NFPA No. 12

Standards

for

CARBON DIOXIDE EXTINGUISHING SYSTEMS

1949

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National Fire Protection Association.

INTERNATIONAL

The National Fire Protection Association was organized in 1896 to promote the science and improve the methods of fire protection and prevention, to obtain and circulate information on these subjects and to secure the co-operation of its members in establishing proper safeguards against loss of life and property by fire. Its membership now includes more than 175 national and regional societies and associations and more than thirteen thousand individuals, corporations, and organizations.

Membership in the National Fire Protection Association is open to any society, corporation, firm or individual interested in the protection of life or property against loss by fire. All the valuable engineering and popular literature issued by the Association is sent, as issued, to every member. The Association is the clearing house for authoritative information on fire protection and prevention and members are privileged to submit to it their individual problems for solution. The Association is always glad to send samples of its publications to prospective members.

This pamphlet is one of a large number of publications on fire safety issued by the Association. The standards, prepared by the technical committees of the National Fire Protection Association and adopted in the conventions of the Associations, are intended to prescribe reasonable measures for minimizing fire losses. All interests concerned have opportunity through the National Fire Protection Association to participate in the development of the standards and to secure impartial consideration of matters affecting them.

Carbon Dioxide Fire Extinguishing Systems.

These standards were initiated by the Committee on Manufacturing Risks and Special Hazards in 1928. They are now under the jurisdiction of the Committee on Carbon Dioxide which reports to the Association through the General Committee on Special Extinguishing Methods. A record of intermediate changes in committee jurisdiction will be found in the NFPA PROCEEDINGS. The first complete edition of the standard was adopted in 1929 with new or revised editions in 1933, 1939, 1940, 1941, 1942 (Jan. and May), 1945, 1946, 1948 and 1949.

Related Standards on Inert Gas for Fire and Explosion Prevention (NFPA No. 12-A) developed by the same committee in cooperation with the Committee on Dust Explosion Hazards are published in the National Fire Codes, Vol. II, Prevention of Dust Explosions, and by the National Board of Fire Underwriters in their Pamphlet No. 12.

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INTRODUCTION.

1. General Discussion.

These standards cover the standard methods of fire protection involving the use of carbon dioxide (carbonic acid gas; CO_2) for the protection of fire hazards which are of such a nature that this form of protection is suitable. Hand fire extinguishers of the carbon dioxide type are not included here, but are covered by the standards for First Aid Fire Appliances.

Examples of where such protection may be called for are certain hazards of flammable liquids in enclosed or open containers, rooms or enclosures containing flammable liquids, ovens, dryers, electrical and other special machinery and apparatus and processes involving the use of flammable liquids, vapors or dusts, fur storage, lumber dry kilns, coal bins, loose textile stocks, grain handling machinery and in other enclosures containing stocks through which gas may permeate and where protection by water or other means may be ineffective or undesirable; also in vaults, library stacks, organs and other such places where fires may be extinguished by carbon dioxide gas with less loss than if water is used.

The total flooding of rooms and entire buildings is also approved where such carbon dioxide gas protection is considered desirable if such protection is approved for the specific location by the inspection department having jurisdiction.

The protection of airplanes and power boats by carbon dioxide extinguishing systems is not covered by these standards. (See special publications relating to airplanes and hangars and rules for marine fire hazards. See also standards for the protection of dry cleaning establishments.)

There are limitations in the use of carbon dioxide gas in the protection of film vaults and other severe pyroxylin plastic hazards or for other like hazards including chemicals where oxygen sufficient to sustain combustion is inherent. Automatic sprinkler or spray nozzle protection is recommended for such hazards. (See standards governing the protection of Pyroxylin Plastics.)

These standards cover the installation and maintenance of automatic and non-automatic means for applying carbon dioxide gas protection. The standards outline only general essentials and the average necessary specifications to make a workable standard. Details for each installation will necessarily vary according to the local conditions and the hazards involved.

Inspection departments having jurisdiction should be consulted as to the application of these standards and all details of installation; also if carbon dioxide gas is to be used whether other additional special hazard protection is required; also as to what protection, if any, outlined by other applicable standards should be called for in each case. (See standards for Finishing Processes and other standards covering the protection of special hazards.)

2. Definition of a High-Pressure System.

The term "High Pressure System" is used in connection with the storage of liquid carbon dioxide at atmospheric temperature.

3. Definition of a "Low-Pressure System".

The term "Low Pressure System" is used in connection with storage of liquid carbon dioxide at a continuously controlled low temperature.

NOTE: Paragraphs relating solely to High-Pressure Systems and to Low-Pressure Systems are so titled. All other paragraphs apply to systems of both types.

GENERAL RULES COVERING ALL SYSTEMS.

(See also the Rules herein for the Special Classes.)

11. General.

(a) The extinguishment of fires in certain hazards above indicated by smothering the fires through the use of carbon dioxide gas can be successfully accomplished. This principle of extinguishing fires can be utilized to advantage not only through the use of first aid hand apparatus but also through other manual, automatic and semi-automatic means whereby the extinguishing gas may be applied to such hazardous occupancies, especially as found in industries. There are also certain conditions where expected fires may be prevented by prior flooding with the gas to dilute the oxygen content of the air. (See Section on Inert Gas for Fire and Explosion Prevention.)

(b) Reducing the oxygen content of air (normally 21%) to 15 per cent by the addition of carbon dioxide will extinguish ordinary flammable liquid fires. Further reductions varying down to 6% are necessary to completely extinguish fires in some other materials.

