacturing models.

NFPA 13's allowance for performance-based design can help revolutionize the industry's knowledge of fire and protection technology. Real-world, innovative, long-term, cost-effective solutions can be developed with engineering expertise.

10.7 Surface protection versus total flooding

Within the "performance based" type tests, the performance or characteristics are determined per aerosol and per generator. These are necessary as a starting point for the design of the systems.

A "total flooding" system has been developed to fill the entire space with the extinguishing substance within a short period of time. Examples are extinguishing gas, aerosol and water mist systems. With "Surface protection", a part of the surface of the room is sprayed with water, possibly supplemented with a foam or another medium with a negative catalytic effect. Examples are sprinkler and water mist systems. Water mist can therefore be used in both concepts because it also has the capacity to completely fill a space. The tests for space filling and surface protection are different.

For surface protection, the proofing methodology is per risk group. For each risk group there is a set of objects/materials that must be checked for fire spread. The reason for this is that the scenario assumes a single source of fire that is trying to spread. Shielding the extinguishing medium by objects from the fire base is always a challenge in this scenario.

The method of proof is different for space security. This is based on the fire classes as defined in EN 2 and the performance per extinguishing agent and extinguisher is determined using a similar method as in EN 3-7. Aerosol extinguishing agents have a unique composition. Where surface security mainly focuses on the physical burden of proof, space security primarily focuses on the chemical methodology of proof. With room protection, the room is filled homogeneously with a minimum density of the medium. Shielding is less relevant because the extinguishing medium has the properties of a gas and as such is distributed evenly throughout the room. The objective in this case is therefore to extinguish and not control the fire. For room extinguishing, the minimum density of the extinguishing medium must be determined per fire class. For gas (fire class C) this is propane, for liquid (fire class B) this is heptane. For solids (fire class A), this is divided into wood (wood crib) and plastic sheet material in a frame. Most tests are carried out with screens around the fire source(s) to determine the characteristic of homogeneous distribution. The minimum density required for effective extinguishing is determined for each fire class. The general experience is that gases and liquids with a lower density of the medium are extinguished effectively because these are surface fires. With solid materials we see a similar trend with plastics because this also concerns a surface fire. With wood we see a more deep seeded fire-like phenomenon. As a result, a higher density of the extinguishing medium is required for this fire class to achieve effective extinguishing. The technical certificate accompanying the product certificate always states that you should work with a minimum design density that is determined with the compatible wood crib. So it is known that this requires higher density of the medium. Where this is carried out separately during the type tests, tests are carried out in combination during the factory visits, in which fire classes A and B and multiple fire sources are tested with an A class density. These tests do not provide any different insights than the tests performed separately. Chemically, this is a self-evident logic based on a negative catalytic effect and space filling.

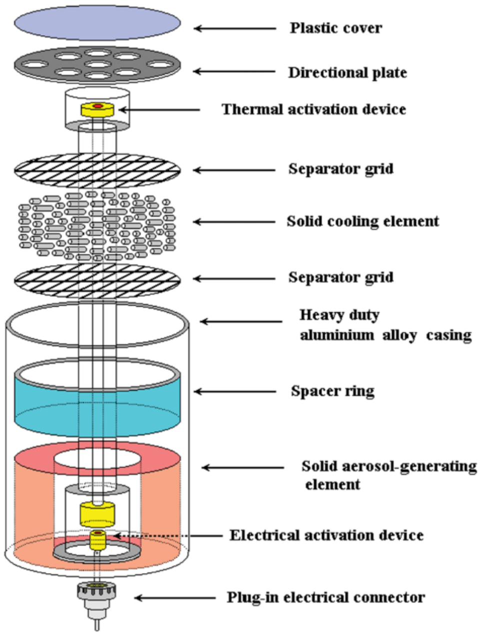
11 Aerosol systems “G”

11.1 Condensed Aerosol Fire Suppression System

Typical fire extinguishing systems found in commercial and industrial locations include sprinklers, carbon dioxide, clean agent, and dry/wet chemical agents. Another fire extinguishing technology available, is condensed aerosol. These systems take advantage of the well-established fire suppression capability of solid particulates, with potentially reduced collateral damage associated with traditional dry chemicals.

