STATE OF ARKANSAS

FIRE EXTINGUISHER SERVICEMAN AND INSTALLER ADVISORY BOARD

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October 8, 1981

Ms. Debbie Scheffield
Arkansas Registar Section
Secretary of State Office
State Capital Building
Little Rock, AR 72201

Dear Ms. Scheffield:

It has come to our attention that we should have filed various National Fire Protection pamphlets, when the Board's Rules & Regulations were filed, some time ago.

Enclosed you will find the following pamphlets for your disposition:

NFPA 11, 1975
NFPA 12, 1973
NFPA 17, 1975
NFPA 96, 1975
NFPA 12A, 1973
NFPA 12B, 1973
C4R Title 49

Sincerely,

Eldridge Bradley

Eldridge Bradley,
Secretary

Enclosures

EB:cb

tested in accordance with the requirements of this section before the tank is returned to transportation service. The requirements of this section shall apply with equal force to all hose used on such tanks, except that such hose may be so tested either before or after installation on the tank.

(6) Liquid pumps or gas compressors, wherever used, must be of suitable design, adequately protected against breakage by collisions, and kept in good condition. They may be driven by motor vehicle power takeoff or other mechanical, electrical, or hydraulic means. Unless they are of the centrifugal type, they shall be equipped with suitable pressure actuated by-pass valves permitting flow from discharge to suction or to the tank.

(7) Each tank used for the shipment of carbon dioxide or nitrous oxide shall be provided with a suitable pressure gauge. A shutoff valve must be installed between the pressure gauge and the tank. This gauge need be used only during the filling operation.

(8) Chlorine cargo tanks. No piping, hose, or other means of loading or unloading may be attached to any valve of a cargo tank containing chlorine except at the time of loading or unloading. No hose, piping, or tubing used for loading or unloading may be mounted or carried on the motor vehicle. Except at the time of loading or unloading, the pipe connection of each angle valve must be closed with a screw plug which is chained or otherwise fastened to prevent misplacement.

(9) Chlorine cargo tank angle valves must be tested before installation to be leak free at not less than 225 p.s.i.g. using dry air or inert gas. The angle valves must also be tested as above once every five loadings or once a week whichever occurs first. At each loading, tanks must be inspected and the angle valves and gasketed joints must be examined and tested at a pressure of not less than 50 p.s.i.g. to determine that they are not leaking and are in proper condition for transportation. Leaks which are detected must be corrected before the cargo tank motor vehicle is shipped.

(10) Liquid chlorine pumps shall not be installed on cargo tank motor vehicles used for the shipment of chlorine.

(g) All materials of construction used in cargo tanks and their appurtenances shall not be subject to destructive attack by the contents of the tank.

(1) All parts of tanks and appurtenances for anhydrous ammonia shall be steel. No copper, silver, zinc, nor their alloys shall be permitted. Brazed joints shall not be permitted.

(h) Each outlet of cargo tanks used for the transportation of liquefied compressed gases, except carbon dioxide, shall be provided with an approved suitable automatic excess-flow valve or in lieu thereof may be fitted with an approved automatic quick-closing internal valve. These valves shall be located inside the tank or at a point outside the tank where the line enters or leaves the tank. The valve seat shall be located inside the tank or shall be located within a welded flange or its companion flange, or within a nozzle, or within a coupling. The installation shall be made in such a manner as reasonably to assure that any undue strain which causes failure requiring functioning of the valve shall cause failure in such a manner that it will not impair the operation of the valve.

Exception: Any liquid level gauging device which is constructed so that the outward flow of tank contents does not exceed that passed by a 0.060-inch diameter opening, or any safety device connection, is not required to be equipped with an excess-flow valve.

(1) Each excess-flow valve must close automatically at the rated flow of gas or liquid as specified by the valve manufacturer. The flow rating of the piping, fittings, valves, and hose on each side of the excess-flow valve must be greater than that of the excess-flow valve. If branching or any other restriction is incorporated in the system so that the flow rating is less than that of the excess-flow valve at the tank, additional excess-flow valves must be located where the flow rates are reduced.

(2) An excess-flow valve may be designed with a bypass, not to exceed 0.040-inch diameter opening, to allow equalization of pressures.

(3) Each filling and discharge line must be provided with a manual shut-off valve located as close to the tank as practicable. However, when an internal shut-off valve that closes automatically is used, a manual shut-off valve must be located in the line ahead of the hose connection. The use of a so-called "stop-check" or excess flow valve to satisfy the requirements of this rule and of paragraph (i) of this section with one valve is prohibited except as provided in § 178.337-11(c) of this subchapter.

(4) Angle valves and excess-flow valves on chlorine tank motor vehicles manufactured on or before December 31, 1974, must conform to the standards of The Chlorine Institute, Inc., as follows:

(i) An angle valve must conform to either Dwg. 104-4 dated May 5, 1958, or Dwg. 104-5, dated September 1, 1972.

(ii) An excess-flow valve conforming to either Dwg. 101-4 dated May 16, 1969, or Dwg. 101-6, dated September 1, 1973, must be installed under each liquid angle valve. An excess-flow valve conforming to either Dwg. 106-3, dated May 16, 1969, or Dwg. 106-5, dated September 1, 1973, must be installed under each gas angle valve.

(5) Angle valves and excess-flow valves on chlorine tank motor vehicles manufactured on or after January 1, 1975, must conform to the standards of The Chlorine Institute, Inc., as follows:

(i) An angle valve must conform to Dwg. 104-5, dated September 1, 1972;

(ii) An excess-flow valve conforming with Dwg. 101-6, dated September 1, 1973, must be installed under each liquid angle valve. An excess-flow valve conforming to Dwg. 106-5, dated September 1, 1973, must be installed under each gas angle valve.

(i) Each tank for chlorine, carbon dioxide, and nitrous oxide must be insulated with a suitable insulation material of such thickness that the overall thermal conductance is not more than 0.08 B.t.u. per square foot per degree F. differential in temperature per hour. The conductance must be determined at 60° F. Insulation material used on tanks for nitrous oxide must be noncombustible. Insulation material used on tanks for chlorine must be corkboard or self-extinguishing polyurethane foam with minimum thickness of 4 inches.

(j) A refrigerating and/or heating coil or coils may be installed in tanks for carbon dioxide and nitrous oxide. Such coils must be tested externally to at least the same pressure as the test pressure of the tank. The coils must also be tested internally to at least twice the working pressure of the heating or refrigerating system to be used but in nocase less than the test pressure of the tank. Such coils shall be securely anchored. The refrigerant or heating medium to be circulated through the coil or coils must be such as to cause no adverse chemical reaction with the tank or tank contents in case of leakage. If desired, the unit furnishing refrigeration may be mounted on the motor vehicle.

(k) Each MC 330 cargo tank used for flammable compressed gas or anhydrous ammonia must be equipped with liquid discharge controls that conform to the requirements of § 178.337-11(c) of this subchapter at each liquid discharge opening. The controls required by this paragraph must be installed not later than the date the tests prescribed by paragraph (e) of this section are required.

§ 173.34 Qualification, maintenance and use of cylinders. (a) General qualification for use of cylinders. (See §§ 173.1 through 173.30 for requirements applying to all shipments.)

(1) No person may charge or fill a cylinder unless it is as specified in this part and Part 178 of this subchapter. A cylinder that leaks, is bulged, has defective valves or safety devices, bears evidence of physical abuse, fire or heat damage, or detrimental rusting or corrosion, must not be used unless it is properly repaired and requalified as prescribed in these regulations.

(2) When cylinders with a marked pressure limit are prescribed, other cylinders made under the same specification but with a higher marked service pressure limit are authorized. For example, cylinders marked DOT-4B500 may be used where DOT-4B300 is specified.

(b) Grandfather clause. A cylinder in domestic use previous to the date upon which the specification therefor was first made effective in these regulations may be used if the cylinder has been properly tested and otherwise complies with the requirements applicable for the gas with which it is charged.

(c) Cylinder marking. Each required marking on a cylinder must be maintained so that it is legible. Retest markings and original markings which are becoming illegible may be reproduced by stamping on a metal plate which must be permanently secured to the cylinder.

(1) Additional markings not affecting any of the prescribed markings may be made in accordance with marking requirements of the specification.

(2) When the space originally provided for dates of subsequent retests becomes filled, the stamping of additional test dates into the external surface of the footring of a cylinder is authorized.

(3) A cylinder marking may not be changed except as follows:

(i) Marked service pressure may be changed only upon application to the Bureau of Explosives and receipt of written instructions as to the procedure to be followed. Such a change is not authorized for a cylinder which has failed to pass the prescribed periodic hydrostatic retest unless it is reheat treated and requalified in accordance with the requirements of this section.

(ii) Changes may be made in serial numbers and in the identification symbols by the owners. Identification symbols must be registered and approved by the Bureau of Explosives. Serial numbers and identification symbols may be changed only by the owner upon his receipt of written approval from the Bureau of Explosives. The request for approval must identify the existing markings (including serial numbers) that correspond with the proposed new markings.

(4) When the space originally provided for dates of subsequent retests becomes filled, the stamping of additional test dates into the external surface of footrings of cylinders is authorized.

(5) [Reserved]

(d) Safety relief devices. Each cylinder charged with compressed gas, unless excepted in this paragraph, must be equipped with one or more safety relief devices approved, as to type, location, and quantity, by the Bureau of Explosives and must be capable of preventing explosion of the normally charged cylinder when it is placed in a fire. Cylinders shall not be shipped with leaking safety relief devices. Safety relief devices must be tested for leaks before the charged cylinder is shipped from the cylinder filling plant; it is expressly forbidden to repair leaking fuse plug devices, where leak is through the fusible metal or between the fusible metal and the opening in the plug body, except by removal of the device and replacement of the fusible metal. Exceptions are as follows:

(1) Except as provided in Notes 1, 2, and 3, safety relief devices are not required on cylinders 12 inches or less in length, exclusive of neck, and 4½ inches or less in outside diameter.

Note 1: Safety relief devices are required on specifications 9, 40, 41, and 39 (§ 178.65 of this subchapter) cylinders. Metal safety relief valves are required on specification 39 cylinders used for liquefied flammable gases. Fusible safety relief devices are not authorized on specification 39 cylinders containing liquefied compressed gases.

Note 2: Safety relief devices are required on cylinders charged with a liquefied gas for which this part requires a service pressure of 1,800 psi or higher.

Note 3: Safety relief devices are required on cylinders charged with nonliquefied gases to a pressure of 1,800 psi or higher at 70° F.

(2) Except for specification 39 cylinders and cylinders for acetylene in solution, safety relief devices are not required on cylinders charged with non-liquefied gas under pressure of 300 p.s.i. or less at 70° F.

(3) Safety relief devices are prohibited on cylinders charged with Poison A gas or liquid.

(4) Safety relief devices are prohibited on cylinders charged with fluorine.

(5) Safety relief devices are not required on cylinders charged with methyl mercaptan; with mono-, di-, or trimethylamine, anhydrous; with not over 10 pounds of nitrosyl chloride; or with less than 165 pounds of anhydrous ammonia.

(6) [Reserved]

(7) Safety relief devices, if used, must be in the vapor space of cylinders containing pyroforic liquids, n.o.s., covered by § 173.134.

(e) Periodic retesting and reinspection of cylinders. Each cylinder becomes due for periodic retest in accordance with the following table and exceptions thereto:

Specification under which cylinder was made	Minimum retest pressure (p.s.i.)	Retest period (years)
DOT-3	3,000 p.s.i.	5.
DOT-3A, 3AA	5/3 times service pressure, except noncorrosive service (see § 173.34(e)(10)).	5 or 10 (see § 173.34(e)(11), (e)(14), and (e)(15))
DOT-3AX, 3AAX	5/3 times service pressure	5.
3B, 3BN	2 times service pressure (see § 173.34(e)(10)).	5 or 10 (see § 173.34(e)(14)).
3C	Retest not required	
3D	5/3 times service pressure	5.
3E	Retest not required	
3HT	5/3 times service pressure	3 (see § 173.34(e)(13)).
3T	5/3 times service pressure	5.
4	700 p.s.i.	10.
4A	5/3 times service pressure (see § 173.34(e)(10)).	5 or 10 (see § 173.34(e)(14)).
4AA480	2 times service pressure (see § 173.34(e)(10)).	5 or 10 (see § 173.34(e)(11)).
4B, 4BA, 4BW, 4B-240ET	2 times service pressure, except noncorrosive service (see § 173.34(e)(10)).	5 or 10 (see § 173.34(e)(9) and (e)(14)).
4C	Retest not required	
4D, 4DA, 4DS	2 times service pressure	5.
DOT-4E	2 times service pressure, except noncorrosive service (see § 173.34(e)(10)).	5.
4L	Retest not required	
8, 8AL	Retest not required	
DOT-9	400 p.s.i. (maximum 600 p.s.i.)	5.
25	500 p.s.i.	5.
26 for filling at over 450 p.s.i.	5/3 times service pressure	5.
26 for filling at 450 p.s.i. and below	2 times service pressure, except noncorrosive service (see § 173.34(e)(10)).	5 or 10 (see § 173.34(e)(9)).
33	800 p.s.i.	5.
38	500 p.s.i.	5.
Any cylinder with marked test pressure	Retest at marked test pressure	5.
Foreign cylinder charged for export	As marked on the cylinder, but not less than 5/3 of any service or working pressure marking.	See § 173.301(j).

Note 1: For cylinders not marked with a service pressure, see § 173.301(e)(1).

(1) This periodic retest must include a visual internal and external examination together with a test by interior hydrostatic pressure in a water jacket or other apparatus of suitable form for the determination of the expansion of the cylinder. The test apparatus must be approved as to type and operation by the Bureau of Explosives. The internal inspection may be omitted for cylinders of the type and in the service described under subparagraphs (9) and (10) of this paragraph.

(2) Cylinders of DOT 4 series, without regard to date of previous test, that show bad dents or other evidence of rough usage, or that are corroded locally to such extent as to indicate possible weakness, or that have lost as much as 5 percent of their official tare weight, must be retested before being again charged and shipped. After any retest, the actual tare weight for those cylinders passing the test may be recorded as their new official tare weight.

(3) In hydrostatic retesting of a cylinder the pressure must be maintained for at least 30 seconds and as much longer as may be necessary to secure complete expansion of the cylinder. The gauge indicating the total expansion of the cylinder must be such that the total expansion can be read with an accuracy of 1 percent, except that a reading to 0.1 cubic centimeter shall be acceptable. The gauge indicating the pressure must be capable of being read to within 1 percent of the test pressure. Any internal pressure applied previous to the test pressure shall not exceed 90 percent of the test pressure. If, due to failure of the test apparatus, the test pressure cannot be maintained, the test may be repeated at a pressure increased by 10 percent or 100 psi, whichever is the lower value.

(4) A cylinder must be condemned when it leaks, or when internal or external corrosion, denting, bulging, or evidence of rough usage exists to the extent that the cylinder is likely to be weakened appreciably, or when the permanent expansion exceeds 10 percent of the total expansion, except that for DOT 4E aluminum cylinders, when the permanent expansion exceeds 12 percent of the total expansion. Except for DOT 4E aluminum cylinders, a cylinder condemned for excessive permanent expansion may be reheat-treated. (See paragraph (g) of this section.) DOT 4 series cylinders, condemned for other than excessive permanent expansion, may be repaired and rebuilt as otherwise provided in this section.

(5) Records showing the result of reinspection and retest must be kept by the owner or his authorized agent until either expiration of the retest period, or until the cylinder is again reinspected or retested, whichever occurs first.

(6) Each cylinder passing reinspection and retest must be marked with the date (month and year), plainly and permanently stamped into the metal of the cylinder or on a metal plate which must be permanently secured to the cylinder. For example, "4-70" for April 1970. The dash between the month and year figures may be replaced by the mark of the testing or inspecting agency. Stamping must be in accordance with marking requirements of the specification. Date of the previous tests must not be obliterated.

(7) Cylinders in chlorine or sulfur dioxide service made before April 20, 1915, must be retested at 500 psi.

(8) For cylinders of not over ten pounds water capacity which are authorized for service pressures not over 300 psi, the hydrostatic testing portion of the retest procedure may consist of application of the prescribed internal hydrostatic test pressure without the use of special apparatus and without the determination of total and permanent expansions. In this test the cylinders shall be examined while under pressure and must show no leak or other harmful defect as enumerated in subparagraph (4) of this paragraph.

(9) Cylinders made in compliance with specifications DOT 4B, DOT

4BA, DOT 4BW, DOT 4E, and ICC-26-300[1] (§§178.50, 178.51, 178.61, 178.68 of this subchapter) which are used exclusively for anhydrous dimethylamine; anhydrous monomethylamine; anhydrous trimethylamine; methyl chloride; liquefied petroleum gas; methylacetylene-propadiene stabilized; or dichlorodifluoromethane, difluoroethane, difluoromonochloroethane, monochlorodifluoromethane, monochlorotetrafluoroethane, monochlorotrifluorethylene, or mixture thereof, or mixtures of one or more with trichloromonofluoromethane; and which are commercially free from corroding components and protected externally by suitable corrosion resisting coatings (such as galvanizing, painting, etc.) may be retested decennially (see Note 2) instead of quinquennially, or, as an alternative such cylinders may be subjected to an internal hydrostatic pressure equal to at least two times the marked service pressure without determination of expansions (see Note 1), but this latter type of test must be repeated quinquennially after expiration of the first 10-year period (see Note 2). When subjected to this latter test, cylinders must be carefully examined under the test pressure and removed from service if leaks or other harmful defects exist.

Cylinders made in compliance with—	*Used exclusively for—*
DOT-4, DOT-3A, DOT-3AA, DOT-3A480X, DOT-4A, DOT-4AA480.	Anhydrous ammonia of at least 99.95% purity.
DOT-3A, DOT-3AA, DOT-3A480X, DOT-3B, DOT-4B, DOT-4BA, DOT-4BW, ICC-26-240,[1] ICC-26-300.[1]	Butadiene, inhibited, which is commercially free from corroding components.
DOT-3A, DOT-3A480X, DOT-3AA, DOT-3B, DOT-4A, DOT-4AA480, DOT-4B, DOT-4BA, DOT-4BW.	Cyclopropane which is commercially free from corroding components.
DOT-3A, DOT-3AA, DOT-3A480X, DOT-4B, DOT-4BA, DOT4BW, DOT-4E.	Fluorinated hydrocarbons and mixtures thereof which are commercially free from corroding components.
DOT-3A, DOT-3AA, DOT-3A480X, DOT-3B, DOT-4B, DOT-4BA, DOT-4BW, DOT-4E, ICC-26-240,[1] ICC-26-300.[1]	Liquefied hydrocarbon gas which is commercially free from corroding components.
DOT-3A, DOT-3AA, DOT-3A480X, DOT-3B, DOT-4B, DOT-4BA, DOT-4BW, DOT-4E, ICC-26-240,[1] ICC-26-300.[1]	Liquefied petroleum gas which is commercially free from corroding components.
DOT-3A, DOT-3AA, DOT-3B, DOT-4B, DOT-4BA, DOT-4BW, DOT-4E.	Methylacetylene-propadiene, stabilized, which is commercially free from corroding components.
DOT-3A, DOT-3AA, DOT-3B, DOT-4B, DOT-4BA, DOT-4BW.	Anhydrous mono, di, trimethylamines which are commercially free from corroding components.

[1] Use of existing cylinders authorized, but new construction not authorized.

Note 1: Cylinders tested by the modified hydrostatic method shall be marked after each retest with the date of test as otherwise required but followed by the symbol S; for example, 8-57S indicating retest by the modified method in August, 1957.

Note 2: Until further order of the Department, the decennial retest period may be extended to a 12-year period, and the quinquennial retest period may be extended to a 7-year period after expiration of the first 12-year period.

(10) Cylinders made in compliance with the specifications listed in the table above and used exclusively in the service indicated may, in lieu of the periodic hydrostatic retest, be given a complete external visual inspection at the time such periodic retest becomes due. External visual inspection as described in CGA Pamphlet C-6 will, in addition to the following requirements prescribed herein, meet the requirements for visual inspection.

When this inspection is used in lieu of hydrostatic retesting, subsequent inspections are required 5 years after the first such inspection and periodically at 5-year intervals thereafter. Inspections shall be made only by competent persons and the results shall be recorded on a suitable data sheet, the completed copies of which shall be kept as a permanent record. The points to be recorded and checked on these data sheets are: Date of inspection (month and year); DOT specification number; cylinders identification (registered symbol and serial number, date of manufacture, and ownership symbol (if needed for adequate identification)); type cylinder protective coating (painted, etc., and statement as to need of refinishing or recoating); conditions checked (leakage, corrosion, gouges, dents or digs in shell or heads, broken or damaged footring or protective ring or fire damage); disposition of cylinders (returned to service, to cylinder manufacturer for repairs or scrapped); a cylinder which passes the inspection prescribed shall have the date recorded in the manner presently prescribed for the recording of the retest date, except that an "E" is to follow the date (month and year) indicating requalification by the external inspection method.

(11) A cylinder made in compliance with specification DOT-3A, DOT-3A480X, or DOT-4AA480 used exclusively for anhydrous ammonia, commercially free from corroding components, and protected externally by suitable corrosion resisting coatings (such as painting, etc.) may be retested every 10 years instead of every 5 years.

(12) All cylinders not exceeding 2 inches outside diameter and length less than 2 feet are exempted from hydrostatic retest.

(13) In addition to the requirements of this paragraph (e), cylinders marked DOT-3HT must be requalified in accordance with CGA Pamphlet C-8 and must comply with the following:

[2] (i) Cylinder shall be subjected, at least once in three years, to a test by hydrostatic pressure in a water jacket, for the determination of the expansion of the cylinder. A cylinder must be condemned if the elastic expansion exceeds the marked rejection elastic expansion.

(ii) A cylinder must be condemned if there is evidence of any denting or bulging.

[2] (iii) A cylinder must be condemned at the termination of a 24-year period following the date of the original test or after 4,380 pressurizations, whichever occurs first. If a cylinder is recharged more than an average of once every other day, an accurate record of the number of rechargings must be maintained by its owner, or his agent.

(iv) Retest dates shall be applied by low stress type steel stamping to a depth no greater than that of the original marking at the time of manufacture. Stamping on sidewall not authorized.

[2] (v) A cylinder made before January 11, 1978 and not yet marked with a rejection elastic expansion (REE) must be marked with that REE in cubic centimeters near the marked original elastic expansion prior to the next retest date. The REE for a cylinder is 1.05 times its original elastic expansion.

(14) Cylinders made in compliance with specifications DOT-3A, DOT-3AA, DOT-3B, DOT-4A, DOT-4BA, and DOT-4BW (§§178.36, 178.37, 178.38, 178.49, 178.51, 178.61 of this chapter) having service pressures up to and including 300 p.s.i. which are used exclusively for methyl bromide, liquid; mixtures of methyl bromide and ethylene dibromide, liquid; mixtures of methyl bromide and chlorpicrin, liquid; mixtures of methyl bromide and petroleum solvents, liquid; or methyl bromide and nonflammable, nonliquefied compressed gas mixtures, liquid; which are commercially free from corroding components, and which are protected externally by suitable corrosion resisting coatings (such as galvanizing, painting, etc.) and internally by a suitable corrosion resisting lining (galvanized, etc.) may be tested decennially instead of quinquennially. All tests must be supplemented by a visual internal and external examination of the cylinder quinquennially. Examination must be as required by CGA Pamphlet C-6. All tests must be supplemented by a very careful examination of the cylinder at each filling, and the cylinder must be rejected if evidence is found of bad dents, corroded areas, a leak, or other conditions that indicate possible weakness which would render the cylinder unfit for service.

(15) A cylinder made in compliance with specification DOT-3A or 3AA, not exceeding 125 pounds water capacity and removed from any cluster, bank, group, rack, or vehicle each time it is filled, may be retested every 10 years instead of every 5 years, provided the cylinder complies with all of the following:

(i) The cylinder is not over 35 years old when it is retested.

(ii) The cylinder is used exclusively for: Air, argon, cyclopropane, ethylene, helium, hydrogen, krypton, neon, nitrogen, nitrous oxide, oxygen, xenon, and permitted mixtures thereof (see §173.301(a)) and permitted mixtures of these gases with up to 30 percent by volume of carbon dioxide. These commodities must have a dewpoint at or below minus 52° F. at 1 atmosphere.

(iii) Prior to each refill, the cylinder is subjected to, and passes the hammer test specified in CGA Pamphlet C-6.

(iv) A cylinder currently in compliance with subdivisions (i), (ii), and (iii) of this subparagraph but which has not been confined to the exclusive use service specified since the last required hydrostatic retest is retested and examined in accordance with the requirements of §173.302(c)(2), (3), and (4) before the periodic retest interval is extended to 10 years.

(v) Each cylinder less than 35 years old is stamped with a five pointed star at least one-fourth of an inch high following the test date. If at any time a cylinder marked with the star is used other than as specified in this paragraph, the star following the most recent test date is obliterated and subsequent tests are made every 5 years.

(vi) The cylinder is dried immediately following hydrostatic testing to remove all traces of free water.

(vii) The cylinder is not used for underwater breathing.

(16) A cylinder that previously contained a commodity classified as a "corrosive liquid" must not be used for the transportation of any compressed gas unless the following requirements are complied with before the subsequent initial filling with the compressed gas.

(i) The cylinder must be visually inspected, internally and externally, in accordance with the CGA Pamphlet C-6.
(ii) Regardless of the previous test or retest date, the cylinder must be tested by interior hydrostatic pressure and must meet the acceptance criteria as specified in subparagraphs (1), (2), (3), and (4) of this paragraph.
(iii) In addition to the record prescribed in subparagraph (5) of this paragraph, the record of the inspection and test shall include the date (month and year) of the inspection and test; the cylinder identification (including ICC or DOT specification number, registered symbol, serial number, date of manufacture, and ownership symbol); the conditions checked (leakage, corrosion, gouges, dents, or digs in shell or heads, broken or damaged footrings, or fire damage) and the disposition of the cylinder (returned to service, returned to the manufacturer for repairs, or scraped).
(iv) A cylinder requalified for compressed gas service in accordance with this subparagraph may have its next retest and inspection scheduled from the date of the inspection and retest prescribed herein.
(v) A cylinder that contained any corrosive liquid, for which decontamination methods cannot remove all significant residue or impregnation by the former corrosive content must not be used for the transportation of any compressed gas.

(f) Cylinders subjected to the action of fire. A cylinder which has been subjected to the action of fire must not again be placed in service until it has been properly reconditioned as follows:

(1) A cylinder made of plain carbon steel with not over 0.25 percent carbon nor over 0.90 manganese need not be reheat-treated but must pass the periodic retest requirements as specified in paragraph (e) of this section.

(2) DOT-8 cylinders made of plain carbon steel with not over 0.25 percent carbon nor over 0.90 percent manganese must be reinspected to determine the condition of the cylinder and the porous filling. If the cylinder is undamaged and the filler is unchanged and intact, the cylinder may be returned to service without reheat treatment or test.

(3) The inner cylinders made under specification DOT-4L (§ 178.57 of this chapter) may be used after again passing the original hydrostatic test.

(4) DOT-4E aluminum cylinders must be removed from service.

(5) Other cylinders must be reheat-treated and reconditioned as specified in paragraph (g) of this section.

(g) Reheat treatment. **(1)** Previous to the reheat treatment procedure hereinafter prescribed, each cylinder must be subjected to a careful internal and external inspection.

(2) Cylinders must be segregated for reheat treatment in lots of 100 or less cylinders of the same general size having practically the same chemical composition.

(3) The reheat treatment operation must be carried out, supervised, and reported as prescribed for the heat treatment in the specification covering the manufacture of the cylinder in question. Data from the original reports of manufacture of the cylinders must be available.

(4) The reheat treatment must be followed by hydrostatic retest, such retest to be carried out, supervised, and reported as prescribed for the hydrostatic tests in the specification covering the manufacture of the cylinder in question. The results of the retest must meet either of the following conditions:
(i) The permanent expansion shall be from zero to 10 percent of the total expansion in the hydrostatic retest and one cylinder from each lot shall pass the requirements of the flattening and physical tests prescribed. Failure to pass the flattening or physical tests will reject the lot or;
(ii) The permanent expansion shall not be less than 3 percent nor more than 10 percent of the total expansion in the hydrostatic retest, in which case the flattening and physical tests are not required. For this alternative method the hydrostatic retest pressure shall not exceed 115 percent of the minimum prescribed test pressure except with specific approval of the Bureau of Explosives.

(h) Repair by welding or brazing of specifications DOT-3A, 3AA, 3B, 3C cylinders. Repair of specifications DOT-3A, 3AA, 3B or 3C (§§ 178.36, 178.37, 178.38, or 178.40 of this subchapter) cylinders by welding or brazing authorized, but only for the removal and replacement of neckrings and footrings attached to cylinders originally manufactured to conform to §§ 178.36-9(a), 178.37-9(a), 178.38-9(a), and 178.40-9(a) of this subchapter. Removal and replacement must be done by a regular manufacturer of this type of cylinder. After removal and before replacement of such parts, cylinders must be inspected, and defective ones rejected. Cylinders, neckrings, footrings, and method of replacement must conform to § 178.36-9(a), § 178.37-9(a), § 178.38-9(a), or § 178.40-9(a) of this subchapter whichever applies. Replacement must be followed by reheat treating, testing, inspection, and supervised and reported as prescribed by the specification covering their original manufacture. Inspector's reports must conform with that required by the specification covering original manufacture with the word "repaired" substituted for "manufactured." Show original markings and the new additional markings added, and statement: "Cylinders were carefully inspected for defects after removal of neckrings and footrings and after replacement, which replacement was made by process of ...."

(Welding-brazing)

(i) Repair by welding or brazing of DOT-4 series, and DOT-8, welded or brazed cylinders. Repairs on DOT-4 series and DOT-8 series welded or brazed cylinders are authorized to be made by welding or brazing. Such repairs must be made by a manufacturer of these types of DOT cylinders or by a repair facility authorized by the Bureau of Explosives and by a process similar to that used in its manufacture and under the following specific requirements:

(1) Cylinders with injurious defects in welded joints in or on pressure parts must be repaired by completely removing the defect prior to rewelding.

(2) Cylinders with injurious defects in brazed joints in or on pressure parts must be repaired by rebrazing.

(3) Cylinders during welding must be free of materials in contact with the welded joint that may impair the serviceability of the metal in or adjacent to the weld. (Precautions must be taken to prevent acetylene cylinder steels from picking up carbon during repair.)

(4) Neckrings, footrings, or other nonpressure attachments authorized by the specification may be replaced or repaired. Repair or replacement of footrings, neckrings, or other nonpressure attachments authorized by the specification for DOT-4BA and 8AL (§§ 178.51 and 178.60 of this subchapter) cylinders may be made without conforming to the requirements of subparagraph (i)(6) of this section provided the following requirements are met:
(i) Must be done by a manufacturer of these types of DOT cylinders or by a repair facility authorized by the Bureau of Explosives.
(ii) The welder shall have available to him information as to the procedure, equipment, and rod used during manufacture and shall use a similar method for repair.
(iii) Repairs must be by metal arc welding only. Welds shall be 3 inches maximum length and spaced at least 3 inches apart.
(iv) Welds shall not be made on or near a brazed joint (to prevent the possibility of copper penetration).
(v) After repair the welds are to be inspected visually for weld quality.
(vi) After repair the weld area is to be leak tested at the service pressure of the cylinder.

(5) After removal, and before replacement of attachments, cylinders must be inspected and defective ones rejected, repaired or rebuilt.

(6) After repair, cylinders must be reheat-treated, tested, inspected and reported when and as prescribed by the specification covering their original manufacture when welding or brazing seams in a pressure part of a cylinder; or when welding or brazing on pressure parts of cylinders of plain carbon steels with carbon over 0.25 percent or manganese over 1.00 percent or of alloy steels except as provided in § 173.34(i)(7).

Note 1: Heat-treatment is not required after welding or brazing weldable low carbon parts to attachments of similar material which has been previously welded or brazed to the top or bottom of cylinders and properly heat-treated, provided such subsequent welding or brazing does not produce a temperature in excess of 400° F. in any part of the top or bottom material.

(7) Repair of cylinders must be followed by a proof pressure leakage test at prescribed test pressure and visual examination for weld quality when welding on pressure parts of cylinders of plain carbon 0.25 percent or less and manganese 1.00 percent or less, or when repairing steel types 1315, NAX and GLX by the following procedure:
(i) Leakage through the welding metal may be repaired without subsequent reheat treatment of the cylinder.
(ii) Repair permitted only by either the metal arc or tungsten inert gas shielded arc process. E7015, 7016, or 7018 electrodes not larger than 1/8 inch diameter shall be used for the metal arc process.
(iii) Weld defects must be removed by grinding or chipping before repair by the metal arc process. The tungsten inert gas shielded arc process may be used for repair only when such repair can be made by puddling. Repair weld shall not exceed 1 inch in length nor be closer than 3 inches to the next repair area.
(iv) Repair of weld defects which have any cracking is not permitted.

(j) Repair of non-pressure attachments. Repair of non-pressure attachments by welding or brazing without affecting a pressure part of the cylinder must be followed by visual examination for weld quality.

(k) Prohibited repairs. Walls, heads or bottoms of cylinders with injurious defects or leaks in base metal shall not be repaired, but may be replaced as provided for in paragraph (l) of this section.

(l) Rebuilding of DOT 4 series and DOT 8, welded or brazed cylinders. Rebuilding of DOT 4 series and DOT 8 series, welded or brazed cylinders is authorized. Such rebuilding must be done by a manufacturer of these types of DOT cylinders or by a repair facility authorized by the Bureau of Explosives and by a process similar to that used in its original manufacture and under the following specific requirements:

(1) The replacement of a pressure part such as wall, heads, or bottoms of cylinders or the replacement of the porous filling material, shall be considered as rebuilding.

(2) Rebuilt cylinders shall be considered as new cylinders and shall conform to all the requirements of the specifications applying, including verification of material, examination, inspection, etc., and the rendering of the proper reports to the purchaser, cylinder rebuilder, and the Bureau of Explosives. Report must show that cylinders were rebuilt.

(3) Information in sufficient detail regarding previous serial numbers and identification symbols must be filed with the Bureau of Explosives.

SUBPART C

EXPLOSIVES; DEFINITIONS AND PREPARATION

§ **173.50 An explosive.** **(a)** For the purpose of Parts 170–189 of this subchapter an explosive is defined as any chemical compound, mixture, or device, the primary or common purpose of which is to function by explosion, i.e., with substantially instantaneous release of gas and heat, unless such compound, mixture, or device is otherwise specifically classified in Parts 170–189 of this subchapter.

§ **173.51 Forbidden explosives.** **(a)** Unless otherwise provided in this subchapter, the offering of the following explosives for transportation is forbidden.

(1) Explosive compositions that ignite spontaneously or undergo marked decomposition when subjected for 48 consecutive hours to a temperature of 75° C. (167° F.).

(2) Explosives containing an ammonium salt and a chlorate.

(3) Liquid nitroglycerin, diethylene glycol dinitrate or other liquid explosives not authorized by §173.53(e) and (h). (For shipment by carrier by motor vehicle other than common carriers, see §177.822(b) of this chapter.)

(4) Explosives condemned by the Bureau of Explosives (except properly packed samples for laboratory examinations). Appeal may be made to the Department from such condemnations.

(5) Leaking or damaged packages of explosives.

(6) Condemned or leaking dynamite must not be repacked and offered for shipment unless the repacking is done by a competent person in the presence of, or with the written consent of, an inspector, or with the written authority of the chief inspector of the Bureau of Explosives.

(7) Firecrackers, flash crackers, salutes, or similar commercial devices which produce or are intended to produce an audible effect, the explosive content of which exceeds 12 grains each in weight, and pest control bombs, the explosive content of which exceeds 18 grains each in weight; and any such devices, without respect to explosive content, which on functioning are liable to project or disperse metal, glass or brittle plastic fragments.

(8) Fireworks that combine an explosive and a detonator or blasting cap.

(9) Fireworks containing an ammonium salt and a chlorate.

(10) Fireworks containing yellow or white phosphorus.

(11) Fireworks or fireworks compositions that ignite spontaneously or undergo marked decomposition when subjected for 48 consecutive hours to a temperature of 75° C. (167° F.).

(12) Fireworks, properly condemned by the Bureau of Explosives, except properly repacked samples for laboratory examinations.

(13) Toy torpedoes, the maximum outside dimension of which exceeds ⅞ inch, or toy torpedoes containing a mixture of potassium chlorate, black antimony and sulfur with an average weight of explosive composition in each torpedo exceeding four grains.

(14) Toy torpedoes containing a cap composed of a mixture of red phosphorus and potassium chlorate exceeding an average of one-half (0.5) grain per cap.

(15) Fireworks containing copper sulfate and a chlorate.

(16) New explosives and explosive devices except as provided for in §173.86.

(17) Loaded firearms.

§ **173.52 Acceptable explosives.** **(a)** For the purposes of this subchapter, acceptable explosives are divided into three classes as follows (acceptable military explosives must be transported on board vessels in accordance with 46 CFR 146.29):

(1) Class A explosives; detonating or otherwise of maximum hazard.

(2) Class B explosives; flammable hazard.

(3) Class C explosives; minimum hazard.

CLASS A EXPLOSIVES; DEFINITIONS

§ **173.53 Definition of class A explosives.** **(a) Type 1.** Solid explosives which can be caused to deflagrate by contact with sparks or flame such as produced by safety fuse or an electric squib, but cannot be detonated (see Note 1) by means of a No. 8 test blasting cap (see Note 2). Example: Black powder and low explosives.

(b) Type 2. Solid explosives which contain a liquid explosive ingredient, and which, when unconfined (see Note 3), can be detonated by means of a No. 8 test blasting cap (see Note 2); or which can be exploded in at least 50 percent of the trials in the Bureau of Explosives' Impact Apparatus (see Note 4) under a drop of 4 inches or more, but cannot be exploded in more than 50 percent of the trials under a drop of less than 4 inches. Example: High explosives, commercial dynamite containing a liquid explosive ingredient.

(c) Type 3. Solid explosives which contain no liquid explosive ingredient and which can be detonated, when unconfined (see Note 3), by means of a No. 8 test blasting cap (see Note 2); or which can be exploded in at least 50 percent of the trials in the Bureau of Explosives' Impact Apparatus (see Note 4) under a drop of 4 inches or more, but cannot be exploded in more than 50 percent of the trials under a drop of less than 4 inches. Example: High explosives, commercial dynamite containing no liquid explosive ingredient, trinitrotoluene, amatol, tetryl, picric acid, urea nitrate, pentolite, and commercial boosters.

(d) Type 4. Solid explosives which can be caused to detonate when unconfined (see Note 3), by contact with sparks or flame such as produced by safety fuse or an electric squib; or which can be exploded in the Bureau of Explosives' Impact Apparatus (see Note 4), in more than 50 percent of the trials under a drop of less than 4 inches. Example: Initiating and priming explosives, lead azide, fulminate of mercury, etc., and high explosives.

(e) Type 5. Desensitized liquid explosives are explosives which may be detonated separately or when absorbed in sterile absorbent cotton, by a No. 8 test blasting cap (see Note 2); but which cannot be exploded in the Bureau of Explosives' Impact Apparatus (see Note 4), by a drop of less than 10 inches. The desensitizer must not be signifi-

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This list represents the membership at the time the committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

Contents

Standard for

Portable Fire Extinguishers

NFPA 10 — 1978

NOTICE: An asterisk (*) preceding the number or letter designating a subsection indicates explanatory material on that section in Appendix A.

Chapter 1 Introduction

*1-1 Scope.

The provisions of this standard apply to the selection, installation, inspection, maintenance and testing of portable extinguishing equipment. The requirements given herein are MINIMUM. Portable extinguishers are intended as a first line of defense to cope with fires of limited size. They are needed even though the property is equipped with automatic sprinklers, standpipe and hose, or other fixed protection equipment (*see 3–1.1, 3–1.4, 3–2.1, 3–2.3*). They do not apply to permanently installed systems for fire extinguishment, even though portions of such systems may be portable (such as hose and nozzles attached to a fixed supply of extinguishing agent).†

*1-2 Purpose.

This standard is prepared for the use and guidance of persons charged with selecting, purchasing, installing, approving, listing, designing, and maintaining portable fire extinguishing equipment. The fire protection requirements of this standard are general in nature and are not intended to abrogate the specific requirements of other NFPA standards for specific occupancies.

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†Fixed systems are covered by the following NFPA standards: NFPA 11, *Foam Extinguishing Systems;* NFPA 11A, *High Expansion Foam Systems;* NFPA 11B, *Synthetic Foam and Combined Agent Systems;* NFPA 12, *Carbon Dioxide Extinguishing Systems;* NFPA 12A, *Halogenated Extinguishing Agent Systems — Halon 1301;* NFPA 12B, *Halogenated Fire Extinguishing Agent Systems — Halon 1211;* NFPA 13, *Installation of Sprinkler Systems;* NFPA 14, *Installation of Standpipe and Hose Systems;* NFPA 15, *Water Spray Fixed Systems;* NFPA 16, *Foam-Water Sprinkler Systems and Foam-Water Spray Systems;* and NFPA 17, *Dry Chemical Extinguishing Systems.* (*See Appendix G.*)

1-3 Definitions.

1-3.1 The basic types of fires are Classes A, B, C, and D as defined in the following subsections.

1-3.1.1 Class A fires are fires in ordinary combustile materials, such as wood, cloth, paper, rubber, and many plastics.

1-3.1.2 Class B fires are fires in flammable liquids, oils, greases, tars, oil base paints, lacquers, and flammable gases.

1-3.1.3 Class C fires are fires which involve energized electrical equipment where the electrical nonconductivity of the extinguishing media is of importance. (When electrical equipment is de-energized, extinguishers for Class A or B fires may be used safely.)

1-3.1.4 Class D fires are fires in combustible metals, such as magnesium, titanium, zirconium, sodium, lithium, and potassium.

1-3.2 Classification and Ratings of Fire Extinguishers.

1-3.2.1 Portable fire extinguishers are classified for use on certain classes of fires and rated for relative extinguishing effectiveness at a temperature of plus 70°F (21.1°C) by nationally recognized testing laboratories. This is based upon the preceding classification of fires and the fire-extinguishment potentials as determined by fire tests.

***1-3.2.2** The classification and rating system described in this standard is that used by Underwriters Laboratories Inc., and Underwriters' Laboratories of Canada and is based on extinguishing preplanned fires of determined size and description as follows:

CLASS A RATING — Wood and excelsior.

CLASS B RATING — Two-in. (5.1 cm) depth n-heptane fires in square pans.

CLASS C RATING — No fire test. Agent must be a nonconductor of electricity.

CLASS D RATING — Special tests on specific combustible metal fires.

1-3.3 Classification of Hazards.

1-3.3.1 Light (Low) Hazard. Where the amount of combustibles or flammable liquids present is such that fires of small size may be expected. These may include offices, schoolrooms, churches, assembly halls, telephone exchanges, etc.

1-3.3.2 Ordinary (Moderate) Hazards. Where the amount of combustibles or flammable liquids present is such that fires of moderate size may be expected. These may include mercantile storage and display, auto showrooms, parking garages, light manufacturing, warehouses not classified as extra hazard, school shop areas, etc.

1-3.3.3 Extra (High) Hazards. Where the amount of combustibles or flammable liquids present is such that fires of severe magnitude may be expected. These may include woodworking, auto repair, aircraft servicing, warehouses with high-piled (over 15 ft [4.51 m] in solid piles, over 12 ft [3.66 m] in piles that contain horizontal channels) combustibles, and processes such as flammable liquid handling, painting, dipping, etc.

1-4 General Requirements.

1-4.1 The classification of extinguishers shall consist of a LETTER which indicates the class of fire on which an extinguisher has been found to be effective, preceded by a rating NUMERAL (Class A and B only) which indicates the relative extinguishing effectiveness.

Exception: Extinguishers classified for use on Class C or D hazards shall not be required to have a numeral preceeding the classification letter.

1-4.2 Portable extinguishers shall be maintained in a fully charged and operable condition, and kept in their designated places at all times when they are not being used.

1-4.3 Extinguishers shall be conspicuously located where they will be readily accessible and immediately available in the event of fire. Preferably they shall be located along normal paths of travel, including exits from an area.

1-4.4 Extinguishers shall not be obstructed or obscured from view.

Exception: In large rooms, and in certain locations where visual obstruction cannot be completely avoided, means shall be provided to indicate the location.

***1-4.5** Extinguishers shall be installed on the hangers or in the brackets supplied, mounted in cabinets, or set on shelves unless the extinguishers are of the wheeled type.

1-4.6 Extinguishers installed under conditions where they are subject to dislodgement shall be installed in brackets specifically designed to cope with this problem.

1-4.7 Extinguishers installed under conditions where they are subject to physical damage, shall be protected from impact.

1-4.8 Extinguishers having a gross weight not exceeding 40 lbs (18.14 kg) shall be installed so that the top of the extinguisher is *not more* than five ft (1.53 m) above the floor. Extinguishers having a gross weight greater than 40 lbs (18.14 kg) (except wheeled types) shall be so installed that the top of the extinguisher is *not more* than 3½ ft (1.07 m) above the floor. In no case shall the clearance between the bottom of the extinguisher and the floor be less than four inch.

1-4.9 Portable extinguishers manufactured after June 1, 1979 shall have only the operating instructions and use-classification(s) on the outward face of the extinguisher. Other labels and markings shall not be placed on the front of the extinguisher.

Exception: The manufacturer's name or brand may appear below the operating instructions and use-classification(s) provided the letter height is not greater than that used for the operating instructions or occupies more than 25 percent of the outward face of the extinguisher.

1-4.10 Extinguishers mounted in cabinets or wall recesses or set on shelves shall be placed in a manner such that the extinguisher operating instructions face outward. The location of such extinguishers shall be marked conspicuously (*see 1-4.4*).

***1-4.11** Water type (water, foam, AFFF, and soda-acid) extinguishers shall not be installed in areas where temperatures are outside the range of 40°F to 120°F (4°C to 49°C). All other types shall not be installed in areas where temperatures are outside the range of −40°F to 120°F (−40°C to 49°C).

Exception 1: When extinguishers are installed in locations subject to temperatures outside these ranges, they should be of a type approved and listed for the temperature to which they are exposed, or they must be placed in an enclosure capable of maintaining the stipulated range of temperatures.

Exception 2: Extinguishers containing plain water only can be protected to temperatures as low as −40°F (−40°C) by the addition of an antifreeze stipulated on the extinguisher nameplate. Calcium chloride solutions shall not be used in stainless steel extinguishers.

Exception 3: Some extinguishers that use nitrogen as an expellant gas rather than carbon dioxide are approved or listed for temperatures as low as −65°F (−54°C).

1-4.12 An extinguisher instruction manual shall be provided to the owner or his agent giving condensed instructions and cautions necessary to the installation, operation, inspection, and maintenance. The manual may be specific to the extinguisher involved or it may cover many types. The manual shall refer to NFPA 10, *Portable Fire Extinguishers*, as a source of detailed instruction (*see Appendix G*).

Chapter 2 Selection of Extinguishers

*2-1 General Requirements.

The selection of extinguishers for a given situation shall be determined by the character of the fires anticipated, the construction and occupancy of the individual property, the vehicle or hazard to be protected, ambient-temperature conditions, and other factors. (*See Table A-2-1, Appendix A.*) The number, size, and placement of extinguishers required shall be determined by using Chapter 3.

2-2 Selection By Hazard.

2-2.1 Extinguishers shall be selected for the specific class or classes of hazards to be protected in accordance with the following subdivisions.

***2-2.1.1** Extinguishers for protecting Class A hazards shall be selected from the following: water, antifreeze, soda-acid, foam, aqueous film forming foam (AFFF), loaded stream, multipurpose dry chemical, and bromochlorodifluoromethane (Halon 1211).

***2-2.1.2** Extinguishers for protection of Class B hazards shall be selected from the following: bromotrifluoromethane (Halon 1301), bromochlorodifluoromethane (Halon 1211), carbon dioxide, dry chemical types, foam, and aqueous film forming foam (AFFF).

***2-2.1.3** Extinguishers for protection of Class C hazards shall be selected from the following: bromotrifluoromethane (Halon 1301), bromochlorodifluoromethane (Halon 1211), carbon dioxide, and dry chemical types.†

***2-2.1.4** Extinguishers and extinguishing agents for the protection of Class D hazards shall be of types approved for use on the specific combustible-metal hazard.

†Carbon dioxide extinguishers equipped with metal horns are not considered safe for use on fires in energized electrical equipment and, therefore, are not classified for use on Class C hazards.

Chapter 3 Distribution of Extinguishers

3-1 General Requirements.

***3-1.1** The minimum number of fire extinguishers needed to protect a property shall be determined as outlined in Chapter 3. Frequently, additional extinguishers may be installed to provide more suitable protection. Extinguishers having ratings less than specified in Tables 3-2.1 and 3-3.1.1 may be installed provided they are not used in fulfilling the minimum protective requirements of this chapter.

***3-1.2** Fire extinguishers shall be provided for the protection of both the building structure, if combustible, and the occupancy hazards contained therein.

3-1.2.1 Required building protection shall be provided by fire extinguishers suitable for Class A fires.

***3-1.2.2** Occupancy hazard protection shall be provided by fire extinguishers suitable for such Class A, B, C, or D fire potentials as may be present.

3-1.2.3 Extinguishers provided for building protection may be considered also for the protection of occupancies having a Class A fire potential.

3-1.2.4 Combustible buildings having an occupancy hazard subject to Class B, and/or Class C fires, shall have a standard complement of Class A fire extinguishers for building protection, plus additional Class B and/or Class C extinguishers. Where fire extinguishers having more than one letter classification (such as 2-A:20-B:C), they may be considered to satisfy the requirements of each letter class.

3-1.3 Rooms or areas shall be classified generally as light (low) hazard, ordinary (moderate) hazard, or extra (high) hazard. Limited areas of greater or lesser hazard shall be protected as required.

3-1.4 The type, size, number, and placement for special storage occupancies is covered by NFPA 231, *Indoor General Storage*, NFPA 231B, *Storage of Cellular Rubber and Plastic Materials*, NFPA 231C, *Rack Storage of Materials*, and NFPA 231D, *Storage of Rubber Tires* (*see Appendix G*).

3-2 Fire Extinguisher Size and Placement for Class A Hazards.

3-2.1 Minimal sizes of fire extinguishers for the listed grades of hazards shall be provided on the basis of Table 3-2.1 except as modified by 3-2.3. Extinguishers shall be located so that the maximum travel distances shall not exceed those specified in Table 3-2.1, except as modified by 3-2.3.

