NFPA No.

12A

HALOGENATED EXTINGUISHING AGENT SYSTEMS HALON 1301 1973

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NATIONAL FIRE PROTECTION ASSOCIATION

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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 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.

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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. 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.

1530. 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.

1531. 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.

1532. 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.

1540. 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 $\pm$ 5% or 600 psig $\pm$ 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.

1541. 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 1547).

1542. 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.

1543. 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.

1544. 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.

1545. Each system shall have a permanent nameplate specifying the number, filling weight, and pressurization level of the containers.

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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 Transportation of Dangerous Commodities by Rail" available from the Queen's Printer, Ottawa, Ontario.

1546. 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.

1547. 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.

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).

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/cm^2 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.

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.

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.

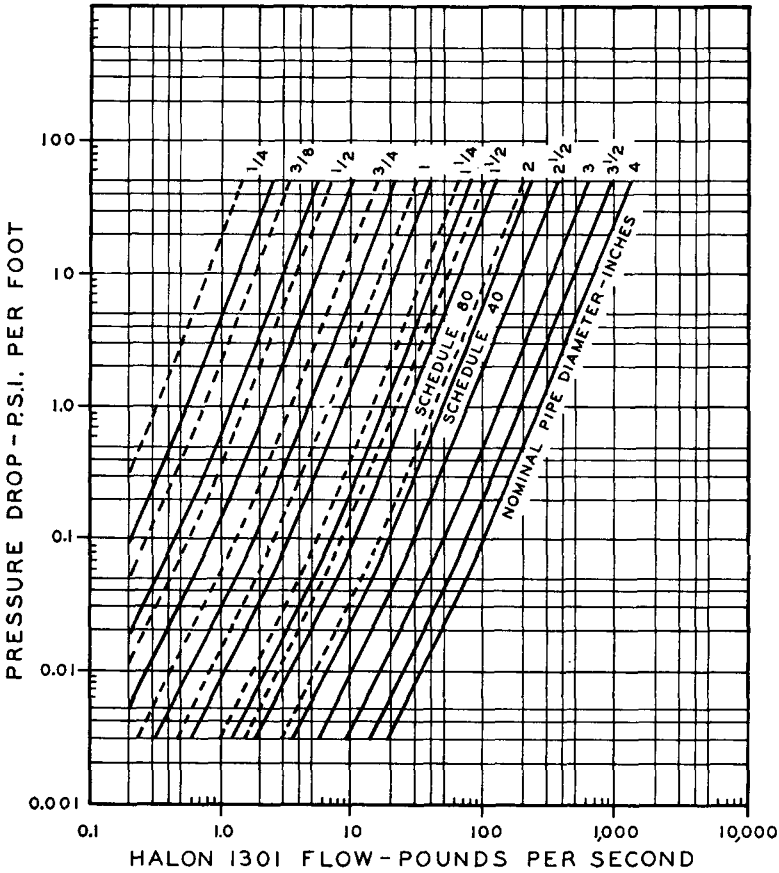

Fig. 1. Pressure drop vs. flow in steel pipe.

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.

Table 2. Halon 1301

ORIFICE DISCHARGE RATES 70°F TEMPERATURE

Pressure Above Orifice psig	Discharge Rate, Lb/sec-in²*	
	At 600 psig Storage Pressure	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

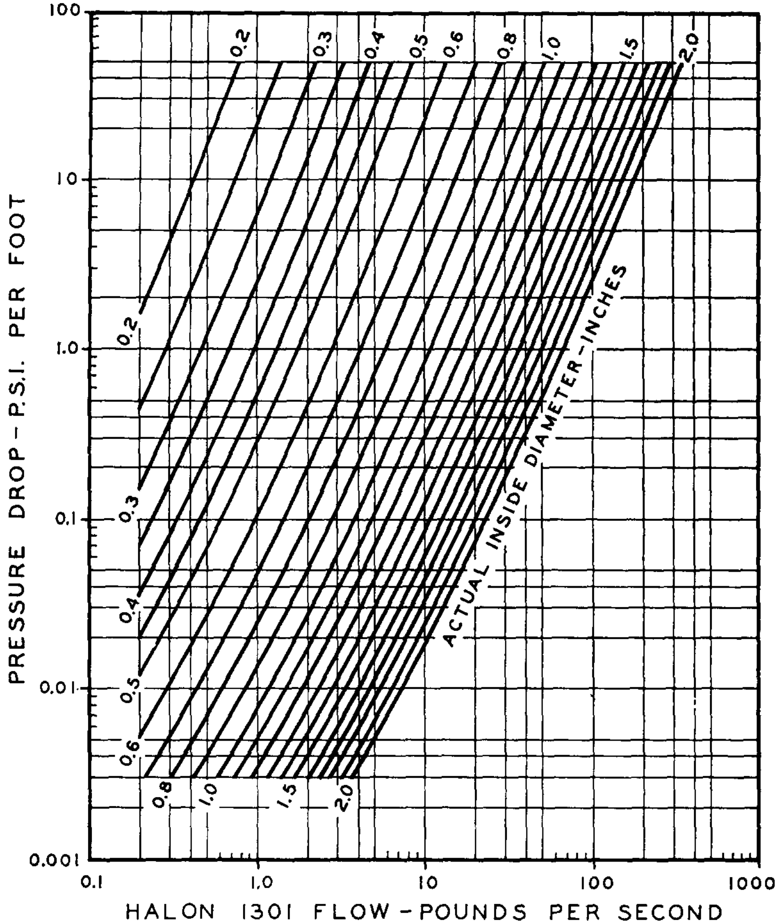

Fig. 2. Pressure drop vs. flow in copper tubing.

