भारतीय मानक ब्यूरो
(उपभोक्ता मामले, खाद्य एवं सार्वजनिक वितरण मंत्रालय, भारत सरकार)
BUREAU OF INDIAN STANDARDS
(Ministry of Consumer Affairs, Food & Public Distribution, Govt. of India)

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व्यापक परिचालन मसौदा

हमारा संदर्भ : सीईडी 22:4/टी-42 **09 सितंबर 2024**

तकनीकी समिति : अग्नि शमन विषय समिति, सीईडी 22

प्राप्तकर्ता :

1. **सिविल अभियांत्रिकी विभाग परिषद, सीईडीसी के सभी सदस्य**
2. **अग्नि शमन विषय समिति, सीईडी 22 और इसकी उपसमितियों के सभी सदस्य**
3. **रुचि रखने वाले अन्य निकाय।**

महोदय/महोदया,

निम्नलिखित मानक का मसौदा संलग्न हैं:

प्रलेख संख्या	शीर्षक
सीईडी 22(25695)WC	संघनित एरोसोल अग्नि शमन प्रणाली का डिज़ाइन, संस्थापना, परीक्षण और रखरखाव — रीति संहिता का भारतीय मानक मसौदा *[आईसीएस 13.220.10]*

कृपया इस मसौदे का अवलोकन करें और अपनी सम्मतियाँ यह बताते हुए भेजे कि यह मसौदा प्रकाशित हो तो इन पर अमल करने में आपको व्यवसाय अथवा कारोबार में क्या कठिनाइयां आ सकती हैं।

सम्मतियाँ भेजने की अंतिम तिथि: 09 अक्टूबर 2024

सम्मति यदि कोई हो तो कृपया अधोहस्ताक्षरी को ई-मेल द्वारा **ced22@bis.gov.in** पर या उपरलिखित पते पर, संलग्न फोर्मेट में भेजें। सम्मतियाँ बीआईएस ई-गवर्नेंस पोर्टल, **www.manakonline.in** के माध्यम से ऑनलाइन भी भेजी जा सकती हैं।

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यह प्रालेख भारतीय मानक ब्यूरो की वेबसाइट **www.bis.gov.in** पर भी उपलब्ध हैं।

धन्यवाद।

भवदीय
ह/-
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संलग्न: उपरलिखित

भारतीय मानक ब्यूरो
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WIDE CIRCULATION DRAFT

Our Reference: CED 22:4/T-42 **09 September 2024**

TECHNICAL COMMITTEE: FIRE FIGHTING SECTIONAL COMMITTEE, CED 22

ADDRESSED TO:

1. All Members of Civil Engineering Division Council, CEDC
2. All Members of Fire Fighting Sectional Committee, CED 22 and its Subcommittees
3. All others interested.

Dear Sir/Madam,

Please find enclosed the following draft:

Doc No.	Title
CED 22(25695)WC	Draft Indian Standard Design, Installation, Testing and Maintenance of Condensed Aerosol Fire Extinguishing System — Code of Practice *[ICS: 13.220.10]*

Kindly examine the attached draft and forward your views stating any difficulties which you are likely to experience in your business or profession, if this is finally adopted as National Standard.

Last Date for comments: 09 October 2024

Comments if any, may please be made in the enclosed format and emailed at ced22@bis.gov.in or sent at the above address. Additionally, comments may be sent online through the BIS e-governance portal, www.manakonline.in.

In case no comments are received or comments received are of editorial nature, kindly permit us to presume your approval for the above document as finalized. However, in case comments, technical in nature are received, then it may be finalized either in consultation with the Chairman, Sectional Committee or referred to the Sectional Committee for further necessary action if so desired by the Chairman, Sectional Committee.

The document is also hosted on BIS website www.bis.gov.in.

Thanking you,

Yours faithfully,
Sd/-
Dwaipayan Bhadra
Scientist 'E' & Head
Civil Engineering Department
Email: ced22@bis.gov.in
Phone: +91-11 2323 5529

Encl: As above

FORMAT FOR SENDING COMMENTS ON THE DOCUMENT

[Please use A4 size sheet of paper only and type within fields indicated. Comments on each clause/sub-clause/ table/figure, etc, be stated on a fresh row. Information/comments should include reasons for comments, technical references and suggestions for modified wordings of the clause. **Comments through e-mail to ced22@bis.gov.in shall be appreciated**.]

Doc. No.: CED 22(25695)WC **BIS Letter Ref**: CED 22:4/T-42

Title: Draft Indian Standard Design, Installation, Testing and Maintenance of Condensed Aerosol Fire Extinguishing System — Code of Practice [ICS: 13.220.10]

Last date of comments: **09 October 2024**

Name of the Commentator/ Organization: ____

Sl No.	Clause/ Para/ Table/ Figure No. commented	Type of Comment (General/ Technical/ Editorial)	Comments/ Modified Wordings	Justification of Proposed Change
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NOTE- Kindly insert more rows as necessary for each clause/table, etc

BUREAU OF INDIAN STANDARDS

DRAFT STANDARD FOR COMMENTS ONLY

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Draft Indian Standard

DESIGN, INSTALLATION, TESTING, AND MAINTENANCE OF CONDENSED AEROSOL FIRE EXTINGUISHING SYSTEM — CODE OF PRACTICE

(ICS 13.220.20)

Fire Fighting Sectional Committee, CED 22	**Last Date for Comments: 09 October 2024**

FOREWORD

(Formal clauses shall be added later)

Fixed firefighting applications are employed for protecting public buildings, industrial premises, or other structures, where it is desired to keep fire losses to the minimum by manual or automatic discharge of fire extinguishing media immediately upon an outbreak of fire.

Condensed aerosol generators are devices which, when assembled into a system, are designed to generate, and discharge fine potassium carbonate particles and inert gases for the extinguishment of fires. Each system consists of one or more generators, actuating assemblies for automatic or manual operation, and miscellaneous subsidiary devices. The generators are suitable for use over a temperature range of - 54 °C to + 75 °C or as otherwise noted in the individual listings.

The total flooding use of condensed aerosol generators is primarily for protection against hazards that are within an enclosure that will permit to establish and maintain the appropriate design factor of condensed aerosol for the required period of time to assure an effective extinguishment.

They are intended for normally occupied, normally unoccupied, and unoccupiable areas. The generated condensed aerosol may create a potential hazard for personnel and equipment in the protected area. In generating aerosol, high temperature products of the extinguishing media are discharged, and this characteristic should be evaluated before the generators are installed. It is important to consult the manufacturer to confirm the intended use and ensure that installation follows the approved guidelines for the specific type and associated risks.

These generators are intended for the protection against fires which fall under Class A, Class B, and Class C categories.

For the formulation of this standard assistance has been derived from the following:

ISO 15779: 2011 Condensed aerosol fire extinguishing systems —

	Requirements and test methods for components and system design, installation and maintenance — General requirements
UL 2775: 2022	Standard for fixed condensed aerosol extinguishing system units
EN 15276: 2019	Fixed firefighting systems — Condensed aerosol extinguishing systems
NFPA 2010: 2020	Standard for fixed aerosol fire-extinguishing systems

An informative Annex B has been included for toxicity and visibility testing.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value observed of calculated, expressing the result of the test, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Draft Indian Standard

DESIGN, INSTALLATION, TESTING, AND MAINTENANCE OF CONDENSED AEROSOL FIRE EXTINGUISHING SYSTEM — CODE OF PRACTICE

1 SCOPE

This standard specifies requirements and describes the methods for the design, installation, testing, maintenance and safety of condensed aerosol firefighting system and the characteristics of the extinguishing media and types of fire for which it is a suitable extinguishing medium.

This standard covers the use of condensed aerosol firefighting system in normally occupied, normally unoccupied, and unoccupiable areas, primarily related to buildings, plant and other specific applications, utilising electrically non-conducting fire extinguishant and for which there are sufficient data available to enable validation of performance characteristics by an appropriate independent authority. It is important to consult the manufacturer to confirm the intended use and ensure that installation follows the approved guidelines for the specific type and associated risks.

2 REFERENCES

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards:

IS No.	*Title*
IS 7673: 2004	Fire fighting equipment — Glossary of terms (*first revision*)
IS 2189: 2008	Selection, installation and maintenance of automatic fire detection and alarm system code of practice (Fourth Revision)
IS 732: 2019	Code of practice for electrical wiring installations (Fourth Revision)

3 TERMINOLOGY

For the purposes of this standard, definitions given in IS 7673, and the following definitions shall apply:

3.1 Actuating or Ignition Device — Any device that is able to ignite the solid aerosol-forming compound at the activation position.

3.2 Extinguishing Agent — The extinguishing agent consisting of finely divided, solid particles and gaseous matter, these being generated by a combustion process of a solid aerosol-forming compound.

3.3 Generator — A non-pressurized device which, when activated, generates a condensed aerosol. It also includes mounting brackets.

3.4 Authority Having Jurisdiction — Organisation, office or individual responsible for approving equipment, installations, or procedures.

3.5 Automatic — Functioning with no human intervention.

3.6 Automatic/ Manual Mode Switch — Means of converting the system from automatic to manual actuation.

3.7 Thermal Clearance — Air distance between a condensed generator and any structure or components sensitive to the temperature developed by the generator.

3.8 Competent Person — Designated person, suitably trained, qualified by knowledge and practical experience and with the necessary instructions to enable the required tests and examinations to be carried out.

3.9 Coolant — Heat-absorbing process or medium included within a condensed aerosol generator that effectively reduces the temperature of an aerosol extinguishing agent prior to exiting through the discharge port(s).

3.10 Design Factor or Design Application Density (g/m^3) — The minimum mass of forming compound per cubic metre of enclosure volume, including a safety factor.

3.11 Design Quantity (g) — Mass of solid forming compound necessary to achieve the design factor (design application density) in the protected volume of a specific risk. Design quantity shall be calculated by multiplying the adjusted design factor with the protected volume (m^3)

3.12 Discharge Time — Time from the generator activation to the end of its discharge.

3.13 Extinguishing Application Density/ Extinguishing Factor (g/m^3) — Minimum mass of forming compound per cubic metre of enclosed volume required to extinguish fire involving a specific fuel under defined experimental conditions, excluding any safety factors.

3.14 Extinguishant — The condensed aerosol extinguishing agent.

3.15 Extreme Conditions — The following environmental conditions are considered extreme for the purposes of assessing the efficiencies of condensed generators:

a) Exterior situations exposed to the sun, ultraviolet radiation, wind, rain, or salt spray.
b) Corrosive atmospheres.
c) Abnormally dusty or moisture-laden atmospheres.
d) Extreme temperatures.
e) Vibrations and shocks.

3.16 Family of Condensed Aerosol Generators — Range of condensed aerosol generators (varying of mass of solid compound), designed with same solid compound, same kind of cooling device and same actuating device, same layout, and same internal/external architecture.

3.17 Fire Classifications

3.17.1 *Class A* — Fires involving solid combustible materials of organic nature such as wood, paper, rubber, plastics, etc, where the cooling effect of water is essential to extinguish the fire.

3.17.2 *Class B* — Fires involving flammable liquids or liquefiable solids or the like where a blanketing effect is essential to extinguish the fire.

3.17.3 *Class C* —Fires involving flammable gases under pressure including liquefied gases, where it is necessary to inhibit the burning gas at fast rate with an inert gas, powder, or vaporizing liquid for extinguishment and energised electrical equipment.

3.18 Fire Detection and Releasing Control Panel — Device third party tested to the relevant Indian standards that are able to control the sequence of events leading to the activation of a condensed aerosol generator.

3.19 Hold Time — Duration required to maintain the extinguishing application density of the condensed extinguishing compound evenly distributed throughout protected volume.

3.20 Hot Work — Grinding, welding, thermal or oxygen cutting or heating and other related heat-producing or spark-producing operations.

3.21 Maintenance — Periodical thorough checks and testing to give maximum assurance that the extinguishing system will operate as intended, resulting in any necessary repairs or replacements of system components.

3.22 Manual Shut-off Device — A manual shut-off switch that prevents the automatic electrical actuation of generators.

3.23 Manufacturer — Legal person that is responsible for the design, manufacturing, packaging and quality insurance of a device before it is placed on the market

3.24 Monitoring — The supervision of the integrity of the operating electrical and functional components of a system

3.25 Net Enclosed Volume — Volume within the protected enclosure less the volume of any permanent and impermeable building elements within the enclosure

3.26 Extinguishing Factor or Extinguishing Density — Minimum mass of a specific aerosol forming compound per m^3 of enclosure volume required to extinguish fire involving particular fuel under defined experimental conditions excluding any safety factor. The extinguishing application density may also be referred to as the extinguishing factor.

3.27 Normally Occupied Area — Area that is occupied by persons under normal circumstances.

3.28 Normally Unoccupied Area — Area that is not occupied by persons under normal circumstances but may be entered occasionally for brief periods

3.29 Particulate Density (may also be referred as particulate concentration) — The concentration of the solid fraction of the aerosol (g/m^3) in the protected space after system discharge at the design application density. This information is necessary to assess the potential health effects of accidental exposure to the agent in occupied spaces, and the potential degree of visibility obscuration.

3.30 Release — The physical discharge or emission of an aerosol as a consequence of the generator activation.

3.31 Safety Factor — Multiplier of the extinguishing application density to determine the design application density.

3.32 Solid Aerosol-Forming Compound — Mixture of oxidant, combustible component and technical admixtures producing fire extinguishing aerosol upon ignition.

3.33 Supplier — Legal person that is responsible for the product and is able to ensure that its quality is ensured.

3.34 Total Flooding System — Firefighting system arranged to discharge extinguishant into an enclosed space to achieve the appropriate design factor (design application density).

3.35 User — Legal person, whom the system is designed for, and who is responsible for operation and to ensure the consistency of performance as described by the supplier and to follow the legal regulations.

4 FIXED EXTINGUISHING SYSTEMS DESCRIPTION AND LIMITATIONS

4.1 General

4.1.1 Condensed aerosol generators consist of a solid compound in a rigid steel casing which aerosolize finely divided solid particles typically based on alkali metal salts and gases typically comprised of nitrogen, carbon dioxide and a minor amount of water vapour. It is self-generated by a combustion process of a solid aerosol-forming compound contained in a non-pressurized canister, an aerosol generator. Generators also contain an actuation device designed to ignite the aerosol-forming compound and may have various insulating materials to cool the prior to its release into a protected area.

4.1.2 The generating combustion process provides sufficient energy for a rapid discharge and efficient distribution of the aerosol. An aerosol generator has discharge outlets in radial or axial positions and are normally placed inside the protected risk area. No piping is required.

4.1.3 Aerosols are electrically non-conductive gas-like media, which are suspended in the air in the protected volume. After period of natural suspension, the remaining after extinguishment, if not ventilated, will eventually settle down forming a dust-like fire retardant residue, normally in very small quantity.

4.1.4 The total flooding use of generators is primarily for protection against hazards that are within an enclosure that will permit to establish and maintain the appropriate design factor of condensed for the required period of time to assure an effective extinguishment.

4.1.5 Condensed aerosols are suitable for extinguishing of Class A, Class B, and Class C fires (*see* **3.17**).

4.1.6 Condensed aerosol generators are intended to be used in normally occupied, normally unoccupied and unoccupiable areas. It is important to consult the manufacturer to confirm the intended use and ensure that installation follows the approved guidelines for the specific type and associated risks.

4.1.7 Aerosol fire-extinguishing agents shall not be used on fires involving the following materials unless the agents have been tested to the satisfaction of the authority having jurisdiction:

a) Deep-seated fires in Class A materials
b) Certain chemicals or mixtures of chemicals, such as cellulose nitrate and gunpowder, that are capable of rapid oxidation in the absence of air
c) Reactive metals such as lithium, sodium, potassium, magnesium, titanium, zirconium, uranium, and plutonium
d) Metal hydrides
e) Chemicals capable of undergoing auto thermal decomposition, such as certain organic peroxides and hydrazine

NOTE — The above list may not be exhaustive.

4.1.8 Under certain conditions the potential for explosive atmospheres may exist. Areas where such potential may exist are classified as hazardous. Condensed aerosols may be used in hazardous areas subject to the manufacturer obtaining the specific listings and approvals for such areas from the ~~appropriate authorities~~ authority having jurisdiction.

4.1.9 Where generators are used in potentially explosive atmosphere, the compatibility of the generator to the atmosphere for the determined lifetime should be assessed.

4.2 Extinguishing Mechanism

4.2.1 “Fire propagation” radicals (OH, H, and O) are essential elements in the propagation of the fire. Condensed aerosol suppresses the fire (primarily) by chemical interference with these free radicals within the fire zone, thus interrupting the on-going fire reaction.

4.2.2 The Condensed aerosol is discharged as solid particles, mainly potassium radicals as components, with a typically diameter less than 5 microns. When introduced into the flaming region of a fire, the reacts with the fire radicals produced during combustion (hydrogen, oxygen, and hydroxyls) resulting in extinguishment of the fire. The small particles provide a large surface area for capturing these radicals making them effective extinguishing agents.

4.2.3 Condensed aerosols are pyrotechnically generated through the combustion of a solid compound in a generator, hereby called a condensed aerosol generator (CAG). The agent is released or formed in the exhaust of the burning compound and propelled throughout the protected enclosure with the combustion by-products of the solid compound, generally a combination of nitrogen, carbon dioxide and a minor amount of water vapour. The agent utilized is generally a combination of potassium salts.

