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GOVERNMENT OF INDIA
CENTRAL PUBLIC WORKS DEPARTMENT

GENERAL SPECIFICATIONS FOR ELECTRICAL WORKS

PART-VIII
GAS BASED FIRE EXTINGUISHING SYSTEM

2013

CPWD

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FOREWORD

Central Public Works Department is responsible for the design, construction and maintenance of a large number of buildings of the Govt. of India. Some of these buildings are housing Data Centers, Server rooms, Command & Control Rooms for Access Control, CCTV Control, IBMS, etc., which require Special Fire Fighting Systems, due to the adverse effect of Water on the assets to be protected. Special application buildings like Art Galleries, Museums, etc. also need non-water based Fire Fighting Systems.

A need was therefore felt to have General Specification for Electrical Works (Gas Based Fire Extinguishing Systems).

Under the mandate from the Specifications Committee for E&M works, General Specification for Electrical Works Part VIII (Gas Based Fire Extinguishing Systems) were drafted by Sh. S.K. Chawla, CE (E). These Specifications include use of environment friendly Fire Extinguishing Gases, comparison between Inert & halocarbon gases for correct selection for occupied Protected Area, unoccupied Protected Area, System engineering and the flooding quantity calculations, etc.

I acknowledge the efforts put in by members of the Specification committee under the chairmanship of Sh R.K. Singhal, Spl.DG (NR) in reviewing and finalizing these specification. I also acknowledge the efforts of Sh. C.K. Varma, CE (E) CSQ and Sh. S.S. Garg, SE (E) TAS, Member Secretary and his team of officers for contributing towards making the publication available in short period of time.

Suggestions for Modifications as well as errors and omissions may be sent to SE (E) TAS, office of the Chief Engineer (E) CSQ, CPWD, Vidyut Bhawan, New Delhi.

In case of any discrepancy between English and Hindi versions, the English version shall be held valid.

Place : New Delhi

Dated : 26.02.2013

(Ashok Khurana)
Director General
CPWD, New Delhi

CPWD

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विशेष महानिदेशक (उत्तरी क्षेत्र)
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PREFACE

The Central Public Works Department (CPWD) is a 158 years old institution and is principal agency of the Government of India responsible for creating assets and providing comprehensive services including planning, designing, construction and maintenance of office and residential buildings as well as other infrastructures of various ministries, departments of Government of India, autonomous bodies and public sector enterprises. Its activities are spread throughout the country.

Some of these buildings are housing data centers, servers, server room, command & control rooms for Access control, CCTV Control, IBMS, etc. Special application buildings like Art galleries, Museums, etc also need non-water based Fire Fighting Systems, due to the adverse effect of water on the assets to be protected.

In view of the above, General Specification for Electrical Works, Part-VIII (Gas Based Fire Extinguishing system) is prepared.

These specifications include use of environment friendly Fire Extinguishing gases, comparison between inert & halocarbon gases for correct selection for occupied protected Area, unoccupied protected Area, system engineering and the flooding quantity calculations, etc.

I am grateful to Shri Ashok Khurana, Director General, CPWD for reposing trust in me to undertake this work and express my deep appreciation to Sh. S.K. Chawla CE(E) and Sh. C.K. Varma, CE(E), for drafting these specifications.

I acknowledge the efforts put in by members of the specification committee, in making the present specification technically update, modern & user friendly.

I also express my deep appreciation to Sh. S.S. Garg, SE(E) TAS, Sh. R.R. Meena , EE(E) TAS, Sh. V.K. Yadav, AE(E) TAS, Sh. P.P. Singh, AE(E) TAS, who made their sincere efforts to update and making the publication available in very short time.

Errors or omissions, and suggestions for improvement, if any, may kindly be brought to the notice of the Superintending Engineer (E) TAS, Office of the Chief Engineer (E) CSQ, CPWD, New Delhi -01

Place : New Delhi

Dated : 26.02.2013

(R.K. Singhal)
Spl. Director General (NR), CPWD
and Chairman, Specifications Committee(E&M)

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17	Sh. S.S. Garg, SE(E)TAS, CSQ(E)	Member Secretary

REFERENCES OF AMENDMENTS

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SECTION 1

GENERAL

1.1 Scope

These General Specifications cover the details of various Clean Agents (Gases), Containers for Clean Agents (Gases), Container Arrangement, distribution system of Clean Agents to the area to be protected, discharge Nozzles, Release systems, etc. for supply, installation, testing and commissioning of Gas Based Fire Extinguishing Systems available and also their selection for various applications.

These General Specifications are subject to revision from time to time.

1.2 Related Documents

1.2.1 These technical specifications be read in conjunction with the standard conditions of the contract with up to date correction slips, as relevant for commercial aspects, as well as schedules and drawings, and the requirements under these specifications.

1.2.2 In the event of any discrepancy between these specifications and the interconnected documents, the technical requirements as per the contract specifications shall be followed and deemed to have over riding value.

1.3 Site Information

1.3.1 The tenderer should, in his own interest, visit the site and familiarise himself with the site conditions before tendering.