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

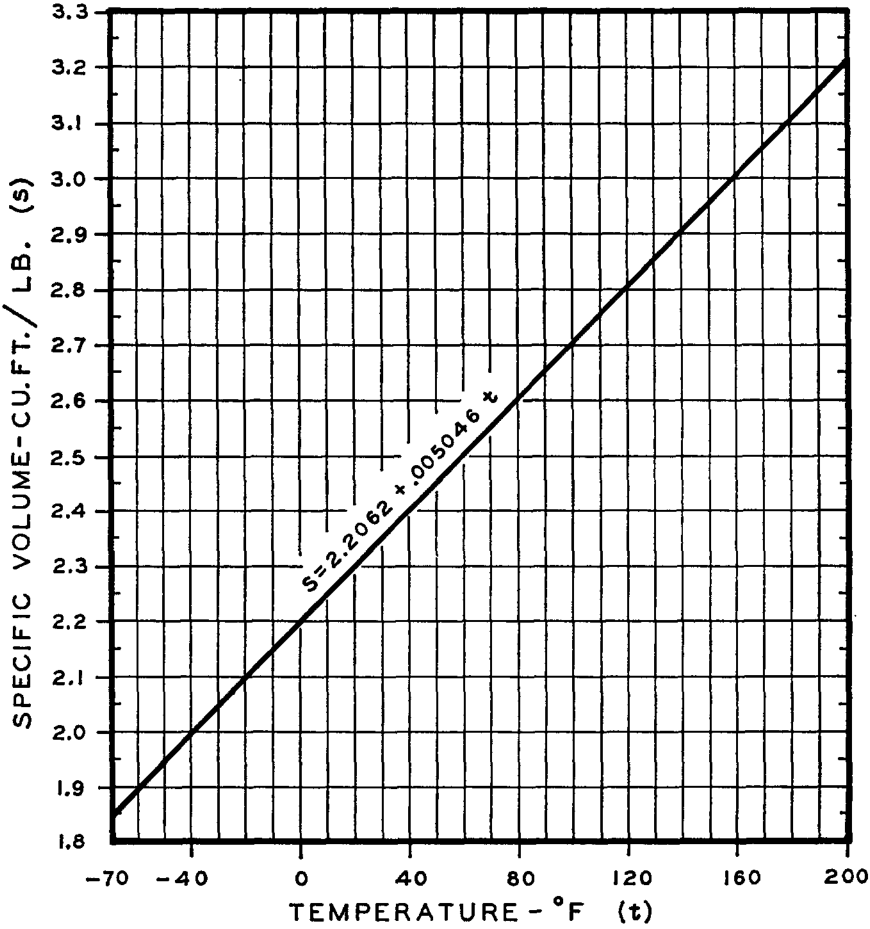

Fig. 3 Specific volume of superheated Halon 1301 vapor (at 1 atmosphere).

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 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 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.

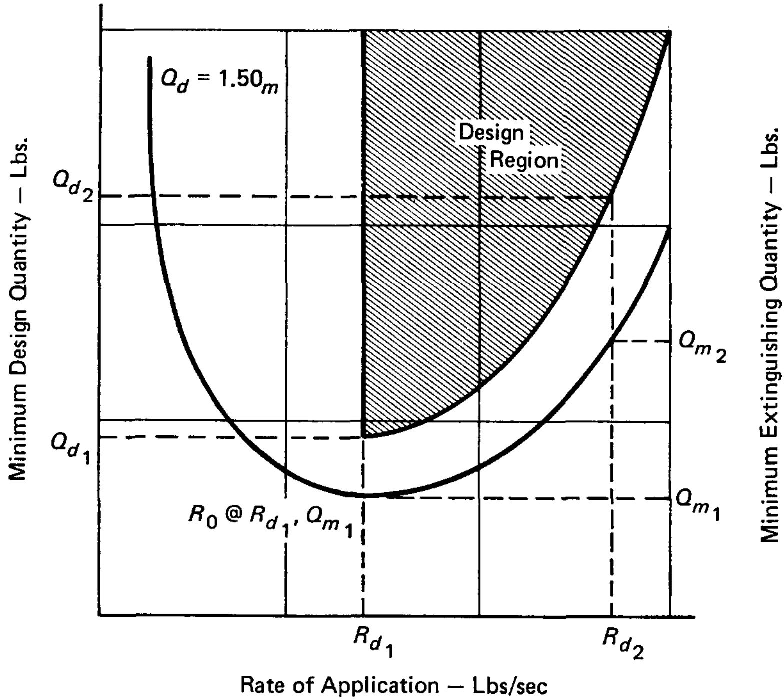

Fig. 4. Typical data presentation for local application nozzles.

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:

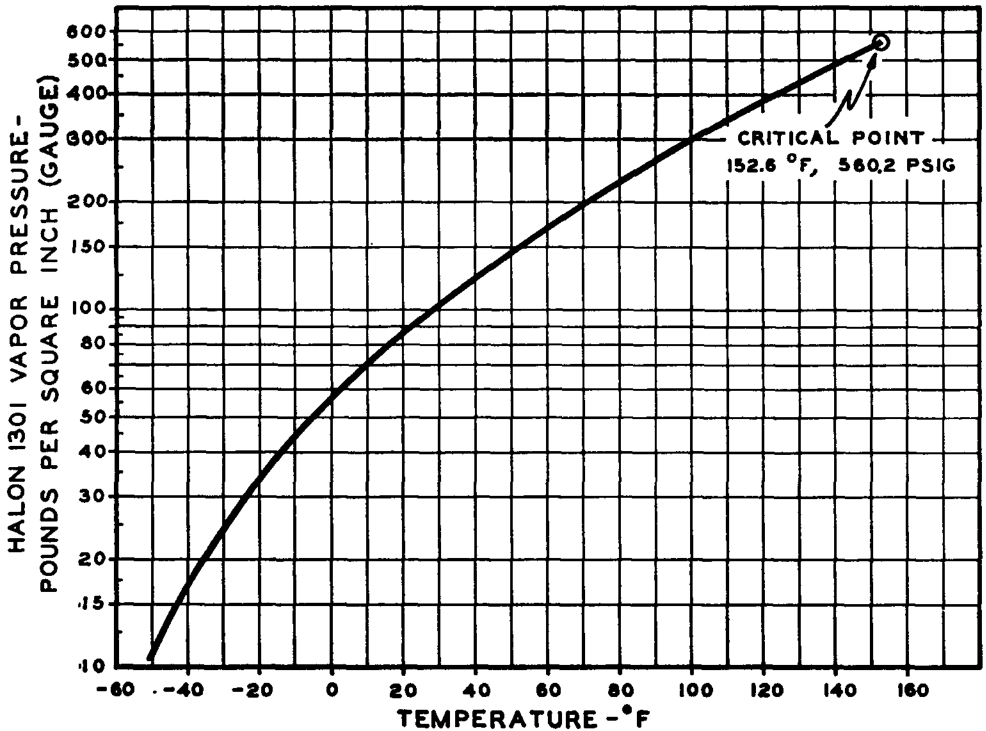

Fig. A–1. Vapor pressure of Halon 1301 vs. temperature.