The NFPA, EN and ISO standards defines condensed aerosol as an extinguishing medium consisting of finely divided solid particles and gaseous matter, generated by a combustion process of a solid aerosol forming compound. Dry chemical agents are powder based agents that normally range in diameter from 25 to 150 micrometres, while condensed aerosols are defined by the standards as particles of less than 10 micrometres in diameter. Both produce large surface areas for reaction and are very effective extinguishants.

The fire tetrahedron identifies four elements needed for fire to occur: heat, fuel, oxidizing agent (usually oxygen), and chemical chain reaction. Fire will burn until at least one of these elements is removed. Condensed aerosol mainly interferes with the chain reaction, similar to halocarbon agents, such as Halon1301. Without the chain reaction, there’s insufficient heat necessary to maintain the fire.



11.2 Construction of Aerosol Generators

Generally, aerosol generators consist of the casing, initiation device (actuator), aerosol-forming compounds, reaction (oxidation) component, cooling component and discharge ports.

The solid aerosol generator constructed according to the principal of blast-pipe grinder which reduces the dried product to fine particles by action of jets of compressed fluid (air or nitrogen, for example) in a circular chamber called a micronizer.

11.3 Contents

The aerosol-generating chemical is a thermoplastic mixture consisting of an oxidiser, a combustible binder and additives. The oxidiser is solid potassium nitrate (KNO_3), the binder is ($C_nH_mN_pO_q$) and other ingredients for stabilisation. Combustion products of the aerosol-generating chemical consists of: potassium carbonate ($KHCO_3$, K_2CO_3), carbon dioxide (CO_2), nitrogen (N_2) and water (H_2O) and represent the actual extinguishing agent, completely environmentally friendly. Also can elements be used like magnesium or iron oxide as oxidiser.

Action of Generators

A. Three potential methods of action
B. Aerosol generation
C. Aerosol distribution

11.4 Working Principle

The principle of the extinguishing action employed by aerosol is unique – a special solid chemical, which when electrically or thermally ignited, produces combustion by products – micron sized dry particles, (mainly potassium carbonates), and a gaseous mixture, (mainly carbon dioxide, nitrogen and water vapour), mixed together into a uniform fire extinguishing aerosol, before being released into the protected area. The hot aerosol propels itself through a unique solid chemical coolant, which decomposes, absorbing huge amounts of heat, thus ensuring a flameless discharge and a uniform distribution of the cool aerosol within the area. The high rate of aerosol discharge ensures a tremendous knock down effect. Micron sized aerosol particles exhibit gas-like three-dimensional qualities that allow the agent to rapidly distribute throughout enclosure and to reach even the most concealed and shielded locations. Homogenous distribution is achieved in a matter of seconds, while long holding times all help to prevent fire re-ignition.

When activated the solid aerosol element undergoes a combustion reaction, which can schematically be represented as follows:

$$KNO_3 (s) + C_nH_mN_pO_q(s) = KHCO_3 (s) + K_2CO_3 (s) + CO_2 (g) + N_2(g) + H_2O (g)$$

Combustion products mainly consist of potassium carbonates ($KHCO_3$, K_2CO_3), carbon dioxide gas (CO_2 (g)), nitrogen gas (N_2 (g)) and water vapour (H_2O(g)) and represent the actual extinguishing agent.

As the reaction temperatures are high, potassium carbonates are formed in the gas phase, but as the vapour cools, the potassium carbonates condense to a liquid and then a solid. As solid potassium carbonates are produced by condensation, the particle size is very small – approximately from 1 to 10 microns. Micron sized solid particles mix with the gaseous carbon dioxide, nitrogen and water into a uniform homogeneous gas-like phase – an aerosol.

Thus, extinguishing aerosol is a suspension of the micron sized solid particles, mainly potassium carbonates, in the gas mix of carbon dioxide, nitrogen and water vapour.

