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Guidance and recommendations on design, selection and installation of vents to safeguard the structural integrity of enclosures protected by gaseous fire-extinguishing systems

Lignes directrices et recommandations relatives à la conception, à la sélection et à l'installation d'évents pour préserver l'intégrité structurelle des enceintes protégées par des systèmes d'extinction d'incendie à gaz

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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This document was prepared by Technical Committee ISO/TC 21, *Equipment for fire protection and firefighting*, Subcommittee SC 8, *Gaseous media and firefighting systems using gas.* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 191, *Fixed firefighting systems*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition cancels and replaces the first edition (ISO/TS 21805:2018), which has been technically revised.

The main changes are as follows:

— subclause 7.8.3 has been amended to cross-reference ISO 6183 for vent area calculations for CO_2;

— Annex A has been added, providing guidance on how testing in order to derive the agent-specific formulae;

— Annex B has been added, providing guidance on the procedure for developing coefficients for any new agents in the ISO 14520 series.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

The guidance presented in this document is based on the results of a joint research programme conducted in 2006 and 2007 by several fire protection system manufacturers and interested parties. The programme of work consisted of several series of tests to evaluate the peak pressure response and pressure-relief vent area effects for each agent addressed in this document. The key data used in the development of this document were the values of peak enclosure pressure response (PMAX) at each value of the volume-normalized pressure-relief vent area of the test enclosure, hereinafter referred to as the “leakage-to-volume ratio” or LVR. Other test parameters (enclosure temperature, agent quantity, discharge time and humidity) were held constant or varied in a specified manner. For each test series employing a single agent, the several pairs of LVR and resultant PMAX values were graphically analysed, and a best-fit correlation curve was determined.

The LVR vs. PMAX correlation curve for each agent or system forms the basis of the associated formulae in cases where the discharge of the agent results in cooling the air temperature below its dew point. Only halocarbon agents cause sufficient cooling to cause humidity-related effects on the peak enclosure pressure. Thus, a correction for humidity effects is included in the formulae for estimating vent area and maximum pressure on the discharge of the following agents:

— FK-5-1-12

— HFC-23

— HFC-125

— HFC-227ea

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The humidity corrections used in this document are based on the results of tests conducted with HFC-227ea at different conditions of humidity.

The resulting values for humidity correction will be assumed to be equally applicable to the agents FK-5-1-12, HFC-125 and HFC-23 until further data or analyses indicate otherwise.

The correlations of LVR to maximum negative pressure and maximum positive pressure were based on test work performed in a test chamber at a relative humidity (RH) of approximately 38 %. If the RH in a protected enclosure differs from 38 % then a correction to the estimated maximum negative and positive pressures can be required. See 7.8 and 7.9 for further information on the effect of humidity. The temperature of the test enclosure was 21°C (nominal) for all tests that form the basis of the estimating methods given in this document.

In conducting the research programme described above, a large number of different venting arrangements were created in the test enclosure. The equivalent leakage area (ELA) for each test was determined by a “door fan test” and data analysis. The average enclosure pressure in effect during the many door fan tests varied from test to test. All values of ELA were normalized to an equivalent enclosure differential pressure of 125 Pa. The resulting enclosure correlations of peak pressure vs. LVR, and any resulting estimate of enclosure pressure-relief vent area, reflect a pressure-relief vent area calculated at an effective enclosure pressure of 125 Pa for a vent with a discharge coefficient of 0,61.

The effectiveness of a gaseous total flooding firefighting system depends, in part, on retention of the air-extinguishant mixture within the protected volume for a period of time. Retention of the extinguishant-air mixture requires that gas exchange (“leakage”) between the enclosure and the ambient environment be restricted. To limit the rate of gas exchange, the enclosure boundary should have a high degree of integrity. To put it another way, the total of the areas of the various penetrations in an enclosure’s bounding surfaces should be low, at least during the gas-retention period (hold time) after the end of the extinguishant discharge.

The addition of a gaseous firefighting extinguishant to an enclosure having a limited pressure-relief vent area will naturally result in a change of pressure therein. If the enclosure is sealed too tightly during the extinguishant discharge, i.e. too little pressure-relief vent area, the pressure change could exceed the structural strength of one or more of its bounding surfaces — windows, doors, walls,

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ceiling. Conversely, if the enclosure has too much pressure-relief vent area then gas exchange with the ambient atmosphere will occur rapidly, leading to a short retention time of the extinguishant within the protected volume.

Thus, the use of gaseous firefighting systems should address two performance considerations:

a) pressure management within the protected volume during the period of extinguishant discharge, and;

b) retention of the extinguishant-air mixture within the enclosure for a specified period of time after the completion of the discharge.

This document provides guidance for limiting pressure extremes in an enclosure during the discharge of a clean agent fire extinguishing system. This document does not provide the information necessary to determine all of the requirements related to the design, installation, service, maintenance, inspection, test and/or requalification of fire suppression systems.

Some limitations and restrictions apply to the use of the formulae contained in this document. Please refer to the text and notes that follow them.

The information in this document does not supersede the manufacturer's guidance. The information contained in this document is presented as being supplementary to the guidance provided by the respective system manufacturers. Guidance from the system manufacturer should always be followed and used for purposes of system design, installation, operation and maintenance.

It has been assumed in the preparation of this document that the execution of its provisions is entrusted to people appropriately qualified and experienced in the specification, design, installation, testing, approval, inspection, operation and maintenance of systems and equipment, for whose guidance it has been prepared, and who can be expected to exercise a duty of care to avoid unnecessary release of extinguishant.

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Guidance and recommendations on design, selection and installation of vents to safeguard the structural integrity of enclosures protected by gaseous fire-extinguishing systems

1 Scope

This document gives guidelines for fulfilling the requirements contained in ISO 6183:2022, 6.4.1 and 7.4.1 and ISO 14520-1:2023, 5.2.1 h) and 5.3 h), in respect to over- and under-pressurization venting and post-discharge extract.

It considers the design, selection and installation of vents to safeguard the structural integrity of enclosures protected by fixed gaseous extinguishing systems and the post-discharge venting provisions where used.

2 Normative references

There are no normative references in this document.

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3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

NOTE For the purposes of this document, the term “bar” signifies “gauge”, unless otherwise indicated. Concentrations or quantities expressed in percentages (%) signify by volume unless otherwise indicated.

3.1
free pressure-relief vent area
sum of all free vent areas of the pressure-relief vents provided

Note 1 to entry: This is determined by the gross pressure-relief vent area multiplied by the vent efficiency.

3.2
gross pressure-relief vent area
total area of the pressure-relief vent

3.3
negative pressure
pressure in the protected room which is lower than the pressure immediately outside the enclosure boundary

3.4
peak pressure
maximum pressure (positive and negative) generated within an enclosure caused by the discharge of the gaseous agent

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3.5
positive pressure
pressure in the protected room which is higher than the pressure immediately outside the enclosure boundary

3.6
enclosure strength
specified differential pressure limit for the protected enclosure

3.7
pressure-relief area
sum of the free pressure-relief vent area and the enclosure leakage area

3.8
pressure-relief vent
device that provides a flow path through an enclosure boundary to limit the pressure therein

3.9
authority
organization, office or individual responsible for approving equipment, installations or procedure

4 Symbols and abbreviated terms

A	pressure-relief vent area (m^2)
A_N	pressure-relief vent area to limit negative pressure to a specified P_N (cm^2 or in^2)
A_P	pressure-relief vent area to limit positive pressure to a specified P_P (cm^2 or in^2)
A_T	total pressure-relief vent area (m^2)
C	agent design concentration (vol. %)
$E_{p,P}$	positive pressure excursion
$E_{p,N}$	negative pressure excursion
f_F	flooding factor (m^3/m^3)
H	relative humidity within the enclosure (%)
$L_{e,p,P}$	enclosure positive pressure limit
$L_{e,p,N}$	enclosure negative pressure limit
m	minimum design quantity of agent (kg)
M_{AGT}	molecular weight of the agent (kg/mol)
M_{AIR}	molecular weight of air (0,029; kg/mol)
M_H	is the mixture molecular weight of the agent (kg/mol)
P	pressure (Pa or psf)
P_{max}	maximum room strength (Pa)
P_N	negative pressure (Pa or psf)
P_P	positive pressure (Pa or psf)

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P_N and P_P represent either

— design pressure limits for estimating A_N or A_P, or

— estimates of maximum values of P_N or P_P for given values of A_N or A_P

Q_R quantity of agent required at reference temperature of 20 °C (m^3)

R gas law constant, 8,314 (J/mol-K)

S specific volume of the agent at the design temperature (m^3/kg)

S_{AIR} specific volume of air (m^3/kg)

S_R specific volume of the agent at the reference temperature (m^3/kg)

t discharge time (s)

t_d gaseous firefighting system discharge time (s)

T temperature (K)

V volume of the protected space (m^3)

V_A specific volume of the agent at the design temperature (m^3/kg)

V_H specific volume of the homogenous agent-air mixture (m^3/kg), which is the inverse of the density

V_V specific vapour volume of extinguishant (m^3/kg)

w maximum mass flow rate of the agent

ρ_H agent-air mixture density

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5 Use and limitations

This document is for the use by those competent in the design, installation, servicing and maintenance of fixed gaseous firefighting systems. It also serves as guidance for those involved in the design, construction and operation of buildings in which such systems are installed.

It does not replace the need for the person responsible for the design, construction and operation of the building to fulfil their obligations in respect to providing adequate structural provisions.

Other trades and services are involved in the complete system and this document is limited to providing the guidance outlined in the Scope.

After applying the enclosure peak pressure and pressure-relief vent area analysis of this document, the user can potentially conclude that an enclosure can require additional pressure-relief vent areas to avoid exceeding specified maximum pressure values upon discharge of a gaseous agent system. If that is the case, it is recommended that the user advise the supplier of a supplemental venting device, which can be specified and selected by use of this document.

The maximum pressure developed in an enclosure on the discharge of a clean agent fire extinguishing system is affected by several characteristics of the system itself and the enclosure being protected. Of particular importance are the thermodynamic properties of the agent and the discharge characteristics of the hardware. Each of the following clauses contains correlation formulae that are specific to the agent type and manufacturer's hardware. The formulae can be used to make estimates of the following:

a) enclosure pressure-relief vent area, given a specified enclosure pressure limit;

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b) maximum positive or negative pressure developed in an enclosure given a stated or calculated pressure-relief vent area.

NOTE The formulae in this document for halocarbon agents have a limited range of applicability based on the parametric limitations of the data from which they were derived. Table 1 indicates the applicable limits of design concentration, discharge time and enclosure pressure response for use in this document. The maximum peak pressure estimates (both positive and negative) based on data obtained for each agent are given in Table 1.

CAUTION — It is physically possible to develop pressures greater than those covered by this document during system discharges.

Table 1 — Summary of formulae application limits

Agent	Minimum agent conc. vol. %	Maximum agent conc. vol. %	Minimum discharge time	Maximum discharge time	Maximum over pressure Pa (pfs)	Maximum under pressure Pa (pfs)
FK-5–1-12	4,2	6	6	10	239 (5)	1 197 (25)
HFC-23	18	30	6	10	1 437 (30)	n/a
HFC-125	8	10,5	6	10	479 (10)	479 (10)
HFC-227ea	6,25	10,5	6	10	383 (8)	958 (20)

6 Safety

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6.1 Structural safety

The provision of correctly designed and engineered pressure venting of enclosures protected by gaseous fire-extinguishing systems is essential for preventing the possibility of failure of structural integrity. This is essential for mitigating forces exerted by the changes in enclosure pressure when gaseous fighting media are discharged into an enclosure.

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6.2 Personnel safety

The operation of pressure-relief vents or extract systems requires the displacement of mixtures of air/gaseous media from a protected enclosure to the atmosphere or another area not necessarily protected. Safety issues can arise due to exposure to the extinguishants themselves or products of combustion and/or extinguishant breakdown products. Also, any hazards arising from the operation of the over/under pressurization vents themselves should be considered.

7 System design — Pressure-relief venting

7.1 General

The basic design principle is to limit the pressure excursions imposed on the structure of the protected enclosure by the discharge of gaseous extinguishant to that within the limits the enclosure can withstand.

A room integrity test can be used to determine the equivalent leakage area, or simply the "vent" area that exists at the time of evaluation. The methods of this document can use the known or estimated pressure-relief vent area to estimate the maximum pressure that will be developed on the discharge of a clean agent system. If the estimated maximum pressure exceeds a specified design threshold, the methods of this document may be used to estimate a pressure-relief vent area sufficient to limit the development of pressure upon system discharge to an acceptable value.

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7.2 Extinguishant characteristics

7.2.1 Positive and negative pressurization

Consideration should be given to positive pressurization created by all extinguishants and additionally to negative pressurization created by some extinguishants as shown in Table 2.

Table 2 — Pressure effects of gaseous extinguishant

Extinguishant name	Positive pressure created	Negative pressure created
FK-5–1-12	Yes	Yes
HFC-125	Yes	Yes
HFC-227ea	Yes	Yes
HFC-23	Yes	No
IG 01	Yes	No
IG 100	Yes	No
IG 55	Yes	No
IG 541	Yes	No
CO_2	Yes	No[a]

[a] Negative pressure has been observed, with adverse effects. It can occur in certain cases where large quantities of CO_2 are released into a space having low leakage to ambient.

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7.2.2 Pressure graphs

The graphs shown in Figure 1 illustrate the typical pressure excursions that would occur during discharge within the protected area.

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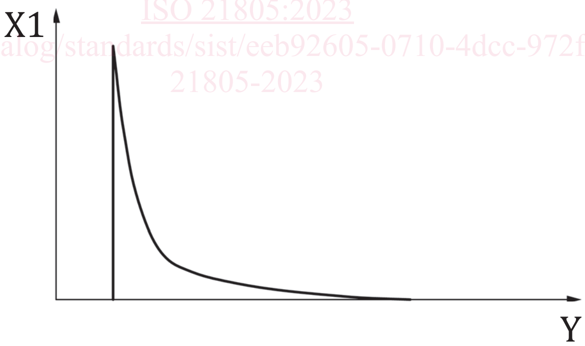
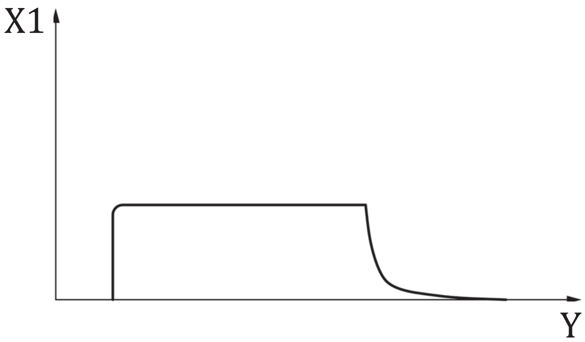
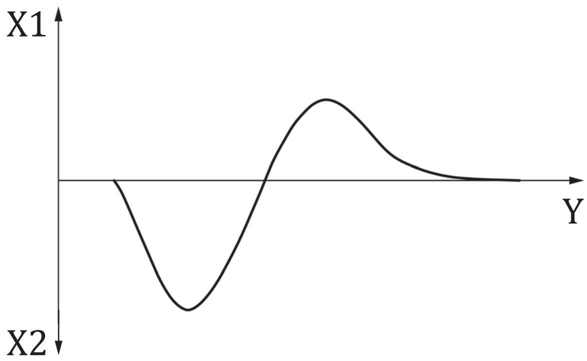


a) Inert gas



b) Inert gas (constant flow)



c) Halocarbon gas

Key

X1 positive pressure

X2 negative pressure

Y time

Figure 1 — Typical pressure excursions

7.3 Enclosure characteristics

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It is the client's responsibility and not the responsibility of the fire protection system supplier to determine room strength. The client should advise the allowable pressure differential the protected enclosures can withstand without sustaining damage.

It is generally accepted that normal masonry construction can withstand 500 Pa, while lightweight structures such as stud partitioning can withstand only 250 Pa. Both figures assume fixings at the top and bottom. Certain structure types can have even lower limits, particularly suspended ceilings. However, fire system engineers are not qualified to give guidance on room strengths, so it is up to the client to provide this information. If the client does not make clear the allowable pressure the enclosure will withstand, it is necessary to obtain their acceptance of the figures used.

Due to issues related to enclosures utilizing suspended ceilings, it is recommended that protection is provided to volumes above and below the suspended ceiling where practical.

7.4 Pressure-relief vent paths

It is generally assumed that positive/negative pressure-relief vent paths will lead to/from the atmosphere. Positive pressure-relief vent paths will assist in the safe transfer of the displaced air/extinguishant volume to the atmosphere in the most efficient, uncomplicated manner as well as ensuring air/extinguishant contaminated with fire by-products also finds a safe route to the outside air.

As positive pressure venting can involve the displacement of smoke, the possible effect on fire detection systems along the vent path should be considered.

Under certain circumstances, it can be necessary to consider the use of adjacent spaces as the means to dissipate the pressure condition, either directly as a function of the volume of that adjacent space or where the adjacent space acts as a transit path to the atmosphere. Under the circumstances described in the latter option, special venting considerations can be required to ensure the pressure condition is not simply transferred to that adjacent space (see 7.9).

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7.5 Types of pressure-relief vents

7.5.1 General

There are various types of pressure-relief vents, which are normally closed to preserve the integrity of the enclosure and which then open to relieve a pressure impulse and close again. These pressure-relief vents can fall into several categories, which are described in the following subclauses.

7.5.2 Gravity vents

The blades for these vents are generally hinged on the top edge. They have no electric or pneumatic actuation but rely totally on the enclosure pressure change to move the vent blades.

This type of vent can provide a free pressure-relief vent area significantly smaller than the gross pressure-relief vent area. In addition, the vent design creates turbulent flow and therefore is likely to create higher pressure loss for any given flow. This additional pressure loss should be factored into the determination of the free pressure-relief vent area required.

Vents, if not fitted with an end stop, for example 'cat flaps', could relieve pressures in both directions. However, these are not recommended unless they can avoid compromising the enclosure fire rating. See Figure 2.

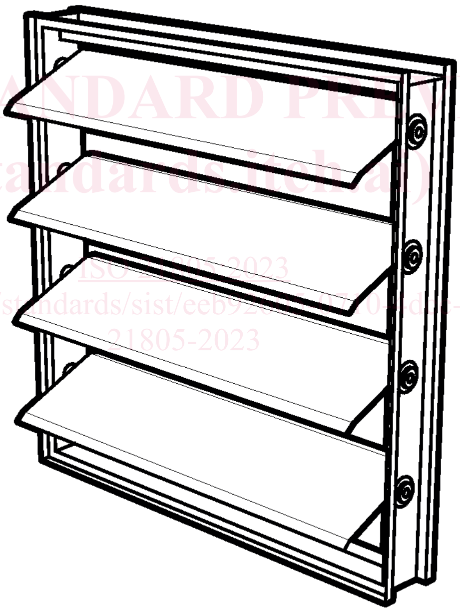

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Figure 2 — Gravity vent

7.5.3 Counterweighted flap vent

This type of vent is configured with the hinge located just off from the centre of gravity so that when positive pressure is exerted on the upstream side of the vent it allows the vent blades to pivot to their fully open positions.

The vent can be designed such that there is a minimum operational release pressure, which will ensure that nuisance movement is avoided.

Typically, these vents are more efficient (i.e. larger discharge coefficient, lower opening pressure, lower intrinsic inertia) than gravity flap vents.

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