VI Halon Systems

A.1. General

Total flooding halon fire extinguishing systems are appropriate for enclosed spaces where fires involving electrical equipment or gaseous and liquid flammable materials may occur. The extinguishing agents used in these systems are halogen substituted hydrocarbons. Several different halon agents exist with variations in the amounts of carbon, chlorine, bromine, and fluorine in the compound. The accepted nomenclature system for these compounds describes the molecular composition of the agent. Each agent is given a number, the first digit represents the number of carbon atoms, the second fluorine, the third chlorine, the fourth bromine, and the fifth iodine. Terminal zeros are dropped. The three most common halogenated extinguishing agents at present are: Bromochlorodifluoromethane (Halon 1211), Bromotrifluoromethane (1301), and Dibromotetrafluoroethane (Halon 2402). Halon 1301 is the only halogenated agent currently accepted by the Coast Guard for fixed shipboard fire extinguishing systems. Other halons are unacceptable because they are either highly toxic themselves, or they can form unacceptable amounts of toxic products of decomposition when exposed to fire. portable fire extinguishers widely used in the past contained Halon 104 (Carbon Tetrachloride) or Halon 1011 (bromochloromethane). Due to the toxicity of both these agents, their marine use was banned by the Coast Guard in 1958. Currently, both Halon 1301 and Halon 1211 portable extinguishers are available, which carry Coast Guard marine approval.

Halon 1301, even though acceptable for shipboard use, is somewhat toxic; however, if discharged properly, the toxic effects are minimal. Halon 1301 is a colorless, odorless gas which chemically interacts with the combustion process to inhibit combustion. Although it is similar to carbon dioxide in application and storage, its extinguishing action is produced by an entirely different process. Halon 1301 chemically interrupts the process which produces combustion, while carbon dioxide extinguishes flames by displacing the atmosphere to effectively reduce the oxygen content below a point where combustion can occur. Halon 1301 should not be used to protect hazards involving chemicals capable of rapid oxidation in the absence of air, combustible or reactive metals, and metal hydrides. Additionally, the use of Halon 1301 on Class A materials has not been thoroughly researched by the U. S. Coast Guard at present and is therefore not acceptable for the protection of cargo holds when carrying general cargoes.

Halon 1301 systems are designed to limit the production of toxic products of decomposition. If Halon 1301 is heated above 900^0F (482^0C), it breaks down to form hydrogen fluoride, free bromine and carbonyl halides. Full scale tests involving flammable liquid fires, conducted at the Coast Guard Fire and Safety Test Facility have shown that if Halon 1301 is discharged into a burning machinery space in 10 seconds or less, the amount of toxic decomposition products formed are of less consequence than the normal combustion products such as carbon monoxide.

A.2 Coast Guard Approval of Halon 1301 Systems

At present, Title 46 of the Code of Federal Regulations does not contain any provisions for the design or requirements of Halon 1301 systems aboard commercial vessels. In essence, the approval of these systems is based upon a provision within the Code of Federal Regulations that grants to the Commandant of the Coast Guard the authority to allow new or unique systems, if it is adequately demonstrated that the proposed system is equivalent to the existing system required by the regulations. Carbon dioxide total flooding fire protection systems are the systems to which Halon 1301 systems must prove equivalence. Therefore, Coast Guard approved Halon 1301 systems are required by Federal Law to be designed with an equivalent degree of fire protection capability and reliability. Where basic deviations in design occur due to the use of the Halon 1301 agent, specific adaptation to the regulations have been developed.

The basic design philosophy of carbon dioxide systems, however, has been retained for halon systems:

a. The protected space must be evacuated before the system is discharged. Pre-discharge alarm is required.

b. The agent storage containers must be located outside of the protected space, except for spaces less than 6000 ft^3 and modular type halon systems.

c. Two separate and distinct actions must be performed to discharge the agent.

d. Manual type release devices are required; automatic release is permitted only for spaces less than 6000 ft^3.

e. Detailed instructions must be provided at the remote release station to explain alternate means of discharging the system.

A.3 Specific Areas of Concern Involving Halon Agents

1. One feature of halon fire extinguishants that must be kept in mind is the possible hazard they may present to personnel. The agents have a certain degree of inherent toxicity; however, if designed and handled properly, the halon agents and systems present no greater risk than carbon dioxide extinguishing equipment and usually much less. Of the current halon agents, 1301 is considered the only halon fire extinguishant which may be used for total flooding applications onboard vessels. The Coast Guard requires a minimum 6% by gross volume concentration (volume 1301/volume air) of the agent for fire extinguishing Systems. At this concentration, toxic effects are minimal; however, personnel should not be exposed to a 7% concentration for more than one minute and a 10% concentration may well be regarded as unsafe for human exposure.

To adequately protect personnel from these hazards, the Coast Guard requires the protected space to be evacuated before Halon 1301 discharge. Additionally, a warning sign is required at each entrance to the protected space, warning personnel that re-entry of the space, after the system is discharged, should not be attempted without self-contained breathing apparatus.