1.3.2 For any clarification, tenderer may discuss with the Engineer-in-charge.

1.4 Safety Codes and Labour Regulations

1.4.1 All the safety procedures outlined in the safety codes listed in Appendix 'A' shall be complied with.

1.4.2 In respect of all labour employed directly or indirectly on the work for the performance of the fire fighting contractor's part of work, the contractor at his own expense, will arrange for the safety provisions as per the statutory provisions, B.I.S recommendations, factory act, workman's compensation act, CPWD code and instructions issued from time to time.

1.4.3 Failure to provide such safety requirements would make the tenderer liable for penalty for Rs. 1000/- for each violation. In addition the Engineer-in-charge,

shall be at liberty to make arrangements and provide facilities as aforesaid and recover the cost from the contractor.

1.4.4 The contractor shall provide necessary barriers, warning signals and other safety measures while laying pipelines, cables etc. or wherever necessary so as to avoid accident. He shall also indemnify CPWD against claims for compensation arising out of negligence in this respect.

1.4.5 Contractor shall be liable, in accordance with the Indian Law and Regulations for any accident occurring due to any cause. The department shall not be responsible for any accident occurred or damage incurred or claims arising there from during the execution of work. The contractor shall also provide all insurance including third party insurance as may be necessary to cover the risk. No extra payment would be made to the contractor due to the above provisions thereof.

1.5 Works to be arranged by the Department

Unless otherwise specified in the tender documents, the following works shall be arranged by the Department:

1.5.1 Space for accommodating all the equipment and components involved in the work.

1.5.2 False ceiling and/or false floor wherever provided as required.

1.5.3 Power supply, Water supply for bona fide use for installation, testing & commissioning of the system.

1.5.4 Openings in Glass for Glazed partitions for carrying pipe lines and cables, wherever specified.

1.6 Works to be done by the Contractor

Unless otherwise mentioned in the tender documents, the following works shall be done by the contractor and therefore, their cost shall be deemed to be included in their tendered cost- whether specifically indicated in the schedule of work or not-

1.6.1 Base and clamping for cylinders including bolts and vibration isolation pads.

1.6.2 Suspenders, brackets and floor/ wall supports for suspending/supporting pipes & nozzles.

1.6.3 Suspenders and/or cable trays for laying the cables.

1.6.4 Sealing of all floor slab/ wall openings provided by the Department or contractor for pipes and cables, from fire safety point of view, after laying of the same.

1.6.5 Painting of all exposed metal surfaces of equipment and components with appropriate colour.

1.6.6 Making openings in the walls/ floors/ slabs or modification in the existing openings wherever provided for carrying pipe line, cables etc.

1.6.7 Making good all damages caused to the structure during installation and restoring the same to their original finish.

1.7 Power Supply and Water Supply

1.7.1 Unless otherwise specified, 3 phase, 415 volts, 50 Hz power supply shall be provided by the department free of charge to the contractor at one point for installation at site. Termination in switchgear however, shall be provided by the contractor. Further extension if required shall be done by the contractor.

1.7.2 The power supply for testing and commissioning of the complete installation shall be made available by the Department free of charge to the contractor. For this purpose, the power supply shall be given at one point through U.G. cable or as specified in the contract. The termination of the feeder in the unit shall be the responsibility of the contractor and nothing extra shall be paid on this account.

1.7.3 Unless otherwise specified in the contract, further power distribution to the various equipment shall be done by the contractor.

1.7.4 Where the power supply has to be arranged by the Department at more than one point as per the terms of the contract, the termination of all such power feeders in the incomer of respective control panels (provided by the contactor) shall be the responsibility of the contractor.

1.7.5 The contractor shall not use the power supply for any other purpose than that for which it is intended for. No major fabrication work shall be done at site. Power shall be used only for welding / cutting works. The power supply shall be disconnected in case of such default and the contractor shall then have to arrange the required power supply at his cost.

1.7.6 Water supply shall be made available to the contractor by the Department free of charge at only one point for pressure testing of pipe installation.Further extension if required shall be done by the contractor.

1.8 Machinery for Installation

All tools and tackles required for unloading/ handling of equipment and materials at site, their assembly, erection, testing and commissioning shall be the responsibility of the contractor.

1.9 Completeness of tender, Submission of Execution Programme, Approval of Drawings, and Commencement of Work

1.9.1 *Completeness of the tender* - All sundry equipment, fittings, assemblies, accessories, hardware items, bolts, supports, termination lugs for electrical

connection, cable glands, junction box and all other sundry items for proper assembly and efficient working of the various equipment and components of the work shall be deemed to have been included in the tender, irrespective of the fact whether such items are specifically mentioned in the tender or not.

1.9.2 *Submission of programme* - Within fifteen days from the date of receipt of the letter of acceptance, the successful tenderer shall submit his programme for submission of drawings, supply of equipment, installation, testing, commissioning and handing over of the installation to the Engineer-in-charge. This programme shall be framed keeping in view the building progress.

1.9.3 *Submission of Drawings* - The contractor shall submit the design calculations and drawings to the Engineer-in-Charge for approval before start of work.

1.9.4 *Commencement of Work* - The contractor shall commence work as soon as the drawings submitted by him are approved.

