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AIRCRAFT FIRE SENTRY

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This report documents the investigation and development of a portable fire detection and suppression system for grounded military cargo aircraft. Several commercially available systems were investigated and rejected in favor of the developed system. This system was tested against a live fire in a C-131 aircraft. Results of this testing revealed that the developed system represented an effective and inexpensive method of providing fire protection to grounded aircraft. A draft purchase description was developed to assist in system procurement. Keywords.

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PREFACE

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This report has been reviewed by the Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

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CONVERSION FACTORS FOR U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

To convert from	To	Multiply by
angstrom	meters (m)	1.000 000 x E -10
atmosphere (normal)	kilo pascal (kPa)	1.013 25 x E +2
degree Celsius	degree kelvin (K)	$t_K = t°_C + 273.15$
degree (angle)	radian (rad)	1.745 329 x E -2
degree Fahrenheit	degree kelvin (K)	$t_K = (t°_F + 459.67)/1.8$
foot	meter (m)	3.048 000 x E -1
gallon (U.S. liquid)	$meter^3$ (m^3)	3.785 412 x E -3
inch	meter (m)	2.540 000 x E -2
micron	meter (m)	1.000 000 x E -6
mil	meter (m)	2.540 000 x E -5
pound-force (lbf avoirdupois)	newton (N)	4.448 222
pound-force/$inch^2$ (psi)	kilo pascal (kPa)	6.894 757
pound-mass/$foot^3$	kilogram/$meter^3$ (kg/m^3)	1.601 846 x E +1

1G = 980665 m/s^2

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SECTION I
INTRODUCTION

A. OBJECTIVE

This report summarizes work accomplished for the Air Force Engineering and Services Center in the development of a fire detection and suppression system for use with parked military cargo aircraft. Operational requirements developed for the system include the following:

1. If a fire occurs, the system must notify ground personnel and the base fire department.

2. The suppression system must be effective against Class A, B, and C fires aboard military cargo aircraft. Class D fires need not be considered.

3. The system must not interfere with the normal activities that take place in and around the aircraft.

4. The maintenance requirements of the system must be minimal.

5. The fire protection system must be easy to install. A labor-intensive system is not acceptable.

6. The fire protection system must be designed so that a single unit can be used with a number of different aircraft without significant alteration.

7. The system must be portable.

B. BACKGROUND

The United States Air Force (USAF) has a large investment in cargo aircraft such as the C-5, C-141, and C-130. When these aircraft are serviced, the aircraft interior has no automatic fire protection. Only hand-held and flight line extinguishers are available. By the time an internal aircraft fire is noticed, it is often out of control and is almost always disastrous.

Internal aircraft fires are difficult to arrest because the aircraft skin contains the heat, resulting in a fire which grows rapidly. Additionally, an internal fire heats the metal components within the aircraft to high temperatures, which facilitates reignition of an extinguished fire. Internal aircraft fires become virtually impossible to contain when an onboard oxygen line burns through. The fire can then become explosive.

C. HISTORY OF FIRES IN AIRCRAFT

A number of fires have occurred aboard parked cargo aircraft. A search of an Air Force data file revealed four accidents resulting in major aircraft losses between 1978 and 1985. A summary of these accidents follows.

1. EC-135P

On 3 January 1980 an EC-135P at Langley AFB, VA, was being readied for a mission. Part of this procedure involved heating a water supply aboard the aircraft. A ground-based power supply was connected to the aircraft for this purpose. The water heating continued for several hours until it was noticed that the circuit breaker on the power supply had tripped. Attempts to reset the power supply failed. Shortly thereafter, flames were noticed coming from the top of the aircraft. Approximately 2 1/2 hours later the fire was extinguished. The loss sustained was over $6.7 million. The fire could not be brought under control sooner because the aircraft could not be entered by firemen. Also, by the time the fire was noticed, it was well developed.

If an automatic fire detection and suppression system had been installed aboard this aircraft, the fire would have been detected at an incipient stage, and the plane could have been saved.

2. C-141B

This fire resulted in the total destruction of a C-141B aircraft with associated damage to the concrete parking ramp and a ground power unit.

Approximately 4 hours before the aircraft's scheduled departure, and 2 hours before the scheduled arrival of the crash fire rescue team, three aircrew members arrived at the aircraft to conduct a tour and to clean the cargo compartment. During the tour an explosion occurred, followed by an intense fire. The aircrew and visitors exited the aircraft without injury. It was determined that available personnel were not capable of combating the fire. The fire spread and engulfed the left inboard fuel tanks, which exploded and involved the rest of the aircraft.

This fire resulted from the catastrophic failure of some hydraulic end caps which had developed fatigue cracks. Just after the cargo doors were closed the top end cap of the forward hydraulic accumulator failed. Fluid-bearing lines and energized wires were damaged in the hydraulic failure. The flammable hydraulic fluids were subsequently ignited by the exposed wires, and a fire resulted. The fire spread and engulfed the aircraft.

An automatic fire protection system which could have detected the fire at its initiation and automatically applied a fire suppression agent would have been effective in combating this fire. The aircraft was lost because the fire could not be attacked in its early stages. The fire continued unchecked until it was no longer possible to save the aircraft.

3. B-52D--Number 1

This mishap occurred during the servicing of a liquid oxygen converter aboard a B-52D aircraft. During the operation, an airman at a nearby aircraft noticed smoke coming from the entrance hatch of the B-52. After confirmation of a fire, servicing of the converter was terminated and the fire department was notified. Within minutes, the fire department arrived and extinguished the fire.

The fire resulted from a fuel leak, a gaseous oxygen leak, and an undetermined ignition source. Considerable water and foam damage was sustained by the Electronic Warfare Officer (EWO) compartment. It was determined that the aircraft was damaged beyond economical repair. The damage from this mishap could have been significantly reduced if an automatic fire detection and suppression system had been installed aboard the aircraft.

4. B-52D--Number 2

The nose section of a B-52D aircraft was extensively damaged when a fire occurred in the forward cockpit area. Electrical maintenance was being performed on the left side panel lighting system at the time of the fire. During the troubleshooting operation, an oxygen leak developed in close proximity to an electrical fault. When power was applied, the circuit faulted in the oxygen-enriched atmosphere and ignited the wiring insulation. The ensuing fire burned through oxygen lines which further intensified the fire. Severe damage was sustained to the pilot, copilot, and EWO stations of the forward crew compartment. A hole was burned through the skin below the pilot's window and through the floor of the aircraft.

An automatic fire detection and suppression system could have minimized the damage sustained by the aircraft in this fire. Although it is difficult to extinguish an oxygen-fed fire, a suppression system would have slowed the fire's growth, and a detection system could have automatically called the fire department and alerted personnel in the area to shut down electrical power.

D. SUMMARY

The circumstances surrounding each of the fires were unique; however, two similarities linked the incidents. First, each involved pure oxygen at some point in the fire's development. Oxygen was not specifically stated as being a contributing factor in Case 2; however, oxygen was known to have been aboard the aircraft. Second, three of the four fires resulted from an electrical fault.

The extinguishment of electrical and oxygen-rich fires requires rapid intervention by the fire department and local personnel. An automatic fire detection and suppression system capable of temporarily extinguishing an internal aircraft fire, and alerting the fire department and ground personnel would have minimized the losses.

SECTION II
FIRE PROTECTION SYSTEMS INVESTIGATED

A. FIREPAC 360 SYSTEM

The FIREPAC 360 system developed by FENWAL, Inc., is a completely portable and self-contained Halon 1301 fire protection system used to provide temporary fire protection for volumes ranging from 1500-2250 ft^3. Up to eight FIREPAC units can be interconnected through an umbilical cord to protect larger areas. An optional alarm station can be obtained to monitor one or more FIREPAC units. This alarm station provides an audible and visual alarm in the event of a fire, power to recharge the nickel cadmium battery pack in each FIREPAC unit, and an interconnection to the facility alarm system.

The standard FIREPAC unit weighs between 80 and 95 pounds, depending on the amount of Halon 1301 used. Installation simply requires placing the unit in position, raising a mast supporting the system's detectors, and turning the power on. Connecting the unit to another unit or to the alarm station is accomplished with umbilical cords having standard aircraft-type connectors (Reference 1).

The complete system resembles a suitcase with a telescoping mast in the middle. The system detection mechanisms are located on top of the mast. These include two DETECT-A-FIRE thermal detectors for both prealarm (140 °F set point) and agent release (190 °F set point). An optional ionization smoke detector warns of smoke but does not discharge the system. The telescoping pole can extend up to 17 feet above the base unit.

When the Halon 1301 is released from the FIREPAC unit, it travels through the telescoping pole and out a spreader head. The height of the spreader head is adjustable from 2-11 feet. The head consists of a hollow ball with a number of holes in it. This system is shown in Figure 1.

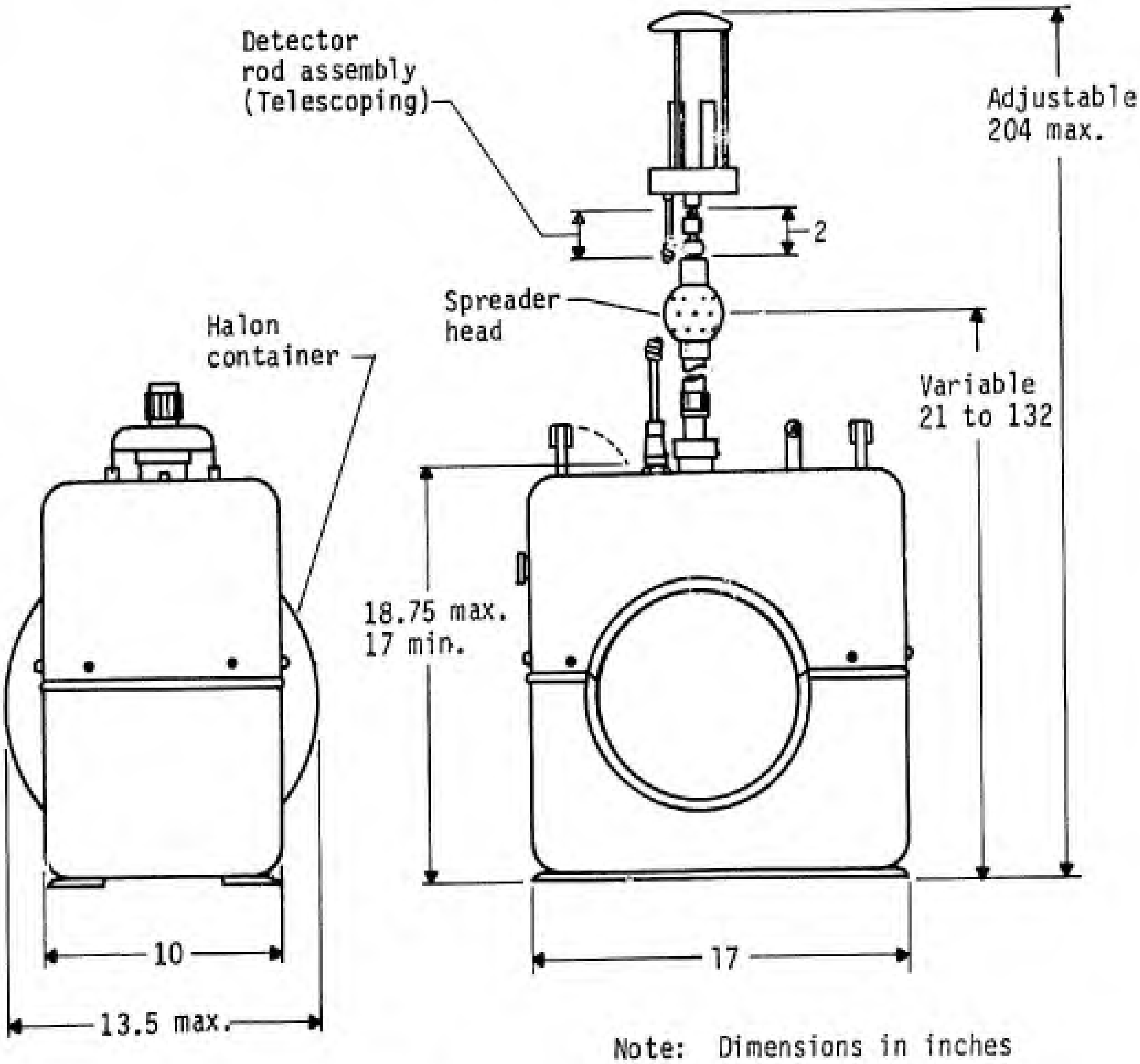


Figure 1. FENWAL FIREPAC 360.