4.2.4 In order to effectively extinguish the fire and preventing re-ignition after extinguishment, the condensed aerosol should be discharged from the generator as quickly as possible in order to flood the entire compartment. An effective design application density in the space not only has to be achieved, it also has to be maintained. The loss of density is due to both leakages from the space and due to fall out of the particles. The first loss mechanism is a function of the leakage area in the space with the flow of out of the enclosure driven by the density difference across the compartment boundaries. The second loss mechanism is driven by the size of the solid particles, with smaller particles remaining airborne in the space for a longer duration of protection.

4.2.5 When activated the aerosol, itself, consists of solid and gas combustion products. The solid phase is composed of highly dispersed particles. The gas phase may contain carbon dioxide (CO_2), nitrogen (N_2) and small amounts of water vapour.

4.3 Components

A Condensed aerosol generator typically consists of the following main components:

a) Solid aerosol forming compound,
b) Cooling mechanism,
c) Activation device,
d) End plate discharge outlets,
e) Housing, and
f) Mounting bracket

The generator is a non-pressurized canister, because is generated and distributed by the combustion process of the solid aerosol-forming compound.

4.4 Safety

4.4.1 Any hazard to personnel created by the actuation and discharge of the generators should be considered in the design of the protection in particular with reference to the hazards associated with particular extinguishant.

4.4.2 Adherence to this document does not remove the user’s statutory responsibility to comply with the appropriate safety regulations.

4.4.3 Protective gloves shall be worn when removing discharged condensed generators immediately after discharge.

4.4.4 As open flame or prolonged exposure to the temperatures exceeding 200° C may cause activation of the condensed generators, they shall be removed from a protected area prior to any hot work being carried out within their vicinity.

4.5 Reduced Visibility

4.5.1 Condensed aerosol generators are intended to be used in normally occupied, normally unoccupied and un-occupiable areas. It is important to consult the manufacturer to confirm the intended use and ensure that installation follows the approved guidelines for the specific type and associated risks. Once a generator is activated, a combustion process occurs within the generator that expels a thick white cloud (products of combustion and very fine particles) throughout the space. The particle sizes are small (< 5 micron) allowing the agent/particulate to remain suspended in the air for a long period of time. These suspended particles significantly reduce the visibility in the space.

4.5.2 If the type of aerosol has a listing for use in occupied areas, If used in occasionally occupied areas, there should be minimum of a 30 s alert, by way of a clearly indicated siren or strobe light, before the generators are activated. Safety items such as personnel training, evacuation plans and exit drills should be included in the operational plan for the occupancy.

4.6 Potential Toxicity

4.6.1 The compound is a solid block that is not friable and is contained in a rigid steel casing. At normal use, the solid blocks inside the generators are not hazardous to personnel.

4.6.2 When activated, condensed generators produce solid particles like potassium carbonate and gases such as carbon dioxide and nitrogen dioxide, which are typical by-products of the generating reaction. Actual concentrations of these by-products depend on the chemical compositions of the solid aerosol-forming compound and coolant, engineering design of the aerosol generators and conditions of the enclosure under protection. Maximum allowable exposure to a design factor of the aerosol under conditions of a sealed enclosure shall be provided for each agent by its manufacturer. At normal extinguishing concentration, the solid particles as well as the gasses present no health hazards to personnel.

4.6.3 The unknown, and potentially harmful, by-products of an actual fire pose the biggest risk to personnel.

4.6.4 A supplier of condensed generators should always provide a material safety data sheet (SDS) that lists the chemical structure of the solid block compound together with all health and safety matters required under national and international legislation. The supplier should always provide an independent report as to the toxicity of the solid, aerosol-forming block contained within their condensed generators. It is important to consult the manufacturer to confirm the intended use.

4.6.5 While the components of the condensed aerosol are not considered toxic at normal concentration levels, ingestion of the ultra-fine particulate may cause short-term discomfort and unnecessary exposure should be avoided. Tests have shown no long-term negative effects from exposure to the aerosol. The condensed aerosol has a high obscuration factor when discharged. Condensed aerosol generators are designed to be used in normally occupied, normally unoccupied and unoccupiable areas Condensed aerosol generators shall only be applied in areas where personnel may be present in conjunction with a 30 s time delay and system isolate switch to ensure egress of personnel prior to discharge.

4.7 Thermal Hazard

4.7.1 A condensed aerosol generator discharges at elevated temperatures. Depending on the intended application(s) of the system, the temperature at the reasonable minimum clearance from the discharge outlet, as specified by the manufacturer of the generators, should not exceed 75 °C for persons, 200 °C for combustible material and 400 °C for non-combustible material respectively. Immediately after discharge the generators can be hot, therefore, protective gloves shall be worn before handling generators up to 30 minutes after discharge.

4.7.2 *Minimum Thermal Clearance*

Condensed generators shall not be employed at less than the minimal thermal clearance as detailed in the technical specifications of the generator.

4.8 Turbulence

Turbulence caused by high-velocity discharge from the condensed generator may cause objects in its path to dislodge. Therefore, all items such as ceiling tiles and light fittings should be properly secured.

4.9 Oxygen Levels

Generators extinguish fires by means of interrupting the flame chain reaction chemically and do not extinguish fires by oxygen depletion. Tests have shown that the oxygen levels, after discharge of a generator, remain at normal levels.

4.10 Temperature Limitations

4.10.1 All devices shall be designed for the service they will encounter and shall not readily be rendered inoperative or susceptible to accidental operation.

4.10.2 Devices normally shall be designed to function properly from - 54 °C to + 75 °C, or marked to indicate temperature limitations, or in accordance with manufacturers' specifications which shall be marked on the nameplate, or (where there is no nameplate) in the manufacturer's instruction manual.

4.10.3 For condensed aerosols a special care shall be used to determine the maximum ambient temperature at which the generator can be installed, without risk of actuation by temperature itself.

4.11 Environmental

When a selecting an extinguishing system or agent to protect a hazard area, the effects of the agent on the environment shall be considered. The Aerosol should have zero ozone depletion potential (ODP) and less than 200 for global warming potential (GWP) after its release in gaseous form. After aerosol release the area shall be well ventilated and vacuum cleaned.

4.11.2 Electrostatic Discharge

Care shall be taken when discharging extinguishant into potentially explosive atmospheres. Electrostatic charging of generators or other conductors not bonded to earth may occur during the discharge of the extinguishant. These conductors may discharge to other objects with sufficient energy to initiate an explosion. Where the system is used for inserting, generators shall be adequately bonded and earthed.

5 EXTINGUISHANT

5.1 General

This clause sets out the requirements for the extinguishant concentrations.

5.2 Design Application Density Requirements

5.2.1 *Fire Classification*

For fire classifications, *see* **3.17**.

5.2.2 *Class B fire*

5.2.2.1 The minimum Class B design application density for each extinguishant shall be a demonstrated extinguishing application density for each Class B fuel multiplied by a safety factor of 1.3. The minimum extinguishing application density used shall be that demonstrated by the minimum extinguishing application density fire test.

5.2.2.2 Procedure, using heptane in the fire extinguishment/area coverage fire test procedure detailed in **D.6.1**. For hazards involving multiple fuels, the value for the fuel requiring the greatest design application density shall be used.

5.2.3 *Class A solid burning surface fire*

The extinguishing application density for Class A surface fires shall be determined by test using the fire test procedure described in **D-6.2** and **D-6.3.** The minimum design application density for Class A fires shall be the extinguishing application density plus a safety factor of 1.3.

5.2.4 *Electronic Data Processing (EDP) Rooms, Telecommunication, and Electronic Risks*

The extinguishing application densities for EDP rooms, telecommunications and electronic risks shall be not less than that determined in **5.2.3**., or not less than that determined from the heptane fire test described in **D.6.1**, whichever is the greater, should be used under certain conditions. These conditions may include:

a) cable bundles greater than 100 mm in diameter;
b) cable trays with a fill density greater than 20 percent of the tray cross-section;
c) horizontal or vertical stacks of cable trays (closer than 250 mm);
d) equipment energized during the extinguishment period where the collective power consumption exceeds 5 kW.

NOTE — Where electrical equipment shut down is delayed, higher concentrations, longer hold times, or other fire protection systems can be considered.

5.2.5 The safety factor of 1.3 relates to the increase of 30 percent from the extinguishing application density to the design application density, which results in additional quantity of agent. Circumstances which may need allowance for additional extinguishant (that is, more than 30 percent) include but not limited to the following:

a) Where leakage occurs from a non-tight enclosure.
b) Where leakage occurs due to doors being opened during or immediately after discharge. This should be covered by operational protocols for individual risks.
c) Where it is important to minimize the quantities of toxic or corrosive products of combustion from the fire.
d) Where it is important to minimize the toxic or corrosive breakdown products from the extinguishant itself.
e) Where excessive leakage occurs from an enclosure due to expansion of the extinguishant.

5.2.6 Under certain conditions, it may be dangerous to extinguish a burning gas jet. As a first measure, the gas supply shall be shut off.

5.2.7 The additional extinguishant required to compensate for one of the above-mentioned circumstances may increase potential inhalation toxicity of the aerosol. Care should be taken to prevent any possibility of personnel exposure to the high initial concentration of the aerosol.

5.3 Condensed Aerosol Generators Performance Requirements

5.3.1 *General*

This clause sets out requirements for the condensed aerosol generators performance.

5.3.2 *Distribution Coverage*

5.3.2.1 *Condensed generators*

The maximum area coverage and the maximum and minimum protected area height limitations for each condensed generator unit size shall be determined by the fire extinguishment/area coverage fire test procedure as described in **D.5.1** and **D.5.2**.

5.3.3 *Effective Discharge*

5.3.3.1 Discharge time shall be specified by the manufacturer and shall not exceed 60 s from the actuation time for 95 percent of the extinguishing material.

5.3.3.2 Condensed aerosol generators and released aerosols shall not cause fire or explosion during actuation and discharge. The minimum clearances from the condensed generator's discharge outlet(s) for 75 °C, 200 °C and 400 °C shall be specified in the product listing. (Refer to **6.5.2** for requirements on minimum thermal clearances.)

5.3.3.3 Parameters of the discharge shall be verified by the test procedure as described in Annex C.

5.3.4 *Ambient Temperature and Humidity Operation Range*

Condensed aerosol generators shall be operable for the total service live period within temperature and humidity range specified by the manufacturer and listed by approval agencies.

The temperature operation range shall be verified by the accelerated aging procedure as described in Annex C.

5.3.5 *Service Life*

5.3.5.1 The service life period includes the storage and installation life period for the product. Condensed aerosol generators shall be designed for the service they will encounter and shall not readily be rendered inoperative or susceptible to accidental operation. The service life of containers for typical applications shall be specified by the manufacturer and listed by approval agencies.

5.3.5.2 The specified service life shall be verified by the Accelerated Aging Test procedure as described in Annex C.

5.3.6 *Vibration and Shock Resistance*

The condensed aerosol generator and its mounting bracket shall withstand the vibration and shock resistance tests as described in Annex C.

5.3.7 *Corrosion*

The Condensed aerosol generator and its mounting bracket shall withstand the corrosion test as described in Annex C.

5.3.8 *Impact*

The packaged condensed generator shall not be a disposal hazard after the impact (drop test) as described in Annex C.

5.3.9 *Actuation Element*

The technical characteristics and actuation processes shall be specified by the manufacturer for all types of actuation devices incorporated in the condensed aerosol generator.

5.3.10 *Exposure to Fire*

Condensed aerosol generators intended for installation inside the protected enclosure shall be tested for reliability of operation and effectiveness of the discharge under the fire conditions by the test procedure as described in Annex C.

5.4 Marking

Manufacturers shall put a permanent nameplate or other permanent marking specifying the following on each container:

a) Extinguishant trade name;
b) Manufacturer;
c) Date of manufacture;
d) Serial number; and
e) Mass of aerosol-forming compound

For condensed aerosols, installers shall attach a durable metallic tag to each generator indicating the installation date, and the expiration date. Installation life (from installation to expiration date) for condensed generators depends on the specific application and the installation environment (based on expected conditions of operation, for example temperature and humidity).

6 SPECIFICATIONS, PLANS AND APPROVALS

6.1 Specifications

6.1.1 Specifications for condensed aerosol fire extinguishing systems shall be prepared under the supervision of a person fully experienced in the design of aerosol extinguishing systems and, where appropriate, with the advice of the authority. The specifications shall include all pertinent items necessary for the proper design of the system such as the designation of the authority, variances from the standard to be permitted by the authority, design criteria, system sequence of operations, the type and extent of the acceptance testing to be performed after installation of the system, owner training requirements and working documents as defined in **A-2**. The specification shall also include mounting parts for the generator.

6.1.2 Layout and system proposal documents shall be submitted for approval to the authority before installation or modification begins. The type of documentation required is specified in **Annex A**.

6.2 Enclosure

6.2.1 *Venting and Structural Strength*

6.2.1.1 The protected enclosure shall have sufficient structural strength and integrity to contain the extinguishant discharge. Venting shall be provided to prevent excessive over-pressurisation or under-pressurisation of the enclosure.

6.2.1.2 A calculation method or formula to estimate a minimum vent area shall be provided by a systems manufacturer. Type and location of pressure relief vents shall ensure maximum possible containment of the agent during and after its discharge.

6.2.2 *Loss of Extinguishant to Adjacent Hazards*

To prevent loss of extinguishant through openings to adjacent hazards or work areas, openings shall be permanently sealed or equipped with automatic closures. Where reasonable confinement of extinguishant is not practicable, protection shall be extended to include the adjacent connected hazards or work areas.

6.2.3 *Forced-Air Ventilating Systems*

Forced-air ventilating systems shall be shut down or closed automatically where their continued operation would adversely affect the performance of the fire-extinguishing system or result in propagation of the fire. Ventilation systems necessary to ensure safety are not required to be shut down upon system activation. An extended extinguishant discharge shall be provided to maintain the design concentration for the required duration of protection. The volumes of both ventilated air and the ventilation system ductwork shall be considered as part of the total hazard volume when determining extinguishant quantities. All services within the protected enclosure (for example, fuel and power supplies, heating appliances, paint spraying) that are likely to impair the performance of the extinguishing system shall be shut down prior to, or simultaneously with, the discharge of the extinguishant.

6.2.4 *Venting Requirements*

6.2.4.1 When an aerosol is discharged into a closed volume, a significant overpressure may be developed due to the amount of gases generated and the effects of increased temperature on the atmosphere.

6.2.4.2 Later, the combined volume of aerosol and air will become greater than the initial room volume. The final result will increase the pressure or will exhaust the excess volume through vent openings. The air temperature is increased during the discharge but will return to normal levels as heat is adsorbed from solid surfaces in the room.

6.2.4.3 The designer/ installer shall provide reliable calculations for venting requirements for each system if applicable.

6.3 Total Flooding Quantity

6.3.1 *General*

6.3.1.1 The effective mass of aerosol in the system shall be at least sufficient for the largest single hazard or group of hazards that are to be protected against simultaneously.

6.3.1.2 The mass of extinguishant required to achieve the design application density shall be calculated from the following equation:

$$m = \rho \times V$$

where,

m = The total flooding quantity, in g;

ρ = Design application density, in g/m^3 (may need to be adjusted to compensate for any special conditions that would adversely affect the extinguishing efficiency, *see* **6.4**);

V = Protected volume, in m^3 (may include adjacent connected hazards or work areas).

6.3.1.3 The design application density is to be specified by the manufacturer in the design manual.

6.3.1.4 In addition to these calculated total flooding quantities, additional quantities of extinguishant may be required by national standards to compensate for any special conditions that would adversely affect the extinguishing efficiency or, if required, by the physical characteristics of the extinguishant.

6.3.1.4 Where required, the reserve quantity shall be as many multiples of the main supply as the authority considers necessary.

6.4 Design Application Density Adjustment

6.4.1 *Effects of Altitude*

The design calculations of the extinguishant shall be adjusted to compensate for ambient pressures that vary by more than 11 percent (equivalent to approximately 1 000 m of elevation change) from standard sea level pressure (101 300 Pa absolute). The ambient pressure is affected by changes in altitude, pressurization or depressurization of the protected enclosure, and weather-related barometric pressure changes.

6.4.2 *Effects of temperature*

6.4.2.1 Temperature, as with altitude, has no effect on condensed aerosol design factor calculations, but it affects the extinguishants spatial distribution.

6.4.2.2 At elevated temperatures, aerosol expands to a greater specific volume. A system designed for standard conditions will therefore develop, at the same design factor, a higher distribution at elevated temperatures. Reduction in quantity of extinguishant is, however, not recommended, as it may result in lower extinguishant performance.

6.4.2.3 At lower temperatures, aerosol may expand to a lesser specific volume. This may result in lower coverage compared to that achieved under standard temperature conditions. The likelihood of this should be low due to a high velocity and the elevated temperature of aerosol being released.

6.4.2.4 At temperatures below zero, the quantity indicated at room temperature shall be increased to compensate for a lower coverage. Design factor determined at room temperature shall be multiplied by a correction factor determined by the manufacturer and included in the design manual.

6.4.3 *Effects of Ventilation*

All ventilation systems should be shut down prior to the actuation of the condensed aerosol system. However, the possibility of aerosol discharge into an enclosure that is ventilated should also be considered. In such enclosures, some extinguishant will be lost with the ventilating air. Assuming that ventilation must continue during and after discharge, a greater amount of extinguishant is required to develop a given design factor. Also, to maintain the design factor at a given level requires continuous extinguishant discharge for the duration of the holding period. The designer/installer shall provide reliable calculations for each system if applicable.

6.4.4 *Compensation for Leakage through Enclosure Openings*

The designer/installer shall provide reliable calculations for the design application density necessary to compensate for any leakage through unclosable openings.