Table 3-2.1

	Light (Low) Hazard Occupancy	Ordinary (Moderate) Hazard Occupancy	Extra (High) Hazard Occupancy
Minimum extinguisher rating	1A	2A	2A
Maximum floor area per unit of A	3000 sq.ft.	1500 sq.ft.	1000 sq.ft.
Maximum floor area per extinguisher	11250 sq.ft.*	11250 sq.ft.*	11250 sq.ft.*
Maximum travel distance to extinguisher	75 ft.	75 ft.	75 ft.

*11250 sq. ft. is considered a practical limit.

NOTE: 1 ft. = 0.305 m
1 sq. ft. = 0.0929 m^2

NOTE: Certain smaller extinguishers which are charged with multipurpose dry chemical or Halon 1211 are rated on Class B and Class C fires, but have insufficient effectiveness to earn the minimum 1-A rating even though they have value in extinguishing smaller Class A fires. They shall not be used to meet the requirements of 3-2.1.

3-2.2 Up to one-half of the complement of extinguishers as specified in Table 3-2.1 may be replaced by uniformly spaced 1½-in. (3.81-cm) hose stations for use by the occupants of the building. When hose stations are so provided they shall conform to NFPA 14, *Installation of Standpipe and Hose Systems* (*see Appendix G*). The location of hose stations and the placement of fire extinguishers shall be in such a manner that the hose stations do not replace more than every other extinguisher.

3-2.3 Where the floor area of a building is less than that specified in Table 3-2.1, at least one extinguisher of the minimum size recommended shall be provided.

3-2.4 The protection requirements may be fulfilled with extinguishers of higher rating provided the travel distance to such larger extinguishers shall not exceed 75 ft (22.7 m).

3-2.5 For Class A extinguishers rated under the rating classification system used prior to 1955, their equivalency shall be in accordance with Table 3-2.5.

Table 3-2.5

All Water & Loaded Stream Types	Pre-1955 Rating	Equivalency
1¼ to 1¾ gal	A-2	1-A
2½ gal	A-1	2-A
4 gal	A-1	3-A
5 gal	A-1	4-A
17 gal	A	10-A
33 gal	A	20-A

NOTE: 1 gal. = 3.785 l

3-3 Fire Extinguisher Size and Placement for Class B Fires Other than for Fires in Flammable Liquids of Appreciable Depth.

3-3.1 Minimal sizes of fire extinguishers for the listed grades of hazard shall be provided on the basis of Table 3-3.1.1. Extinguishers shall be located so that the maximum travel distances shall not exceed those specified in the table used.

Exception: Extinguishers of lesser rating, desired for small specific hazards within the general hazard area, may be used, but shall not be considered as fulfilling any part of the requirements of Table 3-3.1.1.

Table 3-3.1.1

Type of Hazard	Basic Minimum Extinguisher Rating	Maximum Travel Distance to Extinguishers (Ft.)	(m)
Light (low)	5B 10B	30 50	9.15 15.25
Ordinary (moderate)	10B 20B	30 50	9.15 15.25
Extra (high)	40B 80B	30 50	9.15 15.25

NOTE: The specified ratings do not imply that fires of the magnitudes indicated by these ratings will occur, but rather to give the operators more time and agent to handle difficult spill fires that may occur.

3-3.2 Two or more extinguishers of lower rating shall not be used to fulfill the protection requirements of Table 3-3.1.1.

Exception 1: Up to three foam extinguishers of at least 2½ gal (9.46 l) capacity may be used to fulfill light (low) hazard requirements.

Exception 2: Up to three AFFF extinguishers of at least 2½ gal (9.46 l) capacity may be used to fulfill extra hazard (high) requirements.

3-3.3 The protection requirements may be fulfilled with extinguishers of higher ratings provided the travel distance to such larger extinguishers shall not exceed 50 ft (15.25 m).

3-3.4 For Class B extinguishers rated under the rating classification system used prior to 1955, their equivalency shall be in accordance with Table 3-4.5.

3-4 Fire Extinguisher Size and Placement for Class B Fires in Flammable Liquids of Appreciable Depth.†

***3-4.1** Portable fire extinguishers shall not be installed as the sole protection for flammable liquid hazards of appreciable depth (greater than ¼ in. [0.64 cm]) where the surface area exceeds 10 sq ft (0.93 m^2)

Exception: Where personnel who are trained in extinguishing fires in the protected hazards, or its counterpart, are available on the premises, the maximum surface area shall not exceed 20 sq ft (1.86 m^2).

3-4.2 For flammable liquid hazards of appreciable depth such as in dip or quench tanks, a Class B fire extinguisher shall be provided on the basis of at least two numerical units of Class B extinguishing potential per sq ft (0.0929 m^2) of flammable liquid surface of the largest tank hazard within the area.

Exception 1: Where approved automatic fire protection devices or systems have been installed for a flammable liquid hazard, additional portable Class B fire extinguishers may be waived. Where so waived, Class B extinguishers shall be provided as covered in 3-3.1 to protect areas in the vicinity of such protected hazards.

Exception 2: Foam or AFFF type extinguishers may be provided on the basis of 1B of protection per sq ft of hazard.

3-4.3 Two or more extinguishers of lower ratings shall not be used in lieu of the extinguisher required for the largest tank.

†For dip tanks containing flammable or combustible liquids exceeding 150 gal (568 l) liquid capacity or having a liquid surface exceeding four sq ft (0.38 m^2), see NFPA 34, *Dip Tanks (see Appendix G)*, for requirements of automatic extinguishing facilities.

Exception: Up to three foam or AFFF extinguishers of 2½ gal (9.46 l) capacity may be used to fulfill these requirements.

3-4.4 Travel distances for portable extinguishers shall not exceed 50 ft (15.25 m).

3-4.4.1 Scattered or widely separated hazards shall be individually protected. An extinguisher in the proximity of a hazard shall be carefully located so as to be accessible in the presence of a fire without undue danger to the operator.

3-4.5 For Class B extinguishers rated under the rating classification system used prior to June 1, 1969, their equivalency shall be in accordance with Table 3-4.5.

Table 3-4.5 Comparative Ratings

Type and Capacity	Pre-1955	1955 to 1969	June 1, 1969 -
Foam			
2½ gal	B-1	4-B	2-B
5 gal	B-1	6-B	5-B
17 gal	B	10-B	10-B
33 gal	B	20-B	20-B
Carbon Dioxide			
Under 7 lbs.	B-2	1-B	1-B
7 lbs.	B-2	2-B	2-B
10 to 12 lbs.	B-2	4-B	2-B
15 to 20 lbs.	B-1	4-B	2-B
25 to 26 lbs.	B-1	6-B	5-B
50 lbs.	B-1	10-B	10-B
75 lbs.	B-1	12-B	10-B
100 lbs.	B	12-B	10-B
Dry Chemical			
4 to 6¼ lbs.	B-2	4-B	2-B
7½ lbs.	B-2	6-B	5-B
10 to 15 lbs.	B-1	8-B	5-B
20 lbs.	B-1	16-B	10-B
30 lbs.	B-1	20-B	20-B
75 lbs. and up	B	40-B	40-B

NOTE: 1 gal. = 3.785 l 1 lb. = 0.454 kg

NOTE: Vaporizing liquid extinguishers (carbon tetrachloride or chlorobromomethane base) are not recognized in this standard.

3-5 Class B Fire Extinguishers for Pressurized Flammable Liquids and Pressurized Gas Fires.

3-5.1 Fires of this nature are considered to be a special hazard. Class B fire extinguishers containing agents other than dry chemical are relatively ineffective on this type of hazard due to stream and agent characteristics. Selection of extinguishers for this type of hazard shall be made on the basis of recommendations by manufacturers of this specialized equipment. The system used to rate extinguishers on Class B fires (flammable liquids in depth) is not applicable to these types of hazards. It has been determined that special nozzle design and rates of agent application are required to cope with such hazards. Caution: It is undesirable to attempt to extinguish this type of fire unless there is reasonable assurance that the source of fuel can be promptly shut off.

3-5.2 Travel distances for hand portable extinguishers used to protect pressurized flammable liquids or pressurized gas hazards shall not exceed 50 ft (15.25 m).

3-6 Three-dimensional Class B Fires.

3-6.1 A three-dimensional Class B fire involves Class B materials in motion such as pouring, running, or dripping flammable liquids and generally includes vertical as well as one or more horizontal surfaces.

3-6.2 Fires of this nature are considered to be a special hazard. Selection of extinguishers for this type of hazard shall be made on the basis of recommendations by manufacturers of this specialized equipment. The system used to rate extinguishers on Class B fires (flammable liquids in depth) is not directly applicable to this type of hazard. The installation of fixed systems should be considered when applicable.

3-6.3 Travel distances for hand portable extinguishers used to protect three-dimensional, Class B hazards shall not exceed 50 ft (15.25 m).

3-7 Fire Extinguisher Size and Placement for Class C Hazards. Extinguishers with Class C ratings shall be required where energized electrical equipment may be encountered which would require a nonconducting extinguishing media. This will include fire either directly involving or surrounding electrical equipment. Since the fire itself is a Class A or Class B hazard the extinguishers are sized and located on the basis of the anticipated Class A or B hazard.

NOTE: Electrical equipment should be de-energized as soon as possible to prevent reignition.

3-7.1 For extinguishers classified under the system used prior to 1955, the pre-1955 classifications of "C-2," "C-1," and "C" shall be equivalent to the current "C" designation.

Exception 1: Carbon dioxide extinguishers with metallic horns shall not carry any "C" classification.

Exception 2: Vaporizing liquid extinguishers (carbontetrachloride or chlorobromomethane base) are not recognized in this standard.

3-8 Size and Placement for Class D Hazards.

3-8.1 Extinguishers or extinguishing agents with Class D ratings shall be provided for fires involving combustible metals.

3-8.2 Extinguishing equipment shall be located not more than 75 ft (22.7 m) from the Class D hazard.

3-8.3 Size determination shall be on the basis of the specific combustible metal, its physical particle size, area to be covered and recommendations by the extinguisher manufacturer on data from control tests conducted.

Chapter 4 Inspection, Maintenance, and Recharging

4-1 General.

4-1.1 This chapter is concerned with the rules governing inspection, maintenance, and recharging of extinguishers. These factors are of prime importance in ensuring operation at the time of a fire.

4-1.2 The owner or occupant of a property in which extinguishers are located shall be responsible for such inspection, maintenance, and recharging.

4-1.3 Inspection is normally performed by employee personnel designated by the owner or occupant.

***4-1.4** Maintenance and recharging shall be performed by trained persons having available the proper types of tools, recharge materials, lubricants, and manufacturer's recommended replacement parts.

4-2 Definitions.

4-2.1 Inspection. Inspection is a "quick check" that an extinguisher is available and will operate. It is intended to give reasonable assurance that the extinguisher is fully charged and operable. This is done by seeing that it is in its designated place, that it has not been actuated or tampered with, and that there is no obvious or physical damage or condition to prevent operation.

4-2.2 Maintenance. Maintenance is a "thorough check" of the extinguisher. It is intended to give maximum assurance that an extinguisher will operate effectively and safely. It includes a thorough examination and any necessary repair or replacement. It will normally reveal the need for hydrostatic testing.

4-2.3 Recharging. Recharging is the replacement of the extinguishing agent and also includes the expellant for certain types of extinguishers.

4-3 Inspection.

***4-3.1 Frequency.** Extinguishers shall be inspected monthly, or at more frequent intervals when circumstances require.

4-3.2 Procedures.

4-3.2.1 The extinguisher shall be in its designated place.

4-3.2.2 Access to, or visibility of, the extinguisher shall not be obstructed.

4-3.2.3 The operating instructions on the extinguisher nameplate shall be legible and face outward.

4-3.2.4 Any seals or tamper indicators that are broken or missing shall be replaced.

4-3.2.5 For water types without gages, their fullness shall be determined by "hefting."

4-3.2.6 Any obvious physical damage, corrosion, leakage, or clogged nozzles shall be noted.

4-3.2.7 Pressure gage readings when not in the operable range shall be noted.

4-3.3 Corrective Actions. When an inspection reveals that tampering has occurred, or that the extinguisher is damaged, impaired, leaking, under or overcharged, or has obvious corrosion, the extinguisher shall be subjected to applicable maintenance procedures.

4-3.4 Record Keeping.

4-3.4.1 Personnel making inspections shall keep records for those extinguishers that were found to require corrective actions.

4-3.4.2 At least monthly, the date the inspection was performed and the initials of the person performing the inspection shall be recorded.

*4-4 Maintenance.

4-4.1 Frequency. Extinguishers shall be subjected to maintenance not more than one yr. apart or when specifically indicated by an inspection.

Exception 1: It is not necessary during the annual maintenance to internally examine stored pressure extinguishers equipped with pressure indicators or gages except for those types specified in 4-4.1.1. HOWEVER, such extinguishers shall be thoroughly examined externally in accordance with 4-4.2.

Exception 2: Factory sealed ("disposable type") extinguishers shall be inspected and maintained only in accordance with the nameplate instructions.

4-4.1.1 Stored pressure types containing a loaded stream type of agent shall be disassembled on an annual basis and subjected to a complete maintenance. Prior to disassembly the extinguisher shall be fully discharged to check the operation of the discharge valve and pressure gage.

4-4.1.2 Every six yrs., stored pressure extinguishers that require a 12-yr. hydrostatic test shall be emptied and subjected to the applicable maintenance procedures.

Exception 1: Extinguishers having nonrefillable disposable containers are exempt.

Exception 2: When periodic recharging or hydrotesting is performed, the six-yr. requirement shall begin from that date.

4-4.1.3 Extinguishers out of service for maintenance or recharge shall be replaced by spare extinguishers having the same classification and at least equal rating.

*4-4.2 **Procedures.** Maintenance procedures shall include a thorough examination of the three basic elements of an extinguisher:

(a) mechanical parts,

(b) extinguishing agent, and

(c) expelling means.

*4-4.3 **Record Keeping.** Each extinguisher shall have a tag or label securely attached that indicates the month and year the maintenance was performed and shall identify the person performing the service.† The same record tag or label shall indicate if recharging was also performed.

4-4.3.1 For the six-yr. requirement of 4-4.1.1, this information shall be included on the maintenance tag or label. This information shall be transferred to each subsequent maintenance tag or label.

4-4.3.2 Labels indicating inspection, maintenance, hydrostatic retests, and six-yr. maintenance shall not be placed on the front of the extinguisher.

4-5 Recharging.

*4-5.1 **General.** All extinguishers shall be recharged after use or as indicated by an inspection or when performing maintenance. When performing the recharging, the recommendations of the manufacturer shall be followed. For recharge chemicals, see 4-5.3.1.

†Under special circumstances, or when local requirements are in effect, additional information may be desirable or required on record tags.

4-5.2 Frequency.

4-5.2.1 **Annual Recharging.** Every 12 months soda-acid, foam, pump tank water, and pump tank calcium chloride base antifreeze types of extinguishers shall be recharged with new chemicals or water, as applicable.

4-5.3 Procedures.

*4-5.3.1 **Recharge Chemicals.** Only those materials specified on the nameplate, or materials proven to have equal chemical composition and physical characteristics, shall be used. Tests shall be conducted to assure equal performance.

*4-5.3.2 Multipurpose dry chemicals shall not be mixed with alkaline based dry chemicals.

4-5.3.3 Pails or drums containing dry powder agents for scoop or shovel application for use on metal fires shall be kept full and covered at all times. The dry powder shall be replaced if found damp.

4-5.3.4 **Precautionary Pressurization Measures.** The pressure regulator shall be set not to exceed 25 psi (172 kPa) above the operating (service) pressure of the extinguisher.

4-5.3.5 **Conversion of Extinguisher Types.** No extinguisher shall be converted from one type to another, nor shall any extinguisher be converted to use a different type of extinguishing agent.

*4-5.3.6 **Removal of Moisture.** For all nonwater types of extinguishers any moisture shall be removed before recharging.

*4-5.3.7 **Carbon Dioxide Recharging.** The vapor phase of carbon dioxide shall not be less than 99.5 percent carbon dioxide. The water content of the liquid phase shall not be more than 0.01 percent by weight (minus 30°F [minus 34.4°C] dew point). Oil content of the carbon dioxide shall not exceed 10 p.p.m. by weight.

*4-5.3.8 **Leak Test.** After recharging, a leak test shall be performed on stored pressure and self-expelling types.

Chapter 5 Hydrostatic Testing

5-1 General.

5-1.1 Hydrostatic testing shall be performed by persons having a practical knowledge of pressure testing procedures and safeguards, and having available suitable testing equipment and facilities.

5-1.2 If, at any time, an extinguisher shows evidence of corrosion or mechanical injury, it shall be hydrostatically tested, subject to the provisions of 5-1.3 and 5-1.4.

Exception: Pump tanks do not require a hydrostatic test.

5-1.3 Examination of Cylinder Condition. When an extinguisher cylinder or shell has one or more conditions listed in this subdivision, it shall not be hydrostically tested but shall be destroyed by the owner or at his direction:

(a) When there exists repairs by soldering, welding, brazing, or use of patching compounds.

NOTE: For welding or brazing on mild steel shells, consult the manufacturer of the extinguisher.

(b) When the cylinder or shell threads are damaged.

(c) When there exists corrosion that has caused pitting, including under removable nameplate band assemblies.

(d) When the extinguisher has been burned in a fire.

(e) When a calcium chloride type of extinguishing agent was used in a stainless steel extinguisher.

5-1.4 Copper/Brass Soft Solder Shell Construction. Extinguishers having shell construction of copper or brass joined by soft solder (including riveted) shall be removed from service no later than five yrs. from the last hydrostatic test date.[1]

5-2 Definitions.

5-2.1 Service Pressure. The service pressure is the normal operating pressure as indicated on the gage and nameplate.

5-2.2 Factory Test Pressure. The factory test pressure is the pressure at which the shell was tested at time of manufacture. This pressure is shown on the nameplate.

[1] The reliability and safety of this type of construction cannot be determined by standard hydrostatic test methods.

5-2.3 Mild Steel Shell. Except for stainless steel and steel used for compressed gas cylinders, all other steel shells are defined as "mild steel" shells.

5-2.4 Compressed Gas Cylinders. For purposes of this standard, compressed gas cylinders and cartridges are those containing carbon dioxide, nitrogen, or compressed air.

5-2.5 DOT. DOT is the U. S. Department of Transportation, which has jurisdiction over compressed gas cylinders and cartridges as of 1967.

5-2.6 ICC. ICC is the Interstate Commerce Commission, which formerly had jurisdiction over compressed gas cylinders and cartridges prior to 1967.

5-2.7 CTC. CTC is the Canadian Transport Commission, which has jurisdiction over compressed gas cylinders and cartridges.

5-2.8 BTC. BTC is the Board of Transport Commissioners of Canada, which formerly had jurisdiction over compressed gas cylinders and cartridges.

5-3 Frequency.

At intervals not exceeding those specified in Table 5-3, extinguishers shall be hydrostatically tested.

Table 5-3
Hydrostatic Test Interval for Extinguishers

Extinguisher Type	Test Interval (Years)
Soda Acid	5
Cartridge operated Water and/or Antifreeze	5
Stored Pressure Water and/or Antifreeze	5
Wetting Agent	5
Foam	5
AFFF (Aqueous Film Forming Foam)	5
Loaded Stream	5
Dry Chemical with Stainless Steel Shells	5
Carbon Dioxide	5
Dry Chemical, Stored Pressure, with Mild Steel Shells, Brazed Brass Shells, or Aluminum Shells	12
Dry Chemical, Cartridge or Cylinder Operated, with Mild Steel Shells	12
Bromotrifluoromethane — Halon 1301	12
Bromochlorodifluoromethane — Halon 1211	12
Dry Powder, Cartridge or Cylinder Operated, with Mild Steel Shells	12

NOTE 1: All types of extinguishers with copper or brass shells joined by soft solder are prohibited from hydrostatic testing. (*See 5-1.4.*)

NOTE 2: Stored pressure water extinguishers with fiber glass shells (pre-1976) are prohibited from hydrostatic testing due to manufacturer's recall.

Exception 1: Nonrefillable factory-sealed disposable containers do not require hydrostatic testing.

Exception 2: Extinguishers utilizing a cylinder that has DOT or CTC markings shall be hydrostatically tested, or replaced, according to the requirements of DOT or CTC.

Exception 3: For extinguishers not covered in Exceptions 1 and 2 the first retest may be conducted within 12 months of the specified test intervals.

5-3.1 Compressed Gas Cylinders and Cartridges. Nitrogen cylinders or cartridges used for inert gas storage used as an expellant for wheeled extinguishers shall be hydrostatically tested every five yrs.

Exception: Cylinders (except those charged with carbon dioxide) complying with Part 173.34 (e) 15, Title 49, Code of Federal Regulations, may be hydrostatically tested every 10 yrs. (see Appendix G).

5-3.2 Hose Assemblies. A hydrostatic test shall be performed on extinguisher hose assemblies which are equipped with a shutoff nozzle at the end of the hose. The test interval shall be the same as specified for the extingisher on which the hose is installed.

5-4 Test Pressures.

5-4.1 Compressed Gas Cylinders.

5-4.1.1 Carbon dioxide extinguishers shall be tested at 5/3 the service pressure as stamped into the cylinder.

Exception: Carbon dioxide extinguishers having cylinder specification ICC3 shall be tested at 3,000 psi (20,685 kPa).

5-4.1.2 Nitrogen cylinders and carbon dioxide cylinders used with wheeled extinguishers shall be tested at 5/3 the service pressure as stamped into the cylinder.

5-4.2 Stored Pressure Types. All stored pressure and bromochlorodifluoromethane (Halon 1211) types of extinguishers shall be hydrostatically tested at the factory test pressure not to exceed two times the service pressure.

5-4.3 Self-generating and Cartridge Operated Types.

5-4.3.1 Self-generating types (soda acid and foam) of stainless steel construction and cartridge operated water type extinguishers of stainless steel construction shall be hydrostatically tested at 350 psi (2,413 kPa). (For those of copper/brass soft solder shell construction, see 5-1.4.)

5-4.3.2 Cartridge or cylinder operated dry chemical and dry powder types of extinguishers shall be hydrostatically tested at their original factory test pressure as shown on the nameplate or shell.

5-4.4 Test Pressures for Hose Assemblies.

5-4.4.1 Carbon dioxide hose assemblies requiring a hydrostatic pressure test shall be tested at 1,250 psi (8,619 kPa).

5-4.4.2 Dry chemical and dry powder hose assemblies requiring a hydrostatic pressure test shall be tested at 300 psi (2,068 kPa) or at service pressure, whichever is the highest.

5-5 Test Equipment and Procedures.

5-5.1 General.

5-5.1.1 Air or gas pressure shall not be used for pressure testing. The failure of an extinguisher shell may be violent and dangerous.

5-5.1.2 When extinguisher shells, cylinders, or cartridges fail a hydrostatic pressure test, they shall be destroyed by owner or at his direction.

5-5.2 Test Equipment for Compressed Gas Types.

5-5.2.1 The equipment for testing cylinders and cartridges shall be of the water jacket type that meets the specifications of the pamphlet *Methods for Hydrostatic Testing of Compressed Gas Cylinders* (Pamphlet C-1), published by the Compressed Gas Association. (*See Appendix G.*)

5-5.2.2 Hose assemblies of carbon dioxide extinguishers that require a hydrostatic test shall be tested within a protective cage device.

*5-5.3 Test Equipment for Noncompressed Gas Types.

5-5.3.1 The equipment for testing noncompressed gas types consists of the following:

(a) A hydrostatic test pump, hand or power operated, to be capable of producing not less than 150 percent of the test pressure. It is to include appropriate check valves and fittings.

(b) A flexible connection for attachment to the test pump. It shall be provided with necessary fittings to test through the extinguisher nozzle, test bonnet, or hose outlet, as is applicable.

(c) A protective cage or barrier for personnel protection, designed to provide visual observation of the extinguisher under test.

***5-5.3.2** Drying equipment is required to dry all nonwater types of extinguishers that have passed the hydrostatic test.

5-6 Testing Procedures.

5-6.1 Compressed Gas Types.

5-6.1.1 In addition to the visual examinations required prior to test as stated in 5-1.3, an internal examination shall be made prior to the hydrostatic test. The procedures for this internal examination shall be in accordance with the requirements of the *Standard for Visual Inspection of Compressed Gas Cylinders* (CGA C-6), published by the Compressed Gas Association. (*See Appendix G.*)

5-6.1.2 The hydrostatic testing of compressed gas cylinders and cartridges shall be in accordance with the procedures specified in pamphlet *Methods for Hydrostatic Testing of Compressed Gas Cylinders* (Pamphlet C-1), published by the Compressed Gas Association. (*See Appendix G.*)

***5-6.2 Testing Procedures for Noncompressed Gas Types.** The testing procedures for noncompressed gas cylinders and shells and hose assemblies are detailed in Appendix A of this standard.

***5-6.3 Testing Procedures for Hose Assemblies.** The testing procedures for hose assemblies requiring a hydrostatic test are detailed in Appendix A.

5-6.4 Recording of Tests.

5-6.4.1 Compressed Gas Types. For compressed gas cylinders and cartridges passing a hydrostatic test, the month and year shall be stamped into the cylinder in accordance with the requirements set forth by DOT or the Canadian Transport Commission.

NOTE: It is important that the recording (stamping) be placed only on the shoulder, top head, neck, or footring (when so provided) of the cylinder.

***5-6.4.2 Noncompressed Gas Types.** Extinguisher shells of the noncompressed gas types that pass a hydrostatic test shall have the test information recorded on a suitable metallic label or

equally durable material. The label shall be affixed by a heatless process to the shell. These labels shall be self-destructive when removal from an extinguisher shell is attempted. The label shall include the following information:

(a) Month and year the test was performed, indicated by a perforation, such as by a hand punch.

(b) Test pressure used.

(c) Name or initials of person performing the test, or name of agency performing the test.

5-6.4.3 Hose assemblies passing a hydrostatic test do not require recording.

Standard for

Foam Extinguishing Systems

NFPA No. 11 — 1975

1975 Edition of No. 11

The 1975 edition of the Standard on Foam Extinguishing Systems incorporates changes adopted at the 1975 Annual Meeting as recommended by the Committee on Foam.

Origin and Development of No. 11

NFPA committee activity in this field dates from 1921 when the Committee on Manufacturing Risks and Special Hazards prepared standards on foam as a section of the general Standard on Protection of Fire Hazards Incident to the Use of Volatiles in Manufacturing Processes. Subsequently the standards were successively under the jurisdiction of the Committee on Manufacturing Hazards and the Committee on Special Extinguishing Systems, prior to the present committee organization. The present text supersedes the edition of 1974 and prior editions adopted in 1922, 1926, 1931, 1936, 1942, 1950, 1954, 1959, 1960, 1963, 1969, 1970, 1972, and 1973.

Interpretation Procedure of the Committee on Foam

Those desiring an interpretation shall supply the Chairman with five identical copies of a statement in which shall appear specific reference to a single problem, paragraph, or section. Such a statement shall be on the business stationery of the inquirer and shall be duly signed.

When applications involve actual field situations they shall so state and all parties involved shall be named.

The Interpretations Committee will reserve the prerogative to refuse consideration of any application that refers specifically to proprietary items of equipment or devices. Generally inquiries should be confined to interpretation of the literal text or the intent thereof.

Requests for interpretations should be addressed to the National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210.

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Standard for

Foam Extinguishing Systems

NFPA No. 11 — 1975

FOREWORD

Foam for fire protection purposes is an aggregate of air-filled bubbles formed from aqueous solutions and is lower in density than the lightest flammable liquids. It is principally used to form a coherent floating blanket on flammable and combustible liquids lighter than water and prevents or extinguishes fire by excluding air and cooling the fuel. It also prevents reignition by suppressing formation of flammable vapors. It has the property of adhering to surfaces, providing a degree of exposure protection from adjacent fires.

Foam may be used as a fire prevention, control or extinguishment agent for flammable liquid tanks or processing areas. Foam solution for these hazards may be supplied by fixed piped systems or portable foam generating systems. Foam may be applied by foam discharge outlets, which allow it to fall gently on the surface of the burning fuel, or it may be introduced by other means. Foam may also be applied to these hazards by portable hose streams using foam nozzles, portable towers or large capacity monitor nozzles.

Foam may be supplied by overhead piped systems for protection of hazardous occupancies involving potential flammable liquid spills in the proximity of high value equipment, or in large areas. The application of foam for this type of hazard is in the form of a spray or dense "snowstorm." The foam particles coalesce on the surface of the burning fuel after falling from the overhead foam outlets spaced to cover the entire area at a uniform density. For systems required to meet both foam and water design criteria, refer to NFPA No. 16, *Foam Water Sprinkler Systems.*

Large spill fires of flammable liquids can be fought with mobile equipment, such as an airport crash truck or industrial foam truck equipped with agent and equipment capable of generating large volumes of foam at high rates.

Foam for this type of hazard may be delivered as a solid stream or a dispersed pattern. Standards for airport crash trucks may be found in detail in NFPA No. 414.

While other extinguishing agents are also recognized for use on flammable liquid fires, it should be noted that for flammable liquid fires in large storage tanks, only foam has been found to be practical.

Foam does not break down readily, and when applied at an adequate rate, has the ability to extinguish fire progressively. As the application continues, foam flows easily across the burning surface in the form of a tight blanket, preventing re-ignition on the surfaces already extinguished.

Foam may also be used for heat radiation protection. Foam reduces heat transmission to solid surfaces on which it has been applied because of its reflectivity, cooling effect, and insulating characteristic. In the case of certain combustible surfaces these characteristics may prevent ignition.

Asterisks (*) indicate additional information in Appendix in correspondingly numbered paragraphs.

CHAPTER 1.
GENERAL REQUIREMENTS AND INFORMATION

100. Introduction.

1010. PURPOSE: This standard is intended for the use and guidance of those charged with designing, installing, testing, inspecting, approving, listing, operating or maintaining foam fire extinguishing systems, either portable or fixed for interior or exterior hazards.

1020. SCOPE: This standard covers the characteristics of foam-producing materials and the requirements for design, installation, operation and maintenance of equipment and systems. Minimum requirements are covered for flammable and combustible liquid hazards in local areas within buildings, for storage tanks, and for indoor and outdoor processing areas. Methods of testing systems are also included. This standard does not include requirements for synthetic and high expansion foam systems. (See subsection 1133.)

110. Definitions.

1110. FLAMMABLE AND COMBUSTIBLE LIQUIDS.

1111. Flammable Liquids shall mean any liquid having a flashpoint below 100°F (37.8°C) and having a vapor pressure not exceeding 40 lb/sq in. (absolute) at 100°F. Flammable liquids shall be subdivided as follows:

(a) Class I liquids shall include those having flashpoints below 100°F and may be subdivided as follows:

(i) Class IA shall include those having flashpoints below 73°F and having a boiling point below 100°F.

(ii) Class IB shall include those having flashpoints below 73°F and having a boiling point at or above 100°F.

(iii) Class IC shall include those having flashpoints at or above 73°F and below 100°F.

1112. Combustible Liquids shall mean any liquid having a flashpoint at or above 100°F (37.8°C). They may be subdivided as follows:

(a) Class II liquids shall include those having flash-points at or above 100°F and below 140°F.

(b) Class IIIA shall include those having flash-points at or above 140°F (60°C) and below 200°F (93.4°C).

(c) Class IIIB shall include those having flash-points at or above 200°F (93.4°C).

1120. FOAM: Fire-fighting foam within the scope of this standard is a stable aggregation of small bubbles of lower density than oil or water, and shows tenacious qualities for covering and clinging to vertical or horizontal surfaces. It flows freely over a burning liquid surface and forms a tough, air-excluding continuous blanket to seal volatile combustible vapors from access to air. It resists disruption due to wind and draft, or heat and flame attack, and is capable of resealing in case of mechanical rupture. Fire-fighting foams retain these properties for relatively long periods of time.

1121. AIR FOAM or MECHANICAL FOAM is made by mixing air into a water solution containing a foam concentrate by means of suitably designed equipment. One gallon of foam solution will produce about 8 gallons of air foam. This figure is representative of playpipe performance and delivery from fixed air foam makers of the low back pressure type. Foam production from high back pressure type foam makers is 4 gallons of air foam per gallon of solution or less, varying with the back pressure imposed.

1122. CHEMICAL FOAM is made by the reaction of an alkaline salt solution (usually bicarbonate of soda) and an acid salt solution (usually aluminum sulphate) to form a gas (carbon dioxide) in the presence of a foaming agent which causes the gas to be trapped in bubbles to form a tough, fire resistant foam.

NOTE: This type of foam is considered obsolete and has generally been replaced by air foam.

113. AIR FOAM CONCENTRATE. Air foam concentrate is a concentrated liquid foaming agent as received from the manufacturer.

1131. PROTEIN-FOAM CONCENTRATES consist primarily of products from a protein hydrolysate, plus stabilizing additives and inhibitors to protect against freezing, to prevent corrosion of equipment and containers, to resist bacterial decomposition, to control viscosity, and to otherwise assure readiness for use under emergency conditions. They are diluted with water to form 3 percent to 6 percent solutions depending upon the type.

1132. FLUOROPROTEIN-FOAM-CONCENTRATES are very similar to protein-foam concentrates as described above, but with a synthetic fluorinated surfactant additive. In addition to an air-excluding foam blanket, they may also deposit a vaporization preventing film on the surface of a liquid fuel. They are diluted with water to form 3 percent to 6 percent solutions depending on the type.

1133. SYNTHETIC FOAM CONCENTRATES are based on foaming agents other than hydrolysed proteins. They include:

(1) Aqueous Film Forming Foam (AFFF) Concentrates are based on fluorinated surfactants plus foam stabilizers and are diluted with water to a 3 percent or 6 percent solution. The foam formed acts both as a barrier to exclude air or oxygen and to develop an aqueous film on the fuel surface capable of suppressing the evolution of fuel vapors. The foam produced with AFFF concentrate is dry-chemical-compatible and thus is suitable for combined use with dry chemicals. Guidance for use of these materials is given in NFPA No. 11B, *Synthetic Foam and Combined Agent Systems.*

(2) High Expansion Foam Concentrates (usually derived from hydrocarbon surfactant) are used in specially designed equipment to produce foams of foam-to-solution volume ratios of 100:1 to approximately 1000:1. This equipment may be air-aspirating or blower-fan type. Guidance for the use of these materials is given in NFPA No. 11A, *High Expansion Foam Systems.*

(3) Other Synthetic Concentrates are also based on hydrocarbon surface active agents and are listed as wetting agents and/or as foaming agents. In general, their use is limited to portable nozzle application to spill fires within the scope of their listings by nationally recognized laboratories. Guidance for use of the materials is given in NFPA No. 11B, *Synthetic Foam and Combined Agent Systems.*

1134. SPECIAL "ALCOHOL TYPE" FOAM CONCENTRATES form a foam which has an insoluble barrier in the bubble structure which resists breakdown at the interface of the fuel and foam blanket. They are used for fighting fires in water soluble and certain flammable or combustible liquids and solvents which are destructive to regular foams.

1135. COMPATIBILITY OF CONCENTRATES AND THEIR FOAMS. Different types and brands of concentrates may be incompatible and shall not be mixed in storage. Foams generated separately from protein, fluoroprotein and AFFF concentrates, may be compatible to a degree and may be applied to a fire in sequence or simultaneously.

114. FOAM SOLUTION. Foam solution is a homogeneous mixture of water and foam concentrate in the proper proportion.

115. FOAM SOLUTION PROPORTIONING METHOD. Foam solution is produced by continuous introduction of foam concentrate at the recommended ratio to water flow.

116. FOAM SOLUTION PREMIX METHOD. Foam solution is produced by premixing foam concentrate directly into the water in a storage tank.

120. Air Foam.

*121. PROPORTIONING METHODS FOR AIR FOAM SYSTEMS. The methods of proportioning to give the proper solution of water and foam liquid concentrate recognized by this Standard include:

(a) Foam Nozzle Inductor: A suitably designed venturi with "pick-up tube" is included in the foam nozzle construction so that foam liquid concentrate is drawn up through a short length of pipe or flexible tubing connecting the foam nozzle with the container of foam concentrate. The concentrate is thus automatically mixed with the water in recommended proportions.

(b) In-Line Inductor: A venturi inductor is located in the water supply line to the foam maker. This is connected by single or multiple lines to the source of foam concentrate. It is precalibrated and it may be adjustable.

(c) Pump Proportioner: (Around-the-pump proportioner.) The pressure drop between the discharge and suction side of the water pump of the system is used to induct foam concentrate into water by suitable variable or fixed orifices connected to a venturi inductor in a by-pass between the pump suction and the pump discharge.

(d) Metered Proportioning: A separate foam concentrate pump is used to inject foam concentrate into the water stream. Orifices and/or venturis control or measure the proportion of water to foam concentrate. Either manual or automatic adjustment of foam concentrate injection by pressure or flow control may be utilized. Another type of proportioning uses a pump or diaphragm tank to balance the pressure of the water and the concentrate. Variable orifices proportion automatically through a wide range of solution requirements.

(e) Pressure Proportioning Tank: A suitable method is provided for displacing foam concentrate from a closed tank by water (with or without a diaphragm separator), using water flow through a venturi orifice.

(f) Coupled Water-Motor Pump: A suitably designed positive displacement pump in the water supply line is coupled to a second, smaller, positive displacement foam concentrate pump to provide proportioning.

*122. AIR FOAM GENERATING METHODS. The methods of generation of air foam recognized in this standard include:

(a) Foam Nozzles or Fixed Foam Makers: A specially designed hose line nozzle or fixed foam maker designed to aspirate air is connected to a supply of foam solution. They are so constructed that one or several streams of foam solution issue into a space with free access to air. Part of the energy of the liquid is used to aspirate air into the stream and turbulence downstream of this point creates a stable foam capable of being directed to the hazard being protected. Various types of devices may be installed at the end of the nozzle to cause the foam to issue in a wide pattern or a compacted stream.

(b) Pressure Foam Maker (High Back Pressure or Forcing Type): A foam maker utilizing the venturi principle for aspirating air into a stream of foam solution forms foam under pressure. Sufficient velocity energy is conserved in this device so that the resulting foam may be conducted through piping or hoses to the hazard being protected.

(c) Foam Pump: A positive-displacement type pump is connected to a supply of foam solution. Part of the intake of this pump is open to the atmosphere so that when it is operated at the proper speed the air and solution are intimately mixed to form foam under pressure.

123. Storage of Air Foam-Concentrates. In order to insure the correct operation of any foam-producing system, the chemical and physical characteristics of the materials comprising the system are taken into consideration in its design. Since such systems may or may not be operated for long periods after installation, the choice of proper storage conditions and maintenance methods will determine to a large extent the reliability and the degree of excellence of operation of the system when it is called upon to operate.

1231. Foam concentrate may be stored in the containers in which it is transported or it may be transferred to large bulk storage tanks depending on the requirements of the system. These foam concentrates are subject to freezing and deterioration by prolonged storage at high temperatures. For ready use they shall be stored within the listed temperature limitations. The location of stored containers requires special consideration to protect against exterior deterioration due to rusting or other causes. Bulk storage containers also require special design consideration.

130. Chemical Foam. Chemical foam is the oldest form of fire fighting foam (ca. 1903) and is no longer in general use. The excessive maintenance needed to insure reliability and excessive manpower necessary during an emergency have made this type of foam less desirable than air foam.

*131. Chemical Foam Powders. These are dry mixtures of powders used to generate chemical foam by their interaction when mixed with water, at or near the point where the chemical foam is needed. There are three types of chemical foam powders: *Dual powder charges,* where the alkaline salt portion of the chemical foam powder is packed separately from the acidic salt portion of the charge and the containers are marked "A" and "B" powders; *Single powder charges,* where a single blend of all the chemical foam powders needed to produce chemical foam is a single container; *Special "alcohol type" single powder charges,* where a single blend of specially formulated chemical foam powder is packaged for use on fires involving water-miscible solvents such as alcohol, etc. All types are packaged in dry moisture-proof containers. Since chemical foam powders are no longer in general use, replacement materials may not be available from recognized vendors.

132. Chemical Foam Generating Methods. The methods of generation of chemical foam include:

(a) Continuous Foam Generators: An open funnel-shaped container (or dual containers) is positioned at the terminus of a water supply. It is so designed that when dry foam powder (or dual powders) is fed into it the water stream picks up the necessary amount for interaction to produce foam. Some types of continuous generators consist of separate containers for the acid and alkaline salts and the two solutions formed are kept separate until admixture in the system beyond the point of solution in water. The foam formed in either of the above systems is conducted in either piping or hoses to the hazard being protected.

(b) Stored Solution Systems: This is a "wet system" and employs the necessary reacting chemicals as separate water solutions of alkaline salts and acidic salts made and stored in containers separately piped to a central mixing point where foam is generated by their interaction. The resulting foam is piped to the hazard being protected.

*133. Storage of Chemical Foam Materials. Special design and handling are needed when storing chemical foam materials.

140. Use and Limitations of Foams. The uses of foams within the limits of this standard are listed below.

Characteristics and uses of other foams may be found in NFPA No. 11A, *High Expansion Foam Systems,* and NFPA No. 11B, *Synthetic Foam and Combined Agent Systems.*

141. The uses of foam are as follows:

(1) The principal use of foams is the extinguishment of burning liquids lighter than water.

(2) Ignition and fire may be prevented by applying foam blankets to spills or other hazardous areas.

(3) Foams may also be used to insulate and protect exposures from radiant heat. They also act to prevent ignition of open areas of flammable liquids if spread completely over an exposed surface. It is well to remember, however, that foam breakdown can render such a foam protective coating of no value to the fire fighter and frequent renewal may be necessary.

(4) Because of the water content, foams may be used to extinguish surface fires in ordinary combustible materials such as wood, paper, rags, etc.

*142. The limitations of foam are as follows:

(1) Foams are not suitable extinguishing agents for fires involving gases, liquefied gases with boiling points below ambient temperatures such as butane, butadiene, propane, etc., or cryogenic liquids.

(2) Flowing liquid fires, such as overhead tank leakage or pressure leaks, are not readily extinguishable with foams. Other auxiliary agents compatible with foams should be provided in conjunction with foams for fighting fires of this nature.

(3) Foams shall not be used to fight fires in materials which react violently with water, such as metallic sodium and metallic potassium, etc. In certain magnesium fires, foams may be judiciously applied to help restrict burning and cool residual metal.

(4) Foam is a conductor and shall not be used on energized electrical equipment fires.

(5) Judgment must be used in applying foams to hot oils, burning asphalts or burning liquids which are above the boiling point of water. Although the comparatively low water content of foams can beneficially cool such fuels at a slow rate it can also cause violent frothing and "slop-over" of the contents of the tank.

(6) Certain wetting agents and some dry chemical powders may be incompatible with foams. If they are used simultaneously, an instantaneous breakdown of the foam blanket may occur. Precautions must be taken to ensure that such agents are fully compatible with the types of foams being used.

(7) Regular foams are not suitable for water soluble or polar solvent liquids. Special foams designed for these materials are available.

(8) The manufacturer of the concentrate shall be consulted regarding storage life when the concentrate is to be used in a pre-mix solution.

143. Consideration shall be given to potential contamination of water supplies, treating systems, and effluent by foam or solution runoff.

150. Specifications and Plans.

151. The specifications shall designate the authority having jurisdiction and indicate whether submittal of plans is required. They shall state that the installation shall conform to this Standard and meet the approval of the authority having jurisdiction. They shall include the specific tests that will be required to meet the approval of the authority having jurisdiction, and indicate how cost of testing is to be borne.

152. PLANS. Where plans are required, their preparation shall be entrusted only to fully experienced and responsible persons. They shall be submitted for approval to the authority having jurisdiction before foam systems are installed or existing systems modified. These plans shall be drawn to an indicated scale or be suitably dimensioned.

152.1. Plans shall contain or be accompanied by the following information, when applicable, to enable the authority having jurisdiction to evaluate the suitability of the system:

(a) Physical details of the hazard including the location, arrangement, and hazardous materials involved.

(b) Type and percentage of foam concentrate.

(c) Required solution application rate.

(d) Water requirements.

(e) Calculations showing required amount of concentrate.

(f) Hydraulic calculations. (See Chapter 7 of NFPA No. 13, *Installation of Sprinkler Systems*, for hydraulic calculation procedures.)

(g) Identification and capacity of all equipment and devices.

(h) Location of piping, detection devices, operating devices, generators, discharge outlets, and auxiliary equipment.

(i) Schematic wiring diagram.

(j) Explanation of any special features.

153. Where field conditions necessitate any significant change from the approved plan, corrected "as in-

stalled" plans shall be supplied for approval to the authority having jurisdiction.

160. Water Supplies.

161. QUALITY. The water supply to foam systems may be hard or soft, fresh or salt, but shall be of suitable quality so that adverse effects on foam formation or foam stability does not occur. No corrosion inhibitors, emulsion breaking chemicals or any other additives shall be used without prior consultation with the foam concentrate supplier.

162. QUANTITY. The water supply shall be adequate in quantity to supply all the devices that may be used simultaneously. This includes not only the volume required for the foam apparatus but also water which may be used in other fire fighting operations, in addition to the normal plant requirements.

163. PRESSURE. The pressure available at the inlet to the foam system (foam generator, air foam maker, etc.) under required flow conditions shall be at least the minimum pressure for which the system has been designed.

164. TEMPERATURE. Optimum foam production is obtained using water at temperature between 40°F and 100°F. Higher or lower water temperatures may reduce foam efficiency.

***165.** SYSTEM DESIGN. The water system shall be designed and installed in accordance with recognized standards for such extinguishing systems. Where solids of sufficient size to obstruct openings in the foam equipment may be present strainers shall be provided. Hydrants furnishing the water supply for portable foam equipment shall be provided in sufficient number and be located as required by the authority having jurisdiction.

170. Air Foam System Design.

171. AIR FOAM GENERATING AND PROPORTIONING SYSTEM DESIGN. Suitable approved equipment of the type described earlier in this standard shall be furnished in size and type in accordance with the detailed foam application requirements for the hazard to be protected as required by the authority having jurisdiction. This equipment shall include the necessary prime movers, foam concentrate proportioners and storage tanks, foam generators and foam piping and discharge devices.

1711. Foam systems shall be designed so that all components having moving parts can be periodically tested without discharging foam onto the hazard.

1721. DISCHARGE OUTLETS. Discharge outlets shall be designed and located to permit the distribution of the foam over the area to be protected. Discharge outlets may be in combination with mixing devices or may be separate devices.

173. SYSTEM PIPING.

1731. PIPE MATERIALS. Pipe within the hazard area shall be steel, suitable for the pressure involved, but not less than standard weight, in accordance with current American Standards. Pipe specifications normal for water use shall be permitted outside the hazard area.

1732. VALVES. All valves shall be listed for fire protection use. Readily accessible drain valves shall be provided for low points in underground and aboveground piping. Valve specifications normal for water use shall be permitted outside the hazard or diked area. Automatic control valves, shutoff valves and strainers of approved types may be cast iron if outside the fire area, but shall be steel if within the fire area.

1733. FITTINGS. All pipe fittings shall be American Standard for the pressure class involved but not less than 125 lb standard. Iron fittings shall be malleable in dry sections of the piping exposed to possible fire. All fittings subject to stress in self-supporting systems shall be steel or malleable iron.

1734. INSTALLATION. Piping shall be so arranged as to reduce friction to a reasonable minimum. All piping shall be securely supported. All foam distribution piping shall be arranged to drain and shall have a pitch toward drain of ½ inch in each 10 feet. Foam system piping shall be normally empty and where exposed to corrosive influences it shall be protected against corrosion.

1735. PIPE SIZES. Since effective protection depends on having an adequate volume of water (or solutions) at

proper pressure, available at the foam-making devices, each system requires individual consideration as to the size of the piping. The water pressure of the inlet to air foam makers should preferably be not less than 50 psig. Operation is, however, possible with water pressure as low as 30 psig. Friction losses in pipe and fittings carrying water or foam solutions shall be determined by the Hazen and Williams formula using a value of 120 for "c". Pipe sizes shall be so selected as to produce the proper delivery rate and pressure at the discharge outlet. (See Chapter 7 of NFPA No. 13, *Installation of Sprinkler Systems,* for hydraulic calculation procedures.) For friction losses in piping carrying foam, see A-3561.

1736. Flushing After Installation. Water supply mains, both underground and aboveground, shall be flushed thoroughly at the maximum practicable rate of flow, before connection is made to system piping, in order to remove foreign materials which may have entered during installation. The minimum rate of flow for flushing shall not be less than the water demand rate of the system, as determined by the system design and the available water supply. The flow shall be continued for a sufficient time to insure thorough cleaning. Disposal of flushing water must be suitably arranged. All foam system piping shall be flushed after installation, using its normal water supply with foam-forming materials shut off, unless the hazard cannot be subjected to water flow. Where flushing cannot be accomplished, cleanliness of pipe interiors shall be carefully examined visually during installation.

1737. Flushing After Use. Provision shall be made in the design to permit flushing of normally empty foam concentrate and solution piping with clean water after use.

174. Storage of Foam Concentrate Equipment.

1741. Storage Facilities. Storage of foam concentrates and equipment shall be in an accessible location not exposed by the hazard they protect. If housed, they shall be in a noncombustible structure.

1742. Reserve Supply of Foam Concentrate. There shall be a readily available reserve supply of foam-producing materials sufficient to meet design requirements in order to put the system back into service after operation. This supply may be in separate tanks or compartments, in drums or cans on the premises, or available from an approved outside source within 24 hours.

1743. Off-Premises Storage. For outdoor nonautomatic systems, the authority having jurisdiction may permit the storage of foam-concentrate off the premises where these supplies are available at all times. Adequate loading and transportation facilities must be assured. Off-premises supplies shall be of the proper type for use in the systems of the given installation. At the time of a fire these off-premises supplies shall be accumulated in sufficient quantities, before placing the equipment in operation, to ensure uninterrupted foam production at the design rate for the required period of time.

***180. Acceptance Tests.** The completed system shall be inspected and tested by qualified personnel to determine that it is properly installed and will function as intended.

181. Inspection and Visual Examination. Foam systems shall be examined visually to determine that they have been properly installed. They shall be inspected for such items as conformity with installation plans, continuity of piping, removal of temporary blinds, accessibility of valves, controls and gages, and proper installation of vapor seals, where applicable. Devices shall be checked for proper identification and operating instructions.

182. Pressure Tests. All piping, except that handling expanded foam for other than subsurface application, shall be subjected to a two-hour hydrostatic pressure test at 200 psig or 50 psi, in excess of the maximum pressure anticipated, whichever is greater, in general conformity with NFPA No. 13, *Installation of Sprinkler Systems.* All normally dry horizontal piping shall be inspected for drainage pitch.

183. Operating Tests. Before acceptance, all operating devices and equipment shall be tested for proper function.

184. Discharge Tests. Where conditions permit, flow tests shall be conducted to ensure that the hazard is fully protected in conformance with the design specification, and to determine the flow pressures, actual discharge capacity, consumption rate of foam-producing materials, man-

power requirements and other operating characteristics. The foam discharged shall be visually inspected to ensure that it is satisfactory for the purpose intended.