Toxic products of decomposition are formed when Halon 1301 is exposed to flames. If Halon 1301 is discharged in 10 seconds or less, causing rapid extinguishment of flames, the amount of toxic products formed is of little or no consequence. The amount of these toxic products of decomposition formed can be minimized by discharging the halon system as soon as possible after fire discovery. More halon breakdown will occur if the fire has the opportunity to burn freely and heat the metal structure within the protected space. This would seem to suggest that automatic detection and release of the halon agent would be desirable. In buildings, this concept is viable; however, onboard vessels, automatic release is not practical in all cases. To properly extinguish a fire, operating machinery within the protected space must be shut down prior to agent discharge. If a vessel were navigating in a high density shipping channel, an automatically released fire extinguishing system could shut down the main propulsion plant and ship's service generators when needed most.

An engineering trade-off has therefore been made, requiring for all spaces greater than 6000 ft3, manual release of agent, and evacuation of the protected space to protect personnel from potential toxic products of decomposition of the halon.

2. A second problem that may be encountered with Halon 1301 concerns the protection of diesel engines. If carbon dioxide is injected into a running diesel engine, the engine will stop. This has not been observed with Halon 1301; in fact, the engine may even speed up. It is possible that if a diesel engine were to scavenge Halon 1301, toxic products of decomposition from the Halon 1301 breakdown under the high cylinder pressures within the diesel could be released through the diesel exhaust system. Coast Guard design requirements mandate the automatic shutdown, prior to halon discharge, of all diesel engines which receive intake air from the protected space.

A.4 system Types

The purpose of this guide is to explain the requirements for engineered type Halon 1301 systems. There are two other types of Halon 1301 systems which are reviewed by the Coast Guard. Both of these are approved as pre-engineered type systems. The approval for these systems will indicate factors such as maximum-permissible pipe lengths, number of elbows, etc. These systems are as follows:

Approval Number - 162.035/1/1 - Bromotrifluoromethane Systems for Hydrofoil Craft.

These systems are for limited installation in unmanned spaces up to a maximum volume of 2250 cubic feet.

Approval Numbers - 162.029/1/0
162.029/3/0
162.029/4/0
162.029/7/0
162.029/8/0
162.029/9/0
162.029/10/0

Halon 1301 systems for installation in uninspected pleasure craft.

B.1 General Arrangements

The basic arrangement for Halon 1301 systems is similar to approved carbon dioxide systems. The agent cylinders are manifold together and located outside of the protected space. A releasing control should operate one or two pilot cylinders and a stop valve control must be provided to prevent agent discharge if the pilot cylinders are accidentally tripped. The agent is in turn piped to the protected space and discharged through nozzles. The general arrangements shown in Appendix A are acceptable.

Currently, there are no Halon 1301 systems which resemble low pressure carbon dioxide systems. Several manufacturers, however, are currently vending a "modular" type system, which consists of a number of agent containers mounted in various locations throughout the protected space. The containers are not connected to a manifold, but are arranged to discharge individually. The releasing mechanisms are either electric or pneumatic. The review of these systems is done by Headquarters, because of the complex nature of the system control hardware. A very detailed review is done to insure that control and supervisory circuitry will function in the marine environment. A reliability study is also conducted on most electrical components.

B.2 Halon 1301 Concentration

The extinguishing effectiveness of Halon 1301 is highly dependent upon the concentration of the agent in the protected space. Tests conducted by the Coast Guard have shown that for normal shipboard protection, a 6% concentration of Halon 1301 of the total or gross volume of a machinery or other space can effectively extinguish flammable liquid fires in that space. The amount of agent necessary to form this concentration must be calculated for the lowest range of temperature expected in that space. Basically, this is because the specific volume (ft^3/lb) of Halon 1301 vapor varies with the ambient temperature

A 6% halon design concentration calculated at the lowest ambient temperature expected in the space with no deductions being made for machinery could cause the concentration in the protected space to be as high as 7% - 7.4% under actual conditions because temperatures within most machinery spaces are usually greater than 700F under normal operating conditions.

It is felt that this concentration is justifiable for shipboard halon systems for the following reasons:

1. Evacuation of the protected space is required- Automatic release of machinery space halon systems is not permitted because vital ships navigating and propulsion equipment could be stopped at inopportune times. This may cause higher temperatures to be reached within the protected space before agent release which inturn could form unacceptable amounts of toxic halon decomposition products.

2. A 7% concentration is approximately the inerting concentration required for most marine fuels - According to NFPA Standard l2AD the inerting concentration should be used where large amounts of fuel are available which could be atomized or sprayed from broken fuel lines or fittings.

B.3 Determination of Necessary Quantity of Halon 1301

The minimum design concentration of Halon 1301 for machinery spaces, turbine enclosures, or pump rooms containing diesel fuel, gasoline, or crude oil and other similar petroleum products is 6% of the gross volume of the space. If other flammable or combustible materials are present in the protected space, higher concentrations of halon may be needed.