The FIREPAC was developed for an aircraft manufacturer in response to a fire which resulted in the loss of an aircraft just before delivery. After development, several aircraft manufacturers purchased and used the system. However, according to FENWAL and aircraft manufacturers, the FIREPAC is no longer being used or manufactured. The most common problem with the FIREPAC was that the unit obstructed personnel working inside the aircraft. The units were often moved to one area inside the aircraft instead of spread throughout the aircraft interior, or were not installed at all.

The FIREPAC meets several of the desired objectives. The system appears to require little maintenance, is portable, and provides remote notification to the fire department. However, the system appears to be cumbersome and restricts normal activities inside the aircraft. Additionally, the umbilical cords connecting each of the units could become a trip hazard. Consequently, the FIREPAC does not adequately meet established criteria for an interior aircraft fire protection system.

B. WALTER KIDDE/BOEING SYSTEM

A major aircraft line of Boeing Commercial Airplane Company is the Boeing 737-300. Until recently, these aircraft have had no internal fire protection during their manufacture. Early in 1985, Boeing asked Walter Kidde to develop a fire detection and suppression system for the Boeing 737-300 assembly line. After a year of development work, Kidde presented and tested a system which would:

1. Respond only to a real fire,
2. Alert personnel in the event of a smoldering fire, but not attempt to suppress it,
3. Provide an inert atmosphere throughout the aircraft for a period of 10 minutes in the event of a discharge,
4. Use a suppression agent safe for personnel exposure, and
5. Be installed in the aircraft when the wings are put on and removed when construction is complete.

The Kidde system uses multiple stationary supply tanks of Halon 1301 and a control panel. The tanks and control panel are permanently located at given stations in the manufacturing process. Stands, or "christmas trees," are mounted on the floor of each aircraft and support the fire detection devices and the dispensing nozzles for the halon. A christmas tree is stationed in each cargo bay, in the cockpit, and at two locations in the passenger area. The christmas trees are connected to the halon supply and the control panel by several umbilical cords run through open passenger and cargo doors.

The fire detection devices used by this system include both ionization and photoelectric smoke detectors. A warning alarm requires that both of these detectors go into an alarm mode. The combination of ionization and photoelectric smoke detectors was used because these were sensitive to different types of false-alarm stimuli and would minimize the frequency of false alarms.

Activation of the smoke detectors is not sufficient to cause the fire suppression system to discharge in the aircraft. Agent discharge occurs only when a Detector Electronics UV/IR flame detector goes into an alarm mode. It is highly unlikely that these detectors will false-alarm if they are operating properly and have been adjusted for the environment in which they will be used. The UV/IR flame detector was selected because of its reliability and high programmability. A schematic depicting this system is shown in Figure 2 (Reference 2).

The maintenance this system would require is thought to be minimal. Tests performed at the Boeing facility suggest that the system would be effective against fire. The system is relatively easy to install in an aircraft, given that aircraft are always parked in the same locations.

Three features of the Kidde system do not meet the specified objectives:

1. The system requires that an umbilical cord run from the christmas trees inside the aircraft to the control panel and halon supply outside the aircraft through an open door or window. This is not an acceptable storage configuration for military aircraft.

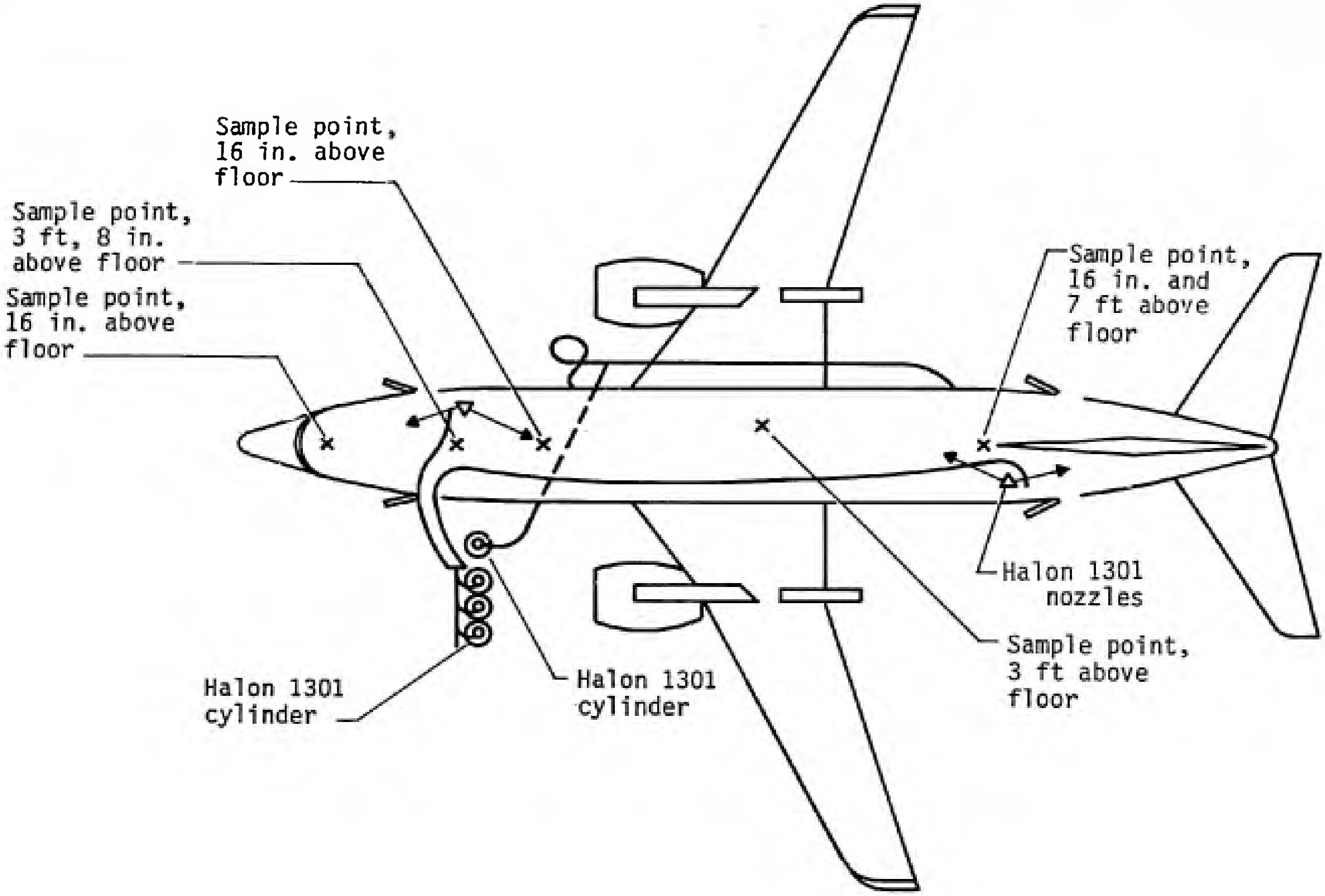


Figure 2. Walter Kidde/Boeing 737-300 System--Aircraft.

2. When the system is installed in an aircraft, the umbilical cords and christmas trees create obstacles which interfere with normal operations taking place inside the aircraft.

3. The system is not portable.

C. PORTABLE CARGO FIRE SUPPRESSION SYSTEM

A portable version of the Kidde system called the Portable Cargo Fire Suppression (PCFS) system was proposed for this project. The proposed PCFS system would have had a high-pressure hose suspended from the ceiling of an aircraft during nonflight maintenance activities. Dual ionization/ photoelectric-type smoke detectors would have been attached to this hose at 10- to 20-foot intervals. At similar intervals, electrically actuated nozzles were to be embedded in the hose. Both the detectors and the nozzles would be electrically tied to a control panel outside the aircraft. The hose would terminate at a manifold attached to a 150-pound Halon 1211 flight line fire extinguisher.

When one of the detectors detected a fire, two audio alarms would sound--one inside and one outside the aircraft. After a delay period, a metron-actuated blow-out disk on the extinguisher would rupture, and one or two nozzles in the vicinity of the alarmed detector would open. The halon would be released through the activated nozzles in the general vicinity of the fire producing a high rate of agent application in the area where it was needed most. Upon system activation, a radio attached to the control panel would transmit a coded signal to a receiver located at the fire station.

A handline identical to that on a 150-pound Halon 1211 flight line extinguishers would also be present with the PCFS system. If this handline were used, the base fire department would be notified by the system's radio. A drawing of the proposed system is shown in Figure 3.

The proposed system was not viewed as an acceptable solution to the problem for three reasons:

1. Installation of the system is labor-intensive.

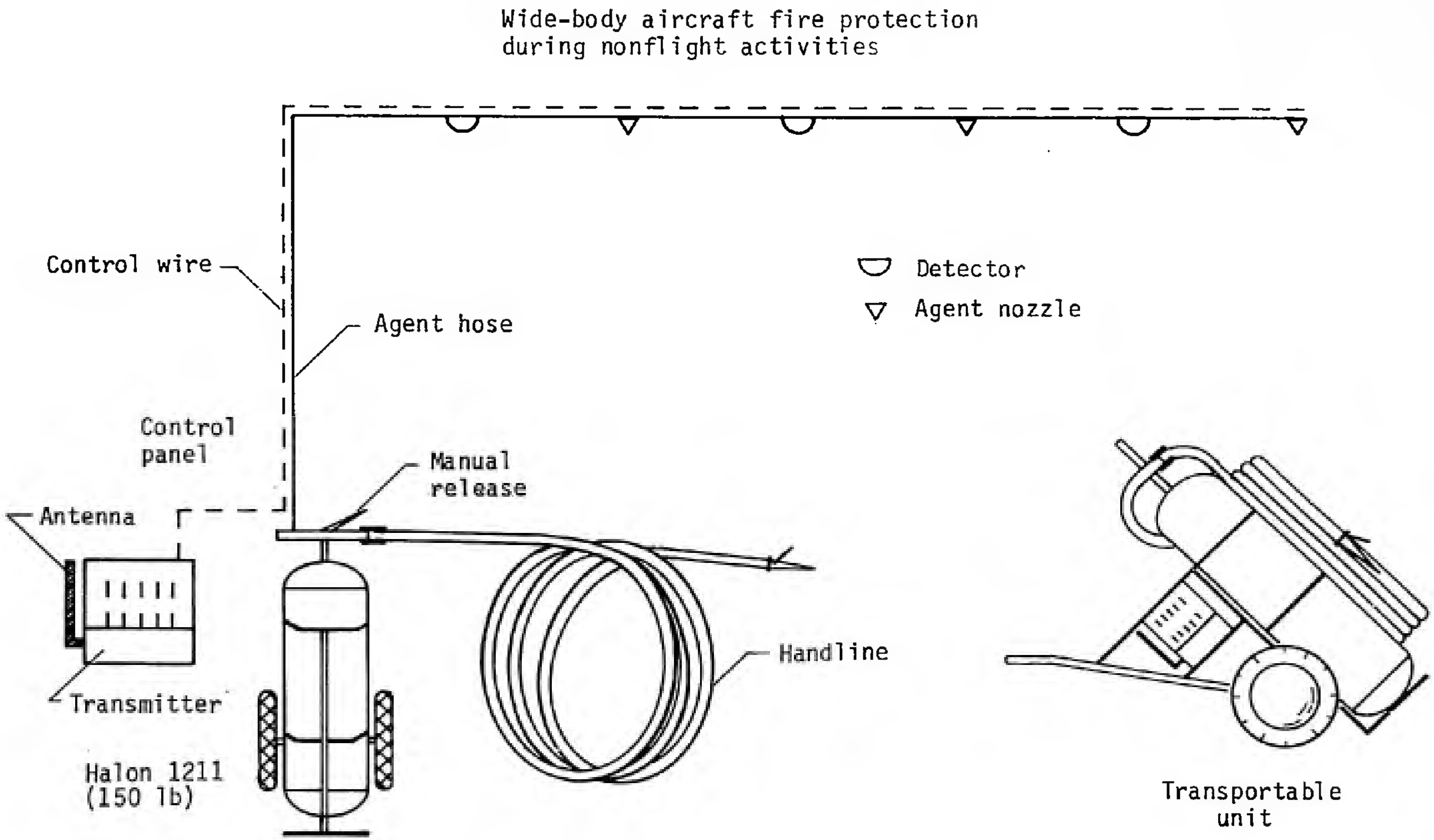


Figure 3. Portable Cargo Fire Suppression System.