185. SYSTEM RESTORATION. After completion of acceptance tests the system shall be flushed and restored to operational condition.

190. Periodic Inspection, Testing and Maintenance. All systems shall be thoroughly inspected by a competent inspector at regular intervals, at least annually, to ensure that they will remain in full operating condition. Regular service contracts with the manufacturer or installer are generally available.

191. FOAM-PRODUCING EQUIPMENT. Proportioning devices, their accessory equipment and foam-makers shall be inspected.

192. PIPING. Aboveground piping shall be examined to determine its condition and that proper drainage pitch is maintained. Pressure tests of normally dry piping shall be made when visual inspection indicates questionable strength due to corrosion or mechanical damage. Underground piping shall be spot checked for deterioration at least every five years.

193. STRAINERS. Strainers shall be inspected and cleaned after each use and flow test.

194. DETECTION AND ACTUATION EQUIPMENT. Control valves including all automatic and manual actuating devices shall be tested at regular intervals.

195. AIR FOAM CONCENTRATES. Periodic inspection shall be made of air foam concentrates and their tanks or storage containers for evidence of excessive sludging or deterioration. Samples of concentrates should be referred to the manufacturer or qualified laboratory for quality condition testing. Quantity of concentrate in storage shall meet design requirements.

196. OPERATING INSTRUCTIONS AND TRAINING. Operating and maintenance instructions and layouts shall be posted at control equipment and at fire headquarters. All persons who may be expected to inspect, test, maintain, or operate foam generating apparatus shall be thoroughly trained and kept thoroughly trained in the functions they are expected to perform.

CHAPTER 2. FIXED FOAM EXTINGUISHING SYSTEMS FOR INDOOR FLAMMABLE LIQUID HAZARDS

200. General.

201. Scope and Application.

2011. This section relates to foam fire extinguishing systems which are intended as the primary protection for specific hazards located in rooms and buildings, or general protection for the contents of the room or building and may or may not include the structure.

2012. These systems are particularly applicable to the indoor storage and handling of flammable liquids having a flash point below 140°F. and heated combustible liquids. Typical applications would be in storage areas, areas subject to large spills, process equipment, pump rooms, open tanks, such as dip tanks, quench tanks, mixing tanks, etc., which may be found in chemical plants, solvent extraction plants, distillation plants, and refineries.

2013. This section does not cover foam-water sprinkler or foam-water spray systems (see NFPA No. 16) or high expansion foam systems (see NFPA No. 11A).

202. Definitions.

2021. SPRAY FOAM SYSTEM: A spray foam system is a special system, pipe-connected to a source of foam producing solution and is equipped with spray nozzles for foam discharge and distribution over the area to be protected.

2022. DISCHARGE DEVICES: Discharge devices generally fall into two categories; those producing foam in a spray or dispersed pattern, and those producing foam in a compact low velocity stream.

(a) Devices which discharge foam in a spray pattern terminate in a deflector or screen which dispenses the foam.

(b) Devices which discharge foam as a compact low velocity stream may or may not have deflectors or stream directors included as an integral part of the device. These devices may take such forms as open pipe fittings, directional flow nozzles, or small foam-making chambers with open outlets.

(c) These discharge devices in approved forms are available in a number of patterns with variations in discharge capacity. Such devices may or may not have the foam maker included as an integral part.

203. Limitations.

Note: For general limitations see 140.

2031. Foams should not be used on water soluble solvents in depth exceeding one inch, through spray foam discharge devices. Alcohol type foams can be used when the system is specially designed for this application and approved by the authority having jurisdiction.

204. Foam Quality.

2041. Foam delivered from spray foam systems shall quickly form a cohesive foam blanket and spread rapidly around obstructions. Foams discharged from such systems, and meeting these requirements, have exhibited "expansions" ranging from 4 to 8; and "25 percent drainage time" values, ranging from 0.30 minute to 1 minute.

2042. Foam discharge from devices producing a compact low velocity stream shall have characteristics within the limits shown in Fig. A-601G.

210. System Description.

211. A system consists of detection devices, an adequate water supply, supply of foam producing materials, suitable proportioning equipment, a proper piping system, foam makers, and discharge devices designed to adequately distribute the foam over the hazard.

2111. These systems are of the open outlet deluge type in which foam discharges from all outlets at the same time, covering the entire hazard within the confines of the system.

2112. Self-contained systems are those in which all components and ingredients, including water, are contained within the systems. Such systems usually have a water supply tank that is pressurized by air or compressed gas, and the release of this pressure into the system puts it in operation. These systems may also be pressurized by the chemical reaction of solutions that are mixed at the time of system operation.

212. Automatic Operation.

2121. In an automatic system there are fire detection devices which may be any of a number of listed detectors. These detectors usually activate the system by operating the water control valve or other actuating device. All other equipment is so interconnected that it is also activated so that properly mixed foam solution is supplied to the foam makers and foam distributed over the hazard.

2122. Automatic detection equipment, whether pneumatic, hydraulic or electric, shall be provided with complete supervision so arranged that failure of equipment or loss of supervising air pressure or loss of electric energy will result in positive notification of the abnormal condition. Small systems for localized hazards may be unsupervised subject to approval of the authority having jurisdiction.

2123. Automatic detection equipment of electric type and any auxiliary equipment of electric type, if in hazardous areas,* shall be expressly designed for use in such areas.

2124. In some special cases it may be desirable to arrange the system to shut off automatically after a predetermined operating time. This feature would be subject to approval of the authorities having jurisdiction.

220. System Design.

221. These systems shall be designed for automatic operation, supplemented by auxiliary manual tripping means.

222. In systems designed for general area protection of rooms or buildings where spray foam devices are used, the discharge outlets should generally be located as high as possible in the area, and spaced in accordance with their discharge patterns so that the system covers the entire protected area.

2221. When floor type outlets are used, they should be located and spaced so the foam will flow as rapidly as possible over the area.

223. Open tanks of flammable liquids may be protected by "tank side" nozzles discharging foam at low velocity directly on the liquid surfaces, or by means of "foam spray" nozzles mounted above the tank.

224. Protection for specific pieces of equipment may be

*See *National Electrical Code* (NFPA No. 70), Article 500 and other Articles in Chapter 5, thereof.

provided by overhead application or by directional discharge devices directed at the equipment. Where the basic objective of the system is extinguishing a spill fire on the floor, enveloping the equipment in the foam discharge has the added advantage of providing an insulating effect to protect the equipment from heat exposure while the fire is being extinguished.

2241. There should be a minimum of one (1) discharge outlet per 100 square feet of protected area unless listing of discharge devices indicates a larger spacing is permitted. These outlets should be located so as to provide good distribution throughout the protected area. However, an added advantage is gained by locating the outlets so that foam discharge envelops the equipment within the protected area. These outlets are located in plan and elevation to provide the most effective protection of the hazard.

225. In some hazard arrangements it may be desirable to design systems utilizing combinations of the system designs described in 2220, 2230, and 2240.

226. Where air-foam concentrate lines to the protective-system injection points are run underground or where they run aboveground for more than 50 feet, air-foam liquid concentrate in these lines shall be maintained under pressure to assure prompt foam application and to provide a means of checking on the tightness of the system.

Pressure may be maintained by a small auxiliary pump, or by other suitable means.

227. Equipment items, such as storage tanks, proportioners, pumps, and control valves shall be installed where they will be accessible, especially during a fire emergency in the protected area and where there will be no exposure from the protected hazard. Automatically controlled valves shall be as close to the hazard protected as accessibility permits so that a minimum of piping is required between the automatic-control valve and the discharge devices. Consideration should be given to provisions of remotely located post-indicator or other shut-off valves to permit system water-supply control under abnormal conditions.

228. **Size of System.** Systems may be used to protect one or more hazards or groups of hazards using the same supply of foam concentrate and water.

2281. The size of a single system should be kept as small as practicable, giving consideration to water supplies and other factors affecting the reliability of the protection.

Where, in the opinion of the authority having jurisdiction, two or more hazards may be simultaneously involved in fire by reason of their proximity, each hazard shall be protected with an individual system or the system shall be arranged to discharge on all potentially involved hazards simultaneously.

230. Rate of Application.

231. For Liquid Hydrocarbons.

2311. For area protection, the discharge of foam outlets shall provide a solution rate of at least 0.16 gpm per square foot of the area protected.

2312. Where there are intervening horizontal surfaces that would collect foam, such as large tanks, mezzanines or decks, etc., these should be taken into consideration in arriving at the design discharge rate.

2313. Where open top tanks are protected by discharge outlets located on the tank, the rate of application shall be 0.16 gpm per square foot of liquid surface.

2314. When small open tanks are protected by spray foam system, close attention must be given to the percentage of the system discharge which actually enters the tank, to assure that the required application rate is being achieved.

232. Water soluble and certain flammable and combustible liquids and polar solvents which are destructive to regular foams require the use of "alcohol" type foams. Systems using these foams require special engineering consideration and may require that higher application rates be used. In all cases, the manufacturer of the foam concentrate and the foam-making equipment should be consulted as to the limitations and for recommendations based on listings or specific fire tests.

240. Operating Time.

241. For Area Protection.

2411. The duration of foam discharge shall be a minimum of 10 minutes. When a system has been designed to have a delivery rate higher than that specified under 230, a proportionate reduction in the discharge time may be made except that it shall not be less than seven minutes.

242. For Tanks of Less Than 400 Square Feet Liquid Surface.

2421. For overhead spray foam discharge outlets, the duration of foam discharge shall be a minimum of 5 minutes.

2422. For tank mounted foam discharge outlets, the duration of foam discharge shall be a minimum of 3 minutes.

2423. Where the normal freeboard is such that if the discharge time would cause a significant quantity of foam to overflow and be wasted, the authority having jurisdiction should be consulted.

2424. Suitable overflow facilities should be provided to maintain a constant freeboard of not less than 2 inches, or 4 inches for tanks of more than 25 square feet in area (see NFPA No. 34, *Dip Tanks*).

243. For tanks of 400 square feet and larger liquid surface area, apply the operating time rules for outdoor tanks.

250. Supply of Foam Producing Materials.

251. Total supply of foam-producing materials shall be the sum of the quantities defined in 252 and 253.

252. There shall be a quantity of foam producing materials sufficient to supply the system in accordance with 230 and 240.

253. Reserve Supply. There shall be a reserve supply of foam-producing materials in accordance with 326.

260. System Piping.

261. System piping shall be hydraulically calculated and sized in order to obtain reasonably uniform foam distribution and to allow for loss of head in water supply piping. Adjustment in pipe sizes to provide uniform discharge should be based on a maximum variation of 15 percent from the assumed average discharge per discharge device provided that the total system design delivers the design application rate. Hydraulic calculations shall be made in accordance with the applicable paragraphs of NFPA No. 16, *Foam-Water Sprinkler and Spray Systems.*

2611. Pipes shall be securely supported and where protecting hazards in rooms where explosions are possible, pipes should be hung from other supports than the roof so that if the roof lifts, the piping will not be broken or disarranged.

2612. Foam distribution piping shall be arranged to drain and should have a pitch toward drain ½ in. in 10 feet.

2613. Hangers: All hangers must be of approved types. Tapping or drilling of load bearing structural members should not be generally permitted. Attachments may be made to existing steel or concrete structures and equipment supports. Where systems are of such a nature that the standard method of supporting pipe for protection purposes cannot be used, the piping shall be supported in such a manner as to produce the strength equivalent to that afforded by such standard means of support.

2614. Installation: The installation standards for foam system piping shall be the applicable sections of the NFPA *Standard for the Installation of Sprinkler Systems* (No. 13) except as herein modified. Welding in accordance with ANSI Code for Pressure Piping is permissible when it can be done without introducing fire hazards. Special care should be taken to insure that the openings are fully cut out and that no obstructions remain in the waterway. The supply piping to foam outlets which protect a hazard in a fire area shall not pass over another hazard in the same fire area.

270. Alarms.

271. A local alarm, actuated independently of water flow, to indicate operation of the automatic detection equipment shall be provided on each system. Central station or proprietary station water-flow alarm service is desirable but provision of this service does not necessarily waive the local-alarm requirement.

272. Outdoor water-motor or electric-alarm gongs, responsive to system water flow, may be required by the authority having jurisdiction.

273. Under conditions where central station or proprietary station water-flow alarm service is not available, it may be advisable to connect electrical alarm units to public Fire Department Headquarters or nearest Fire Department Station or other suitable place where aid may be readily secured.*

*See the NFPA Standards on *Central Station Signaling Systems* (No. 71), on *Local Protective Signaling Systems* (No. 72A), on *Auxiliary Protective Signaling Systems* (No. 72B), on *Remote Station Protective Signaling Systems* (No. 72C), and on *Proprietary Protective Signaling Systems* (No. 72D).

274. A suitable trouble alarm shall be provided for each system to indicate failure of automatic detection equipment (including electric supervisory circuits) or other such devices or equipment upon which the system operation is dependent.

280. Plans and Specifications.

281. The designing and installation of these systems should be entrusted to only fully experienced and responsible persons. Before such systems are installed, complete working plans and specifications shall be submitted for approval to the authority having jurisdiction. Working plans shall be drawn to scale, show all essential details, and be so made that they can be easily reproduced to provide the necessary copies. Information required includes the design purpose of the system; discharge densities and period of discharge; hydraulic calculations; details of tests of available water supply; detailed layout of the piping and of the heat-responsive operating equipment; type of discharge devices to be installed; location and spacing of discharge devices; pipe-hanger installation details; location of draft curtains; an accurate and complete layout of the buildings or hazards to be protected; and other pertinent data to provide a clear explanation of the proposed design.

2811. In addition to the items listed in 2810, plans and specifications shall indicate the quantity and type of air foam producing material to be stored, including the quantity in reserve; and the concentration designation, such as 3 percent or 6 percent.

282. The specifications shall include the specific tests that may be required to meet the approval of the authority having jurisdiction and should indicate how costs of preparing the area, testing, and cleanup is to be borne.

283. Complete plans and detailed data describing pumps, drivers, controllers, power supply, fittings, suction and discharge connections, and suction conditions shall be submitted by the engineer or contractor to the authority having jurisdiction for approval before installation.

2831. Charts showing head, delivery, efficiency and brake horsepower curves of pumps shall be furnished by the contractor.

2832. Controllers governing the starting of electric driven concentrate pumps shall be of approved types. Where control equipment listed by a nationally recognized testing laboratory for fire-protection service is not available, suitable listed industrial-control equipment with adequate interrupting capacity in accordance with NFPA *Standard for the Installation of Centrifugal Fire Pumps* (No. 20) may be used.

CHAPTER 3.

FIXED SYSTEMS FOR EXTERIOR STORAGE TANKS

*300. General.

301. SCOPE: This chapter contains requirements which apply specifically to the several types of foam systems used for the protection of outdoor atmospheric storage tanks containing flammable and combustible liquids by means of fixed foam discharge outlets. System design shall be based on the maximum solution flow for protecting a single tank.

NOTE: Tanks containing Class III liquids are not, as a rule, required to be protected by foam. Foam protection for Class III liquids may be desirable where abnormal situations exist, such as storage of high value stocks or liquids heated above their flash point.

*302. DEFINITIONS:

(a) FIXED FOAM DISCHARGE OUTLET: A device permanently attached to a tank by means of which foam is introduced into the tank.

(b) TYPE I. DISCHARGE OUTLET: An approved discharge outlet which will conduct and deliver foam gently onto the liquid surface without submergence of the foam or agitation of the surface.

(c) TYPE II. DISCHARGE OUTLET: An approved discharge outlet which does not deliver foam gently onto the liquid surface but is designed to lessen submergence of the foam and agitation of the surface.

(d) SUBSURFACE FOAM INJECTION: Discharge of foam into a storage tank from an outlet at the tank bottom or below the liquid surface.

(e) FIXED INSTALLATIONS: These are complete installations piped from a central foam house to the tanks, discharging through fixed delivery outlets on the tanks. Any required pumps are permanently installed.

(f) SEMI-FIXED INSTALLATIONS:

(1) The type in which tanks are equipped with fixed discharge outlets connected to piping which terminates at a safe distance from the tanks. The fixed piping installation may or may not include a foam maker. Necessary foam-producing materials are transported to the scene after the fire starts and are connected to the piping.

(2) The type in which foam-producing solutions are piped from a central foam house through the area, the solution being delivered through hose lines to portable foam towers which are erected after the fire starts (Chapter 4); or applied by hose streams (Chapter 5).

310. Foam Application.

311. RATES: The minimum delivery rate shall be as follows:

3110. TO TANKS CONTAINING LIQUID HYDROCARBONS:

(a) For air foam systems, the foam solution delivery rate shall be at least 0.1 gpm/sq. ft. of liquid surface area of the tank to be protected.

(b) For dry powder chemical foam generator systems the water rate to the generators shall be at least 0.1 gpm/sq. ft. of liquid surface area of the tank to be protected.

(c) For chemical foam systems with stored solutions, delivery rate shall be at least 0.05 gpm of "A" solution and 0.05 gpm of the "B" solution for each square foot of liquid surface of the tank to be protected.

NOTE 1: Flammable liquids having a boiling point of less than 100° F may require higher rates of application. Suitable rates of application should be determined by test.

NOTE 2: For high viscosity liquids heated above 200° F, lower initial rates of application may be desirable to minimize frothing and expulsion of the stored liquid. Judgment must be used in applying foams to tanks containing hot oils, burning asphalts or burning liquids which are above the boiling point of water. Although the comparatively low water content of foams can beneficially cool such liquids at a slow rate, it can also cause violent frothing and "slop over" of the contents of the tanks.

*3111. TO TANKS CONTAINING OTHER FLAMMABLE AND COMBUSTIBLE LIQUIDS REQUIRING SPECIAL FOAMS: Water soluble and certain flammable and combustible liquids and polar solvents which are destructive to regular foams require the use of "alcohol" type foams. Systems using these foams require special engineering consideration. Conditions other than routine may require that higher application rates be used. In all cases, the manufacturer of the foam concentrate and the foam-making equipment should be consulted as to the limitations and for recommendations based on listings or specific fire tests. The following are minimum recommended application rates:

TYPE OF LIQUID	SOLUTION RATE gpm/sq. ft.
Methyl and ethyl alcohol	0.1
Acrylonitrile	0.1
Ethyl acetate	0.1
Methyl ethyl ketone	0.1
Acetone	0.15
Butyl alcohol	0.15
Isopropyl ether	0.15

Products such as isopropyl alcohol, methyl isobutyl ketone, methyl methacrylate monomer, and mixtures of polar solvents in general may require higher application rates. Protection of products such as amines and anhydrides, which are particularly foam destructive, require special consideration.

NOTE 1: The solvent and fire resistance of "alcohol" type air foam may be adversely affected by such factors as excessive solution transit time, the use of foam-making devices not specifically designed or adequately tested for a particular "Alcohol" foam application, operating pressure, failure to maintain proportioning within the recommended concentration limits, the method of application and the characteristics of the particular solvent to which the foam is to be applied.

Solution transit time, that is the elapsed time between injection of the foam concentrate into water and the induction of air, may be limited, depending on the characteristics of the foam concentrate, the water temperature, and the nature of the hazard protected. The maximum solution transit time of each specific installation shall be within the limits established by the manufacturer.

NOTE 2: For protection of combustible or flammable liquids which are highly toxic, high application rates may be desirable to reduce respiratory hazard to personnel by providing for more rapid coverage of the tank contents.

320. Supply of Foam-Producing Materials.

*321. GENERAL: Supplies to be maintained shall be the sum of the quantities defined in 323, 324, 325 and 326.

322. MINIMUM DISCHARGE TIMES: The system shall be capable of operation at the delivery rate specified in 311, for the tank to be protected, for the following minimum periods of time. If the apparatus available has a delivery rate higher than specified in 311, proportionate reduction in the time figures may be made, except that they shall not

be less than 70 percent of the minimum discharge times shown.

FOR TANKS CONTAINING LIQUID HYDROCARBONS	TYPE OF FOAM DISCHARGE OUTLET TYPE I	TYPE II
Lubricating oils; dry viscous residuum (more than 50 seconds Saybolt-Fural at 122 F); dry fuel oils, etc., with flash point above 200°F	15 min.	25 min.
Kerosene; light furnace oils, diesel fuels, etc. with flash point from 100°F to 200°F	20 min.	30 min.
Gasoline; naphtha, benzol and similar liquids with flash point below 100°F	30 min.	55 min.
Crude petroleum	30 min.	55 min.

REQUIRING SPECIAL FOAMS
FOR TANKS CONTAINING OTHER FLAMMABLE AND COMBUSTIBLE LIQUIDS

"Alcohol" type foams require gentle application by Type I devices unless listed as suitable for application by Type II devices. The operation time shall be 30 minutes at the specified application rate, unless the manufacturer of the foam concentrate has established by fire test that a shorter time can be permitted.

3221. DRY POWDER CHEMICAL FOAM GENERATOR CONSUMPTION RATES: For the purpose of the above tables, it shall be assumed that dry powder generators (dual or single powder type) consume 1.25 lbs. of powder per gallon of water. Where "listings" of dry powder generators and powder by nationally recognized testing laboratories show powder consumption less than 1.25 lbs. per gallon of water, such lower figure may be used when the generator is used in the manner on which the listing was based.

323. REQUIREMENTS FOR TANKS: The quantity of foam-producing material shall be determined by multiplying the total flow in gallons per minute for each tank by the appropriate time in 322. The largest resulting value shall determine the quantity required.

*324. SUPPLEMENTARY FOAM HOSE STREAM REQUIREMENTS: Approved foam hose stream equipment shall be provided in addition to tank foam installations as supplementary protection for small spill fires. The minimum number of fixed or portable hose streams required shall be as specified in the following table, and shall be conveniently located to provide protection of the area. For the purpose of this requirement, the equipment for producing each foam hose stream shall have a solution rate of at least 50 gpm.

Hose stream delivery quantities shall be in addition to quantities required for tank areas. Additional foam-producing materials shall be provided to permit operation of the hose stream equipment simultaneous with tank foam installations specified for the period set forth in the following table:

Diameter of largest tank	Minimum number of hose streams required	time* Minimum operating
up to 35 ft.	1	10 min.
over 35 to 65 ft.	1	20 min.
over 65 to 95 ft.	2	20 min.
over 95 to 120 ft.	2	30 min.
over 120 ft.	3	30 min.

*Based on simultaneous operation of the minimum number of 50 gpm hose streams required. Adjustments may be made where streams of greater capacity are provided.

NOTE: In the case of alcohol type air foam solution transit time limitations may require the use of separate water and foam concentrate lines and that the introduction of the foam liquid concentrate be accomplished close to the foam nozzle rather than in the central foam house.

325. REQUIREMENTS TO FILL PIPE LINE: A quantity of foam-producing materials sufficient to produce foam or foam solutions to fill the feed lines actually installed between the source and the most remote tank shall also be provided. Where a water supply source will continue after the foam-producing material is depleted and displace the solution or foam from the lines to the tank, no added quantity is required by this paragraph.

326. RESERVE SUPPLY OF FOAM-PRODUCING MATERIALS: There shall be a readily available reserve supply of foam-producing materials sufficient to meet design requirements in order to put the system back into service after operation. This supply may be in separate tanks or compartments, in drums or cans on the premises, or available from an approved outside source within 24 hours.

330. Foam Discharge Outlets

*331. FIXED DISCHARGE OUTLETS: For the protection of a flammable liquid contained in a storage tank, discharge outlets shall be attached to the tank. Where two or more discharge outlets are required, the outlets shall be equally spaced around the tank periphery and each outlet shall be sized to deliver foam at approximately the same rate. Fixed discharge outlets shall be securely attached at the top of the shell and so located or connected as to preclude the possibility of the tanks overflowing into the foam lines. They shall be securely attached so that displacement of the roof is not likely to subject them to serious damage.

(a) Tanks shall be provided with approved discharge outlets as set forth below:

TANK DIAMETER — FEET (or equivalent area)	MINIMUM NUMBER DISCHARGE OUTLETS
up to 80	1
over 80 to 120	2
over 120 to 140	3
over 140 to 160	4
over 160 to 180	5
over 180 to 200	6

NOTE: It is suggested that for tanks above 200 feet in diameter, at least one additional discharge outlet be added for each additional 5000 sq. ft. of liquid surfaces. Since there has been no experience with foam application to fires in oil tanks over 140 feet in diameter, requirements for foam protection on tanks above this size are based on extrapolation of data from successful extinguishments in smaller tanks. Tests have shown that foam can travel effectively across at least 100 feet of burning liquid surface. On large tanks, sub-surface injection may be used to reduce foam travel distances.

(b) Fixed outlets shall be provided with an effective and durable seal, frangible under low pressure, to prevent entrance of vapors into foam outlets and pipe lines. Fixed outlets shall be provided with suitable inspection means to permit proper maintenance and for inspection and replacement of vapor seals.

*3311. OPEN TOP FLOATING ROOF TANKS: Fixed outlets are generally not required on open top floating roof tanks. These tanks have an excellent fire record. Their design has been for the purpose of fire prevention as well as for conservation of product. It is usually possible to utilize trained personnel to extinguish fires in the annular ring using portable equipment. There are locations, however, where fixed protection may be desired because of value of products stored, remoteness of installation, or lack of fire-fighting personnel. Suggested methods for providing fixed foam systems for open top floating roof tanks will be found in the Appendix.

*3312. COVERED FLOATING ROOF TANKS: Fixed outlets are generally not required on covered floating roof tanks. The possibility of fire is greatly reduced in comparison with other types because of the Faraday Cage type construction of this type of tank. In the event of fire, these tanks are difficult to extinguish using portable equipment. Fixed protection may be desired in certain locations because of value of products stored, remoteness of installations, or lack of fire-fighting personnel. Suggested methods for providing fixed foam systems for these tanks will be found in the Appendix.

NOTE: A "Faraday Cage" is a grounded metallic screen completely surrounding a space or piece of equipment in order to shield it from external electrostatic influence.

332. PORTABLE TOWERS: It is desirable that at least one portable tower be provided as supplementary protection in the event that a fixed discharge outlet is damaged by an explosion within the tank (see Chapter 4).

*333. SEMI-SUBSURFACE INJECTION METHOD: Information for the use of this method will be found in the Appendix.

334. HORIZONTAL ATMOSPHERIC AND PRESSURE TANKS: Fixed outlets are not recommended discharging into horizontal or pressure tanks.

340. Foam System Piping

341. GENERAL REQUIREMENTS:

3411. All piping inside of dikes, and within 50 feet of tanks not diked, should be buried under at least one foot of earth but may be permitted above ground if properly supported and protected against mechanical injury.

3412. Piping which is normally filled with liquids, such as the suction pipes, shall be protected from freezing when necessary.

3413. Piping from the dike or within 50 feet of tanks not diked to the tank foam discharge outlet shall be designed to absorb the upward force and shock due to a tank roof rupture. Preferably, use steel pipe and all-welded construction. One of the following designs may be used:

(a) When piping is buried, a swing joint or other suitable means shall be provided at the base of each tank riser. The swing joint shall consist of a system of approved standard weight steel, ductile, or malleable iron fittings.

(b) When piping is supported above ground, it should have upward and lateral support as needed, but shall not be held down a distance of 50 feet from the tank shell to provide flexibility in an upward direction so that a swing joint is not needed. If threaded connections occur within this distance, they should be back welded for strength.

(c) When tank risers are four inch pipe size or greater, they can be welded to the tank by means of steel brace plates positioned perpendicular to the tank and centered on the riser pipe. One brace shall be provided at each shell course. This design may be used in lieu of swing joints or above ground flexibility as described above.

3414. One flanged or union joint shall be provided in each riser within five feet of the ground to permit hydrostatic testing of the piping system up to this joint. With all welded construction, this may be the only joint that can be opened.

3415. In systems with semi-fixed equipment on fixed roof tanks, the foam or solution laterals to each foam chamber shall terminate in connections which are at a safe distance from the tanks; outside of dikes and at least 50 feet from tanks of 50 feet diameter or less, and one tank diameter from the shell of larger tanks. The inlets to the piping shall be fitted with corrosion-resistant metal connections provided with plugs or caps.

*342. PIPE LINES CARRYING FOAM: Pipe lines carrying chemical or air foam shall be of such sizes and lengths as to deliver on the surface protected the required quantity of foam of standard quality. The size and length of discharge line used beyond foam-making equipment should be in accordance with the conditions under which the device has been tested and listed.

343. VALVES IN SYSTEMS: All valves, except hydrant valves, should be of the O.S. and Y. or post indicator type. The laterals to each foam chamber on fixed roof tanks shall be separately valved outside the dike in fixed installations. Control valves to divert the foam or solutions to the proper tank may be in the central foam house or may be at points where laterals to the protected tanks branch from main feed line. Control valves shall be located outside dikes and not less than the following distances from the shell of the tank which they serve: 50 ft. for tanks less than 50 ft. in diameter; one diameter for tanks 50 ft. in diameter or larger, except that control valves may be permitted at less than the above distances where adequately protected, subject to the approval of the authority having jurisdiction. Where two or more air foam proportioners or chemical foam generators are installed in parallel discharging into the same outlet header, valves shall be provided between the outlet of each device and the header. The water line to each air foam proportioner or chemical foam generator inlet should be separately valved.

344. FOAM SYSTEM HYDRANTS: Centralized fixed piping systems shall be provided with hydrant outlets for foam hose streams for supplementary use on spill fires, supplying portable towers, etc. In lieu of foam (or solution) hydrants, water hydrants and portable generators or other devices acceptable to the authority having jurisdiction may be provided. The minimum number of hydrants, each with at least one outlet, shall be located 50 to 250 feet distance from the shells of tanks protected, as set forth below:

Tank Diameter — Feet	Minimum Number of Hydrants Required
Up to 65	1
65 and over	2

350. Subsurface Foam Injection To Tanks Containing Liquid Hydrocarbons.

*351. GENERAL: Subsurface injection systems are not suitable for protection of products such as alcohols, esters, ketones, aldehydes, anhydrides, etc. Liquid hydrocarbons that contain such products which are foam destructive may require higher application rates. The manufacturer of the foam system should be consulted for recommendations.

NOTE: For pertinent information regarding fire fighting operations, see Appendix A351.

*3511. FOAM-PRODUCING MATERIALS AND EQUIPMENT: Foam-producing materials and equipment for subsurface injection shall be listed for this purpose. Fluoroprotein foam concentrates will provide satisfactory subsurface injection performance.

352. RATES: The minimum delivery rate shall be 0.1 gpm/sq. ft. of liquid surface area of the tank to be protected.

353. SUPPLY OF FOAM-PRODUCING MATERIALS: The minimum total supplies to be maintained shall be the sum of the quantities defined for Type II Foam Discharge Outlets, 323, 324, 325, and 326.

354. SUPPLEMENTARY FOAM HOSE STREAM AND HYDRANT REQUIREMENTS: The minimum requirements for foam hose streams and hydrants shall be as specified in 324 and 344.

355. FOAM DISCHARGE OUTLETS: The discharge outlet into the tank may be the open end of a foam delivery line or product line. Outlets shall be sized so that foam generator discharge pressure and foam velocity limitations are not exceeded. The foam velocity at the point of discharge into the tank contents shall not exceed 10 feet per second for Class IB liquids and shall not exceed 20 feet per second for other type liquids unless actual tests prove higher velocities are satisfactory. (See Appendix A-3561).

Where two or more outlets are required, they should be equally spaced around the tank periphery and each outlet should be sized to deliver foam at approximately the same rate. For even foam distribution, outlets may be shell connections or may be fed through a pipe manifold within the tank from a single shell connection. Shell connections may be made in manway covers rather than installing additional tank nozzles.

3551. Tanks shall be provided with discharge outlets as set forth on next page.

TANK DIAMETER — FEET	MINIMUM NUMBER OF DISCHARGE OUTLETS REQUIRED CLASS IB LIQUIDS	CLASSES IC, II & III LIQUIDS
Up to 80	1	1
Over 80 to 120	2	1
Over 120 to 140	3	2
Over 140 to 160	4	2
Over 160 to 180	5	2
Over 180 to 200	6	3
Over 200 add one inlet for each additional	5000 sq. ft.	7500 sq. ft.

NOTE 1: Class IA Liquids require special consideration.

NOTE 2: The above table is based on extrapolation of fire test data on 25, 93 and 115 foot diameter tanks containing gasoline, crude and hexane, respectively.

NOTE 3: The heaviest fuels which have been extinguished by subsurface injection correspond in viscosity to number 6 fuel oils. In addition to the control provided by the smothering effect of the foam and the cooling effect of the water in the foam which reaches the surface, fire control and extinguishment may be further enhanced by the rolling of cool product to the surface. No known tests have been conducted on products having a higher viscosity than a number 6 fuel oil.

3552. FOAM DISCHARGE OUTLET ELEVATION: Foam discharge outlets should be located above an established water bottom, if possible. Otherwise, if it is established that there is a water bottom in the tank above the foam discharge outlets, it should be drained to below the point of foam injection prior to putting the foam system into operation. If this is not accomplished, efficiency will be reduced as a result of dilution of the foam, prolonging or preventing extinguishment.

356. FOAM SYSTEM PIPING

*3561. PIPELINES CARRYING FOAM: The sizes and lengths of discharge pipe or lines used beyond the foam-maker shall be such that the back pressure is within the range of pressures under which the device has been tested and listed by nationally recognized testing laboratories.

3562. VALVES IN SYSTEMS: In addition to the requirements specified in 3430, each foam delivery line shall be provided with a valve and check valve unless the latter is an integral part of the high back-pressure foam-maker or pressure foam generator to be connected at time of use. When product lines are used for foam, product line valving shall be arranged to ensure foam enters only the tank to be protected.

CHAPTER 4. PORTABLE TOWER SYSTEMS FOR EXTERIOR STORAGE TANKS

400. General.

401. SCOPE: This chapter relates to those systems in which the foam is applied through approved portable towers which are placed in operating position after the fire starts.

NOTE 1: Generally, portable towers are to be regarded as limited in use. Portable tower systems require accessibility to tankage, and an adequate number of men to place and maintain the apparatus in operation; and in some cases, special truck units for the ready transportation of the equipment to the location of the fire. The adequacy of a portable tower system, subject to the approval of the authority having jurisdiction, shall be based upon the number and availability of the men and equipment to extinguish a possible fire. On tanks over 200 ft. diameter, the use of portable foam towers may not be practical, due to the amount of equipment and number of men needed to meet requirements.

NOTE 2: Tanks containing combustible liquids (at or above 140° F. flash point) are not, as a rule, required to be protected by foam. Foam protection for combustible liquids may be desirable where abnormal situations exist, such as storage of high value stocks or liquids heated above their flash point.

*402. DEFINITIONS:

(a) PORTABLE FOAM TOWER: A device which is brought to the scene of the fire, erected and placed in operation for delivering foam to the burning surface of a tank after the fire starts. Portable foam towers may be equipped with either Type I or Type II discharge outlets.

(b) PORTABLE INSTALLATIONS: The type in which the foam apparatus, foam-producing materials, hose, etc., are transported to the scene after the fire starts, the foam being delivered to the tank by portable towers.

410. Foam Application.

411. RATES: The minimum rate of delivery to portable foam towers shall be as specified in 311.

420. Supply of Foam-Producing Materials.

421. GENERAL: The supplies to be maintained shall be the sum of the quantities defined in 4230, 4240, 4250 and 4260.

422. MINIMUM DISCHARGE TIME: The system shall be capable of operation at the delivery rate specified in 411 for the following minimum periods of time. If the apparatus available has a delivery rate higher than that specified in 411, proportionate reduction in the time figures may be made, except that they shall not be less than 70 percent of the minimum discharge times shown.

FOR TANKS CONTAINING LIQUID HYDROCARBONS	TYPE OF PORTABLE FOAM TOWER Type I	Type II
Lubricating oils, dry viscous residuum (more than 50 seconds Saybolt-Furol at 122°F), dry fuel oils, etc., with flash point above 200°F	25 min.	35 min.
Kerosene, light furnace oils, diesel fuels, etc., with flash point from 100°F to 200°F	30 min.	50 min.
Gasoline, naphtha, benzol and similar liquids with flash point below 100°F	55 min.	65 min.
Crude petroleum	55 min.	65 min.

FOR TANKS CONTAINING OTHER FLAMMABLE & COMBUSTIBLE LIQUIDS REQUIRING SPECIAL FOAMS:

"Alcohol" type foams require gentle application by Type I outlets unless listed as suitable for application through Type II devices. The operation time shall be 55 minutes at the specified application rate, unless the manufacturer of the foam concentrate has established by fire test that a shorter time can be permitted.

4221. DRY POWDER CHEMICAL FOAM GENERATOR CONSUMPTION RATES: For the purpose of the above tables, it shall be assumed that dry powder generators (dual or single powder type) consume 1.25 lbs. of powder per gallon of water. Where listings of dry powder generators and powder by nationally recognized testing laboratories show powder consumption less than 1.25 lbs. per gallon, such lower figure may be used when the generator is used in the manner on which the listing was based.

423. REQUIREMENTS FOR TANKS: The quantity of foam-producing material shall be determined by multiplying the total flow in gallons per minute for each tank by the appropriate time in 422. The largest resulting value shall determine the quantity required.

424. SUPPLEMENTARY FOAM HOSE STREAM AND HYDRANT REQUIREMENTS: The minimum requirements for hose streams and hydrants shall be as specified in 324 and 344.

425. REQUIREMENTS TO FILL PIPE LINES: These shall be the same as specified in 325.

426. RESERVE SUPPLY OF FOAM-PRODUCING MATERIALS: There shall be a reserve supply of foam-producing materials the same as specified in 326.

430. Foam Towers.

431. NUMBERS REQUIRED: Towers shall be available in the proper number and size as to deliver foam on the burning liquid surface at a rate to meet the requirements of 411 and as set forth below:

TANK DIAMETER — FEET (or equivalent area)	MINIMUM NUMBER FOAM TOWERS
up to 80	1
over 80 to 120	2
over 120 to 140	3
over 140 to 160	4
over 160 to 180	5
over 180 to 200	6

NOTE 1: When two or more towers are required, they should be sized to deliver foam at approximately the same rate.

NOTE 2: Since there has been no experience with foam application to fires in oil tanks over 140 feet in diameter, requirements for foam protection on tanks above this size are based on extrapolation of data from successful extinguishments in smaller tanks.

CHAPTER 5. SPRAY FOAM SYSTEMS FOR EXTERIOR PROTECTION

500. General.

*501. SCOPE: This chapter relates to systems discharging air foam in a spray pattern that can be effectively used to extinguish spill fires under or around process structures and equipment, horizontal tanks and small vertical tanks. These systems relate to spray discharge of air foam only. Some foam spray systems and devices are not designed to produce effective water patterns for cooling purposes. For system design criteria for discharge of both water and foam, refer to NFPA No. 16, *Standard for Installation of Foam-Water Sprinkler and Foam-Water Spray Systems.*

NOTE 1: Spray foam applied externally to tanks or vessels has the added advantages of cooling and insulating the tanks or vessels while the spill fire is being extinguished.

Foam is not considered an effective agent for extinguishment of three-dimensional running flammable liquid fires. However, in the event of such a fire, the foam can effectively cover and control the pool fire beneath the running fire thus facilitating approach and extinguishment by other means.

NOTE 2: These systems may also be used to protect small open top tanks having a liquid surface area not exceeding 200 sq. ft.

510. Foam Application.

511. RATE: The minimum rate of foam solution application shall be 0.16 gpm/sq. ft. the maximum potential fire area.

520. Supply of Foam-Producing Materials.

521. GENERAL: Supplies to be maintained shall be the sum of the quantities defined in 522 and 523.

522. OPERATING SUPPLY: There shall be a quantity of foam-producing materials sufficient to supply the system at the design rate for a period of ten (10) minutes. If the system discharges at a rate above the minimum specified in 511, then the operating time may be reduced proportionately, but shall not be less than seven (7) minutes.

523. RESERVE SUPPLY: There shall be a reserve supply of foam-producing materials in accordance with 326.

530. Foam Discharge Outlets.

531. NUMBER AND LOCATION: There should be a minimum of one (1) discharge outlet per hundred (100) square feet of protected area unless listing of discharge devices indicates a larger spacing is permitted. These outlets should be located so as to provide good distribution throughout the protected area. However, an added advantage is gained by locating the outlets so that the foam discharge envelops the equipment within the protected area. Therefore, the discharge outlets may be concentrated over closed tanks or equipment rather than being evenly spaced throughout the protected area. These outlets are then located in plan and elevation to provide the most effective protection of the hazard.

540. Operation.

541. AUTOMATIC OPERATION: Foam systems of this type should be automatic in operation. This may be accomplished by use of listed fire detectors installed in accordance with their accepted spacing rule for outdoor applications, and connected to a deluge valve and other equipment to make a complete system. The requirements of 2120 and 27 shall be complied with where applicable.

542. MANUAL OPERATION: Where manually operated systems are used, the controls shall be located in an accessible place, sufficiently removed from the hazard so that they may be safely operated in an emergency. The location and purpose of the control shall be plainly indicated.

550. Foam System Piping.

551. GENERAL REQUIREMENTS: a) Piping which will normally be filled with liquid shall be protected against freezing when necessary. b) The requirements of Section 26 shall be complied with where applicable.

552. Applicable parts of Chapter 3 of the NFPA *Standard for the Installation of Sprinkler Systems* (No.

13) shall be consulted for requirements applicable to piping, valves, pipe fittings, and hangers, including corrosion-protection coatings (galvanizing or other means). In these open-head systems, galvanized pipe and fittings should be used for normal occupancies. Corrosive atmospheres may require other coatings.

Since the systems herein covered are required to be hydraulically designed, the pipe-size tables of NFPA *Standard for Installation of Sprinkler Systems* (No. 13) are not applicable.

553. Piping carrying air-foam liquid concentrate shall be black steel or cast iron.

CHAPTER 6. MONITOR AND HOSE NOZZLES FOR EXTERIOR PROTECTION

600. General.

*601. Scope: This chapter relates to systems in which the foam is applied through fixed or portable monitor or hose nozzles. They are usually recommended as auxiliary protection in conjunction with fixed piping systems or portable towers as specified in Chapters 3 and 4. They are suitable when used alone for extinguishment of spill fires, diked area fires, and fires in small fixed roof atmosphere storage tanks. Portable hose nozzles are also suitable for extinguishment of rim fires in floating roof tanks.

Note 1: Fires in tanks up to 130 feet in diameter have been extinguished when the entire liquid surface was involved by use of large capacity foam monitors. Depending on the fixed roof tank outage and fire intensity, the up draft due to chimney effect may prevent sufficient foam from reaching the burning liquid surface for formation of a blanket. Foam must be applied continuously and evenly. Preferably, it should be directed against the inner tank shell so that it flows gently onto the burning liquid surface without undue submergence. This can be difficult to accomplish as adverse winds, depending on velocity and direction, will reduce the effectiveness of the foam stream. Due to their limitations, monitors should not be depended upon as a primary means of extinguishment for fixed roof tanks over 60 feet in diameter. Monitors operated at grade usually are not recommended for floating roof rim fire extinguishment because of the difficulty of directing foam into the annular space. Fixed foam monitors may be installed for protection of drum storage areas or diked areas.

Note 2: Foam hose streams are suitable as a primary means of extinguishment of fires in tanks not over 30 feet in diameter nor over 20 feet high. Foam hose streams can be used for floating roof rim fire extinguishment when used from the tank wind girder or roof.

Note 3: Large spill fires have been extinguished by foam monitors and foam hose streams. In order to obtain maximum flexibility due to the uncertainty of location and the extent of a possible spill in large tank farms, portable or trailer-mounted monitors are preferred to fixed foam systems. The procedure for fighting dikes area fires is to extinguish or secure one area and then move on to extinguish the next section, within the dike. This technique should be continued until the complete dike area has been extinguished. Generally, trailer or portable monitors, in addition to a few foam hose streams, have been adequate in fighting diked areas and other large spill fires.

*602. DEFINITIONS:

(a) FOAM HOSE STREAM: A foam stream from a hose nozzle which can be held and directed by hand. The nozzle reaction usually limits the solution flow to about 300 gpm.

(b) FOAM MONITOR STREAM: A large capacity foam stream from a nozzle which is supported in position and which can be directed by one man. A solution flow of 300 gpm or higher can be used.

(c) FIXED MONITOR (Cannon): A device which delivers a foam monitor stream and is mounted on a stationary support at grade or elevated. The monitor may be fed solution by permanent piping or hose.

(d) PORTABLE MONITOR (Cannon): A device which delivers a foam monitor stream and is on a movable support or wheels so it can be transported to the fire scene.

610. Foam Application.

611. RATES: The minimum delivery rate for primary protection based on the assumption that all the foam reaches the area being protected shall be as follows:

In determining total solution flow requirements, consideration should be given to potential foam losses from wind and other factors as noted in 601 — Note 1.

6110. FOR LIQUID HYDROCARBONS:

(1) For tank protection the foam solution delivery rate shall be at least 0.16 gpm/sq. ft. of liquid surface area to be protected.

NOTE 1: Flammable liquids having a boiling point of less than 100° F may require higher rates of application. Suitable rates of application should be determined by test. Flammable liquids with a wide range of boiling points can develop a heat layer after prolonged burning and then may require application rates of 0.2 gpm per square foot or more.

NOTE 2: Care should be taken in applying portable foam streams to high viscosity materials heated above 200° F. Judgment must be used in applying foam to tanks containing hot oils, burning asphalts or burning liquids which are above the boiling point of water. Although the comparatively low water content of foams can beneficially cool such fuels at a slow rate, it can also cause violent frothing and "slop over" of the contents of the tank.

6111. FOR OTHER FLAMMABLE AND COMBUSTIBLE LIQUIDS REQUIRING SPECIAL FOAMS: Water soluble and certain flammable and combustible liquids and polar solvents which are destructive to regular foams require the use of alcohol type foams. In general, alcohol type foams can be effectively applied through foam monitor or foam hose streams to spill fires of these liquids when the liquid depth does not exceed 1 inch. For liquids in greater depth, monitor and foam hose streams should be limited for use with special alcohol type foams listed for Type II discharge. Systems using these foams require special engineering consideration. In all cases, the manufacturer of the foam concentrate and the foam-making equipment should be consulted as to limitations and for recommendations based on listings or specific fire tests. The following are minimum recommended application rates.

Type of Liquid	Solution Rate gpm/sq. ft.
Methyl and Ethyl Alcohol	0.16
Acrylonitrile	0.16
Ethyl Acetate	0.16
Methyl Ethyl Ketone	0.16
Acetone	0.24
Butyl Alcohol	0.24
Isopropyl Ether	0.24

Products such as isopropyl alcohol, methyl isobutyl ketone, methyl methacrylate monomer, and mixtures of polar solvents in general may require higher application rates. Protection of products such as amines and anhydrides, which are particularly foam destructive, require special consideration.

NOTE 1: The solvent and fire resistance of alcohol type air foam may be adversely affected by such factors as excessive solution transit time, the use of foam-making devices not specifically designed or adequately tested for a particular alcohol foam application, operating pressures, failure to maintain proportioning within the recommended concentration limits, the method of application and the characteristics of the particular solvent to which the foam is to be applied.

Solution transit time, that is, the elapsed time between injection of the foam concentrate into water and the induction of air, may be limited, depending on the characteristics of the foam concentrate, the water temperature, and the nature of the hazard protected. The maximum solution transit time of each specific installation shall be within the limits established by the manufacturer.

NOTE 2: For protection of flammable or combustible liquids which are highly toxic, higher application rates may be desirable to reduce respiratory hazard to personnel by providing for more rapid coverage.

620. Supply of Foam-Producing Materials.

621. GENERAL: The supplies to be maintained shall be the sum of the quantities defined in 623, 624, 625 and 626.

622. MINIMUM DISCHARGE TIMES: The equipment shall be capable of operation to provide primary protection at the delivery rates specified in 611 for the following minimum periods of time.

FOR TANKS CONTAINING LIQUID HYDROCARBONS

Lubricating Oils; dry viscous residuum (more than 50 seconds Saybolt-Furol at 122°F); dry fuel oils, etc., with flash point above 200°F	35 min.
Kerosene; light furnace oils, diesel fuels, etc., with flash point 100°F to 200°F	50 min.
Gasoline; naphtha, benzol, and similar liquids with flash point below 100°F	65 min.
Crude petroleum	65 min.

FOR TANKS CONTAINING OTHER FLAMMABLE AND COMBUSTIBLE LIQUIDS REQUIRING SPECIAL FOAMS

"Alcohol" type foams require special application procedures as discussed in 6111. The operation time shall be 65 minutes at specified application rate, unless the manufacturer has established by fire test that a shorter time can be permitted.

FOR THE EXTINGUISHMENT OF SPILL FIRES

Where the primary purpose of the protection is for extinguishment of spill fires, the minimum discharge time shall be 10 minutes for fixed equipment. For portable equipment, the minimum discharge time shall be 15 minutes. For protection of diked areas designed to contain the contents of a storage tank, see Note 3 of Paragraph 601.

6221. DRY POWDER CHEMICAL FOAM GENERATOR CONSUMPTION RATES: For the purpose of 611, it shall be assumed that dry powder generators (dual or single powder type) consume 1.25 lbs. of powder per gallon of water. Where "listings" of dry powder generators and powder by nationally recognized testing laboratories show powder consumption less than 1.25 lbs. per gallon of water, such lower figure may be used when the generator is used in the manner on which the listing was based.

623. REQUIREMENTS FOR TANKS: The quantity of foam-producing material shall be determined by multiplying the total flow in gallons per minute for each tank by the appropriate time in 622. The largest resulting value shall determine the quantity required.

624. SUPPLEMENTARY HOSE STREAM AND HYDRANT REQUIREMENTS: Additional foam hose streams and required equipment shall be provided as supplemental protection for ground fires at least as specified in 324 and 344.

625. REQUIREMENTS TO FILL PIPE LINES: These shall be the same as specified in 325.

626. RESERVE SUPPLY OF FOAM-PRODUCING MATERIALS: There shall be a reserve supply of foam-producing materials the same as specified in 326.

630. Hose Requirements.

631. UNLINED FABRIC HOSE: Unlined fabric hose shall not be used with foam equipment.

CHAPTER 7. TESTS FOR THE PHYSICAL PROPERTIES OF FOAM

***700. General:** This chapter relates to the laboratory tests of foam concentrate or foam producing devices when it is desired to correlate physical characteristics with fire extinguishing properties.

***701.** SCOPE: The appendix contains detailed laboratory procedures for the sampling and analysis of fire fighting foam.