To calculate the necessary weight of Halon 1301, the volume of the protected space must first be determined. This volume is the gross volume, i.e. no deductions are made for machinery or any other contents.

The gross volume is then multiplied by the mass flooding factor. The mass flooding factor in pounds per cubic foot is calculated from the specific volume of the halon vapor at a given temperature. when the mass flooding factor is multiplied by the volume of space, the result is the quantity of Halon 1301 in pounds necessary to give a 6% concentration. The mass flooding factors are dependent upon the temperature within the protected space. Standard mass flooding factors have been determined for specific areas. These values should always be used unless circumstances require some special consideration. The mass flooding factor for pump rooms is .0289 lb/ft^3 (0^{0}F) and for machinery spaces and turbine enclosures is .0270 lb/ft^3 (32^{0}F).

If unique conditions arise, the necessary quantity of Halon 1301 may be calculated as follows:

$$W = \frac{V}{s} \qquad \frac{C}{100 - C}$$

W = weight of Halon 1301 required, lbs.

C = Halon 1301 Concentration, % by volume

V = Volume of protected space (ft^3)

s = Specific volume of the Halon 1301 vapor. This value is calculated with the following formula:

s = 2.2062 + .005046T
T = Design Temperature, ^{0}F

B.4 Effects of Ventilation

The extinguishing potential of total flooding Halon 1301 Systems depends upon the "tightness" of the Space, and any leakage of agent from the space will reduce this effectiveness. If there are any openings to the space which cannot be completely closed, a discharge test of the system may have to be conducted to ascertain if an extinguishing concentration can be reached and maintained.

In spaces where power ventilation is installed, the ventilation system must be shut down prior to agent discharge, The shutdown of the ventilation must be automatically accomplished by the operation of the halon system releases. Sufficient time for the rundown of the ventilation must also be allowed before the release of halon.

In the event that ventilation cannot be expediently shut down, an additional quantity of agent must be provided to compensate for the effects of ventilation. The following formula should be used to determine the necessary total amount of agent:

$$Q = \frac{0.01CET}{s\left[1 - e^{\frac{-ET}{V}}\right]}$$

Q = Lbs of halon

C = Halon 1301 Concentration % by volume

E = Ventilation rate, ft^3/sec.

T = Time in sec. (10 sec. max.)

V = Volume of protected space, ft^3

S = Specific volume of Halon 1301 vapor, ft^3/lb. (See Section B.3)

e = Natural logarithm base, 2.71828

B.5 Overpressurization of Protected Space

Due to the high speed discharge of the superpressurized Halon 1301, it will almost always vaporize as it leaves the discharge nozzle, resulting in adiabatic cooling of the protected space and causing a temporary pressure drop. This pressure drop has a tendency to counteract the pressure rise expected because of the partial pressure of the added 6% halon concentration. The halon-air mixture will eventually cause a pressure rise, as heat is transferred into it from the surrounding bulkheads and decks, but this pressure rise is gradual and can usually be vented through any available small openings.

B.6 Agent Storage Containers

Halon 1301 is stored in metal containers in liquid form, and is superpressurized with dry nitrogen to one of two pressures (at 70^0F): 360 or 600 psig. The quantity of Halon 1301 that is stored in each container varies among manufacturers and generally ranges up to a maximum of 250 lbs.

All containers on a common manifold must be of the same size and must contain the same quantity of Halon 1301 to insure an equal rate of flow into the manifold from each container. Manifolded cylinders must be secured with a substantial mounting bracket to prevent damage.

Cylinders should be located as near to the protected space as possible, and the following criteria must also be met:

1. The cylinders must be located outside of the protected space, except for spaces less than 6000 ft^3.

2. The temperature range the cylinders may be exposed to is between 130^0F and -20^0F. Spaces containing Halon 1301 cylinders must be ventilated or heated to maintain the ambient temperature within these limits.

3. Halon 1301 cylinders are fitted with an overpressure relief device (normally a frangible disc) which will allow the relief of excessive pressure within the cylinder. If the cylinders are located adjacent to the protected space, enough heat may be conducted through bulkheads or decks to rupture the overpressure disc. Should this occur, the halon storage room would be filled with agent, and very little, if any, would be available to extinguish the fire. Therefore, common bulkheads and decks between halon storage rooms and protected spaces must be constructed to A-60 class.

B.7 Controls

The releasing mechanisms for halon systems are similar to those used for CO_2 systems. The usual type of mechanical releases are cables. The pull handles of these cables should not require a pull of more than 40 pounds nor a movement of greater than 14 inches to release the contents of the halon containers. Also, the cables as well as the remainder of the releasing mechanism must be protected from the weather. Pneumatic releases are also acceptable on certain systems.

Instructions explaining the system operation and containing a schematic diagram of the piping layout should be posted at each pull box or stop valve control, and in the halon storage room. The instructions should be as follows:

1. The instructions should give specific locations and instructions of where system components are located in relation to where the person attempting to operate system is standing.