Chemical Name	Chemical Formula	Halon Number
Methyl fluoride	CH_3F	11
Methyl chloride	CH_3Cl	101
Methyl bromide	CH_3Br	1001
Methyl iodide	CH_3I	10001
Dichlorodifluoromethane	CCl_2F_2	122
Chlorobromomethane	CH_2ClBr	1011
Dibromodifluoromethane	CBr_2F_2	1202
Bromochlorodifluoromethane	$CBrClF_2$	1211
Bromotrifluoromethane	$CBrF_3$	1301
Dibromotetrafluoroethane	$CBrF_2CBrF_2$	2402

A–1120. Halon 1301.

Halon 1301 chemically is bromotrifluoromethane, $CBrF_3$. Its cumbersome chemical name is often shortened to "bromotri" or even further to "BT." The compound is used as a low-temperature refrigerant and as a cryogenic fluid, as well as a fire extinguishing agent.

A–1121. Physical Properties.

A list of important physical properties of Halon 1301 is given in Table A-1. Under normal conditions, Halon 1301 is a colorless, odorless gas with a density approximately 5 times that of air. It can be liquefied upon compression for convenient shipping and storage. Unlike carbon dioxide, Halon 1301 cannot be solidified at temperatures above –270°F.

The variation of vapor pressure with temperature for Halon 1301 is shown in Figure A-1. As the temperature is increased, the vapor pressure and vapor density increase and the liquid density decreases, until the critical temperature of 152.6°F is reached. At this point the densities of the liquid and vapor phases became equal and the liquid phase ceases to exist. Above the critical temperature, the material behaves as a gas, but it can no longer be liquefied at any pressure.

A–1122. Fire Extinguishment Characteristics.

Halon 1301 is an effective fire extinguishing agent that can be used on many types of fires. It is effective in extinguishing surface fires, such as flammable liquids, and on most solid combusti-

Table A-1

Physical Properties of Halon 1301

Molecular Weight	148.93
Boiling Point at 1 atm. °F	–71.95
°C	–57.75
Freezing Point, °F	–270.
°C	–168.
Critical Temperature, °F	152.6
°C	67.0
Critical Pressure, psia	575.
atm.	39.1
Critical Volume, cu. ft. per lb.	0.0215
Critical Density, lb. per cu. ft.	46.5
g/cc	0.745
Specific Heat, Liquid (Heat Capacity) at 77°F, Btu/lb.–°F	0.208
Specific Heat, Vapor, at constant pressure (1 atm) 77°F Btu/lb.–°F	0.112
Heat of Vaporization at Boiling Point, Btu/lb.	51.08
Thermal Conductivity of Liquid at 77°F, Btu/hr.–ft–°F	0.025
Viscosity, Liquid at 77°F, centipoise	0.15
Viscosity, Vapor, at 77° F, centipoise	0.016
Surface Tension at 77°F, dynes/cm	4.
Refractive Index of Liquid at 77°F	1.238
Relative Dielectric Strength at 1 atm, 77°F (Nitrogen = 1)	1.83
Solubility of Halon 1301 in Water at 1 atm, 77°F, wt. %	0.03
Solubility of Water in Halon 1301 at 70°F, wt. %	0.0095

ble materials except for a few active metals and metal hydrides, and materials which contain their own oxidizer, such as cellulose nitrate, gunpowder, etc.

Extinguishing Mechanism. The mechanism by which Halon 1301 extinguishes fires is not thoroughly known; neither is the combustion process of the fire itself. It appears, however, to be a physiochemical inhibition of the combustion reaction. Halon 1301 has also been referred to as a "chain breaking" agent, meaning that it acts to break the chain reaction of the combustion process. Halon 1301 dissociates in the flame into two radicals:

$$CBrF_3 \rightarrow CF_3^{\cdot} + Br^{\cdot}$$

Two inhibiting mechanisms have been proposed, one which is based on a free radical process, and another based on ionic activation of oxygen during combustion.

The "free radical" theory supposes that the bromide radical reacts with the fuel to give hydrogen bromide,

$$R\text{-}H + Br^{\cdot} \rightarrow R\cdot + HBr$$

which then reacts with active hydroxyl radicals in the reaction zone:

$$HBr + OH\cdot \rightarrow H_2O + Br^{\cdot}$$

The bromide radical again reacts with more fuel, and so on, with the result that active $H^{\cdot}$, $OH^{\cdot}$, and $O^{:}$ radicals are removed, and less reactive alkyl radicals are produced.

The "ionic" theory supposes that the uninhibited combustion process includes a step in which O_2^- ions are formed by the capture of electrons which come from ionization of hydrocarbon molecules. Since bromine atoms have a much higher cross section for the capture of slow electrons than has O_2, the bromine inhibits the reaction by removing the electrons that are needed for activation of the oxygen.

A–1200. Hazards to Personnel.

The discharge of Halon 1301 to extinguish a fire may create a hazard to personnel from the natural Halon 1301 itself and from the products of decomposition that result from exposure of the agent to the fire or other hot surfaces. Exposure to the natural agent is generally of less concern than is exposure to the decomposition products. However, unnecessary exposure of personnel to either the natural agent or to the decomposition products should be avoided.

A–1201. Natural or Undecomposed Halon 1301.

Undecomposed Halon 1301 has been studied in humans and found to produce minimal, if any, central nervous system effects at concentrations below 7 percent for exposures of approximately five minutes' duration. At concentrations of 7 to 10 percent effects such as dizziness, impaired coordination, and reduced mental acuity become definite with exposures of a few minutes' duration; however, these effects are not incapacitating for exposures of one minute or less. At concentrations above 10 percent, these effects increase in intensity and may become incapacitating with exposures longer than about one minute. At concentrations of the order of 15 to 20 percent, there is the risk of unconsciousness and possibly death if the exposure is prolonged, although no subjects have actually lost consciousness as a result of exposure to 10 to 15 percent concentrations of Halon 1301.

Personnel should not attempt to remain in an area following discharge of Halon 1301 in concentrations above 7 percent and furthermore it is recommended that they do not remain in an area for more than four or five minutes even though agent concentrations are below 7 percent. Within the first 30 seconds of exposure to Halon 1301 little effect is noticed, even when concentrations of 10 to 15 percent are inhaled. At these levels, this amount of time appears necessary for the body to absorb a sufficient quantity of the agent to bring about the onset of effects. However, at higher concentrations the onset of symptoms may occur within a few seconds and since an individual may be quickly incapacitated by these higher levels, concentrations greater than 15 percent should not be used where there is any chance of human exposure.