6.5 Unit Size and Quantity of Aerosol Generators

6.5.1 *Maximum or Minimum Protected Height Limitations*

The selected unit sizes shall comply with the maximum distance and area coverage and maximum or minimum protected height limitations as specified for each unit. The maximum and minimum height and coverage distance for each unit size of the aerosol generators are determined by area coverage fire tests as described in Annex D.

6.5.2 *Minimum Thermal Clearance*

6.5.2.1 The selected unit sizes shall be appropriate for the protected area in terms of the minimum thermal clearance from the discharge outlets. If the protected area is congested or contains temperature-sensitive equipment, it would be appropriate to select several smaller units that require less minimum clearance although one large unit may be adequate in terms of achieving the required design quantity.

6.5.2.2 The following general criteria should apply:

a) For locations where personnel may be situated, the minimum thermal clearance shall refer to a temperature not exceeding 75 °C.
b) For locations where combustible materials or equipment may be situated, the minimum thermal clearance shall refer to a temperature not exceeding 200 °C.
c) For locations where non-combustible equipment may be situated, the minimum thermal clearance shall refer to a temperature not exceeding 400 °C.

6.5.3 *Several Smaller Units versus Few Large Units*

In some applications such as cable ducts and trenches, several smaller units of the same family evenly spread along the protected enclosure would provide better distribution and faster achievement of the minimum design density throughout the area although one large unit may fulfil the agent quantity requirement.

6.5.4 *Mounting Locations*

Certain protected enclosures may have very specific permissible mounting locations. This may influence the quantity and size of the units selected.

6.5.5 *Quantity of Aerosol Generators*

6.5.5.1 *general*

Quantity of aerosol generator's units needed to protect a room may be increased in order not to exceed maximum coverage distance.

6.5.5.2 *Same unit size*

$$n = \frac{m}{m_g}$$

where,

n = rounded up integer number of aerosol generators of one size;
m = the design application density, in grams;
m_g = effective mass of aerosol in one generator, in grams.

6.5.5.3 *Different unit size*

If different sizes of aerosol generators should be selected, the total mass of extinguishant shall be not less than the design quantity. If the different sizes have different design application densities, this has to be taken into account.

The height of the protected enclosure shall not exceed the maximum height limitation listed for the smallest unit size selected, unless uniformity of the aerosol distribution for the greater height has been proved by a discharge test.

6.5.6 *Multiple Generator Systems*

In case of the need of more than one aerosol generator to protect a volume, generators of the same chemistry shall be used.

6.6 Operating Conditions

In-service operating conditions, such as temperature, humidity, and vibration, shall be within ranges specified by the manufacturer and as listed by a listing authority for a specific aerosol extinguishant (*see* also **6.4**).

6.7 Duration of Protection

6.7.1 It is important that an effective extinguishant concentration not only be achieved but be maintained for a sufficient period of time to allow effective emergency action. This is equally important in all classes of fires since a persistent ignition source (e.g. an arc, heat source, oxyacetylene torch, or “deep-seated” fire) can lead to resurgence of the initial event once the extinguishant has dissipated.

6.7.2 It is essential to determine the likely period during which the extinguishing concentration will be maintained within the protected enclosure. This is known as the hold time.

6.7.3 Due to the specific characteristics of the extinction process of condensed aerosols that primarily produce particulates, no method is known to evaluate the hold time in real installations, other than real discharge which is not practical. For this reason, a specific test is required for each aerosol formulation to determine the maximum leakage area to volume ratio that provides for the minimum hold time declared by the manufacturer. For condensed aerosols that produce particulates participating in the extinction process, the approach for determining hold time is detailed in Annex D.

6.7.4 The leakage area for a specific room can be determined as the ELA value obtained with the door fan test described in IS 15493: 2021 [*see* DOC: CED 22(26518)WC]. The details of the test to determine the area/volume ratio are given in **D.7**.

6.7.5 To ensure the protection is adequate in terms of hold time, the following comparison must be fulfilled:

$$\frac{ELA}{V_{room}} \leq \text{leakage area to volume ratio } (\textbf{D.7})$$

6.7.6 The hold time shall be not less than 10 min, unless otherwise specified by the authority.

6.7.7 As the application density of a condensed aerosol cannot be measured directly by a gas analysis technique, other physical properties proportional to the application density, such as optical transmittance, could be measured providing the adequate calibration between such property and the design application density can be affected. The measuring technique, procedure and calibration method shall be listed or approved by an appropriate authority.

6.8 System Discharge

6.8.1 *Discharge Time*

The discharge time shall not exceed 60 s from the actuation or as otherwise accepted by the authorities.

6.8.2 *Effectiveness of Discharge*

The system design shall be such that:

a) the design concentration is achieved in all parts of enclosure;
b) the discharge does not cause fire or explosion;
c) the discharge does not unduly splash flammable liquids.

6.8.3 *Thermal Clearance*

In order to minimize the potential heat damage to the enclosure or its contents during discharge of the condensed aerosol generators, minimum thermal clearance from the discharge outlet(s) shall be observed as specified for the selected size of the condensed aerosol generator and as appropriate for the protected contents. Consideration shall also be given to the maximum casing temperature in relation to the heat sensitivity of the mounting and adjacent surfaces.

6.8.4 *Extended Discharge*

Where an extended discharge is necessary, the duration shall be sufficient to maintain the design density concentration for the required hold time.

6.9 Detection, Actuation and Control Systems

6.9.1 *General*

Detection, actuation, and control systems may be either automatic or manual. Where they are automatic, provision shall also be made for manual operation. Detection, actuation, alarm, and control systems shall be installed, tested and maintained in accordance with IS 2189. Unless otherwise specified in a national standard, 72 h minimum standby sources of energy shall be used to provide for operation of the detection, signalling, control, and actuation requirements of the system.

6.9.2 *Automatic Detection*

Automatic detection shall be done by any method or device approved and shall be capable of early detection and indication of heat, flame, smoke, combustible vapours, or any abnormal condition in the hazard that is likely to produce fire.

NOTE — Detectors installed at the maximum approved spacing for fire alarm use may result in excessive delay in extinguishant release, especially where more than one detection device is required to be in alarm before automatic actuation results.

6.9.3 *Operating Devices*

6.9.3.1 *Automatic operation*

Automatic systems shall be controlled by automatic fire detection and actuation systems suitable for the system and hazard and shall also be provided with a means of manual operation. Electrically operated fire detection systems shall comply with IS 2189. The electric power supply shall be independent of the supply for the hazard area and shall include an emergency secondary power supply with automatic changeover in case the primary supply fails. Because an aerosol extinguishant is a smoke-like medium in itself, release of the aerosol may cause unwanted activation of smoke detectors in adjacent areas. When two or more detectors are used, it is preferable for the system to operate only after signals from both types of detectors have been received.

6.9.3.2 *Manual operation*

Provision shall be made for manual operation of the firefighting system by means of a control situated outside the protected space or adjacent to the main exit from the space. In addition to any means of automatic operation, the system shall be provided with the following:

a) one or more means, remote from the aerosol generator containers, of manual operation; or
b) a manual device for providing direct mechanical actuation of the system; or
c) an electrical manual release system in which the control equipment monitors for abnormal conditions in the power supply and provides a signal when the power source is inadequate.

Manual operation shall cause normal operation of the generators as specified by the manufacturer.

NOTE — National standards may not require a manual release or may require the release to operate via the pre- discharge alarms and time delay.

The manual operation device shall incorporate a double action or other safety device to restrict accidental operation. The device shall be provided with a means of preventing operation during maintenance of the system.

NOTE — The choice of the means of operation depends upon the nature of the hazard to be protected. Automatic fire detection and alarm equipment is normally provided on a manual system to indicate the presence of a fire.

6.9.3.4 *Electric control equipment*

Electric control equipment shall be used to supervise the detecting circuits, manual and automatic releasing circuits, signalling circuits, electrical actuating devices and associated wiring and, when required, cause actuation. The control equipment shall be capable of operation with the number and type of actuating devices utilized.

6.9.3.5 *Operating alarm indicators*

6.9.3.5.1 *alarms and indicators*

Alarms or indicators, or both, shall be used to indicate the operation of the system, hazards to personnel, or failure of any supervised device. The type (audible, visual, or olfactory), number, and location of the devices shall be such that their purpose is satisfactorily accomplished. The extent and type of alarms or indicator equipment, or both, shall be approved.

6.9.3.5.2 *audible and visual pre-discharge alarms*

Audible and visual pre-discharge alarms shall be provided within the protected area to give positive warning of impending discharge. The pre-discharge alarms shall operate immediately on commencement of time delay upon detection of fire or manual operation of the system. The operation of the warning devices shall be continued after extinguishant discharge, until positive action has been taken to acknowledge the alarm and proceed with appropriate action.

6.9.3.5.3 *alarms indicating failure*

Alarms indicating failure of supervised devices or equipment shall give prompt and positive indication of any failure and shall be distinct from alarms indicating operation or hazardous conditions.

6.9.3.5.4 *indication for removal of an electric actuator(s)*

Removal of an electric actuator(s) from a condensed aerosol generator(s) shall result in an audible and visual indication of system impairment at the system's releasing control panel.

6.9.3.6 *system isolate switch*

The discharge of electrically operated aerosol generators in total flooding applications in areas where people may be present shall be capable of being excluded by means of a system isolating switch. For systems not compatible with occupied spaces, the system isolate shall be manually operated prior to personnel entering the protected space or adjacent areas which could be rendered hazardous by the discharge of extinguishant. The system isolate switch shall be situated outside the protected area or adjacent to the main exit from the area and protected from an accidental operation. While the system isolate switch is active and the discharge of the system is inhibited, the fire detection and alarm systems shall continue to function, and the system shall return to its operation control when the device is reactivated. The operation of the system isolate switch shall activate an indicator at the fire panel to ensure that the generators cannot be operated.

7 COMMISSIONING AND ACCEPTANCE

7.1 General

This clause sets out the minimum requirements for the commissioning and acceptance of the aerosol extinguishing system.

7.2 Tests

7.2.1 *General*

The completed system shall be reviewed and tested by a competent person to meet the approval of the authority. To determine that the system has been properly installed and will function as specified, the tests specified in **7.2.2** to **7.2.9** shall be performed.

NOTE — A system isolate switch shall be operated prior to entering the protected enclosure.

7.2.2 *Enclosure Check*

7.2.2.1 Determine that the protected enclosure is in general conformance with the plans. The actual enclosure volume and dimensions shall be checked against the protected volume calculations specified in the system design. Fan rundown and damper closure time shall be taken into consideration.

7.2.2.2 All total flooding systems shall have the enclosure checked to locate and then effectively seal any significant air leaks that could result in a failure of the enclosure to hold the specified extinguishant concentration level for the specified holding period.

7.2.2.3 Should pressure relief vents be designed for the application, determine that the effective total vent area is in conformance with the design calculations. Ensure that the type and location of the vents are in accordance with the design recommendations so as to provide maximum possible containment of the aerosol during and after its discharge.

7.2.3 *Review of Design Calculations*

7.2.3.1 The type of enclosure occupancy (occupied, normally unoccupied or unoccupied) shall be checked against that indicated in the design documentation.

7.2.3.2 The actual enclosure volumes shall be checked against those indicated in the design documentation.

7.2.3.3 The fire hazards (classes of fires) shall be checked against those indicated in the design documentation. The selected design application value shall be appropriate for the hazard. In case of multiple fire hazards the greatest design application shall be used.

7.2.3.4 An adequate quantity of extinguishant to produce the design application density shall be provided. Total flooding quantity shall be appropriate for the actual protected volume.

7.2.3.5 Operation temperature range, humidity and other expected ambient conditions shall be checked for compliance with those permissible by the manufacturer.

7.2.4 *Review of the Mechanical Components of Condensed Aerosol Generators*

a) The number and unit size(s) of the aerosol generators shall be checked for conformance to the design calculations. The number shall be adequate to produce the specified total flooding quantity. The unit size(s) shall be appropriate in relation to maximum height and area coverage limitations.
b) Orientation of the generators should be in such a manner that optimum extinguishant dispersal and containment can be affected.
c) The aerosol generators shall be installed in such a manner that they will not potentially cause injury to personnel. Extinguishant shall not directly impinge on areas where personnel may be found in the normal work area, or on any loose objects or shelves, cabinet tops, or similar surfaces where loose objects

could be present and become missiles.

d) Minimum thermal clearances from the discharge outlet(s) shall be checked against those specified in the design documentation for the type of the enclosure occupancy, equipment and materials present in the enclosure.

e) The aerosol generators and mounting brackets shall be securely fastened in accordance with the manufacturer's requirements. Specified mounting brackets or supports shall be used for each unit size of the aerosol generator.

7.2.5 *Review of Electrical Components*

NOTE — Prior to the start of any work, the wiring from the releasing panel(s) to all aerosol generators shall be disconnected. When testing circuitry, it is recommended that a method be used to verify that the necessary current is available by inserting a resistor into the line equivalent to the resistance of the generator and measuring the minimum current that is specified by the manufacturer that is actually delivered.

7.2.5.1 All wiring systems shall be properly installed in compliance with the IS 732 and the system drawings. AC and DC voltage wiring shall not be combined in a common conduit unless properly shielded and grounded.

7.2.5.2 All field circuitry should be tested for maximum supervisory and minimum activation current.

7.2.5.3 All field circuitry shall be tested for ground fault and short circuit condition. When testing field circuitry, all electronic components (such as smoke and flame detectors or special electronic equipment for other detectors, or their mounting bases) shall be removed and jumpers properly installed to prevent the possibility of damage within these devices. Replace components after testing the circuits.

7.2.5.4 Adequate and reliable primary standby sources of energy which comply with **6.9.1** shall be used to provide for operation of the detection, signalling, control, and actuation requirements of the system.

7.2.5.5 All auxiliary functions (such as alarm sounding or displaying devices, remote annunciators, air handling shutdown, power shutdown, etc.) shall be checked for proper operation in accordance with system requirements and design specifications.

7.2.5.6 Alarm devices shall be installed so that they are audible and visible under normal operating and environmental conditions. Where possible, all air-handling and power cut-off controls should be of the type that once interrupted require manual restart to restore power.

7.2.5.7 Check that for systems using alarm silencing, this function does not affect other auxiliary functions such as air handling or power cut-off where they are required in the design specification.

7.2.5.8 Check the detection devices to ensure that the types and locations are as specified in the system drawings and are in accordance with the manufacturer's requirements.

7.2.5.9 Check that manual release devices are properly installed, and are readily accessible, accurately identified and properly protected to prevent damage.

7.2.5.10 Check that all manual release devices used to release extinguishants require two separate and distinct actions for operation. They shall be properly identified. Particular care shall be taken where manual release devices for more than one system are in close proximity and could be confused or the wrong system actuated. Manual release devices in this instance shall be clearly identified as to which hazard enclosure they protect.

7.2.5.11 Check that for systems with a main/reserve capability, the main/reserve switch is properly installed, readily accessible and clearly identified.

7.2.5.12 Check that for systems using isolate switches these are located at each entrance to the protected area, properly installed and clearly identified.

7.2.5.13 Check that the control panel is properly installed and readily accessible. Check that a system isolate switch is located in the panel, properly installed and secured from unauthorized use.

7.2.6 *Preliminary Function Tests*

7.2.6.1 Where a system is connected to a remote central alarm station, notify the station that the fire system test is to be conducted and that an emergency response by the fire department or alarm station personnel is not required. Notify all concerned personnel at the end-user's facility that a test is to be conducted and instruct them as to the sequence of operation.

7.2.6.2 Operate system isolate switch before entering the protected area. For condensed aerosols, the wiring from the releasing panel(s) to all aerosols shall be disconnected. Reconnect the release circuit with a functional device in lieu of each extinguishant unit release mechanism. For electrically actuated release mechanisms, these devices may include suitable lamps, flash bulbs or circuit breakers. Pneumatically actuated release mechanisms may include pressure gauges. Refer to the manufacturer's recommendations in all cases.

7.2.6.3 Check each resettable detector for proper response.

7.2.6.4 Check that polarity has been observed on all polarized alarm devices and auxiliary relays.

7.2.6.5 Check that all required end-of-line devices have been installed.

7.2.6.6 Check all supervised circuits for correct fault response.

7.2.7 *System Functional Operational Test*

7.2.7.1 Operate the detection initiating circuit(s). All alarm functions shall occur according to the design specifications.

7.2.7.2 Operate the necessary circuit to initiate a second alarm circuit if present. Verify that all second alarm functions occur according to design specifications.

7.2.7.3 Operate the manual release device. Verify that manual release functions occur according to design specifications.

7.2.7.4 Where appropriate, operate the system isolate switch. Verify that functions occur according to the design specifications. Confirm that visual and audible supervisory signals are received at the control panel.

7.2.7.5 Check pneumatic equipment, where fitted, for integrity to ensure proper operation.

7.2.7.6 Remove the actuator, where fitted, to verify a fault indication at the panel.

7.2.8 *Remote Monitoring Operations*

7.2.8.1 Disconnect the primary power supply, then operate one of each type of input device while on standby power. Verify that an alarm signal is received at the remote panel after the device is operated. Reconnect the primary power supply.

7.2.8.2 Operate each type of alarm condition and verify receipt of fault condition at the remote station.

7.2.9 *Control Panel Primary Power Source*

7.2.9.1 Verify that the control panel is connected to a dedicated switched off circuit and is labelled properly. This panel shall be readily accessible, but access shall be restricted to authorized personnel only.

7.2.9.2 Test a primary power failure in accordance with the manufacturer's specification, with the system fully operated on standby power.