2. The instructions should also be easy to comprehend in a brief period of time.

3. At each pull box, two sets of instructions should be posted. The first set of instructions should state in some form --- In case of fire in (protected Space) operate extinguishing system by pulling lever, operating valve, etc. --. The second set of instructions should state in some form ---If the extinguishing system fails to operate, go to (some specified location) and follow instructions posted there ---. A map or plan should be included with this instruction, showing the operator exactly where he must go to find the secondary release.

4. The instructions should be printed in letters large enough to be read from a distance of several feet.

5. In the cylinder st3rage room, a general schematic of the entire system should be posted showing the various sections of the system. To facilitate rapid comprehension of the arrangement, each section should be numbered, color coded, or named. Each pilot valve and stop valve should in turn be numbered, named, or color coded. An instruction list should be posted with a heading stating in some terms --- Alternate means of operating fire extinguishing system in case of failure of remote release devices Each protected space should be listed with appropriate instructions for each space, e.g.

   Boiler Room: operate blue stop valves (3) and blue cylinder valves (2)

   Cargo hold #3: operate stop valve number seven and release 14 CO_2 cylinders.

   These instructions should state which valves to operate and how many should be operated. If stop valves are located remote from the cylinder storage room, the instructions should also explain where to find the valve.

6. The instructions should be securely mounted and should be permanently inscribed on metal or plastic plates. Temporary paper instructions which are sealed in plastic may be posted until inscribed instructions can be fabricated.

These guidelines are general in nature, exact wordings and descriptions on nameplates are left up to the manufacturer.

A remote release and control for appropriate stop valves or direction valves must be located as near as possible to at least one exit of the protected space.

B.8 Warning Devices

Alarms which depend on no source of power other than pressure must be installed to signal the impending discharge of the Halon 1301 system. These devices are arranged to sound an alarm when the system release is operated but prior to agent discharge. A discharge delay mechanism must be installed in the halon piping to allow an escape period after the discharge alarm begins sounding. The alarm must be audible throughout the entire protected space while machinery is running. A sign must be posted immediately adjacent to the alarm explaining its purpose.

A warning must be posted at each entrance to the protected space warning personnel not to enter the space without self-contained breathing apparatus after the halon system has been discharged.

B.9 Hydraulic Calculations of Agent Flow

The flow of Halon 1301 through piping requires careful evaluation. Because both liquid and gaseous halon are flowing simultaneously, a condition of two-phase flow can exist. Unlike the calculation of carbon dioxide flow, the calculation of halon flow is very critical.

All Halon 1301 systems should be balanced, i.e., all branches should be roughly of equal length and similar flow rates. This is particularly important if the system is designed to discharge simultaneously into several spaces. when splitting the halon flow at tees, an exact determination of how much agent flows in each direction cannot be guaranteed through unbalanced branches. If a tee and unbalanced piping is used to divide the halon flow into two separate spaces, it is possible to have an insufficient concentration in one of the spaces.

For all submittals, the percent of agent in piping should be evaluated. This is the ratio of the internal volume of the entire discharge piping network to the volume of the Halon 1301 in the storage containers. If the percent of the agent in piping ratio exceeds 100%, there will not be a sufficient amount of agent to completely fill the piping during discharge. The accuracy of flow calculations depends upon having the discharge piping completely filled with agent. If the ratio exceeds 125%, a discharge test should be conducted to evaluate the performance of the system.

Example #1

A tank vessel has a pump room with a volume of 130,000 cubic feet and which is normally unmanned. The installed ventilation system operates at the rate of one complete air change per minute and when shut down, requires an approximate rundown time of 35 seconds. Good engineering practice would suggest that one would design the system to shut down the ventilation with the actuation of the system, and by means of the time delay prevent the discharge of the agent into the hazard area until the ventilation has completely run down. However, for the purposes of illustration of the calculation technique, the time delay is designed for 25 seconds, with the ventilation system operating at full capacity during the 10 seconds of agent discharge.

Under the above conditions, the Halon 1301 quantity required to produce a 6% concentration at 0^{0}F (Section B.3 for pump rooms) at the end of a discharge -.period of 10 seconds with a ventilation rate of 130,000 cubic feet/minute is calculated using the formula in section B.4:

$$Q = \frac{0.01CET}{s\left[1 - e^{\frac{-ET}{V}}\right]}$$

At 0^0F., $s = 2.2062 + 0.005046(T) = 2.2062\ \frac{ft^3}{lb}$

$$E = 130{,}000\ \frac{ft^3}{\min} = 2166.6\ \frac{ft^3}{\sec}$$

T = 10 seconds

$$Q = \frac{0.01(6)\left(2166.6\frac{ft^3}{\sec}\right)(10dec)}{2.2062\frac{ft^3}{lb}\left[1 - e^{\frac{-2166.6(10)}{130,000}}\right]} = \frac{1299.9}{2.2062 \times (0.1535)} = 3838 pounds$$

Example #2

A system is to be installed in a floating nuclear power plant located off the coast of Key West, Florida. The temperature in the protected space will not normally drop below 70^0F. Determine the required quantity of halon needed to protect a volume of 37,000 ft^3.