The effects of exposure to Halon 1301 may persist for a short period of time following exposure; however, recovery may be expected to be rapid and complete. Halon 1301 would not be expected to accumulate in the body even with repeated exposures.

Anyone suffering from the toxic effects of Halon 1301 vapors should immediately move or be moved to fresh air. In treating persons suffering toxic effects due to exposure to this agent, the use of epinephrine (adrenaline) and similar drugs must be avoided because they may produce cardiac arrhythmias, including ventricular fibrillation.

Table A-2 represents Underwriters' Laboratories' classification of comparative life hazards of various chemicals based upon exposure of test animals. While the classification is useful in comparing the toxicity of one compound to that of another, the exposure limits cannot be applied as an absolute measure of toxicity to humans.

Halon 1301 is colorless and odorless. Discharge of the agent may create a light mist in the vicinity of the discharge nozzle, resulting from condensation of moisture in the air, but the mist rarely persists after discharge is completed. Thus, little hazard is created from the standpoint of reduced visibility. Once discharged into an enclosure, it is difficult to detect its presence through normal human senses; in concentrations above about 3 percent, voice characteristics are changed due to the increased density of the agent/air mixture.

In total flooding systems, the high density of Halon 1301 vapor (5 times that of air) requires the use of discharge nozzles that will achieve a well-mixed atmosphere in order to avoid local pockets of higher concentration. It is also possible to develop local pockets of higher concentration in pits or low-lying areas adjacent to local application systems. Once mixed into the air, the agent will not settle out.

A–1202. Decomposition Products of Halon 1301.

Although Halon 1301 vapor has a low toxicity, its decomposi-

Table A-2

Underwriters' Laboratories Classification of Comparative Life Hazard of Various Chemicals (Based upon exposure of Test Animals)

Group	Definition	Examples
6 (least toxic)	Gases or vapors which in concentrations up to at least 20 percent by volume for durations of exposure of the order of 2 hours do not appear to produce injury.	Bromotrifluoromethane (Halon 1301) Dichlorodifluoromethane (Halon 122 or R-12)
5a	Gases or vapors much less toxic than Group 4 but more toxic than Group 6.	Bromochlorodifluoromethane (Halon 1211) Carbon Dioxide
4	Gases or vapors which in concentrations of the order of 2 to 2-½ percent for durations of exposure of the order of 2 hours are lethal or produce serious injury.	Methyl Chloride (Halon 101) Dibromodifluoromethane (Halon 1202) Ethyl Bromide (Halon 2001)
3	Gases or vapors which in concentrations of the order of 2 to 2-½ percent for durations of exposure of the order of 1 hour are lethal or produce serious injury.	Chlorobromomethane (Halon 1011) Carbon Tetrachloride (Halon 114) Chloroform (Halon 103)
2	Gases or vapors which in concentrations of the order of ½ to 1 percent for durations of exposure of the order of ½ hour are lethal or produce serious injury.	Methyl Bromide (Halon 1001) Ammonia
1	Gases or vapors which in concentrations of the order of ½ to 1 percent for durations of exposure of the order of 5 minutes are lethal or produce seious injury.	Sulfur Dioxide

tion products can be hazardous. The most accepted theory is that the vapor must decompose before Halon 1301 can inhibit the combustion reactions (see A-1122). The decomposition takes place on exposure to a flame, or to a hot surface at above about 900°F. In the presence of available hydrogen (from water vapor, or the combustion process itself) the main decomposition products are the halogen acids (HF, HBr), and free halogens (Br_2), with small amounts of carbonyl halides (COF_2, $COBr_2$).

Approximate lethal concentration values for 15-minute exposures to some of these compounds are given in Column 1 of Table A-3. Column 2 of Table A-3 gives the concentrations of these materials that have been quoted as "dangerous for short exposures" by Sax*.

Table A-3

Approximate Lethal Concentrations for Predominate Halon 1301 Decomposition Products

Compound	ALC for 15-Minute Exposure ppm by Volume in Air	Dangerous Concentration* ppm by Volume in Air
Hydrogen Fluoride, HF	2500	50–250
Hydrogen Bromide, HBr	4750	—
Bromine, Br_2	550	50***
Carbonyl Fluoride, COF_2	1500	—
Carbonyl Bromide, $COBr_2$	100–150**	—

* Sax, N. Irving; Dangerous Properties of Industrial Materials; Second Edition; Section 12; Reinhold Publishing Corporation; New York, New York; 1963.
** Value is for carbonyl chloride, $COCl_2$ (phosgene); value for carbonyl bromide is not available.
*** Value is for chlorine (Cl_2); value for bromine is not available.

The decomposition products of Halon 1301 have a characteristic sharp, acrid odor, even in minute concentrations of only a few parts per million. This characteristic provides a built-in warning system for the agent, but at the same time creates a noxious, irritating atmosphere for those who must enter the hazard following the fire.

The amount of Halon 1301 that can be expected to decompose in extinguishing a fire depends to a large extent on the size of the fire, the concentration of Halon vapor and the length of time that the agent is in contact with flame or heated surfaces above 900°F. If there is a very rapid buildup of concentration to the critical value, then the fire will be extinguished quickly, and there will be little decomposition. The actual concentration of the decomposition products must then depend on the volume of the room in which the fire was burning, and on the degree of mixing and ventilation. For example, extinguishment of a 25 square foot heptane fire in a 10,000 cubic foot enclosure within 0.5 seconds produced only 12 ppm HF. A similar test having an extinguishment time of 10 seconds produced an average HF level of 250 ppm over a 9-minute period.

Clearly longer exposure of the vapor to temperatures in excess of 900°F would produce greater concentrations of these gases. The type and sensitivity of detection, coupled with the rate of discharge, should be selected to minimize the exposure time of the vapors to the elevated temperature if the concentration of breakdown products must be minimized. In most cases the area would be untenable for human occupancy due to the heat and breakdown products of the fire itself.

A–1211. Safety Requirements.

The steps and safeguards necessary to prevent injury or death to personnel in areas whose atmospheres will be made hazardous by the discharge or thermal decomposition of Halon 1301 may include the following:

1. Provision of adequate aisleways and routes of exit and keeping them clear at all times.

2. Provision of the necessary additional and/or emergency lighting and directional signs to ensure quick, safe evacuation.