7.2.10 *Completion of Functional Tests*

When all functional tests are complete (**7.2.6** to **7.2.9**), reconnect each extinguishant unit so that activation of the release circuit will release the extinguishant. When reconnecting the units, ensure that the system isolate switch is activated so that release circuit will not operate. After exiting the enclosure, disable the system isolate switch so that the system is returned to its fully operational design condition. Notify the central alarm station and all concerned personnel at the end-user's facility that the fire system test is complete, and that the system has been returned to full-service condition by following the procedures specified in the manufacturers' specifications.

7.2.11 *Completion Certificate and Documentation*

The installer shall provide the user with a completion certificate, a complete set of instructions, calculations and drawings showing the system as installed, and a statement that the system complies with all the appropriate requirements of this standard, providing details of any deviations from appropriate recommendations. The certificate shall give the design parameters and, if carried out, reports of any additional tests including the door fan test.

8 INSPECTION, MAINTENANCE, TESTING AND TRAINING

8.1 General

This clause specifies the requirements for inspection, maintenance and testing of an aerosol fire-extinguishing system and for the training of inspection and maintenance personnel.

8.2 Inspection

8.2.1 *General*

8.2.1.1 At least annually, or more frequently as required by the authority, all systems shall be thoroughly inspected and tested for proper operation by competent personnel.

8.2.1.2 The inspection report with recommendations shall be filed with the owner.

8.2.1.3 At least every six months, all aerosol generator assemblies shall be visually inspected, and the visual inspection shall verify whether:

a) the generator’s casing and actuator(s) are undamaged;
b) the generators are securely mounted;
c) the generators are free from corrosion;
d) the expiration date does not occur prior to the next scheduled inspection; and
e) the generator discharge path is unobstructed.

If the generators are installed in separate housing forming part of the listed assembly, an inspection of the housing meets the intent of this clause.

8.2.1.4 Discharged or expired aerosol generators removed during service or maintenance procedures shall be collected and recycled, or disposed of in an environmentally sound manner, and in accordance with existing laws and regulations.

8.2.1.5 The date of inspection and the name of the person performing the inspection shall be recorded on a tag attached to the aerosol generator.

8.2.2 *Enclosures*

8.2.2.1 At least every 12 months it shall be determined whether boundary penetration or other changes to the protected enclosure have occurred that could affect leakage and extinguishant performance.

8.2.2.2 Where the integrity test reveals increased leakage that would result in an inability to retain the extinguishant for the required period, remedial action shall be carried out.

8.2.2.3 Where it is established that changes to the volume of the enclosure or to the type of hazard within the enclosure, or both, have occurred, the system shall be redesigned to provide the original degree of protection. It is recommended that the type of hazard within the enclosure, and the volume it occupies, be regularly checked to ensure that the required concentration of extinguishant can be achieved and maintained.

8.2.2.4 Where pressure relief vents are installed, the devices shall be inspected for any mechanical damage and other impacts that could affect their operation. The effective vent area shall be checked for conformance with the design calculations.

8.3 Maintenance

8.3.1 *General*

The user shall carry out a programme of inspection, arrange a service schedule, and keep records of the inspections and servicing.

NOTE — The continued capability for effective performance of a firefighting system depends on fully adequate service procedures with, where possible, periodic testing.

Installers should provide the user with a record in which inspection and service details can be entered.

8.3.2 *User's Programme of Inspection*

The installer shall provide the user with an inspection programme for the system and components. The programme shall include instructions on the action to be taken in respect of faults. The user's inspection programme is intended to detect faults at an early stage to allow rectification before the system may have to operate. A suitable programme is as follows:

a) *Weekly* — Visually check the hazard and the integrity of the enclosure for changes which might reduce the efficiency of the system. Carry out a visual check that there is no obvious damage to the system and that all operating controls and components are properly set and undamaged.
b) *Monthly* — Check that all personnel who may have to operate the equipment or system are properly trained and authorized to do so and, in particular, that new employees have been instructed in its use.

NOTE — Always operate a system isolate switch prior to entering the protected enclosure if the unit is not approved for occupied spaces.

8.3.3 *Service Schedule*

A service schedule shall include requirements for periodic inspection and test for the complete installed system, including aerosol containers, as specified in the appropriate national standards. The schedule shall be carried out by a competent person who shall provide to the user a signed, dated report of the inspection, advising any rectification carried out or needed. During servicing, every care and precaution shall be taken to avoid release of extinguishant.

8.4 Training

All persons who may be expected to inspect, test, maintain or operate fire-extinguishing systems shall be trained and kept adequately trained in the functions they are expected to perform. Personnel working in an enclosure protected by an aerosol extinguishant shall receive training in the operation and use of the system, in particular regarding safety issues.

ANNEX A
(*Clauses* 6.1.1 *and* 6.1.2)

DOCUMENTATION REQUIREMENTS

A-1 GENERAL

These documents shall be prepared only by persons fully experienced in the design of extinguishing systems. Deviation from these documents shall require permission from the relevant authority.

A-2 WORKING DOCUMENTS

Working documents shall include at least the following items:

a) location drawings;
b) name of owner and occupant;
c) location of building in which hazard is located;
d) location and construction of protected enclosure walls and partitions;
e) enclosure cross-section, full height, or schematic diagram, including raised access floor and suspended ceiling;
f) type of aerosol generators being used;
g) design application density;
h) description of occupancies and hazards to be protected against;
j) specification of aerosol generators used;
k) equipment schedule or list of materials for each piece of equipment or device, showing device name;
m) manufacturer, model or part number, quantity, and description;
n) system calculation;
p) enclosure pressurization and venting calculations; and
q) description of fire detection, actuation, and control systems.

ANNEX B
(*Foreword*)

TOXICITY AND VISIBILITY TESTING

B-1 INTRODUCTION

In the fire protection sector, health and safety depends upon an individual's ability to escape a fire hazard. This ability could be impaired if a fire suppressant has an immediate toxic effect or decreases visibility necessary to exit an occupied space. These factors may also pose risks in a non-fire situation. Both immediate and delayed toxicity are of concern when powdered aerosols are used. The following discussion provides guidance to assist in characterizing immediate and delayed toxicity. Authorities having jurisdiction may wish to consider this information when assessing powdered aerosol fire extinguishers for occupied spaces. A flowchart of assessment of powdered aerosols is given in Fig. 1.

B-2 ASSESSING TOXICITY: IRRITATION AND INHALATION TOXICITY TESTS

B-2.1 Two toxicity tests have been proposed for assessing the potential for short-term toxicity to humans following the accidental release of a powdered aerosol. The first test is the Draize test (US EPA/OPPTS 870 2400). This test is to be performed in order to analyse the potential for irritation and corrosion in the human eye following exposure to powdered aerosol particulate matter. As reported in the test guidelines, compounds that are already known to be corrosive or caustic do not need to be assessed by this test.

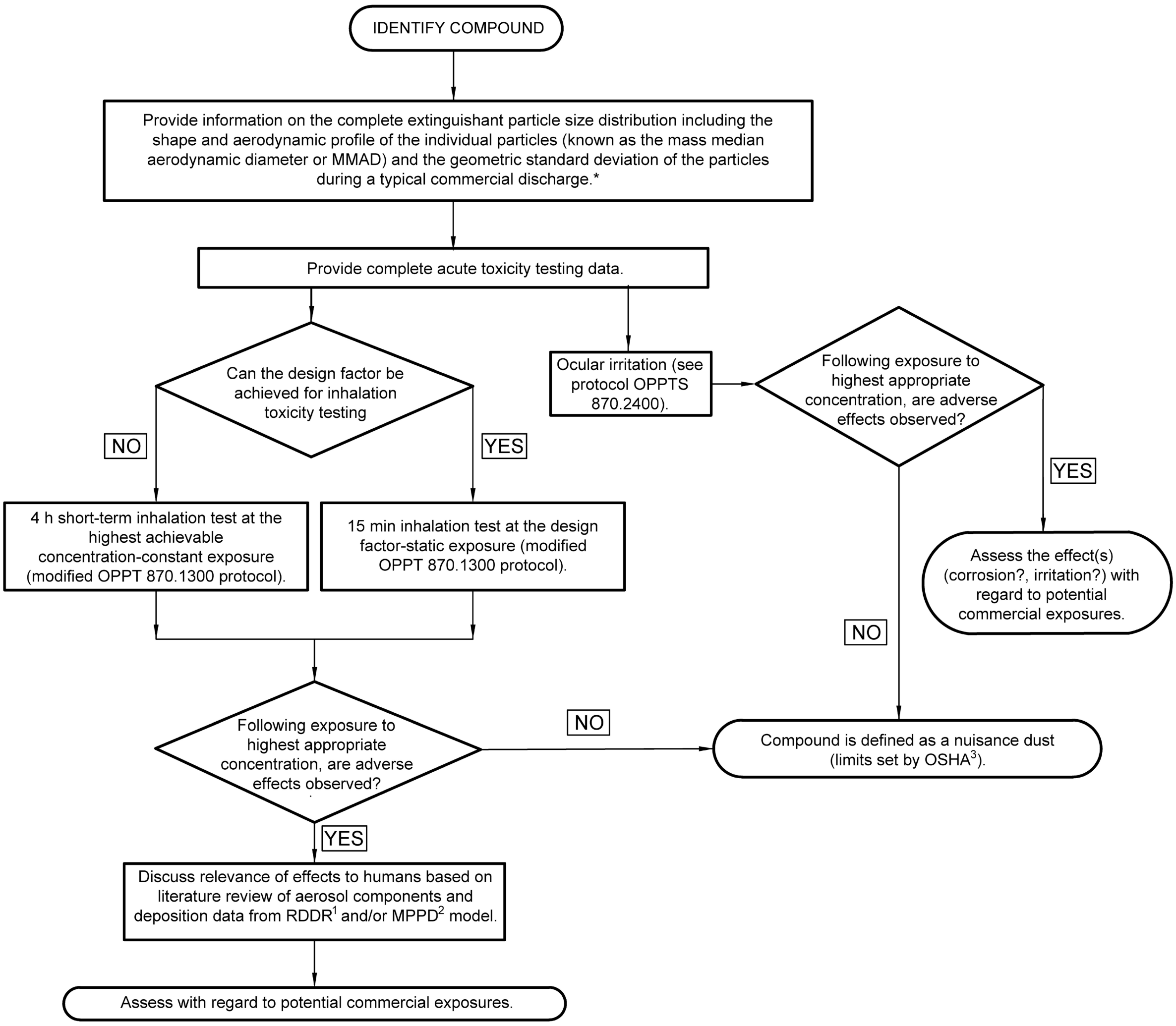
B-2.2 The second toxicity test is a 15 min inhalation test using rats. This test should incorporate an exposure scenario that is similar to release of the powdered aerosol fire extinguisher at its design factor. In other words, the toxicity test will use an exposure of the powdered aerosol that is identical to that to which a human would be exposed at the end use in the event of an accidental release. Two different sets of rats (each set containing a group of controls and exposed rats) should be exposed for no longer than 15 min. This exposure time was chosen to provide a measure of safety regarding potential resultant toxicity because human exposure is limited to only 5 min. The rats should be exposed via whole-body inhalation methodology; nose-only exposures are not appropriate for these compounds. During and immediately following exposure, particular attention should be paid to ocular effects. Following exposure, one set of animals should be evaluated immediately for clinical signs, mortality, and inhalation and systemic toxicity as noted in OPPTS 870.1300, and for histopathology as noted below. Further, the second group of animals should be observed for 14 days post-exposure. Both sets of animals should be examined for gross pathology and histopathology of appropriate organs (e.g. lungs and potentially the nasal passages and the trachea). In addition, wet and dry lung weights should be measured in control and exposed rats to determine if edema has occurred. Specific effects to investigate in the histopathology of the lungs are pneumonia, edema, inflammation, alveolar coalescence, macrophage infiltration, and similar responses.

Evaluation of these parameters may require an additional exposed group. If data are available that indicate that any components of the powdered aerosol affect systemic toxicity or particular target organs, a further evaluation of these organs in the exposed rats may be advisable.

B-2.3 In the event where the design factor cannot be reached during a 15 min inhalation toxicity test, then a 4 h inhalation toxicity test following OPPTS 870.1300 should be performed. The exposure concentration in this assay should be the highest exposure concentration achievable (e.g. the highest airborne particle concentration that can be technologically achieved given the characteristics of the powdered aerosol). The same sets of animals and control and dose groups described in the 15-minute inhalation test should be used in the 4-hour test, and the same endpoints should be measured. Particular attention should be paid to ocular irritation/corrosion during and after the exposure period and throughout the clinical observation period (14-days post-exposure).

B-3 ASSESSING TOXICITY: LITERATURE REVIEW

A comprehensive review of the published literature should be performed regarding the potential toxicity of components of the powdered aerosol, or of the whole product. These data can then be used to determine or predict toxicity of the end product. This evaluation can include, but should not be limited to, an evaluation of appropriate short-term exposure limits and other exposure values set by regulatory agencies for components of the powdered aerosol.



Key

1 Regional Deposited Dose Ratio

2 Minimal Persistent Pigment Dose

3 Occupational Safety and Health Administration (USA)

* The submitter is responsible for developing the appropriate methodology to provide this information, which will be reviewed by EPA on a case-by-case basis. Occupational exposures may be measured as described in protocol (NMAM 0500).

FIG. 1 FLOWCHART OF ASSESSMENT OF POWDERED AEROSOLS

ANNEX C

(*Clauses* 5.3.3.3, 5.3.4, 5.3.5.2, 5.3.6, 5.3.7, 5.3.8, *and* 5.3.10)

TEST METHODS

C-1 GENERAL

The following shall apply to the condensed aerosols generators.

C-2 CONDITIONS

C-2.1 The components shall be tested assembled as recommended for installation by the manufacturer. The tests shall be carried at a temperature of 25 °C ± 10 °C, except when otherwise stated.

C-2.2 The tolerance for all test parameters is 5 percent, unless otherwise stated.

C-3 SAMPLES

C-3.1 The manufacturer shall submit a sufficient number of samples from the same batch for testing.

C-3.2 Unless otherwise noted, a minimum of 200 ignition devices of each type shall be tested for the ignition performance test in **C-14**.

C-3.3 A minimum of five generators in each size within a family shall be tested in the as-received condition for the function test in **C-16**, which also includes the discharge time test in **C-16.1** and the casing and aerosol flow temperature tests in **C-16.2** and **C-16.3**.

C-3.4 A minimum of three generators in the smallest and largest size within a family shall be tested for each of the following tests: temperature and humidity test in **C-8**, low temperature test in **C-8.3**, accelerated ageing test in **C-9**, corrosion test in **C.10**, stress corrosion test in **C-11**, vibration test in **C-12**, drop impact test in **C-13**, and fire exposure test in **C-17**.

C-3.5 The number of generators for coverage determination in **C-6** will depend upon the installation limitations of each generator within a family. A minimum of one generator in each size within a family shall be tested for the minimum height/maximum coverage test in **D-5.1**. A minimum of one generator in each size within a family shall be tested for the maximum height test in **D-5.2**.

C-3.6 The number of generators and generator size for the extinguishing density determination in **C-5** will depend upon the area coverage limitations and generator efficiency. The generator having the smallest efficiency (that is, smallest amount of aerosol extinguishing agent produced related to the generator's solid aerosol-forming compound mass) shall be used.

C-3.7 The sequence of tests is shown in Table 1 and is given by the numbers 1, 2, 3, etc., in the Table 1 A, B, etc., are the different samples.

Table 1 Test Order for Samples
(*Clause* C-3.7)

Sl No.	**Test method**	**Test Order for Sample**												
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(13)	(14)	(15)	(16)
i)	Compliance (*see* **C-4**)	1	1	1	1	1	1	1	1	1	1	1	1	1
ii)	Extinguishing application density determination (*see* **C-5**)	-	-	-	-	-	-	-	-	-	-	-	-	2
iii)	Coverage determination (*see* **C-6**)	-	-	-	-	-	-	-	-	-	-	-	2	-
iv)	Discharge test time (*see* **C-7**)	2	-	-	-	-	-	-	-	-	-	-	-	-
v)	Temperature and humidity test (*see* **C-8**)	-	-	2	-	-	-	-	-	-	-	-	-	-
vi)	Low temperature test (*see* **C-8.3**)	-	-	-	2	-	-	-	-	-	-	-	-	-
vii)	Accelerated ageing test (*see* **C-9**)	-	-	-	-	2	-	-	-	-	-	-	-	-
viii)	Corrosion test (*see* **C-10**)	-	-	-	-	-	2	-	-	-	-	-	-	-
ix)	Stress corrosion test (*see* **C-11**)	-	-	-	-	-	-	2	-	-	-	-	-	-
x)	Vibration test (*see* **C-12**)	-	-	-	-	-	-	-	2	-	-	-	-	-
xi)	Drop impact test (*see* **C-13**)	-	-	-	-	-	-	-	-	-	2		-	-
xii)	Casing and aerosol flow temperature test (*see* **C-14**)	3	-	-	-	-	-	-	-	-	-	-	-	-
xiii)	Ignition performance test (*see* **C-15**)	-	2	-	-	-	-	-	-	-	-		-	-
xiv)	Function test (*see* **C-16**)	4	-	3	3	3	3	3	3	3	3	3	3	3
xv)	Fire exposure test (*see* **C-17**)	-	-	-	-		-	-	-	-	-	2	-	-

NOTES

1 At the option of the manufacture, temperature and humidity test **C-8** can be conducted with the same generator.

2 At the option of the manufacture, Low temperature test **C-8.3** can be conducted with the same generator sample flowing the drop impact test **C-13**.