$$W = \frac{V}{S}\left[\frac{C}{100 - C}\right]$$

where $S = 2.2062 + .005046T$

$T = 70^0F$

$S = 2.2062 + .35322$

$S = 2.55942\ ft^3/lb$

$$W = \frac{37{,}000 ft^3}{2.55942}\ \frac{6\%}{100 - 6\%} = 923 lb$$

C.1 Review of Systems

The following information is required for the complete review of a Halon 1301 submittal:

a. General schematic of system and description of space~to be protected.

b. Piping and fitting schedule.

c. Drawings of components to include:

i. Storage containers and DOT rating

ii. Discharge heads

iii. Release mechanisms

iv. Any detection system parts

v. Nozzles

vi. Alarms

vii. Valving

viii. Warning and instruction signs

ix. Any other component part (e.g. ventilation shutdown, time delay, etc.)

d. Calculations verifying the following:

i. Design concentration 6 percent at lowest possible temperatures anticipated within the protected areas.

ii. Hydraulic calculations to demonstrate discharge within 10 seconds at ambient temperature not to exceed 70^0F.

e. System manual containing:

j. Operation instructions

ii. Maintenance instructions

To eliminate a complex review for each system submitted, a standard parts list will be developed by Headquarters. This will eliminate the need for the vendors to submit component drawings with each system. The standard review procedure will be to check, first of all, the appropriateness of the system for the protected space, then the design temperature, Halon 1301 concentration and quantity. The hydraulics of the system should be checked with the procedures outlined in NFPA standard 12A. Each of the part numbers should be checked to see if they are listed on the standard parts list. Should any problems arise, they may-be referred to Headquarters.

D.1 Design and Review of System

1. Check protected space and determine if total flooding Halon 1301 system is correct application. Halon should not be used to protect Class A materials.

2. Check volume of protected space. If volume exceeds 6000 ft^3, automatic release is not permitted.

3. Check boundaries of protected space to ascertain if the halon concentration can be maintained. Note if ventilation systems can be shut down prior to agent release.

4. Determine quantity of Halon 1301 needed. Extra halon must be supplied to compensate for unclosable vent openings or operating ventilation systems. Check if quantity of Halon 1301 supplied is sufficient.

5. Divide quantity of halon in-pounds by 10 seconds to get required flow rate in lb./sec. Check the sum of flow rates of nozzles to determine if provided system has an adequate flow rate.

6. Check cylinder location. Cylinders must be located externally to protected space except for automatic systems and certain specially approved systems. Cylinder storage room must have temperatures between -20^{0}F and 130^{0}F. Automatically released systems may have cylinders within protected space.

7. Cylinders must be securely mounted, and must be removable for weighing. Each cylinder must have a pressure gage. If cylinders are mounted adjacent to protected space, common bulkhead or deck must be A-60.

8. A pressure relief device must be installed in each cylinder, and the manifold.

9. Check nozzle arrangement to determine if uniform distribution is provided.

10. Piping must be schedule 40 or heavier, and must be galvanized. Piping must extend 2 inches beyond the last nozzle of each branch line to prevent clogging. Pipe exceeding 4 inches in diameter must be schedule.60. Fittings must be 300 lb class malleable iron or other acceptable as listed in 46 CFR Parts 50 to 63.

11. Check piping supports to determine that piping is securely fastened. Aluminum piping supports are unacceptable.

12. Check manual release devices. Two distinct and separate actions should be required to operate the system. A schematic diagram of the system and a procedure for discharging the system if the remote release devices are non-functioning should be posted by each release Station.

13. Check ventilation and other operating machinery in protected space. Devices must be provided in the Halon 1301 system to shut down ventilation before agent release. Diesel engines which intake air from the protected space must be shut down automatically prior to agent release.

14. Check to determine if discharge delay allows adequate time to evacuate protected space before agent is released. The pre-discharge alarm must be loud enough to be heard in the protected space while machinery is running.

15. Check component part numbers with the Coast Guard approved parts list.

16. Check hydraulic calculations according to NFPA Standard 12A. Certain manufacturers use different methods to compute flow. A deviation of 15% of the required nozzle pressures is acceptable.

17. Determine percent of agent in piping. This should not exceed 125%.

D.2 Halon 13Q1 Systems Inspection Procedures

1. The weight of each cylinder must be checked. If a weight loss of more than 5 percent is noted, the cylinder must be replaced or recharged.

2. The pressure of each cylinder must be checked. If a pressure drop (adjusted to temperature) of more than 10 percent is recorded, the cylinder must be replaced or recharged. Cylinder pressures will vary with temperature; the following chart is provided as a guide:

	360 psi system	600 psi system
Temperature	Pressure	Pressure
40°F	275 psig	500 psig
50°F	300 psig	530 psig
60°F	330 psig	565 psig
70°F	360 psig	600 psig
80°F	395 psig	640 psig
90°F	430 psig	680 psig
100°F	470 psig	730 psig

3. Predischarge alarm must be checked and operated with dry air or nitrogen if necessary. The alarm should be audible throughout the space with machinery operating.