It is seen that the 25 percent volume of 50 ml lies within the 2 to 3 minute period. The increment to be added to the lower value of two minutes is found by interpolation of the data:

$$\frac{50 \text{ ml (25\% Volume} - 40 \text{ ml (2 min. Volume)}}{60 \text{ ml (3 min. Volume)} - 40 \text{ ml (2 min. Volume)}} = \frac{10}{20} = 0.5$$

Therefore, the 25 percent drainage time is found by adding 2.0 min. + 0.5 min. and gives a final value of 2.5 min.

In the handling of rapidly draining foams it must be remembered that they lose their liquid rapidly and the expansion determination must be carried out with speed and dispatch in order not to miss the 25 percent drainage volume. It is recommended that the expansion determination be deferred until the drainage curve data has been recorded. The stop watch is started at the time the foam container is filled and continues to run during the time required for recording drainage rate data.

A6320. Method for Determination of Film Forming Capability:

In this test a quantity of foam is placed upon the surface of cyclohexane (a hydrocarbon liquid). The foam is swept from the surface by insertion of a conical screen, and the exposed fuel surface is tested for the presence of an aqueous film by probing with a flame. If film is present the fuel will not sustain ignition; in the absence of film sustained ignition will occur.

A stainless steel beaker of 1000 milliliter capacity (about 4½-inch diameter, 5 inch depth) is equipped with two metal clips at the upper edge. These clips serve to secure an 80 mesh stainless steel conical screen (5 inches height, 4¾- inch diameter) during the test. The procedure is as follows:

1. Place 600 ml of 98 percent (minimum) cyclohexane into the stainless steel beaker.

2. Fill the remainder of the stainless steel beaker with freshly generated foam.

3. Insert the conical screen, closed end of cone down, through the foam. This sweeps the foam aside and exposes an apparently bare cyclohexane surface. Fasten the cone with the metal clips to secure it.

4. After one minute hold a flame ½ inch above the cyclohexane surface. Accumulated fuel vapor may flash, but if aqueous film has formed it will prevent any sustained ignition of the cyclohexane.

Standard on

Carbon Dioxide Extinguishing Systems

NFPA No. 12—1973

1973 Edition of No. 12

The 1973 edition of the Standard for Carbon Dioxide Extinguishing Systems incorporates changes proposed by the Committee on Carbon Dioxide and adopted at the 1973 Annual Meeting of the National Fire Protection Association. It supersedes the 1972 edition.

This 1973 edition of NFPA No. 12 is being submitted to the American National Standards Institute for approval as an ANSI standard. Earlier editions have been so approved, the latest being designated USAS A54.1 — 1968. The ANSI designation and date of approval of the 1973 edition will be printed on the front cover of copies of this edition printed after approval has been received.

Origin and Development of No. 12

Work on this standard was initiated in 1928 by the then Committee on Manufacturing Risks and Special Hazards. The standard was first adopted in 1929 and was revised in 1933, 1939, 1940, 1941, 1942 (January and May), 1945, 1946, 1948, 1949, 1956, 1957, 1961, 1962, 1963, 1964, 1966, and 1968. Revisions adopted 1945–1949 were proposed by the Committee on Special Extinguishing Systems, and those in 1956 and subsequently were proposed by the Committee on Carbon Dioxide.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

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NOTICE

An asterisk (*) preceding the number or letter designating a paragraph indicates explanatary material on that paragraph in Appendix A.

Standard on

Carbon Dioxide Extinguishing Systems

NFPA No. 12 — 1973

INTRODUCTION.

1. Purpose. This Standard is prepared for the use and guidance of those charged with the purchasing, designing, installing, testing, inspecting, approving, listing, operating or maintaining carbon dioxide fire extinguishing systems, in order that such equipment will function as intended throughout its life.

2. Scope. This Standard contains minimum requirements for carbon dioxide fire extinguishing systems. It includes only the necessary essentials to make the Standard workable in the hands of those skilled in this field. Portable carbon dioxide equipment is covered in Standard for the Installation of Portable Fire Extinguishers, NFPA No. 10, and in Recommended Good Practice for the Maintenance and Use of Portable Fire Extinguishers, NFPA No. 10A. Other associated NFPA standards involving the use of carbon dioxide include the following:

No. 69 Inerting for Fire and Explosion Prevention.
No. 302 Motor Craft.
No. 306 Control of Gas Hazards on Vessels to be Repaired.
No. 403 Aircraft Rescue and Fire Fighting Services at Airports and Heliports.
No. 409 Aircraft Hangars.

Only those skilled in the field are competent to design and install this equipment. It may be necessary for many of those charged with the purchasing, inspecting, testing, approving, operating and maintaining this equipment to consult with an experienced and competent fire protection engineer in order to effectively discharge their respective duties.

3. Arrangement. This Standard is arranged as follows:

Introduction.

Chapter 1 — General Information and Requirements.

Chapter 2 — Total Flooding Systems.

Chapter 3 — Local Application Systems.

Chapter 4 — Hand Hose Line Systems.

Chapter 5 — Standpipe Systems and Mobile Supply.

Appendix A — Explanatory.

Appendix B — Examples of Hazard Protection.

Chapters 1 through 5 constitute the body of the Standard and contain the rules and regulations necessary for properly designing, installing, inspecting, testing, approving, operating and maintaining carbon dioxide fire extinguishing systems.

The Appendixes contain educational and informative material that will aid in understanding and applying this Standard.

4. Definitions. For purpose of clarification, the following general terms used with special technical meanings in this Standard are defined:

AUTHORITY HAVING JURISDICTION: The "authority having jurisdiction" is the organization, office, or individual responsible for "approving" equipment, an installation, or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA standards in a broad manner since jurisdictions and "approval" agencies vary as do their responsibilities. Where public safety is primary, the "authority having jurisdiction" may be a federal, state, local, or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, health department, building official, electrical inspector, or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the "authority having jurisdiction."

In many circumstances the property owner or his delegated agent assumes the role of the "authority having jurisdiction"; at government installations, the commanding officer, or a departmental official may be the "authority having jurisdiction."

HIGH PRESSURE is used to indicate that the carbon dioxide is stored in pressure containers at atmospheric temperatures. At 70° F., the pressure in this type of storage is 850 psi.

LOW PRESSURE is used to indicate that the carbon dioxide is stored in pressure containers at controlled low temperatures, at 0° F. At 0° F., the pressure in this type of storage is 300 psi.

Other terms used with special technical meaning are defined or explained where they occur in the Standard.

CHAPTER 1.

GENERAL INFORMATION AND REQUIREMENTS.

11. General Information.

111. Scope. Chapter 1 contains general information, and the design and installation requirements for all features that are generally common to all carbon dioxide systems.

***112. Carbon Dioxide.** Carbon dioxide is a colorless, odorless, electrically nonconductive inert gas that is a suitable medium for extinguishing fires.

1121. Carbon dioxide extinguishes fire by reducing the concentrations of oxygen and/or the gaseous phase of the fuel in the air to the point where combustion stops.

113. Use and Limitations. Carbon dioxide fire extinguishing systems are useful within the limits of this Standard in extinguishing fires in specific hazards or equipment, and in occupancies where an inert electrically nonconductive medium is essential or desirable, where cleanup of other media presents a problem, or where they are more economical to install than systems using other media.

1131. All areas or parts of a hazard to which or from which a fire may spread shall be simultaneously protected.

1132. Some of the more important types of hazards and equipment that carbon dioxide systems may satisfactorily protect include:

1. Gaseous and liquid flammable materials.
2. Electrical hazards such as transformers, oil switches and circuit breakers, and rotating equipment.
3. Engines utilizing gasoline and other flammable fuels.
4. Ordinary combustibles such as paper, wood and textiles.
5. Hazardous solids.

*1133. Carbon dioxide will not extinguish fires where the following materials are actively involved in the combustion process.

1. Chemicals containing their own oxygen supply such as cellulose nitrate.
2. Reactive metals such as sodium, potassium, magnesium, titanium and zirconium.
3. Metal hydrides.

114. Types of Systems. There are four types of systems recognized in this standard:

Total Flooding Systems.

Local Application Systems.

Hand Hose Line Systems.

Standpipe Systems and Mobile Supply.

1141. A TOTAL FLOODING SYSTEM consists of a fixed supply of carbon dioxide normally connected to fixed piping with nozzles arranged to discharge carbon dioxide into an enclosed space or enclosure about the hazard.

1142. A LOCAL APPLICATION SYSTEM consists of a fixed supply of carbon dioxide normally connected to fixed piping with nozzles arranged to discharge carbon dioxide directly on the burning material.

1143. A HAND HOSE LINE SYSTEM consists of a fixed supply of carbon dioxide supplying hose lines.

1144. A STANDPIPE SYSTEM AND MOBILE SUPPLY consists of a mobile supply of carbon dioxide capable of being quickly moved to position and connected to a system of fixed piping supplying fixed nozzles and/or hose lines that may be used for either total flooding or local application.

115. Carbon Dioxide System. A carbon dioxide system may be used to protect one or more hazards or groups of hazards by means of directional valves (with the permission of the authority having jurisdiction). Where two or more hazards may be simultaneously involved in fire by reason of their proximity, each hazard shall be protected with an individual system with the combination arranged to operate simultaneously or be protected with a single system that shall be sized and arranged to discharge on all potentially involved hazards simultaneously.

116. Package Systems (Kits). Package systems consist of system components designed to be installed according to pretested limitations as approved or listed by a nationally recognized testing laboratory.

1161. Package Systems may incorporate special nozzles, flow rates, methods of application, nozzle placement, and quantities of carbon dioxide which may differ from those detailed elsewhere in this Standard since they are designed for very specific hazards. All other requirements of the Standard apply.

1162. Package systems shall be installed to protect hazards within the limitations which have been established by the testing laboratories where listed.

12. Personnel Safety.

***121. Hazards to Personnel.** The discharge of large amounts of carbon dioxide to extinguish fire may create hazards to personnel such as oxygen deficiency and reduced visibility.

1211. The dilution of the oxygen in the air, by the carbon dioxide concentrations that will extinguish fire, may create atmospheres that will not sustain life. Such atmospheres will be produced in spaces protected by total flooding and may be produced by any large volume discharges drifting and settling in adjacent low places such as cellars and pits. Persons rendered unconscious in these atmospheres can usually be revived without any permanent ill effects when promptly removed from such atmospheres.

1212. Large volume discharges of carbon dioxide may seriously interfere with visibility during and immediately after the discharge period.

***122. Safety Requirements.** In any proposed use of carbon dioxide where there is a possibility that men may be trapped in, or enter into atmospheres made hazardous by a carbon dioxide discharge, suitable safeguards shall be provided to insure prompt evacuation of and to prevent entry into such atmospheres and also to provide means for prompt rescue of any trapped personnel. Such safety items as personnel training, warning signs, discharge alarms, pre-discharge alarms and breathing apparatus shall be considered.

***123. Electrical Clearances.** All system components shall be so located as to maintain standard electrical clearances from live parts. See Appendix A-123 for a table of clearances.

13. Specifications, Plans and Approvals.

***131. Purchasing Specifications.** Specifications for carbon dioxide fire extinguishing systems shall be drawn up with care and with the advice of the authority having jurisdiction.

1311. The specifications should designate the authority having jurisdiction and indicate whether plans are required.

1312. The specifications should state that the installation shall conform to this Standard and meet the approval of the authority having jurisdiction.

1313. The specifications should include the specific tests that may be required to meet the approval of the authority having jurisdiction, and indicate how cost of testing is to be borne.

1314. These specifications should require the provision of equipment listed for the use intended.

132. Plans. Where plans are required, their preparations shall be entrusted to none but fully experienced and responsible persons.

1321. These plans shall be drawn to an indicated scale or be suitably dimensioned and shall be made so they can be easily reproduced.

1322. These plans shall contain sufficient detail to enable the authority having jurisdiction to evaluate the hazard or hazards and to evaluate the effectiveness of the system. The detail on the hazards shall include the materials involved in the hazards, the location of the hazards, the enclosure or limits and isolation of the hazards, and the exposures to the hazard.

1323. The detail on the system shall include information and calculations on the amount of CO_2; the location and flow rate of each nozzle including equivalent orifice area; the location, size and equivalent lengths of pipe, fittings and hose; and the location and size of the CO_2 storage facility. Information shall be submitted pertaining to the location and function of the detection devices, operating devices, auxiliary equipment, and electrical circuitry, if used. Sufficient information shall be indicated to identify properly the apparatus and devices used. Any special features should be adequately explained.

133. Approval of Plans. Plans and calculations shall be submitted to the authority having jurisdiction for approval before work starts.

1331. When field conditions necessitate any material change from approved plans, the change shall be submitted to the authority having jurisdiction for approval.

1332. When such material changes from approved plans are made, corrected "as installed" plans shall be supplied to the owner and the authority having jurisdiction.

***134. Approval of Installations.** The completed system shall be tested by qualified personnel to meet the approval of the authority having jurisdiction. These tests shall be adequate to determine that the system has been properly installed and will function as intended. Only listed or approved equipment and devices shall be used in the systems.

14. Operation and Control of Systems.

141. Methods of Actuation. Systems shall be classified as automatic or manual in accordance with the following methods of actuation:

1. Automatic Operation—Operation that does not require any human action.
2. Normal Manual Operation—Operation of the system requiring human action where the device used to cause operation is located so as to be easily accessible at all times to the hazard. See Sub-section 1434. Operation of one control shall be all that is required to bring about the full operation of the system.
3. Emergency Manual Operation—Operation of the system by human means where the device used to cause operation is fully mechanical in nature and is located at or near the device being controlled. Fully mechanical may incorporate the use of system pressure to complete operation of the device.

142. Detection of Fires. Fires or conditions likely to produce fire may be detected by visual (human senses) or by automatic means.

1421. Reliance on visual detection shall be permitted only with permission of the authority having jurisdiction, where fires or conditions likely to produce fire can be readily detected by such means.

1422. Automatic detection shall be by any listed or approved method or device that is capable of detecting and indicating heat, flame, smoke, combustible vapors, or an abnormal condition in the hazard such as process trouble that is likely to produce fire.

1423. An adequate and reliable source of energy shall be used in detection systems.

143. Operating Devices. Operating devices include carbon dioxide releasing devices or valves, discharge controls, and shut-down equipment, all of which are necessary for successful performance of the system.

1431. Operation shall be by listed or approved mechanical, electrical, or pneumatic means. An adequate and reliable source of energy shall be used.

1432. All devices shall be designed for the service they will encounter and shall not be readily rendered inoperative or susceptible to accidental operation. Devices shall be normally designed to function properly from –20° F. to 150° F. or marked to indicate temperature limitations.

1433. All devices shall be located, installed or suitably protected so that they are not subject to mechanical, chemical, or other damage which would render them inoperative.

1434. The normal manual control for actuation shall be located so as to be conveniently and easily accessible at all times including the time of fire. This control shall cause the complete system to operate in its normal fashion.

1435. All valves controlling the release and distribution of carbon dioxide shall be provided with an emergency manual control. This does not apply to slave high pressure cylinders. It is possible for the normal manual control to qualify as the emergency manual control if the provisions of Section 141 are satisfied.

The emergency means, preferably mechanical, shall be easily accessible and located close to the valves controlled. If possible, the system should be designed so that emergency actuation can be accomplished from one location. This does not apply to slave high pressure cylinders.

1436. Manual controls shall not require a pull of more than 40 lbs. (force) nor a movement of more than 14 inches to secure operation.

1437. Where gas pressure from pilot cylinders is used as a means for releasing remaining slave cylinders and the supply consists of less than three cylinders, one cylinder shall be used for such operation. If the supply consists of three cylinders or more, not less than two cylinders shall be used for such operation.

1438. All shut-down devices shall be considered integral parts of the system and shall function with the system operation.

1439. All manual operating devices shall be identified as to the hazard they protect.

144. Supervision. Where supervision of any or all of the following—automatic detection system, the electrical actuation circuit, the electrical power supply—is provided, it shall be arranged to give immediate indication of failure.

145. Alarms and Indicators. Alarms and/or indicators are used to indicate the operation of the system, hazard to personnel, or failure of any supervised device or equipment. The device may be audible, visual or olfactory. The type, number and location of the devices shall be such that their purpose is satisfactorily accomplished. The extent and type of alarm and/or indicator equipment shall be approved.

1451. An alarm or indicator shall be provided to show that the system has operated, that personnel response may be needed, and that the system is in need of recharge.

1452. An alarm should be provided to indicate the operation of automatic systems in case an immediate personnel response is desired.

1453. Alarms shall be provided to give positive warning of a discharge where hazard to personnel may exist. Such alarms shall function to warn against personnel entry into hazardous areas as long as such hazards exist or until such hazards are properly recognized. See Article 12.

1454. Alarms indicating failure of supervised devices or equipment shall give prompt and positive indication of any failure and shall be distinctive from alarms indicating operation or hazardous conditions.

15. Carbon Dioxide Supply.

151. Quantities. The amount of carbon dioxide in the system shall be at least sufficient for the largest single hazard protected or group of hazards which are to be protected simultaneously.

1511. Where hand hose lines may be used on a hazard protected by a fixed system, separate supplies shall be provided unless sufficient carbon dioxide is provided to insure that the fixed protection for the largest single hazard upon which the hose lines may be used will not be jeopardized. See Section 411.

1512. Where continuous protection is required, the reserve quantity shall be as many multiples of these minimum amounts as the authority having jurisdiction considers necessary. See Section 153.

1513. Both primary and reserve supplies for fixed storage shall be permanently connected to the piping and arranged for easy change-over, except where the authority having jurisdiction permits an unconnected reserve.

***152. Quality.** Carbon dioxide used for initial supply and replenishment shall be of good commercial grade, free of water and other contaminants that might cause container corrosion or interfere with free discharge through nozzle orifices. In general, carbon dioxide obtained by converting dry ice to liquid will not be satisfactory unless it is properly processed to remove excess water and oil.

1521. The vapor phase shall be not less than 99.5 percent carbon dioxide with no detectable off taste or odor.

1522. The water content of the liquid phase shall be not more than 0.01 percent by weight (minus 30° F dew point).

1523. Oil content shall be not more than 10 p.p.m. by weight.

153. Replenishment. The time needed to obtain carbon dioxide for replenishment to restore systems to operating condition shall be considered as a major factor in determining the reserve supply needed.

154. Storage Containers. Storage containers and accessories shall be so located and arranged that inspection, testing, recharging and other maintenance is facilitated and interruption to protection is held to a minimum.

1541. Storage containers shall be located as near as possible to the hazard or hazards they protect, but they should not be located where they will be exposed to a fire or explosion in these hazards.

1542. Storage containers shall not be located so as to be subject to severe weather conditions or be subject to mechanical, chemical, or other damage.

1543. When excessive climatic or mechanical exposures are expected, suitable guards or enclosures shall be provided.

***155. High Pressure Storage Containers.** The carbon dioxide supply shall be stored in rechargeable containers designed to hold pressurized carbon dioxide in liquid form at atmospheric temperatures, corresponding to a nominal pressure of 850 psi at 70° F.

1551. High pressure containers or cylinders shall be constructed, tested and marked in accordance with U.S. Department of Transportation specifications† (in current effect upon date of manufacture and test) for DOT-3A, 3AA-1800, or higher, seamless steel cylinders. Charged cylinders shall be tested for tightness before shipment in accordance with an approved procedure.

1552. High pressure cylinders used in fire extinguishing systems shall not be recharged without hydrostatic test (and remarking) if more than five years has elapsed from the date of last test. Cylinders continuously in service without discharging may be retained in service for a maximum of twelve years from the date of last hydrostatic test. At the end of twelve years, they shall be discharged and retested before returning them to service.

† Secs. 178.36 and 178.37 of Title 49, Transportation, Code of Federal Regulations. Parts 171-190 (DOT). Available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20401.

1553. Each cylinder shall be provided with a safety device to relieve excess pressures, safely in advance of the rated cylinder test pressure. I.C.C. approved, frangible safety discs shall be accordingly fitted.

1154. When manifolded, cylinders shall be adequately mounted and suitably supported in a rack provided for the purpose including facilities for convenient individual servicing or content weighings. Automatic means shall be provided to prevent the loss of carbon dioxide from the manifold if the system is operated when any cylinder is removed for maintenance.

1555. Individual cylinders shall be used having a standard weight capacity of 5, 10, 15, 20, 25, 35, 50, 75 or 100 lbs. of carbon dioxide contents except for special temperature charges. See Sub-section 1556. In a multiple cylinder system, all cylinders supplying the same manifold outlet for distribution of agent shall be interchangeable and of one select size.

1556. The general ambient storage temperatures for (a) local application systems shall not exceed 120°F nor be less than 32°F and (b) total flooding systems shall not exceed 130°F nor be less than 0°F, unless the system is designed for proper operation with storage temperatures outside of this range. External heating or cooling may be used to keep the temperature within this range. When special cylinder charges are used the cylinders shall be appropriately marked.

***156. Low Pressure Storage Containers.** Low pressure storage containers shall be designed to maintain the carbon dioxide supply at a nominal pressure of 300 psi corresponding to a temperature of approximately 0° F.

1561. The pressure container shall be made, tested, approved, equipped and marked in accordance with the current specifications of the American Society of Mechanical Engineers (ASME) Code for Unfired Pressure Vessels.* The design working pressure shall be at least 325 psi.

*1562. In addition to the code requirements, each pressure container shall be equipped with a liquid level gauge, a pressure gauge, and a high-low pressure supervisory alarm set at approximately 315 and 250 psi.

* Code for Unfired Pressure Vessels for Petroleum Liquids and Gases (ASME; API-ASME). Available from The American Society of Mechanical Engineers, 345 East 47th Street, New York, New York 10017. 285 pages.

1563. The pressure container shall be insulated and equipped with refrigeration and/or heating means if necessary. Heating need not be provided unless known meteorological data indicates the occurrence of ambient temperatures which will cool the contents of the tank sufficiently to reduce the pressure below 250 psi (approximately -10°F.).

1564. The refrigeration system shall be capable of maintaining 0° F. in the pressure container under the highest expected ambient temperature. Operation shall be automatically controlled within practical limits.

1565. The heating system when required shall be capable of maintaining 0° F. in the pressure container under the lowest expected ambient temperature. Operation shall be automatically controlled within practical limits.

16. Distribution Systems.

161. Piping. Piping shall be noncombustible and shall withstand the expected temperatures without deformation. Copper or brass pipe or tubing may be used in corrosive atmospheres. In mildly corrosive atmospheres, steel pipe and fittings shall be galvanized inside and out. Special corrosion-resistant material or coatings may be required in severely corrosive atmospheres. Because of the low temperatures encountered during discharge, the pipe and fittings used shall be made of material having suitable low temperature characteristics. Steel pipe conforming to ASTM Specification A-53 has been found to have satisfactory low temperature characteristics.

*1611. Flexible piping (hose) shall be used only in accordance with the listings of a nationally recognized testing laboratory for specific carbon dioxide fire extinguishing systems. It shall be inspected regularly and replaced at certain intervals.

1612. Ordinary cast iron pipe and fittings shall not be used.

1613. Generally, welded joints, screwed or flanged fittings (malleable iron, steel, or ductile iron) are used. Flush bushings shall not be used. When hex bushings are used, more than one pipe size reduction shall be provided to maintain adequate strength. Suitable flared, compression-type, or brazed fittings shall be used with copper or brass tubing. Where brazed joints are used, the brazing alloy shall have a melting point of 1000° F or higher.

*1614. In systems using high pressure supply, pipe and fittings shall have a minimum bursting pressure of 5000 psi.

*1615. In systems using low pressure supply, pipe and fittings shall have a minimum bursting pressure of 1800 psi.

162. Arrangement and Installation of Piping and Fittings. Piping shall be installed in accordance with good commercial practices.

1621. All piping shall be laid out to reduce friction losses to a reasonable minimum and care shall be taken to avoid possible restrictions due to foreign matter or faulty fabrication.

1622. The piping system shall be securely supported with due allowance for expansion and contraction and shall not be subject to mechanical, chemical, or other damage. Where explosions are possible, the piping system shall be hung from supports that are least likely to be displaced.

1623. Pipe shall be reamed and cleaned before assembly, and after assembly the entire piping system shall be blown out before nozzles or discharge devices are installed.

1624. In systems where valve arrangement introduces sections of closed piping, such sections shall be equipped with pressure relief devices or the valves shall be designed to prevent entrapment of liquid carbon dioxide. The pressure relief devices shall operate between 2400 and 3000 psi on systems supplied with high pressure storage, and at 450 psi on systems supplied by low pressure storage. Where pressure operated cylinder valves are used, a means shall be provided to vent any cylinder gas leakage from the manifold but which will prevent loss of gas when the system operates.

1625. All pressure relief devices shall be of such design and so located that the discharge of CO_2 therefrom will not injure personnel or be otherwise objectionable.

Table 1. Equivalent Orifice Sizes.

Orifice Code No.	Equivalent Single Orifice Diameter — Inches	Equivalent Single Orifice Area–Sq. In.
—	.026	.00053
—	1/16	.00307
—	.070	.00385
—	.076	.00454
—	5/64	.0048
—	.081	.00515
—	.086	.00581
3	3/32	.0069
3+	7/64	.0094
4	1/8	.0123
4+	9/64	.0155
5	5/32	.0192
5+	11/64	.0232
6	3/16	.0276
6+	13/64	.0324
7	7/32	.0376
7+	15/64	.0431
8	1/4	.0491
8+	17/64	.0554
9	9/32	.0621
9+	19/64	.0692
10	5/16	.0767
11	11/32	.0928
12	3/8	.1105
13	13/32	.1296
14	7/16	.1503
15	15/32	.1725
16	1/2	.1964
18	9/16	.2485
20	5/8	.3068
22	11/16	.3712
24	3/4	.4418
32	1	.785
48	1 1/2	1.765
64	2	3.14

163. Valves. All valves shall be suitable for the intended use, particularly in regard to flow capacity and operation. They shall be used only under temperatures and other conditions for which they are listed or approved.

1631. Valves used in systems with high pressure storage and constantly under pressure shall have a minimum bursting pressure of 6000 psi while those not under constant pressure shall have a minimum bursting pressure of, at least, 5000 psi.

1632. Valves used in systems using low pressure storage shall withstand a hydrostatic test to 1800 psi without permanent distortion.

1633. Valves shall not be subject to mechanical, chemical or other damage.

1634. Valves shall be rated for equivalent length in terms of the pipe or tubing sizes with which they will be used. The equivalent length of cylinder valves shall include syphon tube, valve, discharge head and flexible connector.

164. Discharge Nozzles. Discharge nozzles shall be suitable for the use intended and shall be listed or approved for discharge characteristics. The discharge nozzle consists of the orifice and any associated horn, shield, or baffle.

1641. Discharge nozzles shall be of adequate strength for use with the expected working pressures, be able to resist normal mechanical damage, and constructed to withstand expected temperatures without deformation.

1642. Discharge orifices shall be of corrosion-resistant metal.

1643. Discharge nozzles used in local application systems shall be so connected and supported that they may not readily be put out of adjustment.

1644. Discharge nozzles shall be permanently marked to identify the nozzle and to show the equivalent single orifice diameter regardless of shape and number of orifices. This equivalent diameter shall refer to the orifice diameter of the "Standard" single orifice type nozzle having the same flow rate as the nozzle in question. The marking shall be readily discernible after installation. The "Standard" orifice is an orifice having a rounded entry with a coefficient of discharge not less than 0.98 and flow characteristics as given in Tables 2 and 3.

Table 2. Discharge Rate Per Square Inch of Equivalent Orifice Area for Low Pressure Storage (300 Psia).

Orifice Pressure psia	Discharge Rate Lbs./Min./Sq. In.
300	4220
290	2900
280	2375
270	2050
260	1825
250	1655
240	1525
230	1410
220	1305
210	1210
200	1125
190	1048
180	977
170	912
160	852
150	795
140	741
130	689
120	638
110	589
100	542

For equivalent orifice diameters, see Table 1. The orifice code number indicates the equivalent single orifice diameter in 1/32-inch increments. A plus sign following this number indicates equivalent diameters 1/64 inch greater than that indicated by the numbering system (e.g., No. 4 indicates an equivalent orifice diameter of 4/32 of an inch; a No. 4+, 9/64 of an inch).

1645. Discharge nozzles shall be provided with frangible discs or blow-out caps where clogging by foreign materials is likely. These devices shall provide an unobstructed opening upon system operation.

***165. Pipe and Orifice Size Determination.** Pipe sizes and orifice areas shall be selected on the basis of calculations to deliver the required rate of flow at each nozzle.

1651. The following equation or curves developed therefrom shall be used to determine the pressure drop in the pipe line:

$$Q^2 = \frac{(3647)\ (D^{5.25}Y)}{L + 8.08\ (D^{1.25}Z)}$$

Where Q = Flow rate in Lbs./Min.
D = Inside pipe diameter (actual) in inches.
L = Equivalent length of pipeline in feet.
Y & Z = Factors depending on storage and line pressure.

NOTE: For further explanation see Appendix A-165.

Table 3. Discharge Rate Per Square Inch of Equivalent Orifice Area for High Pressure Storage (750 psia).

Orifice Pressure psia	Discharge Rate Lbs./Min./Sq. In.
750	4630
725	3845
700	3415
675	3090
650	2835
625	2615
600	2425
575	2260
550	2115
525	1985
500	1860
475	1740
450	1620
425	1510
400	1400
375	1290
350	1180
325	1080
300	980
250	780
200	595

1652. For systems with low pressure storage, flow shall be calculated on the basis of an average storage pressure of 300 psia during discharge. The discharge rate for equivalent orifices shall be based on the values given in Table 2. Design nozzle pressures shall not be less than 125 psia.

1653. For systems with high pressure storage, flow shall be calculated on the basis of an average storage pressure of 750 psia during discharge for normal 70° F storage. The discharge rate through equivalent orifices shall be based on the values given in Table 3. Design nozzle pressure at 70° F storage shall not be less than 200 psia.

17. Inspection, Maintenance and Instruction.

***171. Inspection and Tests.** At least annually, all carbon dioxide systems shall be thoroughly inspected and tested for proper operation by competent personnel. See Section 173.

1711. The goal of this inspection and testing shall be not only to insure that the system is in full operating condition but shall indicate the probable continuance of that condition until the next inspection.

1712. Suitable discharge tests shall be made when any inspection indicates their advisability.

1713. An inspection report with recommendations shall be filed with the owner.

1714. Between the regular service contract inspection or tests, the system shall be inspected visually or otherwise by approved or competent personnel, following an approved schedule.

1715. At least semiannually, all high pressure cylinders shall be weighed and the date of the last hydrostatic test noted (see Par. 1552). If, at any time, a container shows a loss in net content of more than 10 per cent, it shall be refilled or replaced.

1716. At least weekly the liquid level gauges of low pressure containers shall be observed. If at any time a container shows a loss of more than 10 per cent, it shall be refilled, unless the minimum gas requirements are still provided.

172. Maintenance. These systems shall be maintained in full operating condition at all times. Use, impairment, and restoration of this protection shall be reported promptly to the authority having jurisdiction.

1721. Any troubles or impairments shall be corrected at once by competent personnel.

173. Instruction. All persons who may be expected to inspect, test, maintain, or operate carbon dioxide fire extinguishing systems shall be thoroughly trained and kept thoroughly trained in the functions they are expected to perform.

1731. Training programs approved by the authority having jurisdiction shall be established to accomplish this.

CHAPTER 2. TOTAL FLOODING SYSTEMS.

*21. General Information.

211. Description. A total flooding system consists of a fixed supply of carbon dioxide permanently connected to fixed piping, with fixed nozzles arranged to discharge carbon dioxide into an enclosed space or enclosure about the hazard.

212. Uses. This type of system may be used where there is a permanent enclosure about the hazard that is adequate to enable the required concentration to be built up, and to be maintained for the required period of time to insure the complete and permanent extinguishment of the fire in the specific combustible material or materials involved.

2121. Examples of hazards that may be successfully protected by Total Flooding Systems include rooms, vaults, enclosed machines, ovens, containers, and the contents thereof.

213. General Requirements. Total flooding systems shall be designed, installed, tested and maintained in accordance with the applicable requirements in the previous chapter and with the additional requirements set forth in this chapter.

22. Hazard Specifications.

221. Enclosure. Under this class of protection, a reasonably well enclosed space is assumed in order to minimize the loss of the extinguishing medium. The area of allowable unclosable openings depends upon the type of combustibles involved.

2211. For flash or surface-type fires such as will be present with flammable liquids, the total square foot area of unclosable openings not exceeding 3 per cent of the cubic foot volume of the space or 10 per cent of the total square foot area of all sides top and bottom of the enclosure, whichever is smaller, shall be compensated for by additional carbon dioxide as specified in Sub-section 2351. If this area is exceeded the system shall be tested to assure proper performance.

2212. For deep seated fires such as will be involved with solids, unclosable openings shall be restricted to small openings near or in the ceiling unless the system is tested to assure proper performance.

2213. To prevent fire from spreading through openings to adjacent hazards or work areas which may be possible re-ignition sources, such openings shall be provided with automatic closures or screening nozzles. The gas required for such protection shall be in addition to the normal requirement for total flooding. See Sub-section 3436. Where such confinement of gas is impracticable, protection shall be extended to include these adjacent hazards or work areas.

2214. In the case of process and storage tanks where safe venting of flammable vapors and gases cannot be realized, the use of external local application systems outlined in Sub-section 3436 is required.

222. Leakage and Ventilation. Since the efficiency of carbon dioxide systems depends upon the maintenance of an extinguishing concentration of carbon dioxide, leakage of gas from the space shall be kept to a minimum and compensated for by applying extra gas.

2221. Where possible, openings such as doorways, windows, etc., shall be arranged to close automatically before or simultaneously with the start of the carbon dioxide discharge or Sub-sections 2351 and 2441 shall be followed.

2222. Where forced air ventilating systems are involved, they shall be preferably shut down and/or closed before or simultaneously with the start of the carbon dioxide discharge or additional compensating gas be provided. See Sub-section 2352.

***223. Types of Fires.** Fires which can be extinguished by total flooding methods may be divided into two categories; namely, (1) surface fires involving flammable liquids, gases and solids and (2) deep seated fires involving solids subject to smoldering.

2231. Surface fires are the most common hazard particularly adaptable to extinguishment by total flooding systems. They are subject to prompt extinguishment when carbon dioxide is quickly introduced into the enclosure in sufficient quantity to overcome leakage and provide an extinguishing concentration for the particular materials involved.

2232. For deep seated fires, the required extinguishing concentration shall be maintained for a sufficient period of time to allow the smoldering to be extinguished and the material to cool to a point at which reignition will not occur when the inert atmosphere is dissipated. In any event, it is necessary to inspect the hazard immediately thereafter to make certain that extinguishment is complete and to remove any material involved in the fire.

*23. Carbon Dioxide Requirements for Surface Fires.

231. General. The quantity of carbon dioxide for surface type fires is based on average conditions assuming fairly prompt extinguishment. A reasonable allowance for normal leakage is included in the basic volume factors but corrections shall be made for the type material involved and any other special conditions.

232. Flammable Materials. Proper consideration shall be given to the determination of the design concentration of carbon dioxide required for the type of flammable material involved in the hazard. The design concentration is determined by adding a suitable factor (20%) to the minimum effective concentration.

2321. Table 4 gives the theoretical minimum carbon dioxide concentration and the suggested minimum design carbon dioxide concentration to prevent ignition of some common liquids and gases.

2322. For materials not given in the above table, the minimum theoretical carbon dioxide concentration shall be obtained from some recognized source or determined by test. If maximum residual oxygen values are available, the theoretical carbon dioxide concentration may be calculated by the following formula:

$$\%CO_2 = \frac{(21-O_2)}{21} \times 100$$

Table 4. Minimum Carbon Dioxide Concentrations for Extinguishment.

Material	Theoretical Min. CO_2 Concentration (%)	Minimum Design CO_2 Concentration (%)
Acetylene	55	66
Acetone	26*	31
Benzol, Benzene	31	37
Butadiene	34	41
Butane	28	34
Carbon Disulphide	55	66
Carbon Monoxide	53	64
Coal or Natural Gas	31*	37
Cyclopropane	31	37
Dowtherm	38*	46
Ethane	33	40
Ethyl Ether	38*	46
Ethyl Alcohol	36	43
Ethylene	41	49
Ethylene Dichloride	21	25
Ethylene Oxide	44	53
Gasoline	28	34
Hexane	29	35
Hydrogen	62	74
Isobutane	30*	36
Kerosene	28	34
Methane	25	30
Methyl Alcohol	26	31
Pentane	29	35
Propane	30	36
Propylene	30	36
Quench, Lube Oils	28	34

NOTE: The theoretical minimum extinguishing concentrations in air for the above materials, were obtained from Bureau of Mines, Bulletin 503†. Those marked * were calculated from accepted residual oxygen values.

Limits of Flammability of Gases and Vapors (Bulletin 503, Bureau of Mines). Available from U. S. Government Printing Office, Washington, D. C. 20401 155 pages.

233. Volume Factor. The volume factor used to determine the basic quantity of carbon dioxide to protect an enclosure containing a material requiring a design concentration up to 34 per cent shall be in accordance with Table 5.

2331. In figuring the net cubic capacity to be protected, due allowance may be made for permanent nonremovable impermeable structures materially reducing the volume.

Table 5. Volume Factors.

(A) Volume of Space (Cu. Ft. Incl.)	(B) Volume Factor (Cu. Ft./Lb. CO_2)	(B) Volume Factor (Lb. CO_2/Cu. Ft.)	(C) Calculated Quan. (Lb.) Not Less Than
Up to 140	14	.072	—
141 – 500	15	.067	10
501 – 1600	16	.063	35
1601 – 4500	18	.056	100
4501 – 50000	20	.050	250
Over 50000	22	.046	2500

2332. As the average small space has proportionately more boundary area per enclosed volume than a larger space, greater proportionate leakages are anticipated and accounted for by the graded volume factors in Table 5.

2333. The least gas quantities for the smallest volumes are tabulated in order to clarify the intent of Column B and thus avoid possible overlapping at borderline volumes.

2334. In two or more interconnected volumes where "free flow" of carbon dioxide can take place, the carbon dioxide quantity shall be the sum of the quantities calculated for each volume, using its respective volume factor from Table 5. If one volume requires greater than normal concentration (See Section 234), the higher concentration shall be used in all interconnected volumes.

234. Material Conversion Factor. For materials requiring a design concentration over 34 per cent, the basic quantity of carbon dioxide calculated from the volume factor given in Section 233 shall be increased by multiplying this quantity by the appropriate conversion factor given in Figure 1.

235. Special Conditions. Additional quantities of carbon dioxide shall be provided to compensate for any special condition that may adversely affect the extinguishing efficiency.

*2351. Any openings that cannot be closed at the time of extinguishment shall be compensated for by the addition of not less than 1 pound of carbon dioxide per square foot of opening. This amount of carbon dioxide shall be applied

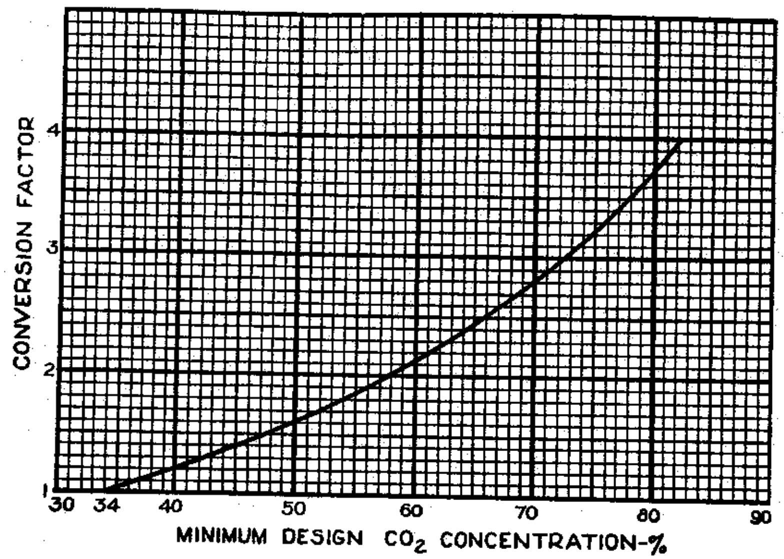

Figure 1. Material conversion factors.

through the regular distribution system. See Sub-section 2211.

2352. For ventilating systems which cannot be shut down, additional carbon dioxide shall be added to the space through the regular distribution system in an amount computed by dividing the volume moved during the liquid discharge period by the flooding factor. This shall be multiplied by the material conversion factor (determined in Section 234) when the design concentration is greater than 34 per cent.

*2353. For applications where the normal temperature of the enclosure is above 200° F, a one per cent increase in the calculated total quantity of carbon dioxide shall be provided for each additional 5° F above 200° F.

2354. For applications where the normal temperature of the enclosure is below 0° F, a one per cent increase in the calculated total quantity of carbon dioxide shall be provided for each degree below 0° F.

2355. Under normal conditions, surface fires are usually extinguished during the discharge period. Except for unusual conditions, it will not be necessary to provide extra carbon dioxide to maintain the concentration.

24. Carbon Dioxide Requirements for Deep Seated Fires.

241. General. The quantity of carbon dioxide for deep seated type fires is based on fairly tight enclosures because the concentration must be maintained for a substantial period of time to assure complete extinguishment. Any possible leakage shall be given special consideration since no allowance is included in the basic flooding factors.

242. Combustible Materials. For combustible materials capable of producing deep seated fires, the required carbon dioxide concentrations cannot be determined with the same accuracy possible with surface burning materials. The extinguishing concentration will vary with the mass of material present because of the thermal insulating effects. Flooding factors have, therefore, been determined on the basis of practical test conditions.

2421. The flooding factors in Table 6 have been established for specific hazards under average use and storage conditions.

Table 6. Flooding Factors for Specific Hazards.

Design Concentration	Flooding Factor (Cu. Ft./Lb. CO_2)	Flooding Factor (Lb. CO_2/Cu. Ft.)	Specific Hazard
50	12	.083	Dry electrical, wiring insulation hazards in general.
50	10	.100	Small elec. machines, wire enclosures, under 2000 cu. ft.
65	8	.125	Record (bulk paper) storage, ducts, and mechanically ventilated covered trenches.
75	6	.166	Fur storage vaults, dust collectors.

2422. Flooding factors for other deep-seated fires shall be justified to the satisfaction of the authority having jurisdiction before use. Proper consideration shall be given to the mass of material to be protected because the rate of cooling is reduced by the thermal insulating effects.

243. Volume Consideration. The volume of the space shall be determined in accordance with Sub-section 2331. The basic quantity of carbon dioxide required to protect an enclosure shall be obtained by treating the volume of the enclosure by the appropriate flooding factor given in Section 242.

244. Special Conditions. Additional quantities of carbon dioxide shall be provided to compensate for any special condition that may adversely affect the extinguishing efficiency. See also Sub-sections 2352, 2353 and 2354.

2441. Any openings that cannot be closed at the time of extinguishment shall be compensated for by the addition of carbon dioxide equal in volume to the expected leakage volume during the extinguishing period. If leakage is appreciable, consideration shall be given to an extended discharge system as covered in Section 253. Also see Sub-section 2212.

25. Distribution System.

251. General. The distribution system for applying carbon dioxide to enclosed hazards shall be designed with due consideration for the materials involved and the nature of the enclosure since these items may require various discharge times and rates of application.

***252. Rate of Application.** The minimum design rate of application shall be based on the quantity of carbon dioxide and the maximum time to achieve design concentration.

2521. For surface fires the design concentration shall be achieved within one minute.

2522. For high pressure systems, if a part of the hazard is to be protected by total flooding, the discharge rate for the total flooding portion shall be computed as specified in Sub-section 3323.

2523. For deep-seated fires the design concentration shall be achieved within seven minutes but the rate shall not be less than that required to develop a concentration of 30 per cent in 2 minutes.

253. Extended Rate of Application. Where leakage is appreciable and the design concentration must be obtained quickly and maintained for an extended period of time, carbon dioxide provided for leakage compensation may be applied at a reduced rate.

2531. This type of system is particularly applicable to enclosed rotating electrical apparatus, such as generators, motors and convertors, but it may also be used on ordinary total flooding applications where suitable.

2532. The minimum design concentration shall be obtained within the time limits specified in Section 252.

2533. The extended rate of discharge shall be sufficient to maintain the minimum concentration.

*2534. For enclosed rotating electrical equipment a minimum concentration of 30 per cent shall be maintained for the deceleration period, but not less than 20 minutes.

254. Piping Systems. Piping shall be designed in accordance with Section 165 to deliver the required rate of application at each nozzle.

*2541. High pressure storage temperatures may range from 0° F to 130° F without requiring special methods of compensating for changing flow rates. See Appendix A.

255. Nozzle Sizing and Distribution. Nozzles used in connection with total flooding systems with either high or low pressure supply shall be of a type suitable for the intended purpose, and shall be located to achieve the best results.

2551. The type of nozzles selected and their placement shall be such that the discharge will not unduly splash flammable liquids or create dust clouds that might extend the fire, create an explosion, or otherwise adversely affect the contents of the enclosure. Nozzles vary in design and discharge characteristics and shall be selected on the basis of their adequacy for the use intended.

26. Venting Consideration.

261. General. The venting of flammable vapors and pressure build-up from the discharge of quantities of carbon dioxide into closed spaces shall be considered. Venting of flammable vapors is covered in Sub-section 2214. The pressure venting consideration involves such variables as enclosure strength and injection rate.

262. Pressure Relief Venting. Porosity and leakages such as at doors, windows, and dampers, though not readily apparent or easily calculated have been found to provide sufficient relief for the normal carbon dioxide flooding systems without need for additional venting. Record storage rooms, refrigerated spaces, and duct work have also been found to need no additional venting when tested under their average system conditions.

2621. For very tight enclosures, the area necessary for free venting shall be calculated from the following formula. Assuming the expansion of carbon dioxide to be 9 cu ft/lb will give satisfactory results.

$$X = \frac{Q}{1.3\sqrt{P}}$$

where: X = Free venting area in sq. in.
Q = Calculated carbon dioxide flow rate in lbs./min.
P = Allowable strength of enclosure in lbs./sq. ft.

2622. In many instances, particularly when hazardous materials are involved, relief openings are already provided for explosion venting. These and other available openings often provide adequate venting.

2623. General construction practices provide the guide in Table 7 for considering the normal strength and allowable pressures of average enclosures.

Table 7. Strength and Allowable Pressures for Average Enclosures.

Type Construction	Windage	Pressure	In. Water	PSI
Light Building	100 MPH	25 lb./sq. ft.*	5	.175
Normal Building	140 MPH	50 lb./sq. ft.†	10	.35
Vault Building	200 MPH	100 lb./sq. ft.	20	.70

* Venting sash remains closed.

† Venting sash designed to open freely.

CHAPTER 3. LOCAL APPLICATION SYSTEMS.

*31. General Information.

311. Description. A local application system consists of a fixed supply of carbon dioxide permanently connected to a system of fixed piping with nozzles arranged to discharge directly into the fire.

312. Uses. Local application systems may be used for the extinguishment of surface fires in flammable liquids, gases, and shallow solids where the hazard is not enclosed or where the enclosure does not conform to the requirements for total flooding.

3121. Examples of hazards that may be successfully protected by Local Application Systems include dip tanks, quench tanks, spray booths, oil-filled electric transformers, vapor vents, etc.

313. General Requirements. Local application systems shall be designed, installed, tested and maintained in accordance with the applicable requirements in previous chapters and with the additional requirements set forth in this chapter.

32. Hazard Specifications.

321. Extent of Hazard. The hazard shall be so isolated from other hazards or combustibles that fire will not spread outside the protected area. The entire hazard shall be protected. The hazard shall include all areas that are or may become coated by combustible liquids or shallow solid coatings such as areas subject to spillage, leakage, dripping, splashing, or condensation, and all associated materials or equipment such as freshly coated stock, drain boards, hoods, ducts, etc., that might extend fire outside or lead fire into the protected area.

3211. A series of interexposed hazards may be subdivided into smaller groups or sections with the approval of the authority having jurisdiction. Systems for such hazards shall be designed to give immediate independent protection to adjacent groups or sections as needed.

322. Location of Hazard. The hazard may be indoors, partly sheltered or completely out of doors. It is essential that the carbon dioxide discharge shall be such that winds or strong air currents do not impair the protection.

33. Carbon Dioxide Requirements.

***331. General.** The quantity of carbon dioxide required for local application systems shall be based on the total rate of discharge needed to blanket the area or volume protected and the time that the discharge must be maintained to assure complete extinguishment.

*3311. For systems with high pressure storage, the computed quantity of carbon dioxide shall be increased by 40 per cent to determine nominal cylinder storage capacity since only the liquid portion of the discharge is effective. This increase in cylinder storage capacity is not required for the total flooding portion of combined local application-total flooding systems.

*3312. Where long pipelines are involved or where the piping may be exposed to higher than normal temperatures, the quantity shall be increased by an amount sufficient to compensate for liquid vaporized in cooling the piping.

332. Rate of Discharge. Nozzle discharge rates shall be determined by either the surface method or the volume method as covered in Articles 34 and 35.

3321. The total rate of discharge for the system shall be the sum of the individual rates of all the nozzles or discharge devices used on the system.

3322. For low pressure systems, if a part of the hazard is to be protected by total flooding, the discharge rate for the total flooding part shall be sufficient to develop the required concentration in not more than the discharge time used for the local application part of the system.

3323. For high pressure systems, if a part of the hazard is to be protected by total flooding, the discharge rate for the total flooding part shall be computed by dividing the quantity required for total flooding by the factor 1.4 and by the time of the local application discharge in minutes.

$$Q_F = \frac{W_F}{1.4\, T_L}$$

Where: Q_F = Rate of flow for the total flooding portion in lbs./min.

W_F = Total quantity of carbon dioxide for the total flooding portion in pounds.

T_L = Liquid discharge time for the local application portion in minutes.

***333. Duration of Discharge.** The minimum effective discharge time for computing quantity shall be 30 seconds. The minimum time shall be increased to compensate for any hazard condition that would require a longer cooling period to assure complete extinguishment.

*3331. Where there is a possibility that metal or other material may become heated above the ignition temperature of the fuel, the effective discharge time shall be increased to allow adequate cooling time. This is especially important with paraffin wax and other materials having low autoignition temperatures.

34. Rate by Area Method.

341. General. The area method of system design is used where the fire hazard consists primarily of flat surfaces or low level objects associated with horizontal surfaces.

3411. System design shall be based on listing or approval data for individual nozzles. Extrapolation of such data above or below the upper or lower limits shall not be permitted.

342. Nozzle Discharge Rates. The design discharge rate through individual nozzles shall be determined on the basis of location or projection distance in accordance with specific approvals or listings.

*3421. The discharge rate for overhead type nozzles shall be determined solely on the basis of distance from the surface each nozzle protects.

*3422. The discharge rate for tankside nozzles shall be determined solely on the basis of throw or projection required to cover the surface each nozzle protects.