(c) High Pressure Systems. Carbon dioxide is applied from cylinders in which it is stored at a pressure of about 850 pounds per square inch at 70° F. It is required that the quantity of carbon dioxide in the cylinders be determined either by weighing or by other means at least once a year.

(d) Low-Pressure Systems. Carbon dioxide gas may be stored in tanks in the liquid form in any capacity. Low-Pressure tanks are kept refrigerated so that the gas pressure may not exceed the designed working pressure of the vessel (usually around 325 lbs. per sq. in.).

(e) Carbon dioxide gas is heavier than air and so has the quality of resting upon the surface of flammable liquids and of permeating through loose goods and into semi-confined spaces where other extinguishing materials might not reach. Being heavier than air the gas settles in the lower part of rooms and enclosures so this fact should be fully considered in planning systems for places where fire may extend to the ceiling. The gas extinguishes fires by diluting the oxygen content of the air to an atmosphere not supporting combustion. The effectiveness of carbon dioxide gas in extinguishing a fire is obtained by the release of a sufficient volume of gas to dilute the air adequately. It is useful for quick, flashy fires not involving glowing coals or other incandescent materials. For the latter type of fire, unless the enclosed space is relatively tight, it may be necessary to apply the gas more or less continuously in a progressive manner during the period necessary to extinguish the glowing fire.

(f) So far as safety to life is concerned the gas, if not breathed in excessive amounts, is not dangerous, but in quantities it is suffocating. However it is well to note that ordinarily people will not be overcome in breathing an atmosphere containing the herein required percentage of carbon dioxide gas for a time amply sufficient for safe retirement. The gas is a non-conductor of electricity and can be safely and effectively applied to fires in live electric apparatus.

NOTE.—A relatively large quantity of gas when discharged is likely to interfere with visibility temporarily. This may result in accidents where there are obstructions or other features tending to interfere with a safe exit. Aisles should be kept clear and, in some cases, guard rails should be provided to protect employees from stumbling or falling upon machinery or other apparatus. Signs calling for a prompt exit are ad-

vised. An automatic fire alarm, set to operate before the carbon dioxide apparatus functions, is also a good safeguard.

(g) The carbon dioxide as stored in containers in liquid form, does not freeze at the lowest climatic temperature and so the protection is available in cold areas as well as warm ones. Pressure in the containers rapidly increases as the temperature is raised. The discharge from cold containers is slower than from containers kept in a warm place which fact should be considered when equipments are installed, except in the case of low pressure systems.

(h) Three methods of extinguishing fires by the use of carbon dioxide gas are specified in these standards, either singly or in combination. The method to be used is to be determined by the kind of hazard to be protected.

(1) Total Flooding. (Class A Systems)

This contemplates the discharge of carbon dioxide into any enclosed space, with dilution of the air to the point where fire is extinguished.

(2) Local Application. (Class B Systems)

In systems of this class carbon dioxide is applied directly to the fire.

(3) Extended discharge. (Class C Systems)

In some "Total Flooding" methods it is necessary to create extinguishing gas concentrations and to maintain them for an extended length of time; this may require a prolonged or intermittent discharge of the gas into the space if there is considerable leakage.

(i) Under Surface Application. The method of extinguishing fires in flammable liquids by projecting carbon dioxide gas beneath the surface, wherein the gas bubbles up through the liquid, diluting and replacing the combustible vapors, is not a regularly approved method of protection. However, there may be special cases where this method is acceptable.

Under surface application shall not be used on paint dip tanks or on any other material which may cause plugging of the under surface discharge outlets. It shall not be used on viscous fluids or fluids tending to foam when under surface gas is released. Acceptance tests on each under surface application shall be conducted to demonstrate that flammable liquid will not be thrown from its containing vessel by the released gas.

(j) The variety of hazards which may be protected by carbon dioxide extinguishing systems is considerable, and in applying these standards care should be taken to first determine under which cases, if any, the hazard to be protected falls that the particular section for that class may be applied. Ordinarily the protection of extremely large oil storage tanks located outdoors is not contemplated but small and medium outside hazards incident to industrial processes may have carbon dioxide protection. The protection of large open dip tanks of highly flammable mixtures inside industrial plants is covered, but whether carbon dioxide protection should be supplemented by other special protection should be considered. The protection of buildings, rooms or large enclosures containing a large amount of flammable liquids or other severe hazard, whether or not a large or small amount of such liquid is exposed, is covered under the standards. The question of installing or waiving other standard protection in places protected by carbon dioxide gas should be considered.

For the protection of carbon bi-sulfide the specifications in these standards relative to quantities of gas do not apply. Where carbon bi-sulfide is protected a considerably larger amount of carbon dioxide gas and a greater speed of application is necessary. (See Article 42.)

NOTE: It is not the intent that these standards shall be confined to the protection of the hazards mentioned in Article 1. These are named

simply as examples. Aside from the protection of pyroxylin plastics, and like materials which contain sufficient oxygen within themselves to support combustion, there is practically no limit to the hazards which may be protected by carbon dioxide if the hazard is localized or enclosed. Attention is called, however, to the fact that carbon dioxide protection is especially adapted to extinguishment of fires in flammable liquids used in the open as local hazards and enclosed rooms where flammable liquids are used; also in all sorts of enclosures having fire hazards such as ovens, dryers, vaults for storage of furs, records, patterns, etc.; also for protection of hazards in machinery where dusts are produced such as grain handling machinery, grain tanks, coal pulverizing equipments, coal handling machinery and coal storage if enclosed, lumber dry kilns, all sorts of loose stocks if enclosed, book stacks in libraries, pipe organs and other such places where damage from water is particularly objectionable; also electric machinery. These also are only examples of hazards which may be covered.