4. Remote release mechanisms must be checked to insure that cables and pulleys are free to move and that the mechanism operates properly.

5. Switches for automatic shutdown of equipment must be checked and tested if necessary.

6. Check to see if all openings to the space can be completely closed.

7. Legible operating instructions detailing release and alternate method of release must be posted at each entrance to the protected space.

8. Visually check all piping for breaks, corrosion, obstructions, etc. If necessary, blow out piping with pressurized air.

9. Check all mounting brackets for proper support.

10. Check date of last hydrostatic test; cylinders must by hydrostatically tested every 12 years.

D.3. Installation Test Requirements

1. Halon 1301 piping systems should be tested as outlined in 46 CFR 76.15-15 (J). The test pressures used shall be equal to one and one half times the design pressure of the system.

REFERENCES

(1) "An Investigation into the effectiveness of Halon 1301 (Bromotrifluoromethane CBrF) as an extinguishing agent for Shipboard Machinery Space Fires." D.F. Sheehan, March 1972, U.S. Coast Guard, Office of Research and Development.

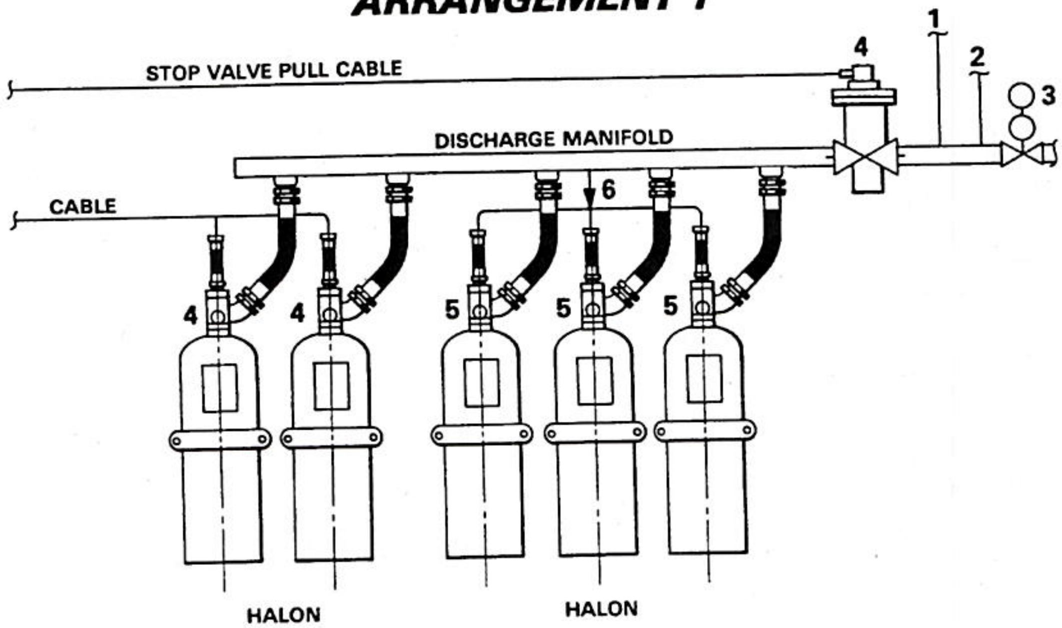
(2) N.F.P.A. Standard *12A

Approved General Arrangements for Halon 1301 Systems

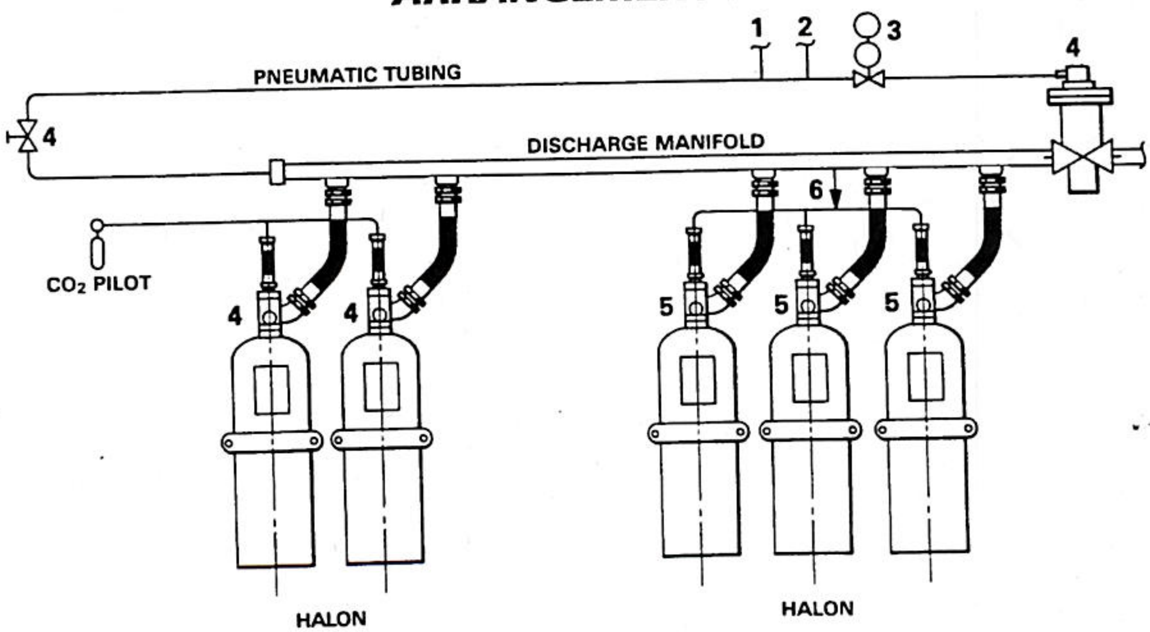
KEY

1. TO PRESSURE OPERATED ALARM.
2. TO PRESSURE OPERATED SWITCHES.
3. TIME DELAY.
4. VALVE CAPABLE OF MANUAL OPERATION.
5. PRESSURE OPERATED VALVE. NO MEANS OF MANUAL OPERATION.
6. CHECK VALVE.

ARRANGEMENT 1



ARRANGEMENT 2



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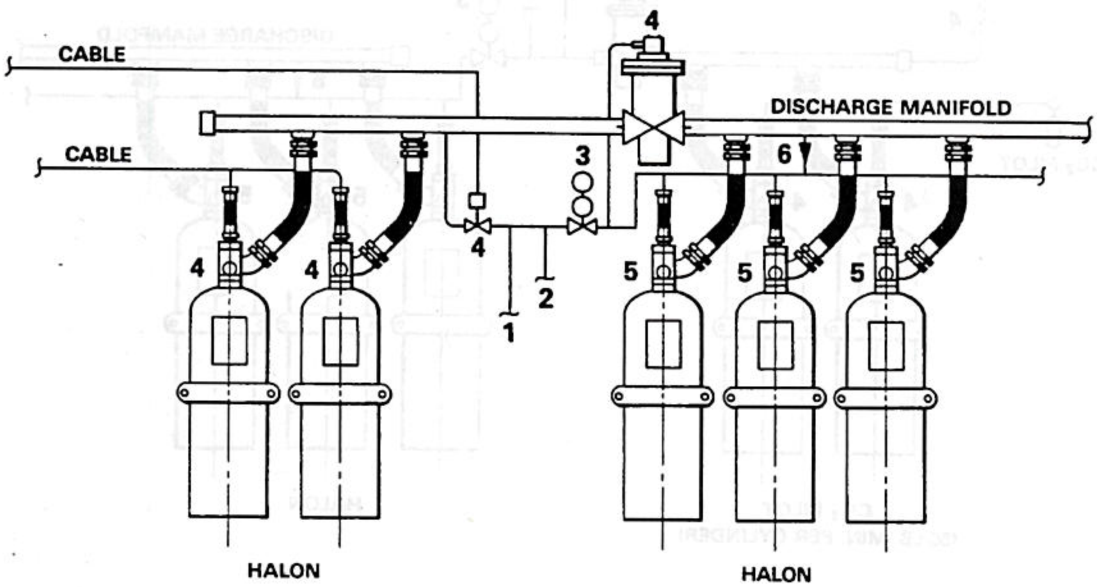
ARRANGEMENT 3



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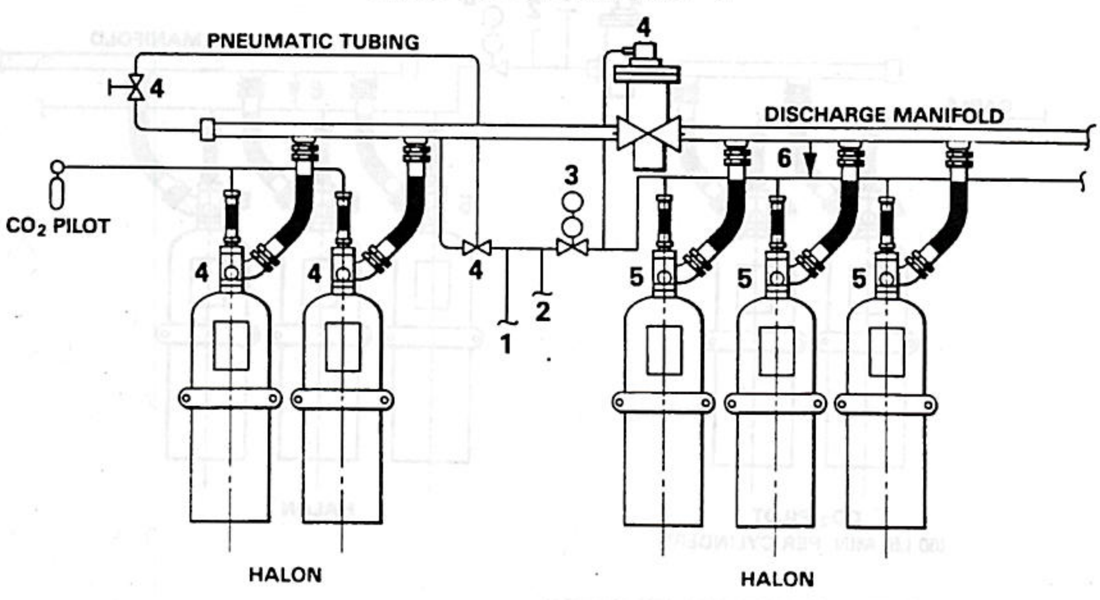

