



Gaseous fire-extinguishing systems



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 - Australian Chamber of Commerce and Industry
 - Australian Industry Group
 - CSIRO
 - Engineers Australia
 - Facility Management Association of Australia
 - Fire Protection Association Australia
 - National Fire Industry Association
-

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Australian Standard®

Gaseous fire-extinguishing systems

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PREFACE

This Standard was prepared by the Standards Australia Committee FP-011, Special Hazard Fire Protection Systems, to supersede AS ISO 14520, Parts 1 to 15—2009, *Gaseous fire extinguishing systems*.

This Standard incorporates Amendment No. 1 (December 2019). The changes required by the Amendment are indicated in the text by a marginal bar and amendment number against the clause, note, table, figure or part thereof affected.

This Standard is based on ISO 14520, series of Standards, *Gaseous media fire-extinguishing systems—Physical properties and system design*, Parts 1 to 15 (published in 2015 and 2016).

This Standard incorporates content with modification from the following ISO Standards in the parts of this Australian Standard as specified in the table below.

ISO Content	Location of modified ISO content
ISO 14520 (series) Gaseous fire-extinguishing systems— Physical properties and system design	AS 4214 Gaseous fire-extinguishing systems
Part 1: General requirements	Body
Part 2: CF3I extinguishant	Appendix D
Part 5: FK-5-1-12 extinguishant	Appendix E
Part 6: HCFC Blend A extinguishant	Appendix F
Part 8: HFC 125 extinguishant	Appendix G
Part 9: HFC 227ea extinguishant	Appendix H
Part 10: HFC 23 extinguishant	Appendix I
Part 11: HFC 236fa extinguishant	Appendix J
Part 12: IG-01 extinguishant	Appendix K
Part 13: IG-100 extinguishant	Appendix L
Part 14: IG-55 extinguishant	Appendix M
Part 15: IG-541 extinguishant	Appendix N

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With the exception of the marine systems as detailed in Appendix A, this Standard does not cover the requirements of CO₂ systems. The committee plans to transfer the requirements of CO₂ marine systems to AS 6183 as part of a future amendment.

The objective of this Standard is to provide designers and installers with minimum requirements for the design, installation, testing and commissioning of gaseous fire extinguishing systems for structures, buildings and plant.

The terms ‘normative’ and ‘informative’ are used in a Standard to define the application of the appendices or annexes to which they apply. A ‘normative’ appendix or annex is an

integral part of a Standard, whereas an ‘informative’ appendix or annex is only for information and guidance.

This Standard incorporates Commentary on some clauses. The Commentary directly follows the relevant clause, is designated by ‘C’ preceding the clause number and is printed in italics in a panel. The Commentary is for information only and does not need to be followed for conformance with the Standard.

Statements expressed in mandatory terms in Notes to Tables and Figures are deemed to be requirements of this Standard.

FOREWORD

Fire fighting systems covered in this Standard are designed to provide a supply of gaseous extinguishing medium for the extinction of fire.

Several different methods of supplying extinguishing agent to, and applying it at, the required point of discharge for fire extinction have been developed in recent years, and there is a need for dissemination of information on established systems and methods. This Standard has been prepared to meet this need.

In particular, new requirements to eliminate the need to release extinguishing agents during testing and commissioning procedures are included. These are linked to the inclusion of enclosure integrity testing.

The requirements of this Standard are made in the light of the best technical data known to the working group at the time of writing but, since a wide field is covered, it has been impracticable to consider every possible factor or circumstance that might affect implementation of the recommendations.

It has been assumed in the preparation of this Standard that the execution of its provisions is entrusted to people appropriately qualified and experienced in the specification, design, installation, testing, approval, inspection, operation and maintenance of systems and equipment. This Standard has been prepared for their guidance, and it is expected that a duty of care will be exercised to avoid unnecessary release of extinguishing agents.

Attention is drawn to the Montreal Protocol on substances that deplete the ozone layer.

It is important that the fire protection of a building or plant be considered as a whole. Gaseous extinguishing agent systems form only a part, though an important part, of the available facilities, but it should not be assumed that their adoption necessarily removes the need to consider supplementary measures, such as the provision of portable fire extinguishers or other mobile appliances for first aid or emergency use, or to deal with special hazards.

Gaseous extinguishing agents have for many years been a recognized effective medium for the extinction of flammable liquid fires and fires in the presence of electrical and ordinary Class A hazards, but it should not be forgotten, in the planning of comprehensive schemes, that there may be hazards for which these media are not suitable, or that in certain circumstances or situations there may be dangers in their use requiring special precautions.

Advice on these matters can be obtained from the appropriate manufacturer of the extinguishing agent or the extinguishing system. Information may also be sought from the appropriate fire authority, the health and safety authorities and insurers. In addition, reference should be made as necessary to other national Standards and statutory regulations of the particular country.

It is essential that fire fighting equipment be carefully maintained to ensure instant readiness when required. Routine maintenance is liable to be overlooked or given insufficient attention by the owner of the system. It is, however, neglected at peril to the lives of occupants of the premises and at the risk of crippling financial loss. The importance of maintenance cannot be too highly emphasized. Installation and maintenance should only be done by qualified personnel.

Inspection, preferably by a third party, should include an evaluation that the extinguishing system continues to provide adequate protection for the risk (protected zones as well as state of the art can change over time).

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STANDARDS AUSTRALIA

Australian Standard

Gaseous fire-extinguishing systems

1 SCOPE

This Standard specifies requirements and gives recommendations for the design, installation, testing, maintenance and safety of gaseous fire-extinguishing systems and the characteristics of the various extinguishing agents and types of fire for which they are a suitable extinguishing medium.

It covers total flooding systems utilizing electrically non-conducting gaseous fire extinguishing agents that do not leave a residue after discharge and for which there is sufficient data currently available to enable validation of performance and safety characteristics by an appropriate independent authority.

Explosion suppression or oxygen reduction fire prevention systems are not within the scope of this Standard.

This Standard is not intended to indicate approval of the extinguishing agents listed therein by the appropriate authorities, as other extinguishing agents may be equally acceptable.

With the exception of marine CO₂ fire extinguishing systems, specified in Appendix A, CO₂ systems are not covered by this Standard as they are covered by AS 6183.

This Standard is applicable to the extinguishing agents listed in Table 1. The physical properties and characteristics of each extinguishing agent are detailed in the relevant appendix of this Standard.

TABLE 1
EXTINGUISHING AGENTS INCLUDED IN THIS STANDARD

Extinguishing agent	Chemical	Formula	CAS No.	Appendix
CF ₃ I	Trifluoroiodomethane	CF ₃ I	2314-97-8	D
FK-5-1-12	Dodecafluoro-2-methylpentane-3-one	CF ₃ CF ₂ C(O)CF(CF ₃) ₂	756-13-8	E
HCFC Blend A				F
HCFC-123	Dichlorotrifluoroethane (4.75%)	C ₂ HCl ₂ CF ₃	306-83-2	
HCFC-22	Chlorodifluoromethane (82%)	CHClF ₂	75-45-6	
HCFC-124	Chlorotetrafluoroethane (9.5%)	CFCIFCF ₃	2837-89-0	
	Isopropenyl-1-methylcyclohexene (3.75%)	C ₁₀ H ₁₆	5989-27-5	
HFC 125	Pentafluoroethane	CHF ₂ CF ₃	354-33-6	G
HFC 227ea	Heptafluoropropane	CF ₃ CHFCF ₃	431-89-0	H
HFC 23	Trifluoromethane	CHF ₃	75-46-7	I
HFC 236fa	Hexafluoropropane	CF ₃ CH ₂ CF ₃	690-39-1	J
IG-01	Argon	Ar	7440-37-1	K
IG-100	Nitrogen	N ₂	7727-37-9	L
IG-55	Nitrogen (50%) Argon (50%)	N ₂ Ar	7727-37-9 7440-37-1	M
IG-541	Nitrogen (52%) Argon (40%) Carbon dioxide (8%)	N ₂ Ar CO ₂	7727-37-9 7440-37-1 124-38-9	N

NOTE: Extinguishing agents listed in Table 1 require assessment for environmental acceptability and occupational safety by the relevant Australian authorities to permit use in Australia.

2 NORMATIVE REFERENCES

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document.

NOTE: Documents referenced for informative purposes are listed in the Bibliography.

AS

- 1210 Pressure vessels
- 1216 Class labels for dangerous goods
- 1530 Methods for fire tests on building materials, components and structures
- 1530.1 Part 1: Combustibility test for materials
- 1670 Fire detection, warning, control and intercom systems—System design, installation and commissioning
- 1670.1 Part 1: Fire
- 1670.5 Part 5: Special hazards systems
- 1850 Portable fire extinguishers—Classification, rating and performance testing
- 1851 Routine service of fire protection systems and equipment
- 2030 Gas cylinders
- 2030.1 Part 1: General requirements
- 2473 Valves for compressed gas cylinders
- 2473.1 Part 1: Specifications, type testing, and manufacturing tests and inspections

AS	
4041	Pressure piping
6183	Fire protection equipment—Carbon dioxide extinguishing systems for use on premises—Design and installation (ISO 6183:2009, MOD)
AS/NZS	
1020	The control of undesirable static electricity
3013	Electrical installations—Classification of the fire and mechanical performance of wiring system elements
4680	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles
ISO	
14520	Gaseous fire-extinguishing systems—Physical properties and system design
14520-1	Part 1: General requirements
IMO	MSC/Circular 848, International Maritime Organization, Marine Safety Committee, 8 June 1998, Revised guidelines for the approval of equivalent fixed gas fire-extinguishing systems, as referred to in SOLAS 74, for machinery spaces and cargo pump-rooms
IPCC	http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html
Montreal Protocol	http://ozone.unep.org/

3 DEFINITIONS

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

NOTE: For the purposes of this Standard, the term ‘bar’ should be taken as ‘gauge’, unless otherwise indicated. Concentrations or quantities expressed in percentages (%) should be taken as by volume, unless otherwise indicated.

3.1 Approved and approval

Approved by, or the approval of, the authority having jurisdiction.

NOTE: In determining the acceptability of installations or procedures, equipment or materials, the authority can base acceptance on conformance with the appropriate Standards.

3.2 Authority having jurisdiction

A minister of the Crown, a government department, or other public authority having power to issue regulations, orders or other instructions having the force of law in respect of any subject covered by an Australian Standard or, in cases where none of these apply, the owner or the owner’s agent.

3.3 Automatic/manual switch

Means of converting the system from automatic to manual actuation.

NOTE: This can be in the form of a manual switch on the control panel or other units, or a personnel door interlock. In all cases, this changes the actuation mode of the system from automatic and manual to manual only or vice versa.

3.4 Clearance

Air gap between equipment, including piping and nozzles and unenclosed or uninsulated live electrical components at other than ground potential.

3.5 Competent person

A person who has acquired through training, qualification, experience, or a combination of these, the knowledge and skill enabling them to correctly perform the required task(s).

3.6 Concentration

3.6.1 *Design concentration*

Concentration of extinguishing agent, including a safety factor, required for system design purposes.

3.6.2 *Extinguishing concentration*

Minimum concentration of extinguishing agent required to extinguish a fire involving a particular fuel under defined experimental conditions excluding any safety factor.

3.6.3 *Maximum concentration*

Concentration achieved from the actual extinguishing agent quantity at the maximum ambient temperature in the protected area.