In considering the application of these rules for any particular hazard one should determine first whether the condition is one representing fast burning material such as flammable liquids and, secondly, whether slow burning materials are involved. The fast burning hazards are the most easily extinguished by carbon dioxide protection providing a large amount of gas is applied quickly and assuming that conditions are such that the material will not be reignited after once extinguished. For the protection of slower burning materials a slower application of gas is effective but it must be continued for a long time until the conditions are such that the fire is extinguished and the temperature reduced to a point where reignition will not occur. However, as in the case of automatic sprinklers where slow burning materials are protected, it is not essential to assume that the entire fire must be extinguished. Sprinklers usually control a fire but very often must be supplemented by first aid apparatus or hose streams to get at the seat of the remaining fire. The same may be assumed in applying carbon dioxide gas protection although it should be borne in mind that once the gas has become exhausted there is danger of a fire starting up again, while sprinklers would keep the fire under control. A much greater factor of safety must be assumed, therefore, when gas is used.

It is not the intent of these standards to specify what hazards shall be protected or what class of protection shall be applied to a particular hazard. This can be determined only by the inspection departments having jurisdiction after a study of the particular hazard. Even hazards of the same type vary so much in different properties that it is impossible to make any general ruling as to hazards.

ELECTRICAL APPARATUS. As some particular attention is necessary to the protection of electrical apparatus by carbon dioxide, special rules, in addition to other rules herein, are given under Articles 61-65.

CLASS A protection (Articles 31-35) should be specified only where it is quite certain that the entire contents of a room or other enclosure, if on fire, can be effectively controlled by a total flooding system.

CLASS B protection (Articles 41-44) should be specified only where the hazard is localized and a fire is not likely to spread to other contents and so get beyond control of the carbon dioxide protection. Where there are automatic sprinklers or other adequate protection for areas outside the hazard more leniency may be used in considering this point.

CLASS C protection (Articles 51-56) should be specified to protect hazards where fires cannot be fully extinguished by the first, quick discharge of gas. It is therefore called for in protecting certain electric equipment and enclosures containing combustibles where fire is likely to reignite or smolder or linger for a considerable time; also where a draft or leakage is likely to dissipate the first discharge of gas and so require its replenishment until all fire is extinguished.

Local conditions vary so much that such hazards require special study and may call for some modification of the treatment specified in these standards, which are drawn to cover average hazards for the class.

INERT GAS FIRE PREVENTION SYSTEMS are particularly adaptable to the prevention of fires and explosions in certain hazardous processes and should be more widely used. Where such processes are not continuous and a hazard may be present when the process and gas systems are not in operation supplementary protection by a carbon dioxide extinguishing system may be necessary for full protection.

(k) Whether the apparatus is to operate automatically or manually is to be determined by a study of each particular hazard, but in all cases automatically operated apparatus shall be provided also with manual means for operation.

(l) Where hazards requiring this form of protection are in separate units, not more than one of which is likely to be involved in a single fire, considering all protection, one equipment based on the requirements for the largest single unit may be installed to cover two or more such separated hazards providing that approved routing devices be used; these to be so arranged that the gas will be discharged to the particular unit wherein the fire originates and not to other units protected by the system. Routing devices may be operated by the gas pressure from two or more cylinders or by other approved means. Piping from routing valves should be tagged or otherwise marked to indicate the hazard supplied.

(m) This class of protection is also available for first aid (hand) apparatus and hand hose and the standards covering such, in addition to those contained herein, shall apply. (See Standards for the Installation, Maintenance and Use of First Aid Fire Appliances.)

12. Relief Vents.

Where carbon dioxide gas under pressure is provided for the protection of tightly enclosed containers, apparatus, vaults or other such enclosures likely to rupture from excess pressures, adequate vents, to relieve excess pressures formed by the introduction of the gas, shall be provided. Ordinarily the total flooding of buildings, rooms or large enclosures will not call for special vents as few of them are tightly enclosed.

Where such enclosures have excessive vents, fans, openings or other outlets, likely to dissipate the gas provided for protection, they shall be shut off or closed automatically by the operation of the carbon dioxide extinguishing apparatus or be protected with gas screening nozzles all as called for in these rules.

13. Plans and Specifications.

Before an equipment is installed or an existing equipment remodeled, complete working plans showing necessary details of the local conditions, hazards and of the proposed equipment shall be submitted for approval to the inspection department having jurisdiction, these plans to include such matter and to be in such form as called for by such department.

14. Approval.

All apparatus and devices used, and their installation, shall be approved and standard so far as such approvals and standards apply.

15. Carbon Dioxide Gas (Carbonic Acid Gas).

Carbon dioxide extinguishing gas for use under these standards shall be commercially pure carbonic acid gas, or pure CO_2 free from moisture and from free oxygen and from other impurities in material quantities and shall be supplied from an approved source.

16. Means of Supply: Containers.

(a) Containers shall not be located where subject to temperatures exceeding 130° Fahr.

(b) Where the carbon dioxide gas is stored in cylinders they shall be made, tested, and marked in accordance with the current specifications of the Interstate Commerce Commission relating to containers for this gas. Charged cylinders used in original equipments with their necessary fittings shall be tested by means of a water seal for leakage for at least six hours at 100° F., or by other approved means before being placed in an equipment and all leaking cylinders shall be rejected.