1.10 Dispatch of Materials to Site and Safe Custody thereof

1.10.1 The contractor shall dispatch materials to site in consultation with the Engineer-in-charge.

1.10.2 Suitable lockable storage accommodation shall be made available free of charge temporarily. Watch & ward however, shall be the responsibility of contractor.

1.10.3 Programme of dispatch of material shall be framed keeping in view the building progress.

1.10.4 Safe custody of all machinery and equipment supplied by the contractor shall be the responsibility of the contractor till final taking over by the department.

1.11 Co-ordination with Other Agencies

1.11.1 The contractor shall co-ordinate with all other agencies involved in the work so that the work of other agencies is not hampered due to delay in his work.

1.11.2 Piping, cabling or any other work, which directly affect the progress of building work, shall be given priority.

1.12 Quality of Materials and Workmanship

1.12.1 The components of the installation shall be of such design so as to satisfactorily function under all conditions of operation.

1.12.2 The entire work of manufacture/ fabrication, assembly and installation shall conform to sound engineering practice.

1.12.3 All equipment and materials to be used in work shall be manufactured in factories of good repute having excellent track record of quality manufacturing, performance and proper after sales service.

1.13 Care of the Building

1.13.1 Care shall be taken by the contractor during execution of the work to avoid damage to the building.

1.13.2 They shall also be responsible for repairing all such damages and restoring the same to the original finish at their cost.

1.13.3 They shall also remove all unwanted and waste materials arising out of the installation from the site of work from time to time.

1.14 Inspection and Testing

1.14.1 Initial inspection of materials & equipment at manufacturer's works will be done by the Engineer-in-charge or his representative. For item/ equipment requiring initial inspection at manufacturer's works, the contractor will intimate the date of testing of equipment at the manufacturer's works before dispatch. The contractor shall give sufficient advance notice regarding the dates proposed for such tests to the department's representative(s) to facilitate his presence during testing. The Engineer-in-charge at his discretion may witness such testing. Equipment will be inspected at the manufacturer/ authorised dealer's premises, before dispatch to the site by the contractor.

1.14.2 The department also reserves the right to inspect the gas filling job at factory and the successful tenderer has to make arrangements for the same.

1.14.3 The materials duly inspected by Engineer-in-charge or his authorised representative shall be dispatched to site by the contractor.

1.14.4 Final Inspection & Testing will be done by the Engineer-in-charge or his representative as per details indicated in Section 3.

1.15 Safety measures

All equipment shall incorporate suitable safety provisions to ensure safety of the operating personnel at all times. The initial and final inspection reports shall bring out explicitly the safety provisions incorporated for all equipment.

1.16 Guarantee

1.16.1 The contractor shall guarantee the complete system to operate satisfactorily and as per design during the activation by Fire Alarm System.

1.16.2 All equipment shall be guaranteed for a period of 12 months from the date of acceptance and taking over of the installation by the Department against unsatisfactory performance and/or breakdown due to defective design, material, manufacture, workmanship or installation. The equipment or component or any part thereof so found defective during the guarantee period shall be repaired or replaced free of cost to the satisfaction of the Engineer-in-charge. In case

it is felt by the department that undue delay is being caused by the contractor in doing this, the same will be got done by the department at the risk & cost of the contractor. The decision of Engineer-in- charge in this regard shall be final.

1.16.3 Any leakage/ release of gas due to defective design, manufacture, workmanship or installation during the guarantee period shall be made good by the contractor free of charge.

1.17 Terms of Payment

The following percentage of contract rates shall be payable against the stages of work shown herein:

1.17.1 After initial inspection & delivery at site in good condition on pro-rata basis - 70%

1.17.2 On completion of pro-rata installation – 10%

1.17.3 On successful testing and commissioning - 20%.

1.18 Tender Drawings, Drawings for Approval and Completion Drawings

1.18.1 *Tender Drawings* - The drawings appended with the tender documents are intended to show the Protected Areas, space allotted for various equipment, tentative routes. The equipment offered shall be suitable for installation in the spaces shown in these drawings.

1.18.2 *Drawings for approval on award of the work* - The contractor shall prepare & submit three sets of following drawings and get them approved from the Engineer-in-charge before the start of the work. The approval of drawings however does not absolve the contractor not to supply the equipment/ materials as per agreement, if there is any contradiction between the approved drawings and agreement.

1.18.2.1 Lay out and isometric drawings of the equipment and pipe work, valves, nozzles to be installed in various rooms.

1.18.2.2 Drawings including section, showing the details of erection of entire equipment including their supports/ mountings etc.

1.18.2.3 Electrical wiring diagrams for all electrical equipment and controls including the sizes and capacities of the various cables and equipment.

1.18.2.4 Any other drawings relevant to the work.

1.18.3 *Completion Drawings* - Three sets of the following laminated drawings shall be submitted by the contractor while handing over the installation to the Department. Out of this one of the sets shall be laminated on a hard base for display in the Control room. In addition one soft copy will be given on compact disc.