343. Area Per Nozzle. The maximum area protected by each nozzle shall be determined on the basis of location or projection distance and the design discharge rate in accordance with specific approvals or listings.

3431. The same factors used to determine the design discharge rate shall be used to determine the maximum area to be protected by each nozzle.

3432. The portion of the hazard protected by individual overhead type nozzles shall be considered as a square area.

3433. The portion of the hazard protected by individual tankside or linear nozzles may be either a rectangular or a square area in accordance with spacing and discharge limitations stated in specific approvals or listings.

3434. When coated rollers or other similar irregular shapes are to be protected, the projected wetted area may be used to determine nozzle coverage.

3435. Where coated surfaces are to be protected, the area per nozzle may be increased by 40 per cent over the areas given in specific approvals or listings. Coated surfaces are defined as those designed for drainage which are constructed and maintained so that no pools of liquid will accumulate over a total area exceeding 10 per cent of the protected surface. This Sub-section does not apply where there is a heavy build-up of residue. See Sub-section 312.

3436. Where local application nozzles are used for protection across openings as defined in Sub-sections 2213 and 2214, the area per nozzle given by specific approval or listing may be increased 20 per cent.

3437. When deep layer flammable liquid fires are to be protected, a minimum freeboard of 6 inches shall be provided unless otherwise noted in approvals or listings of nozzles.

344. Location and Number of Nozzles. A sufficient number of nozzles shall be used to adequately cover the entire hazard area on the basis of the unit areas protected by each nozzle.

3441. Tankside or linear type nozzles shall be located in accordance with spacing and discharge rate limitations stated in specific approvals or listings.

3442. Overhead type nozzles shall be installed perpendicular to the hazard and centered over the area protected by the nozzle. They may also be installed at angles between 45 and 90 degrees from the plane of the hazard surface as prescribed in Sub-section 3443. The height used in determining the necessary flow rate and area coverage shall be the distance from the aiming point on the protected surface to the face of the nozzle measured along the axis of the nozzle.

3443. When installed at an angle, nozzles shall be aimed at a point measured from the near side of the area protected by the nozzle, the location of which is calculated by multiplying the fractional aiming factor in Table 8 by the width of the area protected by the nozzle.

Table 8. Aiming Factors for Angular Placement of Nozzles, Based on 6-Inch Freeboard.

Discharge Angle†	Aiming Factor*
45-60°	¼
60-75	¼-⅜
75-90	⅜-½
90 (perpendicular)	½ (center)

†Degrees from plane of hazard surface.
*Fractional amount of nozzle coverage area.

3444. Nozzles shall be located so as to be free of possible obstructions that could interfere with the proper projection of the discharged carbon dioxide.

3445. Nozzles shall be located so as to develop an extinguishing atmosphere over coated stock extending above a protected surface. Additional nozzles may be required for this specific purpose particularly if stock extends more than 2 feet above a protected surface.

3446. The possible effects of air currents, winds and forced drafts shall be compensated for by properly locating nozzles or by providing additional nozzles to adequately protect the outside areas of the hazard.

35. Rate by Volume Method.

351. General. The volume method of system design is used where the fire hazard consists of three dimensional irregular objects that cannot be easily reduced to equivalent surface areas.

352. Assumed Enclosure. The total discharge rate of the system shall be based on the volume of an assumed enclosure entirely surrounding the hazard.

3521. The assumed enclosure shall be based on an actual closed floor unless special provisions are made to take care of bottom conditions.

3522. The assumed walls and ceiling of this enclosure shall be at least 2 feet from the main hazard unless actual walls are involved and shall enclose all areas of possible leakage, splashing or spillage.

3523. No deductions shall be made for solid objects within this volume.

3524. A minimum dimension of 4 feet shall be used in calculating the volume of the assumed enclosure.

3525. If the hazard may be subjected to winds or forced drafts, the assumed volume shall be increased to compensate for losses on the windward sides.

353. System Discharge Rate. The total discharge rate for the basic system shall be equal to 1 lb./min./cu. ft. of assumed volume.

3531. If the assumed enclosure has a closed floor and is partly defined by permanent continuous walls extending at least 2 feet above the hazard (where the walls are not normally a part of the hazard), the discharge rate may be proportionately reduced to not less than 0.25 lbs./min./cu. ft. for actual walls completely surrounding the enclosure.

354. Location and Number of Nozzles. A sufficient number of nozzles shall be used to adequately cover the entire hazard volume on the basis of the system discharge rate as determined by the assumed volume.

3541. Nozzles shall be located and directed so as to retain the discharged carbon dioxide in the hazard volume by suitable cooperation between nozzles and objects in the hazard volume.

3542. Nozzles shall be located so as to compensate for any possible effects of air currents, winds or forced drafts.

3543. The design discharge rates through individual nozzles shall be determined on the basis of location or projection distance in accordance with specific approvals or listings for surface fires.

3544. Special purpose nozzles may have discharge rates based on other factors.

36. Distribution System.

361. General. The system shall be designed to provide an effective discharge of carbon dioxide promptly before excessive amounts of heat can be absorbed by materials within the hazard.

3611. The carbon dioxide supply shall be located as near to the hazard as practicable and yet not exposed to the fire, and the pipe line shall be as direct as practicable with a minimum number of turns in order to get carbon dioxide to the fire promptly.

3612. The system shall be designed for automatic operation except where the authorities having jurisdiction permit manual operation.

362. Piping Systems. Piping shall be designed in accordance with Section 165 to deliver the required rate of application at each nozzle.

*3621. High pressure storage temperatures may range from 32° F to 120° F without requiring special methods of compensating for changing flow rates.

363. Discharge Nozzles. The nozzles used shall be listed or approved for rate of discharge, effective range, and pattern or area coverage.

3631. The equivalent orifice size used in each nozzle shall be determined in accordance with Section 165 to match the design discharge rate.

3632. Nozzles shall be accurately located and directed in accordance with the system design requirements as covered in Sections 34 and 35.

CHAPTER 4. HAND HOSE LINE SYSTEMS.

41. General Information.

411. Description. Hand hose line systems consist of a hose reel or rack, hose, and discharge nozzle assembly connected by fixed piping to a supply of carbon dioxide. A separate carbon dioxide supply can be provided for hand hose line use or carbon dioxide can be piped from a central storage unit which may be supplying several hose lines or fixed manual or automatic systems. See Sub-section 1511.

412. Uses. Hand hose line systems may be used to supplement fixed fire protection systems or to supplement first aid fire extinguishers for the protection of specific hazards for which carbon dioxide is a suitable extinguishing agent. These systems shall not be used as a substitute for other fixed carbon dioxide fire extinguishing systems equipped with fixed nozzles, except where the hazard cannot adequately or economically be provided with fixed protection. The decision as to whether hose lines are applicable to the particular hazard shall rest upon the authority having jurisdiction.

413. General Requirements. Hand hose line systems shall be installed and maintained in accordance with the applicable requirements of Chapters 1, 2, and 3 except as outlined below.

42. Hazard Specifications.

421. Hand hose line systems may be used to combat fires in all hazards covered under Chapter 1, except those which are inaccessible and beyond the scope of manual fire fighting.

43. Location and Spacing.

431. Location. Hand hose line stations shall be placed such that they are easily accessible and within reach of the most distant hazard which they are expected to protect. In general, they shall not be located such that they are exposed to the hazard.

432. Spacing. If multiple hose stations are used, they shall be spaced so that any area within the hazard may be covered by one or more hose lines.

44. Carbon Dioxide Requirements.

441. **Rate and Duration of Discharge.** The rate and duration of discharge and consequently the amount of carbon dioxide shall be determined by the type and potential size of the hazard. A hand hose line shall have a sufficient quantity of carbon dioxide to permit its use for at least one minute.

442. **Provision for Use by Inexperienced Personnel.** The possibility of these hose lines being used by inexperienced personnel shall be considered and adequate provision made so that there will be a sufficient supply of carbon dioxide to enable them to effect extinguishment of the hazards that they are likely to encounter.

443. **Simultaneous Use Of Hose Lines.** Where simultaneous use of two or more hose lines is possible, a sufficient quantity of carbon dioxide shall be available to supply the maximum number of nozzles that are likely to be used at any one time for at least one minute.

45. Equipment Specifications.

451. **Hose.** Hose lines on systems with high pressure supply shall have a minimum bursting pressure of 5000 psi, and hose lines of systems with low pressure supply shall have a minimum bursting pressure of 1800 psi.

452. **Discharge Nozzle Assembly.** Hose lines shall be equipped with a discharge nozzle assembly which can be easily handled by one man and which contains a quick opening shut-off valve to control the flow of carbon dioxide through the nozzle and a suitable handle for directing the discharge. The attachment of the discharge nozzle assembly to the hose by means of a swivel connection is desirable for providing more ease of manipulation.

453. **Hose Line Storage.** The hose shall be coiled on a hose reel or rack such that it will be ready for immediate use without the necessity of coupling and such that it may be uncoiled with a minimum of delay. If installed outdoors, it shall be protected against the weather.

454. **Charging the Hose Line.** Operation of hand hose line systems depends upon manual actuation and manual manipulation of a discharge nozzle. Speed and simplicity of operation is, therefore, essential for successful extinguishment.

4541. All controls for actuating the system shall be located in the immediate vicinity of the hose reel.

4542. The carbon dioxide supply shall be located as close to the hose reel as possible so that liquid carbon dioxide will be supplied to the hose line with a minimum of delay after actuation.

4543. Except when in actual use, pressure shall not be permitted to remain in the hose line.

46. Training.

461. Successful extinguishment of fire with hand hose lines is greatly dependent upon the individual ability and technique of the operator. All personnel who are likely to use this equipment at the time of a fire shall be properly trained in its operation and in the fire fighting techniques applicable to this equipment.

CHAPTER 5. STANDPIPE SYSTEMS AND MOBILE SUPPLY.

51. General Information.

511. Description. A standpipe system is a fixed total flooding, local application, or hand hose line system without a permanently connected carbon dioxide supply. The carbon dioxide supply is mounted on a mobile vehicle which can be towed or driven to the scene of a fire and quickly coupled to the standpipe system protecting the involved hazard. Mobile supply is primarily fire brigade or fire department equipment requiring trained personnel for effective use.

512. Uses. Standpipe systems and mobile supply may be used to supplement complete fixed fire protection systems or may be used alone for the protection of the specific hazards outlined below. Mobile supply may be used as a reserve to supplement a fixed supply. Mobile supply may also be outfitted with hand hose lines for the protection of scattered hazards. These systems shall be installed only with the approval of the authority having jurisdiction.

513. General Requirements. Standpipe systems and mobile supply shall be installed and maintained in accordance with the requirements in Chapters 1, 2, 3 and 4 in addition to those outlined below. Piping shall be installed in accordance with the requirements applicable for the system if a permanently connected supply were used. Appreciable lengths of piping on the portable supply shall be taken into account.

52. Hazard Specifications.

521. Standpipe systems and mobile supply may be used to protect hazards, included in Chapters 1, 2, 3 and 4, where extinguishment will not be adversely affected by the delay in obtaining effective discharge of carbon dioxide while the mobile supply is being brought to the scene and coupled to the standpipe system.

53. Standpipe Requirements.

531. The supply piping of standpipe systems shall be equipped with quick-change couplings and shall terminate in an

easily accessible and well marked location for connection to the mobile supply. This location shall also be marked with the amount of carbon dioxide required and the required duration of discharge.

54. Mobile Supply Requirements.

541. Capacity. The mobile supply shall have a capacity in accordance with the provisions of Chapters 1, 2, 3, and 4. Extra quantities may be required to compensate for delay in getting mobile supply to the hazard.

542. Coupling. The mobile supply shall be provided with suitable means for transferring carbon dioxide into the standpipe system. Quick-change couplings shall be provided to permit these connections to be made as rapidly as possible.

543. Mobility. The storage container or containers of carbon dioxide shall be mounted on a movable vehicle which may be brought to the scene of the fire by manual means, by a separate motor vehicle, or under its own power. The means of transporting the mobile supply shall be dependable and capable of getting to the fire with a minimum of delay.

544. Location. The mobile supply shall be kept close at hand to the hazards it is intended to protect in order that fire extinguishment may be started as soon as possible after the fire breaks out.

545. Accessories. Mobile supply for standpipe systems may be provided with hand hose lines as accessory equipment for the protection of small scattered hazards, or as a supplement to standpipe systems or other fixed protection.

55. Training.

551. The effectiveness of fire protection provided by standpipe systems and mobile supply depends upon the efficiency and ability of the manpower which handles the mobile supply. It is therefore imperative that those persons assigned to the units shall be properly trained in its use and maintenance. Generally, this equipment is in the category of fire brigade or fire department equipment requiring a regularly assigned crew.

Standard for

Dry Chemical Extinguishing Systems

NFPA 17 — 1975

NOTICE: An asterisk (*) preceding the number or letter designating a subdivision indicates explanatory material on that subdivision in Appendix A.

Chapter 1 Introduction

***1-1 Scope.** This standard includes minimum requirements for dry chemical fire extinguishing systems which discharge dry chemical from fixed nozzles and piping or from hose lines by means of expellant gas. It contains only the essentials and suggesions to make the standard workable in the hands of those skilled in this field. Portable dry chemical equipment is covered in the *Standard for the Installation, Maintenance and Use of Portable Fire Extinguishers* (NFPA 1 —1974).

1-2 Purpose. This standard is prepared for use and guidance to those charged with the purchasing, designing, installing, testing, inspecting, approving, listing, operating or maintaining dry chemical fire extinguishing systems, in order that such equipment will function as intended throughout its life.

1-2.1 Only those skilled in this field are competent to design and install this equipment. It may be necessary for many of those charged with the purchasing, inspecting, testing, approving, operating, and maintaining this equipment to consult an experienced fire protection engineer, competent in this field, in order to effectively discharge their respective duties.

1-3 Definitions. For the purpose of clarification, the following general terms used with special technical meanings in this standard are defined.

Authority Having Jurisdiction is the organization, office, or individual responsible for "approving" equipment, an installation, or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA standards in a broad manner since jurisdictions and "approval" agencies vary as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, health department, building official, electrical inspector, or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances the property owner or his delegated agent assumes the role of the authority having jurisdiction; at government installations the commanding officer or a departmental official may be the authority having jurisdiction.

Calculation and Design refers to the process of computing, with the use of equations, graphs, or tables, the system characteristics such as flow rate, nozzle pressure, and pressure drop. This information is not required for listed pre-engineered systems.

Dry Chemical is a powder composed of very small particles usually of sodium bicarbonate, potassium bicarbonate, urea-based potassium bicarbonate, potassium chloride, or monoammonium phosphate with added particulate material supplemented by special treatment to provide resistance to packing, resistance to moisture absorption (caking) and the proper flow capabilities.

Engineered Systems are those requiring individual calculation and design to determine the flow rates, nozzle pressures, quantities of dry chemical, and the number and types of nozzles and their placement in a specific system.

Multipurpose Dry Chemical is usually monoammonium phosphate-based and is effective on fires in ordinary combustibles, such as wood or paper, as well as on fires in flammable liquids, etc.

Pre-Engineered Systems (sometimes known as "Package" Systems) are those having predetermined flow rates, nozzle pressures, and quantities of dry chemical. These systems have the specific pipe size, maximum and minimum pipe lengths, flexible hose specifications, number of fittings and number and types of nozzles prescribed by a nationally recognized testing laboratory. The hazards protected by these systems are specifically limited as to type and size by a nationally recognized testing laboratory based upon actual fire tests.

Chapter 2 General Information and Requirements

***2-1 Dry Chemical.** The type of dry chemical used in the system shall not be changed unless proved to be changeable by a nationally recognized testing laboratory, recommended by the manufacturer of the equipment, and approved by the authority having jurisdiction. Systems are designed on the basis of the flow and extinguishing characteristics of a specific make and type of dry chemical.

CAUTION: Types of dry chemical shall not be mixed. Mixtures of certain dry chemicals will generate dangerous pressures and will form lumps.

2-2 Use and Limitations.

***2-2.1 Use.** Types of hazards and equipment for which dry chemical extinguishing systems shall be considered satisfactory protection include the following:

(a) Flammable or combustible liquids and combustible gases.

CAUTION: Extinguishment of uncontrolled discharge of flammable liquids or combustible gases may result in a subsequent explosion hazard.

(b) Combustible solids having burning characteristics similar to naphthalene and pitch, which melt when involved in fire.

(c) Flammable liquids, combustible liquids, or combustible gases released from transfer or loading facilities.

(d) Electrical hazards such as transformers or oil circuit breakers.

(e) Textile operations subject to flash surface fires. Where bicarbonate base dry chemical is used, water shall be provided to extinguish possible smoldering or deep seated fire.

(f) Ordinary combustibles such as wood, paper, or cloth using multipurpose dry chemical when it can reach all surfaces involved in combustion.

(g) Kitchen hoods, ducts and associated range-top hazards such as deep fat fryers. [*See also 4-4.1 and A-2-1(3).*] For other specific details, see *Standard for the Installation of Equipment for the Removal of Smoke and Grease-Laden Vapor from Commercial Cooking Equipment* (NFPA 96–1973).

(h) Some plastics depending upon the type of material and their configuration of hazard. For more specific information, consult the manufacturer of the equipment.

2-2.2 Limitations. Types of materials for which dry chemical extinguishing systems shall not be considered satisfactory protection include the following:

(a) Chemicals containing their own oxygen supply such as cellulose nitrate.

(b) Combustible metals such as sodium, potassium, magnesium, titanium, and zirconium. Dry powder systems listed by a nationally recognized testing laboratory for combustible metal fires may be used.

(c) Deep-seated or burrowing fires in ordinary combustibles where the multipurpose dry chemical cannot reach the point of combustion.

2-2.2.1 Before dry chemical extinguishing equipment is considered for use to protect electronic equipment or delicate electrical relays, the effect of residual deposits of dry chemical on the performance of this equipment shall be evaluated.

2-2.2.2 Multipurpose dry chemical shall not be considered satisfactory for use on machinery such as carding equipment in textile operations and delicate electrical equipment because, upon exposure to temperatures in excess of 250°F or relative humidity in excess of 50%, deposits will be formed which may be difficult to remove.

***2-2.2.3** Dry chemical, when discharged, will drift from the immediate discharge area and settle on surrounding surfaces. Prompt cleanup will minimize possible staining or corrosion of certain materials which may take place in the presence of moisture.

2-3 Systems Protecting One or More Hazards.

2-3.1 Where, in the opinion of the authority having jurisdiction, two or more hazards may be simultaneously involved in fire by reason of their proximity, the hazards shall be protected by individual systems installed to operate simultaneously, or by a single system designed to protect all hazards that may be simultaneously involved.

2-3.2 Where hand hose lines may be used on a hazard that is also protected by a fixed system, separate dry chemical supplies shall be provided.

2-3.3 A single dry chemical supply shall be used for both a hand hose line system and a fixed nozzle system only if the hazards protected by the two systems are separated so that the hand hose lines cannot be used on the hazard protected by the fixed nozzle system, and the probability of fire occurring simultaneously in both hazards is slight.

*2-4 Personnel Safety.

2-4.1 Safety Requirements. In total flooding systems where there is a possibility that personnel may be exposed to a dry chemical discharge, suitable safeguards shall be provided to ensure prompt evacuation of such locations, and also to provide means for prompt rescue of any trapped personnel. Such safety items as personnel training, warning signs, discharge alarms, predischarge alarms, and respiratory protection shall be considered. In local application systems where the dry chemical is likely to discharge upon personnel, such as in loading racks, discharge alarms and special personnel training shall be provided.

CAUTION: Hazards to Personnel. The discharge of large amounts of dry chemical may create hazards to personnel such as reduced visibility and temporary breathing difficulty.

2-4.2 When stored-pressure or cartridge operated dry chemical cylinders are not attached to piping, the discharge outlet shall be provided with a protective diffusing safety cap to protect personnel from recoil and high flow discharge in case of accidental actuation. Such protective caps shall also be used on empty cylinders to protect threads. These caps shall be provided by the manufacturer of the equipment.

2-4.3 All system components shall be so located as to maintain minimum clearances from live parts as shown in the following table.

As used in this standard, "clearance" is the air distance between dry chemical equipment, including piping and nozzles, and unenclosed or uninsulated live electrical components at other than ground potential.

The clearances given are for altitudes of 3,300 ft. or less. At altitudes in excess of 3,300 ft., the clearance shall be increased at the rate of 1 percent for each 330 ft. increase in altitude above 3,300 ft.

The clearances are based upon minimum general practices related to design Basic Insulation Level (BIL) values. To coordinate the required clearance with the electrical design, the design BIL of the equipment being protected shall be used as a basis, although this is not material at nominal line voltages of 161 kv or less.

Up to electrical system voltages of 161 kv the design BIL kv and corresponding minimum clearances, phase to ground, have been established through long usage.

At voltages higher than 161 kv, uniformity in the relationship between design BIL kv and the various electrical system voltages has not been established in practice and is dependent upon several variables so that the required clearances to ground shall be based upon the design BIL used rather than on the nominal line or ground voltage.

Possible design variations in the clearance required at higher voltages are evident in the Table, where a range of voltages is indicated opposite the various BIL test values in the high voltage portion of the Table. However, the clearance between uninsulated energized parts of the electrical system equipment and any portion of the dry chemical system shall not be less than the minimum clearance provided elesewhere for electrical system insulations on any individual component.

Table 2-4.3
Clearance from Dry Chemical Equipment To Live Uninsulated Electrical Components

Nominal Line Voltage kv	Nominal Voltage to Ground kv	Design BIL kv	Minimum Clearance inches
15	9	110	6
23	13	150	8
34.5	20	200	12
46	27	250	15
69	40	350	23
115	66	550	37
138	80	650	44
161	93	750	52
196–230	114–132	900	63
		1050	76
287–380	166–220	1175	87
		1300	98
		1550	120
500	290	1675	131
		1800	142
500–700	290–400	1925	153
		2100	168
		2300	184

NOTE: BIL values are expressed as kilovolts (kv), the number being the crest value of the full wave impulse test that the electrical equipment is designed to withstand.

2-5 Specifications, Plans and Approvals.

2-5.1 Specifications. Specifications for dry chemical fire extinguishing systems shall be drawn up with care under supervision of a competent person, and with the advice of the authority having jurisdiction. To ensure a satisfactory system, the following items shall be in the specifications.

2-5.1.1 The specifications shall designate the authority having jurisdiction and indicate whether plans are required.

2-5.1.2 The specifications shall state that the installation shall conform to this standard and meet the approval of the authority having jurisdiction.

2-5.1.3 The specifications shall include the specific tests that may be required, if any, to meet the approval of the authority having jurisdiction, and indicate how the cost of testing is to be borne.

2-5.1.4 These specifications shall indicate the hazard to be protected and shall include such information as physical dimensions, combustibles, air handling equipment, heat sources, etc.

2-5.2 Plans. Where plans are required, the responsibility for their preparation shall be entrusted only to competent persons.

2-5.2.1 These plans shall be drawn to an indicated scale or be suitably dimensioned, and shall be made so that they can be easily reproduced.

2-5.2.2 These plans shall contain sufficient detail to enable the authority having jurisdiction to evaluate the hazard or hazards, and to evaluate the effectiveness of the system. The details on the hazards shall include materials involved, the location and arrangement, and the exposure to the hazard.

2-5.2.3 The details on the system shall include sufficient information and calculations on the amount of dry chemical; the size, length and arrangement of connected piping, or piping and hose; description and location of nozzles so that the adequacy of the system can be determined. Flow rates of nozzles used shall be provided for engineered systems. Information shall be submitted pertaining to the location and function of detection devices, operating devices, auxiliary equipment and electrical circuitry, if used. Sufficient information shall be indicated to identify properly the apparatus and devices used.

2-5.3 Approval of Plans. Where plans are required, they shall be submitted to the authority having jurisdiction for approval before work starts.

2-5.3.1 Where field conditions necessitate any substantial change from the approved plan, the corrected as-installed plans shall be submitted to the authority having jurisdiction for approval.

2-5.4 Approval of Installations. The completed system shall be tested by qualified personnel as required by the authority having jurisdiction. These tests shall be adequate to determine that the system has been properly installed and will function as intended. Only listed equipment and devices shall be used in these systems.

2-5.4.1 The installer shall certify to the authority having jurisdiction that the installation has been made in accordance with the approved plans and the listing of a nationally recognized testing laboratory.

2-5.4.2 Approval tests shall include a discharge of expellant gas through the piping and nozzles. Observations for serious gas leakage and for continuity of piping with free unobstructed flow shall be made. Observations shall be made of the flow of expellant gas through all nozzles. Piping shall not be hydrostatically tested. Where pressure testing is required, it shall be by means of a dry gas. The labeling of devices with proper designations and instructions shall be checked.

2-5.4.3 After any tests, care shall be taken to see that all piping and nozzles have been blown clean, using compressed air or nitrogen if necessary. Care also shall be taken to see that the system is properly charged and placed in the normal "set" condition.

2-6 Operation and Control of Systems. See:

(a) Standard for Central Station Signaling Systems (NFPA 71–1974)

(b) Standard for Local Protective Signaling Systems (NFPA 72A–1974)

(c) Standard for Auxiliary Protective Signaling Systems (NFPA 72B–1974)

(d) Standard for Remote Station Protective Signaling Systems (NFPA 72C–1974)

(e) Standard for Proprietary Protective Signaling Systems (NFPA 72D–1974)

(f) Standard for Automatic Fire Detectors (NFPA 72E–1974)

as applicable to detection, alarm and control functions for dry chemical extinguishing systems.

2-6.1 Methods of Actuation. Systems shall be classified as automatic or manual in accordance with the following methods of actuation:

(a) Automatic Operation. Operation that does not require any human action.

(b) Normal Manual Operation. Operation of a system requiring human action where the device used to cause the operation is located near the hazard so as to be easily accessible at all times (*see 2-6.3.4*). Operation of one control shall be all that is required to bring about the full operation of the system.

(c) Emergency Manual Operation. Operation of the system by human means where the device used to cause operation is fully mechanical in nature and is located on the device being controlled or on its mounting assembly. "Fully mechanical" may incorporate use of the system pressure to complete operation of the device.

2-6.2 Detection of Fires. Fires or conditions likely to produce fire shall be detected by visual (human senses) or by automatic means.

2-6.2.1 Reliance on visual detection shall be permitted only with permission of the authority having jurisdiction where fires or conditions likely to produce fires can be readily detected by such means.

2-6.2.2 Automatic detection shall be by a listed or approved device that is capable of detecting and indicating heat, flame, smoke, combustible vapors, or an abnormal condition in the hazard, such as process trouble, that is likely to produce fire.

2-6.2.3 An adequate and reliable source of energy shall be used in detection systems.

2-6.3 Operating Devices. Operating devices shall mean expellant gas releasing mechanisms, dry chemical discharge controls, and shutdown equipment.

2-6.3.1 Operation shall be by listed mechanical, electrical, or pneumatic means. An adequate and reliable source of energy shall be used.

2-6.3.2 All operating devices shall be designed for the service they will encounter, and shall not be readily rendered inoperative or susceptible to accidental operation. Devices shall be normally designed to function properly from −40 F to +150 F, or marked to indicate temperature limitations.

2-6.3.3 All devices shall be designed, located, installed, or protected so that they are not subject to mechanical, environmental or other conditions that would render them inoperative.

2-6.3.4 The normal manual control for actuation shall be located so as to be conveniently and easily accessible at all times including the time of the fire. The control shall cause the complete system to operate.

2-6.3.5 All valves controlling the release and distribution of dry chemical shall be provided with an emergency manual control.

Exception No. 1: This does not apply to slave cylinders.

Exception No. 2: It is possible for the normal manual control to qualify as emergency manual control if provisions of 2-6 are satisfied.

2-6.3.6 Manual controls shall not require a pull of more than 40 lb. (force) nor a movement of more than 14 in. to secure operation.

2-6.3.7 Means shall be provided for checking the amount of expellant gas to assure that it is sufficient for the proper operation of the system.

2-6.3.8 All shutdown devices shall be considered integral parts of the system and shall function with the system operation. If the expellant gas is used to pneumatically operate these devices, then the gas must be taken prior to its entry into the dry chemical tank.

2-6.3.9 All remote manual operating devices shall be identified as to the hazard that they protect.

2-6.4 **Supervision.** Where supervision of any or all of the following is provided, it shall be arranged to give indication of failure: the automatic detection system, the electrical actuation circuit, the electrical power supply.

2-6.5 **Alarms and Indicators.** Alarms and/or indicators are used to indicate the operation of the system, hazard to personnel, or failure of any supervised device or equipment. The devices may be audible or visual. The type, number, and location of the devices shall be such that their purpose is satisfactorily accomplished. The extent and type of alarm and/or indicator equipment shall be approved.

2-6.5.1 An alarm or indicator shall be provided to show that the system has operated, that personnel response may be needed, and that the system is in need of recharge.

2-6.5.2 Alarms indicating failure of supervised devices or equipment shall give prompt and positive indication of any failure and shall be distinctive from alarms indicating operation or hazardous conditions.

2-7 Dry Chemical Supply.

2-7.1 **Quantity.** The amount of dry chemical in the system shall be at least sufficient for the largest single hazard protected, or for the group of hazards which are to be protected simultaneously.

2-7.2 **Quality.** The dry chemical used in the system shall be supplied by the manufacturer of the equipment. The characteristics of the system are dependent upon the composition of the dry chemical and the type of expellant gas, as well as upon other factors, and, therefore, it is imperative to use the dry chemical provided by the manufacturer of the system and the type of expellant gas specified by the manufacturer of the system.

2-7.2.1 Where carbon dioxide or nitrogen is used as the expellant gas, it shall be of good commercial grade, free of water and other contaminants that might cause container corrosion.

2-7.2.1.1 Carbon doxide used as an expellant gas shall meet the following specifications:

(a) The vapor phase shall not be less than 99.5 percent carbon dioxide.

(b) The water content of the liquid phase shall not be more than 0.01 percent by weight (−30 F dew point).

(c) Oil content shall not be more than 10 ppm by weight.

2-7.2.1.2 In general, carbon dioxide obtained by converting dry ice to liquid shall not be satisfactory unless it is properly processed to remove excess water and oil.

*2-7.3 **Reserve Supply.** Where a dry chemical system protects multiple hazards by means of selector valves, sufficient dry chemical and expellant gas shall be kept on hand for one complete recharge of the system. For single hazard systems, a similar supply shall be kept on hand if the importance of the hazard is such that it cannot be shut down until recharges can be procured.

2-7.4 **Storage.** Storage of charging supplies of dry chemical shall be in a constantly dry area, and the dry chemical shall be contained in metal drums or other containers which will prevent the entrance of moisture even in small quantities. Prior to charging the dry chemical chamber, the dry chemical shall be carefully checked to determine that it is in free-flowing powdery condition, and the pressure or weight of the expellant gas shall be checked as stipulated by the manufacturer to determine that it is above the required minimum.

2-7.4.1 The dry chemical tank and expellant gas assemblies shall be located near the hazard or hazards protected, but not where they will be exposed to a fire or explosion in these hazards.

2-7.4.2 The dry chemical tank and expellant gas assemblies shall be located so as not to be subjected to severe weather conditions, or to mechanical, chemical, or other damage. When excessive climatic or mechanical exposures are expected, suitable enclosures or guards shall be provided.

2-7.4.3 The dry chemical tank and expellant gas assemblies utilizing nitrogen shall be located where the ambient temperature is normally between −40 F and 120 F. Assemblies utilizing carbon dioxide shall be located where the ambient temperature is normally between 32 F and 120 F. Exposure extremes of short duration can be tolerated. Otherwise, methods shall be provided for maintaining the temperatures within the ambient ranges given.

NOTE: Systems for use at higher or lower temperatures can be specially designed.

2-7.4.4 The dry chemical tank and expellant gas assemblies shall be located where they will be easy to inspect, maintain and service.

2-8 Distribution System.

***2-8.1 Pipe and Fittings.** Threaded pipe and fittings shall be galvanized malleable iron, galvanized steel, stainless steel, copper, or brass. Black steel pipe with welded joints or malleable iron threaded fittings may be used when the atmosphere is relatively noncorrosive. Special corrosion resistant materials shall be used for corrosive atmospheres. Steel pipe shall not be less than Schedule 40 and brass and copper pipe shall be not less than the approximate Schedule 40 wall thickness (regular pipe) for pipe sizes of 6 in. or less.

2-8.1.1 Cast iron pipe and fittings shall not be used.

2-8.1.2 Tubing shall not be used for dry chemical distribution.

2-8.1.3 Flexible piping (hose) shall be used only in accordance with the listings of a nationally recognized testing laboratory as they are stated for specific dry chemical fire extinguishing systems. (*See A-2-8.1.*)

2-8.1.4 Piping for systems to be installed for protection of cryogenic liquid spill fires shall be protected from submergence in the liquid, localized liquid impingement, and the simultaneous exposure to cryogenic liquid and flame temperatures. Where the dry chemical supply lines are installed underground within the potential spill area, the individual branch lines shall be brought up through insulated sleeves. The insulated sleeves shall be extended above the maximum anticipated cryogenic liquid accumulation depth. Any sub-branching abovegrade shall also be protected against localized impingement by the cryogenic liquid.

***2-8.2 Arrangement and Installation of Pipe and Fittings.** Piping shall be installed in accordance with good commercial practices.

2-8.2.1 All piping shall be laid out to produce the desired dry chemical flow rate at the nozzles, and care shall be taken to avoid possible restrictions due to foreign matter and faulty fabrication and/or improper installation.

2-8.2.2 The piping system shall be securely supported and shall not be subject to mechanical, chemical, or other damage. Where explosions are possible, the piping system shall be hung from supports that are least likely to be displaced.

2-8.2.3 Pipe shall be reamed and cleaned before assembly, and after assembly the entire piping system shall be blown out with dry gas before nozzles or discharge devices are installed. The use of pipe-thread compound or tape shall not be used.

2-8.3 Valves. All valves shall be listed for the intended use, particularly in regard to flow capacity and operation. Selector valves shall be of the quick-opening type, allowing essential free passage of the dry chemical without restriction.

2-8.3.1 Valves shall not be easily subject to mechanical, chemical, or other damage.

2-8.4 Discharge Nozzles. Discharge nozzles shall be listed for the use intended, in accordance with subsequent chapters.

2-8.4.1 Discharge nozzles shall be of adequate strength for use with the expected working pressures.

2-8.4.2 Discharge nozzles shall be of brass, stainless steel, or other corrosion-resistant materials, or be protected inside and out against corrosion. They shall be made of noncombustible materials, and shall withstand the expected fire exposure without deformation.

2-8.4.3 All nozzles shall be designed and subsequently located, installed or protected so that they are not subject to mechanical, environmental or other conditions that would render them inoperative.

2-8.4.4 Discharge nozzles shall be so connected and supported that they may not be readily put out of alignment. Where nozzles are connected directly to flexible hoses, they shall be provided with mounting brackets or fixtures to assure that they can be aligned properly and that the alignment will be maintained.

2-8.4.5 Discharge nozzles shall be clearly marked for identification of type and size.

2-8.4.6 Where external clogging by foreign materials is likely, the listed discharge nozzle assemblies shall include protective caps.

2-8.5 Pipe Size and Nozzle Determination. Pipe sizes and nozzles shall be selected on the basis of calculations to deliver the required dry chemical flow rate at each nozzle or, for pre-engineered systems, in accordance with limitations set by a nationally recognized testing laboratory.

2-8.5.1 Equations, or graphs derived therefrom, shall be used to determine the pressure drop in the pipe line in engineered systems. This design information shall be based on tests performed by the manufacturer and confirmed by a nationally recognized testing laboratory. It is not required in pre-engineered systems.

2-9 Electrical Wiring and Equipment.

2-9.1 Installation. Electrical wiring and equipment shall be installed in accordance with the *National Electrical Code*, NFPA 70-1975, or the requirements of the local authority having jurisdiction.

2-10 Inspection, Maintenance, and Instruction.

***2-10.1 Inspection and Tests.** At least annually, all dry chemical systems including alarms, shutdowns, and other associated equipment shall be thoroughly inspected and checked for proper operation by competent personnel. (*See 2-6 and 2-10.1.9.*)

2-10.1.1 The purpose of this inspection and testing shall be not only to ensure that the system is in full operating condition, but also to indicate the probable continuance of that condition until the next inspection. Attention at this inspection shall be given to any extension of the hazard protected by the system. A suitable gas discharge test shall be made when this inspection indicates it to be advisable. (*See 2-10.1.*)

2-10.1.2 The inspector's report, with recommendations, if any, shall be filed with the owner or with whomever is designated by the owner.

2-10.1.3 Between the regular service contract inspection or tests, the system shall be inspected visually or otherwise by competent personnel, following an approved schedule.

2-10.1.4 At least semiannually, all expellant gas containers shall be checked by pressure or weight against the required minimums.

2-10.1.5 At least semiannually, all stored pressure dry chemical containers shall be checked by pressure and weight against the required minimums.

2-10.1.6 Except for stored pressure systems, at least annually the dry chemical in the system storage container shall be sampled from the top center and also near the wall to determine the existence of lumps harder than will be friable when dropped from a height of 4 inches.

2-10.1.7. The following parts of dry chemical systems with dry chemical chambers of less than 150 pounds nominal capacity (based on sodium bicarbonate agent) shall be hydrostatically tested at an interval not to exceed twelve years: dry chemical chambers, auxiliary pressure containers, valve assemblies, hoses and fittings (not including field piping), check valves, directional valves, manifolds, and hose nozzles. The procedures shall be those approved by a nationally recognized laboratory for each type of equipment.

(a) The dry chemical removed from the chamber prior to testing shall be discarded.

(b) Care shall be exercised to make certain that all equipment tested is thoroughly dried prior to recharging.

(c) To protect the hazard during this operation, if there is no automatic connected reserve, alternate protection acceptable to the authority having jurisdiction shall be provided.

2-10.1.8. When annual inspection of any dry chemical chambers or system components reveals conditions such as but not limited to corrosion or pitting in excess of manufacturer's limits, structural damage or fire damage, repairs by soldering, welding or brazing, the affected part(s) shall be replaced or hydrostatically tested in accordance with the recommendations of the manufacturer or the original certifying agency or both. The hydrostatic testing of dry chemical chambers shall follow the applicable procedures outlined in 2-10.1.7.

2-10.1.9 Fixed temperature sensing elements of the fusible alloy type shall be replaced at least annually or more frequently if necessary to assure proper operation of the system.

2-10.2 Maintenance. These systems shall be maintained in full operating condition at all times. Use, impairment, and restoration of this protection shall be reported promptly to the owner and the authority having jurisdiction.

2-10.2.1 Any troubles or impairments shall be corrected at once by competent personnel.

2-10.3 Instruction. All persons who may be expected to inspect, test, maintain, or operate dry chemical fire extinguishing systems shall be thoroughly trained and kept thoroughly trained in the functions that they are expected to perform.

2-10.3.1 Training programs shall be established that are approved.

Chapter 3 Total Flooding Systems

3-1 General Information.

3-1.1 Definition. A total flooding system means a supply of dry chemical permanently connected to fixed piping, with fixed nozzles arranged to discharge dry chemical into an enclosed space or enclosure about the hazard.

3-1.2 Uses. This type of system shall be used only where there is a permanent enclosure about the hazard that is adequate to enable the required concentration to be built up. The total area of unclosable openings shall not exceed 15 percent of the total area of the sides, top, and bottom of the enclosure.

3-1.2.1 Consideration shall be given to the elimination of probable sources of reignition because the extinguishing action of a dry chemical flooding system is transient.

3-1.2.2 Deep-seated fires involving solids subject to smoldering shall be protected by multipurpose dry chemical systems where the dry chemical can reach all surfaces involved in combustion. Bicarbonate-base dry chemicals shall not be used for protection against this type of fire.

3-1.3 General Requirements. Total flooding systems shall be designed, installed, tested, and maintained in accordance with the applicable rules in Chapter 2 and with the additional rules set forth in this chapter.

3-2 Hazard Specifications.

3-2.1 Enclosure. In the design of total flooding systems the characteristics of the enclosure shall be considered as follows:

3-2.1.1 The total area of unclosable openings for which no compensation is provided shall not exceed 1 percent of the total area of the sides, top, and bottom of the enclosure. Unclosable openings having an area in excess of 1 percent and not exceeding 5 percent shall be compensated for by the provision of additional dry chemical. Unclosable openings having an area in excess of 5 percent of the total enclosure area and not exceeding 15 percent shall be screened by local application of additional dry chemical. (*See 3-3.4.1.*)

3-2.2 Leakage and Ventilation. The leakage of dry chemical from the protected space shall be minimized since the effectiveness of the flooding system depends upon obtaining an extinguishing concentration of dry chemical.

3-2.2.1 Where possible, openings such as doorways, windows, etc., shall be arranged to close before, or simultaneously with, the start of the dry chemical discharge, or 3-3.4.1 shall be followed.

3-2.2.2 Where forced air ventilating systems are involved, they shall either be shut down and/or closed before, or simultaneously with, the start of the dry chemical discharge, or 3-3.4.2 shall be followed.

3-3 Dry Chemical Requirements and Distribution.

***3-3.1 General.** The following factors shall be considered in the total flooding of enclosed spaces with dry chemical:

(a) Minimum quantity of dry chemical required.

(b) Minimum rate of flow of dry chemical.

(c) Spacing limitations of the nozzles.

Exception: In the case of pre-engineered systems, the rate of flow need not be considered since it is governed by the piping and nozzle limitations verified by a nationally recognized testing laboratory.

3-3.1.1 The quantity of dry chemical and the flow rate shall be sufficient to create a fire extinguishing concentration in all parts of the enclosure.

3-3.1.2 The nozzles shall be placed so as to provide not less than the minimum design concentration of dry chemical in all parts of the enclosure. For fires in ordinary combustibles where multipurpose dry chemical shall be used for protection, additional dry chemical applied by local application may be required in order to protect adequately all exposed surfaces.

3-3.1.3 The nozzles shall be located so that the discharge will not be obstructed.

3-3.2 Volume Allowances. In calculating the net volume to be protected, allowance shall be permitted for permanently located structures, etc., that materially reduce the volume.

3-3.3 Rate of Application. In engineered systems the minimum design rate of application shall be based on the quantity of dry chemical and the maximum time to obtain the design concentration.

Exception: In pre-engineered systems, these factors are established for specific volume and other conditions given in the listing of such systems by nationally recognized testing laboratories. (See Appendix, A-3-3.1.)

3-3.3.1 In engineered systems, the rate of application shall be such that the design concentration in all parts of the enclosure shall be obtained within 30 seconds.

3-3.4 Compensation for Special Conditions. Additional quantities of dry chemical, and additional nozzles, if necessary, shall be provided to compensate for any special condition that may adversely affect the extinguishing effectiveness of the system.

3-3.4.1 Unclosable openings having areas in excess of 1 percent of the total area of the sides, top, and bottom of the enclosure, and not exceeding 5 percent, shall be compensated for by the use of supplemental dry chemical in the proportions of not less than 0.5 lb. per sq. ft. of unenclosed opening, applied through the regular distribution system. When the unclosable openings have areas exceeding 5 percent of the total of the sides, top, and bottom of the enclosure, and not exceeding 15 percent, compensation shall be furnished by additional dry chemical in the proportion of not less than 1 lb. per sq. ft. of unclosed opening, applied simultaneously by location application over the openings. A system that is listed by a nationally recognized testing laboratory for or including protection of unclosable openings may be used in lieu of the above.

3-3.4.2 For ventilating systems that will not be shut down, supplementary dry chemical shall be added to the protected volume through the regular distribution system. The supplementary dry chemical shall be added at the point or points of air inlet and shall be in proportion to the volume of air removal during the period of dry chemical discharge, calculating as if it were additional volume to be protected.

Exception: Pre-engineered systems listed for restaurant hood and duct protection are suitable for use with or without shutdown of the ventilation system or closure of dampers.

Chapter 4 Local Application Systems

4-1 General Information.

4-1.1 Definition. A local application system means a supply of dry chemical permanently connected to a system of fixed piping with nozzles arranged to discharge directly onto the fire.

***4-1.2 Uses.** Local application systems shall be used for the extinguishment of fires in flammable or combustible liquids, gases, and shallow solids such as paint deposits, where the hazard is not enclosed or where the enclosure does not conform to the requirements for total flooding. Application of dry chemical shall be from nozzles mounted on the tank side or overhead.

4-1.3 General Requirements. Local application systems shall be designed, installed, tested, and maintained in accordance with the applicable requirements in Chapter 2 and with the additional requirements set forth in this chapter.

4-2 Hazard Specifications.

4-2.1 Extent of Hazard. The hazard shall be so isolated from other hazards or combustibles that fire will not spread outside the protected area. The entire hazard shall be protected. The hazard shall include all areas that are or may become coated by combustible or flammable liquids or shallow solid coatings, such as areas subject to spillage, leakage, dripping, splashing, or condensation, and all associated materials or equipment such as freshly coated stock, drainboards, hoods, ducts, etc., that might extend fire outside or lead fire into the protected area.

Exception: Protection of the entire hazard may require the combined use of local application and total flooding systems such as in a restaurant kitchen where the deep-fat fryers can be protected by a local application system and the space above the grease filters in the hood can be protected by a combination local application-total flooding system.

4-2.2 Location. The design of the system shall consider the location of the hazard which may be indoors, partly sheltered or completely outdoors so as to provide a discharge that will not be affected by winds or other stray air currents.

4-3 Dry Chemical Requirements and Distribution.

4-3.1 General. The following factors shall be considered in the design of local application systems:

(a) Minimum quantity of dry chemical.

(b) Minimum flow rate.

(c) Nozzle distribution patterns.

(d) Nozzle placement limitations with respect to flammable liquid surfaces.

(e) Possible obstruction to nozzle distribution pattern.

Exception: In the case of the pre-engineered systems, the rate of flow need not be considered since it is governed by the pipe and nozzle limitations verified by a nationally recognized testing laboratory (see A-3.3.1).

4-3.2 Draft Conditions. The quantity of dry chemical, the dry chemical flow rate, and the number of nozzles shall be sufficient to extinguish fires under the most severe wind or the most severe draft conditions expected in the hazard area.

4-3.2.1 The maximum allowable draft condition shall be that specified by a nationally recognized testing laboratory.

4-3.3 Nozzle Placement. The nozzles shall be placed so as to provide an extinguishing concentration of dry chemical over the entire hazard during discharge.

4-3.3.1 The nozzles shall be placed about (tankside) and/or above (overhead) the flammable liquid surface within the limits of the listing in order to prevent splashing during discharge.

4-3.4 Coated Surfaces. Although it is recognized that fires on coated surfaces are less severe than fires in deep layer flammable liquids, such areas shall be treated as if they were deep layer flammable liquid areas because no distinction has been made in this standard.

4-3.5 Duration of Discharge. The minimum effective discharge time shall be determined by the required minimum quantity of dry chemical and the minimum application rate.

Exception: In the case of pre-engineered systems, these factors need not be considered since they are governed by the piping and nozzle limitations gathered by a nationally recognized testing laboratory.

*4-3.5.1 In the case of engineered systems, the minimum discharge time shall be increased to compensate for any hazard condition that would require a longer discharge period to assure complete extinguishment.

Exception: Hot saponifiable fats do not require an extended discharge period when sodium bicarbonate-base dry chemical is the extinguishing agent.

4-4 Special Considerations.

4-4.1 Where systems protect hazards which are normally heated, such as deep fat fryers, char broilers, upright broilers, griddles and ranges in kitchens, or wax tanks, the power or fuel supply to heaters shall be shut off automatically upon actuation of the extinguishing systems.

Chapter 5 Hand Hose Line Systems

5-1 General Information.

5-1.1 Definition. Hand hose line systems means a hose and nozzle assembly connected, by fixed piping or directly, to a supply of dry chemical. A separate dry chemical supply may be provided for hand hose line use, or dry chemical may be piped from a central storage unit which may be supplying several hose lines or fixed manually or automatically operated systems (*see 2-3.2 and 2-3.3*).

5-1.2 Uses. Hand hose line systems shall be acceptable to supplement fixed nozzle fire protection systems or to supplement portable fire extinguishers for the protection of specific hazards for which dry chemical is a suitable extinguishing agent. These systems shall not be used as a substitute for dry chemical fire extinguishing systems equipped with fixed nozzles except where the hazard cannot be adequately or economically provided with fixed nozzle protection. The decision as to whether hose lines are applicable to the particular hazard shall rest with the authority having jurisdiction.

5-1.3 General Requirements. Hand hose line systems shall be installed and maintained in accordance with the applicable provisions of Chapters 2, 3, and 4, except as outlined below.

5-2 Hazard Specifications.

5-2.1 Hand hose line systems shall be considered suitable for combatting fires in all hazards covered under Chapter 2 except those which are inaccessible and beyond the scope of manual fire fighting.

5-3 Location and Spacing.

5-3.1 Location. Hand hose line stations shall be placed so that they are easily accessible and have hose lines long enough to reach the most distant hazard that they are expected to protect. In general they shall be located so that they are not exposed to the hazard.

5-3.2 Spacing. If multiple hose stations are used, they shall be spaced so that any area within the hazard may be covered by one or more hose lines.

5-3.3 Actuation. Manual actuation shall be possible at each hose line station.

5-4 Dry Chemical Requirements.

***5-4.1 Rate and Duration of Discharge.** The rate and duration of discharge, and consequently the amount of dry chemical, shall be determined by the type and potential size of the hazard. A hand hose line shall have a sufficient quantity of dry chemical to permit its effective use for a minimum of 30 seconds. The minimum flow rate shall also be sufficient to prevent surging and interrupted discharge. These values for minimum flow rate shall be confirmed by a nationally recognized testing laboratory.

5-4.2 Provision for Use by Inexperienced Personnel. The possibility of these hose lines being used by inexperienced personnel shall be considered and adequate provision made so that there will be a sufficient supply of dry chemical to enable them to effect extinguishment of fires in the hazards that they are likely to encounter.

5-4.3 Simultaneous Use of Hose Lines. Where simultaneous use of two or more hose lines is possible, a sufficient quantity of dry chemical shall be available to supply the maximum number of nozzles that are likely to be used at any one time for at least 30 seconds and at the appropriate flow rates.

5-5 Equipment Specifications.

5-5.1 Hose. Hose lines on systems shall incorporate hose listed for this use. Normally, identifying marking on the hose will indicate the acceptability of the hose for this purpose.

5-5.2 Nozzle Assemblies. Nozzles shall be so designed that they can be handled by one man and shall incorporate a quick-opening shutoff arrangement to control the flow of dry chemical.

5-5.3 Hose Line Storage. The hose shall be coiled on a hose reel or rack so that it will be ready for immediate use without the necessity of coupling and may be uncoiled with a minimum of delay. If installed outdoors, it shall be protected against the weather.

***5-5.4 Operation of Hose Lines.**

5-5.4.1 The pressurizing valve shall remain in the open position during the entire fire fighting operation.