C-4 COMPLIANCE

A visual and measurement check shall be made to determine whether the condensed generator corresponds to the description in the technical literature (drawings, parts lists, description of functions, operating and installation instructions).

C-5 EXTINGUISHING APPLICATION DENSITY DETERMINATION

The extinguishing application density for specific fuels under different classes of fires shall be determined by specific test using the fire test procedure described in Annex D. Extinguishing application density tests should be conducted with generator(s) of the same family. Number of generator units shall be sufficient to provide the needed extinguishing application density in the test enclosure. Mass of generator's unit prior and after discharge shall be registered. Other generator's units sizes which belong to the same family shall be subjected to a cold discharge. Mass prior and after discharge shall be registered. These data shall be compared to results from fire tests to get extinguishing factor for each generator unit type.

C-6 COVERAGE DETERMINATION

The maximum coverage and maximum and minimum height of the protected enclosure for each generator unit size shall be determined by test using the fire test procedures described in Annex D.

C-7 DISCHARGE TIME TEST

Discharge time test is integral part of the function test. See **C-16.1** for the discharge time test procedure.

C-8 TEMPERATURE AND HUMIDITY OPERATION RANGE TESTS

C-8.1 Objective of the Test

The objective of the test is to demonstrate the ability of the equipment to function correctly at high relative humidity (with condensation) which may occur for short periods in the anticipated service environment.

C-8.2 Test Procedure

C-8.2.1 *General*

The test procedure described in IS/IEC 60068-2-30 using the variant 1 test cycle and controlled recovery conditions shall be used.

C.8.2.2 *Conditioning*

Apply the following severity of conditioning:

a)	lower temperature:	25 °C ± 3 °C
b)	upper temperature:	55 °C ± 2 °C
c)	relative humidity at lower temperature:	95 percent ± 3 percent
d)	relative humidity at upper temperature:	95 percent ± 3 percent
e)	number of cycles:	10

C-8.2.3 *Final measurements*

After the recovery period, the sample shall be visually checked for mechanical damage externally and shall be subjected to the function test.

C-8.2.4 *Requirements*

When subjected to the function test, the sample shall respond correctly.

C-8.3 Low Temperature Test

Condition the sample at -20^{+0}_{-2} °C, or the service temperature recommended by the manufacturer $\square^{+0}_{-2}$ °C, whichever is the lower, for minimum of 16 h. Then carry out function test immediately. When subjected to the function test, the sample shall respond correctly.

C-9 ACCELERATED AGEING TEST

C-9.1 After being weighed and conditioned in a circulating air oven for the aging duration corresponding to the aging temperature based upon the useful life limitations specified in the manufacturer's design, installation, operation and maintenance instruction manual, condensed aerosol generator samples representative of each size and design of extinguishing system unit and automatic extinguisher unit shall:

a) Operate as intended;
b) Have a discharge time within ± 20 percent or within ± 5 seconds (whichever is greater) of the average discharge time determined at 21 °C ± 4 °C in the discharge test, **C-7**; and
c) Have an agent discharge quantity at least 83 percent of the average agent discharge quantity determined at 21 °C ± 4 °C in the discharge test, **C-7**.

C-9.2 The aging duration as a function of the aging temperature and useful life is given by the following formula.

$$t = A\,e^{-kT}$$

where,

t = Aging duration in days; t ≥ 25 days
T = Aging temperature in °C; T ≥ 80 °C
K = 0.1 In(2) = 0.069315
A = Constant and is a function of the useful life as specified in Table 2.

Table 2 Values of Constant A as a Function of Useful Life
(*Clause* C-9.2)

S No.	**Useful Life** years	**Constant, A**
(1)	(2)	(3)
i)	10	40 895
ii)	15	59 325
iii)	20	77 755
iv)	25	96 175

C-9.3 The selected values based on the above equation is given in Table 3.

Table 3 Ageing Duration as a Function of Useful Life
(*Clause* C-9.3)

Sl No.	Aging Temperature, T (°C)	Aging duration, t (days), as a Function of Useful Life			
		10 years	15 years	20 years	25 years
(1)	(2)	(3)	(4)	(5)	(6)
i)	80	160	232	304	375
ii)	85	113	164	215	266
iii)	90	80	116	152	188
iv)	95	56	82	107	133
v)	100	40	58	76	94
vi)	105	28	41	54	66
vii)	110	[1]	29	38	47
viii)	115	[1]	[1]	27	33

[1] Aging duration for the indicated aging temperature is less than permitted; t ≥ 25 days

C-9.4 The condensed aerosol generator samples to be aged are to be supported in a full-draft, circulating-air oven that has been preheated at full draft to the test temperature ± 2 °C. Samples are not to touch one another or the sides of the oven. The samples are to be aged at full draft and then allowed to cool in air at 21 °C ± 4 °C for at least 16 hours before conducting the discharge test, **C-7**. As used in this test, the term "full draft" refers to the oven used with inlet and outlet vents open and the air vent damper control at a setting that provides 250 to 350 air changes per hour. After aging, each aerosol generator samples shall be conditioned to 21°C ± 4 °C and discharged as described in **C-16**.

C-10 CORROSION TEST

C-10.1 The sample shall be exposed to a salt spray within a fog chamber. The essential components and properties of the reagents and the test configuration are:

a) Solution consists of NaCl in distilled water;
b) Concentration of the solution — 5 percent ± 1 percent;
c) pH Value — 6.5 to 7.5;
d) Spray pressure — 0.6 bar to 1.5 bar;
e) Spray volume — 1 ml/h to 2 ml/h on an area of 80 cm^2;
f) Temperature in test cabinet — $35^{+1.0}_{-1.7}$ °C;
g) Position of the sample — 15° to the vertical axis;
h) Spray time — 240 h ± 2 h;
i) Drying time — 168 h ± 5 h at a humidity of maximum 70 percent.

C-10.2 The sample shall be inspected for external mechanical damage and shall be subjected to a function test in accordance with **C-16**.

C-11 STRESS CORROSION TEST

C-11.1 This test is to be conducted only on generators using copper alloys. The stress corrosion test is to be conducted unless it can be shown that the materials used in the construction are not susceptible to ammonia stress corrosion.

C-11.2 The aqueous ammonia solution shall have a specific weight of 0.94 kg/l ± 0.02 kg/l. The sample shall be filled with 10 ml ± 0.5 ml of the solution for each litre of container volume.

C-11.3 The sample shall be degreased for the test and shall be exposed for 10 days to the moist atmosphere of ammonia and air, at a temperature of 34 °C ± 2 °C. The samples shall be positioned 40 mm ± 5 mm above the level of the liquid.

C-11.4 After testing, the samples shall be cleaned and dried and subjected to careful visual examination. To make cracking clearly visible, the liquid penetration method shall be used.

C-12 VIBRATION TEST

C-12.1 The drawings and the technical data shall be checked to determine whether vibration could have an adverse effect on the performance. The sample is attached to a vibration table using fixing materials provided by the manufacturer. The test apparatus and procedure shall be as described in IS/IEC 60068-2-6, Test Fc:

a) Frequency range — 10 Hz to 150 Hz
b) Acceleration amplitude for components which are designed to be attached to machinery:
   1) 10 Hz to 50 Hz — 9.81 m/s^2 (1.0 g_n)
   2) 50 Hz to 150 Hz — 29.43 m/s^2 (3.0 g_n)
c) Acceleration amplitude for components which are designed to be attached to walls:
   1) 10 Hz to 50 Hz — 1.962 m/s^2 (0.2 g_n)
   2) 50 Hz to 150 Hz — 4.905 m/s^2 (0.5 g_n)
d) Sweep rate — 1 octave per 30 min
e) Number of sweeps — 0.5 per axis
f) Number of axes — 3 mutually perpendicular

C-12.2 The sample shall not operate during the test as a result of the vibrations. No deterioration or detachment of parts shall occur. The sample shall be inspected for external mechanical damage and shall be subjected to a function test in accordance with **C-16**.

C-13 DROP IMPACT TEST

C-13.1 Impact Surface

C-13.1.1 The impact surface is a solid base with a reasonably smooth surface. An example of such a surface is as follows:

steel plate, with a minimum thickness of 75 mm and Brinell hardness of not less than 200, solidly supported by a concrete foundation having a minimum thickness of 600 mm.

C-13.1.2 The length and width of the surface should not be less than one and a half times the dimension of the unit being tested.

C-13.2 Procedure

The test unit without packaging is dropped from a height of 2 m as measured from the lowest point of the test unit to the impact surface. A safe waiting period following impact prescribed by the test laboratory should be observed, even if no visible initiation or ignition occurs at impact.

C-13.3 Requirements

The sample shall be subjected to a function test in accordance with **C-16**.

C-14 CASING AND FLOW TEMPERATURES TEST

C-14.1 Casing Temperature Test

Casing temperature test is an integral part of the function test. See **C-16.4** for casing temperature test procedure.

C-14.2 Flow Temperature Test

Flow temperature test is an integral part of the function test. See **C-16.2** for flow temperatures test procedure.

C-15 IGNITION PERFORMANCE TEST

The ignition of the generator shall be tested in accordance with the manufacturer's specifications. 25 samples of the complete ignition devices shall operate as intended. The power output of the ignition device shall not be less than that specified by the manufacturer at minimum power output sufficient to ignite the maximum designed mass of the aerosol-forming compound at the most disadvantageous operating conditions. Ignitors already certified by authority for ignition reliability will not be re-tested.

C-16 FUNCTION TEST

C-16.1 Discharge Time

Discharge time shall be measured by using one or more of the following techniques:

a) thermocouples recording temperature changes at the start and end of the discharge;
b) infrared video recording;
c) generator combustion pressure;
d) visual;
e) audible.

NOTE — The reference points identified as the start and the end of the generator discharge should be the same as taken during performance testing and as defined by the manufacturer.

C-16.2 Aerosol Flow Temperatures

C-16.2.1 Flow temperatures shall be measured by thermocouples. The following thermocouples arrangement shall be used for measuring temperatures at the specified minimum distances for 75 °C, 200 °C and 400 °C:

a) three cross-shaped poles are used as a support for the thermocouples and installed at the specified minimum clearances;
b) centre of each cross should be in line with a centre of a condensed generator's discharge outlet with the ends of the cross being within the cone-shaped discharge path;
c) crosses may be rotated against each other (that is, X, Y, Z axis) to minimize the impact of the flow on the temperature readings;
d) five thermocouples may be used — one at the centre of the cross, and four at its ends; three highest readings out of five shall be taken for recording.

C-16.2.2 Any other than above-described suitable measuring technique acceptable to and approved by an authority having jurisdiction may be used for measuring discharge time, temperatures, and enclosure pressure.

C-16.3 Test Procedure

Condition a fully assembled condensed generator for 16 h at ambient temperature of 21 °C ± 4 °C. Discharge the generator in a test enclosure.

C-16.4 Casing Temperature Test

The following thermocouples arrangement may be used for measuring temperature of the outer generator's casing:

a) Three thermocouples should be attached to the outer casing of the generator in the locations with the highest expected temperature.

C-16.5 Effective Mass of Extinguishant

The mass of aerosol generator shall be measured before and after the discharge. The difference of mass shall be recorded and is called effective mass of aerosol.

C-16.6 Requirements

Full function requirements apply to the discharge of a condensed generator prior to conducting any of the performance testing. The conditions are described in Table 4.

Table 4 — Test Conditions for Function Test
(*Clause* C-16.6)

Sl No.	Parameter	Clause	Requirement	Tolerance
(1)	(2)	(3)	(4)	(5)
i)	Visual examination		During discharge: no flame coming out from discharge outlet	–
ii)	Discharge time	**C-16.1**	As specified by manufacturer	± 20 percent or ± 5 s (whichever is greater)
iii)	Temperatures at the specified minimum clearances for 75 °C, 200 °C and 400 °C	**C-16.2**	As specified by manufacturer	–
iv)	Temperature of the outer casing	**C-16.4**	As specified by manufacturer	–
v)	Mass of compound discharged	**C.16.5**	–	+ 5 percent

C-17 FIRE EXPOSURE TEST

NOTE — This test relates to the requirements of **5.3.10**.

C-17.1 Objective of the Test

The objective of the fire exposure test is to demonstrate the safe operation of the condensed generator during and/or after its exposure to an external fire simulating a realistic accident.

C.17.2 Test Procedure

C.17.2.1 Each sample shall be weighed and installed in a mounting bracket such that the bottom most portion of the generator is centred 915 mm ± 15 mm above the bottom of the pan specified in **D-5.1.2.3**.

C.17.2.2 For each test at least 2.5 cm of heptane is to be placed in the pan, ignited, and burn for at least 60 s. During or after fire exposure, each aerosol generator sample shall be discharged as described in **C-16.3** except the environmental condition need not to be maintained at 21 °C ± 4 °C.

C.17.3 Requirements

a) Operate as intended.
b) Have a discharge time within 20 percent or within 5 ± s of the average discharge time determined at 21 °C ± 4 °C in the function test in **C.16.1**.
c) Have an agent discharge quantity at least 90 percent of the average agent discharge quantity determined at 21 °C ± 4 °C in the discharge test in **C.16.3**.

The discharge time shall be in accordance with the function requirements as specified in the Function test.

ANNEX D
(*Clauses* 5.2.2.2, 5.2.3, 5.3.2.1, 6.5.1, C-5, *and* C-6)

EXTINGUISHING APPLICATION DENSITY/COVERAGE TEST PROCEDURE

D-1 GENERAL

The tests shall be carried out in accordance with Table 5.

Table 5 Tests
(*Clause* D-1)

Test Objective	Enclosure Size	Test Fires	Tests in Accordance With
Aerosol generator distribution verification tests:	To suit aerosol generator's unit size		
a) Minimum height/ maximum protected volume and distance		heptane test pans	**D-5.1**
b) Maximum height/ maximum protected volume and distance		heptane test pans	**D-5.2**
Extinguishing factor	≥ 100 m^3 no side less than 4 m, height: not less than 3.5 m	(a) n-heptane pan	**D-6.1**
		(b) polymeric sheet i) PMMA ii) Polypropylene iii) ABS	**D-6.2**
		(c) Compatible Wood Crib	**D-6.3**

D-2 PRINCIPLE

D-2.1 An engineered or pre-engineered extinguishing system unit shall mix and distribute its extinguishant and shall totally flood the enclosure when tested in accordance with this test method under the maximum design limitations and most severe installation instructions. (See also **D-2.2**)

D-2.2 When tested as described in **D-5.1**, **D-5.2** and **D-6.1** an extinguishing system unit shall extinguish all visible flaming within 30 s after the end of extinguishant discharge. When tested as described in **D-6.3** an extinguishing system unit shall extinguish all visible flaming and prevent re-ignition of the fires after a 10 min soak period (also measured from the end of extinguishant discharge). When tested as described in **D-6.2** an extinguishing system unit shall extinguish all visible flaming within 60 s after the end of extinguishant discharge and also prevent re-ignition of the fires after a 10 min soak period (also measured from the end of extinguishant discharge).

D-2.3 The tests described herein consider the intended use and limitations of the extinguishing system unit, with specific reference to:

a) the coverage for each condensed aerosol generator size ;
b) the maximum and minimum height of the protected enclosure for each condensed aerosol generator size;
c) location of condensed aerosol generators in the protected area;
d) maximum pressure built up during discharge;
e) maximum discharge time; and
f) extinguishing design factor for specific fuels.

D-3 EXTINGUISHING SYSTEM

D-3.1 For the extinguishing tests described in **D-6.1**, **D-6.2**, and **D-6.3**, jet energy from the discharge outlets shall not influence the development of the fire. Therefore, the discharge outlets shall be directed away from the fires.

D-3.2 Adequate pressure relief vents in forms of closable flaps shall be provided during all tests. Calculations for the minimum vent area as well as location of the vents shall be in accordance with manufacturer's specifications.

D-4 EXTINGUISHING APPLICATION DENSITY

The extinguishing application density for each test is to be 76.9 percent of the intended end use design application density specified in the manufacturer's design and installation instructions at the ambient temperature of 20 °C ± 5 °C within the enclosure. In the tests described in **D.5.1** and **D.5.2**, the same extinguishing application density shall be used as in the tests described in **D.6.1**.