(c) High Pressure Systems. All cylinders shall be securely mounted so as to be adequately protected against injury and displacement and in an upright position or not inclined more than 30° unless equipped with special means for effectively discharging the contents in other positions. Where subject to moisture the bottom of the cylinders shall be supported above floors at least two inches. Cylinders shall not be placed where subject to corrosion or they shall be protected from corrosion in a reliable and permanent manner. The discharge from cylinders subject to low temperatures is relatively slow, which fact should be considered in installing equipment. The effectiveness of the gas discharge from cold cylinders is, however, not impaired.

(d) Containers should be located near the hazard to be protected to minimize friction loss and time consumed in transmitting gas through long pipe lines, due consideration to the safety of the equipment being given.

(e) All containers and their fixtures shall be readily accessible for cleaning and maintenance and shall be safely located to prevent injury or interference to the apparatus or they shall be thoroughly fenced and guarded.

(f) High Pressure Systems. Cylinders shall be so mounted and connected to the pipe system as to facilitate easy removal for inspection and recharging, proper unions being provided in the connections. Where check valves are not provided on each independent cylinder discharge, plugs or caps, for closing outlets when cylinders are removed for examination, shall be provided and kept on hand.

(g) Containers other than cylinders made according to Interstate Commerce Commission specifications shall be made, approved, tested and marked in accordance with the current specifications of the A.S.M.E. Code for Unfired Pressure Vessels.

(h) Low Pressure Systems. Large storage containers should be located as specified in Articles 16 (d) and 16 (e). The storage containers should not be located where they may be subjected to severe fire exposure or to injury by corrosion or flooding. If combustible insulation is used, it should be sealed in a fire-resistant housing.

(i) Containers other than I.C.C. specification cylinders shall be provided with both approved safety valves and frangible safety relief discs.

(j) Containers other than I.C.C. specification cylinders are to be provided with approved means for checking losses of gas by leakage or otherwise and be equipped with such fittings as to provide for recharging without interfering with the fixed equipment.

(k) Containers other than I.C.C. specification cylinders shall be located as near the hazards protected as is practicable, to avoid needlessly long pipe lines, but, unless adequately protected, shall not be located where subject to severe exposure from fire.

(l) Low Pressure Systems. Where refrigerated containers are maintained normally at a temperature to prevent excess pressures (usually not exceeding 325 pounds per square inch) this shall be done by means of approved refrigerating apparatus equipped with approved controls to insure continuous operation. The entire installation shall conform to other standards where such apply. (Refer to National Electrical Code and other standards.)

17. Extra Gas Supply (for Recharging).

(a) It is usually desirable to have an extra supply of carbon dioxide sufficient to re-protect the largest hazard. Where recharging of the system will usually be done within 36 hr., an extra supply of carbon dioxide will not be required on the premises except in special cases. The Inspection Department having jurisdiction should be consulted.

(b) High Pressure Systems. Spare cylinders shall be interchangeable with those used in the equipment and they shall have discharge devices of the same size opening as those of the rest of the equipment.

18. Gas Release Devices.

(a) Each container shall be fitted with one or more approved gas release devices. Such devices may be designed for manual or automatic and manual operation. They shall be ruggedly built for repeated operation without injury and shall not be subject to failure from corrosion or cause freezing of the gas discharge. Where the device contains a renewable disc or seal, such disc or seal shall bear a symbol identifying the manufacturer. Records should be kept and filed by the manufacturers showing to whom and in what quantities such parts are furnished that the parts may be later identified.

(b) High Pressure Systems. Release devices for cylinders shall have an opening when operated sufficient to discharge eighty-five per cent of the gas contained in the cylinder in not more than thirty seconds (at a temperature of 70° Fahr.) nor at a rate of less than 1½ lbs. of gas per second for the first 85% of the contents.

(c) Devices for shutting off the flow of gas shall be provided where such devices are required to preserve the remaining supply of gas in the container, when sufficient gas shall have been released, as called for by the hazard protected.

19. Pipe Systems.

(a) All pipe and fittings made of ferrous material shall be protected inside and out against corrosion and shall be free from scale.

(b) Piping shall be arranged so as to reduce friction to a reasonable minimum. Pipe lines should be run in the shortest possible course and unnecessary fittings avoided. All piping shall be reamed and cleaned before

assembly, and after assembly the entire pipe system shall be blown out before discharge orifices are installed. All dead end lines shall extend at least 2 inches beyond the last orifice and shall be closed with a cap or plug.

(c) All piping shall be securely supported and where necessary, protected against injury. In rooms where explosions are possible the piping shall be hung from other supports than roofs, floors and partitions which are subject to displacement.

(d) Pipe sizes shall conform to the requirements as given in these rules under the various classes. (See Articles 35, 44 and 55.)

(e) High pressure systems. All pipe and fittings shall have a minimum bursting pressure of 6,000 pounds per square inch. Where discharge pipes of a high-pressure system are equipped with closed routing valves the manifold to which the cylinders feed shall be equipped with a pressure relief device operative at a pressure not less than 2400 lbs. and not exceeding 2800 lbs. per sq. in. Safety devices should be of such design and so located that the discharge of gas therefrom will not be likely to injure personnel.

(f) Low pressure systems. For systems protected by relief valves set at not over 375 pounds per square inch and with automatic controls designed to keep container pressures below 305 pounds per square inch the following provisions apply

(1) All steel or wrought-iron pipe shall be of standard weight, or heavier. Any other pipe or tubing, if used, shall be at least equivalent to standard weight steel pipe in strength and resistance to mechanical injury.

(2) If malleable-iron fittings are used they shall be of the 300-pound working pressure class (300-pound steam rating). If fittings are made of any other material they shall at least have equivalent strength. Cast-iron fittings shall not be used.