5-5.4.2 The hose lines shall be cleared of dry chemical immediately after use.

5-6 Training.

5-6.1 All personnel who are likely to use this equipment shall be kept properly trained in its operation and in the fire fighting techniques applicable to this equipment.

Appendix A

A-1-1 Scope. The dry chemical systems described in this standard are designed to discharge dry chemical from fixed nozzles and piping, or from hose lines by means of an expellant gas. The intent of the standard is to present the design considerations applicable to these systems.

Because the flow of dry chemical (solid particles suspended in a gaseous medium) does not follow general hydraulic theories, most of the flow principles have been determined experimentally. The dry chemicals produced by various manufacturers are usually not identical in all characteristics and each manufacturer designs equipment for use with a specific dry chemical. Therefore, system design principles applicable to the products of one manufacturer are not applicable to the products of another manufacturer. As a result, it is not practical to include system design details as a part of this standard.

It is now generally accepted that the flame extinguishing properties of dry chemicals are due to the interaction of the particles to stop the chain reaction that takes place in flame combustion. Dry chemicals vary in their flame extinguishing effectiveness. Multipurpose dry chemical owes its effectiveness in extinguishing fires in ordinary combustibles such as wood and paper to the formation of a glow-retarding coating over the combustible material. For additional information on dry chemicals and their extinguishing characteristics, see Appendix A-2-1.

A-2-1 Agent Characteristics: A dry chemical extinguishing agent is a finely divided powdered material that has been specially treated to be water repellent and capable of being fluidized and free-flowing so that it may be discharged through hose lines and piping when under expellent gas pressure. Dry chemicals currently in use may be described briefly as follows:

1. *Sodium Bicarbonate ($NaHCO_3$) Based Dry Chemical*

This agent consists primarily of sodium bicarbonate and is suitable for use on all types of flammable liquid and gas fires (Class B) and also for fires involving energized electrical equipment (Class C).

Its effect on fires in common cooking oils and fats is particularly good, as in combination with these materials the sodium bicarbonate based agent reacts to form a type of soap (saponification), which floats on the liquid surface such as in deep fat fryers and effectively prevents reignition of the grease.

Official NFPA Definitions

Adopted Jan. 23, 1964: Revised Dec. 9, 1969 and June 26, 1973. Where variances to these definitions are found, efforts to eliminate such conflicts are in process.

SHALL is intended to indicate requirements.

SHOULD is intended to indicate recommendations or that which is advised but not required.

APPROVED* means acceptable to the authority having jurisdiction. In determining the acceptability of installations or procedures, equipment or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure or use. The authority having jurisdiction may also refer to the listings or labeling practices of nationally recognized testing laboratories, inspection agencies, or other organizations concerned with product evaluations which are in a position to determine compliance with appropriate standards for the current production of listed items, and the satisfactory performance of such equipment or materials in actual usage.

* The National Fire Protection Association does not approve, inspect or certify any installations, procedures, equipment or materials nor does it approve or evaluate testing laboratories.

LISTED: Equipment or materials included in a list published by a nationally recognized testing laboratory, inspection agency, or other organization concerned with product evaluation that maintains periodic inspection of production of listed equipment or materials, and whose listing states either that the equipment or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.

LABELED: Equipment or materials to which has been attached a label, symbol or other identifying mark of a nationally recognized testing laboratory, inspection agency, or other organization concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling is indicated compliance with nationally recognized standards or tests to determine suitable usage in a specified manner.

AUTHORITY HAVING JURISDICTION: The organization, office or individual responsible for "approving" equipment, an installation, or a procedure.

Statement on NFPA Procedures

This material has been developed in the interest of safety to life and property under the published procedures of the National Fire Protection Association. These procedures are designed to assure the appointment of technically competent Committees having balanced representation from those vitally interested and active in the areas with which the Committees are concerned. These procedures provide that all Committee recommendations shall be published prior to action on them by the Association itself and that following this publication these recommendations shall be presented for adoption to the Annual Meeting of the Association where anyone in attendance, member or not, may present his views. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accepts any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

Standard for the Installation of Equipment for the

Removal of Smoke and Grease-Laden Vapors from Commercial Cooking Equipment

NFPA No. 96 — 1973

1973 Edition of No. 96

This edition of NFPA 96 supersedes the 1971 edition. It incorporates amendments recommended by the Committee on Chimneys and Heating Equipment and adopted at the 1973 NFPA Annual Meeting.

Changes, other than editorial, are denoted by a vertical line in the margin of the pages in which they appear except new Section 22 and revised Section 10.

Origin and Development of No. 96

The subject of the ventilation of restaurant type cooking equipment was first considered by the NFPA Committee on Blower and Exhaust Systems. That Committee developed material on ventilation of restaurant type cooking equipment to be included in NFPA Standard No. 91, Blower and Exhaust Systems. This was adopted by the Association in 1946. Revisions to the Section were adopted in 1947 and 1949.

When the NFPA Committee on Chimneys and Heating Equipment was organized in 1955, the material on ventilation of restaurant cooking equipment in NFPA No. 91 was assigned to this new Committee with the suggestion that it be revised and published as a separate standard. Thus in recent years this Standard has been published as NFPA No. 96 and this is the latest edition thereof. Previous editions of the Standard prepared by the Committee on Chimneys and Heating Equipment were adopted by the Association in 1961, 1964, 1969, 1970, and 1971.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

CONTENTS

Standard for the Installation of Equipment for the

Removal of Smoke and Grease-Laden Vapors from Commercial Cooking Equipment

NFPA No. 96 — 1973

1. Scope.

11. This edition of NFPA Standard No. 96 covers basic requirements for the design, installation and use of exhaust system components including (1) hoods; (2) grease removal devices; (3) exhaust ducts; (4) dampers; (5) air moving devices; (6) auxiliary equipment; and (7) fire extinguishing equipment for the exhaust system and the cooking equipment used therewith in commercial, industrial, institutional and similar cooking applications. This standard does not apply to installations for normal residential family use.

2. Requirements.

21. Cooking equipment used in processes producing smoke or grease-laden vapors shall be equipped with an exhaust system complying with the following:

211. A hood or canopy complying with the requirements of Section 3, and

212. A duct system complying with the requirements of Section 4, and

213. Grease removal equipment complying with the requirements of Section 6, and

214. Fire extinguishing equipment complying with the requirements of Section 10.

22. If required by the authority having jurisdiction, notification in writing shall be given of any alteration, replacement, or relocation of any exhaust or extinguishing system or part thereof, or cooking equipment.

3. Hood or Canopy.

31. Materials.

311. The hood or that portion of a primary collection means designed for collecting cooking vapors and residues shall be constructed of and be supported by steel not lighter than No. 18

Manufacturers Standard Gage, stainless steel not lighter than No. 20 Manufacturers Standard Gage or of other approved material of equivalent strength, fire, and corrosion resistance.

32. Construction.

321. All seams and joints shall have a liquidtight continuous external weld.

322. Troughs or gutters shall not be permitted except as provided in Section 6.

33. Hoods or enclosures of listed grease extractors or listed automatic damper and hood assemblies, evaluated under the same fire severity as the hood or enclosure of listed grease extractors, are considered as complying with the material and construction requirements of Section 3. The clearances specified in Section 7 shall be maintained.

4. Duct Systems.

41. Duct systems from hoods, canopies, or other collection systems shall comply with 411 or 412.

411. Listed grease ducts installed in accordance with the terms of the listing and the manufacturer's instructions.

412. Ducts complying with the following requirements:

4121. Materials. Ducts shall be constructed of and supported by steel not lighter than No. 16 Manufacturers Standard Gage or stainless steel not lighter than No. 18 Manufacturers Standard Gage.

4122. Installation Requirements for Interior Locations.

(a.) All seams and joints shall have a liquidtight continuous external weld.

Note: Temperatures in excess of 2,000 F. may be experienced within ducts in event of a fire. Means for expansion of long lengths of ducts should be provided.

(b.) All ducts should lead, as directly as possible, to the exterior of the building and shall be installed without forming dips or traps which might collect residues.

(c.) Vertical ducts should be located outside the building and adequately supported. If absolutely necessary to locate vertical ducts within a building, the ducts shall be enclosed in a continuous enclosure constructed of materials which are not combustible, such as masonry (see Appendix B), and extending from the ceiling above the hood to or through the roof so as to maintain the integrity of the fire separations required by the applicable building code provisions. The enclosure shall conform to the following:

(1.) If the building is less than 4 stories in height, the enclosure wall shall have a fire resistance rating of not less than 1 hour.

(2.) If the building is 4 stories or more in height, the enclosure wall shall have a fire resistance rating of not less than 2 hours.

(3.) Clearance from the duct to interior surfaces of the enclosure shall be not less than 6 inches.

(4.) If openings in the enclosure walls are provided they shall be protected by approved self-closing fire doors of proper rating. See Standard For Fire Doors and Windows, NFPA No. 80–1973.

(d.) Each duct system shall constitute an individual system serving only exhaust hoods on one floor.

(e.) Duct systems shall not be interconnected with any other building ventilating or exhaust system.

(f.) An opening shall be provided at each change in direction of the duct for purposes of inspection and cleaning. Openings shall be at the sides and large enough to permit cleaning. In horizontal sections the lower edge of the opening shall be not less than 1½ inches from the bottom of the duct. Covers shall be constructed of the same material and thickness as the duct and shall be greasetight when in place.

(g.) Ducts shall not pass through fire walls or fire partitions.

(h.) Where ducts pass through partitions or walls of combustible material the material shall be cut away to provide a clearance to the duct not less than 18 inches unless protection is provided in accordance with Appendix B.

4123. Installation Requirements for Exterior Locations.

(a.) The vertical portion of exhaust ducts shall be connected to the horizontal portion of the duct system and shall be installed and adequately supported on the exterior of a building.

(b.) All seams and joints shall have a liquidtight continuous external weld.

NOTE: Temperatures in excess of 2,000 F. may be experienced within ducts in event of a fire. Means for expansion of long lengths of ducts should be provided.

(c.) All ducts, except those constructed of stainless steel, shall be protected on the exterior by paint or other suitable weather-protective coating.

(d.) A residue trap shall be provided at the base of each vertical riser with provisions for cleanout.

413. Termination of Ducts. Ducts shall extend above the building in which located and shall terminate as follows:

4131. With at least forty (40) inches clearance from the outlet to the roof surface.

4132. With a minimum of ten (10) feet of clearance from the outlet to adjacent buildings, property lines, air intakes and adjoining grade levels.

4133. With the direction of flow of exhaust air away from the surface of the roof. If such is not possible, a metal pan shall be provided on the roof surface to catch residues that pass through the system. The pan shall have a minimum one (1) inch lip at all edges to retain residues and should be cleaned regularly in accordance with Appendix C.

5. Air Movement.

51. Exhaust Fans. Exhaust fans and motors shall be approved and rated for continuous operation and shall be installed to comply with the following requirements:

511. All wiring and electrical equipment shall comply with the National Electrical Code, NFPA No. 70–1971. See Section 9.

512. When the fan is not visible a signal light shall be installed in the kitchen area to indicate when the fan is operating.

513. Means shall be provided for inspections, servicing, and cleaning.

NOTE: To offset the possibility of leaks in the duct system, it is recommended the fan be located near the discharge end of the duct.

52. Air Flow. The air velocity through any duct shall not be less than 1,500 feet per minute. Air volume through any duct shall not be less than that specified in Appendix A.

53. Replacement Air. Adequate replacement air shall be provided as specified in Appendix A.

6. Grease Removal Devices.

61. Grease removal devices shall be provided and shall consist of one of the following types:

611. Listed Grease Extractors. Listed grease extractors shall be installed in accordance with the terms of the listing and the manufacturer's instructions.

612. Listed Grease Filters or Other Grease Removal (Not Including Grease Extractors). Listed grease filters or other listed means of grease removal shall comply with the following requirements.

6121. MATERIALS.

(a.) Grease filters, including frames, or other grease removal devices shall be constructed of noncombustible materials.

(b). Grease filter shall be a type listed for use with commercial cooking equipment.

6122. INSTALLATION.

(a.) The distance between the grease filter or other grease removal device and the cooking surface shall be as great as possible. Where grease filters or other grease removal devices are used in conjunction with charcoal or charcoal-type broilers, including gas or electrically heated char-broilers, a minimum vertical distance of 4 feet shall be maintained between the lower edge of the grease filter or removal device and the cooking surface.

(b.) Grease filters or other grease removal devices shall be protected from combustion gas outlets and from direct flame impingement occuring during normal operation of cooking appliances producing high flue gas temperatures such as deep fat fryers, upright or high broiler (salamander broilers) when the distance between the filter or removal device and the appliance outlet (heat source) is less than 18 inches. This protection may be accomplished by the installation of a steel or stainless steel baffle plate between the heat source and the filter or removal device. The baffle plate shall be so sized and located that flames or combustion gases must travel a distance not less than 18 inches from the heat source to the grease filter or removal device. The baffle shall be located not less than 6 inches from filters or removal devices.

(c.) Filters shall be tight fitting and firmly held in place, yet be easily accessible and removable for cleaning.

(d.) Filters shall be installed at an angle not less than 45° from the horizontal and shall be equipped with a drip tray beneath the lower edge of the filters. The tray shall be kept to the minimum size needed to collect the grease and be pitched to drain to an enclosed metal container having a capacity not exceeding one gallon.

7. Clearance.

71. Hoods, grease extractors, and ducts shall have a clearance of at least 18 inches to unprotected combustible material unless listed for lesser clearances or protected in accordance with Appendix B.

8. Dampers.

81. Dampers shall not be installed in ducts or duct systems unless specifically listed for such use or are required as part of a listed grease extractor, an approved extinguishing system, or an approved fan bypass system.

9. Auxiliary Equipment.

91. Wiring systems of any type shall not be installed in ducts. Motors, lights and other electrical devices shall not be installed in ducts or hoods or located in the path of travel of exhaust products unless specifically approved for such use.

92. Lighting units having steel enclosures mounted on the outer surface of the hood and separated from exhaust products by tight-fitting glass may be used. Lighting units on hoods shall not be located in concealed spaces unless part of a listed grease extractor.

93. All electrical equipment shall be installed in accordance with the National Electrical Code, NFPA No. 70–1971, with due regard to the effects of heat, vapor, and grease on the equipment.

94. Fume incinerators or other devices shall not be installed in ducts or hoods or located in the path of travel of exhaust products unless specifically approved for such use.

10. Fire Extinguishing Equipment.

101. Approved fire extinguishing equipment shall be provided for the protection of duct systems, grease removal devices, and hoods. Cooking equipment (such as fat fryers, ranges, griddles, and broilers), which may be a source of ignition of grease in the hood, grease removal device, or duct, shall also be protected by approved extinguishing equipment. If acceptable to the authority having jurisdiction, that portion of the fire extinguishing system required for protection of the duct may be omitted when all cooking equipment is served by listed grease extractors. The extinguishing equipment shall include both of the following types:

1011. Automatically operated fixed pipe systems, or other automatic systems specifically shall be listed for the hazard.

1012. Portable extinguishers installed in the kitchen area. Those adjacent to cooking equipment shall include the alkaline dry chemical type (sodium bicarbonate or potassium bicarbonate base) having a rating of at least 20 BC. Other extinguishers in the kitchen area shall be installed in accordance with Standard for Installation of Portable Fire Extinguishers, NFPA No. 10–1972.

NOTE: Acidic base extinguishing materials, such as ammonium phosphate base multipurpose types, impede saponification. Therefore, if the cooking equipment being protected involves exposed liquefied fat or oil in depth such as fat fryers, extinguishers employing these extinguishing agents are not recommended.

102. Listed fire extinguishing systems shall be installed in accordance with the terms of their listing and the manufacturer's instructions. Other fire extinguishing equipment shall be installed in compliance with the provisions of the following applicable standards.

(a.) Standard on Carbon Dioxide Extinguishing Systems, NFPA No. 12–1973.

(b.) Standard for the Installation of Sprinkler Systems, NFPA No. 13–1973.

(c.) Standard for the Installation of Foam-Water Sprinkler Systems and Foam-Water Spray Systems, NFPA No. 16–1968.

(d.) Standard for Dry Chemical Extinguishing Systems, NFPA No. 17–1973.

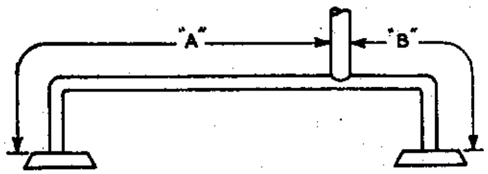
103. Fixed pipe extinguishing equipment shall be installed to conform with the following requirements:

1031. A readily accessible means to manually activate the fire extinguishing system, except a sprinkler system, shall be provided in a path of exit or egress and shall be clearly identified. Such means shall be mechanical and shall not rely on electrical power for actuation unless a reserve power supply is provided.

1032. Fixed pipe extinguishing systems, except automatic sprinkler systems, in a single hazard area shall be arranged for simultaneous automatic operation upon actuation of any one of the systems. A single hazard area is one which

(a) includes all cooking equipment, hoods, and duct work within 125 running feet of duct from any hood served, and

(b) any other cooking equipment, hoods, and duct work connected by less than 125 running feet of duct from the closest hood served. See Figure 1.



BOTH "A" AND "B" MUST BE 125 FEET TO CLASSIFY AS SEPARATE HAZARD AREAS. IF EITHER "A" OR "B" IS LESS THAN 125 FEET, BOTH PORTIONS ARE TO BE CONSIDERED A SINGLE HAZARD AREA.

Figure 1

1033. The operation of any extinguishing system shall automatically shut off all sources of fuel and heat to all equipment protected by an extinguishing system or located under ventilating equipment protected by an extinguishing system.

NOTE: Electrically heated equipment other than fat fryers, need not be shut off.

1034. Visual means shall be provided to show that the extinguishing system is energized if actuation is electrical.

1035. If required by the authority having jurisdiction, detailed information of the system shall be submitted for review.

1036. Installation of systems shall be made only by persons properly trained and qualified to install the specific system being provided. The installer shall certify to the authority having jurisdiction that the installation is in complete agreement with the terms of the listing and the manufacturers instructions and/or approved design.

NOTE: It is recommended that such training and qualification be by the manufacturer of the equipment being installed.

11. Procedures for the Use and Maintenance of Equipment.

111. Operating Procedures.

1111. Exhaust systems should be operated during all periods of cooking and should be equipped with a timing device which will continue the operation of the exhaust system for at least two (2) hours after cooking devices are turned off to allow fat fryers and other appliances to cool.

1112. Care must be exercised not to create flash grease fires by placing solid fats on preheated cooking surfaces. Solid fats heated too rapidly can be ignited at the edges before entirely melted.

1113. Filter equipped exhaust systems should not be operated with filters removed.

1114. Openings provided for replacing air exhausted through ventilating equipment should not be restricted by covers, dampers or any other means which would reduce the operating efficiency of the exhaust system.

1115. Instructions for manually operating the fire extinguishing system should be posted conspicuously in the kitchen and should be reviewed periodically with employees by the management.

1116. Listed grease extractors should be operated in accordance with the terms of their listings and manufacturer's instructions.

112. Inspection.

1121. An inspection and servicing of the fire extinguishing system by properly trained and qualified persons shall be made at least every six months. All actuation components including remote manual pull stations, mechanical or electrical devices, detectors, actuators, etc., shall be checked for proper operation during the inspection. In addition to these requirements, specific inspection requirements in the applicable NFPA standard (see Section 102) shall also be followed. Fusible links shall be replaced at least annually or more frequently if necessary to assure proper operation of the system. If required, certificates of inspection and maintenance performed shall be forwarded to the authority having jurisdiction.

NOTE: It is recommended that such training and qualification be by the manufacturer of the equipment being inspected and serviced.

1122. Depending on the amount of cooking equipment usage the entire exhaust system, including grease extractors, should be inspected daily or weekly to determine if grease or other residues have been deposited within. When grease or other residues are in evidence as deposits within the hood, grease removal devices, and/or ducts, the system should be cleaned in accordance with 113.

113. Cleaning.

1131. Hoods, grease removal devices, fans, ducts, and other appurtenances shall be cleaned at frequent intervals prior to surfaces becoming heavily contaminated with grease or oily sludge. Flammable solvents or other flammable cleaning aids shall not be used. At the start of the cleaning process all electrical switches, detection devices and system supply cylinders shall be locked, pinned, protectively covered and/or sealed to prevent the accidental starting of fans or actuating the fire extinguishing system. Care should be taken not to apply cleaning chemicals on fusible links or other detection devices of the automatic extinguishing system. WHEN CLEANING PROCEDURES ARE COMPLETED, ALL ELECTRICAL SWITCHES, DETECTION DEVICES, SYSTEM SUPPLY CYLINDERS, ETC., SHALL BE RETURNED TO AN OPERABLE STATE. COVER PLATES SHALL BE REPLACED AND DAMPERS AND DIFFUSERS SHALL BE POSITIONED FOR PROPER AIR FLOW.

NOTE: Satisfactory cleaning results have been obtained with a powder compound consisting of one part calcium hydroxide and two parts calcium carbonate. This compound saponifies the grease or oily sludge, thus making it easier to remove and clean. Proper ventilation must be provided and safety precautions taken if cleaning is done inside the duct or fan housings.

1132. Listed grease extractors should be operated and cleaned in accordance with their listings and the manufacturer's instructions.

12. Recommended Minimum Safety Requirements for Cooking Equipment.

121. Cooking Equipment.

1211. Cooking equipment should be approved based on:

1. Listings by a nationally recognized testing laboratory, or
2. Test data acceptable to the authority having jurisdiction.

1212. INSTALLATION.

(a.) All listed appliances should be installed in accordance with the terms of their listings and the manufacturer's instructions.

(b.) All fat fryers should be installed with at least a 16-inch space between the fryer and surface flames from adjacent cooking equipment.

122. Operating Controls.

1221. Deep fat fryers should be equipped with a separate high limit control in addition to the adjustable operating control (thermostat) to shut off fuel or energy in the event the fat exceeds a temperature of 425F.

Committee on Dry Chemical Extinguishing Systems

Interpretation Procedure of the Committee on Dry Chemical Extinguishing Systems

Those desiring an interpretation shall supply the Chairman with five identical copies of a statement in which shall appear specific reference to a single problem, paragraph, or section. Such a statement shall be on the business stationery of the inquirer and shall be duly signed.

When applications involve actual field situations they shall so state and all parties involved shall be named.

The Interpretations Committee will reserve the prerogative to refuse consideration of any application that refers specifically to proprietary items of equipment or devices. Generally inquiries should be confined to interpretation of the literal text or the intent thereof.

Requests for interpretations should be addressed to the National Fire Protection Association, 470 Atlantic Avenue, Boston, MA 02210.

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If the top of the pit is partially covered so that the open area is less than 3 per cent of the cubic foot volume expressed in square feet, the quantity of carbon dioxide required may be determined on a total-flooding basis using an additional quantity of gas for leakage compensation equal to one pound per square foot of open area.

For pits exceeding the minimum specified depth limitation, the discharge nozzles should be located at the two-thirds level above the floor, providing that the discharge rate versus distance factor is not exceeded so that there will be no danger of splashing any liquids that may be present. In any case, it is preferable to keep the nozzles below the open top to minimize the entrainment of air down into the pit. If the pit exceeds 20 feet in depth, it is desirable to locate the nozzles somewhat above the two-thirds level from the floor to make sure of adequate mixing within the pit. When the quantity of carbon dioxide is computed on the basis of normal total flooding techniques, the nozzle should have sufficient velocity and turbulence effects to completely fill the pit volume with a thoroughly mixed atmosphere of carbon dioxide and air.

Standard on

Halogenated Fire Extinguishing Agent Systems—

Halon 1301

NFPA No. 12A–1973

1973 Edition of No. 12A

This standard was prepared by the National Fire Protection Association Committee on Halogenated Fire Extinguishing Agent Systems, and this edition was adopted at the Annual Meeting of the National Fire Protection Association held at St. Louis, Mo., May 14–18, 1973.

The 1973 Edition makes numerous revisions and additions to the 1972 Standard in both the main body and the appendix. This is the result of improved technology and advancement in the state of the art.

Origin and Development of No. 12A

The Committee on Halogenated Fire Extinguishing Agent Systems was formed in the fall of 1966 and held its first meeting during December of that year. The committee was organized into four subcommittees, who separately prepared various portions of the standard for review by the full committee at meetings held in September and December 1967.

The Standard was submitted and adopted at the Annual Meeting in Atlanta, Georgia, May 20–24, 1968. The 1968 edition was the first edition of this Standard and was adopted in tentative form in accordance with NFPA regulations. In 1969 the committee determined that the Standard had not yet been sufficiently tested and elected to carry it in tentative status for one more year. It was presented for official adoption in 1970. The first official Standard was adopted at the annual meeting of the NFPA held at Toronto, Ontario in May 1970.

Committee on Halogenated Fire Extinguishing Agent Systems

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Nonvoting Member

H. V. Williamson, NFPA Committee on Carbon Dioxide

This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

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Standard on

Halogenated Fire Extinguishing Agent Systems— Halon 1301

NFPA No. 12A–1973

Introduction

1. Purpose. This Standard is prepared for use and guidance of those charged with the purchasing, designing, installing, testing, inspecting, approving, listing, operating, and maintaining halogenated agent extinguishing systems (Halon 1301), in order that such equipment will function as intended throughout its life.

Pre-engineered systems (packaged systems) consist of system components designed to be installed according to pretested limitations as approved or listed by a nationally recognized testing laboratory. Pre-engineered systems may incorporate special nozzles, flow rates, methods of application, nozzle placement, pressurization levels, and quantities of agent which may differ from those detailed elsewhere in this Standard since they are designed for very specific hazards. All other requirements of the Standard apply. Pre-engineered systems shall be installed to protect hazards within the limitations which have been established by the testing laboratories where listed.

2. Scope. This standard contains minimum requirements for halogenated agent fire extinguishing systems. It includes only the necessary essentials to make the Standard workable in the hands of those skilled in this field. Portable halogenated agent extinguishers are covered in NFPA No. 10, Installation of Portable Fire Extinguishers, and No. 10A, Maintenance and Use of Portable Fire Extinguishers.

Only those skilled in this work are competent to design and install this equipment. It may be necessary for many of those charged with the purchasing, inspecting, testing, approving, operating, and maintaining this equipment to consult with an experienced and competent fire protection engineer in order to effectively discharge their respective duties.

3. Arrangement. This Standard is arranged as follows:

Introduction.
Chapter 1—General Information and Requirements.
Chapter 2—Total Flooding Systems.
Chapter 3—Local Application Systems.
Appendix—Explanatory.

Chapters 1 through 3 constitute the body of the Standard and contain the rules and regulations necessary for properly designing, installing, inspecting, testing, approving, operating, and maintaining halogenated agent fire extinguishing systems.

The Appendix contains educational and informative material that will aid in understanding and applying this Standard.

4. Definitions. For purpose of clarification, the following general terms used with special technical meanings in this Standard are defined:

APPROVED refers to approval by the authority having jurisdiction.

AUTHORITY HAVING JURISDICTION: The "authority having jurisdiction" is the organization, office, or individual responsible for "approving" equipment, an installation, or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA standards in a broad manner since jurisdictions and "approval" agencies vary as do their responsibilities. Where public safety is primary, the "authority having jurisdiction" may be a federal, state, local, or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, health department, building official, electrical inspector, or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the "authority having jurisdiction."
In many circumstances the property owner or his delegated agent assumes the role of the "authority having jurisdiction"; at government installations, the commanding officer, or a departmental official may be the "authority having jurisdiction."

LISTED refers to the listing for the use intended, of devices and materials that have been examined by and meet the recognized standards of such testing laboratories as the Factory Mutual Research Corporation, the Underwriters' Laboratories, Inc., and Underwriters' Laboratories of Canada. All equipment shall bear a label or some other identifying mark.

SHALL is intended to indicate requirements.

SHOULD is intended to indicate recommendations or that which is advised but not required.

NORMALLY OCCUPIED AREA is one which is intended for occupancy.

Other terms used with special technical meaning are defined or explained where they occur in the Standard.

CHAPTER I. GENERAL INFORMATION AND REQUIREMENTS

1100. General Information.

1110. Scope. Chapter 1 contains general information, and the design and installation requirements for all features that are generally common to all Halon 1301 (bromotrifluoromethane $CBrF_3$) systems.

***1120. Halon 1301.** Halon 1301 is a colorless, odorless, electrically nonconductive gas that is an effective medium for extinguishing fires.

1121. According to present knowledge Halon 1301 extinguishes fires by inhibiting the chemical reaction of fuel and oxygen. The extinguishing effect due to cooling, or dilution of oxygen or fuel vapor concentration, is minor.

1130. Use and Limitations. Halon 1301 fire extinguishing systems are useful within the limits of this Standard in extinguishing fires in specific hazards or equipment, and in occupancies where an electrically nonconductive medium is essential or desirable, where cleanup of other media presents a problem, or where weight vs. extinguishing potential is a factor.

1131. Some of the more important types of hazards and equipment that Halon 1301 systems may satisfactorily protect include:

1. Gaseous and liquid flammable materials.

2. Electrical hazards such as transformers, oil switches and circuit breakers, and rotating equipment.

3. Engines utilizing gasoline and other flammable fuels.

4. Ordinary combustibles such as paper, wood, and textiles.

5. Hazardous solids.

6. Electronic Computers, Data Processing equipment and control rooms.

1132. Halon 1301 has not been found effective on the following:

1. Chemicals containing their own oxygen supply such as cellulose nitrate.

2. Reactive metals such as sodium, potassium, magnesium, titanium, zirconium, uranium, and plutonium.

3. Metal hydrides.

1133. Specific limitations are placed on Halon 1301 total flooding systems. See paragraphs 2112 and 2113.

1140. Duration of Protection. It is important that an effective agent concentration not only be achieved but that it be maintained for a sufficient period of time to allow effective emergency action by trained personnel. This is equally important in all classes of fires since a persistent ignition source (e.g., an arc, heat source, oxyacetylene torch or "deep seated" fire) can lead to a reoccurrence of the initial event once the agent has dissipated. Halon extinguishing systems normally provide protection for a period of minutes but are exceptionally effective for certain applications. Water supplies for standard sprinklers, on the other hand, are normally designed to provide protection for one-half to 4 hours duration but sprinklers may be less effective in controlling many fires. The designer, the buyer and the emergency force in particular should be fully aware of the advantages and limitations of each, the residual risks being assumed and the proper emergency procedures.

1150. Types of Systems. There are two types of systems recognized in this standard:

Total Flooding Systems.
Local Application Systems.

1151. A Total Flooding System consists of a supply of Halon 1301 arranged to discharge into, and fill to the proper concentration, an enclosed space or enclosure about the hazard.

1152. A Local Application System consists of a supply of Halon 1301 arranged to discharge directly on the burning material.

1160. Halon 1301 System. A Halon 1301 system may be used to protect one or more hazards or groups of hazards by means of directional valves. Where two or more hazards may be simultaneously involved in fire by reason of their proximity, each hazard shall be protected with an individual system with the combination arranged to operate simultaneously or be protected with a single system that shall be sized and arranged to discharge on all potentially involved hazards simultaneously.

***1200. Safety.**

1210. Hazards to Personnel. The discharge of Halon 1301 may create hazards to personnel such as dizziness, impaired coordination, reduced visibility and exposure to toxic decomposition products.

1211. Safety Requirements. In any proposed use of Halon 1301 where there is a possibility that people may be trapped in or enter into atmospheres made hazardous, suitable safeguards shall be provided to ensure prompt evacuation of and to prevent entry into such atmospheres and also to provide means for prompt rescue of any trapped personnel. Such safety items as personnel training, warning signs, discharge alarms, and breathing apparatus shall be considered.

1220. Electrical Clearances. All system components shall be so located as to maintain standard electrical clearances from live parts. See Appendix A for Table of Clearances.

1300. Specifications, Plans and Approvals.

1310. Specifications. Specifications for Halon 1301 fire extinguishing systems shall be prepared with care under the supervision of a competent engineer and with the advice of the authority having jurisdiction. The specifications shall include all pertinent items necessary for the proper design of the system such as the designation of the authority having jurisdiction, variances from the standard to be permitted by the authority having jurisdiction and the type and extent of the approval testing to be performed after installation of the system.

1320. Plans. Where plans are required, they shall be prepared with care under the supervision of a competent engineer and with the advice of the authority having jurisdiction.

1321. These plans shall be drawn to an indicated scale or be suitably dimensioned and shall be made so they can be easily reproduced.

1322. These plans shall contain sufficient detail to enable an evaluation of the hazard or hazards and the effectiveness of the system. The detail of the hazards shall include the materials involved in the hazards, the location of the hazards, the enclosure or limits and isolation of the hazards, and the exposures to the hazard.

1323. The detail on the system shall include information and calculations on the amount of Halon 1301; container storage pressure; internal volume of the container; the location and flow rate of each nozzle including equivalent orifice area; the location, size and equivalent lengths of pipe, fittings and hose; and the location and size of the storage facility. Information shall be submitted pertaining to the location and function of the detection devices, operating devices, auxiliary equipment, and electrical circuitry, if used. Sufficient information shall be indicated to identify properly the apparatus and devices used. Any special features shall be adequately explained.

1330. Approval of Plans. Plans and calculations shall be submitted for approval before work starts.

1331. When field conditions necessitate any material change from approved plans, the change shall be approved.

1332. When such material changes from approved plans are made, corrected "as installed" plans shall be provided.

***1340. Approval of Installations.** The completed system shall be tested by qualified personnel to meet the approval of the authority having jurisdiction. These tests shall be adequate to determine that the system has been properly installed and will function as intended. Only listed or approved equipment and devices shall be used in the systems.

1400. Detection and Actuation.

1410. Automatic detection and automatic actuation shall be used except that other detection, and manual actuation only, may be used if acceptable to the authority having jurisdiction. (See Appendix A-1420).

Some points to be considered are:

a. hazards to personnel,
b. undesirable side reaction,
c. an increase in the hazard,
d. other alternatives.

1420. Automatic Detection. Automatic detection shall be by any listed or approved method or device that is capable of detecting and indicating heat, flame, smoke, combustible vapors, or an abnormal condition in the hazard such as process trouble that is likely to produce fire.

1421. Heat detectors installed on standard spacing are about equal to an ordinary sprinkler in response time. If detectors are installed at reduced spacing from that recognized in approvals or listings response time may be reduced. An adequate and reliable source of energy shall be used in detection systems.

1430. Operating Devices. Operating devices include Halon 1301 releasing devices or valves, discharge controls, and shutdown equipment, all of which are necessary for successful performance of the system.

1431. Operation shall be by listed or approved mechanical, electrical, or pneumatic means. An adequate and reliable source of energy shall be used.

1432. All devices shall be designed for the service they will encounter and shall not be readily rendered inoperative or susceptible to accidental operation. Devices shall be normally designed to function properly from —20°F to 150°F (—30°C to 65°C) or marked to indicate temperature limitations.

1433. All devices shall be located, installed, or suitably protected so that they are not subject to mechanical, chemical, or other damage which would render them inoperative.

1434. The normal manual control for actuation shall be located so as to be conveniently and easily accessible at all times including the time of fire. This control shall cause the complete system to operate in its normal fashion.

1435. All automatically operated valves controlling agent release and distribution shall be provided with approved independent means for emergency manual operation. If the means for manual actuation of the system required in 1410 provides approved positive operation independent of the automatic actuation, it may be used as an emergency means. The emergency means, preferably mechanical, shall be easily accessible and located close to the valves controlled. Emergency actuation that can be accomplished from one location is desirable. This does not require the emergency manual control on "reserve" containers to control any selector valves or equipment beyond the containers.

1436. Manual controls shall not require a pull of more than 40 pounds (18.2Kg.) (force) nor a movement of more than 14 inches (36 cm.) to secure operation.

1437. Where gas pressure from the system or pilot containers is used as a means for releasing the remaining containers the supply and discharge rate shall be designed for releasing all of the remaining containers.

1438. All devices for shutting down supplementary equipment shall be considered integral parts of the system and shall function with the system operation.

1439. All manual operating devices shall be identified as to the hazard they protect.

1440. Supervision. Supervision of automatic systems is advisable where the possible loss because of any delay in actuation may be high and/or where the detection or control systems are so extensive and complex that they cannot be readily checked by visual or other inspection. When supervision is provided it shall be so arranged that there will be immediate indication of failure. The extent and type of supervision shall be approved by the authority having jurisdiction.

1450. Operating Alarms and Indicators. Alarms and/or indicators are used to indicate the operation of the system, hazards to personnel, or failure of any supervised device. The type (audible, visual, or olfactory), number and location of the devices shall be such that their purpose is satisfactorily accomplished. The extent and type of alarms and/or indicator equipment shall be approved.

1451. A positive alarm or indicator shall be provided to show that the system has operated.

1452. Alarms shall be provided to give positive warning of a discharge or pending discharge where a hazard to personnel may exist.

1453. Alarms indicating failure of supervised devices or equipment shall give prompt and positive indication of any failure and shall be distinctive from alarms indicating operation or hazardous conditions.

1454. Warning and instruction signs at entrances to and inside protected areas shall be provided.

1500. Halon 1301 Supply.

1510. Quantities. The amount of Halon 1301 in the system shall be at least sufficient for the largest single hazard protected or group of hazards which are to be protected simultaneously.

1511. Where uninterrupted protection is required, the reserve quantity shall be as many multiples of these minimum amounts as the authority having jurisdiction considers necessary.

1512. Both primary and reserve supplies for fixed storage shall be permanently connected to the piping and arranged for easy changeover, except where the authority having jurisdiction permits an unconnected reserve.

1520. Quality. Specification MIL-M-12218B requires a technical purity of Halon 1301 as shown in Table 1520 below:

Table 1520

Requirements for Halon 1301 (Bromotrifluoromethane) Specification MIL-M-12218B†

Property	Requirement
Bromotrifluoromethane, mole percent minimum	99.6
Chlorotrifluoromethane, trifluoromethane, difluorodichloromethane, chlorodifluoromethane, tetrafluoromethane, mole percent maximum	0.385
Bromodifluoromethane, mole percent maximum	0.005
Dibromodifluoromethane, mole percent maximum	0.005
Fixed gases in vapor phase, percent by volume maximum	1.5
Moisture in liquid phase, percent by weight maximum	0.001
High boiling residue, percent by volume	0.05
HF, HBr, halogens and other acids, mole percent maximum	None
Suspended matter, maximum	None

†May be obtained from: Naval Publications and Forms Center
5801 Tabor Avenue
Philadelphia, PA 19120

1530. Replenishment. The time needed to obtain Halon 1301 for replenishment to restore systems to operating condition shall be considered as a major factor in determining the reserve supply needed.

1540. Storage Container Arrangement. Storage containers and accessories shall be so located and arranged that inspection, testing, recharging and other maintenance is facilitated and interruption to protection is held to a minimum.

1541. Storage containers shall be located as near as possible to the hazard or hazards they protect, but where they will not be exposed to fire or explosion, and preferably not located within the hazard area.

1542. Storage containers shall not be located so as to be subject to severe weather conditions or be subject to mechanical, chemical, or other damage. When excessive climatic or mechanical exposures are expected, suitable guards or enclosures shall be provided.

1550. Storage Containers. The Halon 1301 supply shall be stored in containers designed to hold Halon 1301 in liquefied form at ambient temperatures. Containers shall not be charged to a filling density greater than 70 pounds per cubic foot (1.122 kg/liter). They shall be superpressurized with dry nitrogen to 360 psig ± 5% or 600 psig ± 5% total pressure at 70°F (25.91 kg/cm^2 abs. ± 5% or 42.75 kg/cm^2 abs. ± 5% total pressure at 20°C). Containers shall be distinctively and permanently marked with the type and quantity of agent contained therein, together with the degree of superpressurization.

1551. The Halon 1301 containers used in these systems shall be designed to meet the requirements of the U.S. Department of Transportation or the Canadian Board of Transport Commissioners*, if used as a shipping container. If not a shipping container, it shall be designed, fabricated, inspected, certified and stamped in accordance with Section VIII of the ASME Unfired Pressure Vessel Code; independent inspection and certification is recommended. The design pressure shall be suitable for the maximum pressure developed at 130°F (55°C) or at the maximum controlled temperature limit (see paragraph 1557).

* Subpart C. Section 178.36 to and including 178.68 of Title 49, Transportation, Code of Federal Regulations. Parts 170–190. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20401. In Canada the corresponding information is set forth in the "Canadian Transport Commission's Regulations for Transportation of Dangerous Commodities by Rail" available from the Queen's Printer, Ottawa, Ontario.

1552. A reliable means of indication, other than weighing, shall be provided to determine the pressure in refillable containers. The means of indication shall account for variation of container pressure with temperature.

1553. Charged containers shall be tested for tightness before shipment in accordance with an approved procedure. Shipping containers in service shall be hydrostatically retested for continuing service at least every 12 years in accordance with the test procedure and apparatus set forth in the regulations of the U.S. Department of Transportation or Board of Transport Commissioners.

1554. When manifolded, containers shall be adequately mounted and suitably supported in a rack which provides for convenient individual servicing or content weighings. Automatic means shall be provided to prevent agent loss from the manifold if the system is operated when any containers are removed for maintenance.

1555. Each system shall have a permanent nameplate specifying the number, filling weight, and pressurization level of the containers.

1556. In a multiple cylinder system, all cylinders supplying the same manifold outlet for distribution of agent, shall be interchangeable and of one select size and charge.

1557. Storage temperatures shall not exceed 130°F (55°C) nor be less than —20°F (—29°C) for total flooding systems unless the system is designed for proper operation with storage temperatures outside of this range. For local application systems, container storage temperatures shall be within a range from +32°F (0°C) to +130°F (55°C) unless special methods of compensating for changing flow rates are provided. External heating or cooling may be used to keep the temperature within desired ranges. When special container charges are used, the containers shall be appropriately marked.

1600. Distribution

*** 1610 Piping.** Piping shall be of noncombustible material having physical and chemical characteristics, such that its deterioration under stress can be predicted with reliability. Special corrosion-resistant materials or coatings may be required in severely corrosive atmospheres. Examples of materials for piping and the standards covering these materials are:

Ferrous Piping: (Seamless) Black or Galvanized Steel Pipe: ASTM A-53 or A-106, ANSI B-36.10.

Nonferrous Piping (Drawn, Seamless), Copper: ASTM B-88. Flexible Metallic Hose: ANSI B140.1-72.

The above listed materials do not preclude the use of other materials such as Stainless Steel or other pipe or tubing, which will also satisfy the requirements of this paragraph. See Appendix A-1610 for stress calculations.

Schedule 40 steel pipe up to 4 in. nominal pipe size conforming to the above specifications is satisfactory for both the 360 psig (25.91 kg/cm^2) and 600 psig (42.75 kg/cm^2) charging pressures specified in this standard.

Type M copper tubing conforming to the above specification is satisfactory for all 360 psig (25.91 kg/cm^2) charging pressure.

For 600 psig (42.75 kg/cm^2) charging pressures Type M is satisfactory for nominal sizes up to ¾ inch, Type L up to 1½ inch size and Type K up to 2½ inch size.

1611. Ordinary cast iron pipe or steel pipe conforming to ASTM A-120 shall not be used.

1612. Flexible piping tubing or hoses (including connections) where used shall be of approved materials and pressure ratings.

1620. Piping Joints. The type of piping joint shall be suitable for the design conditions and shall be selected with consideration of joint tightness and mechanical strength. Example of suitable joints and fittings are screwed, flanged, welded, brazed, flared and compression.

1621. Examples of materials used for fittings are:

Malleable iron 300 lb class only—ASTM A-197
Ductile Iron 300 lb class only—ASTM A-445
Steel—ASTM A-234

Pressure temperature ratings have been established for certain types of fittings. A list of ANSI Standards covering the different types of fittings are given Table 126.1 of ANSI B-31.1.0. Where fittings not covered by one of these standards are used, the design recommendations of the manufacturer of the fittings shall not be exceeded. The above listed materials do not preclude the use of other materials which will satisfy the requirements of this paragraph.

1622. Ordinary cast iron fittings shall not be used.

1623. All threads used in joints and fittings shall conform to ANSI B-2.1. Joint compound, tape or thread lubricant shall be applied only to the male threads of the joint.

1624. Welding and brazing shall conform to ANSI B-31.1.0. Brazing alloys shall meet or exceed ANSI A-5 classification B Cup-3.

1625. Copper stainless steel or other suitable tubing may be joined with flared compression type fittings. The pressure-temperature ratings of the manufacturer of the fitting shall not be exceeded.

1630. Arrangement and Installation of Piping and Fittings. Piping shall be installed in accordance with good commercial practice. Care should be taken to avoid possible restrictions due to foreign matter, faulty fabrication or improper installation.

1631. The piping system shall be securely supported with due allowance for agent thrust forces, thermal expansion and contraction and shall not be subjected to mechanical, chemical, vibration or other damage. ANSI B-31.1.0. shall be consulted for guidance on this matter. Where explosions are likely, the piping shall be attached to supports that are least likely to be displaced.

1632. Piping shall be blown out before nozzles or discharge devices are installed.

1633. In systems where valve arrangement introduces sections of closed piping, such sections shall be equipped with pressure relief devices or the valves shall be designed to prevent entrapment of liquid. Where pressure-operated container valves are used, a means shall be provided to vent any container leakage from the manifold but which will prevent loss of the agent when the system operates.

1634. All pressure relief devices shall be of such design and so located that the discharge therefrom will not injure personnel or be otherwise objectionable.

1640. Valves. All valves shall be suitable for the intended use, particularly in regard to flow capacity and operation. They shall be used only under temperatures and other conditions for which they are listed.

1641. Valves shall be protected against mechanical, chemical, or other damage.

1642. Valves shall be rated for equivalent length in terms of the pipe or tubing sizes with which they will be used. The equivalent length of container valves shall be listed and shall include siphon tube, valve, discharge head and flexible connector.

1650. Discharge Nozzles. Discharge nozzles shall be listed for the use intended and for discharge characteristics. The discharge nozzle consists of the orifice and any associated horn, shield, or baffle.

1651. Discharge orifices shall be of corrosion-resistant metal.

1652. Discharge nozzles used in local application systems shall be accurately located and directed in accordance with the system design requirements as covered in 3300. Discharge nozzles used in local application systems SHALL be so connected and supported that they may not readily be put out of alignment.

1653. Discharge nozzles shall be permanently marked to identify the nozzle and to show the equivalent single orifice diameter regardless of shape and number of orifices. This equivalent diameter shall refer to the orifice diameter of the "standard" single orifice type nozzle having the same flow rate as the nozzle in question. The marking shall be readily discernible after installation. The "standard" orifice is an orifice having a rounded entry with coefficient of discharge not less than 0.98 and flow characteristics as given in Table 2. For equivalent orifice diameters, the code given in Table 1 may be used.

1654. Discharge nozzles shall be provided with frangible discs or blow-out caps where clogging by foreign materials is likely. These devices shall provide an unobstructed opening upon system operation.

***1660. Pipe and Orifice Size Determination.** Pipe sizes and orifice areas shall be selected on the basis of calculations to deliver the required rate of flow at each nozzle.

1661. Figures 1 and 2 shall be used to determine the pressure drop in the pipe line: The system shall be designed based on a 70°F ambient temperature.

1662. Flow shall be calculated on the basis of an initial storage pressure of 600 or 360 psig. (42.75 or 25.91 kg/cm² abs.)

(as applicable) adjusted for the initial drop in storage pressure required to fill the piping system. The discharge rate for equivalent orifices shall be based on the values given in Table 2. Design nozzle pressures shall be not less than 200 psig.

Table 1. Equivalent Orifice Sizes

Orifice Code No.	Equivalent Single Orifice Diameter–Inches	Equivalent Single Orifice Area–Sq. In.
——	.026	.00053
——	1/16	.00307
——	.070	.00385
——	.076	.00454
——	5/64	.0048
——	.081	.00515
——	.086	.00581
3	3/32	.0069
3+	7/64	.0094
4	1/8	.0123
4+	9/64	.0155
5	5/32	.0192
5+	11/64	.0232
6	3/16	.0276
6+	13/64	.0324
7	7/32	.0376
7+	15/64	.0431
8	1/4	.0491
8+	17/64	.0554
9	9/32	.0621
9+	19/64	.0692
10	5/16	.0767
11	11/32	.0928
12	3/8	.1105
13	13/32	.1296
14	7/16	.1503
15	15/32	.1725
16	1/2	.1964
18	9/16	.2485
20	5/8	.3068
22	11/16	.3712
24	3/4	.4418
32	1	.785
48	1 1/2	1.765
64	2	3.14

NOTE: The orifice code number indicates the equivalent single orifice diameter in 1/32 inch increments. A plus sign following this number indicates equivalent diameters 1/64 inch greater than that indicated by the numbering system (e. g., No. 4 indicates an equivalent orifice diameter of 4/32 of an inch; a No. 4+, 9/64 of an inch).

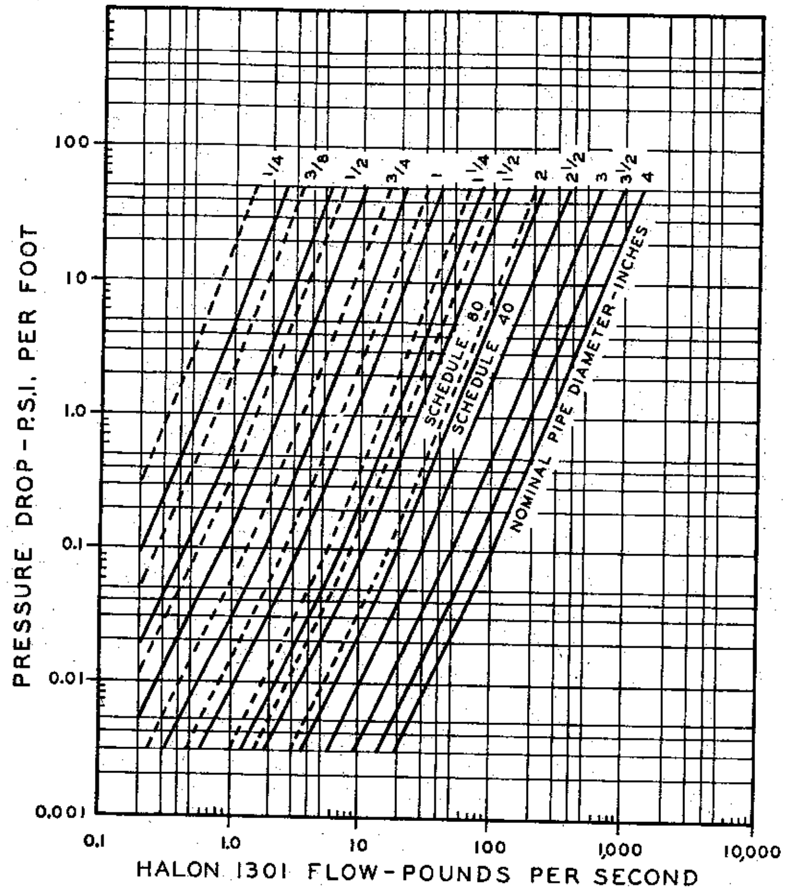

Fig. 1. Pressure drop vs. flow in steel pipe.