D-5 GENERATOR DISTRIBUTION VERIFICATION TESTS

D-5.1 Minimum Height/Maximum Coverage Test

D-5.1.1 *Test Facility*

D-5.1.1.1 *Construction*

The test enclosure shall meet the following requirements:

a) The area (a × b) and height (H) of the enclosure (*see* Fig. 2) shall correspond to the maximum area coverage and minimum height specified by the manufacturer for a specific generator unit size.
b) Test room volume shall be determined from the result of heptane fire test (see **D.6.1**)

$$V_{test}=\frac{M}{0.769R_{max}}\,(m^3)$$

where,

M = the generator's effective mass of extinguishant in grams;

R_{max} = design application density, in grams per cubic metre.

c) Area sides *a* and *b* shall be calculated to fulfil following requirements:

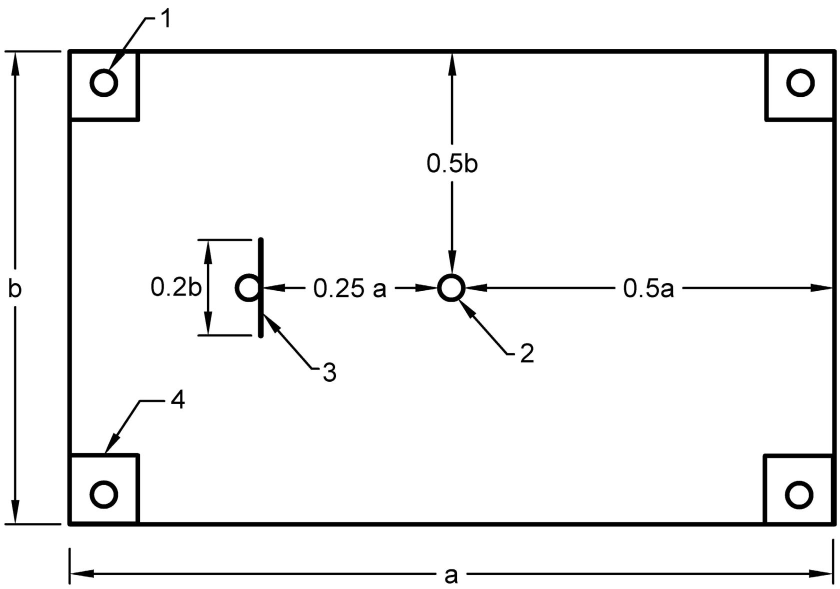
$$a \times b = \frac{V_{test}}{H}$$

The distance *c* (see Fig. 2 and Fig. 3) shall be equal to maximum coverage distance (R_{max}) specified by manufacturer.

d) Means of pressure relief shall be provided,

e) Closable openings shall be provided directly above the test pans to allow for venting prior to system actuation.

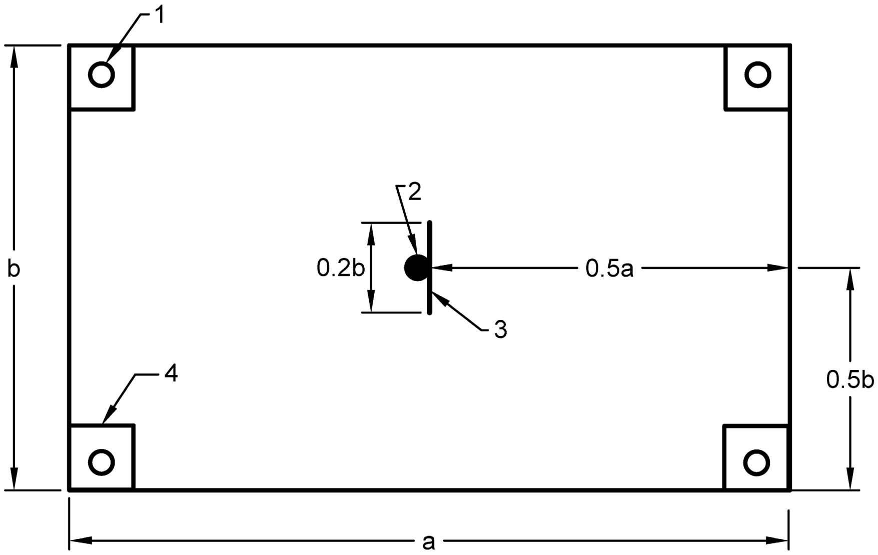
f) One baffle is to be installed between the floor and ceiling with the height of the room. It is to be installed halfway between the discharge outlet location and the walls of the enclosure (see Fig. 2 for centre mounting generator and Fig. 3 for side mounting generator). The baffle is to be perpendicular to the direction between the discharge outlet location and walls of the enclosure (see Fig. 2 and Fig. 3) and be 20 percent of the length of the short wall of the enclosure.



Key

a × b Maximum generator area coverage for a single generator
1 Test pans
2 Generator
3 Baffle
4 Vents

FIG. 2 EXAMPLE CONFIGURATION FOR GENERATOR MINIMUM HEIGHT/ MAXIMUM COVERAGE TEST FOR CENTRE MOUNTING GENERATOR



Key

a × b Maximum generator area coverage for a single generator
1 Test pans
2 Generator
3 Baffle
4 Vents

FIG. 3 EXAMPLE CONFIGURATION FOR GENERATOR MINIMUM HEIGHT/ MAXIMUM COVERAGE TEST FOR SIDE MOUNTING GENERATOR

D-5.1.1.2 *Instrumentation*

Sampling and storage of data from the sensors described below shall occur at a rate of at least 4 Hz.

D-5.1.1.3 *Oxygen Concentrations*

The oxygen level shall be measured by a calibrated oxygen analyser capable of measuring the percentage oxygen to within at least one decimal place (0.1 percent). The sensing equipment shall be capable of continuously monitoring and recording the oxygen level inside the enclosure throughout the duration of the test. The accuracy of the measuring devices shall not be influenced by any of the fire products.

At least three sensors shall be located within the enclosure (*see* Fig. 4 and Fig. 5). The three sensors shall be located in a horizontal distance from the centre of the room 850 mm to 1 250 mm and in the following heights: 0.1 × H, 0.5 × H and 0.9 × H (H = height of the enclosure) above the floor.

D-5.1.1.4 *Discharge Pressure*

The pressure built up during system discharge shall be recorded by a pressure transducer at a distance not greater than 1 m from the generator.

D-5.1.1.5 *Enclosure Temperature*

At least the temperature in a horizontal distance from the centre of the room of 850 mm to 1 250 mm and 0.5 × H (H = room height) above the floor shall be recorded (Fig. 4 and Fig. 5).

NOTE — It is recommended to use K type thermocouples (Ni-CrNi), diameter 1 mm.

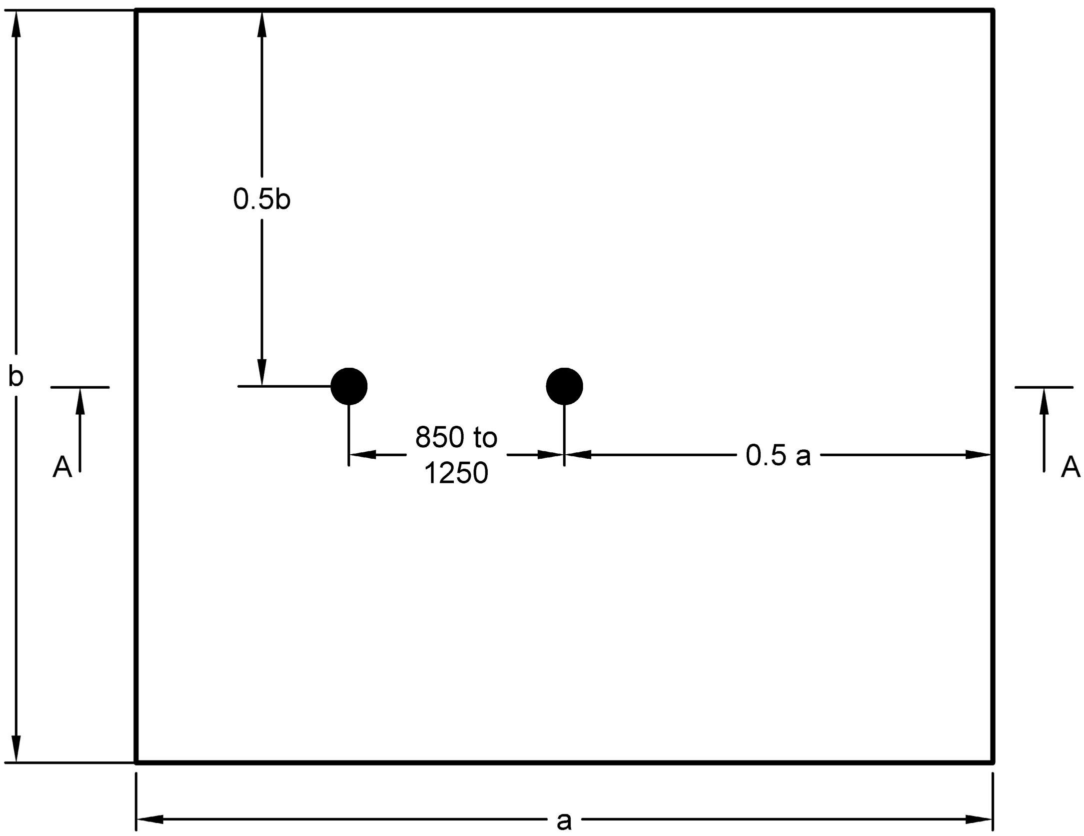
D-5.1.1.6 *Temperature and Discharge Times*

A thermocouple shall be placed just outside the discharge outlet of the generator to record temperature at the outlet as well as commencement and end of the discharge. Additional thermocouples may be placed at the minimum thermal clearance from the discharge outlet as specified by the manufacturer for each unit size of the generators.

NOTE — It is recommended to use K type thermocouples (Ni-CrNi), diameter 1 mm.

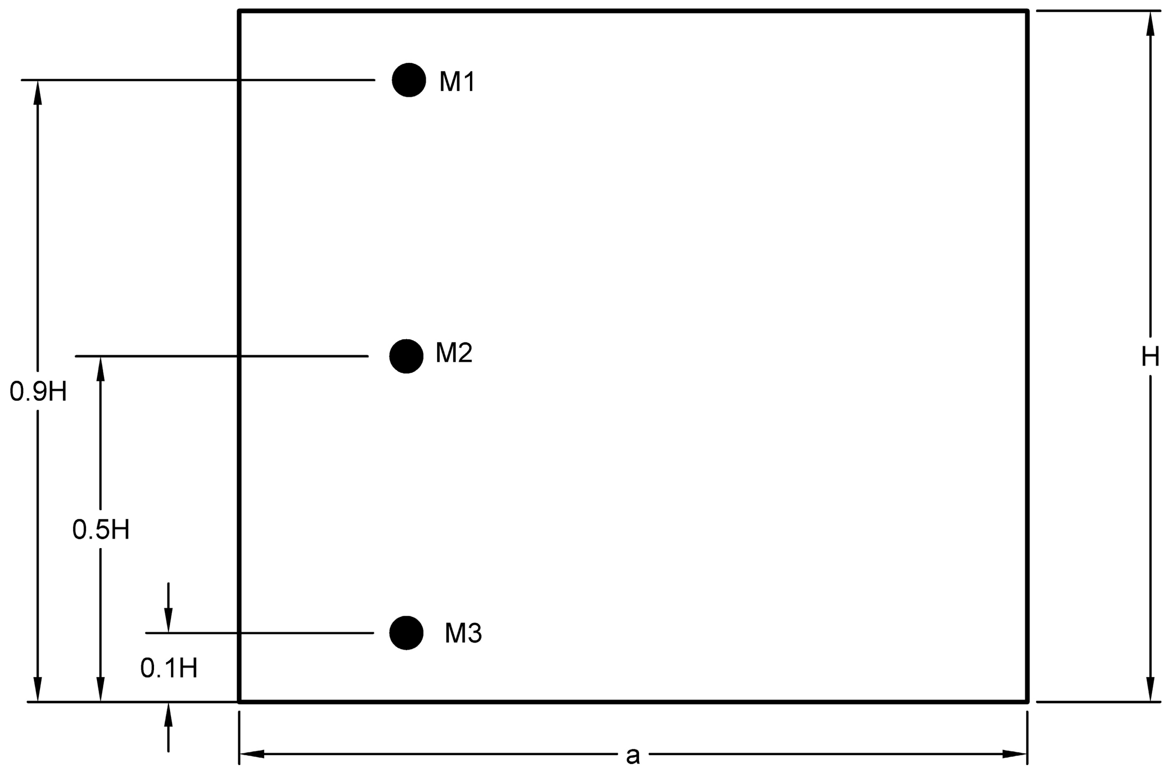
D-5.1.1.7 *Flame Out Times*

Cameras, e.g. infrared-cameras, or an alternative means of directly viewing the fire can be provided as an aid to determining flame out times. A thermocouple can be located centrally 30 mm above each fire pot to provide additional information.



Dimensions in mm

FIG. 4 PLAN VIEW OF INSTRUMENTATION PLACEMENT FOR GENERATOR MINIMUM HEIGHT/MAXIMUM AREA COVERAGE AND MAXIMUM HEIGHT/MAXIMUM AREA COVERAGE TEST



Key

M1 At measuring point 1, record the O_2 concentration.

M2 At measuring point 2, record the O_2 concentration and temperature.

M3 At measuring point 3, record the O_2 concentration.

Dimensions in mm

Section A-A

FIG. 5 SIDE VIEW OF INSTRUMENTATION PLACEMENT FOR GENERATOR MINIMUM HEIGHT/MAXIMUM AREA COVERAGE AND MAXIMUM HEIGHT/MAXIMUM AREA COVERAGE TEST

D-5.1.2 *Fuel Specification*

D-5.1.2.1 *Test Pans*

The test pans are to be cylindrical 80 mm ± 5 mm in diameter and at least 100 mm high made of mild or stainless steel with a thickness of 5 mm to 6 mm.

D-5.1.2.2 *n-Heptane*

The heptane shall be n-heptane or commercial grade having the following characteristics:

a) Distillation
   1) Initial boiling point = 90 °C
   2) Dry point = 96.5 °C
b) Density at 15.6 °C = 700 kg/m^3 ± 50 kg/m^3

D-5.1.2.3 *Fire Configuration and Placement*

The test pans may contain either n-heptane or n-heptane and water. If they are to contain n-heptane and water, the n-heptane is to be at least 50 mm deep. The level of n-heptane in the pans shall be at least 50 mm below the top of the can. The test pans are to be placed within 50 mm of the corners of the test enclosure and in addition directly behind the baffle (*see* Fig. 2 and Fig. 3) and located vertically within 300 mm of the top or bottom of the enclosure, or both top and bottom if the enclosure permits such placement.

D-5.1.3 *Test Procedure*

D-5.1.3.1 *General*

Prior to commencing tests, the composition of the extinguishing shall be analysed.

D-5.1.3.2 *Operation*

The heptane filled test pans are to be ignited and allowed to burn for 30 s with the closable openings above in the open position. After 30 s all openings are to be closed and the extinguishing system is to be manually actuated. At the time of actuation of the system, the amount of oxygen within the enclosure shall not be more than 0.5vol% lower than the normal atmospheric oxygen concentration. During the test, the oxygen concentration shall not change more than 1.5vol% due to fire products. This change shall be determined by comparing the oxygen concentration measured in the cold discharge test with the measured oxygen concentration in this test (averaged over the three sensors).

D-5.1.3.3 *Results Recording*

After the required pre-burn period, record the following data for each test:

a) The discharge time of extinguishant, in seconds;
b) the time required to achieve extinguishment, in seconds. This time shall be determined by visual observation, thermocouples readings or other suitable means.

D-5.1.4 *Determination of Distribution Performance of the Generator*

Using the extinguishing factor for n-heptane, determined according to **D-5.2**, all test pans have to be extinguished within 30 s after the end of agent discharge.

D-5.2 *Maximum Height Test*

D-5.2.1 *Test Facility*

D-5.2.1.1 *Construction*

The test enclosure shall meet the following requirements:

a) The area (a × b) and height (H) of the enclosure (*see* Fig. 2) shall correspond to the maximum area coverage and maximum height specified by the manufacturer for a specific generator's unit size.

b) Test room volume shall be determined from the result of heptane fire test (see **D-6.1**)

$$V_{test} = \frac{M}{0.769\ c} (m^3)$$

where,

M = generator's effective mass of extinguishant in grams;

c = design factor, in grams per cubic metre.

c) Area sides a and b shall be calculated to fulfil following requirements:

$$a \times b = \frac{V_{test}}{H}$$

The distance *c* (see Fig. 2 and Fig. 3) shall be equal to maximum coverage distance (R_{max}) specified by manufacturer and shall be the same specified for minimum height.

d) Means of pressure relief shall be provided.

e) Closable openings shall be provided directly above the test pans to allow for venting prior to system actuation.

f) One baffle is to be installed between the floor and ceiling with the height of the room. It is to be installed halfway between the nozzle location and the walls of the enclosure (see Fig. 2 for centre mounting generator and Fig. 3 for side mounting generator). The baffle is to be perpendicular to the direction of nozzle discharge and be 20 percent of the length of the short wall of the enclosure.

D-5.2.1.2 *Instrumentation*

Instrumentation of the enclosure is as described in **D-5.1.1.2**.

D-5.2.2 *Fuel Specification*

D-5.2.2.1 *Test Pans*

Specification of test pans is as described in **D-5.1.2.1**.

D-5.2.2.2 *n-Heptane*

The n-heptane is commercial grade as specified in **D-5.1.2.2**.

D-5.2.2.3 *Fire Construction and Placement*

The test can filling requirements and placement within the enclosure are as described in **D-5.1.2.1**.

D-5.2.3 *Test Procedure*

D-5.2.3.1 *General*

Prior to commencing tests the composition of the extinguishing shall be analysed.

D-5.2.3.2 *Operation*

The heptane filled test pans are to be ignited and allowed to burn for 30 s with the closable openings above in the open position. After 30 s all openings are to be closed and the extinguishing system is to be manually actuated. At the time of actuation of the system, the amount of oxygen within the enclosure shall not be more than 0.5 vol percent lower than the normal atmospheric oxygen concentration. During the test, the oxygen concentration shall not change more than 1.5 vol% due to fire products. This change shall be determined by comparing the oxygen concentration measured in the cold discharge test with the measured oxygen concentration in this test (averaged over the three sensors).

D-5.2.3.3 *Results Recording*

Results are to be recorded as specified in **D-5.1.3.3**.

D-5.2.4 *Determination of Distribution Performance of The Generator*

Using the extinguishing factor for heptane, determined according to **D-6.1**, all test pans have to be extinguished within 30 s after the end of agent discharge.