3.7 Engineered system

System in which the supply of extinguishing agent is discharged through a system of pipes and nozzles in which the size of each section of pipe and nozzle orifice has been calculated in accordance with this Standard.

3.8 Extinguishing agent

Electrically non-conducting gaseous fire extinguishing agent that, upon evaporation, does not leave a residue (see Table 1).

3.9 Fill density

Mass of extinguishing agent per unit volume of storage container.

3.10 Flooding quantity

Mass or volume of extinguishing agent required to achieve the design concentration within the protected volume.

3.11 Hold time

Period of time during which a concentration of extinguishing agent greater than the fire extinguishing concentration surrounds the hazard.

3.12 Inspection

Visual check to give reasonable assurance that the extinguishing system is fully charged and operable.

NOTE: This is done by seeing that the system is in place, that it has not been activated or tampered with, and that there is no obvious physical damage or condition to prevent operation.

3.13 Liquified gas

Gas or gas mixture (normally a halocarbon) which is liquid at the storage container pressurization level at room temperature (20°C).

3.14 Listed

Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, and which maintains periodic inspection of production or listed equipment or materials or periodic evaluation of services and whose listing states that either the equipment, material, or service meets appropriate designated Standards or has been tested and found suitable for a specified purpose.

NOTES:

- 1 Examples of recognized testing and approval bodies are organizations accredited by JAS-ANZ, CSIRO Actifire, Factory Mutual (FM), Loss Prevention Certification Board (LPCB), SP Technical Research Institute of Sweden, Underwriters Laboratories (UL) and Verband der Schadenverhütung (VdS).
- 2 A manufacturer's statement of compliance does not by itself confirm that a system has been listed. The authority having jurisdiction should seek evidence of conformity to demonstrate that the system has been independently verified as being appropriate for the intended application.

3.15 Lock-off device

Manual shut-off valve installed in the discharge piping downstream of the agent storage containers or another type of device that mechanically prevents agent discharge into the protected space.

NOTES:

- 1 The actuation of this device provides an indication of system isolation.
- 2 The intent is to prevent the discharge of agent into the hazard area when the lock-off device is activated.

3.16 Lowest observed adverse effect level (LOAEL)

Lowest concentration at which an adverse toxicological or physiological effect has been observed.

3.17 Maintenance

Thorough check, comprising a thorough examination and any necessary repair or replacement of system component, to give assurance that the extinguishing system will operate as intended.

3.18 Maximum developed pressure

Equilibrium pressure within a storage container at the maximum working temperature.

3.19 Net volume

Volume enclosed by the building elements around the protected enclosure, minus the volume of any permanent impermeable building elements within the enclosure.

3.20 Non-liquified gas

Gas or gas mixture (normally an inert gas) which, under service pressure and permissible service temperature conditions, is always present in the gaseous form.

3.21 No observed adverse effect level (NOAEL)

Highest concentration at which no adverse toxicological or physiological effect has been observed.

3.22 Normally occupied area

An area where, under normal circumstances, people are present.

3.23 Normally unoccupied area

An area not normally occupied by people but which may be entered occasionally for brief periods.

3.24 Pre-engineered systems

System consisting of a supply of extinguishing agent of specified capacity coupled to pre-calculated pipework and nozzle arrangement up to a maximum permitted limit.

NOTE: No deviation is permitted from the limits specified by the manufacturer or authority.

3.25 Regulated discharge valve system

Gaseous systems in which a valve controls the discharge of gas at controlled or reduced flow or pressure.

3.26 Safety factor

Multiplier of the agent extinguishing concentration to determine the agent minimum design concentration.

3.27 Sea level equivalent of agent

The agent concentration (volume percent) at sea level for which the partial pressure of agent matches the ambient partial pressure of agent at a given altitude.

3.28 Sea level equivalent of oxygen

The oxygen concentration (volume percent) at sea level for which the partial pressure of oxygen matches the ambient partial pressure of oxygen at a given altitude.

3.29 Selector valve

Valve installed in the discharge piping downstream of the agent storage containers, to direct the agent to the appropriate hazard enclosure.

NOTE: It is used where one or more agent storage containers are arranged in order to selectively discharge agent to any of several separate hazard enclosures.

3.30 Shall

Indicates a mandatory requirement.

3.31 Should

Indicates a recommendation.

3.32 Storage Container

A cylinder or other pressure vessel used to store the extinguishing agent.

3.33 Superpressurization

Addition of a gas to the extinguishing agent storage container, where necessary, to achieve the required pressure for proper system operation.

3.34 Total flooding system

System arranged to discharge extinguishing agent into an enclosed space to achieve the appropriate design concentration.

3.35 Unoccupiable area

Area that cannot be occupied due to dimensional or other physical constraints, e.g. shallow voids and cabinets.

4 USE AND LIMITATIONS

4.1 General

Extinguishing agents are three-dimensional to effectively extinguish, suppress or inert through physical or chemical action, or a combination of both.

The hazards against which these systems offer protection, and any limitations on their use, shall be contained in the system supplier's design manual.

The design, installation, service and maintenance of gaseous fire-extinguishing systems shall be performed by those competent in fire extinguishing system technology. Maintenance and installation shall only be completed by competent personnel.

Total flooding fire-extinguishing systems are used to protect hazards that are in enclosures or equipment that, in itself, includes an enclosure to contain the extinguishing agent. The following are typical of such hazards (the list is not exhaustive):

- (a) Electrical and electronic equipment located within rooms or enclosed machines.
- (b) Telecommunications and data centre facilities.
- (c) Archive stores.
- (d) Flammable and combustible liquids storage and processing areas.
- (e) Engine and machinery compartments.

4.2 Protection of multiple enclosures

Gaseous fire extinguishing systems using a single storage container bank may be used to protect more than one enclosure by means of selector valves.

Where two or more enclosures may be simultaneously involved in a fire by reason of their proximity, such enclosures shall be protected by—

- (a) individual systems designed to allow simultaneous operation; or
- (b) a single system sized and arranged to discharge simultaneously on all potentially involved hazards.

Safety precautions shall be as specified in Table 2.

C4.2 *When protecting multiple enclosures, care should be taken not to exceed the LOAEL concentration in each normally occupied enclosure.*

4.3 Extinguishing agents

4.3.1 General

Any agent that is to be recognized by AS 4214 (this Standard) or proposed for inclusion in AS 4214, shall first be evaluated in a manner equivalent to the process used by the U.S. Environmental Protection Agency's (EPA) SNAP Programme or other internationally recognized extinguishing agent approval institutions. In addition, the agents shall meet the requirements of applicable Australian legislation.

The extinguishing agents referred to in this Standard are electrically non-conductive.

The extinguishing agents and specialized system parameters are each covered individually in the relevant Appendices D to N of this Standard.

Unless relevant testing has been carried out to the satisfaction of the authority, the extinguishing agents referred to in AS 4214 shall not be used on fires involving the following:

- (a) Chemicals containing their own supply of oxygen, such as cellulose nitrate.
- (b) Mixtures containing oxidizing materials, such as sodium chlorate or sodium nitrate.
- (c) Chemicals capable of undergoing autothermal decomposition, such as some organic peroxides.
- (d) Reactive metals (such as sodium, potassium, magnesium, titanium and zirconium), reactive hydrides, or metal amides, some of which may react violently with some gaseous extinguishing agents.
- (e) Environments where significant surface areas exist at temperatures greater than the breakdown temperature of the extinguishing agent and are heated by means other than the fire.

4.3.2 Environmental properties

Global warming potential (GWP) and ozone depletion potential (ODP) values applicable to the gaseous extinguishing agents are detailed in Appendices D to N.

NOTE: GWP is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. The scale is a relative comparison on a mass basis where a clean agent is compared to carbon dioxide, which has a GWP equal to one. ODP provides a relative comparison of the ability to react with ozone at altitudes within the stratosphere. ODP values are reported relative to the same mass of CFC-11, which has an ODP equal to one. The intergovernmental panel on climate change (IPCC) and the parties of the Montreal Protocol provide up to date environmental information provided by those organisations that understand the significance of the environmental properties of the agents in AS 4214.

The list of compounds and their global warming potentials can be found at the IPCC site at: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

The list of compounds and their ozone depletion potentials can be found at the Montreal Protocol site at: <http://ozone.unep.org/>

4.4 Electrostatic discharge

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

4.5 Compatibility with other extinguishing agents

Mixing of extinguishing agents in the same storage container shall be permitted only if the system is listed for use with such a mixture.

Systems using the simultaneous discharge of different gaseous extinguishing agents to protect the same enclosed space shall not be permitted.

4.6 Temperature limitations

All devices shall be designed for the service they will encounter and shall not readily be rendered inoperative or susceptible to accidental operation. Devices shall function properly from -20°C to $+50^{\circ}\text{C}$, or in accordance with manufacturers' listed temperature limitations which shall be marked on the name-plate, or (where there is no name-plate) in the manufacturer's instruction manual.

5 SAFETY

5.1 Hazard to personnel

Any hazard to personnel created by the discharge of gaseous extinguishing agents shall be considered in the design of the system, in particular with reference to the hazards associated with particular extinguishing agents in the Appendices. Unnecessary exposure to all gaseous extinguishing agents shall be avoided.

Adherence to AS 4214 does not remove the user's statutory responsibility to comply with the appropriate safety regulations.

Non-liquefied agents do not decompose measurably in extinguishing a fire. As such, toxic or corrosive decomposition products are not found. However, breakdown products of the fire itself can still be substantial and could make the area untenable for human occupancy.

The decomposition products generated by the clean agent breaking down in the presence of very high degrees of heat can be hazardous. All of the present halocarbon agents contain fluorine. In the presence of available hydrogen (from water vapour, or the combustion process itself), the main decomposition product is hydrogen fluoride (HF).

These decomposition products have a sharp, acrid odour, even in minute concentrations of only a few parts per million. This characteristic provides a built-in warning system for the agent, but at the same time creates a noxious, irritating atmosphere for those who need to enter the hazard following a fire.

The amount of agent that can be expected to decompose in extinguishing a fire depends to a large extent on the size of the fire, the particular clean agent, the concentration of the agent, and the length of time the agent is in contact with the flame or heated surface. If there is a very rapid build-up of concentration to the critical value, then the fire will be extinguished quickly and the decomposition will be limited to the minimum possible with that agent. Should that agent's specific composition be such that it could generate large quantities of decomposition products, and the time to achieve the critical value is lengthy, then the quantity of decomposition products can be quite great. The actual concentration of the decomposition products then depends on the volume of the room in which the fire was burning and on the degree of mixing and ventilation.

Clearly, longer exposure of the agent to high temperatures would produce greater concentrations of these gases. The type and sensitivity of detection, coupled with the rate of discharge, should be selected to minimize the exposure time of the agent to the elevated temperature if the concentration of the breakdown products is to be minimized.

5.2 Safety precautions

5.2.1 General

The requirements of Appendix O for safe personnel exposure guidelines should be followed.

The safety precautions required by AS 4214 do not address toxicological or physiological effects associated with the products of combustion caused by the fire. The maximum exposure time assumed by the safety precautions in this Standard is five minutes. Exposure times longer than five minutes may involve physiological or toxicological effects not addressed by AS 4214.

5.2.2 For normally occupied areas

The minimum safety precautions taken for automatic systems shall be in accordance with Table 2.