(3) The piping shall be so arranged and have valves of such design as to prevent the entrapment of liquid carbon dioxide and consequent development of pressure in excess of 375 pounds per square inch. Otherwise the piping between valves, wherein the liquid can be trapped, shall be equipped with relief devices of adequate capacity and these devices shall be set for 375 pounds per square inch pressure.

20. Gas Discharge Outlets.

(a) Discharge outlets for distributing the gas shall be of a type best suited for the particular local conditions. They shall be made of non-corrodible and heat resisting material and shall be so designed as to prevent freezing in operation.

(b) The maximum discharge outlet for Class B systems shall be not over three-fourths inch diameter and the minimum not less than one-eighth inch except that perforated pipes, screening nozzles and sealed discharge outlets may have holes smaller than one-eighth inch.

(c) Under some conditions perforated pipes may be accepted as discharge outlets but where such are used with holes less than one-eighth inch in diameter they should be protected by a non-corrodible screen or strainer. Screens located in pipe lines shall have a net area at least equal to that of the pipe in which they are inserted and no openings larger than that of the smallest discharge outlet so protected.

(d) Screening nozzles for protecting openings into enclosures shall be so designed as to adequately protect such openings. Perforated pipes are also approved for this purpose.

(e) Where discharge outlets are subject to clogging they shall be of the sealed type. Seals shall be non-corrodible and not subject to deterioration from liquids, vapors or other local influence. Seals shall not resist pressures of over 75 lbs. per square inch before breaking and shall be so designed as to leave the outlet fully unobstructed.

21. Release Devices (for the Operation of Systems Controlled Automatically and Manually).

(a) Systems may be manually or automatically operated but all automatically operated systems shall also have means for manual control. Inspection departments having jurisdiction shall be consulted as to whether all or part of the apparatus shall be manually or automatically operated and as to the locations from which manual control shall be operative.

(b) Automatic releasing apparatus, and the spacing of fire detecting units in connection therewith, shall conform in all respects to the applicable standards for the installation of such devices. An adequate number of additional fire detecting devices shall be installed within apparatus, minor enclosures and other such places where necessary to give prompt and adequate protection.

(c) Manual releases shall be arranged for convenient and safe operation. Under some circumstances this may call for manual operation both at the hazard and remote control. Remote control operating points shall be marked with an adequate sign to designate the apparatus under control and location of the hazard. Manual controls should be located where convenient to operatives of protected machines except, in specially hazardous locations, the controls should be located a safe distance away.

(d) Release devices may be combined with the container discharge outlets or be separate units to produce the required operation. Automatic heat actuators and other fire detecting devices, in addition to operating the means of supply, may operate other necessary appurtenances to the protective apparatus such as means for shutting down fans, closing windows, doors, covers, etc. For operating automatic drains for dip tanks separate release units are required.

(e) Where a carbon dioxide gas system is operated automatically, inspection departments having jurisdiction should be consulted in regard to the sensitiveness of the automatic actuators in their relation to other automatically actuated protection which may be present.

NOTE 1: Where there is an automatic sprinkler equipment, the gas should be applied before sprinklers operate and where there is an automatic fire alarm system it would be well to have the alarm set to operate before the gas system to warn employees. Fire doors should be preferably operated by more sensitive actuators than fusible links, arranged to close them simultaneously with the application of the gas. It should be borne in mind that the gas tends to lower the temperature and this may have some effect on other thermo-sensitive units. (See rule (b) above.)

NOTE 2: Solder, electric and pneumatic thermostatic release devices are approved. These rules do not prohibit the use of ordinary automatic sprinklers or other approved type of fusible unit adapted to the use specified providing the above rules are complied with and the devices are accepted by the inspection departments having jurisdiction. Automatic devices classed as smoke detectors, light detectors and flammable gas detectors may be accepted when approved as especially adapted to the protection required.

(f) Operation of carbon dioxide systems protecting fur vaults should be by smoke detectors approved for fur vault use, arranged to sound an alarm sufficiently in advance of the carbon dioxide discharge to allow escape from the vaults.

Signs warning of the hazard of smoking in vaults and that smoke detectors may be actuated by smoke from a cigarette, should be permanently posted.

(g) Release devices shall be so designed that they are not likely to be rendered inoperative by corrosion.

(h) High Pressure Systems. Automatic and manually operated release devices of high pressure systems may be arranged to operate directly only a portion of the gas releasing devices on the cylinders providing that such cylinders also actuate devices to release the remaining required cylinders. Where gas pressure from the cylinders is used as a means for releasing remaining cylinders not less than two cylinders shall be used for such operation.

NOTE: Care should be taken that adequate gas pressure shall be available from the actuating cylinders to operate all the release devices on the other cylinders. Where actuating cylinders discharge to large or extensive piping such piping may absorb too much volume of gas and thereby reduce the pressure to such an extent that certain operation of the remaining cylinders is not assured. Therefore more than two actuating cylinders are called for where the piping is large or extensive unless the full pressure from the actuating cylinders is made available on the other cylinder release devices by direct means.

(i) Manual devices may be operative through mechanical, pneumatic, electric or other approved means. If mechanically operated the pull on levers or handles required for operation shall not exceed 40 lbs. nor require a movement for effective operation of over 14 inches. Apparatus for manual operation shall be amply strong to resist breakage. If pneumatically or electrically operated the manual control may be operative in conjunction with the automatic gas release system or separately.

NOTE: The use of a manual tripping device which requires only a single operation such as pulling a handle or breaking a glass is ordinarily recommended. Where there is the possibility of accidental operation or tampering, an operating device requiring a dual operation such as breaking a glass followed by pushing a button is acceptable.