1663. Flow calculations shall be performed to insure that the adjusted storage pressure and the pressure losses due to flow are within 3 psig of each other.

1700. Inspection, Maintenance and Instructions.

1710. Inspection and Tests. At least annually, all systems shall be thoroughly inspected and tested for proper operation by competent personnel.

Table 2. Halon 1301

ORIFICE DISCHARGE RATES 70°F TEMPERATURE

Pressure Above Orifice psig	Discharge Rate, Lb/sec–in²* At 600 psig Storage Pressure	Discharge Rate, Lb/sec–in²* At 360 psig Storage Pressure
200	10.3	19.3
210	11.3	21.4
220	12.4	23.5
230	13.5	25.9
240	14.6	28.3
250	15.8	30.8
260	17.1	33.4
270	18.4	36.1
280	19.7	39.0
290	21.1	41.9
300	22.5	45.0
310	24.0	48.1
320	25.5	51.4
330	27.1	54.8
340	28.7	58.2
350	30.4	61.8
360	32.1	65.5
370	33.9	
380	35.7	
390	37.5	
400	39.4	
410	41.4	
420	43.4	
430	45.4	
440	47.5	
450	49.7	
460	51.8	
470	54.1	
480	56.4	
490	58.7	
500	61.1	
510	63.5	
520	65.9	
530	68.5	
540	71.0	
550	73.6	
560	76.3	
570	79.0	
580	81.7	
590	84.5	
600	87.4	

* Orifice discharge coefficient = 0.98

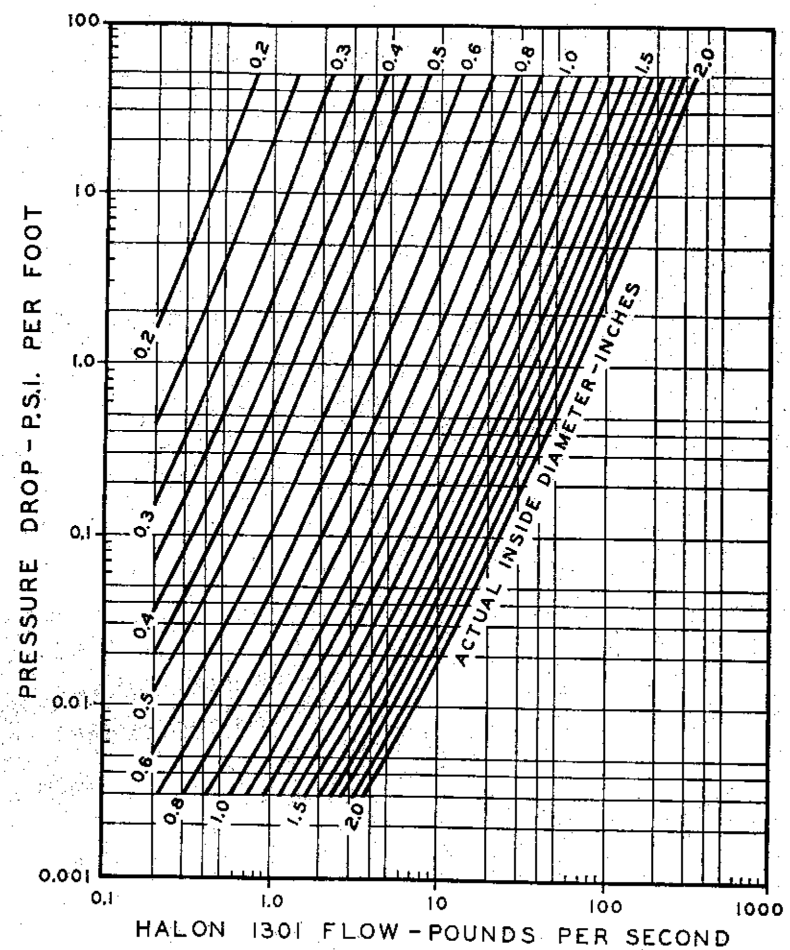

Fig. 2. Pressure drop vs. flow in copper tubing.

1711. The goal of this inspection and testing shall be to ensure that the system is in full operating condition.

1712. Suitable discharge tests shall be made when inspection indicates their advisability.

1713. The inspection report with recommendations shall be filed with the owner.

1714. Between the regular service contract inspection or tests, the system shall be inspected visually or otherwise by competent personnel, following an approved schedule and procedure.

1715. At least semiannually, the weight and pressure of refillable containers shall be checked. If a container shows a loss in net weight of more than 5 percent or a loss in pressure (adjusted for temperature) of more than 10 percent, it shall be refilled or replaced.

1716. Factory charged nonrefillable containers which do not have a means of pressure indication shall be weighed at least semiannually. If a container shows a loss in net weight of more than 5 percent, it shall be replaced.

1717. The weight and pressure of the container shall be recorded on a tag attached to the container.

***1720. Maintenance.** These systems shall be maintained in full operating condition at all times. Use, impairment, and restoration of this protection shall be reported promptly to the authority having jurisdiction.

1721. Any troubles or impairments shall be corrected at once by competent personnel.

1730. Instruction. All persons who may be expected to inspect, test, maintain, or operate fire extinguishing systems shall be thoroughly trained and kept thoroughly trained in the functions they are expected to perform.

CHAPTER 2. TOTAL FLOODING SYSTEMS

***2100. General Information.**

2110. Uses. This type of system may be used where there is a fixed enclosure about the hazard that is adequate to enable the required concentration to be built up and maintained for the required period of time to ensure the effective extinguishment of the fire in the specific combustible materials involved where the ambient temperature is above —70°F.

2111. Total flooding systems may provide fire protection within rooms, vaults, enclosed machines, ovens, containers, storage tanks and bins. Where ambient temperatures exceed 900°F. (See paragraph A1202.)

*2112. Halon 1301 total flooding systems shall not be used in concentrations greater than 10 percent in normally occupied areas. For the purposes of this standard, a "normally occupied" area is defined as an area intended for occupancy. Areas which may contain 10 percent Halon 1301 should be evacuated immediately upon discharge of the agent. Where egress cannot be accomplished within one minute, Halon 1301 total flooding systems shall not be used in normally occupied areas in concentrations greater than 7 percent.

2113. Halon 1301 total flooding systems utilizing concentrations greater than 10 percent but not exceeding 15 percent may be used in areas not normally occupied, provided egress can be accomplished within 30 seconds. Where egress cannot be accomplished within 30 seconds or concentrations greater than 15 percent must be used, provisions shall be made to prevent inhalation by personnel.

2120. General Requirements. Total flooding systems shall be designed, installed, tested and maintained in accordance with the applicable requirements in Chapter 1 and with the additional requirements set forth in this chapter.

2200. Hazard Specifications.

2210. Types of Fires. Fires which can be extinguished by total flooding methods may be divided into three categories:

1. Fires involving flammable liquids or gases.
2. Surface fires involving flammable solids.
3. Deep-seated fires, such as can occur with certain Class A materials subject to spontaneous heating, smoldering, and high heat retention.

2211. Flammable liquid and gas fires are subject to prompt extinguishment when Halon 1301 is quickly introduced into the enclosure in sufficient quantity to provide an extinguishing concentration for the particular materials involved. NFPA No. 69, Inerting for Fire and Explosion Prevention should be referred to when the possibility of flammable concentrations from gas leakage dictates explosion protection techniques.

2212. Surface fires associated with the burning of solid materials are also quickly extinguished by Halon 1301. In many solid materials, smoldering combustion may continue at the surface of the fuel after extinguishment of the flames. These surface embers will normally be extinguished by low concentrations of Halon 1301 maintained for short periods of time.

2213. Deep-seated fires may become established beneath the surface of a fibrous or particulate material. This may result from flaming combustion at the surface or from ignition within the mass of fuel. Smoldering combustion then progresses slowly through the mass. A fire of this kind is referred to in this standard as a "deep-seated" fire. The burning rate of these fires can be reduced by the presence of Halon 1301, and they may be extinguished if a high concentration can be maintained for an adequate soaking time. However, it is not normally practical to maintain a sufficient concentration of Halon 1301 for a sufficient time to extinguish a deep-seated fire.

2220. Enclosure. In the design of total flooding systems, the characteristics of the enclosure must be considered as follows:

*2221. For all types of fires, the area of unclosable openings shall be kept to a minimum. These openings shall be compensated for by additional quantities of agent according to the design procedures outlined in Appendix A-2530. The authority having jurisdiction may require tests to assure proper performance as defined by this standard.

2222. To prevent fire from spreading through openings to adjacent hazards or work areas and to make up for leakage of the agent, openings shall be compensated for with automatic closures, screening nozzles or additional agent, and shall be arranged to operate simultaneously with system discharge. The agent required by screening nozzles shall be in addition to the normal requirement for total flooding. Where reasonable confinement of agent is impracticable, protection shall be extended to include the adjacent hazards or work areas.

2223. For deep-seated fires, forced air ventilating systems shall be shut down or closed with the start of agent discharge; or, additional compensating gas shall be provided. Refer to Appendix A-2530.

2224. For surface fires, forced air ventilation may also be required to be shut down or closed with the start of agent discharge; or, additional compensating gas may need to be provided. Refer to Appendix A-2530.

***2300. Halon 1301 Requirements for Liquid and Gas Fires.**

2310. General. The quantity of Halon 1301 for fires involving flammable liquids and gases is based upon normal conditions with the extinguishing system meeting the requirements specified herein.

2320. Flammable Materials. In the determination of the design concentration of Halon 1301, proper consideration shall be given to the type and quantity of flammable material involved, the conditions under which it normally exists in the hazard, and any special conditions of the hazard itself. For a particular fuel, two minimum levels of Halon 1301 concentration may be used: either

Table No. 3
Halon 1301 Design Concentrations for Flame Extinguishment

IN AIR AT 1.0 Atm. and 70°F

Material	Minimum Design Concentration* % by Volume
Commercial Denatured Alcohol	4.0
n-Butane	2.9
i-Butane	3.3
Carbon Disulfide	12.0
Carbon Monoxide	1.0
Ethane	3.3
Ethyl Alcohol	4.0
Ethylene	7.2
n-Heptane	3.7
Hydrogen	20.0
Methane	2.0
Propane	3.2
Kerosene	2.8
Petroleum Naphtha	6.6

* Includes a safety factor of 10 percent minimum above experimental threshold values. For other temperatures or pressures, specific test data shall be obtained.

is permitted for situations where only flame extinguishment is required; the higher level of concentration shall be used where complete inerting is required to prevent a subsequent reflash or possible explosion.

Appendix A-2300 contains additional guidelines for determining the concentration level which should be selected for a particular hazard.

2321. Flame Extinguishment Data. Table No. 3 gives the minimum design concentration required to extinguish normal fires involving certain flammable gases and liquids at atmospheric pressure. These values are permitted if it can be shown that a probable explosive atmosphere cannot exist in the hazard as a result of the fire. An explosion potential is improbable when:

(a) The quantity of fuel permitted in the enclosure is less than that required to develop a maximum concentration equal to one-half of the lower flammable limit. Additional information is given in Appendix A-2100 and 2300.

(b) The volatility of the fuel before the fire is too low to reach the lower flammable limit in air (maximum ambient temperature or fuel temperature does not exceed the closed cup flash point temperature), and fire may be expected to burn less than 30 seconds before extinguishment.

2322. Inerting Data. Table No. 4 gives flammability peak

Table No. 4
Halon 1301 Design Concentrations for Inerting

IN AIR AT 1.0 Atm. and 70°F

Material	Minimum Design Concentration* % by Volume
Acetone	5.3
Benzene	4.3
i-Butane	8.0
Carbon Disulfide	12.0
Diethyl Ether	6.3
Ethyl Alcohol	4.0
Ethyl acetate	4.6
Ethylene	11.0
Hydrogen	20.0
n-Heptane	8.0
JP-4	6.6
Methane	2.0
i-Pentane	6.3
Propane	6.5

* For other temperatures or pressures, specific test data shall be obtained.

data obtained with Halon 1301 for several materials. These values shall be used when the conditions of 2321 are not or cannot be met. The concentrations shown are greater than those given in Table No. 3, and are sufficient to "inert" the atmosphere against all proportions of fuel in air. Specifically, they should be used in the following situations:

(a) The quantity of fuel in the enclosure is greater than that permitted in 2321(a).

(b) The volatility of the fuel is greater than that permitted in 2321(b).

(c) The system response is not rapid enough to detect and extinguish the fire before the volatility of the fuel is increased to a dangerous level as a result of the fire.

2323. For materials not given in the above tables, the Halon 1301 design concentration shall be obtained by test of flame extinguishing effectiveness plus a 10 percent minimum safety factor or by determination of the inerting concentration.

2324. For combinations of fuels the values for the fuel requiring the greatest concentration shall be used.

2325. Where gaseous or highly volatile or atomized fuels are expected, additional protective measures such as actuation by hazardous vapor detectors are recommended. NFPA Standard No. 69 covering explosion suppression techniques should also be consulted for such situations.

***2400. Halon 1301 Requirements for Fires in Solid Materials.**

2410. General. Flammable solids may be classed as those which do not develop deep-seated fires, and those which do. Materials which do not become deep-seated undergo surface combustion only and may be treated much as a flammable liquid fire. Most materials which develop deep-seated fires do so after exposure to flaming combustion for a certain length of time which varies with the material. In others, the fire may begin as deep-seated through internal ignition, such as spontaneous heating.

2420. Solid Surface Fires. Almost all flammable solids begin burning on the surface. In many materials, such as unfilled plastics (without filler materials), surface combustion is the only type that occurs. These fires are readily extinguished with low concentrations, (e.g., 5%) of Halon 1301. Although glowing embers may remain at the surface of the fuel following extinguishment of flames, these embers will be completely extinguished within a short time (e.g., 10 minutes) provided the Halon 1301 concentration is maintained around the fuel for this time (called "soaking" time).

2430. Deep-Seated Fires. Halon 1301, like other halogenated hydrocarbons, chemically inhibits the propagation of flame. However, although the presence of Halon 1301 in the vicinity of a deep-seated fire will extinguish the flame, thereby greatly reducing the rate of burning, the quantity of agent required for complete extinction of all embers is difficult to assess. It depends on the nature of the fuel, its state of comminution, its distribution within the enclosure, the time during which it has been burning, the ratio of the area of the burning surface to the volume of the enclosure, and the degree of ventilation in the enclosure. It is usually difficult or impractical to maintain an adequate concentration for a sufficient time to ensure the complete extinction of a deep-seated fire (see Appendix A-2400).

2431. Where the solid material is in such a form that a deep-seated fire can be established before a flame extinguishing concentration has been achieved, provision shall be made to the satisfaction of the authority having jurisdiction for means to effect complete extinguishment of the fire (see A-2400).

2500. Determination of Halon 1301 Quantity for Total Flooding Systems.

2510. General. The Halon 1301 concentration requirements established in Sections 2300 and 2400 are converted into agent weight requirements through mathematical computations considering the volume of the hazard and the specific volume of the superheated Halon 1301 vapor. In addition to the concentration requirements, additional quantities of agent may be required to compensate for unclosable openings, forced ventilation or other special conditions which would affect the extinguishing efficiency.

***2520. Total Flooding Quantity.** Figure 3 depicts the specific volume of superheated Halon 1301 vapor at various temperatures. The amount of Halon 1301 required to achieve the design concentration is calculated from the following formula:

$$W = \frac{1}{s}\left(\frac{C}{100-C}\right)V$$

W = Weight of Halon 1301 required, pounds
s = Specific volume superheated Halon 1301, cubic feet/pound
C = Halon 1301 concentration, % by volume
V = Volume of hazard, cubic feet

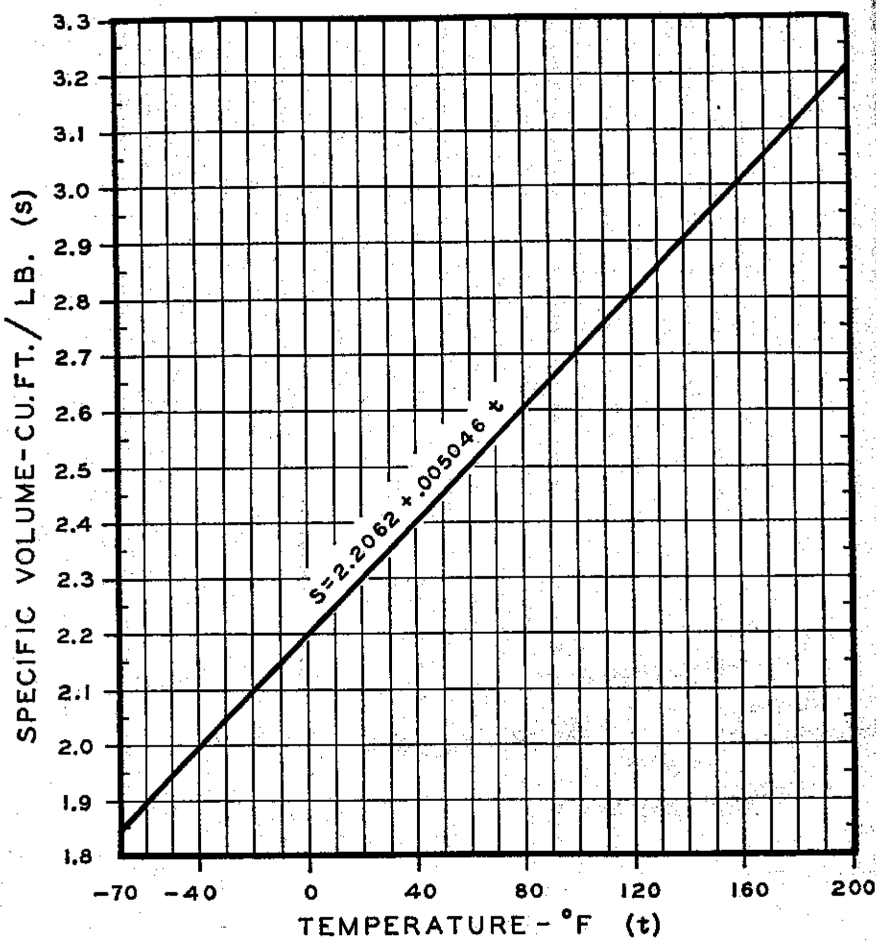

Fig. 3 Specific volume of superheated Halon 1301 vapor (at 1 atmosphere).

This calculation includes an allowance for normal leakage from a "tight" enclosure due to agent expansion. Since the amount of gas and, therefore, the concentration produced by a given weight of Halon 1301 is greatly affected by the temperature it encounters, the specific volume of superheated Halon 1301 vapor for the lower operating minimum anticipated ambient temperature limit shall be used in the design of a Halon 1301 total flooding system. Table 5 is a tabulation of the Halon 1301 weight per cubic foot of hazard volume required to produce the specified concentration of various hazard temperature conditions.

All Halon 1301 total flooding systems shall be capable of producing the required concentration of agent under the conditions of maximum net volume (gross volume of the hazard minus the volume occupied by solid objects), maximum ventilation and minimum anticipated ambient temperature. In areas where wide variations in net volume are encountered under normal operations such as storage rooms, warehouses, etc., or where wide variations in ambient temperatures are experienced as in unheated rooms, the agent concentration generated under these extremes shall be calculated to determine compliance with paragraphs 2112 and 2113.

***2530. Special Conditions.** Additional quantities of Halon 1301 shall be provided to compensate for any special conditions, such as unclosable openings, forced ventilation, or other causes of agent loss. It shall be the responsibility of the system designer to show that such conditions have been taken into account in the design of a system.

2600. Distribution System.

2610. General. The distribution system for applying Halon 1301 to enclosed hazards shall be designed with due consideration for the materials involved, the type of burning expected, and the nature of the enclosure. These factors all may affect the discharge times and rates of application.

***2620. Rate of Application.** The minimum design rate of application shall be based on the quantity of agent required for the desired concentration and the time allotted to achieve the desired concentration.

2621. Discharge time. The agent discharge shall be substantially completed in a nominal 10 seconds or a shorter time if practicable, unless a longer discharge time is specifically permitted by the authority having jurisdiction. This period shall be measured as the interval between the first appearance of liquid at the nozzle and the time when the discharge becomes predominantly gaseous. This point is distinguished by a marked change in both the sound and the appearance of the discharge.

2630. Extended Application Rate. Where leakage is appreciable and the design concentration must be obtained quickly and maintained for an extended period of time, agent quantities provided for leakage compensation may be applied at a reduced rate.

2631. This type of application is particularly suitable to enclosed rotating electrical apparatus, such as generators, motors and

Table 5
Halon 1301 Total Flooding Quantity

Temperature t °F (2)	Halon 1301 Specific Vapor Volume Ft. 3/Lb. (3)	Halon 1301 Weight Requirements/Cubic Foot of Hazard Volume (1) — Halon 1301 Concentration—C—% By Volume (4): 3	4	5	6	7	8	9	10
— 70	1.8468	.0167	.0225	.0285	.0345	.0407	.0471	.0536	.0602
— 60	1.8986	.0163	.0219	.0277	.0336	.0396	.0458	.0521	.0585
— 50	1.9502	.0158	.0213	.0270	.0327	.0386	.0446	.0507	.0570
— 40	2.0016	.0154	.0208	.0263	.0319	.0376	.0434	.0494	.0555
— 30	2.0530	.0151	.0203	.0256	.0311	.0366	.0423	.0482	.0541
— 20	2.1042	.0147	.0198	.0250	.0303	.0357	.0413	.0470	.0528
— 10	2.1552	.0143	.0193	.0244	.0296	.0349	.0403	.0459	.0515
0	2.2062	.0140	.0189	.0239	.0289	.0341	.0394	.0448	.0504
10	2.2571	.0137	.0185	.0233	.0283	.0334	.0385	.0438	.0492
20	2.3078	.0134	.0181	.0228	.0277	.0326	.0377	.0429	.0481
30	2.3585	.0131	.0177	.0223	.0271	.0319	.0369	.0419	.0471
40	2.4091	.0128	.0173	.0218	.0265	.0312	.0361	.0411	.0461
50	2.4597	.0126	.0169	.0214	.0260	.0306	.0354	.0402	.0452
60	2.5101	.0123	.0166	.0210	.0254	.0300	.0346	.0394	.0443
70	2.5605	.0121	.0163	.0206	.0249	.0294	.0340	.0386	.0434
80	2.6109	.0118	.0160	.0202	.0244	.0288	.0333	.0379	.0426
90	2.6612	.0116	.0156	.0198	.0240	.0283	.0327	.0371	.0417
100	2.7114	.0114	.0154	.0194	.0235	.0277	.0320	.0365	.0410

Table 5
Halon 1301 Total Flooding Quantity

Temperature t °F (2)	Halon 1301 Specific Vapor Volume Ft. 3/Lb. (3)	Halon 1301 Weight Requirements/Cubic Foot of Hazard Volume (1) — Halon 1301 Concentration—C—% By Volume (4): 3	4	5	6	7	8	9	10
110	2.7616	.0112	.0151	.0190	.0231	.0272	.0315	.0358	.0402
120	2.8118	.0110	.0148	.0187	.0227	.0267	.0309	.0351	.0395
130	2.8619	.0108	.0145	.0184	.0223	.0263	.0303	.0345	.0388
140	2.9119	.0106	.0143	.0181	.0219	.0258	.0298	.0340	.0382
150	2.9620	.0104	.0140	.0178	.0215	.0254	.0293	.0334	.0375
160	3.0120	.0103	.0138	.0175	.0212	.0250	.0289	.0328	.0369
170	3.0169	.0101	.0136	.0172	.0208	.0246	.0284	.0323	.0363
180	3.1119	.0099	.0134	.0169	.0205	.0242	.0280	.0318	.0357
190	3.1618	.0098	.0132	.0166	.0202	.0238	.0275	.0313	.0351
200	3.2116	.0096	.0130	.0164	.0199	.0234	.0271	.0308	.0346

(1) Agent Weight Requirements ($\frac{W}{V}$—lb./ft.^{3})—Pounds of agent required per cubic foot of protected volume to produce indicated concentration at temperature specified.

$$\frac{W}{V} = \frac{1}{s}\left(\frac{C}{100-C}\right)$$

(2) Temperature (t—°F)—The design temperature in the hazard area.

(3) Specific Volume (s—ft.^{3}/lb.)—Specific volume of superheated Halon 1301 vapor at the temperature indicated.

$$s = 2.2062 + .005046\ t$$

(4) Concentration (C—%)—Volumetric concentration of Halon 1301 in air at the temperature indicated.

convertors, and also may be needed for total flooding protection of deep-seated fires.

2632. The initial discharge shall be completed within the limits specified in paragraph 2620.

2633. The rate of extended discharge shall be sufficient to maintain the desired concentration for the duration of application.

2640. Piping and Supply. Piping shall be designed in accordance with the requirements outlined in Chapter 1 to deliver the required rate of application at each nozzle.

2650. Nozzle Choice and Location. Nozzles used with total flooding systems shall be of the type listed for tne intended purpose, and shall be located with the geometry of the hazard and enclosure taken into consideration.

2651. The type of nozzles selected, their number, and their placement shall be such that the design concentration will be established in all parts of the hazard enclosure, and such that the discharge will not unduly splash flammable liquids or create dust clouds that might extend the fire, create an explosion, or otherwise adversely affect the contents of the enclosure. Nozzles vary in design and discharge characteristics and shall be selected on the basis of their adequacy for the use intended. Nozzles shall be placed within the hazard area in compliance with listed limitations with regard to spacing, floor coverage and alignment.

2700. Venting Consideration.

2710. General. Venting of an enclosure may be necessary to relieve pressure build-up due to the discharge of large quantities of Halon 1301. Appropriate pressure relief depends on the injection rate of the Halon 1301 and enclosure strength.

2720. Pressure Relief Venting. Porosity and leakages such as around doors, windows and dampers, though not readily apparent or easily calculated, will usually provide sufficient relief for Halon 1301 flooding systems without need for additional venting. Record storage rooms, refrigerated spaces and duct work also generally need no additional venting.

2721. For very tight enclosures, the area necessary for free venting may be calculated from the following formula, taking the specific volume of Halon 1301 vapor at 70°F to be 2.56 cubic feet per pound:

$$x = \frac{13.2\,Q}{\sqrt{p}}$$

x—Free venting area, sq. in.
Q—Halon 1301 injection rate, lb. per sec.
p—Allowable strength of enclosure, lb./sq. ft.

Table No. 6

Strength and Allowable Pressures for Average Enclosures

Type Construction	Windage miles/hour	PRESSURE lb/sq. ft.	In Water	psi
Light Building	100	25*	5	.175
Normal Building	140	50†	10	.35
Vault Building	200	100	20	.70

* Venting sash remains closed.
† Venting sash designed to open freely.

2722. In many instances, particularly when hazardous materials are involved, relief openings are already provided for explosion venting. These and other available openings often provide adequate venting.

2723. Table 6, based on general construction practices, provides a guide for considering the normal strength and allowable pressures of average enclosures.

CHAPTER 3. LOCAL APPLICATION SYSTEMS.

***3100. General Information.**

3110. Uses. Local application systems are used where there is no fixed enclosure about the hazard or hazards and for the protection of individual hazards in large enclosures. Where deep-seated fires are expected, the total flooding requirements of Chapter 2 apply.

3111. Examples of hazards that may be successfully protected by local application systems include dip tanks, quench tanks, spray booths, oil-filled electric transformers, vapor vents, and similar types of hazards.

3112. For all Halon 1301 local application systems located in normally occupied confined spaces, the calculations described in paragraph 2520 shall be performed to determine the volumetric concentration of the agent developed in that volume. The limitations of use shall be governed by the requirements of paragraph 2112 and 2113. Since it is not the object of a local application system to distribute the agent evenly throughout the entire volume, locally high concentrations may be experienced.

3120. General Requirements. Local application systems shall be designed, installed, tested and maintained in accordance with the applicable requirements of Chapter 1 and with the additional requirements set forth in this chapter.

3200. Hazard Specifications.

3210. Extent of Hazard. The hazard shall be so isolated from other hazards or combustibles that fire will not spread outside the protected area. The entire hazard shall be protected. The hazard shall include all areas that are or may become coated by combustible liquids or thin solid coatings such as areas subject to spillage, leakage, dripping, splashing, or condensation, and all associated materials or equipment such as freshly coated stock, drain boards, hoods, ducts, etc., that might extend fire outside or lead fire into the protected area.

3211. When a series of interexposed hazards is subdivided into smaller groups or sections, the systems for such hazards shall be designed to provide immediate independent protection to the adjacent groups or sections.

3220. Location of Hazard. The hazard may be indoors or partly sheltered. If the hazard is completely out of doors, it is essential that the agent discharge be such that winds or strong air currents do not impair the protection. It shall be the responsibility of the system designer to show that such conditions have been taken into account in the design of a system.

***3300. Halon 1301 Requirements.**

3310. General. The quantity of agent required for local application systems shall be based on liquid discharge only and on the total rate of discharge needed to protect the hazard and the time that the discharge must be maintained to assure complete extinguishment.

3311. Since only the liquid portion of the discharge is effective in this application, the computed quantity of agent shall be increased to compensate for the residual agent in the storage container at the end of liquid flow. This additional agent is not required for the total flooding portion of a combined total flooding and local application system.

*3312. The system shall be designed to compensate for any agent vaporized in the pipe lines due to heat absorption from the piping.

3320. Rate of Discharge. Nozzle discharge rates shall be determined as outlined below:

3321. If part of the hazard is to be protected by total flooding, the discharge rate for the local application portion of the system shall be maintained for a period not less than the discharge time for the total flooding portion.

3322. The minimum design rate (R_d) shall not be less than the optimum rate (R_o) required for extinguishment (see Figure 4). The minimum design quantity (Q_d) shall be no less than 1.5 times the minimum quantity (Q_m) required for extinguishment at any selected design rate (R_d). The minimum design discharge time (T_d) shall be determined by dividing the design quantity (Q_d) by the design rate (R_d).

3323. The basis for nozzle selection for local application systems shall be a curve similar to Figure 4 together with other performance data that clearly depict the interrelationship between agent quantity, discharge rate, discharge time, area coverage and the distance of the nozzle from the protected surface.

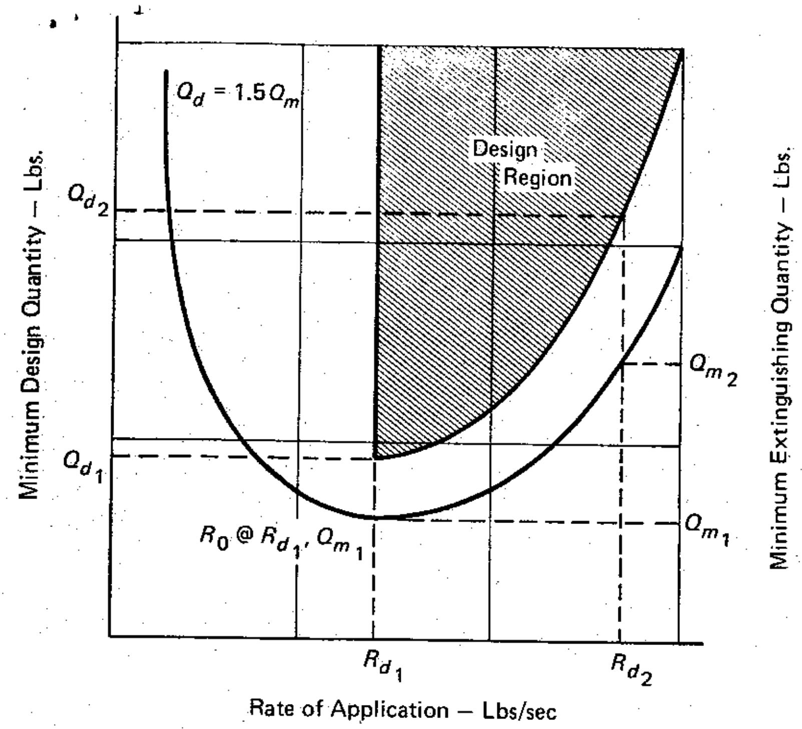

Fig. 4. Typical data presentation for local application nozzles.

3324. The information in paragraph 3323 shall be contained in the listings of a nationally recognized testing laboratory.

3325. Where there is the likelihood that metal, fuel or other material may become heated over the ignition temperature of the fuel, additional means shall be provided to prevent reignition. Examples of such additional means are extending the discharge time of the local application system, using a halon total flooding system or using other agents.

3326. Where there is a possibility that metal or other material may become heated above the ignition temperature of the fuel, the effective discharge time shall be increased to allow adequate cooling time. This is especially important with paraffin wax and other materials having low auto-ignition temperatures.

3327. The total rate of discharge for the system shall be the sum of the individual rates of all the nozzles or discharge devices used on the system.

3330. Area Per Nozzle. The maximum area protected by each nozzle shall be determined on the basis of nozzle discharge pattern, distance from the protected surface, and the design discharge rate in accordance with listings of a nationally recognized testing laboratory.

3331. Irregular shaped or three dimensional hazards shall be protected by a nozzle or combination of nozzles to insure complete agent coverage of all exposed surfaces. The projected surface area shall be used to determine the nozzle coverage, but all surfaces protected by a nozzle shall lie within the nozzle's listed range limitations.

3332. When deep layer flammable liquids are to be protected, a minimum freeboard shall be provided in accordance with the listings of a nationally recognized testing laboratory.

3340. Location and Number of Nozzles. A sufficient number of nozzles shall be used to cover the entire hazard area on the basis of the unit areas protected by each nozzle.

3341. Tankside or linear type nozzles shall be located in accordance with spacing and discharge rate limitations stated in nozzle listings.

3342. Overhead type nozzles shall be installed perpendicular to the hazard and centered over the area protected by the nozzle. They may also be installed at other angles to the surface in accordance with nozzle listings.

3343. Nozzles shall be located so as to be free of possible obstructions that could interfere with the proper projection of the discharged agent.

3344. Nozzles shall be located so as to develop an extinguishing concentration over coated stock or other hazard extending above a protected surface.

3345. The possible effects of air current, winds and forced drafts shall be compensated for by locating nozzles or by providing additional nozzles to protect the outside areas of the hazard.

APPENDIX

THE FOLLOWING APPENDIX MATERIAL IS PROVIDED TO EXPLAIN THE BASIC PRINCIPLES, AGENT AND EQUIPMENT CHARACTERISTICS, AND MAINTENANCE AND INSTALLATION PRACTICES.

A-1100. Halogenated Extinguishing Agents.

A halogenated compound is one which contains one or more atoms of an element from the halogen series: fluorine, chlorine, bromine and iodine. When hydrogen atoms in a hydrocarbon compound, such as methane (CH_4) or ethane (CH_3CH_3), are replaced with halogen atoms, the chemical and physical properties of the resulting compound are markedly changed. Methane, for example, is a light, flammable gas. Carbon tetrafluoride (CF_4) is also a gas, is chemically inert, nonflammable and extremely low in toxicity. Carbon tetrachloride (CCl_4) is a volatile liquid which is not only nonflammable, but was widely used for many years as a fire extinguishing agent in spite of its rather high toxicity. Carbon tetrabromide (CBr_4) and carbon tetraiodide (CI_4) are solids which decompose easily under heat. Generally, the presence of fluorine in the compound increases its inertness and stability; the presence of other halogens, particularly bromine, increase the fire extinguishing effectiveness of the compound. Although a very large number of halogenated compounds exist, only the following five are used to a significant extent as fire extinguishing agents:

Halon 1011, bromochloromethane, CH_2BrCl

Halon 1211, bromochlorodifluoromethane, $CBrClF_2$

Halon 1202, dibromodifluoromethane, CBr_2F_2

Halon 1301, bromotrifluoromethane, $CBrF_3$

Halon 2402, dibromotetrafluoroethane, $CBrF_2CBrF_2$

Halon Nomenclature System. The Halon system for naming halogenated hydrocarbons was devised by the U.S. Army Corps of Engineers to provide a convenient and quick means of reference to candidate fire extinguishing agents. The first digit in the number represents the number of carbon atoms in the compound molecule; the second digit, the number of fluorine atoms; the third digit, the number of chlorine atoms; the fourth digit, the number of bromine atoms; and the fifth digit, the number of iodine atoms. Terminal zeros are dropped. Valence requirements not accounted for are assumed to be hydrogen atoms (number of hydrogen atoms = 1st digit times 2, plus 2, minus the sum of the remaining digits.) Examples of this numbering system are:

HALON 1301 VAPOR PRESSURE-
POUNDS PER SQUARE INCH (GAUGE)

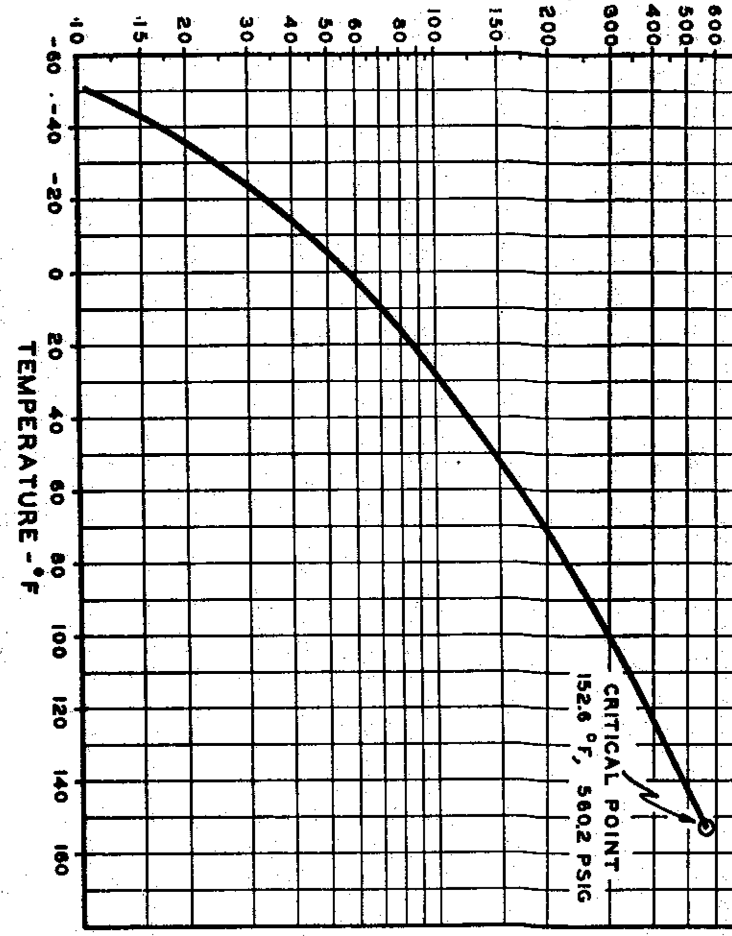

Fig. A-1. Vapor pressure of Halon 1301 vs. temperature.

Official NFPA Definitions

Adopted Jan. 23, 1964; Revised Dec. 9, 1969. Where variances to these definitions are found, efforts to eliminate such conflicts are in process.

SHALL is intended to indicate requirements.

SHOULD is intended to indicate recommendations or that which is advised but not required.

APPROVED means acceptable to the authority having jurisdiction. The National Fire Protection Association does not approve, inspect or certify any installations, procedures, equipment or materials nor does it approve or evaluate testing laboratories. In determining the acceptability of installations or procedures, equipment or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure or use. The authority having jurisdiction may also refer to the listings or labeling practices of nationally recognized testing laboratories,* i.e., laboratories qualified and equipped to conduct the necessary tests, in a position to determine compliance with appropriate standards for the current production of listed items, and the satisfactory performance of such equipment or materials in actual usage.

*Among the laboratories nationally recognized by the authorities having jurisdiction in the United States and Canada are the Underwriters' Laboratories, Inc., the Factory Mutual Research Corporation, the American Gas Association Laboratories, the Underwriters' Laboratories of Canada, the Canadian Standards Association Testing Laboratories, and the Canadian Gas Association Approvals Division.

LISTED: Equipment or materials included in a list published by a nationally recognized testing laboratory that maintains periodic inspection of production of listed equipment or materials, and whose listing states either that the equipment or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.

LABELED: Equipment or materials to which has been attached a label, symbol or other identifying mark of a nationally recognized testing laboratory that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling is indicated compliance with nationally recognized standards or tests to determine suitable usage in a specified manner.

AUTHORITY HAVING JURISDICTION: The organization, office or individual responsible for "approving" equipment, an installation, or a procedure.

Statement on NFPA Procedures

This material has been developed in the interest of safety to life and property under the published procedures of the National Fire Protection Association. These procedures are designed to assure the appointment of technically competent Committees having balanced representation from those vitally interested and active in the areas with which the Committees are concerned. These procedures provide that all Committee recommendations shall be published prior to action on them by the Association itself and that following this publication these recommendations shall be presented for adoption to the Annual Meeting of the Association where anyone in attendance, member or not, may present his views. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accepts any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

Standard on

Halogenated Fire Extinguishing Agent Systems

Halon 1211

NFPA No. 12B — 1973

1973 Edition of No. 12B

This Standard was prepared by the National Fire Protection Association Committee on Halogenated Fire Extinguishing Agent Systems, and was adopted at the Annual Meeting of the National Fire Protection Association held at St. Louis, Mo., May 14-18, 1973.

Origin and Development of No. 12B

In regular committee meeting on May 14, 1969 the Chairman appointed a sub-committee of five members under the chairmanship of Mr. Norman W. Lemley which was given the specific charge to review and evaluate data developed and presented to the committee to determine what additional work would be necessary to integrate Halon 1211 into the Standard on Halogenated Fire Extinguishing Agent Systems. The sub-committee concluded that the public would be better served by a separate standard. The tentative Standard No. 12B-T was the result of their work, and was tentatively adopted in May, 1971 at the Annual Meeting.

This 1973 edition is a revision of the tentative standard, and all amendments are indicated by vertical lines in the margin.

Committee on Halogenated Fire Extinguishing Agent Systems

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Robert T. Wickham, Wickham Associates
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Timo Siimes, Fire Equipment Manufacturers' Institute of Canada (Alternate to R. G. Lewis)

Nonvoting Member

H. V. Williamson, NFPA Committee on Carbon Dioxide

This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

TABLES AND GRAPHS

TABLE OF CONTENTS

Standard on

Halogenated Extinguishing Agent Systems

Halon 1211

NFPA No. 12B — 1973

Introduction

1. Purpose. This Standard is prepared for use and guidance of those charged with the purchasing, designing, installing, testing, inspecting, approving, listing, operating, and maintaining halogenated agent extinguishing systems (Halon 1211), in order that such equipment will function as intended throughout its life.

Pre-engineered systems (packaged systems) consist of system components designed to be installed according to pretested limitations as approved or listed by a nationally recognized testing laboratory. Pre-engineered systems may incorporate special nozzles, flow rates, methods of application, nozzle placement, pressurization levels, and quantities of agent which may differ from those detailed elsewhere in this Standard since they are designed for very specific hazards. All other requirements of the Standard apply. Pre-engineered systems shall be installed to protect hazards within the limitations which have been established by the testing laboratories where listed.

2. Scope. This Standard contains minimum requirements for halogenated agent fire extinguishing systems. It includes only the necessary essentials to make the Standard workable in the hands of those skilled in this field. Portable halogenated agent extinguishers are covered in NFPA No. 10, Installation of Portable Fire Extinguishers, and No. 10A, Maintenance and Use of Portable Fire Extinguishers.

Only those skilled in this work are competent to design and install this equipment. It may be necessary for many of those charged with the purchasing, inspecting, testing, approving, operating, and maintaining this equipment to consult with an experienced and competent fire protection engineer in order to effectively discharge their respective duties.

3. Arrangement. This Standard is arranged as follows:

Introduction.
Chapter 1 — General Information and Requirements.
Chapter 2 — Total Flooding Systems.
Chapter 3 — Local Application Systems.
Appendix — Explanatory.

Chapters 1 through 3 constitute the body of the Standard and contain the rules and regulations necessary for properly designing, installing, inspecting, testing, approving, operating, and maintaining halogenated agent fire extinguishing systems.

The Appendix contains educational and informative material that will aid in understanding and applying this Standard. Appendix material is denoted by an asterisk preceding paragraph.

4. Definitions. For purpose of clarification, the following general terms used with special technical meanings in this Standard are defined:

APPROVED refers to approval by the authority having jurisdiction.

AUTHORITY HAVING JURISDICTION: The "authority having jurisdiction" is the organization, office, or individual responsible for "approving" equipment, an installation, or a procedure.

NOTE: The phrase "authority having jurisdiction" is used in NFPA standards in a broad manner since jurisdictions and "approval" agencies vary as do their responsibilities. Where public safety is primary, the "authority having jurisdiction" may be a federal, state, local, or other regional department or individual such as a fire chief, fire marshal, chief of a fire prevention bureau, labor department, health department, building official, electrical inspector, or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the "authority having jurisdiction."
In many circumstances the property owner or his delegated agent assumes the role of the "authority having jurisdiction"; at government installations, the commanding officer, or a departmental official may be the "authority having jurisdiction."

LISTED refers to the listing for the use intended, of devices and materials that have been examined by and meet the recognized standards of such testing laboratories as the Factory Mutual Research Corporation, the Underwriters' Laboratories, Inc., and Underwriters' Laboratories of Canada. All equipment shall bear a label or some other identifying mark.

SHALL is intended to indicate requirements.

SHOULD is intended to indicate recommendations or that which is advised but not required.

NORMALLY OCCUPIED AREA is one which is intended for occupancy.

Other terms used with special technical meaning are defined or explained where they occur in the Standard.

CHAPTER 1. GENERAL INFORMATION AND REQUIREMENTS

***1100. General Information.**

1110. Scope. Chapter 1 contains general information, and the design and installation requirements for all features that are generally common to all Halon 1211 (bromochlorodifluoromethane, $CBrClF_2$) systems.

***1120. Halon 1211.** Halon 1211 is a colorless, faintly sweet-smelling electrically nonconductive gas that is an effective medium for extinguishing fires.

*1121. According to present knowledge Halon 1211 extinguishes fires by inhibiting the chemical reaction of fuel and oxygen. The extinguishing effect due to cooling, or dilution of oxygen or fuel vapor concentration, is minor.

1130. Use and Limitations. Halon 1211 fire extinguishing systems are useful within the limits of this Standard in extinguishing fires in specific hazards or equipment, and in occupancies where an electrically nonconductive medium is essential or desirable, where cleanup of other media presents a problem, or where weight vs. extinguishing potential is a factor.

1131. Some of the more important types of hazards and equipment that Halon 1211 systems may satisfactorily protect include:

1. Gaseous and liquid flammable materials.
2. Electrical hazards such as transformers, oil switches and circuit breakers, and rotating equipment.
3. Engines utilizing gasoline and other flammable fuels.
4. Ordinary combustibles such as paper, wood, and textiles.
5. Hazardous solids.

1132. Halon 1211 has not been found effective on the following:

1. Chemicals containing their own oxygen supply such as cellulose nitrate.
2. Reactive metals such as sodium, potassium, magnesium, titanium, zirconium, uranium, and plutonium.
3. Metal hydrides.

1133. Specific limitations are placed on Halon 1211 total flooding systems. See paragraphs 2112 and 2113.

1140. Duration of Protection. It is important that an effective agent concentration not only be achieved but that it be maintained for a sufficient period of time to allow effective emergency action by trained personnel. This is equally important in all classes of fires since a persistent ignition source (e.g., an arc, heat source, oxyacetylene torch or "deep seated" fire can lead to a reoccurrence of the initial event once the agent has dissipated. Halon extinguishing systems normally provide protection for a period of minutes but are exceptionally effective for certain applications. Water supplies for standard sprinklers, on the other hand, are normally designed to provide protection for one-half to 4-hour duration but sprinklers may be less effective in controlling many fires. The designer, the buyer and the emergency force in particular should be fully aware of the advantages and limitations of each, the residual risks being assumed and the proper emergency procedures.

1150. Types of Systems. There are two types of systems recognized in this Standard:

Total Flooding Systems.

Local Application Systems.

1151. **A Total Flooding System** consists of a supply of Halon 1211 arranged to discharge into, and fill to the proper concentration, an enclosed space or enclosure about the hazard.

1152. A Local Application System consists of a supply of Halon 1211 arranged to discharge directly on the burning material.

1160. Halon 1211 Systems. A Halon 1211 System may be used to protect one or more hazards or groups of hazards by means of directional valves. Where two or more hazards may be simultaneously involved in fire by reason of their proximity, each hazard shall be protected with an individual system with the combination arranged to operate simultaneously or be protected with a single system that shall be sized and arranged to discharge on all potentially involved hazards simultaneously.

***1200 Safety.**

1210. Hazards to Personnel. The discharge of Halon 1211 may create hazards to personnel such as dizziness, impaired coordination, reduced visibility and exposure to toxic decomposition products.

*1211. Safety Requirements. In any proposed use of Halon 1211 where there is a possibility that people may be trapped in or enter into atmospheres made hazardous, suitable safeguards shall be provided to ensure prompt evacuation of and to prevent entry

into such atmospheres and also to provide means for prompt rescue of any trapped personnel. Such safety items as personnel training, warning signs, discharge alarms, and breathing apparatus shall be considered.

***1220. Electrical Clearances.** All system components shall be so located as to maintain standard electrical clearances from live parts. See Appendix A for Table of Clearances.

1300. Specifications, Plans and Approvals.

1310. Specifications. Specifications for Halon 1211 fire extinguishing systems shall be prepared with care under the supervision of a competent engineer and with the advice of the authority having jurisdiction. The specifications shall include all pertinent items necessary for the proper design of the system such as the designation of the authority having jurisdiction, variances from standard to be permitted by the authority having jurisdiction and the type and extent of the approval testing to be performed after installation of the system.

1320. Plans. Where plans are required, they shall be prepared with care under the supervision of a competent engineer and with the advice of the authority having jurisdiction.

1321. These plans shall be drawn to an indicated scale or be suitably dimensioned and shall be made so they can be easily reproduced.

1322. These plans shall contain sufficient detail to enable the authority having jurisdiction to evaluate the hazard or hazards and to evaluate the effectiveness of the system.

1323. The detail on the system shall include information and calculations on the amount of Halon 1211; container storage pressure: internal volume of the container; the location and flow rate of each nozzle including equivalent orifice area; the location, size and equivalent lengths of pipe, fittings and hose; and the location and size of the storage facility. Information shall be submitted pertaining to the location and function of the detection devices, operating devices, auxiliary equipment, and electrical circuitry, if used. Sufficient information shall be indicated to identify properly the apparatus and devices used. Any special features shall be adequately explained.