TABLE 2
MINIMUM SAFETY PRECAUTIONS

Maximum concentration	Time delay device	Automatic/manual switch	Lock-off device
Up to and including the NOAEL	Required	Required	Not required
Above the NOAEL and up to the LOAEL	Required	Required	Not required
LOAEL and above	Required	Required	Required

NOTE: The intent of the requirements is to avoid unnecessary exposure of occupants to extinguishing agent discharged. Factors such as the time for egress and the risk to the occupants by the fire should be considered when determining the system discharge time delay.

C5.2.2 *Automatic/manual switches are not generally required for manual only systems or small pre-engineered systems unless the discharge presents a risk to personnel who are in the immediate vicinity of the protected area. Lock-off valves are required to permit persons prior to entering the protected area to manually prevent discharge of the system. The lock-off valve position is monitored so that when it is closed the extinguishing system inoperative sign will be activated. This will provide visual indication that this system will not discharge automatically.*

When using inert gas agents, the NOAEL and LOAEL are the agent concentrations that result in low-limit partial pressures of oxygen of 12.1 kPa (91.0 mm Hg) and 10.2 kPa (76.6 mm Hg), respectively. These agent concentrations depend upon the barometric pressure at the altitude at which the hazard is located. The relationship of the altitude to average atmospheric pressure is as follows:

$$P = 101.325(1 - 0.000\,022\,55\,7\,h)^{5.25588} \quad \dots 5.2.2(1)$$

where

h = the altitude, m

P = the atmospheric pressure, Pa

The maximum inert gas concentration, C_{MAX} , that reduces the oxygen partial pressure to the low-limit value, can be calculated using the following formula:

$$C_{\text{MAX}} = 476.2 \times \frac{(0.21P_{\text{ATM}} - P_{\text{O2,LOW_LIMIT}})}{P_{\text{ATM}}} \quad \dots 5.2.2(2)$$

where

C_{MAX} = the maximum allowable agent concentration, vol. %

P_{ATM} = the local atmospheric pressure, Pa

$P_{\text{O2,LOW_LIMIT}}$ = the minimum allowed oxygen partial pressure in the agent-air mixture, Pa

The effect of applying these formulae on C_{MAX} as a function of altitude is shown in Table 3.

TABLE 3
MAXIMUM ALLOWED INERT GAS AGENT CONCENTRATION
AT THE NOAEL AND LOAEL LIMITS
AS A FUNCTION OF ALTITUDE

Altitude (h)	Atmospheric pressure (P)	Partial pressure of oxygen at local atmospheric pressure ($P_{O_2,ATM}$)	NOAEL $P_{O_2,NOAEL}$ (kPa) 12.1 Maximum allowed agent concentration ($C_{MAX,NOAEL}$)	LOAEL $P_{O_2,LOAEL}$ (kPa) 10.2 Maximum allowed agent concentration ($C_{MAX,LOAEL}$)
m	Pa	kPa	vol. %	vol. %
0	101.325	21.28	43.1	52.1
250	98.358	20.66	41.4	50.6
500	95.461	20.05	39.6	49.1
750	92.634	19.45	37.8	47.6
1 000	89.875	18.87	35.9	46.0
1 250	87.182	18.31	33.9	44.3
1 500	84.556	17.76	31.9	42.6
1 750	81.994	17.22	29.7	40.8
2 000	79.495	16.69	27.5	38.9
2 250	77.058	16.18	25.2	37.0
2 500	74.683	15.68	22.8	35.0
2 750	72.366	15.20	20.4	32.9
3 000	70.109	14.72	17.8	30.7

5.2.3 For normally unoccupied areas

Personnel shall not enter a room where the maximum concentration exceeds the LOAEL unless the lock-off device has been operated to prevent discharge.

For systems where the NOAEL is expected to be exceeded the system shall be placed in non-automatic mode whilst the room is occupied.

WARNING: Any change to the enclosure volume, or addition or removal of non-permeable contents that was not covered in the original design will affect the concentration of extinguishing agent. In such instances the system shall be recalculated to ensure that the required design concentration is achieved and the maximum concentration is consistent with Table 2.

5.2.4 For unoccupiable areas

The maximum concentration may exceed the LOAEL for the extinguishing agent used, without the need for a lock-off device to be fitted.

5.3 Occupiable areas

In areas that are protected by total flooding systems and that are capable of being occupied, the following shall be provided:

- (a) Time delay devices:
 - (i) For applications where a discharge delay does not significantly increase the threat to life or property, from fire, extinguishing systems shall incorporate a pre-discharge alarm with a time delay sufficient to allow personnel evacuation prior to discharge.

- (ii) Time delay devices shall be used only for personnel evacuation or to prepare the hazard area for discharge.
- (b) Automatic/manual switch, and lock-off devices where required in accordance with Clause 5.2.
NOTE: Although lock-off devices are not always required, they are essential in some situations, particularly for some specific maintenance functions.
- (c) Exit routes, which shall be kept clear at all times.
- (d) Emergency lighting and direction signs.
- (e) Outward-swinging (in the direction of egress from the protected space) self-closing doors that can be opened from the inside, including when locked from the outside.
- (f) Continuous visual and audible alarms at entrances and designated exits inside the protected area and continuous visual alarms outside the protected area, which operate until the protected area has been made safe.
- (g) Appropriate warning notices in accordance with Clause 5.7.
- (h) Where required, pre-discharge alarms within such areas, which are distinctive from all other alarm signals, and which, upon detection of the fire, will operate immediately on commencement of time delay.
- (i) Means for prompt natural or forced-draft ventilation of such areas after any discharge of extinguishing agent.

Forced-draft ventilation will often be necessary. Care shall be taken to completely dissipate hazardous atmospheres and not just move them to other locations, as most extinguishing agents are heavier than air.

NOTE: Natural ventilation may be appropriate where the hazard has doors which open directly to the atmosphere.

- (j) Instructions and drills for all personnel within or in the vicinity of, protected areas, including maintenance or construction personnel who may be brought into the area.

NOTE: In addition to the above requirements, personnel should not enter the enclosure until it has been verified as being safe to do so.

5.4 Electrical hazards

Where exposed electrical conductors are present, electrical clearances shall be no smaller than those specified by electrical safety regulations.

5.5 Electrical earthing

Systems within electrical substations or switchrooms shall be bonded and earthed to prevent the metalwork becoming electrically charged.

5.6 Electrostatic discharge

Where potentially explosive atmospheres exist or where the system is used for inerting, pipework fittings and nozzles shall be adequately bonded and earthed to minimize the risk of electrostatic discharge.

C5.6 *Electrostatic charging of pipework and nozzles not bonded and earthed may occur during the discharge of extinguishing agent. Pipework and nozzles may discharge to other objects with sufficient energy to initiate an explosion (refer to AS/NZS 1020).*

5.7 Warning notices

Warning notices shall have black lettering on a yellow background with a letter size equal to or greater than that detailed in Figures 1, 2, 3 and 4 (when this document is printed in full size on A4 paper). Notices shall be provided at the following locations:

- (a) At all entrances to the protected enclosure (see Figures 1 and 3 and Note).
- (b) At each emergency manual release point (see Figure 2).
- (c) At each lock-off valve (see Figure 4).

NOTE: Where a lock-off valve is fitted, the notice illustrated in Figure 3 is complementary to the notice in Figure 1 and should be located adjacent to it. Alternatively, the text may be incorporated into the warning notice shown in Figure 1.