22. Alarms.

Systems should be equipped with one or more alarms so arranged that an alarm will be given when the apparatus operates either by fire or accidentally. Inspection departments having jurisdiction shall be consulted as to whether alarms are needed and as to where the alarm sounding devices shall be placed.

NOTE: Alarms are not called for on small systems covering minor hazards and limited areas. Where employees may be present in buildings or closed rooms where a total flooding system is employed, some automatic fire alarm set to operate, preceding the application of gas, is necessary under some conditions in addition to an alarm on the carbon dioxide gas system. Whether in addition to a local alarm at the hazard protected a remote alarm elsewhere may be needed is a matter governed by the local conditions. Signs should be placed warning occupants of the necessity of immediate exit.

23. Tests for Approval.

A test of the installation shall be made before final approval. Inspection departments having jurisdiction shall be consulted before such tests are made, as to the tests required. If such departments require a part of the gas to be discharged for an approval test such rulings shall prevail, but otherwise the actual discharge of containers is not required for an approval test. No more gas than is necessary to test all operative devices is required to be discharged under this rule.

NOTE: The discharge of gas and its replacement is not usually included in contracts so this question should be agreed upon when plans and specifications are approved. In unusual cases where fans may be operating or where there may be any openings or explosion vents making it difficult to accurately figure carbon dioxide requirements, it may be desirable to make a complete flooding test. This should be agreed upon in advance by the purchaser, manufacturer and inspection department having jurisdiction. Unless unusual conditions prevail, however, a complete flooding test is not warranted as the provisions of these standards provide an adequate factor of safety.

24. Maintenance.

(a) Systems shall be maintained in full operative condition at all times. All enclosures to confine the gas within the protected space shall be maintained in good repair and all automatic shutters in connection therewith shall be kept fully operative.

(b) Gas Replenishment.

(1) High Pressure Systems. Any cylinder showing a loss of gas of over 10 per cent by weight of the original content shall be replaced or recharged.

(2) Low Pressure Systems. A tank showing a contents loss of more than 10 per cent shall be refilled if its capacity is equal only to the amount of gas required to protect the largest hazard. For systems designed to give immediate reprotection for the largest hazard after a fire is extinguished, the quantity of gas that shall be maintained shall be at least equal to twice that required for the largest hazard.

(c) Where required by inspection departments having jurisdiction the owners of equipments shall have them thoroughly inspected at least twice a year by the manufacturer or installing company, a copy of the inspection report to be filed with the owner and with the inspection department having jurisdiction. Such inspections shall include checking the amount of gas in the containers at least once annually, including the testing of automatic and manual release devices and checking any changes which may have been made in the hazard, surroundings and apparatus affecting the protection.

(d) All piping, apparatus and devices located at the gas supply (con tainers) shall be adequately protected against accidental injury and obstruction, and where containers are out of doors shall be adequately protected from rain, snow, etc., by non-combustible enclosures.

25. Classification. (See Article 11 (j).)

Equipments for the protection of hazards subject to carbon dioxide gas protection are to be determined under the following classifications and the additional specific rules for the class are to be applied accordingly.

CLASS A. Equipments for protection by the total flooding of enclosed spaces.

CLASS B. Equipments for protection by local application of gas on particular hazards.

CLASS C. Equipments for protection where, by the use of special equipment, a continued application of gas to maintain a concentration is provided.

CLASS A SYSTEMS.

Equipments for Protection by the Total Flooding of Enclosed Spaces.

31. General. (See Articles 11 (f) and (g).)

(a) The preceding General Rules (Sections 11-24) shall apply and in addition the following:

(b) This section relates to carbon dioxide fire extinguishing equipment to be used for the protection of such things as buildings, rooms, closed tanks, closed ovens, closed machines, and the contents thereof.

NOTE: Containers such as tanks and ovens should be considered as being without contents when determining the quantity of gas required. A closed container is defined as one having a permanent and relatively tight cover. In the case of fans and conveying or venting tubes, their volume shall be considered. If fans are not shut down, it may be necessary to discharge carbon dioxide into them at such a rate that the entering atmosphere contains not less than 35 per cent carbon dioxide.

32. Enclosures and Ventilation. (See also Art. 12.)

Under this class of protection, a reasonably well enclosed space, room or building is assumed. Rooms, buildings or other enclosures having large openings or forced air ventilating systems require the use of standard equipment for automatically closing such openings or screening them with approved carbon dioxide gas discharge outlets or other approved screening devices or both and for shutting down such forced air ventilating systems before or simultaneously with the operation of the carbon dioxide gas extinguishing system. The protection of openings which have the major portion lower than half the height of the rooms or enclosures is important and may need special attention. The protection of small vents at the top of enclosures may or may not be important. Sometimes they are of value for the escape of air, thereby assisting in the filling of the enclosure with the proper concentration of carbon dioxide and avoiding blowing fire out of the enclosure through other openings by the rapid discharge of the carbon dioxide gas. Openings wider than eight feet should be protected by other than gas screens, unless local application to the hazard within the space is used. In no case should the total area in square feet of all openings unprotected, unscreened and screened exceed three per cent of the volume in cubic feet of the enclosure protected.

33. Gas Supply. (See also Art. 16 and 17.)

(a) Due allowance shall be made for an extra supply of gas to supply screening nozzles at openings.

Where enclosure openings are to be protected by gas with discharge outlets one-half of the gas so used may be considered as effective for protection within the enclosure protected and such amount should be allowed for in determining the total amount of gas required to protect the hazard.