1.18.3.1 Installation drawings giving complete details of all the equipment, including their mountings/ supports.

1.18.3.2 Plumbing layout drawings giving sizes and lengths of all the pipes and the sizes and locations of valves, nozzles and including isometric drawings for the entire piping.

1.18.3.3 Electrical wiring diagrams for all electrical equipment and controls including the sizes and capacities of the various cables and equipment, wiring with all alarm components and sequence of operations to explain the operation and release of Gas.

1.19 After Sales Service

The contractor shall ensure adequate and prompt after sales service in the form of maintenance, spares and personnel as and when required and shall minimize the breakdown period. In case of equipment supplied by other manufacturers the firm shall furnish a guarantee from the manufacturer for the same before the installation is taken over.

1.20 Documents to be provided on Completion of Work

Three sets of following documents shall be furnished to the department by the contractor on completion of work.

1.20.1.1 Completion drawings as per 1.18.3.

1.20.1.2 3 sets of manufacturer's technical catalogues of all equipment and accessories.

1.20.1.3 Operation and maintenance manual of all major equipment, detailing all adjustments, operation and maintenance procedure.

1.21 Definitions

1.21.1 **Class A Fires –** Fire in ordinary combustible materials such as wood, cloth, paper, rubber, plastics, electrical and electronic equipment without any flammable fluid or gas.

1.21.2 **Class B Fires –** Fire in flammable liquids, oils, greases, tar, oil based paint, lacquers etc.

1.21.3 **LC50 –** (Lethal Concentration 50) is the concentration of a chemical which kills 50% of a sample population. This measure is generally used when exposure to a chemical is through the animal breathing it in.

1.21.4 **Protected Area –** The enclosed space protected by/ covered by the Gaseous Total Flooding Systems.

1.21.5 **Clean Agent –** Electrically non-conducting, volatile, or gaseous fire extinguishant that does not leave a residue upon evaporation.

1.21.6 **Halocarbon Agent –** An agent that contains as primary components one or more organic compounds containing one or more of the elements fluorine, chlorine, bromine, or iodine.

1.21.7 **High Pressure –** Indicates that the carbon dioxide is stored in pressure containers at ambient temperatures. At 70°F, the pressure in this type of storage is 850 psi.

1.21.8 **Inert Gas Agent –** An agent that contains as primary components one or more of the gases helium, neon, argon, or nitrogen. Inert gas agents that are blends of gases can also contain carbon dioxide as a secondary component.

1.21.9 **Local Application –** A system consisting of a supply of extinguishing agent arranged to discharge directly on the burning material.

1.21.10 **Lowest Observable Adverse Effect Level (LOAEL) –** The lowest concentration at which an adverse physiological or toxicological effect has been observed.

1.21.11 **No Observed Adverse Effect Level (NOAEL) –** The highest concentration at which no adverse toxicological or physiological effect has been observed.

1.21.12 **Total Flooding –** The act and manner of discharging an agent for the purpose of achieving a specified minimum agent concentration throughout a hazard volume.

1.22 Conformity with Statutory Acts, Rules, Regulations, Standards and Safety

(i) All components shall conform to relevant Indian Standard Specifications, wherever existing, amended to date.

(ii) All electrical works shall be carried out in accordance with the provisions of Indian Electricity Act, 2003 and Indian Electricity Rules, 1956 amended to date. They shall also conform to CPWD General Specifications for Electrical Works, Part-I: Internal, 2013 and Part-II: External, 1994 as amended up to date.

SECTION 2

SELECTION OF GAS FOR THE APPLICATIONS

2.1 Gaseous Total Flooding Systems are used for suppression of Class A and Class B type of fires. (See 1.21 “Definitions” for Class of fire). These are useful in specific hazards or equipment and in occupancies where an electrically non-conductive medium is essential or where cleanup of other fire suppression agents/ material/ media is not possible. Thus, in building construction industry, such Gaseous Total Flooding Systems applications, due to the high cost of such system, are being provided at present for protection of high value electronic equipment, rare books etc., where water based firefighting systems cannot be provided.

2.2 Gaseous Total Flooding Systems work on principle of reduction of oxygen concentration to extinguish fire, hence require specific concentration of the Gas released by the system for specified period of time. These are thus effective in a fixed enclosure, i.e. rooms, vaults, cabinets, containers, storage tanks, enclosed machines, enclosed flammable liquid/ gas storage, engines using flammable fuels, electronic & electrical equipment, space below false floor, high value assets etc. and cannot be used for open/ large areas.

2.3 Systems using simultaneous discharge of different gases to protect the same area are not permitted.

2.4 Gaseous Total Flooding Systems should not be used on fires involving chemicals such as cellulose nitrate, gun powder, etc., which are capable of rapid oxidation in the absence of air; chemicals capable of undergoing auto-thermal decomposition, such as organic peroxides and hydrazine, etc.; oxidizing materials such as sodium chlorate, sodium nitrate, etc.; reactive metals such as lithium, sedum, titanium, zirconium, plutonium, etc.; metal hydrides or metal amides, etc., which may react violently with the clean agent proposed to be used; areas where the normal working temperatures are greater than the breakdown temperature of the clean agent proposed to be used.