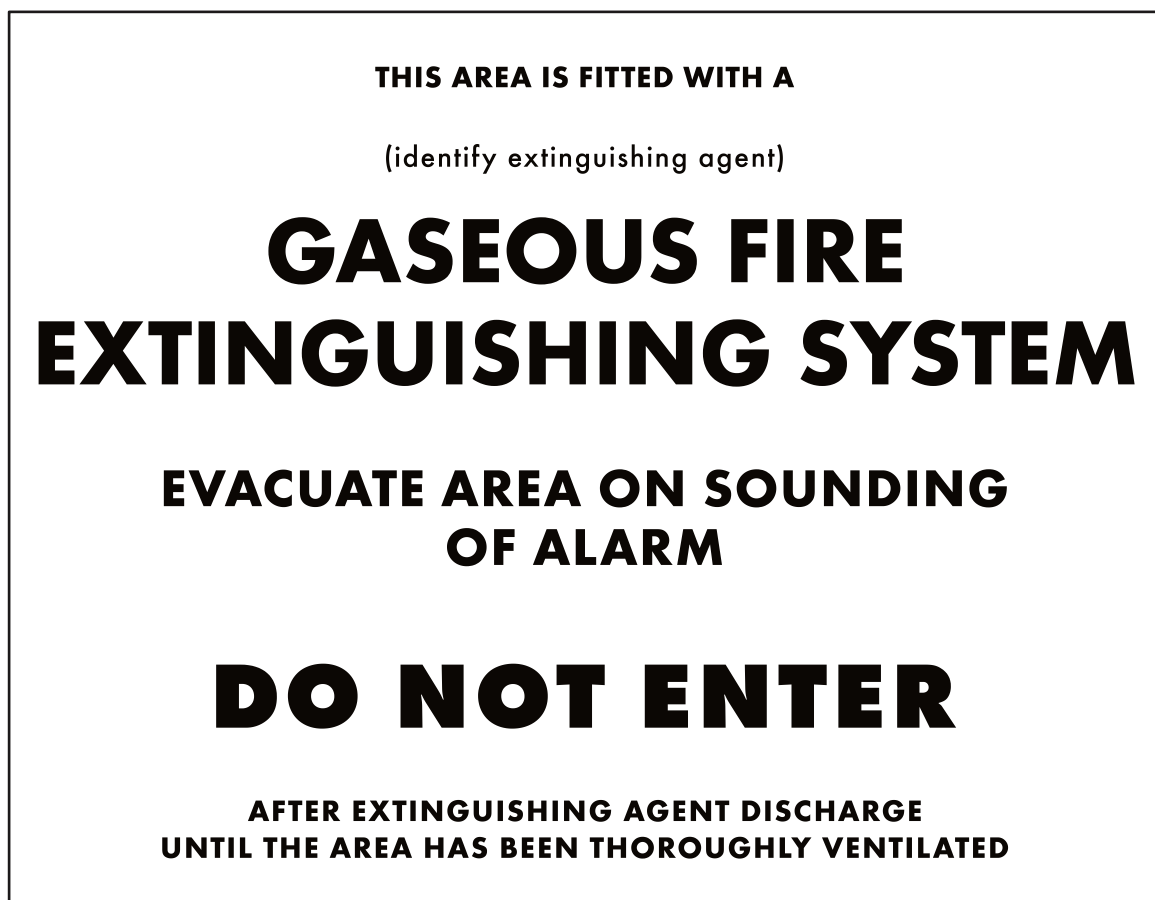


FIGURE 1 TYPICAL WARNING NOTICE TO BE DISPLAYED AT EACH ENTRY TO THE PROTECTED AREA OR ENCLOSURE

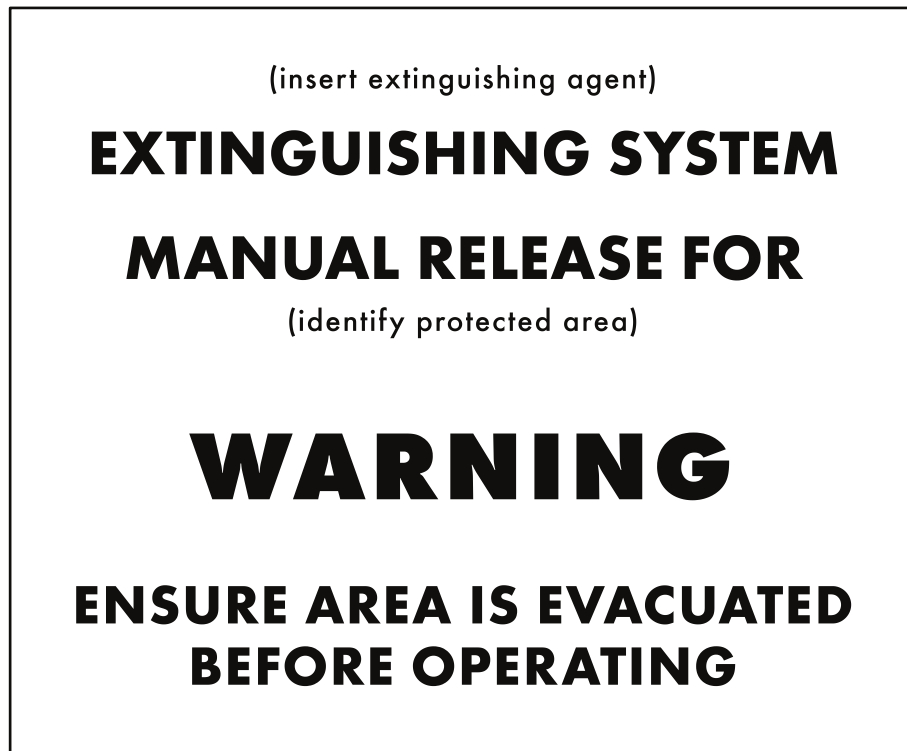


FIGURE 2 TYPICAL WARNING NOTICE TO BE DISPLAYED
AT MANUAL RELEASE



FIGURE 3 LOCK-OFF WARNING SYSTEM NOTICE

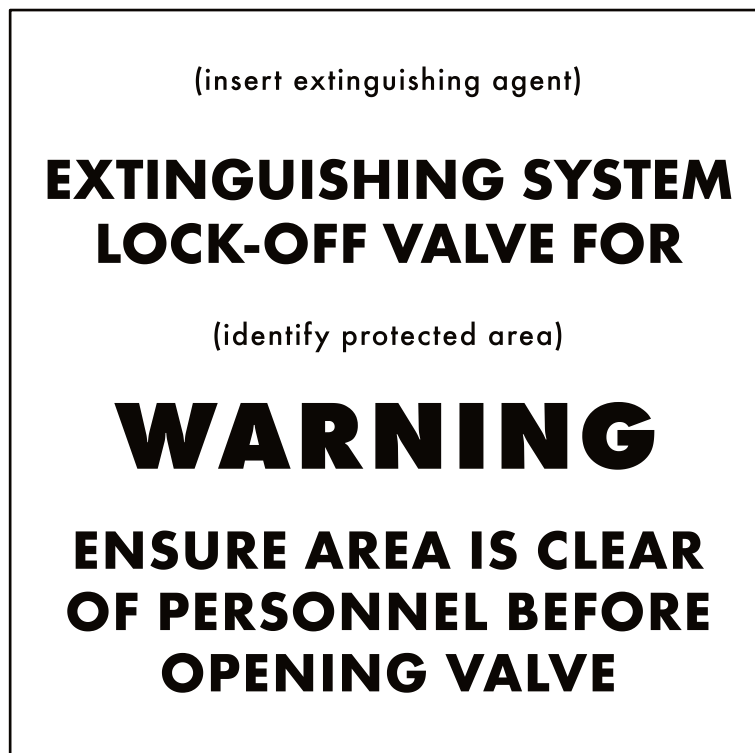


FIGURE 4 LOCK OFF VALVE NOTICE

6 SYSTEM DESIGN

6.1 General

This Clause sets out the requirements for the design of the extinguishing system.

To meet the requirements of this Standard, all fire protection systems shall be listed (see Clause 3.14, definition for Listed).

All ancillary systems and components shall conform with the relevant national or international Standards.

6.2 Extinguishing agent supply

6.2.1 Quantity

The amount of extinguishing agent in the system shall be at least sufficient for the largest single hazard or group of hazards that are to be protected simultaneously.

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

Where uninterrupted protection is required, both the main and reserve supply shall be permanently connected to the distribution piping and arranged for easy changeover.

6.2.2 Quality

The extinguishing agent shall conform with the relevant appendix of this Standard.

6.2.3 Storage container arrangement

Arrangements shall be made for storage containers and valve assemblies and accessories to be accessible for inspection, testing and other maintenance when required.

Storage containers shall be adequately mounted and suitably supported according to the systems installation manual so as to provide for convenient individual servicing of the storage container and its contents.

Storage containers shall be located as near as is practical to the enclosure they protect, preferably outside the enclosure. Storage containers can be located within the enclosure only if sited so as to minimize the risk of exposure to fire and explosion.

Storage containers shall not be located where they will be subjected to severe weather conditions or to potential damage due to mechanical, chemical or other causes. Where potentially damaging exposure or unauthorized interference are likely, suitable enclosures or guards shall be provided.

NOTE: Direct sunlight has the potential to increase the storage container temperature above that of the surrounding atmospheric temperature.

Where storage containers are located in areas where their leakage could lead to development of a concentration greater than the NOAEL, a warning notice shall be provided to identify the potential hazard together with adequate ventilation to minimize the hazard.

6.2.4 Storage containers

6.2.4.1 General

Storage containers shall be designed to hold the specific extinguishing agent. Storage containers shall not be charged to a fill density greater than that specified in the relevant appendix in this Standard (AS 4214).

The storage containers used in these systems shall be designed to meet the requirements of AS 2030.1.

During transport and storage of storage container assemblies, the valves shall be fitted with outlet and actuator port caps, plugs or locking devices to prevent accidental discharge. Care shall be taken to ensure that all such outlet and actuation caps, plugs and locking devices are removed prior to commissioning the system.

NOTE: The actuation caps, plugs and locking devices should be kept to allow for the safe handling and transport of cylinders for the life of the system.

Storage container discharge valves or valve protection shall have sufficient strength to be able to withstand impact with an object on the ground due to the fully charged storage container toppling from the vertical position. After the completion of the impact strength test, the storage container valve shall be capable of safely emptying the storage container when charged at the fill pressure and the reference temperature.

NOTE: A suitable valve strength test is described in AS 2473.1.

6.2.4.2 Contents indication

Means shall be provided to indicate that each storage container is correctly charged.

6.2.4.3 Marking

Each storage container shall be permanently marked in accordance with AS 2030.1 or AS 1210.

The following information, as a minimum, shall be displayed on the storage container by means of painting or durable labels in clearly visible black lettering, not less than 3 mm high, on contrasting background:

- (a) System manufacturer's name or trademark.
- (b) Name or chemical description of gaseous extinguishing agent.
- (c) UN number.
- (d) HAZCHEM number and class label to AS 1216.
- (e) The words 'In emergency, dial 000 Police or Fire Brigade'.
- (f) Storage container's filler, and 24 hour contact phone number.

- (g) Charge pressure and volumetric contents at 15°C and 1.013 bar (Non-liquefied gases).
- (h) Storage container assembly gross mass, tare and agent mass and charge pressure (Liquefied gases).
- (i) Any other cautionary statement required.

6.2.4.4 *Manifolded storage containers*

When two or more storage containers are connected to the same manifold, automatic means (such as check valves) shall be provided to prevent extinguishing agent loss from the manifold if the system is operated when any storage containers are removed for maintenance.

Storage containers connected to a common manifold in a system shall be—

- (a) of the same nominal form and capacity;
- (b) filled with the same nominal mass of extinguishing agent; and
- (c) pressurized to the same nominal working pressure.

Different sized storage containers connected to a common manifold may be used for non-liquefied gas storage containers, provided they are all pressurized to the same nominal working pressure.

6.2.4.5 *Operating temperatures*

Storage containers shall not be used outside their listed temperature limits.

External heating or cooling should be used to keep the temperature of the storage container within the specified range unless the system is designed for proper operation with operating temperatures outside this range.

6.3 Distribution

6.3.1 *General*

Pipework and fittings shall conform with AS 4041, shall be non-combustible and able to withstand the expected pressures and temperatures without damage.

Piping, including flexible connections, shall be deemed not combustible when tested in accordance with AS 1530.1 and shall withstand the maximum working pressure listed for the system.

Steel pipe and fittings shall be galvanized inside and outside in accordance with AS/NZS 4680, or otherwise suitably protected against corrosion. Copper, brass or stainless steel pipe and fittings may be used without corrosion protection.

NOTE: The attention of the designer is drawn to the potential of moisture condensing in the system pipework resulting in corrosion.

The materials of construction of all components shall be mutually compatible as well as being compatible with all fixings and the extinguishing agent used.

Before final assembly, pipe and fittings shall be inspected visually to ensure they are clean and free of burrs and rust, and that no foreign matter is inside and the full bore is clear. After assembly, the system shall be thoroughly blown through with dry air or other compressed gas.

A dirt trap consisting of a tee with a capped nipple, at least 50 mm long, shall be installed at the end of each nozzle pipe run. Drain traps protected against interference by unauthorized personnel should be fitted at the lowest points in the pipework system if there is any possibility of a buildup of water.

In systems where valve arrangements introduce sections of closed piping, such sections shall be equipped with the following:

- (a) Indication of extinguishing agent trapped in piping.
- (b) Means for safe manual venting.
- (c) Automatic relief of over pressures.

Over-pressure relief devices shall be designed to operate at a pressure no greater than the test pressure of the pipework.

Pressure relief devices shall be installed so that their discharge, in the event of operation, will not injure or endanger personnel.

In systems using pressure-operated storage container valves, automatic means shall be provided to vent any storage container leakage that could build up pressure in the pilot system and cause unwanted opening of the storage container valve. The means of pressure venting shall not prevent operation of the storage container valve.

Manifolds upstream of the pressure-reducing devices and all potentially closed-sections of pipework upstream of the pressure-reducing devices shall be hydrostatically tested to:

- (i) $1.5 \times$ maximum working pressure, for systems that do not incorporate regulated discharge valves.
- (ii) The maximum pressure produced by the regulated discharge valve, for systems that do incorporate regulated discharge valves.

The test period shall be two minutes, during which time there shall be no leakage. On completion of the test, the pipework shall be purged to remove moisture.

Adequate protection shall be given to pipes, fittings or support brackets and steelwork that are likely to be affected by corrosion. Special corrosion-resistant materials or coatings shall be used in highly corrosive atmospheres.

6.3.2 Piping

The thickness of the pipe wall shall be calculated in accordance with AS 4041. The pressure for this calculation shall be the developed pressure in the storage containers at a temperature of not less than 50°C. If higher operating temperatures are approved for a given system, the design pressure shall be adjusted to the developed pressure at maximum temperature. In performing this calculation, all joint factors and threading, grooving or welding allowances shall be taken into account.

Where a static pressure-reducing device or regulated discharge valves are used in a non-liquefied gas system, the maximum working pressure in the distribution pipework downstream of the device shall be used in the calculation of the downstream pipe wall thickness.

6.3.3 Fittings

For systems that use a pressure-reducing device or regulated discharge valves in the distribution piping, the fittings downstream of the device shall have a minimum rated working pressure equal to or greater than the maximum anticipated pressure in the downstream piping. If selector valves are used, this lower working pressure shall not be used upstream of the selector valves unless the closed head pressure is limited to this lower working pressure.

NOTE: Some regulated discharge valves will limit the maximum pressure within a closed section of pipework to a value lower than storage container pressure, whilst others will subject the pipework to full storage container pressure.