(b) Where total flooding equipments cover enclosed hazards subject to quick flash fire, or other fire susceptible to prompt extinguishment, and not involving a material amount of slow burning materials possibly subject to glow and smoldering, the following quantities of gas shall be provided.

A supply of carbon dioxide gas shall be maintained in the containers for delivery within the spaces protected of not less than 1 lb. of compressed gas for each 22 cu. ft. In figuring the cubic capacity to be protected, due allowance may be made for permanent, impermeable structures and contents materially reducing the volume. A relatively greater amount of gas is required for small spaces than for large ones and the above minimum figure may be used only for large volumes and favorable conditions.

For spaces up to 1,600 cu. ft. net volume the quantity of gas shall be not less than as shown in the following table:

Volume of Space (Cu. Ft. Net)	Carbon Dioxide in Lbs.
100	7.5
140	10
220	15
300	20
375	25
500	35
800	50
1100	70
1600	100

For spaces larger than 1,600 cu. ft. the space protected, per pound of gas, shall not be more than the following:

18 cu. ft. per lb. of gas up to 4,500 cu. ft. space protected
20 cu. ft. per lb. of gas up to 50,000 cu. ft. space protected
2,500 lbs. of gas from 50,000-55,000 cu. ft.
22 cu. ft. per lb. of gas over 55,000 cu. ft. space protected

(These figures are inclusive.)

Inspection departments having jurisdiction shall be consulted in each case as to the minimum amount of gas to be required.

(c) Where total flooding equipments cover hazards not as defined under Article 33 (b), where there is a moderate amount of combustible material in which fire may linger, smolder, or glow and where space is relatively tight, larger quantities of carbon dioxide are required; for example: fur vaults and record vaults.

For extinguishment of fur vault fires, one pound of carbon dioxide shall be provided for each six cubic feet of vault volume.

NOTE: A lesser amount, one pound of carbon dioxide for each sixteen cubic feet of vault volume, should retard spread of fire and prevent building damage, but will not adequately protect the materials stored and is not recommended.

It is important that the space be kept closed during and after discharge for a prolonged period (at least 30 minutes) and when opened the contents should be carefully inspected for any tendency to re-kindle, and if there is any such tendency the material should be removed and/or locally extinguished. Where conditions permit it is desirable to keep the vault closed for a period of one and one-half hours to insure thorough cooling before opening.

It is recommended that automatic sysem operation be provided, to prevent extensive damage of the contents.

(d) Where total flooding equipments cover hazards other than specified in Articles 33 (b) and 33 (c), the combustibles constituting a considerable amount of material in which fire may linger, smolder or glow and where reasonable tightness of the enclosure cannot be maintained, the amount of gas required must exceed that specified in Article 33 (c) according to the character of the stock, ventilation and other local conditions or a Class C system may be called for.

The approval of inspection departments having jurisdiction shall be obtained for a Class A system, under Article 33 (d).

34. Gas Discharge Outlets.

(See also Article 20 and Article 35 (b).)

(a) The discharge outlets shall be so located as to prevent the drawing-in of air from openings in the enclosure and to prevent the blowing of fire through such openings. The number, type and location of discharge outlets shall be such as to give uniform gas distribution throughout the enclosed space. This may be accomplished by wide distribution of relatively small discharge outlets throughout the enclosed space or by larger capacity outlets located so that the discharged gases will mix intimately with the air in the enclosed space because of the convection currents developed.

Stock piles, racks and any other obstructions shall not be so located with reference to the gas discharge outlets as to interfere with the proper distribution of the gas.

(b) Where high velocity discharge outlets point directly at liquid surfaces they shall not be located closer to such surfaces than shown in the following table, except a modification or waiving of this rule may be permitted where heavy liquids, not subject to splashing, are protected.

Diameter Inches	Area Sq. in.	Minimum Distance from Flammable Liquid Surface
Less than 1/16	....	2.5 ft.
1/16	.0030	2.5 ft.
3/32	.0069	3.0 ft.
1/8	.0123	3.5 ft.
5/32	.0192	4.0 ft.
3/16	.0276	4.5 ft.
7/32	.0376	5.0 ft.
1/4	.0491	5.5 ft.
9/32	.0621	6.0 ft.
5/16	.0767	6.5 ft.
11/32	.0928	7.0 ft.
3/8	.1105	7.5 ft.
13/32	.1296	8.0 ft.
7/16	.1503	8.5 ft.
15/32	.1725	9.0 ft.
1/2	.1964	9.5 ft.
9/16	.2485	10.0 ft.
5/8	.3068	10.5 ft.
11/16	.3712	11.0 ft.
3/4	.4418	11.5 ft.

(c) Rate of Gas Discharge.

(1) High-Pressure systems. For systems protecting flash hazards as described in Paragraph 33 (b), the total area of all discharge outlets shall be calculated from the sum of the minimum required areas of the outlets of the release devices or from the minimum area of the supply pipe, whichever is the smaller, and shall not exceed 85% nor be less than 40% of such area.

For systems protecting Class A combustibles as discussed in Article 33 (c) and (d), the total areas of all discharge outlets should be further restricted but not to less than 3 per cent of the sum of the areas of all container release orifices discharging to the system.

(2) Low-Pressure Systems. For Systems protecting flammable liquids, the quantity of carbon dioxide required as set forth in Article 33 (b) should be discharged into the hazard within an interval of approximately one minute. The Inspection Department having jurisdiction shall be consulted in special cases.