2.5 As per IS 15493:2004, the installer of the Gaseous Total Flooding Systems / Clean Agent System has to be certified by a reputed national/ international agency / laboratory and such certification should be valid at the time of installation. The design, installation, service and maintenance of the Gaseous Total Flooding Systems / Clean Agent System shall be performed by those competent in the respective field in accordance with IS15496:2004.

2.6 The clean agents normally available & used in Gaseous Total Flooding Systems are shown in Table I. The fluorocarbons, which have been discontinued due to Ozone layer depletion reasons, have not been included in this table as same are not to be used. Where ever these have been provided, they have to be replaced forthwith after following necessary codal formalities. The selection of the clean agent is to be done on the basis of fire hazard, occupancy, system pressure acceptable/ manageable etc.

Table I (Ref. Para 2.6)
Clean Agents

	Clean Agent, Name, Formula			*Adverse Effect Levels (Percentage by Volume)*		
Inert Gas Agents-						
Sr No.	*Commercial Name*	*Formula*	*Chemical Name*	*NOAEL*	*LOAEL*	*LC50*
1	IG 01	Ar	Argon (100%)	43%	52%	NA
2	lG 100	N_2	Nitrogen (100%)	43%	52%	NA
3	IG 55	Ar, N_2	Argon (50%), Nitrogen (50%)	43%	52%	NA
4	IG 541	N_2, Ar, CO_2	Nitrogen (52%), Argon (40%), Carbon Dioxide (8%)	43%	52%	NA
Halocarbon Agents-						
1	HCFC Blend A	$CHCl_2CF_3$ $CHClF_2$ $CHClFCF_3$ Detoxifier $C_{10}H_{16}$	Dichlorotrifluoromethane (HFC-123) (4.75%) Chlorodifloromethane (HFC-22) (82%) Chlorotetrafluoroethane (HCFC-124) (9.5%) lsopropenyl-I-methylcyclohexane (3.75%)	10%	>10%	64%
2	HFC-227ea (FM200)	CF_3CHFCF_3	Hepta fluoro prepane (single compound of 99% purity)	10%	>10%	>80%

NOAEL – No Observed Adverse Effect Level. LOAEL – Lowest Observed Adverse Effect Level.

LC50 – Lethal Concentration 50, i.e. concentration of chemical which kills 50% of a sample population.

NA – Not Applicable.

As the LC 50 of the Halocarbons is high, its use is recommended to be restricted and with caution.

SECTION 3

SYSTEM ENGINEERING

3.1 Building & Other Services Requirements

3.1.1 The Protected Area should be without openings to ensure the required concentration of the gas is available to extinguish the fire. The openings in floor & walls for the cables, pipes and ducts, and similar utility services etc. should be sealed so as to avoid leakage of the gas from the Protected Area.

3.1.2 The Protected Area, hence, shall generally be air conditioned in case of it being occupied or having costly electronic equipment installed.

3.1.3 The air conditioning system should have the required interlocks etc. for shut down in case of fire. All dampers in the ducts should close.

3.1.4 In case it is not possible to shut down air conditioning for purpose maintaining the inside temperature for continuous running of equipment installed even in case of fire, the air-conditioning system should have automatic closure of fresh air opening. In such case the volume of the AHU, ducts etc. should be taken in to consideration for calculation of quantity of gas to be released for meeting designed concentration for extinguishing the fire.

3.1.5 All such appliances, equipment such as heaters, spray guns, pumps etc. in the Protected Area, which are likely to disperse the gas released should stop working at the time of release of gas. Hence all the power point circuits in the Protected Area, except for those which feed to such systems which need to run even in case of fire, should be fed from a separate DB with facility to trip the supply on activation of fire alarm signal from the Protected Area.

3.2 Gases for Gaseous Total Flooding Systems

3.2.1 The system components should be designed to function properly in the temperature range of (-) 21°C to + 55°C.

3.2.2 Gaseous Total Flooding Systems can be used for protection of more than one enclosure by means of directional valves.

3.2.3 *Quantity of Gas* – The quantity of gas required for fire extinguishing is to be calculated on basis of minimum concentration (kg/m^3) by volume of the Protected Area required for extinguishing the fire. In case of more than one enclosure are to be protected, the volume is to be taken for the largest enclosure protected.

3.2.4 The concentration of gas required shall vary with the inside temperature & altitude of the Protected Area, materials inside the Protected Area (Class of fire).

3.2.5 The minimum concentration for various types of gases for Class A fire (Similar to a normal Server Room type of installation, without ventilation at time of release of gas, is given in Table II, as an example). The concentration is at atmospheric pressure (0.1MPa) and 20°C room temperature. For other class of fire(s), weight(s) and correction for temperatures, altitudes, etc., the Indian Standards as given in the Table II may be referred.

3.2.6 The normal working temperature in an occupied building may be seen for selection of the suitable Gaseous Total Flooding Systems (Table II).

3.2.7 The toxicity considerations with reference to Table I, giving the LC50, LOAEL & NOAEL for all the Gases, helps to select the safest Gas for Gaseous Total Flooding Systems in occupied area.