Cast iron fittings shall not be used. Welding and brazing alloys shall have a melting point above 500°C. Welding shall be performed in accordance with AS 4041.

6.3.4 Pipe and valve supports

Pipe and valve supports shall be of a non-combustible material, shall be suitable for the expected temperature and shall be able to withstand the dynamic and static forces involved. Due allowance shall be made for the stresses induced in the pipe work by temperature variations. Adequate environmental protection shall be given to supports and associated steelwork. The distance between pipe supports shall be as specified in Table 4.

Adequate support shall be provided for nozzles and their reactive forces such that in no case shall the distance from the last support be greater than as follows:

- (a) ≤ 25 mm pipe: ≤ 100 mm.
- (b) > 25 mm pipe: ≤ 250 mm.

Movement of pipework, caused by temperature fluctuations arising from environment or the discharge of extinguishing agent, may be considerable particularly over long lengths and should be taken into account when deciding support fixing methods.

TABLE 4
MAXIMUM PIPEWORK SPANS

Nominal diameter of pipe DN	Maximum pipework span m
6	0.5
10	1.0
15	1.5
20	1.8
25	2.1
32	2.4
40	2.7
50	3.4
65	3.5
80	3.7
100	4.3
125	4.8
150	5.2
200	5.8

6.3.5 Valves

All valves, gaskets, O-rings, sealants and other valve components shall be constructed of materials that are compatible with the extinguishing agent and shall be suitable for the maximum working pressure.

6.3.6 Nozzles

6.3.6.1 Nozzle choice and location

Nozzles, including nozzles directly attached to storage containers, shall be approved and shall be located with the geometry of the enclosure taken into consideration.

The type number and placement of nozzles shall be such that—

- (a) minimum nozzle clearances are achieved to allow for complete vapourisation of the agent;
- (b) the design concentration is achieved in all parts of the enclosure;
- (c) the discharge does not unduly splash flammable liquids or create dust clouds that might extend the fire, create an explosion or otherwise adversely affect the occupants; and

(d) the velocity of discharge does not adversely affect the enclosure or its contents.

Where clogging by foreign materials is possible, the discharge nozzles shall be provided with frangible discs or blow-out caps. These devices shall provide an unobstructed opening upon system operation and shall be designed and arranged so they will not injure personnel.

Nozzles shall be suitable for the intended use and shall be approved for discharge characteristics, including area coverage and height limitations.

Nozzles shall be of adequate strength for use with the maximum working pressures, and shall be constructed to withstand expected temperatures without deformation.

Nozzle discharge orifice inserts shall be of corrosion-resistant material.

6.3.6.2 *Nozzles in ceiling*

Precautions shall be taken to prevent the displacement of lightweight tiles during discharge.

NOTE: The discharge velocities created by the design of nozzles can be a factor in the displacement of ceiling tiles.

6.3.6.3 *Marking*

Discharge nozzles shall be permanently marked to identify the type, and the size of nozzle. The markings shall be discernible after installation.

NOTE: The type and size of nozzle may be identified by part number, orifice code, orifice diameter, or other suitable markings.

6.3.6.4 *Filters*

The inlet of any nozzle assembly or pressure-reducing assembly which contains an orifice of area less than 7 mm² shall be provided with an internal filter capable of preventing obstruction of the orifice.

6.3.7 *Pressure reducing orifice assembly*

Pressure reducing orifice assemblies shall be permanently marked to identify the size of the orifice. This marking shall be readily visible after the assembly is installed.

6.4 Detection, actuation and control systems

6.4.1 *General*

Detection, actuation and control systems may be either automatic or manual. Where they are automatic, provision shall also be made for manual operation.

6.4.2 *Automatic detection*

Automatic detection shall be by any method or device acceptable to the authority 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.

6.4.3 *Operating devices*

6.4.3.1 *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.

Automatic systems shall perform all functions necessary for the successful operation of the system, including time delay and ancillary functions (for example equipment shutdown, damper closure and fuel shut-off). All ancillary equipment shall incorporate manual reset facilities.

Electrically operated fire detection and actuation systems shall conform with AS 1670.5.

6.4.3.2 *Manual operation*

Provision shall be made for manual operation of the fire fighting system by means of a control situated outside the protected space or adjacent to the main exit from the space. The manual device shall incorporate a two-step mechanism or other safety device to restrict accidental operation.

In addition to any means of automatic operation, the system shall be provided with the following:

- (a) One or more means, of manual mechanical actuation, on or remote from, the storage containers.
- (b) A remote mechanical or 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, situated immediately adjacent to and preferably outside the main exit from the protected area.

Manual operation shall cause simultaneous operation of the appropriate automatically operated valves for extinguishing agent release and distribution.

NOTE: Pre-engineered systems utilising fire detection and extinguishing agent delivery via the same tubing or piping systems do not require a manual release device to be fitted.

6.4.3.3 *Manual mechanical release*

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.

6.4.4 *Control equipment*

6.4.4.1 *Electric control equipment*

Electric control equipment shall conform with AS 1670.5.

6.4.4.2 *Local Control Station (LCS)*

Where electric control systems are used provision shall be made for manual operation of the fire fighting system by means of a Local Control Station (LCS), situated outside the protected space or inside adjacent to the main exit from the space.

The LCS may be incorporated within the control and indicating equipment (CIE) when the CIE is located either within or adjacent to the protected area. Access to the LCS facilities shall not require the opening of any equipment door, and operation of the LCS controls shall not require the use of any key.

6.4.4.3 *Pneumatic control equipment*

Where pneumatic control equipment is used, the lines shall be protected against crimping and mechanical damage. Where installations could be exposed to conditions that could lead to loss of integrity of the pneumatic lines, special precautions shall be taken to ensure that no loss of integrity occurs.

Pneumatic release systems shall be operated by pressure from a reliable stored source. Extinguishing agent from the system's main storage container or a separate pilot cylinder may be used as a source of energy for system release. Where separate pilot cylinders are used to actuate the system they shall be duplicated unless provided with a means of continuous contents indication. Where gas pressure from pilot cylinders is used as a means of releasing the remaining slave storage containers, the supply and discharge rate shall be designed to release all of the slave storage containers for that risk simultaneously.

Where gas pressure from the system discharge manifold (that is, using back pressure rather than a separate pilot line) is used to release slave storage containers sufficient master storage containers shall be provided to ensure the required manifold pressure is developed to initiate actuation of all slave storage containers.

6.4.5 Audible alarms and visual warning devices

Audible alarms and visual warning devices shall conform with AS 1670.5.

Audible alarms shall be provided within the protected area to give positive warning of detection of the presence of fire and impending discharge. The sequence of operation and tone of the audible alarm shall be in accordance with AS 1670.5.

Visual fire alarm warning devices shall be provided for all systems including those protecting only underfloor areas, incorporating the words, as follows:

- (a) 'FIRE ALARM' shall be readily visible to the occupants of the protected area.
- (b) 'DO NOT ENTER' shall be located above each access door of the spaces likely to be occasionally entered. They shall be readily visible to persons having access to the protected area.
- (c) 'EVACUATE AREA' shall be readily visible to the occupants of the protected area.
- (d) 'EXTINGUISHING SYSTEM INOPERATIVE' shall be readily visible to persons having access to the protected area.

NOTES:

- 1 The intent of the Standard is that only one extinguishing system inoperative sign is required per hazard or risk.
- 2 For systems protecting unoccupiable spaces other than underfloor areas, the above warning devices may be omitted.

The letter sizes, colours, and operation of the visual warning devices shall be in accordance with AS 1670.5.

7 EXTINGUISHING AGENT SYSTEM DESIGN

7.1 General

This Clause sets out the requirements for the specifications, system flow calculations and extinguishing agent concentrations. It shall be read in conjunction with the appropriate appendix for the specific agent.

7.2 Specifications, plans and approvals

Layout and system proposal documents shall be provided to the authority having jurisdiction. The type of documentation required is specified in Appendix B.

7.3 System flow calculations

7.3.1 General

System flow calculations shall be carried out at a nominal extinguishing agent storage temperature of 20°C. The calculation method shall have been validated by an accredited approval authority by appropriate tests such as those described in this Standard. The system design shall be within the manufacturer's specified limitations (refer to ISO 14520-1, Annex H).

NOTES:

- 1 Variations from the nominal 20°C storage temperature affect flow conditions used in calculations.
- 2 Pre-engineered systems do not require a flow calculation when used within approved limitations.

7.3.2 Friction losses

Allowance shall be made for the friction losses in pipes and in storage container valves dip tubes, flexible connectors, selector valves, time delay devices and other equipment (e.g. pressure-reducing devices) within the flow line.

NOTE: The flow of a liquefied gas has been demonstrated to be a two-phase phenomenon, the fluid consisting of a mixture of liquid and vapour the proportions of which are dependent on pressure and temperature. The pressure drop is non-linear, with an increasing rate of pressure loss as the line pressure reduces by pipe friction.

7.3.3 Pressure drop

The pressure drop shall be calculated using two-phase flow equations for liquefied gases and single-phase flow equations for non-liquefied gases.

NOTE: These equations use friction factors and constants dependent on pressure and density obtained empirically. As the equations cannot be solved directly, a computer program is usually used to assist with the large number of iterative calculations in which pipe and nozzle sizes and, if appropriate, size of pressure reducing devices are selected within prescribed pressure losses.

7.3.4 Valves and fittings

Valves, fittings and check valves shall be rated for resistance coefficient or equivalent length in terms of pipe, or tubing sizes with which they will be used. The equivalent length of the storage container valves shall be listed and shall include syphon tube (where fitted), valve, discharge head, flexible connector and check valve.

7.3.5 Liquefied gases—Specific requirements

The minimum discharge rate for liquefied extinguishing agents shall be sufficient to maintain the velocity required for turbulent flow to prevent separation.

NOTE: If turbulent flow is not maintained, separation of the liquid and gaseous phases will occur, which can lead to unpredictable flow characteristics.

7.4 Enclosures

The protected enclosure shall have sufficient structural strength and integrity to contain the extinguishing agent discharge. Venting shall be provided to prevent excessive over- or underpressurization of the enclosure. Calculations of over and under pressure shall be provided.

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

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.

The volumes of ventilation system ductwork shall be considered as part of the total hazard volume when determining extinguishing agent quantities.

All services within the protected enclosure (e.g. 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 extinguishing agent.

Ventilation systems necessary to ensure safety are not required to be shut down upon system activation. In such cases, measures such as extended discharge shall be put in place to ensure the agent concentration is maintained at or above the extinguishing concentration for the required duration of protection.

7.5 Extinguishing agent concentration requirements

7.5.1 Flame extinguishment

For fire classifications, refer to AS 1850 *Portable fire extinguishers—Classification, rating and performance testing*.

The minimum Class B design concentration for each extinguishing agent shall be a demonstrated extinguishing concentration for each Class B fuel plus a safety factor of 1.3. The extinguishing concentration used shall be that demonstrated by the cup burner test, carried out in accordance with the method set out in ISO 14520-1:2015 Annex B, that has been verified with the heptane pan tests detailed in ISO 14520-1:2015, Annex C, Clause C.6.2. For hazards involving multiple fuels, the value for the fuel requiring the greatest design concentration shall be used. The extinguishing concentration shall be taken as the cup burner value or the heptane pan test value, whichever is greater.

The extinguishing concentration for Class A surface fires shall be the greater of the values determined by the wood crib and polymeric sheet fire tests described in ISO 14520-1:2015, Annex C. The minimum design concentration for Class A fires shall be the extinguishing concentration increased by a safety factor of 1.3. For non-cellulosic Class A fuels, higher design concentrations may be required.

NOTE: It is recognized that the wood crib and polymeric sheet Class A fire tests may not adequately indicate extinguishing concentrations suitable for the protection of certain Higher Hazard Class A fuels (e.g. electrical and electronic type hazards involving grouped power or data cables such as computer and control room under-floor voids, telecommunication facilities, etc.). An extinguishing concentration not less than that determined in accordance with Clause 7.5.1.3, or not less than 95% of that determined from the heptane fire test described in ISO 14520-1:2015, Annex C, Clause C.6.2, whichever is the greater, shall be used under certain conditions.

Higher Hazard Class A fuels include—

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

If polymeric sheet fire test data are not available, an extinguishing 95% of that determined from the heptane fire test shall be used.

In some circumstances additional agent may be required, as follows:

- (i) Where leakage occurs from a non-tight enclosure. This is covered in this Standard by the requirement for a room integrity test and sealing of the enclosure to achieve a defined hold time.
- (ii) Where leakage occurs due to doors being opened during or immediately after discharge. This should be covered by operational protocols for individual risks.
- (iii) Where it is important to minimize the quantities of toxic or corrosive products of combustion from the fire.
- (iv) Where it is important to minimize the toxic or corrosive breakdown products from the extinguishing agent itself.
- (v) Where excessive leakage occurs from an enclosure.
- (vi) Where hot surfaces, heated by fire or other means, may cause degradation of the extinguishing agent and hence reduce the efficiency of the agent.
- (vii) Where metal surfaces, heated by the fire, may act as an ignition source if not adequately cooled during agent discharge and hold time.

7.5.2 *Inerting*

Inerting concentrations shall be used where conditions for subsequent reflash or explosion could exist. These conditions exist when both—

- (a) the quantity of fuel permitted in the enclosure is sufficient to develop a concentration equal to or greater than one-half of the lower flammable limit throughout the enclosure; and
- (b) the volatility of the fuel before the fire is sufficient to reach the lower flammable limit in air (maximum ambient temperature or fuel temperature exceeds the closed cup flash point temperature) or the system response is not rapid enough to detect and extinguish the fire before the volatility of the fuel is increased to a dangerous level as a result of the fire.

The minimum design concentrations used to inert atmospheres involving flammable liquids and gases shall be determined by the test specified in ISO 14520-1:2015, Annex D, plus a safety factor of 10%.

7.6 Total flooding quantity

7.6.1 *General*

The amount of extinguishing agent required to achieve the design concentration shall be calculated from Equations 7.6.2 or 7.6.3 as appropriate, or from the data of the agent specific appendix.

In addition to these calculated concentration requirements, additional quantities of extinguishing agent may be required by national Standards to compensate for any special conditions that would adversely affect the extinguishing efficiency (see Clause 7.5.1), or if required by the physical characteristics of the extinguishing agent (see Clause 7.9.2).

7.6.2 *Liquefied gases*

For liquefied gases, the quantity of extinguishing agent required is calculated using the formula:

$$Q = \frac{C}{100 - C} \times \frac{V}{v} \quad \dots 7.6.2$$

where

Q = the total flooding quantity, in kilograms

C = the design concentration in percent by volume

V = the net volume of the hazard, in cubic metres (i.e. enclosed volume minus fixed structures impervious to extinguishing agent)

v = the specific volume, in cubic metres per kilogram:

$$v = k_1 + k_2 \times T$$

k_1, k_2 = constants specific to the extinguishing agent being used, supplied by the extinguishing agent manufacturer

T = the minimum anticipated ambient temperature of the protected volume, in degrees centigrade

7.6.3 *Non-liquefied gas*

For non-liquefied gases, the quantity of extinguishing agent required is calculated using the formula:

$$A1 \quad \left| \quad Q = \frac{V}{v} \ln \left(\frac{100}{100 - C} \right) \quad \dots 7.6.3 \right.$$

NOTE: For some purposes (e.g. filling of storage containers) it may be convenient to express the flooding quantity as volume at given reference (standard) conditions. For those cases the total flooding quantity is equivalent to:

$$Q_R = Q \times v_R$$

where

Q_R = the total flooding quantity, in cubic metres, expressed at ambient pressure (1.013 bar absolute) and T_R

Q = the total flooding quantity, in kilograms

v_R = the specific volume at reference temperature, in cubic metres per kilogram

$$v_R = k_1 + k_2 \times T_R$$

k_1, k_2 = are constants specific to the extinguishing agent being used, supplied by the extinguishment manufacturer

T_R = is the reference temperature, in degrees centigrade

7.7 Altitude adjustment

The design quantity of the extinguishing agent shall be adjusted to compensate only for ambient pressures that vary more than 11% (equivalent to approximately 1000 m of elevation change) from standard sea level pressure (1.013 bar absolute). The ambient pressure is affected by changes in altitude, pressurization or depressurization of the protected enclosure, and weather-related barometric pressure changes. The extinguishing agent quantity is determined by multiplying the quantity determined in Clause 7.6 by the ratio of the average ambient enclosure pressure to the standard sea level pressure. Correction factors for gaseous agents are shown in Table 5.

TABLE 5
CORRECTION FACTORS

Equivalent altitude m	Correction factor
-1 000	1.130
0	1.000
1 000	0.885
1 500	0.830
2 000	0.785
2 500	0.735
3 000	0.690
3 500	0.650
4 000	0.610
4 500	0.565

7.8 Duration of Protection

It is important that the extinguishing agent concentration not only be achieved, but is 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 extinguishing agent has dissipated.

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. The predicted hold time shall be determined by the door fan test specified in ISO 14520-1:2015, Annex E, or a full discharge test based on the following criteria:

- (a) At the start of the hold time, the concentration throughout the enclosure shall be greater than the extinguishing concentration.
- (b) At the end of the hold time, the extinguishing agent concentration at the protected height within the enclosure being protected shall be not less than the extinguishing concentration.
- (c) The hold time shall be not less than 10 minutes, unless otherwise specified by the authority.

7.9 System performance

7.9.1 Discharge time

7.9.1.1 Liquefied extinguishing agent

The liquefied extinguishing agent discharge shall be completed as quickly as possible to suppress the fire and limit the formation of decomposition products. In no case shall the discharge time required to achieve 95% of the design concentration exceed 10 seconds at 20°C, or as otherwise required by the authority.

The discharge time period is defined as the time required to discharge from the nozzles 95% of the extinguishing agent mass required to achieve the design concentration at 20°C. For liquefied extinguishing agents, this can be approximated as the interval between the first appearance of liquid at the nozzle and the time when the discharge becomes predominantly gaseous. Flow calculations performed in accordance with Clause 7.3 or with the approved pre-engineered systems instruction manuals shall be used to demonstrate conformance with this requirement.

7.9.1.2 Non-liquefied extinguishing agent

The discharge time required to achieve 95% of the design concentration for non-liquefied extinguishing agents shall not exceed 60 seconds for Class B fuel hazards or 120 seconds for Class A hazards. Flow calculations performed in accordance with Clause 7.3 or with the approved pre-engineered systems instruction manuals shall be used to demonstrate conformance with this requirement.

7.9.2 Extended discharge

When an extended discharge is necessary, the rate shall be sufficient to maintain the desired concentration for the required hold time.

NOTE: Consideration needs to be given to agent concentrations achieved during the discharge in relation to the NOAEL and LOAEL levels.

8 COMMISSIONING AND ACCEPTANCE

8.1 General

This Clause sets out the minimum requirements for the commissioning and acceptance of the gaseous extinguishing system.

8.2 Tests

8.2.1 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 Clauses 8.2.2 to 8.2.8 shall be performed.

8.2.2 Enclosure check

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.

8.2.3 *Review of design calculations*

The type of enclosure occupancy (normally occupied, normally unoccupied) shall be checked against that indicated in the system designer calculations.

The actual enclosure volumes shall be checked against those indicated in the system designer calculations.

The fire hazards (classes of fires) shall be checked against those indicated in the system designer documentation.

The selected design application density shall be appropriate for the hazard. In case of multiple fire hazards the greatest design application shall be used.

An adequate quantity of extinguishing agent to produce the required design concentration shall be provided. Total flooding quantity shall be appropriate for the actual protected volume.

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

8.2.4 *Review of mechanical components*

The following reviews apply:

- (a) All extinguishing agent storage containers shall be properly located in accordance with 'approved for construction' set of system drawings.
- (b) All storage containers and mounting brackets shall be securely fastened in accordance with the manufacturer's requirements.
- (c) The number and size(s) of storage containers shall be checked for conformance to the design calculations. The number shall be adequate to contain the total flooding quantity.
- (d) The piping distribution system shall be inspected to determine that it is in conformance with the design and installation documents.
- (e) Nozzles and pipe sizes and, if appropriate, pressure-reducing devices, shall be in accordance with system drawings. The means for pipe size reduction and orientation of tees shall be checked for conformance to the design.
- (f) Piping joints, discharge nozzles and piping supports shall be securely fastened to prevent unacceptable vertical or lateral movement during discharge. Discharge nozzles shall be installed in such a manner that piping cannot become detached during discharge.
- (g) The piping distribution system shall be inspected internally to detect the possibility of any oil or particulate matter which could soil the hazard area or affect the extinguishing agent distribution due to a reduction in the effective nozzle orifice area.
- (h) The discharge nozzles shall be oriented in conformance with the manufacturer's installation guidelines.
- (i) If nozzle deflectors are installed, they shall be positioned to obtain the maximum benefit.
- (j) The discharge nozzles, piping and mounting brackets shall be installed in such a manner that they will not potentially cause injury to personnel. Extinguishing agent 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 may be dislodged.

- (k) Unless the total piping contains not more than one change in direction fitting between the storage container and the discharge nozzle, and unless all piping has been physically checked for tightness, the following tests shall be carried out:
- (i) All open-ended piping shall be pneumatically tested in a closed circuit for a period of 10 minutes at 3 bar. At the end of 10 minutes, the pressure drop shall not exceed 20% of the test pressure.
 - (ii) All closed-section pipework and pipework upstream of pressure-reducing devices shall be hydrostatically tested to a minimum of 1.5 times the maximum working pressure for two minutes during which there shall be no leakage. On completion of the test, the pipework shall be purged to remove moisture.

NOTE: It is recommended that hydrostatic testing be carried out prior to installation.

WARNING: Pneumatic pressure testing creates a potential risk of injury to personnel in the area, as a result of airborne projectiles if rupture of the piping system occurs. Prior to conducting the pneumatic pressure test, the protected area shall be evacuated and appropriate safeguards shall be provided for test personnel.

- (l) A test using nitrogen, or a suitable alternative, shall be performed on the piping network to verify that flow is continuous and that the piping and nozzles are unobstructed.

8.2.5 *Review of enclosure integrity*

All total flooding systems shall have the enclosure checked in order to locate and then effectively seal any significant air leaks that could result in a failure of the enclosure to hold the specified extinguishing agent concentration level for the specified holding period. Unless otherwise required by the authority, the test specified in ISO 14520-1:2015 Annex E shall be used.

Review the structural integrity of the enclosure and assess its ability to withstand the developed pressure fluctuations during system discharge taking into account:

- (a) The equivalent leakage area determined from the enclosure integrity test.
- (b) The provision of any required additional pressure vents.