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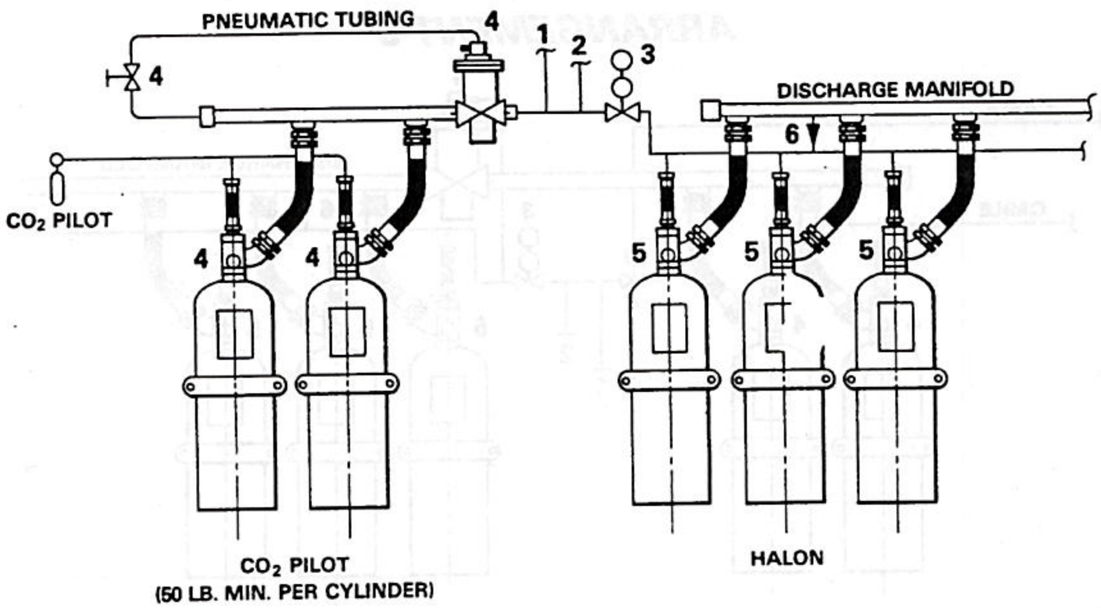
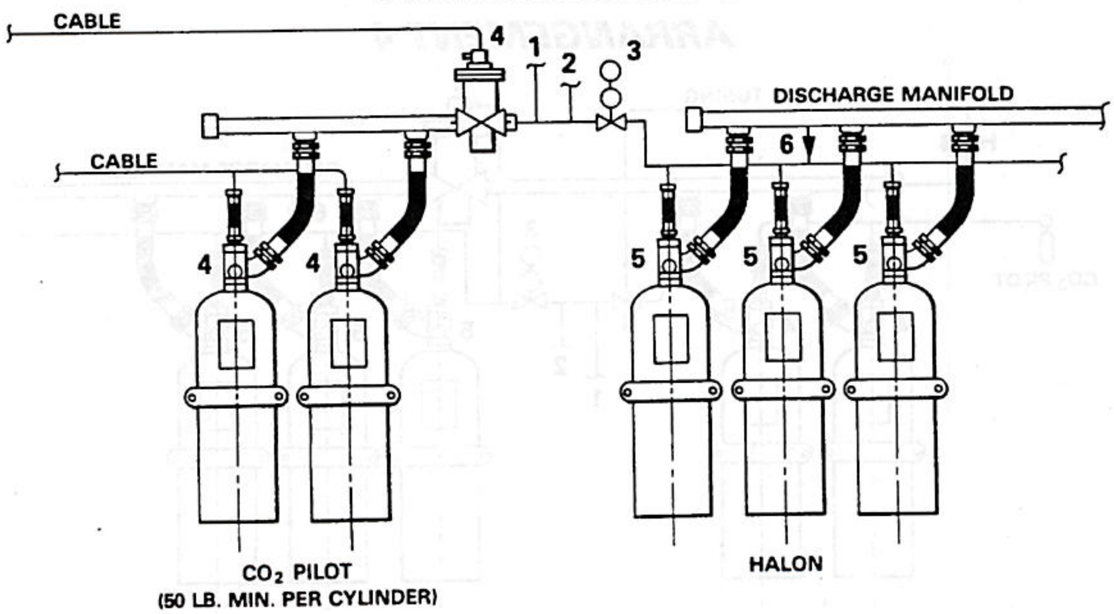
ARRANGEMENT 5



ARRANGEMENT 6



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