D-6 EXTINGUISHING APPLICATION DENSITY TESTS

D-6.1 n-Heptane Pan Test

D-6.1.1 *Test Facility*

D-6.1.1.1 *Construction*

The test enclosure shall meet the following requirements:

a) the test enclosure shall have a minimum volume of 100 m^3. The height shall be at least 3.5 m. The floor dimensions shall be at least 4 m wide by 4 m long;
b) a means of pressure relief shall be provided;
c) the temperature in the test enclosure shall be 20 °C ± 5 °C at the beginning of each test and there shall be enough time between the tests so that the enclosure can adapt to this temperature.

D-6.1.1.2 *Instrumentation*

Sampling and storage of data from the sensors described below shall occur at a rate of at least 4 Hz.

D-6.1.2 *Fuel Specification*

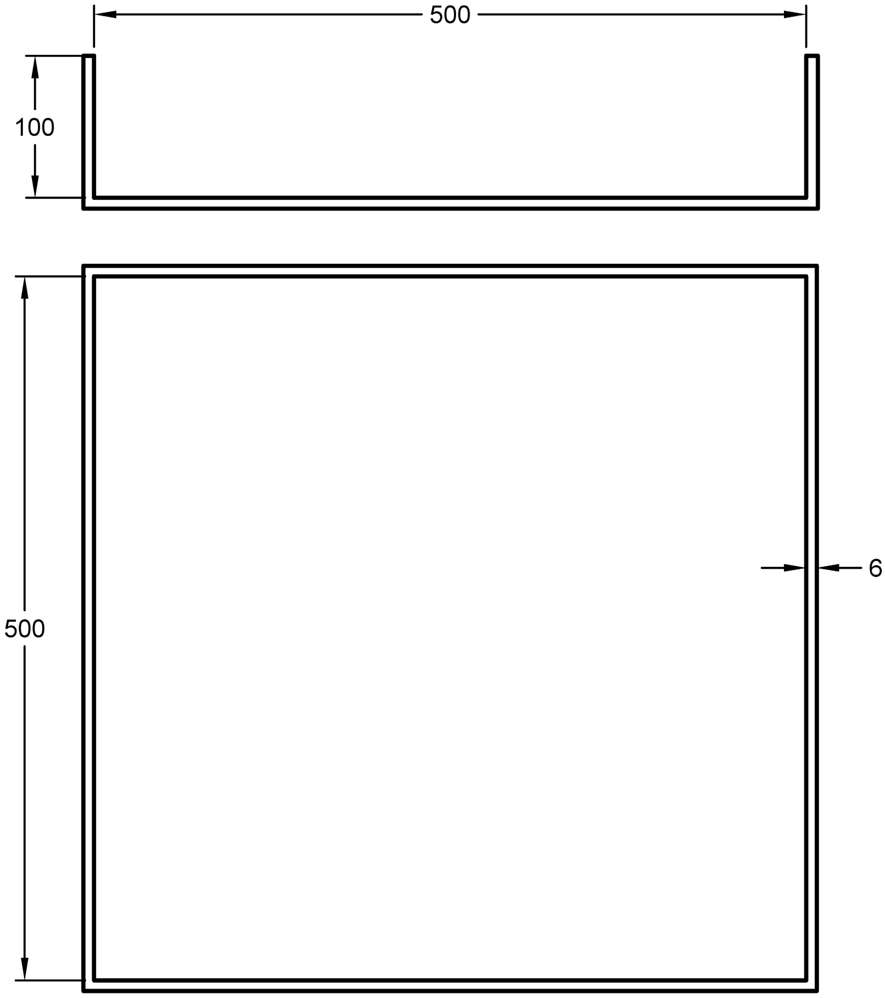
D-6.1.2.1 *n-Heptane*

The n-heptane is commercial grade as specified in **D-5.1.2.2**.

D-6.1.2.2 *Fire Configuration and Placement*

The fire will be a square steel pan of 0.25 m^2, 100 mm high with a wall thickness of

6 mm (see Fig. 6).



All dimensions in mm

FIG. 6 PAN GEOMETRY FOR N-HEPTANE PAN FIRE TEST

The test pan is to contain 12.5 litre of n-heptane. The resulting n-heptane surface is then 50 mm below the top of the pan. The steel pan shall be located in the centre of the test enclosure with the bottom 600 mm above the floor of the test enclosure.

D-6.1.3 *Test Procedure*

D-6.1.3.1 *General*

Prior to commencing tests the composition of the extinguishing shall be analysed.

D-6.1.3.2 *Operation*

The n-heptane is to be ignited and allowed to burn for 30 s. After 30 s all openings are to be closed and the extinguishing system is to be manually actuated. At the time of actuation of the system, the amount of oxygen within the enclosure shall not be more than 0,5vol percent lower than the normal atmospheric oxygen concentration. During the test, the oxygen concentration shall not change more than 1,5vol percent due to fire products. This change shall be determined by comparing the oxygen concentration measured in the cold discharge test with the oxygen concentration measured in this fire test (averaged values). If necessary, amend the extinguishant extinguishing factor and repeat the experimental programme until three successive, successful extinguishments are achieved.

D-6.1.3.3 *Results Recording*

After the required pre-burn period, record the following data for each test:

a) the discharge time of extinguishant, in seconds;
b) the time required to achieve extinguishment, in seconds. This time shall be determined by visual observation, thermocouples readings or other suitable means;
c) the soaking time (time from the end of system discharge until the opening of the test enclosure);

D-6.1.4 *Determination of Extinguishant Design Application Density*

The laboratory extinguishing application density is that which achieves satisfactory extinguishment of the fire over three successive tests (no flaming 30 s after the end of extinguishant discharge). The design factor is the laboratory extinguishing factor multiplied by an appropriate safety factor. Extinguishing application density shall be calculated dividing the total mass of compound installed by the test room volume.

D-6.2 Polymeric Sheet Fire Test

D-6.2.1 *Test Facility*

D-6.2.1.1 *Construction*

Construction of the enclosure is as described in **D-6.1.1.1**.

D-6.2.1.2 *Instrumentation*

Instrumentation of the enclosure is as described in **D-6.1.1.2**.

D-6.2.2 *Fuel Specification*

D-6.2.2.1 *Igniter Fuel*

The ignition source is a heptane pan (constructed of 2 mm thick mild or stainless steel) with inside to inside 51 mm × 112 mm and 21 mm deep centred 12 mm below the bottom of the plastic sheets of polymeric fuel (*see* Fig. 7). The 51 mm side of the pan is orientated parallel to the sheets of polymeric fuel. The pan is filled with 6.0 ml of commercial grade heptane (specified in **D-5.1.2.2**) on a water base of 40 ml.

D-6.2.2.2 *Polymeric Fuel*

Tests are to be conducted with three plastic fuels:

a) Polymethyl methacrylate (PMMA);
b) Polypropylene,

c) Acrylonitrile-butadiene-styrene polymer (ABS).

Plastic properties are given in Table 6.

Table 6 Plastic Properties 25 kW/m^2 Exposure in Cone Calorimeter - ISO 5660-1 Cone Calorimeter Test

(*Clause* D-6.2.2.2)

Sl No.	**Fuel**	**Colour**	**Density** g/cm^3	**Ignition Time** s (± 30 percent)	**180 s Average Heat Release Rate** kW/m^2 (± 25 percent)	**Effective Heat of Combustion** MJ/kg (± 25 percent)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	PMMA	Black	1.19	77	286	23.3
ii)	Polypropylene	Natural (White)	0.905	91	225	39.6
iii)	ABS	Natural (Cream)	1.04	115	484	29.1

D-6.2.2.3 *Polymeric Fuel Array*

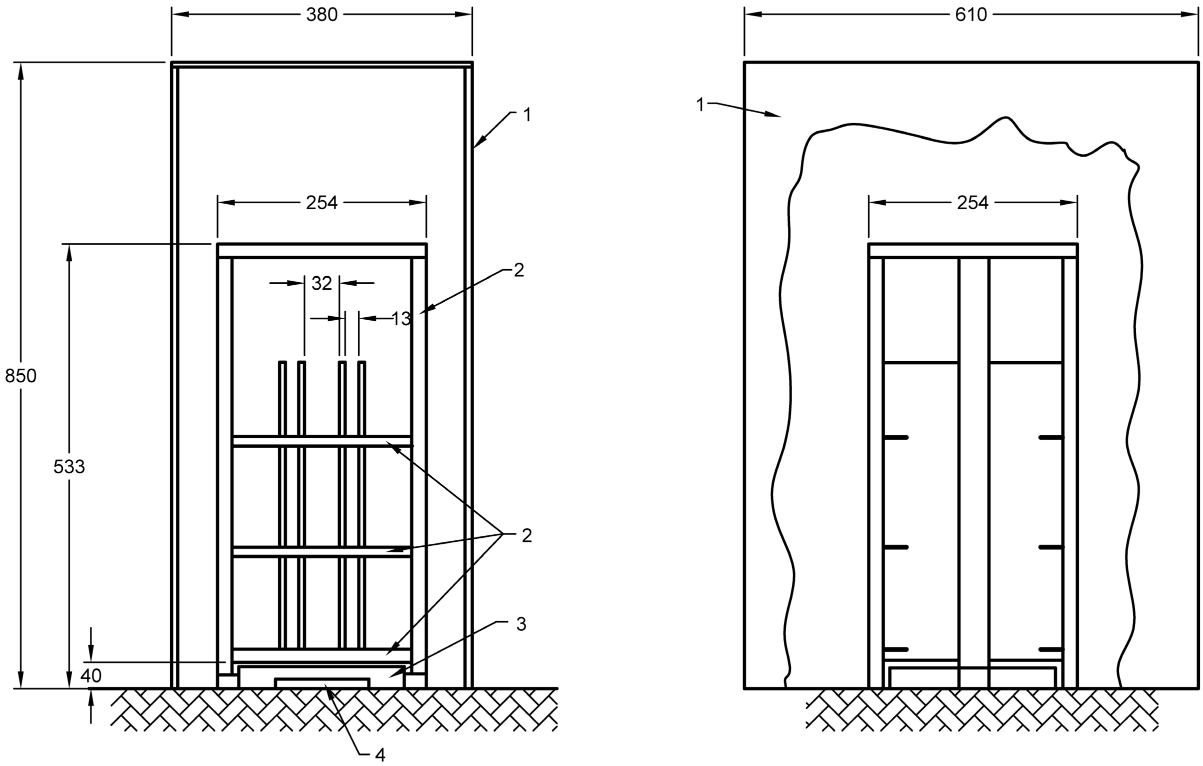
The polymeric fuel array shall consist of 4 sheets of polymer, which are cut to 405 mm ± 5 mm high by 200 mm ± 5 mm wide. The thickness of the sheets shall be as follows:

a) Polymethyl methacrylate (PMMA) — 10.0 mm ± 1 mm,
b) Polypropylene (PP) – 10 mm ± 1 mm,
c) Acrylonitrile-butadiene-styrene polymer (ABS) – 10.0 mm ± 1 mm.

Sheets are spaced and located as per Fig. 7. The bottom of the fuel array is located 203 mm from the floor. The fuel sheets shall be mechanically fixed at the required spacing. The sheets of plastic shall not significantly bend during the test. The fuel array shall be located centrally within the enclosure.

D-6.2.2.4 *Fuel Shield*

A fuel shield consisting of a metal frame with sheet metal on the top and two sides shall be provided around the fuel array as indicated in Fig. 7. The fuel shield is 380 mm wide, 850 mm high and 610 mm deep. The 610 mm (wide) × 850 mm (high) sides and the 610 mm × 380 mm top are metal sheet. The two remaining sides and bottom are open. The metal sheet shall be aluminium with a wall thickness of 2 mm to 3 mm. The fuel array is oriented in the fuel shield such that the 200 mm dimensions of the fuel array is parallel to the 610 mm side of the fuel shield.



Key

1 Channel metal frame covered with metal sheeting on top and two sides
2 Metal angle frame
3 Fuel guide bars
4 Load cell

FIG. 7 POLYMERIC SHEET FIRE

D-6.2.2.5 *External Baffles*

External baffles are constructed as shown in Fig. 8 and are located around the exterior of the fuel shield. The baffles are placed 90 mm above the floor. The top baffle is rotated 45° with respect to the bottom baffle.

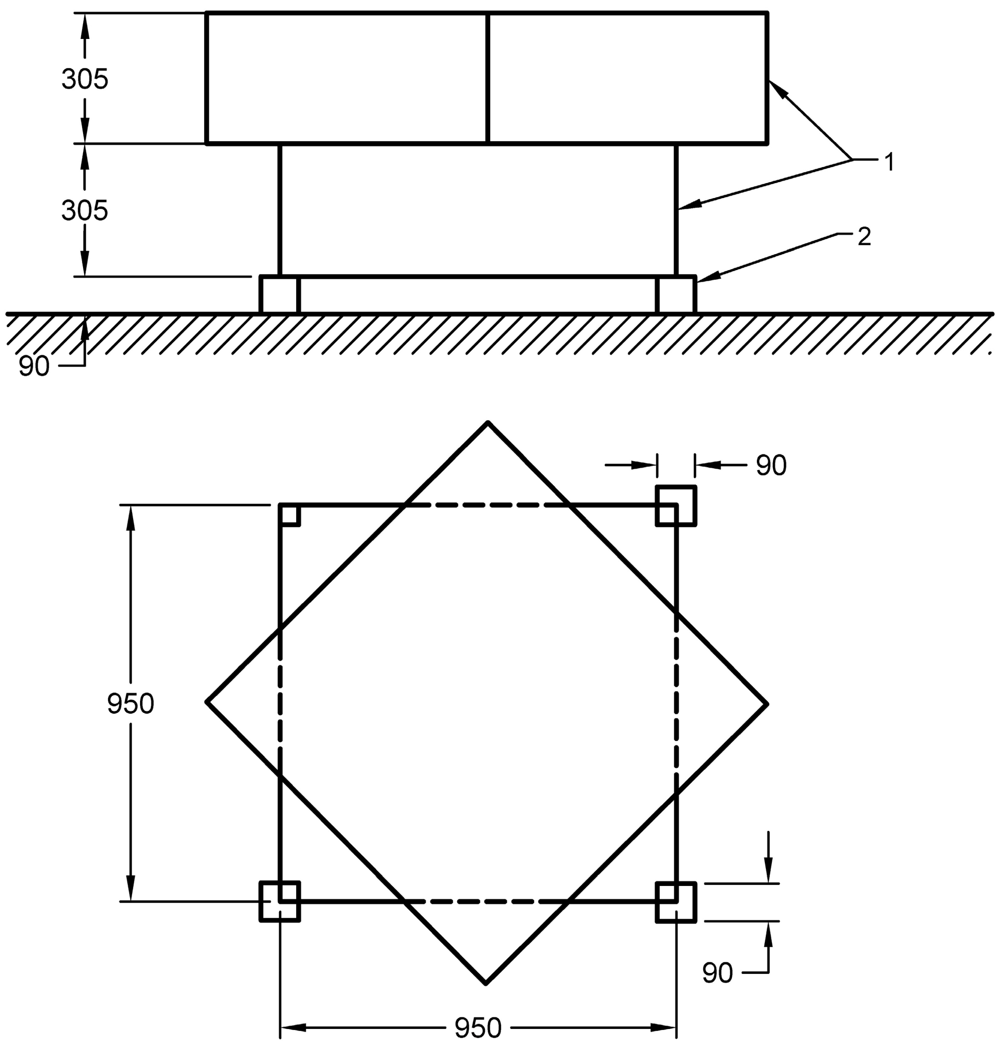


FIG. 8 POLYMERIC SHEET FIRE BAFFLE ARRANGEMENT

D-6.2.3 *Test Procedure*

D-6.2.3.1 *General*

Prior to commencing tests, the composition of the extinguishing aerosol shall be analysed. Record the mass of the plastic sheets prior to the test.

D-6.2.3.2 *Operation*

The n-heptane is ignited and allowed to burn completely. 210 s after ignition of the n-heptane, all openings are to be closed and the extinguishing system is to be manually actuated. At the time of actuation of the system, the amount of oxygen within the enclosure at the level of the fuel shall not be more than 0.5vol% lower than the normal atmospheric oxygen concentration. During the test, the oxygen concentration shall not change more than 1.5vol% due to fire products. This change shall be determined by comparing the oxygen concentration measured in the cold discharge test with the oxygen concentration measured in this fire test (averaged values). The enclosure is to remain sealed for a total of 10 min from end of discharge. After the soak period, ventilate the enclosure and observe to determine that sufficient fuel remains to sustain combustion and for signs of re-ignition. The following shall be recorded:

a) presence and location of burning fuel;
b) whether or not the fire re-ignites; and
c) mass of the fire structure after the test.

If necessary, amend the extinguishing factor and repeat the experimental programme until three successive, successful extinguishments are achieved.

D-6.2.3.3 *Results Recording*

After the required pre-burn period, record the following data for each test:

a) The discharge time of extinguishant, in seconds.
b) The time required to achieve extinguishment, in seconds. This time shall be determined by visual observation, thermocouples readings or other suitable means.
c) The soaking time (time from the end of system discharge until the opening of the test enclosure).

D-6.2.4 *Determination of the Extinguishant Design Application Density*

The laboratory extinguishing application density for each fuel is that which achieves satisfactory extinguishment of the fire over three successive tests (flame knock down within 60 s, no flaming after 180 s, and no reignition after 10 min, all from end of discharge).

The design application density is the highest of the laboratory extinguishing factors for the three fuels (*see* **D-6.2.2.2**) multiplied by an appropriate safety factor.

Extinguishing application density shall be calculated dividing the total mass of compound installed by the test room volume.