3. Provision of alarms within such areas that will operate immediately upon detection of the fire.

4. Provision of only outward swinging self-closing doors at exits from hazardous areas, and, where such doors are latched, provision of panic hardware.

5. Provision of continuous alarms at entrances to such areas until the atmosphere has been restored to normal.

6. Provision of warning and instruction signs at entrances to and inside such areas. This sign should inform persons in or entering the protected area that a Halon 1301 system is installed and may contain additional instructions pertinent to the conditions of the hazard.

7. Provision for prompt discovery and rescue of persons rendered unconscious in such areas. This may be accomplished by having such areas searched immediately by trained men equipped with proper breathing equipment. Self-contained breathing equipment and personnel trained in its use, and in rescue practices, including artificial respiration, should be readily available.

8. Provision of instruction and drills of all personnel within or in the vicinity of such areas, including maintenance or construction people who may be brought into the area, to insure their correct action when Halon 1301 protective equipment operates.

9. Provision of means for prompt ventilation of such areas. Forced ventilation will often be necessary. Care should be taken to

really dissipate hazardous atmospheres and not merely move them to another location. Halon 1301 is heavier than air.

10. Provision of such other steps and safeguards that a careful study of each particular situation indicates are necessary to prevent injury or death.

A–1220. Electrical Clearance.

The clearances in Table A-4 were obtained from the National Electrical Code and publications of the National Electrical Manufacturers Association (NEMA).

Table A-4

Minimum Clearance of System Components from Live Electrical Apparatus

Line Voltage	Distance (in.)	Line Voltage	Distance (in.)
600 or less	1*	92,000	30
2,500	2*	115,000	37
5,000	3*	138,000	44
15,000	6	161,000	52
25,000	8	196,000	63
34,500	12	230,000	76
46,000	15	287,000	98
69,000	23	345,000	120

* For interior dry locations.

NOTE: With the exception of those marked with an asterisk, the clearances given are for transformers operating at altitudes of 3,300 feet or less. For operation at altitudes in excess of 3,300 feet, the clearance shall be increased at the rate of 1 percent per 330 feet increase in altitude in excess of 3,300 feet.

A–1340. Approval of Installations. Such tests should include:

1. A test for tightness up to the selector valve.

2. Continuity of piping with free unobstructed flow beyond the selector valve.

3. The labeling of devices with proper designations and instructions shall be checked.

4. Operational tests should be conducted on all devices except cylinder valves in multicylinder systems.

5. A suitable discharge test or concentration analysis should be made when conditions prevail that make it difficult to determine adequately the system requirement or design.

A-1420. Methods of Actuation.

Because of the high efficiency and rapidity of flame knockdown that can be achieved by Halon 1301, it is ideally suited to use in automatic systems. Any unnecessary delay in the actuation of a system may reduce its effectiveness because the size of the fire may be increased. This could result in an increase in the concentration of breakdown products. It is for these reasons that automatic detection and operation should be used whenever possible. However, it is recognized that there may be exceptional circumstances in which manual operation is to be preferred. For example, on a continuously manned manufacturing plant there may be a low probability of a potentially disastrous fire, and a much higher probability of minor fires. An automatic system is needed to protect against the major hazard, but hand extinguishers are adequate for the minor ones. It is difficult to devise a fast-operating detection system that can differentiate between the risks, so it is arranged that when the fire alarm sounds in the Control Room, the decision is taken whether to actuate the extinguishing system, or whether to use the hand extinguishers. This obviates the risk that the system will discharge to extinguish a minor fire, leaving the plant temporarily unprotected against the major hazard.

A-1520. Quality. Specification MIL-M-12218B requires a technical purity of Halon 1301 as shown in Table A-1520 below:

Table A–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

A–1550. Storage Containers.

Storage containers for Halon 1301 must be capable of withstanding the total pressure exerted by the Halon 1301 vapor plus the nitrogen partial pressure, at the maximum temperature contemplated in use. Generally, steel cylinders meeting the U.S. Department of Transportation requirements will be used to contain quantities up to about 100 pounds Halon 1301, or manifolded cylinders for larger installations.

Each container must be equipped with a discharge valve capable of discharging liquid Halon 1301 at the required rate. Containers with top-mounted valves require an internal dip tube extending to the bottom of the cylinder to permit discharge of liquid phase Halon 1301.

Nitrogen Superpressurization. Although the 199 psig vapor pressure of Halon 1301 at 70°F is adequate to expel the contents of the storage containers, this pressure decreases rapidly with temperature. At 0°F, for example, the vapor pressure is 56.6 psig, and at –40°F it is only 17.2 psig. The addition of nitrogen to Halon 1301 storage containers to pressurize the agent above the vapor pressure, called "super-pressurizing," will prevent the container pressure from decreasing so drastically at low temperatures. In addition, it will maintain the agent in the liquid state during flow through pipelines, provided the pipeline pressure does not drop below the vapor pressure of the agent. This latter characteristic permits greatly simplified pressure drop-vs-flow calculations in the design of Halon 1301 discharge systems.

Superpressurization causes some of the nitrogen to permeate the liquid portion of the Halon 1301. This "solubility" is related both to the degree of superpressurization and to temperature as follows:

$$H_x = \frac{P_n}{x_n}$$

Where:

H_x = Henry's Law constant, psi per mole fraction.
P_n = Partial pressure of nitrogen above solution, psi.
x_n = Nitrogen concentration in liquid Halon 1301, mole fraction.

Nitrogen partial pressure may be calculated from the total pressure of the system and the vapor pressure of Halon 1301 (Figure A-1) as follows:

$P_n = P - (1 - x_n) P_v$

Where: P = Total pressure of system, psi absolute (psi gauge +14.696).
P_v = Vapor pressure of Halon 1301, psi absolute (psi gauge +14.696).

Figure A-2 shows the variation of Henry's Law constant, H_x, with temperature.

Filling Density

The filling density of a container is defined as the number of pounds of Halon 1301 per cubic foot of container volume. Isometric diagrams for Halon 1301 superpressurized with nitrogen—Figures A-3 (360 psig total pressure at 70°F) and A-4 (600 psig total pressure at 70°F)—show the relationship of storage container pressure vs. temperature with lines of constant fill density.

These curves demonstrate the danger in overfilling containers with Halon 1301. A container filled completely with liquid Halon 1301 at 70°F (97.79 lbs per cu. ft.) and subsequently superpressurized to 600 psig would develop a pressure of 3000 psig when heated to 130°F; if filled to 70 lb/cu. ft. or less as permitted in this standard, a pressure of 1040 psig would be developed. The same principles apply to liquid Halon 1301 that becomes trapped between two valves in pipelines. Adequate pressure relief should always be provided in such situations.