1330. Approval of Plans. Plans and calculations shall be submitted for approval before work starts.

1331. When field conditions necessitate any material change from approved plans, the change shall be approved.

1332. When such material changes from approved plans are made, corrected "as installed" plans shall be provided.

***1340. Approval of Installations.** The completed system shall be tested by qualified personnel to meet the approval of the authority having jurisdiction. These tests shall be adequate to determine that the system has been properly installed and will function as intended. Only listed or approved equipment and devices shall be used in the systems.

1400. Detection and Actuation

***1410.** Automatic detection and automatic actuation shall be used except that other detection, and manual actuation only, may be used if acceptable to the authority having jurisdiction.

Some points to be considered are:

a. Hazards to personnel,

b. Undesirable side reaction,

c. An increase in the hazard,

d. Other alternatives.

1420. Automatic detection shall be by any listed or approved method or device that is capable of detecting and indicating heat, flame, smoke, combustible vapors, or an abnormal condition in the hazard such as process trouble that is likely to produce fire.

1421. Heat detectors installed on standard spacing are about equal to an ordinary sprinkler in response time. If detectors are installed at reduced spacing from that recognized in approvals or listings response time may be reduced. An adequate and reliable source of energy shall be used in detection systems.

1430. Operating Devices. Operating devices include Halon 1211 releasing devices or valves, discharge controls, and shutdown equipment, all of which are necessary for successful performance of the system.

1431. Operation shall be by listed or approved mechanical, electrical, or pneumatic means. An adequate and reliable source of energy shall be used.

1432. All devices shall be designed for the service they will encounter and shall not be readily rendered inoperative or susceptible to accidental operation. Devices shall be normally designed to function properly from −20°F to 150°F or marked to indicate temperature limitations.

1433. All devices shall be located, installed, or suitably protected so that they are not subject to mechanical, chemical, or other damage which would render them inoperative.

1434. The normal manual control for actuation shall be located so as to be conveniently and easily accessible at all times including the time of fire. This control shall cause the complete system to operate in its normal fashion.

1435. All automatically operated valves controlling agent release and distribution shall be provided with approved independent means for emergency manual operation. If the means for manual actuation of the system required in 1410 provides approved positive operation independent of the automatic actuation, it may be used as an emergency means. The emergency means, preferably mechanical, shall be easily accessible and located close to the valves controlled. Emergency actuation that can be accomplished from one location is desirable. This does not require the emergency manual control on "reserve" containers to control any selector valves or equipment beyond the containers.

1436. Manual controls shall not require a pull of more than 40 pounds (18.2 kg.) (force) nor a movement of more than 14 inches (36 cm) to secure operation.

1437. Where gas pressure from the system or pilot containers is used as a means for releasing the remaining containers the supply and discharge rate shall be designed for releasing all of the remaining containers.

1438. All devices for shutting down supplementary equipment shall be considered integral parts of the system and shall function with the system operation.

1439. All manual operating devices shall be identified as to the hazard they protect.

1440. Supervision. Supervision of automatic systems is advisable where the possible loss because of any delay in actuation may be high and/or where the detection or control systems are so extensive and complex that they cannot be readily checked by visual or other inspection. When supervision is provided it shall be so arranged that there will be immediate indication of failure. The extent and type of supervision shall be approved by the authority having jurisdiction.

1450. Operating Alarms and Indicators. Alarms and/or indicators are used to indicate the operation of the system, hazards to personnel, or failure of any supervised device. The type (audible, visual, or olfactory) number and location of the devices shall be such that their purpose is satisfactorily accomplished. The extent and type of alarms and/or indicator equipment shall be approved.

1451. A positive alarm or indicator shall be provided to show that the system has operated.

1452. Alarms shall be provided to give positive warning of a discharge, or a pending discharge.

1453. Alarms indicating failure of supervised devices or equipment shall give prompt and positive indication of any failure and shall be distinctive from alarms indicating operation or hazardous conditions.

1454. Warning and instruction signs at entrances to and inside protected areas shall be provided.

1500. Halon 1211 Supply.

1510. Quantities. The amount of Halon 1211 in the system shall be at least sufficient for the largest single hazard protected or group of hazards which are to be protected simultaneously.

1511. Where uninterrupted protection is required, the reserve quantity shall be as many multiples of these minimum amounts as the authority having jurisdiction considers necessary.

1512. Both primary and reserve supplies for fixed storage shall be permanently connected to the piping and arranged for easy changeover, except where the authority having jurisdiction permits an unconnected reserve.

***1520. Quality.** The Halon 1211 shall comply with the Military Specification MIL-B-38741 (USAF) Bromochlordifluoromethane, Technical. (See Appendix A-1520)

1530. Replenishment. The time needed to obtain Halon 1211 for replenishment to restore systems to operating condition shall be considered as a major factor in determining the reserve supply needed.

1540. Storage Container Arrangement. Storage containers and accessories shall be so located and arranged that inspection, testing, recharging and other maintenance is facilitated and interruption to protection is held to a minimum.

1541. Storage containers shall be located as near as possible to the hazard or hazards they protect, but they should not be located where they will be exposed to a fire or explosion in these hazards.

1542. Storage containers should not be located so as to be subject to severe weather conditions or be subject to mechanical, chemical, or other damage.

1543. When excessive climatic or mechanical exposures are expected, suitable guards or enclosures shall be provided.

***1550. Storage Containers.** The Halon 1211 supply shall be stored in containers designed to hold Halon 1211 in liquefied form at ambient temperature. Containers shall not be charged to a filling density at 70°F greater than 102 pounds per cubic foot. They shall be superpressurized with nitrogen to 150 psig ± 10 psig, or to 360 psig ± 20 psig total pressure at 70°F. In exceptional circumstances, and with the specific approval of the authority having jurisdiction, containers may be charged to pressures other than 150 psig or 360 psig. Containers shall be distinctively and permanently marked with the type and quantity of agent contained therein, together with the degree of superpressurization.

1551. The Halon 1211 containers used in these systems shall be designed to meet the requirements of the U.S. Department of Transportation or the Canadian Board of Transport Commissioners*, if used as a shipping container. If not a shipping container,

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**Subpart C. Section 178.36 to and including 178.68* of Title 49, Transportation, Code of Federal Regulations. Parts 170-190. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20401. In Canada the corresponding information is set forth in the *"Canadian Transport Commission's Regulations for the Transportation of Dangerous Commodities by Rail"* available from the Queen's Printer, Ottawa, Ontario.

it shall be designed, fabricated, inspected, certified, and stamped in accordance with Section VIII of the ASME Unfired Pressure Vessel Code; independent inspection and certification are recommended. The design pressure shall be suitable for the maximum pressure developed at 130°F or at the maximum controlled temperature limit. (See Paragraph 1557.)

1552. A reliable means of indication, other than weighing, shall be provided to determine the pressure in refillable containers. The means of indication shall account for variation of container pressure with temperature.

1553. Charged containers shall be tested for tightness before shipment in accordance with an approved procedure. Shipping containers in service shall be hydrostatically retested for continuing service at least every 12 years in accordance with the test procedure and apparatus set forth in the regulations of the U.S. Department of Transportation or Board of Transport Commissioners.

1554. When manifolded, containers shall be adequately mounted and suitably supported in a rack provided for the purpose of including facilities for convenient individual servicing or content weighings. Automatic means shall be provided to prevent the loss from the manifold if the system is operated when any containers are removed for maintenance.

1555. Each system shall have a permanent nameplate specifying the number, filling weight, and pressurization level of the containers.

1556. In a multiple cylinder system, all cylinders supplying the same manifold outlet for distribution of agent, shall be interchangeable and of one select size and charge.

1557. Storage temperatures shall not exceed 130°F nor be less than 32°F unless the system is designed for proper operation with storage temperatures outside of this range. External heating or cooling may be used to keep the temperature within this range. When special container charges are used, the containers shall be appropriately marked.

1600. Distribution.

1610. Piping. Piping shall be of noncombustible material having physical and chemical characteristics, such that its deterioration under stress can be predicted with reliability. Special corrosion-resistant materials or coatings may be required in severely corrosive atmospheres. Examples of materials for piping and the standards covering these materials are:

Ferrous Piping: (Seamless) Black or Galvanized Steel Pipe; ASTM A-53 or A-106, ANSI B-36.10.
Nonferrous Piping (Drawn, Seamless), Copper: ASTM B-88.
Flexible Metallic Hose: ANSI B140.1-72.

The above listed materials do not preclude the use of other materials such as Stainless Steel or other pipe or tubing, which will also satisfy the requirements of this paragraph. See appendix *A-1610* for stress calculations.

Schedule 40 steel pipe up to 4 in. nominal pipe size conforming to the above specifications is satisfactory for both the 150 psig and 360 psig charging pressures specified in this standard.

Type M copper tubing conforming to the above specification is satisfactory for the 150 and 360 psig charging pressures specified in this standard.

1611. Ordinary cast iron pipe or steel pipe conforming to ASTM A-120 shall not be used.

1612. Flexible piping tubing or hoses (including connections) where used shall be of approved materials and pressure ratings.

1620. Piping Joints. The type of piping joint shall be suitable for the design conditions and shall be selected with consideration of joint tightness and mechanical strength. Example of suitable joints and fittings are screwed, flanged, welded, brazed, flared and compression.

1621. Examples of materials used for fittings are:

Malleable iron 300 lb. class only	ASTM A-197
Ductile Iron 300 lb. class only	ASTM A-445
Steel	ASTM A-234

Pressure temperature ratings have been established for certain types of fittings. A list of ANSI Standards covering the different types of fittings are given in Table 126.1 of ANSI B-31.1.0. Where fittings not covered by one of these standards are used, the design recommendations of the manufacturer of the fittings shall not be exceeded. The above listed materials do not preclude the use of other materials which will satisfy the requirements of this paragraph.

The 150 lb. class fittings are suitable for the 150 psig charging pressure. For the 360 psig charging pressure the 300 lb. class fittings are required. Pressure temperature ratings have been established for certain types of fittings. A list of ANSI Standards covering the different types of fittings is given in Table 126.1 of ANSI B-31.1.0. Where fittings not covered by one of these standards are used, the design recommendations of the manufacturer of the fittings shall not be exceeded. The above listed materials do not preclude the use of other materials which will satisfy the requirements of this paragraph.

1622. Ordinary cast-iron fittings shall not be used.

1623. All threads used in joints and fittings shall conform to ANSI B-2.1. Joint compound, tape or thread lubricant shall be applied only to the male threads of the joint.

1624. Welding and brazing shall conform to ANSI B-31.1.0. Brazing alloys shall meet or exceed ANSI A-5 classification B Cup-3.

1625. Copper stainless steel or other suitable tubing may be joined with flared compression type fittings. The Pressure-Temperature ratings of the manufacturer of the fitting shall not be exceeded.

1630. Arrangement and Installation of Piping and Fittings. Piping shall be installed in accordance with good commercial practice. Care should be taken to avoid possible restrictions due to foreign matter, faulty fabrication or improper installation.

1631. The piping system shall be securely supported with due allowance for agent thrust forces, thermal expansion and contraction and shall not be subjected to mechanical, chemical, vibration or other damage. ANSI B-31.1.0 shall be consulted for guidance on this matter. Where explosions are likely, the piping shall be attached to supports that are least likely to be displaced.

1633. In systems where valve arrangement introduces sections of closed piping, such sections shall be equipped with pressure relief devices or the valves shall be designed to prevent entrapment of liquid. Where pressure-operated container valves are used, a means shall be provided to vent any container leakage from the manifold but which will prevent loss of the agent when the system operates.

1634. All pressure relief devices shall be of such design and so located that the discharge therefrom will not injure personnel or be otherwise objectionable.

1640. Valves. All valves shall be suitable for the intended use, particularly in regard to flow capacity and operation. They shall be used only under temperatures and other conditions for which they are listed.

1641. Valves shall be protected against mechanical, chemical or other damage.

1642. Valves shall be rated for equivalent length in terms of the pipe or tubing sizes with which they will be used. The equivalent length of container valves shall be listed and shall include siphon tube, valve, discharge head and flexible connecter.

Table 1. Equivalent Orifice Sizes

Orifice Code No.	Equivalent Single Orifice Diameter–Inches	Equivalent Single Orifice Area–Sq. In.
——	.026	.00053
——	1/16	.00307
——	.070	.00385
——	.076	.00454
——	5/64	.0048
——	.081	.00515
——	.086	.00581
3	3/32	.0069
3+	7/64	.0094
4	1/8	.0123
4+	9/64	.0155
5	5/32	.0192
5+	11/64	.0232
6	3/16	.0276
6+	13/64	.0324
7	7/32	.0376
7+	15/64	.0431
8	1/4	.0491
8+	17/64	.0554
9	9/32	.0621
9+	19/64	.0692
10	5/16	.0767
11	11/32	.0928
12	3/8	.1105
13	13/32	.1296
14	7/16	.1503
15	15/32	.1725
16	1/2	.1964
18	9/16	.2485
20	5/8	.3068
22	11/16	.3712
24	3/4	.4418
32	1	.785
48	1 1/2	1.765
64	2	3.14

NOTE: The orifice code number indicates the equivalent single orifice diameter in 1/32 inch increments. A plus sign following this number indicates equivalent diameters 1/64 inch greater than that indicated by the numbering system (e.g., No. 4 indicates an equivalent orifice diameter of 4/32 of an inch; a No. 4+, 9/64 of an inch).

***1650. Discharge Nozzles.** Discharge nozzles shall be listed for the use intended and for discharge characteristics. The discharge nozzle consists of the orifice and any associated horn, shield, or baffle.

1651. Discharge orifices shall be of corrosive-resistant metal.

1652. Discharge nozzles used in local application systems shall be accurately located and directed in accordance with the system design requirements as covered in 3300. Discharge nozzles used in local application systems shall be so connected and supported that they may not readily be put out of alignment.

1653. Discharge nozzles shall be permanently marked to identify the nozzle and to show the equivalent single orifice diameter regardless of shape and number of orifices. This equivalent diameter shall refer to the orifice diameter of the "standard" single orifice type nozzle having the same flow rate as the nozzle in question. The marking shall be readily discernible after installation.

The "standard" orifice is an orifice having a rounded entry with a coefficient of discharge of water not less than 0.98, and flow characteristics of Halon 1211 as shown in Figure 5. It should be noted that the discharge coefficient for nitrogen-saturated Halon 1211 is different from that for water. The nozzles used for the data in *Figure 5* had a coefficient for water of 0.98, and for Halon 1211 of 0.87. The diameter/length ratio of the nozzle throat has a marked effect on the discharge coefficient of nitrogen-saturated Halon 1211. An indication of this effect in nozzles with rounded entries is given in Table 2.

Table 2

Ratio of Nozzle Diameter to Length	Discharge Coefficient Halon 1211	Discharge Coefficient Water
1:0	0.91	0.91
1:1*	0.87	0.98
1:2.5	0.75	0.90
1:4.5	0.70	0.90
1:4.8	0.69	0.92

*This nozzle was used to obtain the results shown in Figure 5. The values shown in Figure 5 may be used over the temperature range 55°F to 115°F.

1654. Discharge nozzles shall be provided with frangible discs or blow-out caps where clogging by foreign materials is likely. These devices shall provide an unobstructed opening upon system operation.

***1660. Pipe and Orifice Size Determination.** Pipe sizes and orifice areas shall be selected on the basis of calculations to deliver the required rate of flow at each nozzle.

1661. *Figures 3 and 4* shall be used to determine the pressure drop in the pipe line. The system shall be designed based on a 70°F ambient temperature.

1662. Flow shall be calculated on the basis of an initial storage pressure of 150 or 360 psig (as applicable) adjusted for the initial drop in storage pressure required to fill the piping system. The discharge rate for equivalent orifices shall be based on the values given in Figure 5. Design nozzle pressure shall not be less than 30 psig.

1663. Flow calculations shall be performed to insure that the adjusted storage pressure and the pressure losses due to flow are within 3 psig of each other.

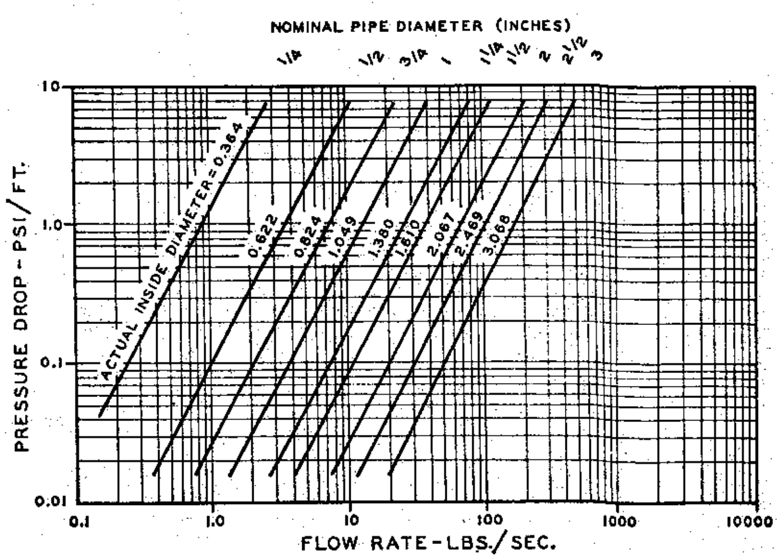

Fig. 3. Pressure loss due to Halon 1211 flow through schedule 40 galvanized steel pipe.

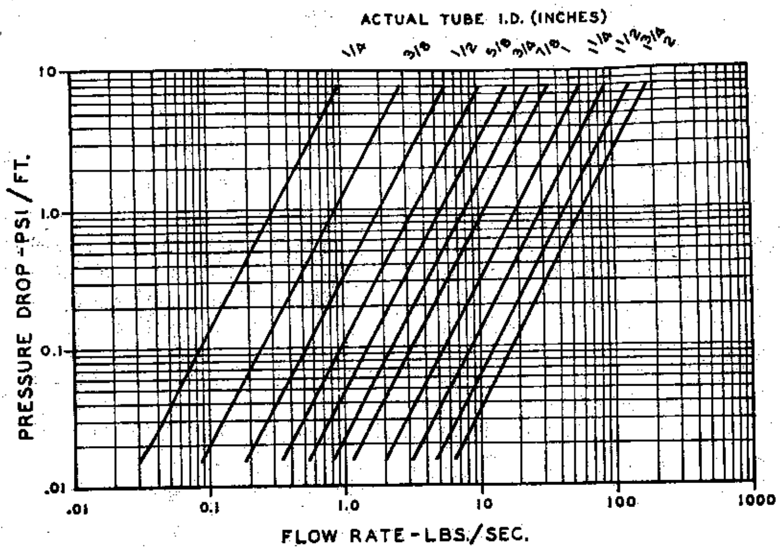

Fig. 4. Pressure loss due to Halon 1211 flow through copper tubing.

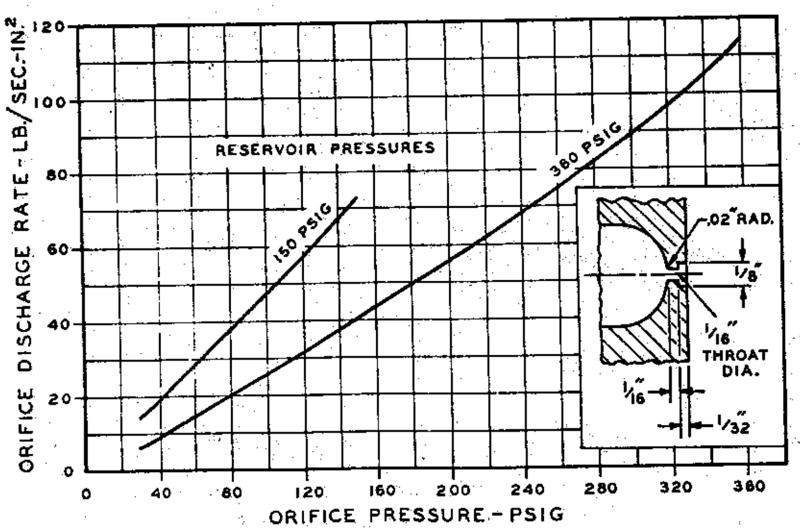

Fig. 5. Orifice discharge rates of Halon 1211 at 70° F through a nozzle with a water discharge coefficient of 0.98.

1700. Inspection, Maintenance and Instructions.

1710. Inspection and Tests. At least annually, all systems shall be thoroughly inspected and tested for proper operation by competent personnel.

1711. The goal of this inspection and testing shall be to ensure that the system is in full operating condition.

1712. Suitable discharge tests shall be made when inspection indicates their advisability.

1713. The inspection report with recommendations shall be filed with the owner.

1714. Between the regular service contract inspection or tests, the system shall be inspected visually or otherwise by competent personnel, following an approved schedule and procedure.

1715. At least semiannually, the weight and pressure of refillable containers shall be checked. If a container shows a loss in net weight of more than 5 percent or a loss in pressure (adjusted for temperature) of more than 10 percent, it shall be refilled or replaced.

1716. Factory charged nonrefillable containers which do not have a means of pressure indication shall be weighed at least semiannually. If a container shows a loss in net weight of more than 5 percent, it shall be replaced.

1717. The weight and pressure of the container shall be recorded on a tag attached to the container.

1720. Maintenance. These systems shall be maintained in full operating condition at all times. Use, impairment, and restoration of this protection shall be reported promptly to the authority having jurisdiction.

1721. Any troubles or impairments shall be corrected at once by competent personnel.

1730. Instruction. All persons who may be expected to inspect, test, maintain, or operate fire extinguishing systems shall be thoroughly trained and kept thoroughly trained in the functions they are expected to perform.

CHAPTER 2. TOTAL FLOODING SYSTEMS

*2100. General Information.

2110. Uses. This type of system may be used where there is a fixed enclosure about the hazard that is adequate to enable the required concentration to be built up and maintained for the required period of time to ensure the effective extinguishment of the fire in the specific combustible materials involved where the ambient temperature is above 30°F.

2111. Total flooding systems provide fire protection within rooms, vaults, enclosed machines, ovens, containers, storage tanks and bins.

*2112. Halon 1211 total flooding systems shall not be used in normally occupied areas. For purposes of this Standard, a normally occupied area is defined as an area intended for occupancy. (See Appendix A-2112.)

2113. Halon 1211 total flooding systems may be used only in normally unoccupied areas where egress of personnel can be accomplished in less than 30 seconds.

2120. General Requirements. Total flooding systems shall be designed, installed, tested and maintained in accordance with the applicable requirements in Chapter 1 and with the additional requirements set forth in this chapter.

2200. Hazard Specifications.

2210. Types of Fires. Fires which can be extinguished by total flooding methods may be divided into three categories: (1) Fires involving flammable liquids or gases; (2) Surface fires involving flammable solids; and (3) Deep-seated fires such as can occur with certain Class A materials subject to spontaneous heating, smoldering, and high heat retention.

2211. Flammable liquid and gas fires are subject to prompt extinguishment when Halon 1211 is quickly introduced into the enclosure in sufficient quantity to provide an extinguishing concentration for the particular materials involved. NFPA No. 69, Inerting for Fire and Explosion Prevention should be referred to when the possibility of flammable concentrations from gas leakage dictates explosion protection techniques.

2212. Surface fires associated with the burning of solid materials are also quickly extinguished by Halon 1211. In many solid materials, smoldering combustion may continue at the surface of the fuel after extinguishment of the flames. These surface embers will normally be extinguished by low concentrations of Halon 1211 maintained for short periods of time.

2213. Deep-seated fires may become established beneath the surface of a fibrous or particulate material. This may result from flaming combustion at the surface or from ignition within the mass of fuel. Smoldering combustion then progresses slowly through the mass. A fire of this kind is referred to in this Standard as a "deep-seated" fire. The burning rate of these fires can be reduced by the presence of Halon 1211, and they may be extinguished if a high concentration can be maintained for an adequate soaking time. However, it is not normally practical to maintain a sufficient concentration of Halon 1211 for a sufficient time to extinguish a deep-seated fire.

2220. Enclosure. In the design of total flooding systems, the characteristics of the enclosure must be considered as follows:

2221. For all types of fires, the area of unclosable openings shall be kept to a minimum. These openings shall be compensated for by additional quantities of agent according to the design procedures outlined in Appendix A-2530. The authority having jurisdiction may require tests to assure proper performance as defined by this Standard.

2222. To prevent fire from spreading through openings to adjacent hazards or work areas and to make up for leakage of the agent, openings shall be compensated for with automatic closures, screening nozzles or additional agent, and shall be arranged to operate simultaneously with system discharge. The agent required by screening nozzles shall be in addition to the normal requirement for total flooding. Where reasonable confinement of agent is impracticable, protection shall be extended to include the adjacent hazards or work areas.

2223. For deep-seated fires forced air ventilating systems shall be shut down or closed with the start of agent discharge; or, additional compensating gas shall be provided. Refer to Appendix A-2530.

2224. For surface fires, forced air ventilation may also be required to be shut down or closed with the start of agent discharge; or additional compensating gas may need to be provided. Refer to Appendix A-2530.

*2300. Halon 1211 Requirements for Liquid and Gas Fires.

2310. General. The quantity of Halon 1211 for fires involving flammable liquids and gases is based upon normal conditions with the extinguishing system meeting the requirements specified herein.

2320. Flammable Materials. In the determination of the design concentration of Halon 1211, proper consideration shall be given to the type and quantity of flammable material involved, the conditions under which it normally exists in the hazard, and any special conditions of the hazard itself. For a particular fuel, two minimum levels of Halon 1211 concentration may be used: either is permitted for situations where only flame extinguishment is required; the higher level of concentration shall be used where complete inerting is required to prevent a subsequent reflash or possible explosion.

Appendix A-2300 contains additional guidelines for determining the concentration level which should be selected for a particular hazard.

2321. Flame Extinguishment Data. Table No. 6 gives the minimum design concentration required to extinguish normal fires involving certain flammable gases and liquids at atmospheric pressure. These values are permitted if it can be shown that a probable

TABLE 6

Halon 1211 Design Concentrations for Flame Extinguishment in Air at 1.0 atm. and 70°F

Material	Minimum Design Concentration* % by Volume
Methane	4.3
Ethane	5.6
Propane	4.8
Butane	4.1
i-Butane	3.9
Ethylene	6.5
Hydrogen	22.6
n-Heptane	4.3
n-Hexane	4.1
Cyclohexane	4.2
Ethanol	5.0
Methylated Spirit	5.0
Methanol	9.1
Acetone	4.2
Avtur	3.9
Solvent 40**	4.2
Carbon Disulphide	2.7
Kerosene	4.2
No. 1 Fuel Oil	3.6
Pentane	4.5
Light Distillate	3.9
Gasoline	4.2
Benzene	3.9
Toluene	2.5
Mixed Xylenes	2.4

*Includes a safety factor of 10% minimum above experimental threshold values. For other temperatures or pressures, specific test data shall be obtained.

**Similar to Stove and Lamp Naphtha

explosive atmosphere cannot exist in the hazard as a result of the fire. An explosion potential is improbable when:

(a) The quantity of fuel permitted in the enclosure is less than that required to develop a maximum concentration equal to one-half of the lower flammable limit. Additional information is given in Appendix A-2200.

(b) The volatility of the fuel before the fire is too low to reach the lower flammable limit in air (maximum ambient temperature or fuel temperature does not exceed the closed cup flash point temperature), and fire may be expected to burn less than 30 seconds before extinguishment.

2322. Inerting Data. Table No. 7 gives flammability peak data obtained with Halon 1211 for several materials. These values shall be used when the conditions of 2321 are not or cannot be met. The concentrations shown are greater than those given in Table No. 6, and are sufficient to "inert" the atmosphere against all proportions of fuel in air. Specifically, they should be used in the following situations:

(a) The quantity of fuel in the enclosure is greater than

Table 7

Halon 1211 Design Concentration for Inerting in Air at 1.0 Atm. and 70°F

Material	Minimum Design Concentration* % by Volume
Ethylene Dichloride	2.7**
Toluene	3.3
n-Heptane	6.5**
n-Hexane	5.8
Cyclohexane	5.7
Ethanol	6.2**
Methanol	24.7**
iso-Propyl-Alcohol	5.6
Benzene	4.8
Acetone	4.9
Methyl-Ethyl-Ketone	5.8
Hydrogen	26.9
Propylene	6.15
n-Butane	5.9
Propane	5.9
Methane	4.0
Ethane	5.8
i-Butane	5.2
Ethylene	9.6
Vinyl Chloride	5.37

*For other temperatures or pressures, specific test data shall be obtained.

**These values were obtained at 122°F. The vapor pressure of these fuels at 70°F is too low to form a stoichiometric mixture with air.

that permitted in 2321(a).

(b) The volatility of the fuel is greater than that permitted in 2321(b).

(c) The system response is not rapid enough to detect and extinguish the fire before the volatility of the fuel is increased to a dangerous level as a result of the fire.

2323. For materials not given in the above tables, the Halon 1211 design concentration shall be obtained by test of flame extinguishing effectiveness plus a 10 percent minimum safety factor or by determination of the inerting concentration.

2324. For combinations of fuels the values for the fuel requiring the greatest concentration shall be used.

2325. Where gaseous or highly volatile or atomized fuels are expected, additional protective measures such as actuation by hazardous vapor detectors are recommended. NFPA Standard No. 69 covering explosion suppression techniques should also be consulted for such situations.

***2400. Halon 1211 Requirements for Fires in Solid Materials.**

2410. General. Flammable solids may be classed as those which do not develop deep-seated fires, and those which do. Materials which do not become deep-seated undergo surface combustion only, and may be treated much as a flammable liquid fire. Most materials which develop deep-seated fires do so after exposure to flaming combustion for a certain length of time which varies with the material. In others, the fire may begin as deep-seated through internal ignition, such as spontaneous heating.

2420. Solid surface fires. Almost all flammable solids begin burning on the surface. In many materials, such as unfilled plastics (without filler materials), surface combustion is the only type that occurs. These fires are readily extinguished with low concentrations (e.g., 5%) of Halon 1211. Although glowing embers may remain at the surface of the fuel following extinguishment of flames, these embers will be completely extinguished within a short time (e.g., 10 minutes) provided the Halon 1211 concentration is maintained around the fuel for this time (called "soaking" time).

2430. Deep-Seated Fires. Halon 1211, like other halogenated hydrocarbons, chemically inhibits the propagation of flame. However, although the presence of Halon 1211 in the vicinity of a deep-seated fire will extinguish the flame, thereby greatly reducing the rate of burning, the quantity of agent required for complete extinction of all embers is difficult to assess. It depends on the nature of the fuel, its state of comminution, its distribution within the enclosure, the time during which it has been burning, the ratio of the area of the burning surface to the volume of the enclosure, and the degree of ventilation in the enclosure. It is usually difficult or impractical to maintain an adequate concentration for a sufficient time to ensure the complete extinction of a deep-seated fire. (See Appendix A-2400.)

2431. Where the solid material is in such a form that a deep-seated fire can be established before a flame extinguishing concentration has been achieved, provision shall be made to the satisfaction of the authority having jurisdiction for means to effect the complete extinguishment of the fire. (See Appendix A-2400.)

2500. Determination of Halon 1211 Quantity for Total Flooding Systems.

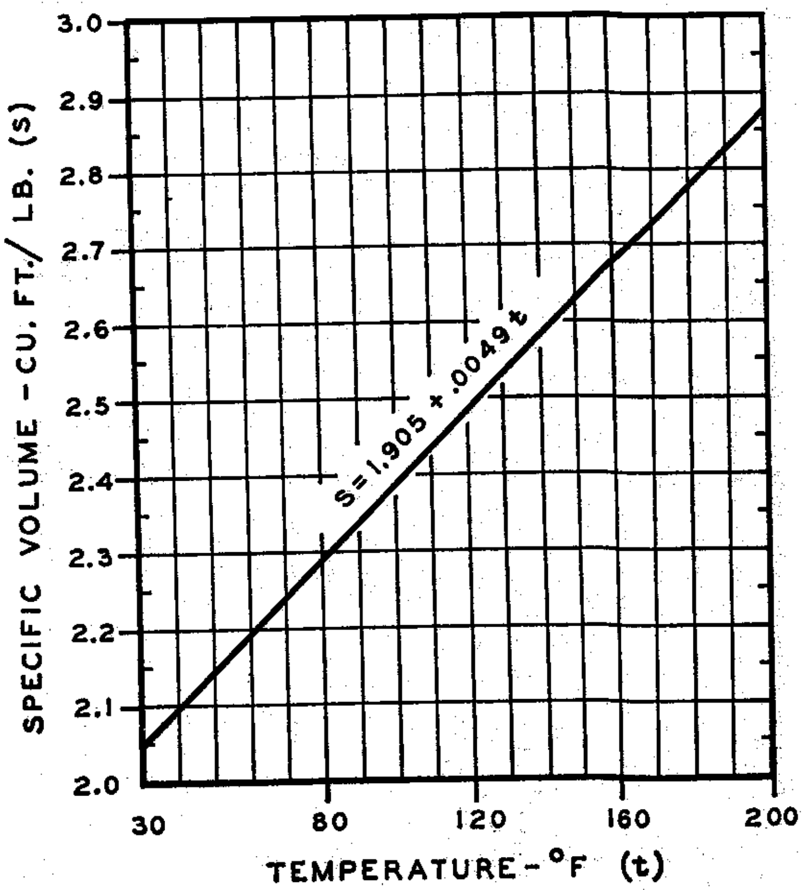

Fig. 8. Specific Volume of Superheated Halon 1211 Vapor (at 1 atmosphere).

2510. General. The Halon 1211 concentration requirements established in Sections 2300 and 2400 are converted into agent weight requirements through mathematical computations considering the volume of the hazard and the specific volume of the superheated Halon 1211 vapor. In addition to the concentration requirements, additional quantities of agent may be required to compensate for unclosable openings, forced ventilation or other special conditions which would affect the extinguishing efficiency.

2520. Total Flooding Quantity. Figure 8 depicts the specific volume of superheated Halon 1211 vapor at various temperatures. The amount of Halon 1211 required to achieve the design concentration is calculated from the following formula:

$$W = \frac{1}{s} \cdot \frac{C}{100 - C} \cdot V$$

W = Weight of Halon 1211 required, pounds
s = Specific volume superheated Halon 1211, cubic feet/pound
C = Halon 1211 concentration, % by volume
V = Volume of hazard, cubic feet

This calculation includes an allowance for normal leakage from a "tight" enclosure due to agent expansion. Since the amount of gas and, therefore, the concentration produced by a given weight of Halon 1211 is greatly affected by the temperature it encounters, the specific volume of superheated Halon 1211 vapor for the lower operating minimum anticipated ambient temperature limit shall be used in the design of a Halon 1211 total flooding system. Table 9 is a tabulation of the Halon 1211 weight per cubic foot of hazard volume required to produce the specified concentration of various hazard temperature conditions.

All Halon 1211 total flooding systems shall be capable of producing the required concentration of agent under the conditions of maximum net volume (gross volume of the hazard minus the volume occupied by solid objects), maximum ventilation and minimum anticipated ambient temperature. In areas where a wide variations in net volume are encountered under normal operations such as storage rooms, warehouses, etc., or where wide variations in ambient temperatures are experienced as in unheated rooms, the agent concentration generated under these extremes shall be calculated to determine compliance with paragraphs 2112 and 2113.

***2530. Special Conditions.** Additional quantities of Halon 1211 shall be provided to compensate for any special conditions such as unclosable openings, forced ventilation, or other causes of

Table 9

Halon 1211 Total Flooding Quantity

Temperature t °F.	Halon 1211 Specific Vapor Volume Ft.³/Lb.	Halon 1211 Weight Requirements/Cubic Foot of Hazard Volume (1) — Halon 1211 Concentration — C — % by Volume[4]							
(2)	(3)	3	4	5	6	7	8	9	10
30	2.052	.0151	.0203	.0256	.0311	.0367	.0424	.0482	.0541
40	2.101	.0147	.0198	.0250	.0304	.0358	.0414	.0471	.0529
50	2.150	.0144	.0194	.0245	.0297	.0350	.0405	.0460	.0517
60	2.199	.0141	.0190	.0239	.0290	.0342	.0396	.0450	.0505
70	2.248	.0137	.0185	.0234	.0284	.0335	.0387	.0440	.0494
80	2.297	.0135	.0181	.0229	.0278	.0328	.0379	.0431	.0484
90	2.346	.0132	.0178	.0224	.0272	.0321	.0371	.0422	.0474
100	2.395	.0129	.0174	.0220	.0266	.0314	.0363	.0413	.0464
110	2.444	.0126	.0171	.0215	.0261	.0308	.0356	.0405	.0455
120	2.493	.0124	.0167	.0211	.0256	.0302	.0349	.0397	.0446
130	2.542	.0122	.0164	.0207	.0251	.0296	.0342	.0389	.0437
140	2.591	.0119	.0161	.0203	.0246	.0291	.0336	.0382	.0429
150	2.640	.0117	.0158	.0199	.0242	.0285	.0330	.0375	.0421
160	2.689	.0115	.0155	.0196	.0237	.0280	.0324	.0368	.0413
170	2.738	.0113	.0152	.0192	.0233	.0275	.0318	.0361	.0406
180	2.787	.0111	.0150	.0189	.0229	.0270	.0312	.0355	.0399
190	2.836	.0109	.0147	.0185	.0225	.0266	.0307	.0349	.0392
200	2.885	.0107	.0145	.0182	.0221	.0261	.0302	.0343	.0385

Notes to Table 9.

(1) *Agent Weight Requirements* ($\frac{W}{V}$ — lb./ft.^{3}) — Pounds of agent required per cubic foot of protected volume to produce indicated concentration at temperatures specified.

$$\frac{W}{V} = \frac{1}{s} \cdot \frac{C}{100 - C}$$

(2) *Temperature* (t — °F.) — The design temperature in the hazard area.

(3) *Specific Volume* (s — ft.^{3}/lb.) — Specific volume of superheated Halon 1211 vapor at the temperature indicated.

$$s = 1.905 + .0049\ t$$

(4) Concentration (C — %) — Volumetric concentration of Halon 1211 in air at the temperature indicated.

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agent loss. It shall be the responsibility of the system designer to show that such conditions have been taken into account in the design of a system.

2600. Distribution System.

2610. General. The distribution system for applying Halon 1211 to enclosed hazards shall be designed with due consideration for the materials involved, the type of burning expected, and the nature of the enclosure. These factors all may affect the discharge times and rates of application.

***2620. Rate of Application.** The minimum design rate of application shall be based on the quantity of agent required for the desired concentration and the time allotted to achieve the desired concentration.

2621. Discharge Time. The agent discharge shall be subpracticable, unless a longer discharge time is specifically permitted stantially completed in a nominal 10 seconds or a shorter time if by the authority having jurisdiction. This period shall be measured as the interval between the first appearance of liquid at the nozzle and the time when the discharge becomes predominantly gaseous. This point is distinguished by a marked change in both the sound and the appearance of the discharge.

2630. Extended Application Rate. Where leakage is appreciable and the design concentration must be obtained quickly and maintained for an extended period of time, agent quantities provided for leakage compensation may be applied at a reduced rate.

2631. This type of application is particularly suitable to enclosed rotating electrical apparatus, such as generators, motors and convertors.

2632. The initial discharge shall be completed within the limits specified in paragraph 2621.

2633. The rate of extended discharge shall be sufficient to maintain the desired concentration for the duration of application.

2640. Piping and Supply. Piping shall be designed in accordance with the requirements outlined in Chapter 1 to deliver the required rate of application at each nozzle.

2650. Nozzle Choice and Location. Nozzles used with total flooding systems shall be of the type listed for the intended purpose, and shall be located with the geometry of the hazard and enclosure taken into consideration.

2651. The type of nozzles selected, their number, and their placement shall be such that the design concentration will be established in all parts of the hazard enclosure, and such that the discharge will not unduly splash flammable liquids or create dust clouds that might extend the fire, create an explosion, or otherwise adversely affect the contents of the enclosure. Nozzles vary in design and discharge characteristics and shall be selected on the basis of their adequacy for the use intended. Nozzles shall be placed within the hazard area in compliance with listed limitations with regard to spacing floor coverage and alignment.

2700. Venting Consideration.

2710. General. Venting of an enclosure may be necessary to relieve pressure build-up due to the discharge of large quantities of Halon 1211. Appropriate pressure relief depends on the injection rate of the Halon 1211 and enclosure strength.

2720. Pressure Relief Venting. Porosity and leakages such as around doors, windows and dampers, though not readily apparent or easily calculated, will usually provide sufficient relief for Halon 1211 flooding systems without need for additional venting. Record storage rooms, refrigerated spaces and duct work also generally need no additional venting.

2721. For very tight enclosures, the area necessary for free venting may be calculated from the following formula, taking the specific volume of Halon 1211 vapor at 70°F to be 2.26 cubic feet per pound:

$$x = \frac{7.8\,Q}{\sqrt{p}}$$

x — Free venting area, sq. in.
Q — Halon 1211 injection rate, lb. per sec.
p — Allowable strength of enclosure, lb./sq. ft.

Table No. 12

Strength and Allowable Pressures for Average Enclosures

Type Construction	Windage miles/hour	PRESSURE lb/sq. ft.	In Water	psi
Light Building	100	25*	5	.175
Normal Building	140	50†	10	.35
Vault Building	200	100	20	.70

*Venting sash remains closed.
†Venting sash designed to open freely.

2722. In many instances, particularly when hazardous materials are involved, relief openings are already provided for explosion venting. These and other available openings often provide adequate venting.

2723. Table 12, based on general construction practices, provides a guide for considering the normal strength and allowable pressures of average enclosures.

CHAPTER 3. LOCAL APPLICATION SYSTEMS.

*3100. General Information.

3110. Uses. Local application systems are used where there is no fixed enclosure about the hazard or hazards and for the protection of individual hazards in large enclosures. Where deep-seated fires are expected, the total flooding requirements of Chapter 2 apply.

3111. Examples of hazards that may be successfully protected by local application systems include dip tanks, quench tanks, spray booths, oil-filled electric transformers, vapor vents and similar types of hazards.

3112. For all Halon 1211 local application systems located in normally occupied confined spaces, the calculations described in 2520 shall be performed to determine the volumetric concentration of the agent developed in that volume. This concentration shall be less than 4 percent for all normally occupied areas. For the purposes of this standard, a normally occupied area is an area intended for occupancy *(See A-1200)*. Since it is not the object of a local application system to distribute the agent evenly throughout the entire volume, locally high concentrations may be experienced.

3120. General Requirements. Local application systems shall be designed, installed, tested and maintained in accordance with the applicable requirements of Chapter 1 and with the additional requirements set forth in this chapter.

3200. Hazard Specifications.

3210. Extent of Hazard. The hazard shall be so isolated from other hazards or combustibles that fire will not spread outside the protected area. The entire hazard shall be protected. The hazard shall include all areas that are or may become coated by combustible liquids or thin solid coatings such as areas subject to spillage, leakage, dripping, splashing, or condensation, and all associated materials or equipment such as freshly coated stock, drain boards, hoods, ducts, etc., that might extend fire outside or lead fire into the protected area.

3211. When a series of interexposed hazards are subdivided into smaller groups or sections, the systems for such hazards shall be designed to provide immediate independent protection to the adjacent groups or sections.

3220. Location of Hazard. The hazard may be indoors or partly sheltered. If the hazard is completely out of doors, it is essential that the agent discharge be such that winds or strong air currents do not impair the protection. It shall be the responsibility of the system designer to show that such conditions have been taken into account in the design of a system.

***3300. Halon 1211 Requirements.**

3310. General. The quantity of agent required for local application systems shall be based on liquid discharge only and on the total rate of discharge needed to protect the hazard and the time that the discharge must be maintained to assure complete extinguishment.

3311. Since only the liquid portion of the discharge is effective in this application, the computed quantity of agent shall be increased to compensate for the residual agent in the storage container at the end of liquid flow.

*3312. The system shall be designed to compensate for any agent vaporized in the pipe lines due to heat absorption from the piping.

3320. Rate of Discharge. Nozzle discharge rates shall be determined as outlined below:

3321. If part of the hazard is to be protected by total flooding, the discharge rate for the local application portion of the system shall be maintained for a period not less than the discharge time for the total flooding portion.

3322. The minimum design rate (R_d) shall not be less than the optimum rate (R_o) required for extinguishment *(See Figure 13)*. The minimum design quantity (Q_d) shall be no less than 1.5 times the minimum quantity (Q_m) required for extinguishment at any selected design rate (R_d). The minimum design discharge time (T_d) shall be determined by dividing the design quantity (Q_d) by the design rate (R_d).

3323. The basis for nozzle selection for local application systems shall be a curve similar to Figure 13 together with other performance data that clearly depicts the interrelationship between agent quantity, discharge rate, discharge time, area coverage and the distance of the nozzle from the protected surface.

3324. The information in paragraph 3323 shall be contained in the listings of a nationally recognized testing laboratory.

3325. Where there is the likelihood that metal, fuel or other material may become heated over the ignition temperature of the fuel, additional means shall be provided to prevent reignition. Examples of such additional means are extending the discharge time of the local application system, using a halon total flooding system or using other agents.

3326. Where there is a possibility that metal or other material may become heated above the ignition temperature of the fuel, the effective discharge time shall be increased to allow adequate cooling time. This is especially important with paraffin wax and

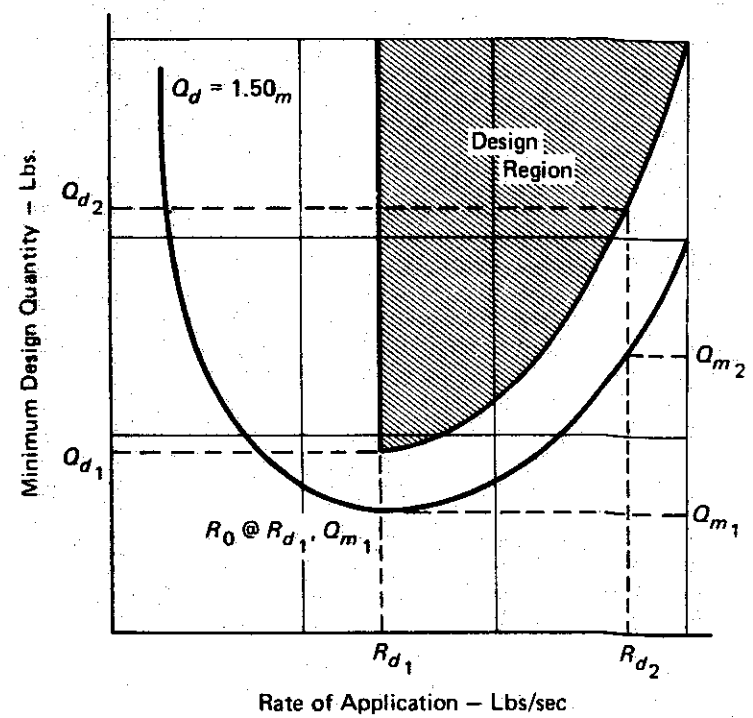

Fig. 13. Typical data presentation for local application nozzles.

other materials having low auto-ignition temperatures.

3327. The total rate of discharge for the system shall be the sum of the individual rates of all the nozzles or discharge devices used on the system.

3330. Area Per Nozzle. The maximum area protected by each nozzle shall be determined on the basis of nozzle discharge pattern, distance from the surface protected, and the design discharge rate in accordance with listings of a nationally recognized testing laboratory.

3331. Irregular shaped or three dimensional hazards shall be protected by a nozzle or combination of nozzles to insure complete agent coverage of all exposed surfaces. The projected surface area shall be used to determine the nozzle coverage, but all surfaces protected by a nozzle shall lie within the nozzle's listed range limitations.

3332. When deep layer flammable liquids are to be protected, a minimum free board shall be provided in accordance with the listings of a nationally recognized testing laboratory.

3340. Location and Number of Nozzles. A sufficient number of nozzles shall be used to cover the entire hazard area on the basis of the unit areas protected by each nozzle.

3341. Tankside or linear type nozzles shall be located in accordance with spacing and discharge rate limitations stated in nozzle listings.

3342. Overhead type nozzles shall be installed perpendicular to the hazard and centered over the area protected by the nozzle. They may also be installed at other angles to the surface in accordance with nozzle listings.

3343. Nozzles shall be located so as to be free of possible obstructions that could interfere with the proper projection of the discharged agent.

3344. Nozzles shall be located so as to develop an extinguishing concentration over coated stock or other hazard extending above a protected surface.

3345. The possible effects of air current, winds and forced drafts shall be compensated for by locating nozzles or by providing additional nozzles to protect the outside areas of the hazard.

APPENDIX

THE FOLLOWING APPENDIX MATERIAL IS PROVIDED TO EXPLAIN THE BASIC PRINCIPLES, AGENT AND EQUIPMENT CHARACTERISTICS, AND MAINTENANCE AND INSTALLATION PRACTICES.

A-1100. Halogenated Extinguishing Agents.

A halogenated compound is one which contains one or more atoms of an element from the halogen series: fluorine, chlorine, bromine and iodine. When hydrogen atoms in a hydrocarbon compound, such as methane (CH_4) or ethane (CH_3CH_3), are replaced with halogen atoms, the chemical and physical properties of the resulting compound are markedly changed. Methane, for example, is a light, flammable gas. Carbon tetrafluoride (CF_4) is also a gas, is chemically inert, nonflammable and extremely low in toxicity. Carbon tetrachloride (CCl_4) is a volatile liquid which is not only nonflammable, but was widely used for many years as a fire extinguishing agent in spite of its rather high toxicity. Carbon tetrabromide (CBr_4) and carbon tetraiodide (CI_4) are solids which decompose easily under heat. Generally, the presence of fluorine in the compound increases its inertness and stability; the presence of other halogens, particularly bromine, increase the fire extinguishing effectiveness of the compound. Although a very large number of halogenated compounds exist, only the following five are used to a significant extent as fire extinguishing agents:

Halon 1011, bromochloromethane, CH_2BrCl
Halon 1211, bromochlorodifluoromethane, $CBrClF_2$
Halon 1202, dibromodifluoromethane, CBr_2F_2
Halon 1301, bromotrifluoromethane, $CBrF_3$
Halon 2402, dibromotetrafluoroethane, $CBrF_2CBrF_2$

Halon Nomenclature System. The Halon system for naming halogenated hydrocarbons was devised by the U.S. Army Corps of Engineers to provide a convenient and quick means of reference to candidate fire extinguishing agents. The first digit in the number represents the number of carbon atoms in the compound molecule; the second digit, the number of fluorine atoms; the third digit, the number of chlorine atoms; the fourth digit, the number of bromine atoms; and the fifth digit, the number of iodine atoms. Terminal zeros are dropped. Valence requirements not accounted for are assumed to be hydrogen atoms (number of hydrogen atoms = 1st digit times 2, plus 2, minus the sum of the remaining digits.) Examples of this numbering system are: