MARINE

FIRE PROTECTION SYSTEM

0437/24

0086/2025

ADROIT FIRE

HAFEX®

HYBRID AEROSOL FIRE EXTINGUISHING SYSTEMS

HAFEX CONDENSED AEROSOL

FIRE EXTINGUISHING SYSTEM

01

Aerosol fire-extinguishing systems

Aerosol fire-extinguishing systems involve the release of a chemical agent to extinguish a fire by interruption of the process of the fire.

02

Condensed aerosol fire-extinguishing systems

Condensed aerosol is a fire-extinguishing medium consisting of finely divided solid particles of chemicals, generally in the order of magnitude of microns in diameter suspended in gas, releasedinto a protected space. The condensed aerosols are created in pyrotechnical generators through the combustion of the solid aerosol-generating compound.

03

Aerosol generator

Aerosol generator is a device for creating a fire-extinguishing medium by pyrotechnical means.

04

Solid aerosol-generating compound

Solid aerosol-generating compound is mixture of oxidant, combustible component and techni, cal admixtures producing fire extinguishing aerosol upon ignition.

05

Effective mass

Solid aerosol-generating compound is mixture of oxidant, combustible component and technical admixtures producing fire extinguishing aerosol upon ignition.

06

Efficiency coefficient

Efficiency coefficient is the percentage (%) of the aerosol extinguishing agent mass actually discharged from a specific aerosol generator. It is determined by comparing the mass loss of aerosol generator after discharge to initial mass of solid aerosol-generating compound.

07

Design Application Density

The design application density is the net mass of agent per unit volume (g/m3) required by the system designer for the fire protection application.

08

Net Volume

The net volume of a protected space is that part of the gross volume of the space, which is accessible to the fire-extinguishing agent.

DESIGN OF THE CONDENSED AEROSOL FIRE EXTINGUISHING SYSTEM

The required amount of solid aerosol-generating compound for the protected space should be calculated at the minimum expected ambient temperature using the design application density based on the net volume of the protect, ed space, including the casing.

Installation, Operation and Maintenance Manual for Marine Applications

$$W = \frac{V \times qe}{f}$$

where:
W: Total m ass of t he solid a erosol-generating compound required for the protected volume (g),V: Net volume of the protected space (m3),
qe: Design a pplication d ensity a s effective mass (g/m3),
f: Efficiency coefficient of the aerosol generator (%) – Table 3 .1.

Table 3.1. Effective mass and efficiency coefficient of the HAFEX condensed aerosol generators.

Generator Model	Compound Mass (g)	Effective Mass (g)	Efficiency Coefficient (%)
HFX-50	50	34	68
HFX-100	100	63	63
HFX-200	200	124	62
HFX-500	500	305	61
HFX-1100	1100	687	62.4
HFX-2200	2200	1353	61.5
HFX-3400	3400	2074	61
HFX-4500	4500	2790	62
HFX-6000	6000	3720	62

DESIGN OF AEROSOL

Alternative Design Calculation Method Without Effective Mass Concept

Aerosol fire extinguishers, according to the way the extinguishing agent is applied to the protected volume; They are divided into condensed and dispersed aerosol extinguishers (IMO MSC.1/Circ.1270, Page 3, General).

By using pyrotechnic methods in condensed aerosols, aerosol mist (alkaline metal carbonate and bicarbonate in the form of particles smaller than 10 microns, a mixture of nitrogen, water vapor, carbon dioxide) is produced from solid aerosol-generating compound stored in the aerosol generatorvia redox reaction and discharged to the protected volume. In other words, in condensed aerosols, aerosol mist components with fire extinguishing effect are not stored in the metal body of the aerosol generator but are produced chemically during discharge as a result of the redox reaction created by pyrotechnic methods. No valves, pipes, nozzles, or pressurization are required to discharge condensed aerosol extinguishing units into the protected volume.

Due to the fact that international standards on aerosol fire extinguishing systems have been prepared in general to cover both condensed and dispersed aerosols until recent years, and these two types of aerosol extinguishers show fundamental design differences with each other, there are some conceptual confusions. At the beginning of these complexities is the misuse of the concept of effective mass or efficiency coefficient. In dispersed aerosol extinguishers, the extinguishing chemical is stored in a pressurized metal body, mixed with an inert propellant. Since the extinguishing chemical is stored in the aerosol unit body, the amount of the extinguishing agent remaining in the unit body (due to insufficient amount of propellant inert gas or insufficient siphon length) after the extinguishing agent in the aerosol unit is discharged to the protected volume is important. The amount of extinguishant discharged from the dispersed aerosol extinguisher to the protected volume is called the effective mass, and the amount of extinguishant remaining in the unit body without discharge is called the residual mass. As for each type of fire extinguisher in which the chemical substance with fire extinguishing action is stored in a pressurized body, the design application intensity in dispersed aerosol is determined by the ratio of the minimum amount of extinguishing agent to the total volume, which is sufficient to extinguish the fire by being discharged into the protected volume. Therefore, the determination of the effective mass is necessary to determine the design application density of dispersed aerosol extinguishers.

In condensed aerosol extinguishers, on the other hand, the chemical substance that has an extinguishing effect, namely the aerosol mist consisting of a mixture of alkali metal carbonate and bicarbonate microparticles, nitrogen, water vapor and carbon dioxide, is not stored in the aerosol generator body, unlike dispersed aerosols. Inside the non-pressurized metal body of the condensed aerosol generator, there is solid aerosol-generating compound that pyrotechnically creates fire extinguishing aerosol mist when the generator is operated. Since the aerosol mist, which has fire extinguishing effect in condensed aerosols, is not stored in the generator body, the concept of effective mass ceases to be a valid and meaningful concept for condensed aerosols. As a result of the redox reaction occurring in the aerosol-generating compound solid blocks inside the condensed aerosol generator, besides the chemically produced aerosol mist, redox reaction residues and by-products, which do not have fire extinguishing properties and can pollute or damage the protected volume if they go out of the generator body, also produce. These reaction residues, which do not have a fire extinguishing effect, are retained by the filtration layers used in the aerosol generator body and remain in the body. These reaction by-products, which are specially filtered and retained within the aerosol generator body and do not contribute to the extinguishing efficiency of the aerosol generator, should not be confused with the concept of the residual mass in dispersed aerosol extinguishers that store the extinguishing agent within the unit body. The residual mass that remains in the body of dispersed aerosols without being discharged for various reasons is the chemical with fire extinguishing effect and has a negative effect on the fire extinguishing performance of the dispersed aerosol since it is not discharged into the protected volume. However, the amount of mass remaining in the condensed aerosol extinguisher is a chemical reaction by-product that does not have a fire extinguishing effect and can have a polluting or harmful effect on the environment if discharged into the protected volume. The aerosol mist, which has an extinguishing effect, is produced chemically in the aerosol generator, and is completely discharged to the protected volume. Therefore, as with dispersed aerosols, it does not need to be included in the calculation of residual mass and effective mass (efficiency coefficient)

Aerosol-generating compound mass (g) = Effective mass (g) / Efficiency coefficient

Effective mass (g) = Aerosol-generating compound mass (g) x Efficiency coefficients

Since the international standards on aerosol fire extinguishing systems have generally been arranged to cover all condensed and dispersed aerosols in the past years, the effective mass calculation has been used for both dispersed and condensed aerosols within the scope of the relevant standards. However, in the 2020 version of the NFPA 2010 standard on condensed aerosol fire extinguishers, all sections related to dispersed aerosols and all concepts unrelated to condensed aerosol extinguishers have been removed in order to prevent conceptual confusion in aerosol fire extinguishing systems, which are divided into two different types as dispersed and condensed aerosol fire extinguishers. The new version of the standard is designed to define condensed aerosols only (NFPA 2010:2020 – Standard for Fixed Aerosol Fire-Extinguishing Systems, page 4, Origin and Development of NFPA 2010). Therefore, the concept of effective mass (or efficiency coefficient) is not included in the NFPA 2010 standard, as of the 2020 version, as it is not related to condensed aerosol extinguishers.

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In the IMO MSC.1/Circ.1270, the approach in which both dispersed and condensed aerosol extinguishing systems are evaluated together is used, and the ratio of the difference between the mass of the aerosol generator before discharge and after discharge to the mass of the solid aeroso generating compound in the aerosol generator is called the efficiency coefficient. In the IMO MSC.1/Circ.1270 standard, the design application density is requested to be specified as the effective mass (due to the efficiency coefficient). However, since this method does not apply to the concept of effective mass for condensed aerosol extinguishing systems, and because it unneces, sarily complicates and prolongs the aerosol extinguishing system design, the design application density in the installation and user manuals of the manufacturers can be specified as mass of the solid aerosol-generating compound in the aerosol generators instead of the effective mass.

The calculation formula for required amount of the solid aerosol-generating compound is as follows:

$$W = V \times qc$$

where:
W: Total mass of the solid aerosol-generating compound required for the protected volume (g),
V: Net volume of the protected space (m3),
qc: Design application density as aerosol-generating compound mass (g/m3),

qc = 201 g/m3

The total number of the aerosol generators required for the protected volume:

$$N = \frac{W}{m}$$

where:
N: Total number of the aerosol generators required for the protected volume. It must be rounded up as an integer if it is not an integer,
W: Total mass of the solid aerosol-generating compound required for the protected volume (g),
m: Mass of the solid aerosol-generating compound contained in an aerosol generator model intended to be used in the protected volume (g) - Table 3.1.

If different generator models should be selected, the total mass of the solid aerosol-generating compound shall not be less than the required total compound mass (W)

Discharge Characteristics of Condensed Aerosol Generators

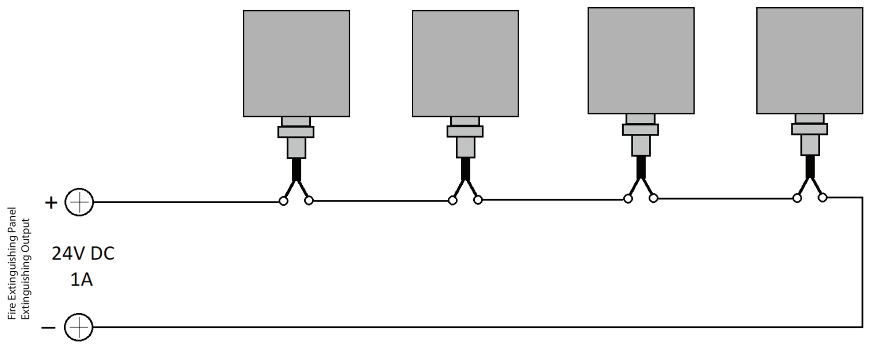
When designing the aerosol extinguishing system in environments where human beings exist, the discharge distances and minimum thermal clearance values of the aerosol generators should be considered, and the mounting heights and aerosol generator models, of which aerosol discharge temperature does not exceed the 75°C limit and which the human beings in the environment are not exposed to high aerosol discharge temperature, should be selected. In the environment where combustible and flammable materials exist, the maximum discharge temperature limit of 200°C should be considered when determining the aerosol discharge distance, suitable aerosol genera, tor models and mounting heights of the aerosol generators. The discharge characteristics of HAFEX aerosol generators models determined within the scope of IMO MSC.1/Circ.1270 are given in Table 3.2.

Table 3.2. Discharge characteristics of the HAFEX condensed aerosol generators.

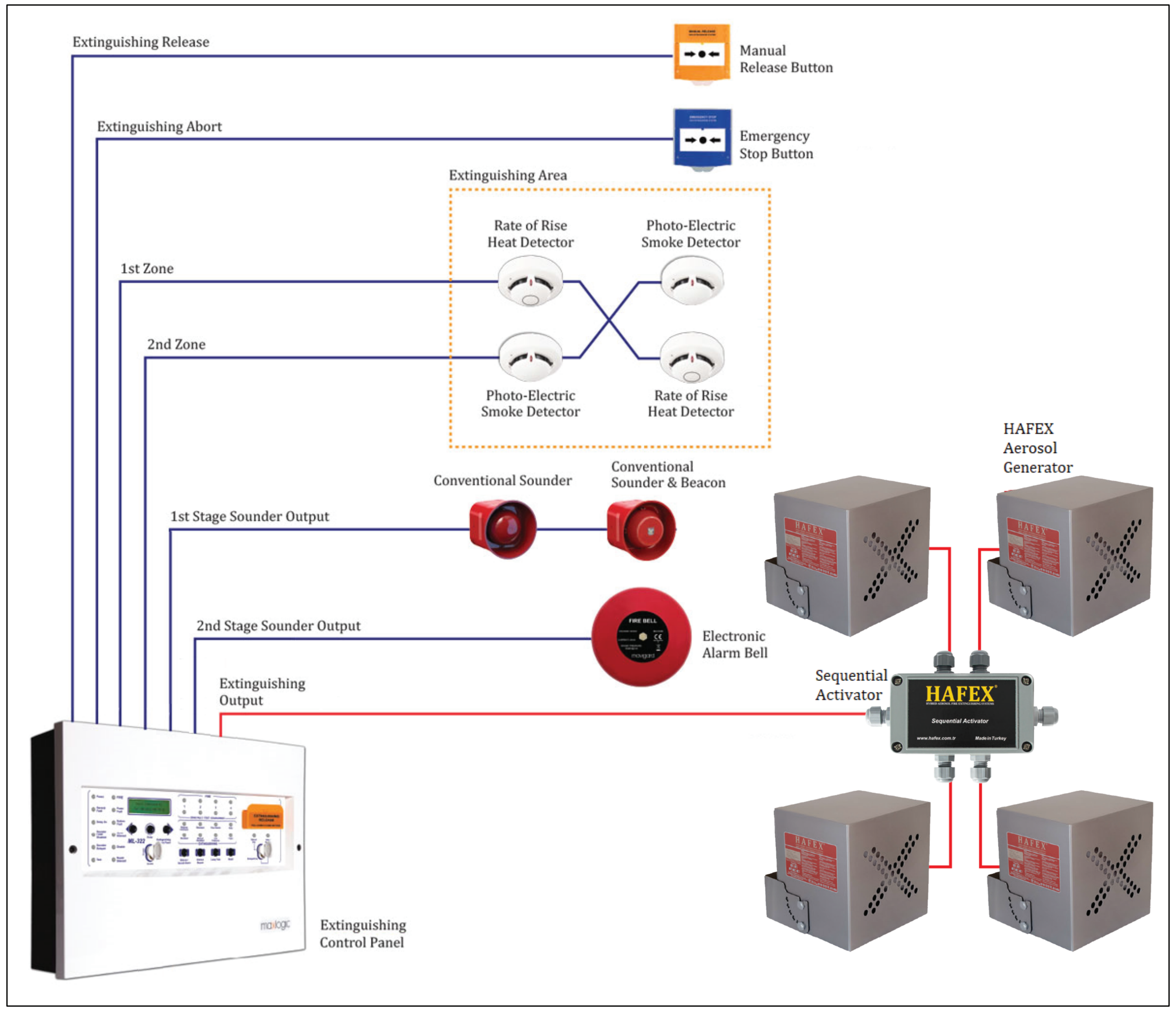
Generator Model	75°C Distance (m)	200°C Distance (m)	400°C Distance (m)	Discharge Time (sec)
HFX-50	-	-	-	3 – 5
HFX-100	0.05	-	-	4 – 6
HFX-200	0.05	-	-	4 – 6
HFX-500	0.45	0.15	-	5 – 7
HFX-1100	1.20	0.30	-	13 – 16
HFX-2200	1.50	0.30	-	14 – 17
HFX-3400	1.50	0.30	-	14 – 17
HFX-4500	2.00	1.00	0.10	15 – 18
HFX-6000	2.00	1.10	0.20	16 – 19

HAFEX MARINE FIRE DETECTION AND EXTINGUISHING SYSTEM

ANNEX-A EXAMPLES OF ELECTRICAL CONNECTION OF THE AEROSOL GENERATORS

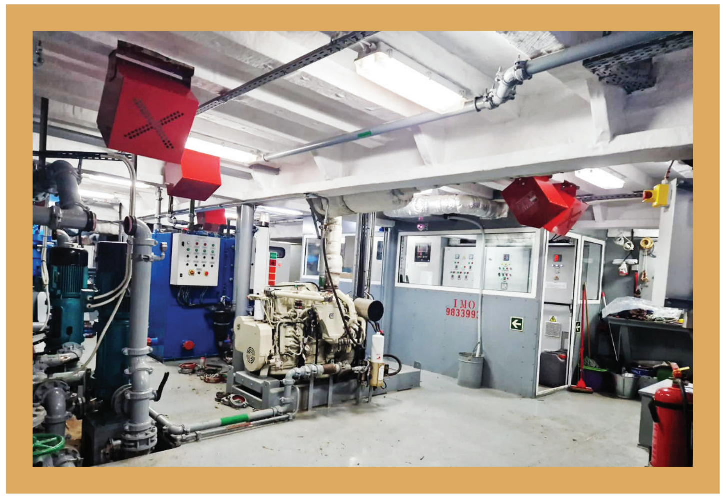


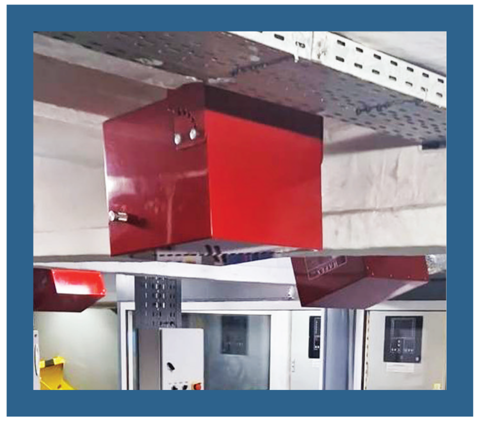
Serial connection of aerosol generators for 24V-1A extinguishing output of fire etinguishing panel



General conventional aerosol fire extinguishing system configuration

HAFEX AEROSOL PHOTO GALLERY





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