Review over and under pressure calculations and confirm pressure relief vents (where fitted) are of the required size.

If pressure relief vents are required 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 extinguishing agent during and after its discharge.

8.2.6 *Review of electrical components*

All wiring systems shall be properly installed in conformance with the relevant part of AS 1670. Check all electrical components are installed and located in accordance with the system design.

8.2.7 *System functional test*

Prior to conducting any functional test, remove actuators from storage container valves to avoid unintended discharge of the system.

System functional testing shall be in accordance with the commissioning section of AS 1670.5 and include the following:

- (a) Operate the detection initiating circuit(s). Verify that all alarm functions occur according to the design specifications.

- (b) Operate the necessary circuit to initiate a second alarm circuit if present. Verify that all second alarm functions occur according to design specifications.
- (c) Operate the manual release device. Verify that manual release functions occur according to design specifications.
- (d) Test all system interfaces function as intended, for example, air handling systems, dampers, equipment shutdown.
- (e) Where appropriate, operate the automatic/manual switch (inhibit). Verify that functions occur according to the design specifications. Confirm that visual and audible supervisory signals are received at the control panel.
- (f) Check the function of all resettable valves and actuators, unless testing the valve will release extinguishing agent.

NOTE: 'One-shot' valves, such as those incorporating frangible discs, should not be tested.

- (g) Check pneumatic equipment, where fitted, for integrity, to ensure proper operation.

A discharge test for extinguishing agents is generally not recommended.

NOTE: However, if a discharge test is to be conducted it should be in accordance with the procedure given in Appendix C.

Other assessment methods may normally be used to reduce unnecessary discharge into the environment, for example, the door fan pressurization test specified in ISO 14520-1:2015, Annex E. However, a discharge test may be conducted if acceptable to the authority.

8.2.8 Completion of functional tests

When all functional tests are complete, check all actuators have been reset before being refitted to the storage containers. Reconnect each storage container so that activation of the release circuit will release the extinguishing agent.

Return the system 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.

8.3 Completion certificate and documentation

The installer shall provide the owner or owners agent with a completion certificate, a complete set of instructions, calculations and drawings showing the system as installed, and a statement that the system conforms 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.

See Appendix B: Paragraph B4, Table B1 and Figure B1.

8.4 Block plan

A durable block plan, shall be securely fixed adjacent to the agent storage containers where it can be readily seen when standing in front of the storage containers. A copy of the block plan shall also be provided at Special Hazards Control and Indicating Equipment (SHCIE) (see Figure 5).

The block plan shall include the following elements:

- (a) The heading 'Gaseous Fire Extinguishing System Block Plan'.
- (b) A short description of the area protected by the gaseous extinguishing system.
- (c) A diagram showing—
 - (i) a layout of the general area in which the gaseous extinguishing system is installed;

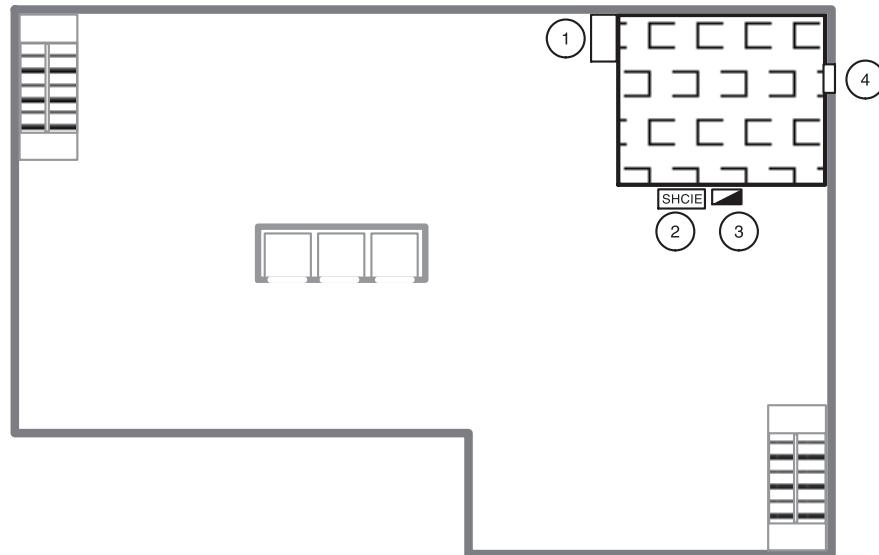
- (ii) identification of the area(s) protected;
 - (iii) location(s) of the agent storage containers;
 - (iv) location of the SHCIE;
 - (v) location of any post discharge ventilation system controls (as applicable);
 - (vi) locations and size of un-closable openings considered in the design of the system;
 - (vii) a statement that the system has been designed and installed in accordance with this Standard. With any departures from the Standard noted;
 - (viii) the name of the installer; and
 - (ix) the month and year of installation and of any major extensions thereto.
- (d) A schedule of design and commissioning parameters including:
- (i) Identification of the protected spaces within the areas protected.
 - (ii) The gross volume of the protected space(s).
 - (iii) The net volume of the protected space(s).
 - (iv) The agent.
 - (v) The design fuel.
 - (vi) The design concentration.
 - (vii) The minimum agent quantity.
 - (viii) The estimated maximum concentration based upon the installed agent quantity.
 - (ix) The minimum required pressure relief vent free area.
 - (x) The approved design hold time.
 - (xi) The hold time achieved at commissioning.
 - (xii) The hold time criteria (e.g. descending interface or mechanical mixing).
 - (xiii) The maximum protected height (as applicable).
 - (xiv) Other data as relevant to the installation.

The block plan shall have a minimum size of 210 mm × 297 mm (A4 paper). The following forms of protection are deemed to conform with the durability requirements:

- (A) Paper laminated with 100 micron (or greater) lamination film.
- (B) A frame with a protective cover (e.g. plastic or glass).
- (C) An engraved plan on a solid substrate (e.g. metal or plastic).

GASEOUS FIRE EXTINGUISHING SYSTEM BLOCK PLAN

ACME INDUSTRIES, MAIN ST NEWTOWN LEVEL 3 COMPUTER ROOM



- (1) AGENT CONTAINER STORAGE
- (2) SPECIAL HAZARDS CONTROL & INDICATING EQUIPMENT
- (3) POST DISCHARGE VENTILATION CONTROL PANEL
- (4) UNCLOSABLE OPENING (1.1m²)

THE GASEOUS SUPPRESSION SYSTEM HAS BEEN DESIGNED AND INSTALLED TO AUSTRALIAN STANDARD AS 4214 - 2017 WITH THE FOLLOWING PARAMETERS

PROTECTED SPACE(S)	IN-ROOM & SUB-FLOOR
GROSS VOLUME	179m ³
NET VOLUME	179m ³
AGENT	HFC-227ea
DESIGN FUEL	HIGHER HAZARD CLASS A
DESIGN CONCENTRATION	8.50%
AGENT QTY. REQUIRED	128kg
ESTIMATED MAX CONCENTRATION	8.67%
PRESSURE RELIEF VENT AREA (MIN)	0.68m ²
REQUIRED HOLD TIME (MIN)	10 min
COMMISSIONED HOLD TIME	11.3 min
HOLD TIME CRITERIA	MECHANICAL MIXING
MAX PROTECTED HEIGHT	N/A

INSTALLED BY: **ABC GAS SUPPRESSION CO.**

MONTH AND YEAR OF INSTALLATION: **JANUARY 2017**

FIGURE 5 BLOCK PLAN

9 MAINTENANCE

Maintenance of gaseous fire protection systems shall be carried out in accordance with AS 1851–2012, Section 7 Special Hazard Systems.

APPENDIX A

MARINE

(Normative)

A1 GENERAL

This Appendix sets out the requirements for the design and application of gaseous fire extinguishing systems for machinery spaces and cargo pump rooms for commercial marine vessels that, through State or Territory marine legislation, require an extinguishing system.

NOTE: This Appendix should also be used as the basis for design of gaseous fire extinguishing systems for recreational craft.

Where the marine provisions of this Appendix conflict with the requirements of this Standard, this Appendix shall take precedence.

CAI(a) *Where a marine vessel is required to comply with Marine Orders Part 15 and Safety of Life at Sea (SOLAS) resolutions as administered by the Australian Maritime Safety Authority (AMSA) certain requirements of this Standard may be of assistance in the design of distribution pipework systems.*

Refer also to the National Standard for Commercial Vessels administered by AMSA.

Prior to acceptance of the listing, technical documentation such as the system design manual, test reports or listing reports shall be presented to the authority having jurisdiction. The documentation shall show that the system and its individual components are compatible, employed within tested limitations and suitable for marine use.

The listing organization shall—

- (a) verify fire tests conducted in accordance with predetermined Standards;
- (b) verify component tests conducted in accordance with predetermined Standards;
- (c) review component quality assurance program;
- (d) review design and installation manual;
- (e) identify system and component limitations;
- (f) verify integrity and reliability of the system as a whole;
- (g) have a follow-up program; and
- (h) publish a list of approved equipment.

CAI(b) *A marine authority may only accept a gaseous fire extinguishing system that has been approved by a ship classification society, or has been tested and specifically listed for the purpose by an internationally recognized fire protection testing and approval authority.*

A2 USE AND LIMITATIONS

Total flooding gaseous fire extinguishing systems that are arranged for manual operation only shall be used.

Plant or machinery typically protected by total flooding extinguishing systems is either situated within enclosures, such as a room, or the equipment forms an enclosure capable of containing the agent.

Some typical areas and spaces that would be suitable for protection by gaseous fire extinguishing systems include, but are not limited to, the following:

- (a) Main machinery spaces.
- (b) Emergency generator rooms.
- (c) Pump rooms.
- (d) Flammable liquid storage and handling areas and paint lockers.

A3 AGENT SELECTION

A3.1 Halocarbon agents

Halocarbon agents shall only be used if they—

- (a) are listed in Table 1 of this Standard;
- (b) have been assessed and approved for their environmental acceptability and occupational safety by the relevant Australian authorities; and
- (c) have successfully passed the test protocol as detailed in the IMO (International Maritime Organization) MSC/Circular 848 (Marine Safety Committee).

A3.2 Use of halocarbon agents

In addition to the limitations specified in Clause 4, halocarbon agents shall not be used to protect dry cargo holds or bulk cargo.

The impact of extinguishing agent decomposition on fire protection effectiveness and equipment shall be considered where the agent is used in circumstances of high equipment temperatures.

A3.3 Inert gases

Inert gaseous agents shall only be used if they—

- (a) are listed in Table 1 of this Standard;
- (b) have been assessed and approved for their environmental acceptability and occupational safety by the relevant Australian authorities; and
- (c) have successfully passed the test protocol as detailed in the IMO (International Maritime Organization) MSC/Circular 848 (Marine Safety Committee).

Carbon dioxide (CO₂) shall be deemed to satisfy these requirements.

NOTE: For the protection of cargo spaces, refer to AMSA requirements.

A4 SAFETY REQUIREMENTS

For the purposes of this Appendix, except for carbon dioxide, safety precautions shall be applied in accordance with the following:

- (a) The design quantity of agent shall be calculated using the minimum design concentration and assuming the minimum anticipated temperature in the protected space.
- (b) The maximum agent concentration shall be calculated using the design quantity applicable to the net volume of the protected space at a maximum temperature of 40°C.
- (c) In no case shall an agent be used where its maximum concentration is in excess of its LOAEL, with the exception of CO₂ where a lock off valve shall be fitted in all installations.