3.2.8 The Application Rate and Discharge time of the Gases in the Gaseous Total Flooding Systems shall be as given in Table II.

3.2.9 *Total Flooding Quantity* - The Gaseous Total Flooding Systems work on the principle of reduction in concentration of Oxygen to a level where the sustaining of the fire is not possible. Normal concentration of Oxygen in air is 20.95%. If this is reduced to 15% and below, normal surface fires become unsustainable and are extinguished. Using this principle, the percentage by volume has been shown in table III. The calculation of mass is done as per the following formula. For Inert Gas Agents- $M = 2.303 \times (V/S) \times Vs \times \text{Log}_{10} 100/(100-C)$;

For Halocarbon Agents- $M = V \times C / (S \times (100-C))$

Where – $S = K_1 + K_2(T)$, and-

M = Total Flooding Quantity in Kg.

C = Design Concentration in percentage by Volume.

V = Net volume of the Protected Area.

T = Minimum inside temperature of the Protected Area.

Vs = Specific Volume of the Gas at 21°C & Atmospheric Pressure (0.1MPa) in m^3/kg.

K_1 & K_2 – Specific Volume Constants Specific to the Gas being used.

Table II (Ref. Para 3.2.6 & 3.2.8)

Sr. No.	*Commercial Name*	*Minimum concentration required for Class A Fire Hazard (including safety factor of 20%)*	*System operating nominal Pressure*	*Application Rate & Discharge Time*			*Indian Standard*
				Minimum Theoretical Injected Concentration in	*Actual Injected Concentration in*	*95% of Minimum Design Qty. to be released in*	
	Inert Gas Agents						
1	IG 01	35% by volume (0.432 kg/m^3 of protected volume at 20°C)	16 MPa/ 20 Mpa at 15°C	35% in 1 min.	2 min.	1 min.	IS 15497:2004
2	IG 100	34% by volume (0.416 kg/m^3 of protected volume at 20°C)	15 MPa/ 20 Mpa at 15°C	34% in 1 min.	2 min.	1 min.	IS 15525:2004
3	IG 55	35% by volume (0.433 kg/m^3 of protected volume at 20°C)	15 MPa/ 20 Mpa at 21°C	34% in 1 min.	2 min.	1 min.	IS 15506:2004
4	IG 541	36.5% by volume (0.432 kg/m^3 of protected volume at 20°C)	15 MPa/ 20 Mpa at 15°C	36.5% in 1 min.	2 min.	1 min.	IS 15501:2004
	Halocarbon Agents						
1	HFC Blend A	8.64% by volume (0.366 kg/m^3 of protected volume at 20°C)	2.5 MPa/ 4.2 Mpa at 21°C	-	-	10 sec.	IS 15505:2004
2	HFC-227ea (FM200)	8.4% by volume (0.669 kg/m^3 of protected volume at 20°C)	2.5 MPa/ 4.2 Mpa at 21°C	-	-	10 sec.	IS 15517:2004

Table III (Ref. Para 3.2.9)

Sr. No.	*Gas*	*C*	K_1	K_2	*Vs*
1	IG 01	35%	0.79968	0.00293	0.602
2	IG 100	34%	0.79968	0.00294	0.858
3	IG 55	35%	0.6598	0.00242	0.708
4	IG 541	36.5%	0.658	0.00239	0.705
5	HCFC Blend A	8.64%	0.2413	0.00088	0.259
6	HFC 227ea	8.4%	0.1269	0.0005	0.137

3.2.10 The above Total Flooding Quantity is to be increased for compensation for the un-closeable openings, forced ventilation which cannot be stopped at the time of release of gas, if any, etc.

3.2.11 In addition compensation for temperature & altitude shall be required to be made. Relevant Indian Standard for the Gas selected should be referred to for this purpose.

3.2.12 The reserve/ standby quantity are normally taken as 100% of the quantity required for the Largest Protected Area.

3.2.13 Where uninterrupted protection is required, the main and the standby/ reserve cylinders shall be permanently connected to the distribution system with arrangement for easy changeover.

3.3 Storage Cylinders

3.3.1 The storage cylinders shall conform to IS 7285 & IS 15493.

3.3.2 The Storage cylinders should be seamless cylinders designed, fabricated, inspected and certified in accordance to requirements of Chief Controller of Explosives, Nagpur.

3.3.3 The design pressure for the Storage cylinders shall be suitable for maximum pressure developed at 65°C or at maximum controlled temperature limit. However the storage temperature range shall be (-)21°C to +55°C.

3.3.4 Each Cylinder should have permanent markings indicating the following-

For Halocarbon Gases – Name of the Gas; Tare Weight; Gross Weight; Super Pressurization Level of the Cylinder.

For Inert Gases – Name of the Gas; Pressurization Level of the Cylinder; Nominal Gas Volume.

3.3.5 The cylinders should be located outside the Protected Area, but as near to it as possible. The cylinders and the accessories should be located & arranged for ease of maintenance and minimum interruption to protection. The cylinders should be mounted on a stand/ base to enable free flow of air below the cylinder base and also for full on-site inspection of the base of the cylinder. The space around the cylinders also should be so arranged to facilitate the on-site inspection.