A-1610. Although Halon Systems are not subjected to continuous pressurization, some provisions should be made to insure that the type of piping installed can withstand the maximum stress at maximum storage temperatures. Maximum allowable stress levels for this condition should be established at values of 90 percent of the minimum yield strength or 50 percent of the minimum tensile strength, whichever is less. All joint factors should be applied after this value is determined. Stress is to be calculated as shown in ANSI-B31.1.0, Section 104.

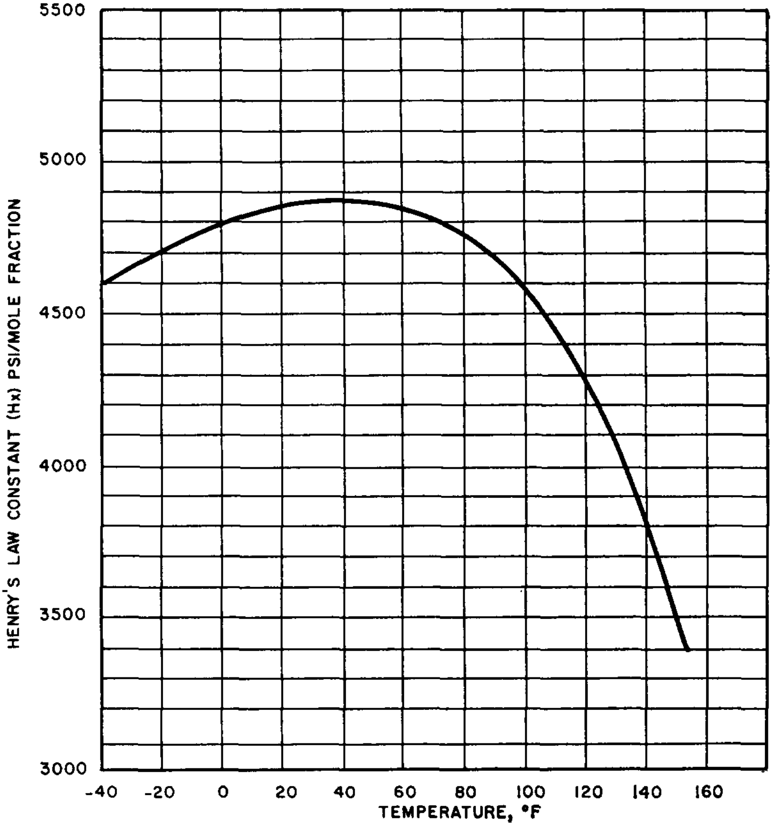

Fig. A-2. Henry's Law Constant for Nitrogen Solubility in Liquid Halon 1301

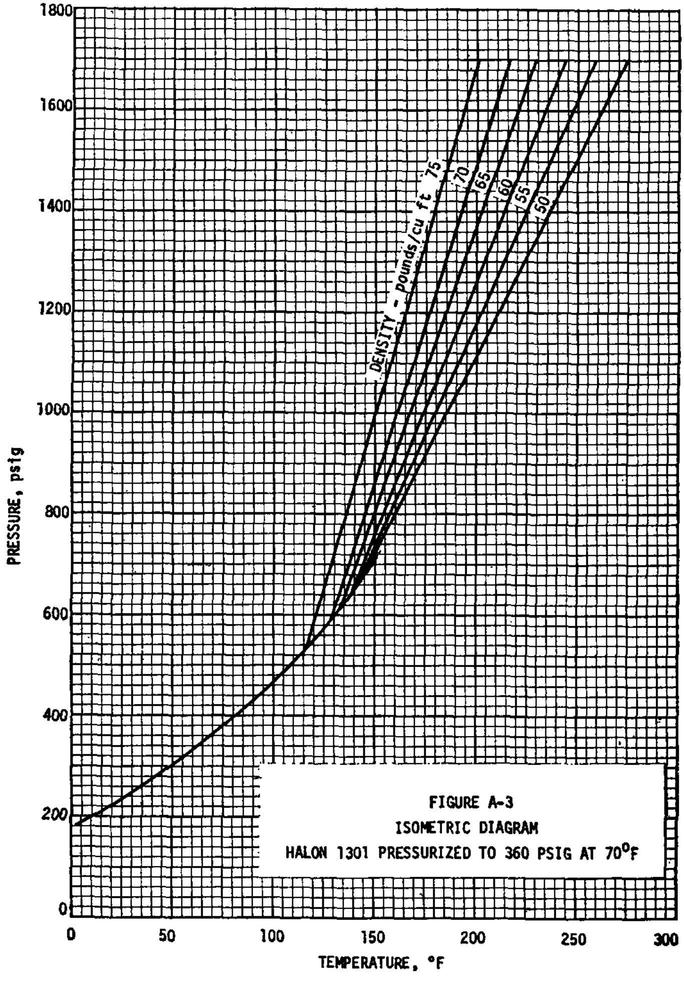

Fig. A–3. Isometric diagram. Halon 1301 pressurized to 360 psig at 70° F.