D-6.3 Class A Compatible Wood Crib Test

D-6.3.1 *Fuel Configuration*

This Class A compatible fire test shall consist of two (2) wood cribs, each measuring 0.3 m × 0.3 m × 0.3 m. The crib is to consist of eight alternate layers of four trade size 3.8 cm × 3.8 cm kiln-dried spruce or fir lumber 0.3 m long. The alternate layers of lumber shall be placed at right angles to the adjacent layers. The individual wood members in each layer are to be evenly spaced along the length of the previous layer of wood members and fastened by staples or nails. The wood cribs shall be preconditioned to have a moisture content of 9 percent and 13 percent by weight.

D-6.3.2 *Fuel Placement*

D-6.3.2.1 One crib is to be placed behind a baffle installed between the floors and ceiling at the midpoint between the direction of discharge and a wall. The baffle is to be perpendicular to the direction of nozzle discharge and be 20 percent of the length or width of the enclosure, whichever is applicable with respect to discharge location. The crib is to be placed on a stand and supported by four 5.1 cm bricks placed at each corner of the crib such that the bottom of the crib is 50 mm above the floor. The crib shall have a 113.5 g mass of shredded newspaper placed under the crib in the centre of the four blocks.

D-6.3.2.2 One crib is to be placed on a stand in the centre of the enclosure and supported by four 5.1 cm bricks placed at each corner of the crib such that the bottom of the crib is 50 mm above the floor. The crib shall have a 113.5 g mass of shredded newspaper placed under the crib in the centre of the four bricks.

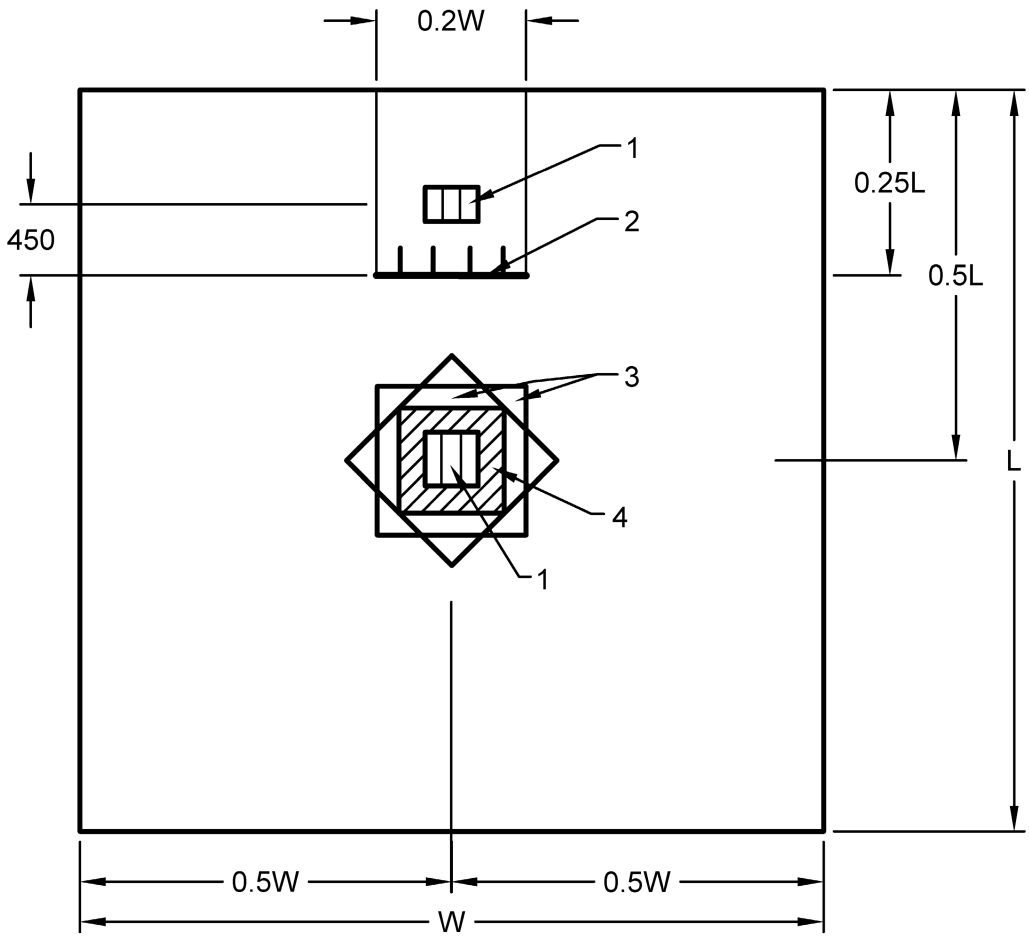
D-6.3.3 *Fuel Shield*

D-6.3.3.1 A fuel shield consisting of a metal frame with sheet steel on the top shall be provided around the crib located in the centre of the enclosure as indicated in Fig. 9 and Fig. 10. The fuel shield is to be 76 cm wide, 82.5 cm high and 76 cm deep. The 76 cm by 76 cm top is to be sheet steel. The remaining four sides and the bottom are to be open.

D-6.3.3.2 Two external baffles measuring 1 m square and 30 cm tall are to be located around the exterior of the fuel shield as shown in Fig. 9 and Fig. 10. The baffles are to be placed 9 cm above the floor. The lower baffle is to be oriented with its sides parallel to the fuel shield and the top baffle is to be rotated 45 degrees with respect to the bottom baffle.

D-6.3.3.3 A baffle is to be installed between the floor and ceiling at the midpoint between the centre of the enclosure and a wall parallel to the baffle width. The floor to ceiling baffle width is to be 20 percent of the length of the walls parallel to the baffle as indicated in Fig. 9 and Fig. 10.

D-6.3.3.4 The two cribs are to be placed on the floor supported by four 5.1 cm high bricks, one at each corner of the crib as indicated in Fig. 9 and Fig. 10. One of the cribs is to be centred between the two walls perpendicular to the floor to ceiling baffle with two sides of the crib parallel to the floor to ceiling baffle and the centre of the crib located 45 cm behind the floor to ceiling baffle relative to the centre of the enclosure. The other crib is to be centred in the enclosure.



Key

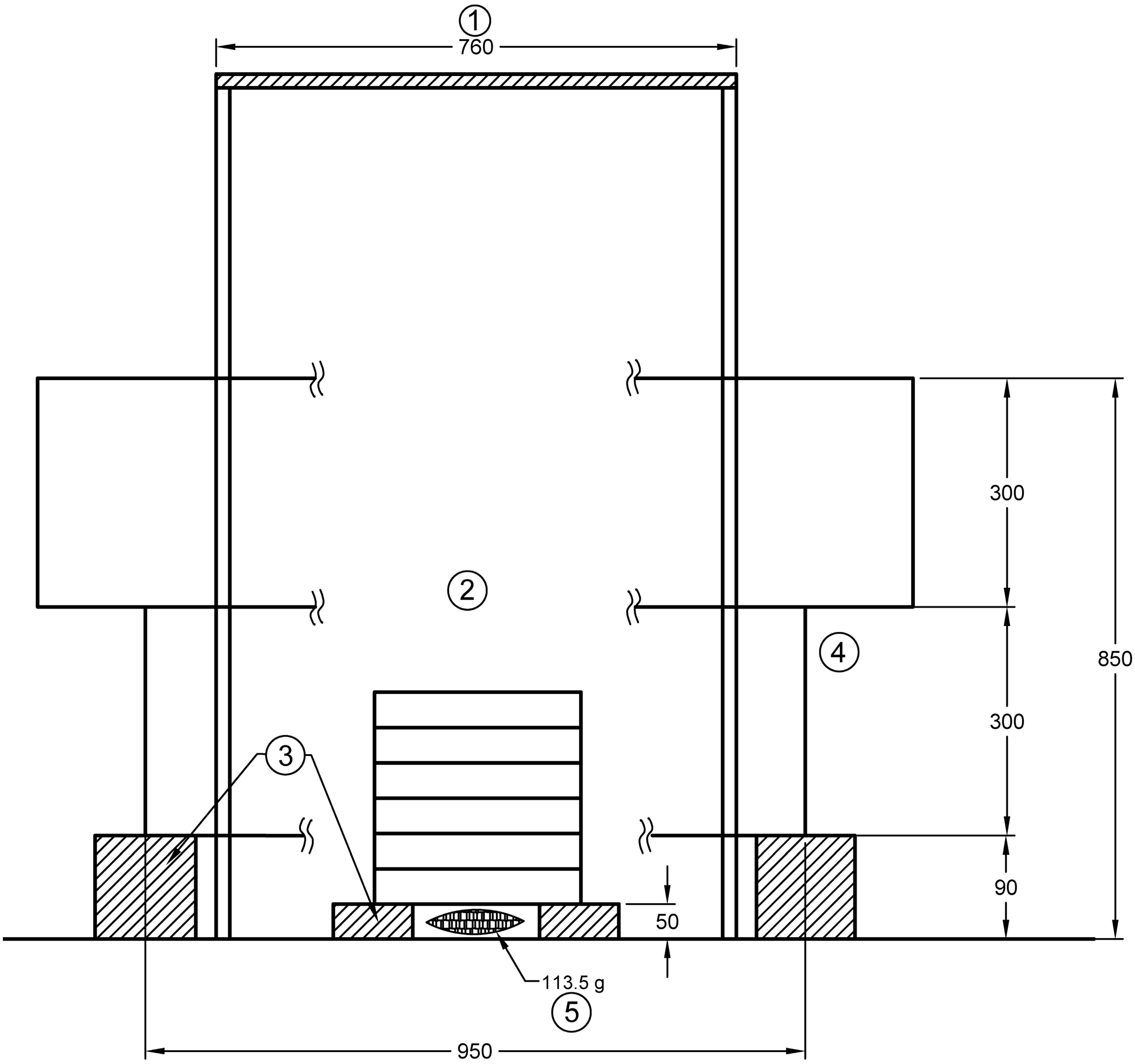
1 Wood crib location

2 Floor-to-ceiling baffle

3 Polycarbonate baffles

4 Fuel Shield

FIG. 9 WOOD CRIB LOCATIONS — PLAN VIEW



Key

1 Table baffle

2 Wood crib (eight layers of four members – trade 5 cm & 5 cm & 30 cm

3 Brick

4 Polycarbonate Baffles

5 Shredded newspaper

All dimensions in mm

FIG. 10 CENTRE WOOD CRIB DETAIL — ELEVATION VIEW

D-6.3.4 *Test Procedure*

D-6.3.4.1 *General*

Prior to commencing tests the composition of the extinguishing aerosol shall be analysed. Record the mass and the moisture of the crib prior to the test.

D-6.3.4.2 *Operation*

D-6.3.4.2.1 *Generators Placement*

The condensed aerosol generator(s) shall be installed under the maximum design limitations and most severe installation instructions according to the methods specified in the manufacturer's design and installation instructions. For the Class A Wood Crib Fire Tests, the condensed aerosol generator(s) shall be installed on the side of the enclosure opposite the crib located behind the floor to ceiling baffle. The generator(s) are to be conditioned to 21 °C ± 2.8 °C.

D-6.3.4.2.2 *Fuel Ignition*

Each crib shall have a 113.5 g mass of shredded newspaper placed under the crib in the centre of the four bricks, 236 ml of denatured ethyl alcohol is to be poured over each crib and paper, and then ignited.

D-6.3.4.2.3 *Pre-burn*

After ignition, each crib is to be allowed to burn for 2 minutes. The percent of oxygen is to be measured by a calibrated analyser at locations, which are at the same height as the wood cribs and centred from the edge of the crib to the near wall. Two additional measurements are to be made at 0.1 H and 0.9 H, with H being the height of the enclosure. Just prior to discharging agent into the enclosure, the vents, except for the pressure relief, are to be quickly closed and the generator system is to be manually actuated. At the time of system discharge, the percent oxygen within the enclosure at the level of the cribs is to be within 0.5 units of the normal oxygen level at atmospheric conditions.

D-6.3.4.2.4 C*ondensed Aerosol Generators Actuation*

Except for the pressure relief, the vents are to be closed and the system is to be actuated. At the time of actuation, the percent oxygen within the enclosure at the level of the crib shall be within 0.5 units of the normal oxygen level at atmospheric conditions. The percent of oxygen is to be measured by a calibrated analyser at a location, which is at the same height as the bottom of the wood crib and centred from the edge of the crib to the wall. Two additional measurements are to be made at 0.1 H and 0.9 H, with H being the height of the enclosure.

D-6.3.4.2.5 *Results Recording*

The following shall be recorded:

a) presence and location of burning embers;
b) whether or not the glowing embers or crib re-ignites; and
c) mass of the crib after the test.

If necessary, amend the extinguishing factor and repeat the experimental programme until 3 successive, successful extinguishments are achieved. After the required pre-burn period, record the following data for each test:

a) The discharge time of extinguishant, in seconds;
b) The time required to achieve extinguishment, in seconds. This time shall be determined by visual observation, thermocouples readings or other suitable means;
c) The soaking time (time from the end of system discharge until the opening of the test enclosure);
d) Recording the temperature profile of the wood crib, using the infrared camera, is recommended.

D-6.3.4.2.6 *Pass/ Fail Criteria*

After the start of system discharge, observations shall be made for crib extinguishment. The enclosure is to remain sealed for a total of 600 seconds after the end of discharge. After the 600 second soak period, the cribs are to be quickly removed from the enclosure, observed to determine whether fuel remains to sustain combustion and for signs of re-ignition.

D-6.3.4.2.7 *Determination of the Extinguishant Application Density*

The laboratory extinguishing application density is that which achieves satisfactory extinguishment of the fire over three successive tests (no re-ignition or existence of burning embers after 10 min after end of discharge). The design application density is the laboratory extinguishing factor multiplied by an appropriate safety factor. Extinguishing application density shall be calculated dividing the total mass of compound installed by the test room volume. The extinguishing application density for each test shall be 76.9% ~~percent~~ of the intended end use design application density or densities specified in the manufacturer's design and installation instructions.

D-7 HOLD TIME TEST OF THE DETERMINATION OF THE MAXIMUM LEAKAGE AREA/VOLUME RATIO

An aerosol extinguishing system shall be able to keep extinguishing conditions for the hold time when tested in accordance with this test method under the maximum design limitations and most severe installation instructions.

The test is based on the ability of the extinguishing unit to prevent re-ignition of heptane cans distributed through the enclosure.

D-7.1 Test Facility

D-7.1.1 *Construction*

D-7.1.1.1 Construction of the enclosure shall be is as described in **D-6.1.1.1**.

D-7.1.1.2 Two identical open areas shall also be provided, one on the ceiling of the enclosure and the other on the bottom centre opposite on the short side of the enclosure. The shape shall be square or rectangular with a base: height maximum ratio of 2:1. The sum of the two areas will be taken as the leakage area.

D-7.1.2 *Instrumentation*

Instrumentation of the enclosure is as described in **D-6.1.1.2**. Cameras or an alternative method described for flame out time in **D-6.1.1.7** shall be used to determine the appearance of flames. All cans described shall be monitored.

D-7.2 Fuel Specification

D-7.2.1 *n-Heptane*

The n-heptane is commercial grade as specified in **D-5.1.2.2**.

D-7.2.2 *Fire Configuration and Placement*

D-7.2.2.1 Test cans will be as described in **D-5.1.2.1**.

D-7.2.2.2 The test cans may contain either n-heptane or n-heptane and water. If they are to contain n-heptane and water, the n-heptane is to be at least 50 mm deep. The level of n-heptane in the pans shall be at least 50 mm below the top of the can.

D-7.2.2.3 Two sets of three test cans are to be placed within 500 mm of two walls. One set will be located opposite to the other and for each set the cans will be located at 10 percent, 50 percent, and 90 percent of the height of the enclosure.

D-7.2.2.4 Means for remote ignition shall be provided for each of the test cans.

D-7.3 Test Procedure

D-7.3.1 *General*

Prior to commencing tests, the composition of the extinguishing aerosol shall be analysed.

D-7.3.2 *Operation*

The extinguishing system is to be manually actuated.

Prior to the expected hold time, all the remote ignitors will begin to actuate in 60 seconds interval.

D-7.3.3 *Results Recording*

Record the following data for each test.

a) The discharge time of extinguishant, in seconds.
b) The time at which each actuation of the ignitors is produced, in seconds.
c) The time required for the first can to ignite, in seconds. This time shall be determined by visual observation, thermocouples readings or other suitable means.

D-7.4 Determination of Hold Time

D-7.4.1 The hold time for the test is the time from the end of discharge until the last activation of all the ignitors that did not produce ignition of any of the cans. The test is to be repeated three times. The maximum hold time applicable to the specified leakage area to volume ratio is the shortest hold time obtained from the three tests.

D-7.4.2 If the hold time obtained is less than 10 min, the test shall be repeated using a smaller leakage area.

D-7.4.3 Different leakage area values can be tested to provide different hold times for different leakage area to volume ratios.

D-7.4.4 The parameter(s) obtained shall be given as m^2 leakage area/m^3 volume protected for the specified hold time.

D-7.4.5 *First test* — Based on Maximum Leakage Area/Volume ratio for hold time of 10 min.

D-7.4.6 *Second test (optional)* — Based on 0.1 percent leakage area/volume ration for hold time of 30 min.

D-7.4.7 *Definition of re-ignition* — Test cans constantly burning for more than 1 min.

D-7.4.8 *Fail test criteria for the first test* — Re-ignition before or at 9 min.

D-7.4.9 *Fail test criteria for the second test* — Re-ignition before or at 29 min.

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