3.3.6 All cylinders should be securely fastened to ensure their stability during Gas discharge conditions.

3.4 Distribution system & Pipe Network

3.4.1 Non-metallic or cast iron pipes shall not be used. The thickness of Pipes should be as per provisions in IS 6631. For this purpose the internal pressure of pipes shall be taken as normal charging pressure of gas at 21°C or 80% of the pressure of gas in the cylinder at 55°C, whichever is higher. Accordingly the minimum design pressure for selection of thickness of the pipe has been given in Tables IV A & IV B.

Table IV A - For Halocarbon Gases (Ref. Clause 3.4.1)

Sr. No.	*Gas*	*Cylinder Charging Pressure at 21°C, (super pressurized with Nitrogen.)* *kPa*	*Cylinder Charging Pressure at 55°C* *kPa*	*Minimum Piping Design Pressure at 21°C* *kPa*	*Maximum Expected pressure at 55°C* *MPa*
1	HFC-227ea	1034 2482 4137	1703 3585 4950	1365 3868 3958	 4.19 6.58
2	HCFC Blend A	4137 2482	5860 3723	4689 2979	6.58 4.19

Table IV B - For Inert Gases (Ref. Clause 3.4.1)

Sr. No.	*Gas*	*Cylinder Charging Pressure at 21°C kPa*	*Cylinder Charging Pressure at 55°C kPa*	*Minimum Piping Design Pressure at 21°C, Upstream of Pressure Reducer kPa*	*Minimum Piping Design Pressure at 21°C, Downstream of Pressure Reducer kPa*	*Maximum Expected pressure at 55°C MPa*
1	IG-01	16341	18271	16341	6723	20
		20424	22778	14997	6728	25
2	IG-541	14997	17755	14997	6895	22.5
		19996	23671	19996	6895	30
3	IG-55	15521	17065	15318	6550	23
		20424	22753	20424	6550	30
		30636	34130	30635	6550	45
4	IG-100	16580	19300	16580	6895	20
		22311	26014	22311	6895	25

3.4.2 The pipe joints shall be threaded up to 50 mm dia., and welded for higher diameters. Flanged joints can also be used. For welding, the welding alloy (welding rod) selected should have the melting point above 538°C. The welding should be done as per IS 10234.

3.4.3 The size & dimensions for the pipe fittings shall be as per IS 1239 (Part 2), the fittings shall be able to withstand the minimum working pressure as per 3.4.1 above. Cast Iron Fittings shall not be used.

3.4.4 The pipe shall be duly supported with independent supports. The maximum distance between the supports shall be as per Table V.

Table V (Ref. Clause 3.4.4)

Sr. No.	*Nominal Dia. of Pipe mm*	*Maximum Support to Support Distance m*
1	6	0.5
2	10	1
3	15	1.5
4	20	1.8
5	25	2.1
6	32	2.4
7	40	2.7

3.4.5 The piping should withstand the maximum expected pressure at 55°C given in Table III, and should be tested for same (at room temperature) before commissioning of system.

3.4.6 'C' Class, MS Pipe and fittings duly galvanized inside & outside or suitably protected against corrosion or stainless steel pipe and fittings shall be used for this system.

3.4.7 The pipe sizing is done through approved computer flow calculation programme/ software.

3.5 Discharge Nozzles material, sizes & placement

3.5.1 The discharge nozzles shall be made of brass.

3.5.2 The nominal sizes of the nozzles and the corresponding sizes of the orifice in the nozzles are as given in Table VI.

Table VI (Ref. Para 3.5.2)

Sr. No.	*Nozzle Size*	*Maximum Orifice dia. (mm)*
1	3/8"	10.47
2	½"	13.22
3	¾"	17.51
4	1"	22.29
5	1 ¼"	29.32
6	1 ½"	34.22
7	2"	43.92

3.5.3 Normally for area of 30 m^2 or less, one nozzle is provided. Thereafter, the selection of nozzle is done on basis of the amount of gas to be discharged in to the protected area. The quantity of gas to be discharged in to an enclosure/ protected area is calculated as per Clause 3.2.9.

3.5.4 The quantity of gas discharged through a specific orifice size shall depend on the gas selected, and is not same for all the gases. The size of the nozzle shall be selected through the hydraulic calculations.

3.5.5 Selection of number of Nozzles and their placement in a particular enclosure shall, however, should take in to consideration the shape of enclosure, raised floor, false ceiling, installed equipment, obstructions, so as to ensure unobstructed and immediate delivery of the gas to all the area in the enclosure in adequate quantity to extinguish the fire.

3.5.6 The nozzles shall be placed in all concealed spaces, below false floor, above false ceiling, etc. besides the main area of the protected space.

3.5.7 The minimum nozzle height above the floor level shall be 20 cm.

3.5.8 Maximum nozzle height above the floor level shall be 3.5 m.

3.5.9 The distance of the nozzle from the walls should be 0.5 m (50 cm) minimum to 3 m maximum.

3.5.10 The maximum distance between nozzles should not exceed 6 m.

3.6 Hydraulics Design of the System

3.6.1 The hydraulics design software is available with respective manufacturer and the dealer of the Gas selected.

3.6.2 The design results are to be studied to check –

(a) The weight of the Gas discharge from the nozzle(s) predicted by the design software should be within (-)5% to +10% of the actual requirement calculated.