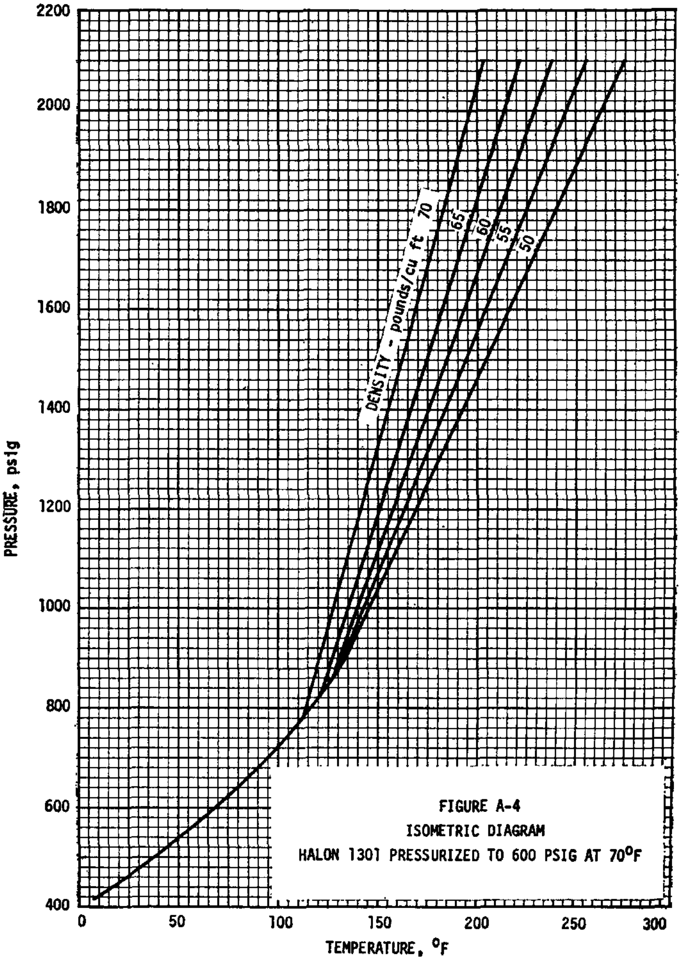

Fig. A–4. Isometric diagram. Halon 1301 pressurized to 600 psig at 70° F.

A–1660. Piping Flow Characteristics.

Piping must be designed to handle the required flow of agent, utilizing the following maximum available pressure drops from storage container to nozzle:

360 psig Storage Pressure: 160 psi.

600 psig Storage Pressure: 400 psi.

Two sources of pressure drop exist:

a. A drop in storage pressure occurs as the liquid Halon 1301 fills the piping system initially. The pressure drop can be estimated from the following formula:

$$\triangle P_2 = \triangle P_1 \left(1 - \frac{V_c - V_s}{V_c + V_s + V_p} \right)$$

where $\triangle P_2$ = pressure drop, psi

$\triangle P_1$ = available pressure drop, psi, based on storage pressure level

= 160 psi for 360 psig storage pressure
= 400 psi for 600 psig storage pressure

V_c = internal volume of vapor space in container, cu. in.

V_s = internal volume of the portion of dip tube above liquid level in container, cu. in.

V_p = internal volume of the external piping and distribution system, cu. in.

Internal volume figures for steel pipe and tubing are given in Tables A-5 and A-6.

b. Friction losses occur as the liquid Halon 1301 flows through the pipeline to the discharge orifice. Allowance must be made for the equivalent lengths of the container valve, dip tube, and flexible connectors, selector valves, time delays, and other installed equipment through which the agent must flow. Equivalent lengths for these components must be obtained from the approval laboratory listings for the individual components. Equivalent lengths of common pipe fittings and valves are given in Tables A-7 and A-8.

Changes in elevation are accounted for by subtracting 0.68 psi for each foot above the storage container (or by adding, if below) from the available pressure drop.

Table A-5 Internal Volume of Steel Pipe

Cubic Inches Per Foot of Length

Nominal Pipe Diameter in.	Schedule 40	Schedule 80
¼	1.244	0.864
⅜	2.298	1.693
½	3.646	2.817
¾	6.411	5.184
1	10.368	8.623
1¼	17.971	15.396
1½	24.433	21.168
2	40.262	35.424

Table A-6 Internal Volume of Tubing

Cubic Inches Per Foot of Length

Actual Inside Diameter inches	Internal Volume cu. in./ft. *
0.20	0.377
0.25	0.589
0.30	0.848
0.35	1.155
0.40	1.508
0.45	1.909
0.50	2.356
0.60	3.393
0.70	4.618
0.80	6.032
0.90	7.634
1.00	9.425
1.25	14.726
1.50	21.206
1.75	28.863
2.00	37.699

* Internal Volume per foot = $9.42477d^2$
where d = actual inside diameter (inches)

Table A-7

Equivalent Length in Feet of Threaded Pipe Fittings
Schedule 40 Steel Pipe

Pipe Size, in.	Elbow Std. 45°	Elbow Std. 90°	Elbow 90° Long Rad. & Tee Thru Flow	Tee Side	Union Coupling or Gate Valve
⅜	0.6	1.3	0.8	2.7	0.3
½	0.8	1.7	1.0	3.4	0.4
¾	1.0	2.2	1.4	4.5	0.5
1	1.3	2.8	1.8	5.7	0.6
1¼	1.7	3.7	2.3	7.5	0.8
1½	2.0	4.3	2.7	8.7	0.9
2	2.6	5.5	3.5	11.2	1.2
2½	3.1	6.6	4.1	13.4	1.4
3	3.8	8.2	5.1	16.6	1.8
4	5.0	10.7	6.7	21.8	2.4
5	6.3	13.4	8.4	27.4	3.0
6	7.6	16.2	10.1	32.8	3.5

Table A-8

Equivalent Length in Feet of Welded Pipe Fittings
Schedule 40 Steel Pipe

Pipe Size, in.	Elbow Std. 45°	Elbow Std. 90°	Elbow 90° Long Rad. & Tee Thru Flow	Tee Side	Gate Valve
⅜	0.2	0.7	0.5	1.6	0.3
½	0.3	0.8	0.7	2.1	0.4
¾	0.4	1.1	0.9	2.8	0.5
1	0.5	1.4	1.1	3.5	0.6
1¼	0.7	1.8	1.5	4.6	0.8
1½	0.8	2.1	1.7	5.4	0.9
2	1.0	2.8	2.2	6.9	1.2
2½	1.2	3.3	2.7	8.2	1.4
3	1.5	4.1	3.3	10.2	1.8
4	2.0	5.4	4.4	13.4	2.4
5	2.5	6.7	5.5	16.8	3.0
6	3.0	8.1	6.6	20.2	3.5

A–1720. Maintenance.

The entire fire extinguishing system should be completely inspected at least annually. More frequent general inspections are recommended. Regular service contracts with the manufacturer or installing company are recommended.

In the annual inspection particular attention should be given to:

1. Detection and Actuation System.
2. Agent Supply.
3. Piping and Nozzles.
4. Auxiliary Equipment.

1. Detection and Actuation System.

A. The detectors should be checked (and cleaned if necessary) to assure that they are free of foreign substances.

B. If the detection system is supervised, the supervisory features should be checked to determine that the detection system is in satisfactory condition. The methods and procedures for this inspection should be in accordance with the manufacturer's recommendations.

C. Automatic actuating controls should be removed from the containers equipped with such controls ("pilot cylinders") and a test made of the detection system by introducing a simulated fire condition at one or more detectors (heat, smoke, etc., as applicable). The actuating controls must move to the "discharged" position.