When the hazard being protected contains Class A combustibles, the quantity of carbon dioxide required as set forth in Articles 33 (c) and 33 (d) shall be discharged into the hazard within a seven minute interval unless the hazard contains unusually valuable combustibles, in which case the required quantity of carbon dioxide should be discharged into the room during a much shorter period.

See Article 35 (b).

35. Piping. (See also Article 19)

(a) HIGH PRESSURE SYSTEMS.

(1) For high pressure equipment installed under Paragraph 33 (b), the discharge piping shall conform to the following table. Where several smaller pipes are to be run in lieu of the pipe specified, the aggregate area shall be no less than the theoretically correct area required for the quantity of gas discharged. This theoretical area may be determined by interpolation from the figures given in the table.

Maximum quantity in lbs. of CO_2 required for normal flooding	Nominal sizes, pipe and fittings, inches	Actual internal area of pipe sq. in.
100	½ Standard	.304
200	¾ "	.533
300	1 Extra Heavy	.719
600	1¼ "	1.282
1000	1½ "	1.767
2450	2 "	2.953
2500	2½ "	4.238
4450	3 "	6.605
7100	3½ "	8.888
10450	4 "	11.497
15000	4½ "	14.455
20900	5 "	18.194
33600	6 "	26.067

For quantities over 33,600 lbs. the ratio of .000775 sq. in. pipe area per lb. of carbon dioxide shall be maintained.

(2) Cylinders having release device outlets different from those of the cylinders used in the original installation shall not be used for replacement unless the system is changed to comply with above.

(3) For equipment installed under Article 33 (c), the following table shall be used:

Maximum quantity in lbs. of CO_2 required	Nominal pipe sizes, inches	Actual internal area of pipe sq. in.
1800	½ Standard	.304
3200	¾ "	.533
4350	1 Extra Heavy	.719
7750	1¼ "	1.282
10700	1½ "	1.767

For quantities over 10,700 lbs., the ratio of .000165 sq. in. pipe area per lb. of carbon dioxide shall be maintained.

(4) When larger pipe sizes are needed for equipment installed under Article 33 (c), extra heavy pipe shall be used.

(b) LOW-PRESSURE SYSTEMS.

The rate of low-pressure liquid carbon dioxide flow from nozzle orifices should be approximately 600 pounds of carbon dioxide per square inch of orifice area per minute under average conditions. In determining what size pipe and discharge nozzle to use, the above value shall be employed in conjunction with Articles 33 (b), (c), and (d). The following table gives data that shall be used in determining maximum nozzle orifice areas with relation to pipe areas supplying such orifices. If the piping is such that the ratio of the nozzle orifice area to pipe area is a smaller value than that given in the table, then the rate of flow will be greater than the desired 600 pounds per square inch per minute minimum.

Length of Smallest Area Pipe Line in Feet	Maximum Ratio (Total Nozzle Orifice Area Divided By Smallest Area of Pipe Line)
Under 100	1.35
100 to 200	1.25
200 to 300	1.15
300 to 400	1.05
400 to 500	.95
500 to 600	.85
600 to 700	.75
700 to 800	.65

Installations shall be tested to determine that the required amount of gas will be discharged at the required rate in case of fire.

CLASS B SYSTEMS.

Equipments for Protection by Local Application of Gas on Particular Hazards.

41. General. (See Article 11 (h), (i), (j), (k), (l).)

(a) The preceding General Rules (Sections 11 to 24) shall apply and in addition the following:

(b) Class B systems differ from Class A systems in that the extinguishing gas concentrations must be developed in the fire zone without the aid of enclosing walls. This local, direct application of the carbon dioxide in the fire zone is accomplished as defined in this portion of the standards by fixed piping and nozzles.

The hazard may be indoors, partly sheltered, or completely out of doors. If indoors, the entire enclosed space may be protected by a total flooding carbon dioxide system or by automatic sprinkler or other suitable type of protection. It may be desirable to extinguish relatively small, local hazards within this space by local, direct application of carbon dioxide.

If the hazard protected by local, direct application is out of doors or only partly sheltered from natural winds, it is essential that the application of the gas be such that these winds do not impair the protection.

Examples of the hazards which may be protected by fixed equipment (local, direct application) include dip tanks, quench tanks, spray booths, oil filled electrical transformers and other flammable liquid hazards.

42. Gas Supply. (See also Articles 16 and 17.)

A supply of carbon dioxide gas shall be maintained sufficient to deliver on the surface of flammable liquids not less than one pound of gas for each 0.6 square feet of liquid surface. For drip boards and stock freshly coated with flammable materials not less than one pound for each 0.8 square feet of coated flammable surface. Where the hazard is not enclosed, enough gas should be supplied to protect all flammable material likely to be involved in a fire starting in the protected hazard.

NOTE.—The above figures do not apply to the protection of carbon bi-sulphide hazards where approximately twice the quantity of gas is required for the same volume or area.

43. Discharge Outlets. (See also Articles 20 and 34.)

(a) Outlets shall apply gas to the surface of flammable liquids and shall be so located as to uniformly cover the area protected and in addition all adjacent areas and surfaces likely to be coated with flammable liquids or their residues for which allowance has been made in figuring the amount of gas required under Article 42.

Inspection departments having jurisdiction should be consulted as to the extent of the gas protection required beyond the immediate area of the liquid.

(b) In local, direct application of carbon dioxide, the discharge shall be made in such manner that flaming material will not be blown outside of the protected area and so that adequate concentration of the gas will be effected.

44. Pipe Systems. (See also Article 19.)

Piping shall conform to Article 35 (a) for high-pressure systems and 35 (b) for low-pressure systems.