(b) The discharge time from each nozzle predicted by the software is within (-)5% to +5% of the requirement.

3.6.3 The size of the pipes and the nozzles are to be adjusted/ re-selected to meet the above conditions.

3.7 Commissioning and Acceptance

3.7.1 The entire installation, including the Fire Alarm System integrated to the Gaseous Fire Extinguishing System, should be tested as per IS 15493.

3.7.2 The sizes of pipes and nozzles to be checked with respect to those given in the approved design.

3.7.3 During execution of work the pipes internal surface should be checked to ensure it does not contain any moisture, oil etc., which, at the time of release of gas, shall spoil the Protected Area or chock the nozzles.

3.7.4 The pipe supports, joints, nozzles should be checked for being properly and securely fastened to prevent any vertical or lateral movement at the time of discharge.

3.7.5 All the open ended pipes shall be tested in a close circuit for a period of 10 minutes at a pressure of 3 kg/cm^2. The pressure drop at the end of the test period should not be more than 20% of the test pressure i.e. 0.6 kg/cm^2. This test is done under pneumatic pressure.

3.7.6 All the closed section pipes should be tested at minimum 1.5 times the maximum operating pressure, during which there should be no leakage. This test is done with hydraulic pressure. On successful completion of the test, the pipes should be immediately flushed/ purged to remove all moisture.

3.7.7 The installation should be tested for operation and to verify that flow is continuous and the pipes and nozzles are unobstructed by use of a nitrogen cylinder at the designed pressure in place of the Gas to be used.

SECTION 4

SAFETY PRECAUTIONS

Safety aspects, besides the training of personnel, warning signs, pre-discharge alarm(s), and safety interlocks are required to be provided in all buildings/ area(s) provided with the Gaseous Total Flooding Systems. This is very essential and important as the toxic effect(s) of gases available & being used are to be taken care of. The concentration levels at which the adverse effects take place have been listed against each type of gas, as given in Table I under Section 2.

4.1 Occupied Areas

4.1.1 It is mandatory to provide a time gap between the fire alarm and the release of the gas. The time gap should be based on the assessment of time likely to be taken for the occupants to leave the protected area. It is normally taken as 30 sec. for small areas protected with this system.

4.1.2 It is mandatory that the pre-release fire alarm in the protected area should be distinct from the other alarms, if any in the area.

4.1.3 It is mandatory to provide for minimum safety interlocks and lock off valves as per IS 15493:2004 as given in Table VII.

4.1.4 It is mandatory that the exit routes be kept clear at all times. Exit direction signage & illumination of exit routes & signage with essential power supply is also to be provided mandatorily.

4.1.5 It is mandatory that the doors of the protected area should be self-closing type with outward swing, openable from inside, even when locked from outside.

4.1.6 It is mandatory that continuously sounding and visible alarm should be provided at entrances and exits. This alarm should continue until the protected area is cleared of the released gas.

Table VII (Ref. Clause 4.1.3)

Sr. No.	*Injected Gas Levels*	*Minimum Safety to be Provided*			
		Inhibit Switch & time delay	*Evacuation within in 30 sec.*	*Safety Interlock*	*Lock Off valve*
1.	Up to NOAEL	R	NR	NR	NR
2.	Above NOAEL & up to LOAEL	R	R	R	NR
3.	Above LOAEL	R	NA*	R	R

R – Required NR – Not required NA* – Not Applicable*

* Since concentration above LOAEL is not permitted in Occupied Areas, hence Evacuation within 30 sec. is not applicable.

4.1.7 It is mandatory that forced draft ventilation for removal of gas after extinguishing of fire to open area(s) is provided. The gases being heavier than air, care should be taken to locate the suction points/ openings of the ventilation system to be near the floor of the protected area and for selection of proper area(s) for discharge of the ventilation system.

4.1.8 It is recommended to add an odour to the gas so that the occupants can recognize the release of the gas and self-contained breathing apparatus & gas detectors are kept in the protected area to assist the occupants.

4.1.9 The release of the gas from the system causes development of electrostatic charge & may result in electrical shock and or electric arc of sufficient charge on discharge to other objects. It is hence recommended to earth the pipe system etc.

4.1.10 The enclosure of the Protected Area should be strong enough to be able to withstand the inside pressure increase at the time of release of Gas. It is important to inform the Architects the likely pressure inside at the time of release of Gas to enable them to select correct materials for the partitions etc. Fragile materials such as ordinary glass may break and be a source of injury to the occupants.

APPENDIX – A
IS SAFETY CODES

IS 660	Safety Code for Mechanical Refrigeration
IS 659	Safety Code for air conditioning
IS 3016	Code of Practice for Fire precautions in welding and cutting operations
IS 818	Code of practice for safety and health requirements in electrical and gas welding and cutting operations.
IS 5216	Code for safety procedure and practice in electrical works
IS 3696	Safety code for scaffolds and ladders