D. All manual operating devices (pull boxes, manual electric switches, etc.) should be operated with the actuating control removed from the supply containers equipped with such controls ("pilot cylinders"). The actuating control must move to the "discharged" position.

E. All actuating controls must be reset and reinstalled after testing.

2. Agent Supply.

A. All containers shall be weighed to determine the contents of the container. Any container showing a loss of more than 5 percent of the marked net contents shall be refilled or replaced.

B. Containers shall be examined for evidence of corrosion or mechanical damage.

C. When required (see paragraph 1552) the pressure within the container shall be checked against the marked pressure. If the pressure (corrected for temperature) within the container varies more than 10 percent from the marked pressure the container shall be refilled or replaced.

D. Container bracketing, supports, etc., should be checked to determine that their condition is satisfactory.

3. Piping and Nozzles.

A. Piping should be examined for any evidence of corrosion.

B. Pipe hangers and/or straps should be examined to see that the piping is securely supported.

C. Nozzles should be checked to determine that the orifices are clear and unobstructed.

D. Where nozzle seals are provided, they should be checked for signs of deterioration, and replaced if necessary.

E. Nozzles should be checked for proper position and alignment.

4. Auxiliary Equipment.

A. All auxiliary and supplementary components such as switches, door and window releases, interconnected valves, damper releases, supplementary alarms, etc., should be manually operated (where possible) to ensure that they are in proper operating condition.

B. All devices should be returned to normal "standby" condition after testing.

A–2100. General Information on Total Flooding Systems.

From a performance viewpoint, a total flooding system is designed to develop a concentration of Halon 1301 that will extinguish fires in combustible materials located in an enclosed space. It must also maintain an effective concentration until the maximum temperature has been reduced below the reignition point.

The concentration of Halon 1301 required will depend on the type of combustible material involved. This has been determined for many surface-type fires, particularly those involving liquids and gases. For deep-seated fires, the critical concentration required for extinguishment is less definite, and has in general been established by practical test work.

A-2112. For the purposes of this standard, a normally occupied area is defined as an area which is intended for occupancy. Spaces which are occasionally visited by personnel, such as transformer bays, switch-houses, pump rooms, vaults, engine test stands, records centers, magnetic tape storage areas, cable trays and tunnels, microwave relay stations, flammable liquid storage areas, enclosed energy systems, etc., are examples of areas which are considered to be *not* normally occupied.

A–2300. Halon 1301 Requirements for Surface Fires.

Two basic types of extinguishment data have been obtained for Halon 1301:

(1) flame extinguishment data, which determine the agent concentration necessary to extinguish a flame of a particular fuel.

(2) inerting data, which determine the minimum agent concentration to suppress propagation of a flame front at the "flammability peak," or stoichiometric fuel/air composition.

Flame extinguishment data generally relate closest to the concentration actually required in a fire extinguishing system. The measurements are often made with pan fires on a large scale, so that realistic conditions exist. The concentration requirements for large scale fires have been found to be the same as determined from small-scale pan fires in laboratory apparatus, provided the test conditions do not permit a significant amount of oxygen depletion before or during the extinguishment test. Agent concentrations obtained by this type of test are characteristically 20 to 50 percent lower than concentrations required for complete inerting.

In inerting measurements, a fuel/air/agent mixture is contained in a test chamber, such as an explosion burette, and an ignition source is activated. If the mixture cannot support a flame front, the mixture is considered to be nonflammable. The results may be plotted as shown in Figure A-5.

The normal flammability range which exists when no agent is present is shown at the left-hand side of the graph. As Halon 1301 is added to the system, the flammability range is reduced until it finally disappears entirely. The agent concentration at which this occurs is called the "flammability peak" concentration. All fuel-air mixtures containing concentrations of agent equal to or greater than the flammability peak value are nonflammable, hence the term "inert."

The choice between using the flame extinguishing concentration or the inerting concentration for a given fuel depends upon (1) the volatility characteristics of the fuel, (2) the quantity of fuel present, and (3) the conditions of use in the hazard. Applying Halon 1301 at the flame extinguishment concentration to actual fires will effectively extinguish the fire at no sacrifice in the reliability of the system. It is desirable to use this lower concentration when possible because of the following advantages:

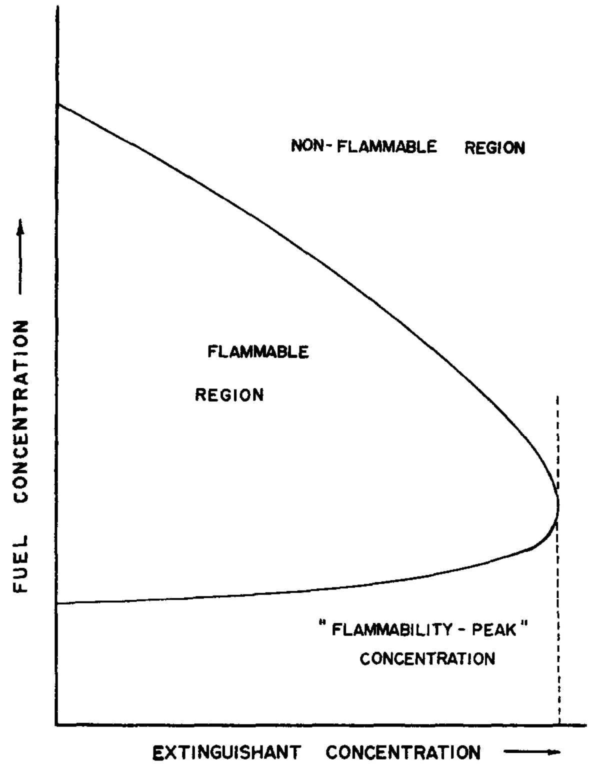

Fig. A–5. Typical flammability-peak presentation.

(1) The cost of the system will be correspondingly lower.

(2) Reduced concentration to which personnel will be (inadvertently) exposed.

(3) The level of decomposition products formed from breakdown in the fire will likely be lower.

The danger in supplying this lower concentration is that at some time after extinguishment, a flammable concentration of fuel, air and agent could possibly be attained through release or vaporization of additional fuel. This is more likely with highly volatile liquid fuels, gaseous fuels, or fuels which are heated to near their flash point, than with high flash point liquids or solid fuels. In addition, stratification of the evolved fuel vapors, the size and possible duration of the fire, and other materials which may become heated