11.5 Aerosol Extinguishing Action

(i) Removal of Flame Propagation Radicals– “chain carriers” OH, H and O in the flame zone. The chemical action of potassium radicals in aerosol is similar to that of bromine radicals in Halons and can be schematically represented as follows:

$K + OH = KOH$

$KOH + H = K + H_2O$

(ii) Recombination of flame propagation radicals– Gaseous potassium carbonates condense to a liquid and then a solid form producing a large number of micron sized particles. Being so small, the particles produce a large surface area, where recombination of “chain carriers” takes place:

$O + H = OH$

$H + OH = H_2O$

Secondarily, aerosol extinguishing action is achieved by lowering fire temperature to a temperature below which the fire reaction cannot continue (thermal cooling). Several physical mechanisms can be underlined:

(a) Heat absorption via endothermic phase changes:

$K_2CO_3 (s) \longrightarrow K_2CO_3 (l) \longrightarrow K_2CO_3 (g)$

(b) Heat absorption – via endothermic decomposition reaction:

$2KHCO_3 (s) \longrightarrow K_2CO_3 (s) + CO_2 (g) + H_2O (g)$

(iii) Dilution of the fire combustion zone by the aerosol cloud

– The extremely high surface area of the micron-size aerosol particles increases the likelihood of radical recombination and heat absorbing reactions, thus ensuring rapid extinguishment with a small amount of agent. The high rate of aerosol discharge ensures a tremendous knockdown effect. Micron sized aerosol particles exhibit gas-like three-dimensional qualities that allow the agent to rapidly distribute throughout enclosure and reach the most concealed and shielded locations. Homogeneous distribution is achieved in a matter of seconds, while long holding times all help to prevent fire re-ignition.

11.6 Application

Aerosols may be used as a fixed fire suppressant system in total flooding (prime application) and local applications to fight fires. For class C fires consideration should be given to the use of vapour detection, explosion venting or explosion suppression systems where an explosion potential may exist, owing to the possible presence of gaseous, volatile or atomised fuels either before or following a fire. It may be dangerous, under certain conditions to extinguish a burning jet of flammable gases without first shutting off its supply. The design application density required to suppress normal fires involving flammable gases and liquids at atmospheric pressure shall apply if it can be shown that a potentially explosive atmosphere cannot exist in the enclosure either before or as a result of the fire.

- Flammable liquid storage (not requiring classified electrical equipment)
- Turbine enclosures
- Electrical cabinets

- Vehicle engine compartments
- Storage vaults
- Marine engine rooms
- CNC machines
- Aviation: aircraft dry-bays, cargo compartments, engine nacelles.
- Data centres*
- Telecommunication facilities*
- Typical potential applications include the following normally non-occupied areas or enclosures (Annex C NFPA2010: Chapter 5 with annex B4 in ISO 15779: Chapter 5 in EN15276-2). When used in normally occupied areas there is a need for further assessing the risk of the users of the areas in context to the low visibility. When these users are trained in the effects of these systems together with the other technical requirements like pre-alarm and delayed discharge, this risk be assessed as reasonable. When used in an evacuation route with people that are not trained in the effects of these systems for example related to low visibility, this risk be assessed as adequate. #

Notes:

Chapter 3.33 in ISO 15779 - normally occupied area - area that is occupied by persons, under normal circumstances.

Chapter 3.41 in unoccupiable area - area which cannot be occupied due to dimensional or other physical constraint requiring intentional intervention to accomplish a function (chapter 33 in EN 15276-2).

Chapter 3.30 in EN 15276-2 - normally unoccupied area - area that is not occupied by persons under normal circumstances but may be entered occasionally for brief periods.

* Note:

When condensed aerosol is used in data centres and telecommunication facilities, Kiwa recommends to assess the application with the user and third parties based on the potential for damage to sensitive electronic equipment.

ADR classes	Additional requirements
2 – Gases EN2 = C	The generators are provided with an ATEX product certificate. The packaging content is not more than 10 litres.
3 – Flammable liquids EN2 = B	The generators have been tested according to K21045 – SCP02. The packaging content is not more than 5 litres.
4 – Flammable solids EN2 = A	With the exception of; Reactive metals (such as sodium, potassium, magnesium, titanium and zirconium), reactive hydrides, or metal amides, some of which may react violently with some aerosol extinguishants (ADR 4); Pyrophoric materials such as white phosphorous or metallo-organic compounds (ADR 4).
5 – Oxidizing substances and organic peroxides EN2 = A	With the exception of; Chemicals capable of undergoing autothermal decomposition, such as some organic peroxides (oxidizing ADR 5); Oxidizing agents such as nitric oxides and fluorine (oxidizing ADR 5); Chemicals containing their own supply of oxygen, such as cellulose nitrate (oxidizing ADR 5); Mixtures containing oxidizing materials, such as sodium chlorate or sodium nitrate (oxidizing ADR 5).
6 – Toxic and infectious substances EN2 = A of B	
8 – Corrosive substances EN2 = A of B.	The following applies for the storage of substances that fall within ADR class 8; the bases and acids are separated.
9 - Miscellaneous dangerous substances and articles EN2 = *not defined*	The following substances are not permitted for the storage of substances that fall within ADR class 9, unless a type / system test has indicated that this application is successful for the application with this extinguishing system. The substances mentioned would in principle be classified in a different category should be, but with ADR class 9 (substances without additional danger or various hazardous substances) this could be unclear. Example of this application: - SCP05 Lithium-ion.

Table 14

11.7 Limitations

The protected area should not normally be occupied due to potential hazards including reduced visibility and eye irritation during and after discharge (up to one hour), potential toxic gases generated by the aerosol-generating reaction, and hot products of combustion during discharge. Personnel should not enter the area after a system discharge until the aerosol agent has settled or is properly ventilated. Condensed aerosol agents shall not be used on fires involving the following materials:

- Deep-seated fires in Class A materials (i.e. paper, wood, cloth, rubber)

- Certain chemicals or mixtures of chemicals, such as cellulose nitrate and gunpowder, that are capable of rapid oxidation in the absence of air
- Reactive metals such as lithium, sodium, potassium, magnesium, titanium, zirconium, uranium, and plutonium
- Metal hydrides
- Chemicals capable of undergoing auto thermal decomposition, such as certain organic peroxides and hydrazine

11.8 Recommendations

Before planning to install an aerosol fire extinguishing system, please contact Kiwa to discuss the proposed application. In addition, the following should be thoroughly considered:

The design, installation, maintenance, inspection and testing should be in accordance with the latest edition of the Standards for Fixed Aerosol Fire-Extinguishing Systems. Submit system specifications, working plans, design calculations and manufacturer specification sheets for all equipment to Kiwa for review and approval prior to installation.

- Verify the protected area is not normally occupied.
- Consider the potential adverse effects of agent particulate residue on sensitive equipment and other objects. For sensitive electronic equipment, not designed for tough conditions like high humidity in combination with high contents of chlorides, Kiwa recommends using other types of fire extinguishing systems (i.e. clean agent, etc.) based on the potential for corrosion damage / dust influence.
- Select aerosol fire extinguishing systems listed by Kiwa. The system shall be installed and used to protect hazards within the limitations established by the listing.
- Ensure the structural strength and integrity of the protected enclosure in the design of a total flooding system.
- Install the aerosol generators securely at a minimum safe distance from combustible materials in accordance with the manufacturer’s recommendations.
- Provide audible and visual pre-discharge alarms within the protected area to give positive warning of impending discharge.
- Develop appropriate procedures for cleaning and restoring the protected area after system discharge.

Establish a recorded maintenance program following the equipment manufacturer’s guidelines, including the following:

- Monthly – verify the system is operational with no obvious deficiencies.
- Annually – have a qualified contractor inspect the system for proper operation, test the system according to the manufacturer’s procedures, and inspect the integrity of the protected enclosure.