A5 SYSTEM DESIGN

A5.1 Specification, plans and approvals

Specifications, plans and approvals shall be in accordance with Clause 7.2.

A5.2 Acceptance of installations

The completed installation shall be commissioned in accordance with Clause 8, except as modified by the requirements of Paragraph A11.

A5.3 Approval of components

Approval of components shall be in accordance with Clause 8.

A5.4 Design concentration

A5.4.1 *Agent*

The requirements of Clause 7.5 shall not apply to marine applications. The minimum design concentration for machinery spaces shall be that concentration successfully tested in accordance with IMO MSC/Circular 848.

A5.4.2 *Combination of fuels*

For combinations of fuels, the design concentration derived from the flame extinguishing values for the fuel requiring the greatest concentration shall be used. For a particular fuel, the design concentration referred to in the appropriate appendix covering gaseous extinguishing agents shall be used. In no case shall the design concentration be below that required in Paragraph A5.1.

A5.5 Total flooding quantity

A5.5.1 *General*

The requirements given in Clause 7.6 shall not apply to this Clause. They shall be replaced by the requirements of Paragraphs A5.5.2 to A5.5.4.

A5.5.2 *Halocarbon or inert gas*

The quantity of halocarbon or inert gas agent shall be based on the net volume of the space. When calculating the net volume of the machinery space, the net volume shall include the volume of the bilge, the volume of the stack uptake and the volume of the free air contained in air receivers, which, in the event of a fire, may be released into the protected space.

Objects that occupy volume in the protected space shall be subtracted from the volume of the space. These objects include, but are not necessarily limited to, the following:

- (a) Auxiliary machinery.
- (b) Boilers.
- (c) Condensers.
- (d) Evaporators.
- (e) Main engines.
- (f) Reduction gears.
- (g) Tanks.
- (h) Trunks.

A5.5.3 Carbon Dioxide (CO₂)

The quantity of carbon dioxide (CO₂) shall be based on the gross volume of the space. When calculating the volume of the machinery space, the volume shall include the volume of the bilge, the volume of the stack uptake and the volume of the free air contained in air receivers, which, in the event of a fire, may be released into the protected space.

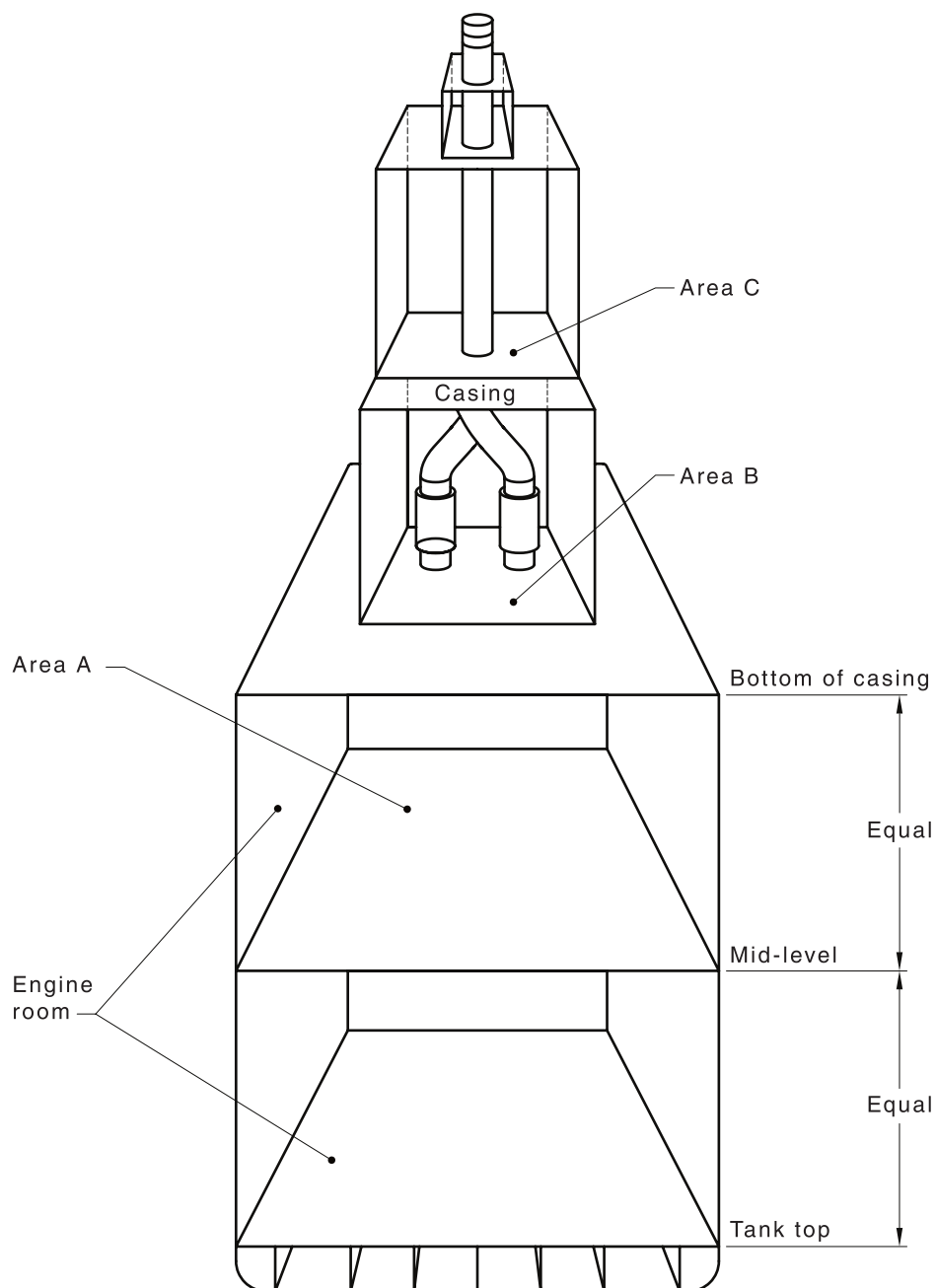
The volume calculation shall be permitted to exclude the portions of the stack uptake that have a horizontal cross-sectional area less than 40% of the horizontal cross-sectional area of the main machinery space (see Figure A1). The horizontal cross-sectional area of the main machinery space shall be measured midway between the lowest level (tank top) and the highest level (bottom of the stack casing).

The total flooding quantity shall be calculated from the following equation:

$$M = \frac{(V \times C)}{0.56} \quad \dots \text{A5.5.3}$$

where

- M = total flooding quantity, in kilograms
- V = the gross volume calculated as above, in cubic metres
- C = design concentration of 35% by volume
- 0.56 = the free volume of carbon dioxide released to atmosphere, in cubic metres per kilogram



For the casing to be considered separate from the gross volume of the machinery space, Area B is to be 40 percent or less of Area A.

If Area B is greater than 40 percent of Area A, the volume of casing up to Area C (or where the area is 40 percent or less of Area A) is to be included in the gross volume of the space.

Any area of the casing containing boilers, internal combustion machinery or oil-fired installations is to be included in the gross volume of the engine room.

FIGURE A1 MACHINERY SPACE VOLUME CALCULATION

A5.5.4 Multiple spaces

Where more than one space is to be protected, the following requirements shall apply:

- (a) Where the spaces to be protected are adjoining and are not separated by bulkheads or deckheads with an appropriate fire rating, independent systems shall be provided, with sufficient agent for each space concerned.
- (b) Where multiple spaces to be protected have different volumes, but share a common bank of storage containers for agent supply, the system shall be configured to ensure that the resultant concentration(s) of the extinguishing agent into smaller volume spaces shall conform with the LOAEL requirements of Paragraph A4(c) of this Appendix.
- (c) Where multiple spaces share a common bank of storage containers for agent supply, directional valves shall be used to control the discharge into each space.

A5.6 Special conditions

Special conditions, as outlined in Clause 7.5.1, shall be considered in calculating the total flooding quantity.

A5.7 Discharge time

A5.7.1 Halocarbon agents

For systems using halocarbon agents, 95% of the design concentration shall be achieved in 10 seconds or less.

A5.7.2 Inert gases (including CO₂)

For systems using inert gas agents, 95% of the design concentration shall be achieved within 120 seconds.

A5.8 Duration of protection

The extinguishing agent concentration holding time shall be a minimum of 15 minutes and be as specified in Clause 7.8; however, a door fan test or full discharge test need not be conducted unless required by the authority having jurisdiction.

A5.9 System flow calculations

System flow calculations shall be carried out in accordance with Clause 7.3.

A5.10 Nozzle choice and location

Nozzles shall be of the type listed for the intended purpose. Limitations shall be determined based on testing in accordance with the IMO MSC/Circular 848, or acceptable listing body protocols. Nozzle spacing, area coverage, height and alignment shall not exceed listing limitations.

A6 ENCLOSURE REQUIREMENTS

The requirements for the protected enclosure shall be in accordance with Clause 7.4.

CA6 *The formula used in the calculation of total flooding quantities is based on 'free efflux' from the space upon agent discharge. This means that the displaced atmosphere will contain an air/agent mixtures.*

Where a particularly tight space, such as a fully watertight compartment, is to be protected or venting is only available at the top of the space, this free efflux effect of air and agent mixture may be limited or may not occur.

Consequently, when an agent with a design concentration close to the NOAEL at 20°C is used, the concentration may exceed the subsequent LOAEL level when the resulting maximum concentration is calculated for an enclosure temperature of 40°C.

A7 AGENT SUPPLY

A7.1 General

The requirements of Clause 6.2 shall apply, except as modified by Paragraphs A7.2 to A7.3 of this Appendix.

A7.2 Storage container brackets

Storage containers shall be secured with brackets specifically listed and designed to cater for the maximum expected mass, vibration and shock loading associated with marine vessel movements. Storage container brackets shall be insulated from the storage container body, to prevent chafing.

A7.3 Protection against corrosion

Storage containers shall be protected against corrosion and shall be installed such that a space of at least 50 mm between the deck and the bottom of the storage container is provided.

A7.4 Location of storage containers

Gas storage containers should be located as near as practicable to the area they protect and preferably external to that area. Gas storage containers may be located within the area to be protected; however, they shall be sited so as to minimize the risk from fire and explosion. The storage container and associated controls shall be listed for maximum ambient temperatures expected in the area.

Additionally the following requirements apply:

- (a) No part of any fixed fire extinguishing installation shall be fitted forward of the collision bulkhead in any marine vessel.
- (b) Where extinguishing agent storage containers are outside a protected area, they shall be stored in a room situated in a safe and readily accessible position and shall be effectively ventilated. Any entrance to such a storeroom shall be from the open deck and be independent of the protected area. Access doors shall open outwards. Container storage rooms shall be gas-tight (to prevent migration of agent to adjacent compartments) adequately insulated, dry and well lit.

A8 DISTRIBUTION SYSTEM

A8.1 General

The distribution system shall conform with the requirements of Clause 6.3 and Paragraphs A8.2 to A8.4 of this Appendix.

A8.2 Piping

Where steel piping and fittings are used, they shall be protected from corrosion by hot-dip galvanizing. Exposed threads shall be kept to a minimum and, after installation, such exposed threads shall be protected from corrosion.

A8.3 Aluminium

Aluminium components shall not be used.

A8.4 Penetrations

Where distribution piping penetrates watertight or fire-rated bulkheads or deckheads, provision shall be made to maintain their integrity.