2. The installed system would require that a door or window on the aircraft always be left open for the hose and detection system.

3. The system would require a high level of maintenance because of the use of portable smoke detectors. Failure to provide the necessary maintenance to the system could result in false alarms or other system malfunctions.

D. AIRCRAFT FIRE SUPPRESSION SYSTEM

1. System Description

The fire protection system selected for development under the Aircraft Robotic Fire Sentry project is called the Aircraft Fire Suppression (AFS) system. The AFS is composed of two parts: a portable ground-based unit, and a unit that is permanently installed aboard the protected aircraft.

The portable ground-based unit is composed of a supply of extinguishing agent such as Halon 1211 or Halon 1301, an automatic control and release system, and a radio-frequency (RF) transmitter. The unit installed aboard the protected aircraft contains a fire detection system and a dry pipe halon distribution system.

When an aircraft is parked for an extended period of time, the AFS system is connected to the exterior of the aircraft. The ground-based unit provides power and monitors the detection system aboard the aircraft. In the event of a fire, an alarm inside the aircraft alerts personnel to evacuate. After a delay of 15 to 60 seconds, the system releases the contents of the ground-based extinguisher inside the aircraft, flooding the interior cavity.

During the system discharge, a strobe and siren on the AFS system will alert ground personnel of the emergency. Simultaneously, an RF transmitter will send a distress signal to the base fire department identifying the location of the emergency. A pull-box is located on the AFS system to permit direct rapid notification of the base fire department.

This system meets all design criteria developed in Section I of this report, and was approved by the project task officer for development. Two prototype systems resulted from this effort. These two systems are referred to as the AFS-1 and the AFS-2. The following outlines the design criteria for these systems.

2. AFS System Design Criteria

a. Agent Selection

A critical component of the AFS system is the fire suppression agent. The agent used dictates the size and type of plumbing system installed in the aircraft, the type and size of flexible hose used for the umbilical cord connecting the agent supply to the aircraft, and the configuration of the agent storage and release mechanism.

The requirements of the fire suppression agent used in this system were determined to be: (1) the agent must be effective against Class A, B, and C fires, (2) the agent should remain in suspension for a period of time after it is discharged for the purpose of inerting the environment. The intent of the system is not to provide final extinguishment of the fire, but rather to control the situation until the fire department can respond.

b. Halon 1211 Versus Halon 1301

The two fire suppression agents considered for use in the AFS system were Halon 1211 and Halon 1301. The primary disadvantage of Halon 1211 is its higher toxicity. According to the National Fire Protection Association (NFPA), the maximum safe exposure limits for humans to Halon 1211 is 4 to 5 percent for 1 minute (Reference 3); the maximum safe limit of Halon 1301 is 7 to 10 percent for a period of 1 minute (Reference 4). The NFPA recommends that Halon 1211 not be used in an enclosure which is normally occupied. However, if a normally unoccupied area can be evacuated by personnel in less than 30 seconds, total flood Halon 1211 systems are permitted. The guidelines for Halon 1301 are much less restrictive, permitting its use in occupied areas providing that evacuation can be accomplished in 30 seconds.

Halon 1301 is superior to Halon 1211 as a total flood fire suppression agent in two areas.

(1) The boiling point of Halon 1211 is 25.9 °F, while that of Halon 1301 is -71.9 °F. Since Halon 1301 vaporizes faster than Halon 1211 a Halon 1301 system is less dependent on nozzle design for a more even distribution of halon.

(2) Halon 1301 is lighter than Halon 1211 resulting in a longer suspension time.

In spite of these two features of Halon 1301, Halon 1211 was selected for use in the AFS system.

(1) At 70 °F the vapor pressure for Halon 1211 and Halon 1301 are 35 $lb/in.^2$ and 205 $lb/in.^2$, respectively. The lower vapor pressure of Halon 1211 allows the use of lighter weight and less expensive materials such as the 150-pound flight line fire extinguisher to store and handle the agent. This extinguisher is currently part of the Air Force inventory.

(2) The lower pressures associated with the use of Halon 1211 also permit lighter weight materials to be used for the aircraft halon distribution system.

(3) The logistics necessary to support Halon 1211 in the field are currently in place within the Air Force. This is not true for Halon 1301.

c. Agent Design Parameters

The minimum discharge requirement for a halon fire suppression system suggested by the NFPA (Reference 3) specifies that the design concentration of Halon 1211 be obtained throughout the protected facility within a period of 10 seconds. AFS-1 was designed to exceed this guideline by requiring that the design concentration be established within 5 seconds. AFS-2 was designed to meet the minimum NFPA guidelines.

The AFS system is also required to maintain a minimum 5-percent concentration of halon within the protected aircraft for a period of 90 seconds. This is achieved through an extended discharge period, and by producing a sufficiently high initial halon concentration. Ninety seconds was selected based on interviews with Air Force fire department personnel which indicated that the base fire department could respond within 60 seconds following the fire report. An inertion period for the aircraft one and one-half times as long as the estimated response time was determined to be adequate to permit fire department intervention.

The design concentration of Halon 1211 was determined from recommendations given in Table 2-3.2.2 in Reference 3. The most flammable substance inside cargo aircraft is expected to be JP-4 jet fuel. While the design concentrations for JP-4 is not specifically called out in Reference 3, the combustion properties of JP-4 resemble those of n-heptane. The NFPA suggests a design concentration of 5 percent Halon 1211 when n-heptane is expected to be the principal combustible involved in a fire. Therefore, the prototype AFS systems were designed to provide a minimum average concentration of Halon 1211 of 5 percent for a period of 90 seconds.

d. Halon Requirement Model

The ability to maintain a 5-percent concentration inside an aircraft for the design period is a function of the number and size of the openings in the aircraft and the ventilation rate through the aircraft. Several assumptions were made in the design of the AFS system based on the configuration of the protected aircraft. A worst-case scenario for a fire aboard a C-130 aircraft would include the cargo door and all the personnel hatches and windows being open. An aircraft in this configuration is likely to have personnel nearby loading cargo or working inside the aircraft. The AFS prototype system was designed for a C-130 aircraft in a configuration consistent with the expected hazards of a single open personnel hatch with the cargo door closed.

A computer program was developed which determined that 150 pounds of Halon 1211 must be discharged in a C-130 aircraft to maintain a minimum 5-percent concentration for 90 seconds with the stated design conditions. This program was developed from algorithms obtained from Reference 3. A listing and description of this program are included in Appendix A. This program has not been verified with test data for a C-130, but should give a reasonable approximation.

3. AFS System--Portable Ground-based Unit Design

a. AFS System Control Panel

The AFS system control panel performs several functions. The control panel monitors and provides power to an aircraft's internal fire detection system. It monitors the cable connecting the control panel to the aircraft and the internal functions of the panel. Upon alarm of the detection system, the control panel actuates the fire suppression system, transmits a distress signal to the fire department, and alerts ground personnel of the emergency.

The control panel also is equipped with a pull-box to allow personnel to manually report a fire. When the pull-box is activated, the AFS system's transmitter broadcasts a distress signal to the fire station. The system's siren and strobe light are also activated. In this alarm mode, the automatic and manual release mechanism of the AFS system remain armed.

The control panel selected for the prototype AFS systems was developed for the Air Force Engineering and Services Center (AFESC) for use in the Mobile Tactical Shelter. Two manufacturers developed panels for this program; FENWAL developed the Mini Halon 1301 Release Panel, and Monaco developed the Firefly panel. Both of these panels are acceptable for use in the AFS system with the addition of a custom relay card (Appendix B).

Each control panel operates on 115 or 230 volts AC or 12 volts DC. They were originally designed to operate with two smoke detectors pulling a maximum of 0.150 microamperes at 12 volts. The system is capable of powering many more detection devices than the two smoke detectors provided that a sufficient power source is available to the panel. Higher loads from additional detection devices will decrease the operational life of the panel's battery pack.

b. Remote Radio Transmission

Equipment to relay alarm messages over a radio link has been manufactured for several years by companies such as King-Fisher, Monaco, and Ademco (Appendix C).

Radio links for alarm systems typically operate in one of several ways. When a high level of confidence in the radio link's integrity must be assured, the alarm transmitter will periodically send a coded signal to a base station to verify the existence of the radio link. The alarm transmitter may send this coded signal as often as every 30 seconds or as infrequent as once every 24 hours. If a signal from the alarm transmitter is not received on schedule, it is assumed that there is a problem with the system. In the event that the system goes into an Alarm mode, a different coded signal is sent to the base station.

The transmission equipment system consists of a base station located at the fire station or some other central location, and a small transmitter located with each AFS system ground-based unit. The integrity of the radio link between the AFS system and the base fire department would be checked each time the AFS system is put into service. However, the radio link would not be periodically verified, as described above, to conserve the AFS system's batteries. If the AFS system goes into an alarm or trouble mode, a coded signal would be transmitted to the base station indicating the location of the system, and the type of problem being experienced.

The transmission frequency used by the AFS system transmitter will be different at each Air Force base. The frequency band most suited for this application lies between 902 to 928 MHz. This frequency band is restricted to military use only, and is dedicated to alarm system transmissions. The specific frequency used at each base will have to be coordinated with the base frequency manager.

c. Halon Storage Cylinder

The storage container for the Halon 1211 must be sufficiently large to store the required quantity of halon with a safe fill ratio, and the container must be portable. Additionally, it would be desirable to use materials currently found in the Air Force inventory for this container and trailer.

The 150-pound Halon 1211 flight line fire extinguisher meets these requirements. The unit is equipped with a hitch so that it may be towed behind a vehicle, and it can be filled with 150 pounds of Halon 1211 with a 52-percent fill ratio. The unit is also a standard piece of equipment on virtually all military bases.

4. AFS System--Installed Unit Design

a. Aircraft Halon Distribution System Design

The dry pipe halon distribution system in the protected aircraft will be unique for each type of aircraft allowing for special hazards and varying interior configurations. Agent supplied to the distribution system enters through one of several access ports located on the exterior of the airframe. These interface couplings are of the quick-disconnect variety for rapid system installation.

Behind each quick-disconnect coupling is a blow-out disk. These disks serve two purposes.

(1) When the aircraft is in flight, the blow-out disks allow the interior of the aircraft to be pressurized. Without these blow-out disks, the atmosphere inside the aircraft would leak out through the halon distribution system.

(2) When the AFS system activates, halon travels from the halon supply toward the aircraft. When the pressure on the blow-out disk reaches its yield pressure, the disk gives way and allows the halon to enter the aircraft's distribution system. The blow-out disks sealing alternate access ports prevent agent from exiting the distribution system during the system discharge.

Halon 1211 is not commonly used in total flood applications. As a result, flow data for total flood Halon 1211 systems are limited. The standards that exist pertaining to the design of these plumbing systems provide only approximations of system performance. A widely accepted standard for designing Halon 1211 distribution systems is the "BCF (Halon 1211) System Design Manual" produced by Imperial Chemical Industries (ICI) Limited (Reference 5). This publication should be used in the design of the aircraft halon distribution system. An example of a system designed for a C-130 aircraft is given in Appendix D of this report.

b. Detection System

Fires aboard parked wide-body aircraft typically develop quickly, and require rapid detection to minimize damage. The sensors considered for fire detection aboard the protected aircraft were optical flame detectors, smoke detectors, thermistor wire, and heat sensors. Each of these detection devices may have application aboard specific aircraft; however, there are distinct advantages and disadvantages to each form of detection. A brief discussion of each of these forms of detection follows.

Optical flame detectors are the poorest choice for the stated application for two reasons.

(1) Optical flame detectors typically require more power than other detection devices. Low power consumption is essential to prolong the life of the batteries powering the AFS system.

(2) Optical flame detectors require that a flame be visible before they will alarm. A fire that develops in a concealed area could go undetected.

Ionization and photoelectric smoke detectors are the most applicable to the AFS system. These types of detectors have a successful history of operation aboard both military and commercial aircraft. They offer a broad range of fire-sensing capabilities. When designing systems utilizing these detectors it should be recognized that ionization detectors are better at detecting fires that develop quickly rather than smoldering fires, and photoelectric detectors detect slowly developing fires better than they detect rapidly developing fires. The fire hazard these detectors are used against should be carefully considered before their use is specified.

Thermistor wire and thermal links could also be useful as detection sensors aboard aircraft. These devices consume very little power and are virtually free from sounding false alarms. The reaction time of these detectors to a fire is much slower than the other forms of detection. They would best be used in areas where other forms of detection cannot be used because of the possibility of false alarms.

SECTION III
AFS SYSTEM PROTOTYPES

The primary differences between the AFS-1 and the AFS-2 systems are based on the varying design parameters used in their development. The AFS-1 system was required to provide a 5-percent concentration of Halon 1211 within a 5-second period, while the AFS-2 system was required to establish a 5-percent concentration in 10 seconds. The AFS-1 system was required to be 50 feet from the protected aircraft, while the AFS-2 system was located 25 feet from the aircraft. These requirements were established somewhat arbitrarily since a standard does not currently exist. Finally, the AFS-1 system was required to use a 1-inch chemical hose between the halon storage container and the protected aircraft. A similar restriction was not imposed on the AFS-2 system. A 1-inch hose was selected because it is commonly used at base fire departments. Other size chemical hoses are not commonly used and would be more difficult to stock. The AFS-2 system was not restricted as to the size chemical hose between the halon storage container and the protected aircraft.

A. AIRCRAFT FIRE SUPPRESSION SYSTEM NUMBER 1 (AFS-1)

1. System Description

The AFS-1 prototype system was designed to provide fire protection to an aircraft as large as a C-130. Major components include a standard 150-pound flight line extinguisher which serves as the halon storage container, an 80-ft^3 high-pressure nitrogen cylinder, a control panel, an RF transmitter, and a metron-actuated blow-out disk.

The 150-pound Halon 1211 flight line fire extinguisher is modified to support the nitrogen cylinder and the system control panel. The manual hose line and valve are removed from the extinguisher and a custom dip tube is mounted in the vessel to permit automatic operation of the AFS-1 system.

The discharge of the system occurs when a metron-actuated blow-out disk is made to yield, allowing nitrogen to travel from the high-pressure nitrogen cylinder into the halon storage container. When the pressure in this container reaches the yield pressure of a second blow-out disk, the disk yields allowing halon to travel from the storage container toward the aircraft through the chemical hose. A third blow-out disk at the aircraft fails when the pressure in the chemical hose reaches its yield pressure. When this occurs, halon is permitted to enter the aircraft's halon distribution system where it is dispensed throughout the aircraft (Figure 4).

To demonstrate the concept of the AFS-1 prototype system, a smaller version of the system was developed and tested on a C-131 aircraft. The internal volume of the C-131 aircraft is approximately 3200 ft^3; the internal volume of the C-130 is approximately 5000 ft^3. The smaller AFS-1 system developed for this test will be referred to throughout this report as the AFS-1 Test System.

The AFS-1 Test System is identical to the proposed system with three exceptions.

a. The nitrogen release mechanism for the AFS-1 Test System was not a metron-actuated blow-out disk, owing to procurement time constraints. Instead, a 3/4-inch solenoid valve was used.

b. Optical flame detectors were used as the detection sensor instead of ionization or photoelectric smoke detectors. The test of the AFS-1 Test System involved a hot JP-4 fire in the center of the C-131 aircraft which would have destroyed smoke detectors located near the flames. Optical flame detectors could be protected from the intense heat associated with the fire, and could provide instant response.

c. A surplus 10-gallon CB (chlorobromomethane) extinguisher was used instead of a 150-pound flight line fire extinguisher for the halon storage container. The primary reason for this substitution was economics.

2. AFS-1 Test System--Components

The AFS-1 Test System (Figures 5 and 6) consisted of the materials and equipment described in Table 1.

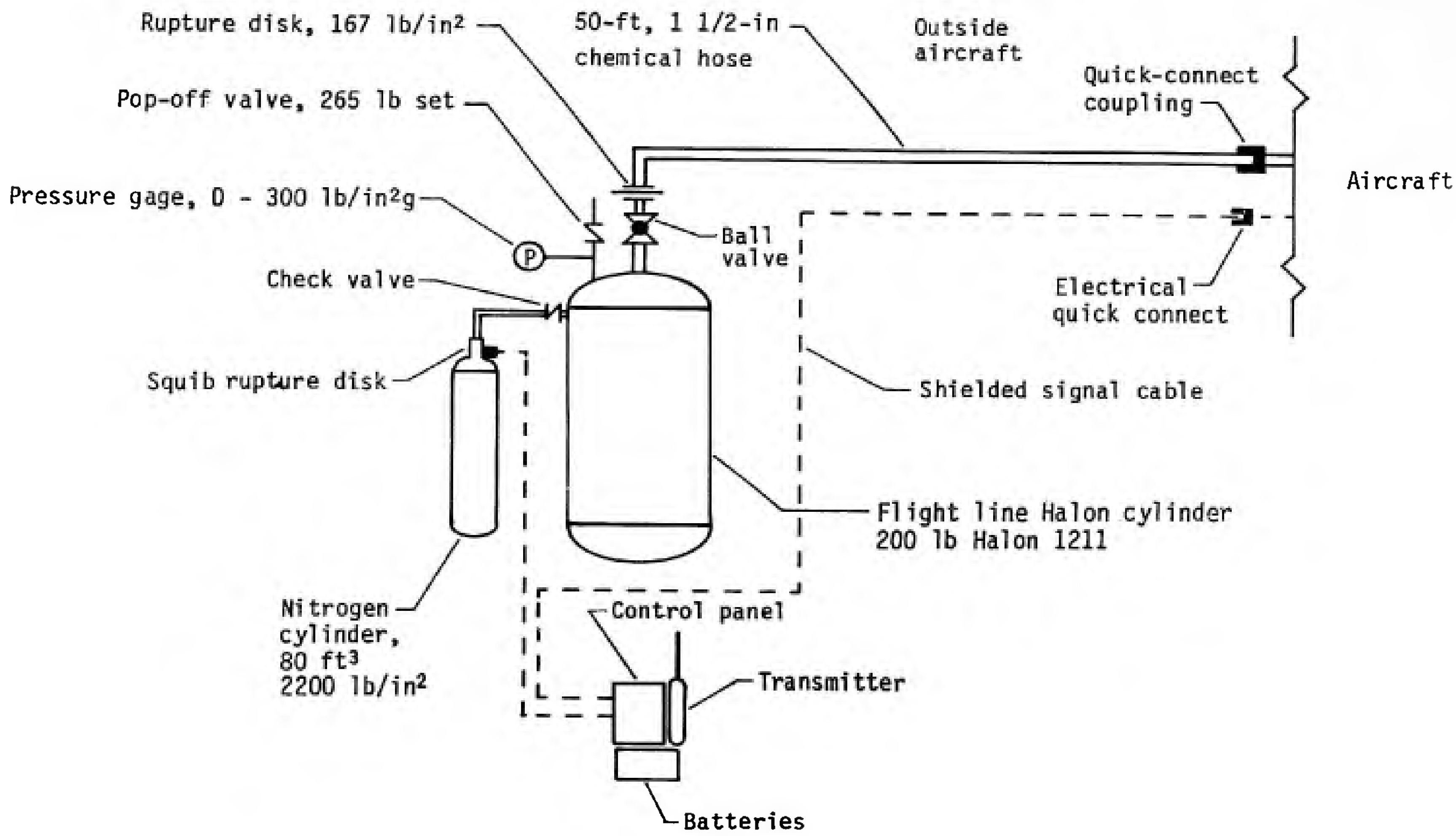


Figure 4. AFS-1 System.

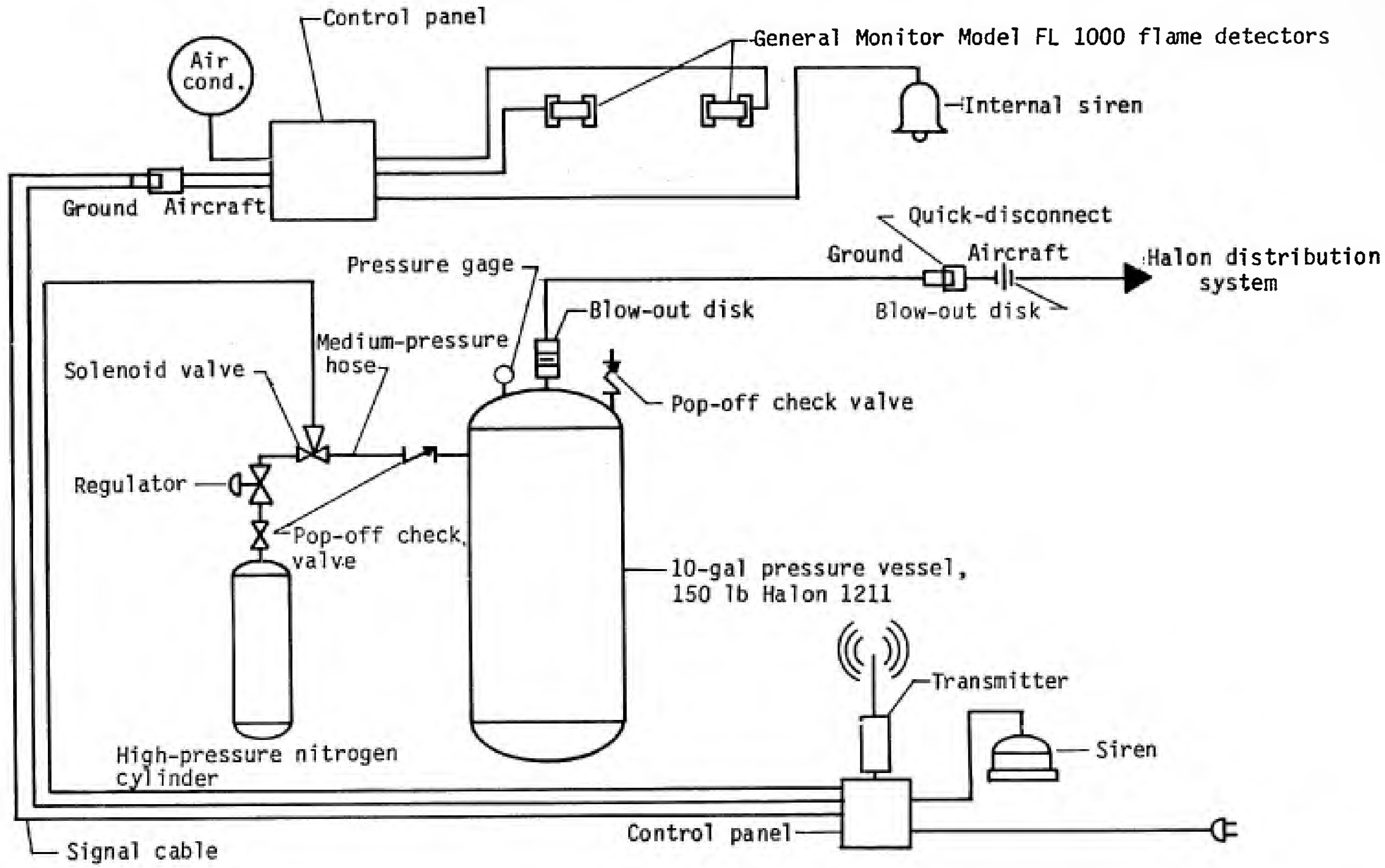


Figure 5. AFS-1 Test System--Schematic.

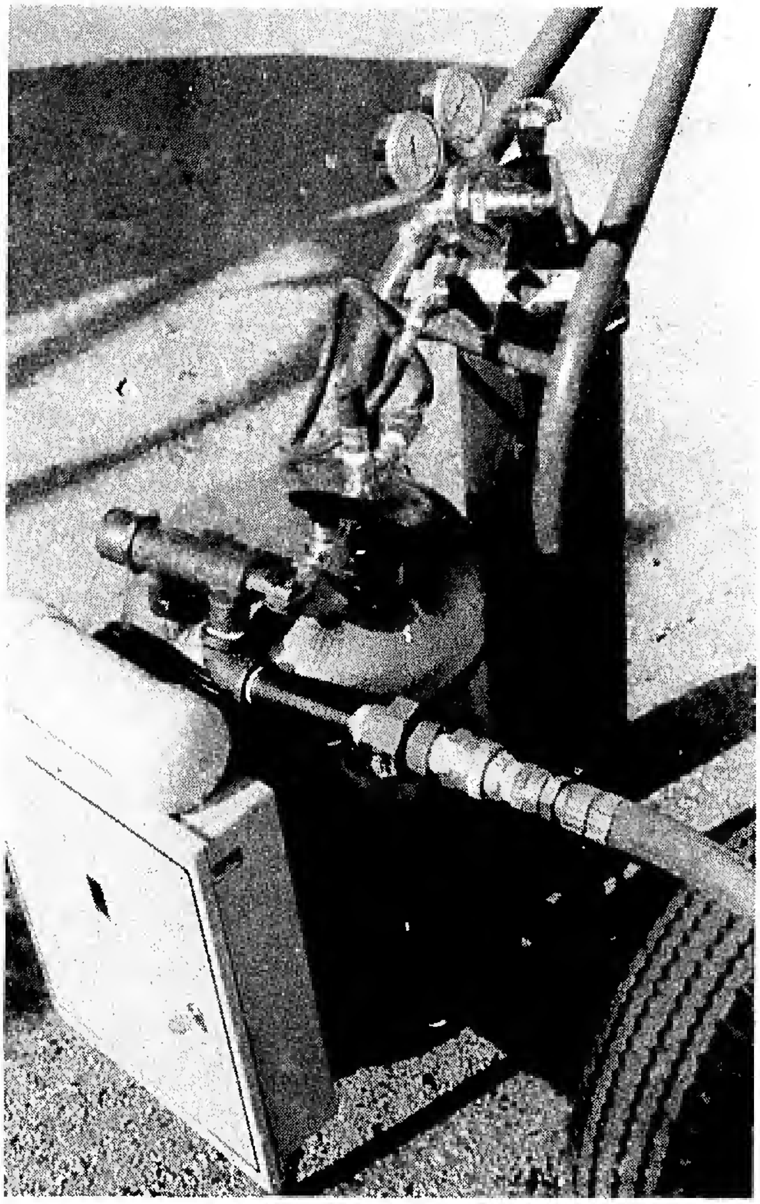


Figure 6. AFS-1 Test System.

TABLE 1. AFS-1 TEST SYSTEM COMPONENTS.

Item	Description
1	Ten-gallon stainless steel CB extinguisher and trailer containing approximately 150 pounds of Halon 1211.
2	High-pressure nitrogen cylinder, 42 ft^3.
3	Single-stage nitrogen regulator.
4	Three feet of 3/8-inch medium-pressure hose.
5	One-half-inch pop-off check valve, 3 lb/in^2 rating.
6	One-half-inch pop-off check valve, 200 lb/in^2 rating.
7	One-half-inch brass cross.
8	Pressure gage, 0-200 lb/in^2 rating.
9	Three-eights-inch ball valve.
10	Three-eights-inch brass plug.
11	Two 1-inch blow-out disk unions with 167 lb/in^2 blow-out disks.
12	Schedule 40 nipple, 4- by 1-inch carbon steel.
13	Three 1-inch quick-connect pairs.
14	Sixty feet of 1-inch chemical hose.
15	Fike Control Panel 10-042.
16	Sixty feet of 2-pair, 22-gauge signal cable.
17	Linear D22A Panic Transmitter.
18	Linear D67 radio receiver.
19	PRO-4061 siren.
20	Three-quarter-inch, 300 lb/in^2 solenoid valve.
21	Two 1-inch quick-connect couplings.
22	Twenty feet of 1-inch medium pressure chemical hose.
23	Six 1-inch full-cone nozzles, 21/64-inch orifice.
24	Five 1-inch tee fittings, PVC (polyvinylchloride).
25	Two 1-inch ell fittings, PVC.
26	Seven 1-inch PVC to NPT adapter fittings, PVC.
27	Fifty feet of 1-inch schedule-40 PVC pipe.
28	Schedule-40 nipple, 6- by 1-inch carbon steel.
29	Two General Monitor Model FL 1000 Unitized UV/IR flame detectors and a custom-built control panel.

The internal halon distribution system in the C-131 aircraft was designed using data from Reference 5. The halon nozzles were spaced as shown in Figure 7. The calculations predicting the flow rate of halon through these nozzles are included in Appendix D.

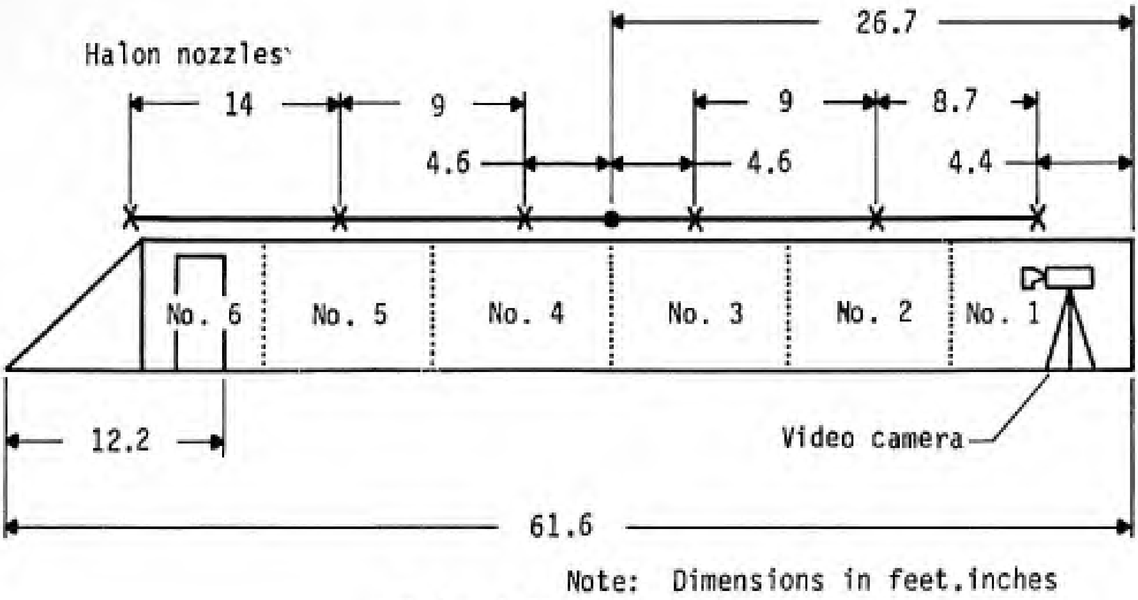
3. AFS-1 Test System--Tests

Two tests were conducted with the AFS-1 Test System in the C-131 aircraft. The first test was conducted without a fire in the aircraft. The second test was conducted with an 8 ft^2 pan fire in the center of the aircraft.

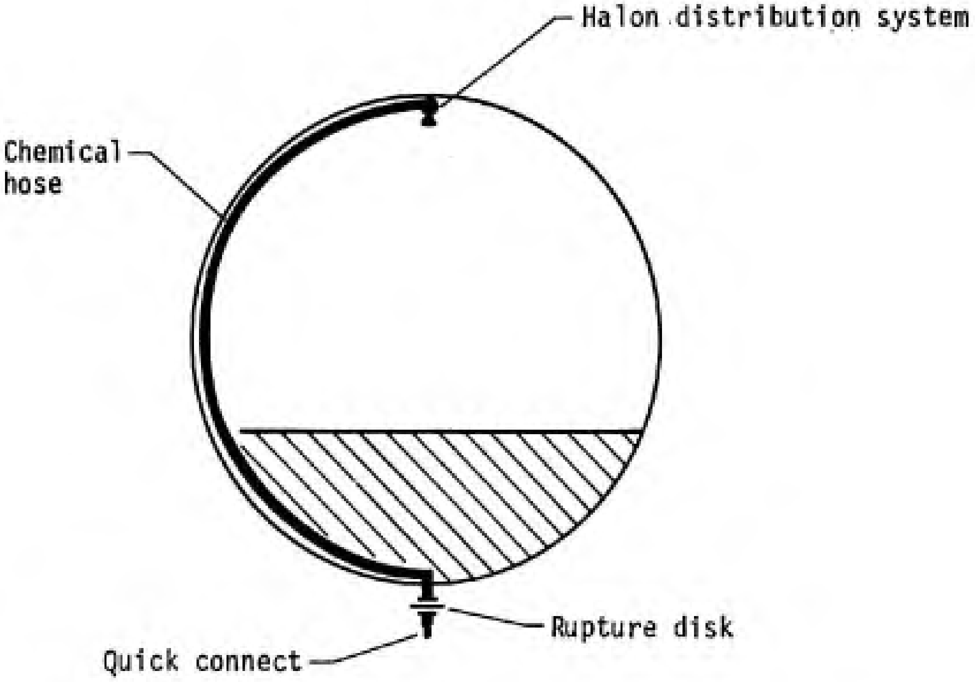
a. Test 1. This test provided data regarding the halon concentrations achieved inside the aircraft as a function of time. The AFS-1 Test System was manually activated while the Halon 1211 concentrations were monitored using both a Perco analyzer and grab samples.

In preparation for these tests, the interior of the C-131 aircraft was lined with thermal insulation. The aircraft was fitted with a halon distribution system composed of 1-inch Schedule 40 PVC pipe and 1-inch chemical hose. Full-cone nozzles with a 21/64-inch orifice were mounted on the distribution system at about 9-foot intervals. The access port on the distribution system was composed of a 1-inch quick-disconnect fitting and a blow-out disk rated at 167 lb/in^2. A video camera was placed in Cell 1 at the back of the aircraft to monitor the halon discharge (Figure 7).

The AFS-1 Test System was charged with 142 lb of Halon 1211. The halon was not stored under nitrogen pressure; however, there was evidence that there was dissolved nitrogen in the halon. Dissolved nitrogen will affect the rate at which the halon is discharged into the aircraft. Other preparations for this test included regulating the pressure from the high-pressure nitrogen cylinder to 200 lb/in^2. Nitrogen only comes in contact with the halon during the actual discharge of the AFS-1 Test unit and is not given opportunity to dissolve into the halon.



Halon diffusion cells



Cross-section of
C-131 aircraft

Figure 7. AFS-1 Test--C-131 Aircraft.

The halon concentration in the aircraft was measured by two methods. First, 18 sample bottles were positioned in the aircraft, 9 in Cell 2 and 9 in Cell 5. In both cells, 3 bottles were located 18 inches from the ceiling of the aircraft, 3 bottles were located 18 inches from the floor of the aircraft, and 3 bottles were located halfway in between. At three time intervals a sample was taken at each of the three elevations in each of the two cells. Samples were taken at 5 seconds, 35 seconds, and 65 seconds after the completion of the halon discharge.

A Perco analyzer was also used to monitor the halon concentration inside the aircraft. Two plastic sample tubes 50 feet long were used to sample Cell 5 at elevations of 18 inches from the ceiling of the aircraft and 18 inches from the floor of the aircraft. The data were corrected for flow irregularities inherent with this type of sampling technique.

The data from the sample bottles are presented in Table A-2. These data are unreliable, for the following reasons:

(1) Results from 10 of the 18 sample bottles were erroneous because of a malfunction of the gas chromatograph used to determine the halon concentration. The malfunction was discovered when only eight of the sample bottles could be reexamined.

(2) Some of the solenoid valves used to open the sample bottles during the test were found to have leaks which may have resulted in diluted samples.

(3) Results from the sample bottles and the Perco analyzer data taken at the same location failed to agree.

The data taken with the Perco analyzer are thought to provide a good indication of the halon concentration because the equipment was calibrated prior to the test, and the data agreed well with numerical predictions.

b. Test 2. The purpose of this test was to validate the AFS-1 Test System in a situation which included a JP-4 fire. The detection and suppression systems were fully armed when a pan fire was electrically ignited inside the C-131 aircraft.

For this test, the AFS-1 Test System was installed, adjoining the aircraft, as previously described. A 1-inch hose, 60 feet long, connected the internal halon distribution system to the AFS-1 Test System. The AFS-1 Test System was filled with approximately 145 pounds of Halon 1211.

To increase the operating speed of the AFS-1 Test System, two alterations were made: (1) line restrictions between the nitrogen cylinder and the halon container were removed, and (2) the pressure of the regulated nitrogen was raised from 200 lb/in^2 to 250 lb/in^2.

The detection system installed in the C-131 used two General Monitor FL 1000 UV/IR flame detectors. One detector was located in Cell 5 and monitored the rear of the aircraft (Figure 7). The other detector was located in Cell 6 and monitored the front of the aircraft. The signal and power cables for these detectors were run through a conduit which joined at the floor of Cell 4, where the conduit was run through the floor of the aircraft to an electrical junction. Both detectors were insulated to protect them from heat generated during the test.

Two fire pans were located in the center of the aircraft in Cell 4. These pans measured approximately 2 by 2 feet and were placed next to each other and parallel to the length of the aircraft. The pans were filled with approximately 5 gallons of JP-4. A small piece of fabric was placed across the lip of the two fire pans and a nichrome wire was placed on top of the fabric to ignite the fuel.

In preparation for this test the interior of the C-131 aircraft was cleaned of the previous test equipment and cabling. The halon distribution system was pressure checked and insulated, and a camera box was constructed to protect the video camera from the high temperatures and smoke generated by the fire.

The Kirtland Air Force Base fire department provided backup in case the AFS-1 Test System did not function properly. This backup consisted of a P-13 with a penetrator tool supplied with Halon 1211. Additionally, the fire department had a P-4 on location if the fire got out of control.

The optical detection system inside the aircraft sounded the alarm approximately 8 seconds after the ignition of the fire pans. This time delay was a function of the setting of the system. Although this delay was longer than desired, it permitted the fire inside the aircraft to become highly developed.

Approximately 4 seconds after the alarm sounded, halon began emerging from the distribution system. Just under 6 seconds elapsed from the time halon first appeared inside the aircraft to the time the fire was extinguished. The total discharge time for the system was approximately 13 seconds, suggesting that a 5-percent Halon 1211 concentration was achieved in 5.4 seconds.

Test 2 was successful. The operation of the AFS-1 Test System was validated by the timely extinguishment of the aircraft fire. Excellent video coverage of the test was also obtained. Photographs of Test 1 and Test 2 are included as Figures 8 and 9.

B. AIRCRAFT FIRE SUPPRESSION SYSTEM NUMBER 2 (AFS-2)

1. System Description

The AFS-2 prototype system was designed to provide fire protection to an aircraft as large as a C-130. It is composed of a 150-pound Halon 1211 flight line extinguisher, a battery-operated control panel and RF transmitter, a metron-actuated blow-out disk, a 2-inch chemical hose, and other miscellaneous hardware. A schematic of the AFS-2 system is shown in Figure 10. System components are identified in Table 2.

The AFS-2 system differs from the AFS-1 system in the following ways: (1) it does not require a high-pressure nitrogen cylinder to force

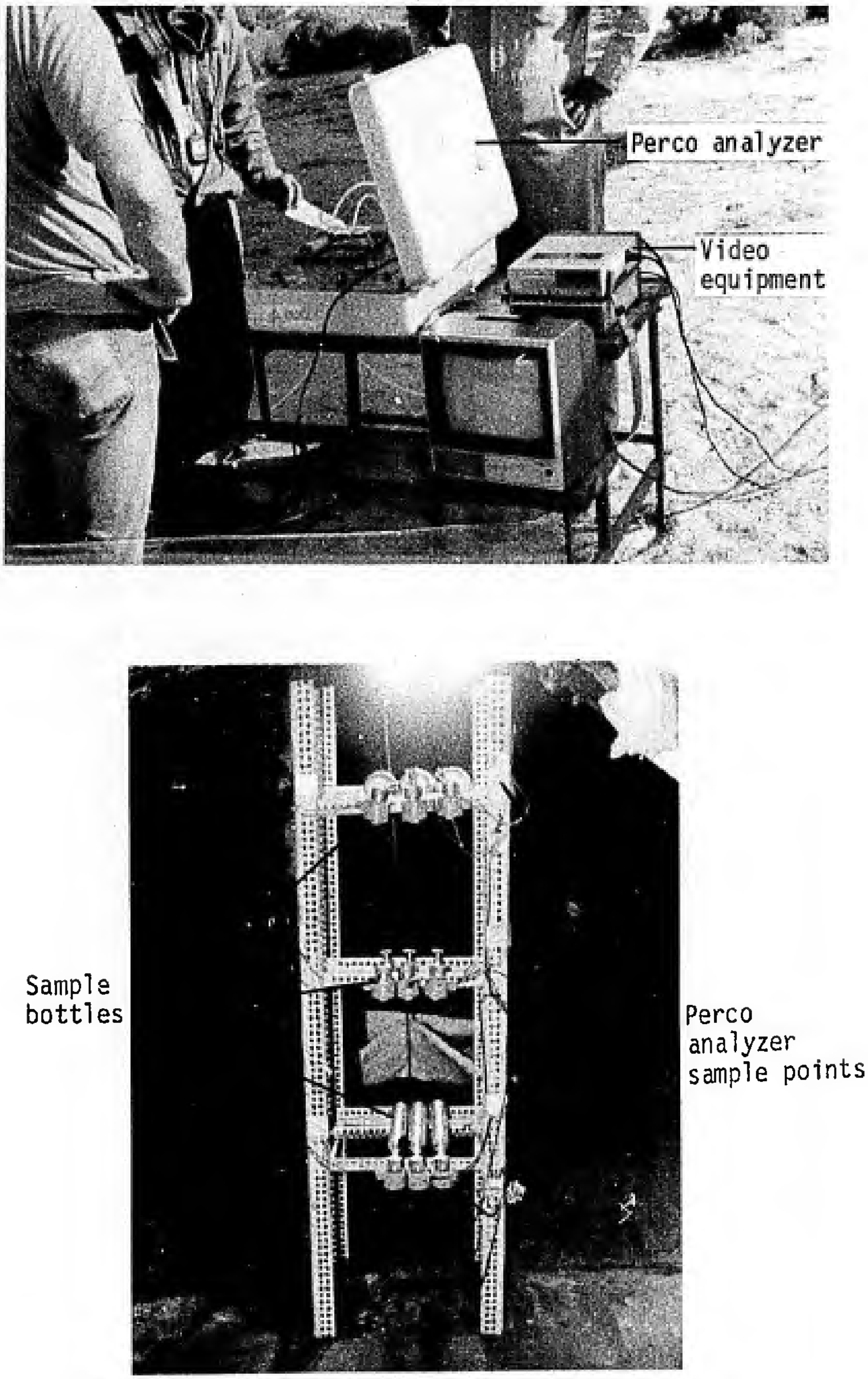
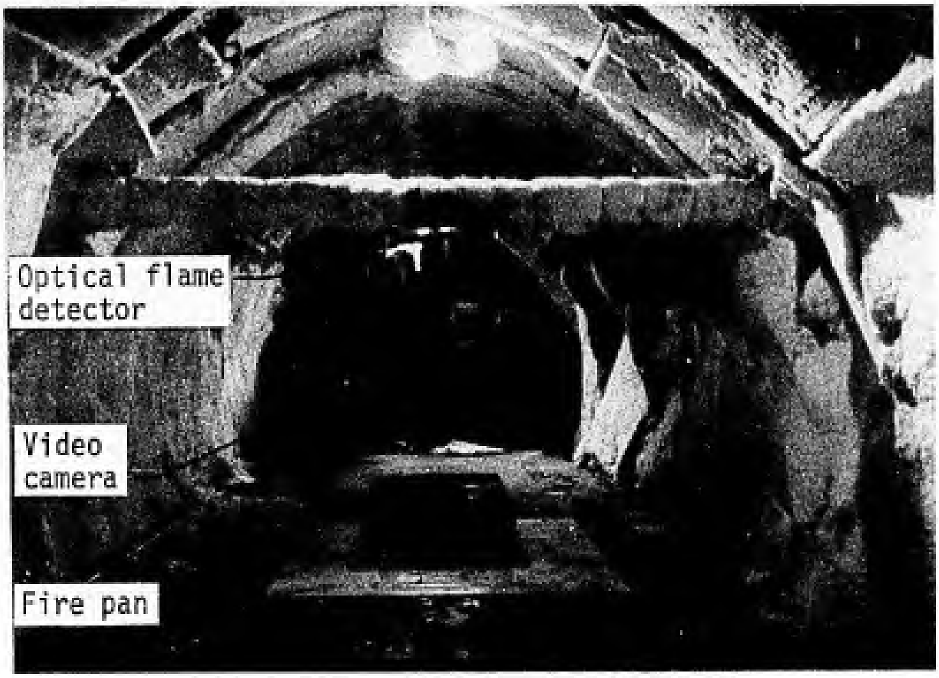


Figure 8. Measurement Setup--Test 1.



a. C-131 Aircraft Interior Pretest.

b. Halon Discharge During Test.

Figure 9. AFS Test 2.

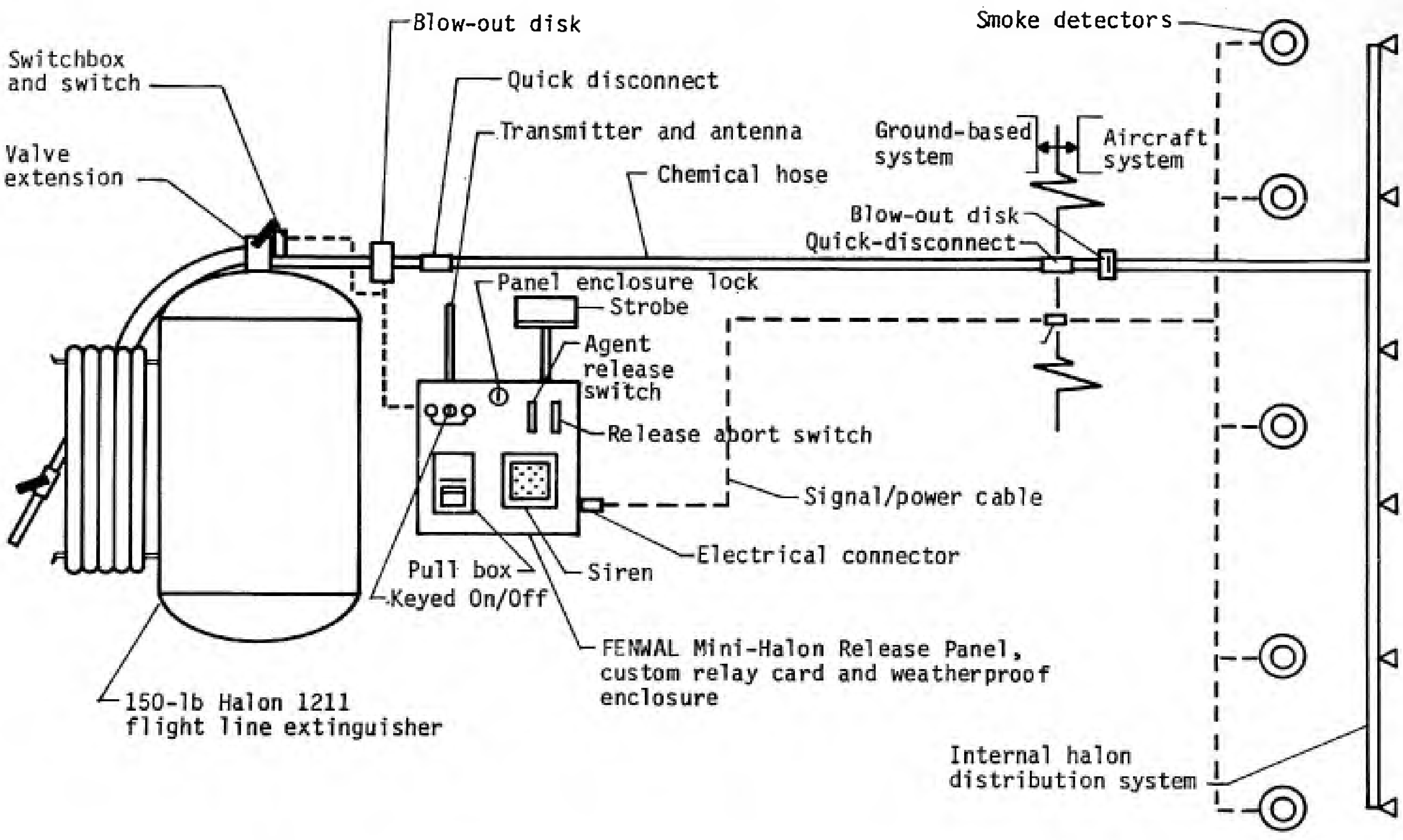


Figure 10. AFS-2 Demonstration Unit--Schematic.

TABLE 2. AFS-2 DEMONSTRATION UNIT COMPONENTS.

Item	Description
1	Amerex 150-pound Halon 1211 Flight line Extinguisher, model 600.
2	FENWAL Mini Halon Release panel, custom relay card (Figure B-1), and weatherproof enclosure.
3	Blow-out disk rated at 300 lb/in^2 and metron indicator.
4	Custom valve switch-box and switch (Figure B-2).
5	Quick-disconnect coupling.
6	RF transmitter and antenna.
7	Strobe.
8	Halon release abort switch.
9	Keyed on/off switch.
10	Pull-box.
11	Siren.
12	Four-contact electrical connector.
13	Detection system signal/power cable.
14	Four-contact electrical connector at aircraft.
15	Chemical hose, 25 feet long.
16	Quick-disconnect coupling.
17	Smoke detectors aboard aircraft.
18	Internal halon distribution system.
19	Blow-out disk at aircraft.
20	Agent release switch.
21	Panel enclosure lock.
22	Custom valve extension (Figure B-3).

the halon through the distribution system, (2) the halon delivery rate for the AFS-2 system is half that of the AFS-1, (3) it does not require that the halon travel as far to the aircraft as the AFS-1 system. The AFS-1 system is located 50 feet from the aircraft; the AFS-2 system is 25 feet from the aircraft.

The AFS-2 system uses a 150-pound Halon 1211 flight line fire extinguisher which has been modified with a discharge valve that permits manual or automatic discharge. Automatic discharge of the extinguisher is accomplished by the rupture of a metron-actuated blow-out disk. Upon yielding of this disk, halon is forced from the extinguisher, through a chemical hose connecting the AFS-2 system and the protected aircraft.

The extinguisher can be used manually by removing a safety pin from a ball valve and opening the valve. As with conventional flight line fire extinguishers, this action charges a handline to be used by ground personnel. Unlike conventional flight line extinguishers, when the handline of the AFS-2 system is charged, a strobe and siren alert ground personnel of the situation and a distress signal is transmitted by the AFS-2 system to the base fire department.

A demonstration AFS-2 unit has been constructed for this project and is shown in Figure 11. This unit was developed to demonstrate the functions of the AFS-2 system, and is not fully operational.

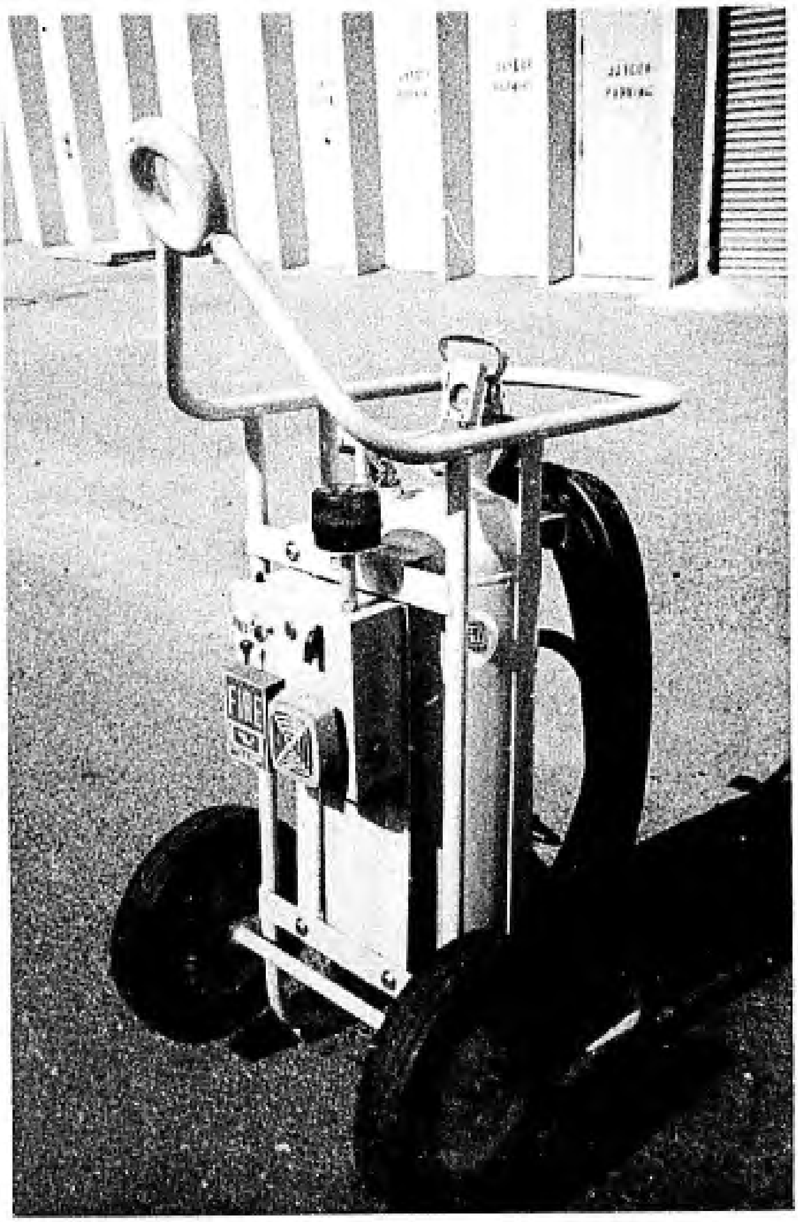


Figure 11. AFS-2 System.

SECTION IV
CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The AFS system meets all the system requirements developed for this project. The AFS system will automatically detect and suppress fires in a variety of military aircraft and provide an inert atmosphere following system discharge. The system requires little maintenance, is easy to install aboard aircraft, and does not interfere with the normal ground activities of the aircraft. A single AFS unit can be used with aircraft having internal volumes up to 5000 ft^3. Multiple AFS units can protect larger volumes.

Additional features of the AFS system include the ability to notify the fire department of any emergency involving the AFS system, and to serve as a stand-alone pull box. The AFS system utilizes many components currently existing in the Air Force inventory, and would be relatively inexpensive to deploy compared to traditional installed fire detection and suppression systems.

Of the two AFS systems developed for this project, the AFS-2 system is superior to the AFS-1 system, for these reasons:

1. The AFS-2 system retains the use of the flight line extinguisher's handline while the AFS-1 system does not. A conventional 150-pound flight line extinguisher would have to be deployed with the AFS-1 unit to meet the fire protection requirements of aircraft where a single AFS-2 unit would be sufficient.

2. The high-pressure nitrogen cylinder on the AFS-1 unit significantly alters the center of balance of the flight line extinguisher, making it awkward to handle, and unstable during discharge. The flight line extinguisher trailer would require significant redesign to adequately accomodate the nitrogen cylinder and control panel. This redesign and other alterations to the halon storage cylinder would nullify any advantage gained by using the 150-pound flight line extinguisher in the system design.

3. The nitrogen cylinder associated with the AFS-1 system decreases the reliability of the unit because of the increased number and complexity of the components. High reliability of the AFS unit is essential to the system. Therefore, the system recommended for further development is the AFS-2 system.

B. RECOMMENDATIONS

It is recommended that an AFS-2 system Operational Test and Evaluation (OTE) be conducted. This OTE should involve a minimum of five AFS-2 systems for a minimum of 6 months. This level of experience with the unit will be sufficient to provide insight into operational deficiencies and problems associated with the use of the system.

The HC-130 aircraft would be an ideal test base on which to conduct the AFS-2 system OTE. The internal volume of the HC-130 is approximately 5000 ft^3. These aircraft have relatively simple internal configurations, and could be easily fitted with a Halon 1211 distribution system and a compatible smoke/fire detection system. A possible location for the proposed OTE is Kirtland AFB where the 1550th Combat Crew Training Wing is stationed with several HC-130 aircraft. The exact number of HC-130 aircraft stationed at Kirtland AFB is not available; however, there are thought to be three to five in the area that could participate in the OTE.

As a result of this research effort, a draft purchase description for the AFS-2 system was developed, and is included in Appendix E. This draft document describes all components of the AFS-2 system. Information obtained from the OTE will be used to modify the AFS-2 system and provide direction regarding its future deployment.

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2. Parrish, David J., "Boeing 737-300, Halon 1301 Extended Discharge Tests," Walter Kidde, Fire Systems Operations, Wake Forest, NC, 1985.

3. National Fire Protection Association, National Fire Code Number 12B-1980, "Halon 1211 Fire Extinguishing Systems," Batterymarch Park, Quincy, MA, 1980.

4. National Fire Protection Association, National Fire Code Number 12A-1985, "Halon 1301 Fire Extinguishing Systems," Batterymarch Park, Quincy, MA, 1985.

5. Imperial Chemical Industries Limited, Mond Division, BCF (Halon 1211) Systems Design Manual, Runcorn, Cheshire, England, 1980.

APPENDIX A

HALON 1211 MODELS FOR C-130 AIRCRAFT

	Page
Halon 1211 Diffusion Model	42
Halon 1211 Requirements Model	55

HALON 1211 DIFFUSION MODEL

```
c This program predicts the concentration of Halon 1211 in an aircraft
c after a discharge through an internal halon plumbing system.  The
c program allows an individual to specify how many halon nozzles
c are aboard the aircraft, where they are located and the discharge
c rate of halon through the nozzles.  It is assumed that the discharge
c of halon is the same through each nozzle.  Modifications can be made
c to the program which allow for specification of individual discharge
c rates through nozzles.
c
c The diffusion equations for this program were taken from the NFPA
c NFC #12B.  They have not been applied in the manner in which they
c were intended.  Consequently, there is room for modification to
c accommodate specific situations.
c
c The parameters that the program defaults to are for a C-131 aircraft
c with the passenger door open.
c
c
c d(x)=distance between each nozzle
c w(x)=weight of the halon present in each cell during/after discharge
c r(x)=diffusion rate between cells
c v(x)=volume of each cell
c c(x)=concentration of halon in each cell
c con(itime,x)=concentration of halon in each cell wrt time
c b(x)=length of each cell
c
c
      $debug
      dimension d(20),w(20),r(20),v(20),c(20),con(150,20),b(20)
      dimension rk(20),e(20)
c
      character*64 outfile
      open (4,file='ricl')
c
```

```
c *******************************************************************
c s=specific gravity of Halon 1211 at 70 deg. F.
        s=2.248
c
c This is the default data input for a C-130 aircraft
c
c j and k - The number of nozzles
        j=6
        kk=6
c
c Halon 1211 Discharge Rate Through Each Nozzle.
        q=1.99
c
c ww - The total amount of Halon 1211 available.
        ww=150.0
c
c x - The total length of the protected area in the aircraft.
        x=41.00
c
c dw - The width of the crew door.
        dw=2.81
c
c dh - The height of the crew door.
        dh=5.02
c
c a - The cross-sectional area of the aircraft interior (approximate).
        a=94.7
c
c ah - The height of the aircraft interior (approximate).
        ah=9.2
c
c aw - The width of the aircraft interior (approximate).
        aw=10.3
c
c d(1) - The distance of the first nozzle from the front of the aircraft.
        d(1)=3.0
```

```
c d(2) - The distance of the second nozzle from the first nozzle.
        d(2)=7.0
        d(3)=7.0
        d(4)=7.0
        d(5)=7.0
        d(6)=7.0
        go to 85
c *******************************************
c *********** Length Of Cells **************
c
85      b(1)=d(1)+d(2)/2.0
        do 99 i=2,j-1,1
        b(i)=(d(i)+d(i+1))/2.0
99      continue
        b(j)=d(j)/2.0+d(1)
c
c *******************************************
c ********** New Diffusion Cells ***********
c
        no=1
        do 410 i=1,j,1
        e(no)=b(i)/3.0
        e(no+1)=e(no)
        e(no+2)=e(no)
        no=no+3
410     continue
    no=no-1
    kk=(kk*3)-2
c
c *******************************************
c *********** Volume Of Cells **************
c
        do 420 i=1,no,1
        v(i)=a*e(i)
420     continue
c
```

```
c ******************************************
c ********* Diffusion Constants ***********
c
c rrl=diffusion constant throughout aircraft volume
        rrl=0.00145*aw*(ah**1.53)
c rrdoor=diffusion constant through door to outside
        rrdoor=0.00145*dw*(dh**1.53)
c
c These values are constants.
        www=ww
        qq=q
        iflag=0
        jk=j
        j=no
c
c itime is the variable that indicates elapsed time in seconds.
        do 1000 itime=1,150,1
c
c These if statements control the discharge of agent
c
        if(iflag.eq.2)go to 23
        if(ww.lt.jk*q)iflag=1
        if(iflag.eq.1)q=ww/jk
        if(iflag.eq.1)iflag=2
c
c Halon concentration at the beginning of the second
c during halon discharge
c
        do 22 i=2,no,3
        w(i)=w(i)+q
        ww=ww-q
22      continue
c
c Halon concentration after discharge.
c
        do 422 i=1,j,1
        c(i)=(100.0*w(i)*s)/(v(i)+w(i)*s)
```

```
422     continue
c
c Diffusion Of Halon Between Cells.
c
23      do 100 i=1,j-1,1
        cc=abs(c(i)-c(i+1))
        r(i)=rr1*(cc**1.51)
100     continue
c
c Diffusion of halon begins only after the discharge of
c halon is complete.
        if(iflag.ne.2)go to 156
c
c Diffusion Of Halon To Outside Of Aircraft Through Door
        r(j)=rrdoor*(c(kk)**1.51)
c
c
156     continue
c
c Halon diffusing into/out-of cells.
        do 200 i=1,j-1,1
        if(c(i).gt.c(i+1))then
          w(i)=w(i)-r(i)
          w(i+1)=w(i+1)+r(i)
        end if
c
        if(c(i).lt.c(i+1))then
          w(i)=w(i)+r(i)
          w(i+1)=w(i+1)-r(i)
        end if
c
200     continue
c
c Diffusion To The Outside
        if(iflag.eq.2) w(kk)=w(kk)-r(j)
c
```

```
c Halon Concentration At The End Of The Time Interval (Second)
        do 300 i=1,j,1
        c(i)=(100.0*w(i)*s)/(v(i)+w(i)*s)
        con(itime,i)=c(i)
300     continue
c
c
1000    continue
c
c *******************************************************************
c ********************** PRINTING STATEMENTS ***********************
c
        do 3007 i=1,jk
3007    write(4,3000)i,d(i)
3000    format(1x,'D(',i2,') = ',f5.2)
        write(4,3001)qq
3001    format(1x,'Halon 1211 Discharge per Nozzle = ',f5.2,/)
        write(4,3002)www
3002    format(1x,'Total Halon 1211 Supply Available = ',f6.2,/)
        write(4,3004)dw,dh
3004    format(1x,'Outside Door Dimensions ',f5.2,' x ',f5.2,/)
        write(4,3005)a
3005    format(1x,'Aircraft Cross-Sectional Area ',f6.2,/)
        write(4,1100)
1100    format(1x,'Time',20x,'Nozzle No.',/,1x,'(sec)    1', )
        do 1102 i=2,jk,1
        write(4,1101)i
1101    format(7x,i1, )
1102    continue
        write(4,1103)
1103    format(1x,/)
c
        do 1201 m=1,itime-1,1
        write(4,1210)m
1210    format(1x,i4, )
        do 1200 n=2,no,3
        write(4,1220)con(m,n)
```

```
1220    format(3x,f5.2, )
1200    continue
        write(4,1221)
1221    format(1x)
c
c
1201    continue
        stop
        end
```

The time concentration predictions for a flood of 150 pounds of Halon 1211 in a C-130 aircraft are depicted below. These concentrations were arrived at by the program entitled, "Halon 1211 Diffusion Model."

TABLE A-1. HALON 1211 DIFFUSION MODEL OUTPUT.

Time, s	Concentration v/v Halon 1211					
	Nozzle No.					
	1	2	3	4	5	6
1	-.89	-.53	-.53	-.53	-.53	-.89
2	1.38	1.39	1.39	1.39	1.39	1.38
3	.73	.87	.81	.81	.87	.73
4	2.83	2.71	2.69	2.69	2.71	2.83
5	2.11	2.27	2.22	2.22	2.27	2.11
6	4.15	3.99	3.95	3.95	3.99	4.15
7	3.56	3.67	3.57	3.57	3.67	3.56
8	5.48	5.23	5.18	5.18	5.23	5.48
9	4.88	5.04	4.90	4.90	5.04	4.88
10	6.74	6.43	6.37	6.37	6.43	6.74
11	6.21	6.39	6.20	6.20	6.39	6.21
12	7.96	7.59	7.52	7.52	7.59	7.96
13	7.93	7.91	7.73	7.73	7.91	7.93
14	8.14	7.93	7.77	7.77	7.93	7.85
15	8.15	7.95	7.79	7.79	7.91	7.53
16	8.16	7.96	7.80	7.80	7.79	7.48
17	8.17	7.97	7.81	7.81	7.71	7.17

Notes:

D(1) = 3.00 feet

D(2) = 7.00 feet

D(3) = 7.00 feet

D(4) = 7.00 feet

D(5) = 7.00 feet

D(6) = 7.00 feet

Halon 1211 Discharge per Nozzle = 1.99 pounds per second

Total Halon 1211 Supply Available = 150 pounds

Outside Door Dimensions = 2.81 x 5.02 feet

Aircraft Cross-Sectional Area = 94.70 feet

TABLE A-1. HALON 1211 DIFFUSION MODEL OUTPUT (CONTINUED).

	Concentration v/v Halon 1211					
Time,	Nozzle No.					
s	1	2	3	4	5	6
18	8.17	7.97	7.82	7.82	7.57	7.16
19	8.17	7.98	7.82	7.82	7.51	6.87
20	8.17	7.98	7.82	7.82	7.38	6.87
21	8.16	7.98	7.83	7.83	7.33	6.59
22	8.16	7.98	7.83	7.83	7.19	6.61
23	8.16	7.98	7.83	7.83	7.16	6.35
24	8.16	7.98	7.84	7.82	7.02	6.37
25	8.16	7.98	7.84	7.81	7.00	6.13
26	8.15	7.98	7.84	7.80	6.86	6.14
27	8.15	7.98	7.84	7.78	6.85	5.93
28	8.15	7.98	7.85	7.76	6.71	5.94
29	8.15	7.98	7.85	7.74	6.71	5.75
30	8.15	7.99	7.85	7.71	6.57	5.75
31	8.14	7.99	7.85	7.68	6.57	5.58
32	8.14	7.99	7.85	7.65	6.44	5.58
33	8.14	7.99	7.85	7.62	6.45	5.43
34	8.14	7.99	7.85	7.59	6.32	5.42
35	8.14	7.99	7.85	7.56	6.32	5.29
36	8.14	7.99	7.85	7.53	6.20	5.27
37	8.13	7.99	7.85	7.49	6.21	5.15
38	8.13	7.99	7.85	7.46	6.09	5.14
39	8.13	7.99	7.85	7.42	6.10	5.03
40	8.13	7.99	7.85	7.39	5.99	5.01
41	8.13	7.99	7.84	7.36	5.99	4.92
42	8.13	7.99	7.84	7.32	5.89	4.89
43	8.13	7.99	7.83	7.29	5.89	4.81
44	8.12	7.99	7.83	7.26	5.80	4.78
45	8.12	7.99	7.82	7.22	5.79	4.71
46	8.12	7.99	7.81	7.19	5.71	4.68
47	8.12	7.99	7.80	7.16	5.70	4.62
48	8.12	7.99	7.79	7.12	5.63	4.58
49	8.12	7.99	7.78	7.09	5.61	4.53

TABLE A-1. HALON 1211 DIFFUSION MODEL OUTPUT (CONTINUED).

	Concentration v/v Halon 1211					
Time,	Nozzle No.					
s	1	2	3	4	5	6
50	8.12	7.99	7.77	7.06	5.55	4.49
51	8.11	7.99	7.76	7.03	5.53	4.44
52	8.11	7.99	7.74	7.00	5.47	4.41
53	8.11	7.99	7.73	6.96	5.45	4.36
54	8.11	7.98	7.72	6.93	5.40	4.33
55	8.11	7.98	7.71	6.90	5.38	4.28
56	8.11	7.98	7.69	6.87	5.33	4.25
57	8.11	7.98	7.68	6.84	5.30	4.21
58	8.11	7.98	7.66	6.81	5.26	4.18
59	8.11	7.98	7.65	6.78	5.24	4.14
60	8.10	7.97	7.63	6.75	5.19	4.11
61	8.10	7.97	7.62	6.72	5.17	4.08
62	8.10	7.97	7.60	6.70	5.13	4.05
63	8.10	7.96	7.58	6.67	5.11	4.02
64	8.10	7.96	7.57	6.64	5.07	3.99
65	8.10	7.96	7.55	6.61	5.05	3.96
66	8.10	7.95	7.54	6.58	5.01	3.93
67	8.10	7.95	7.52	6.56	4.99	3.90
68	8.09	7.94	7.50	6.53	4.96	3.87
69	8.09	7.94	7.49	6.50	4.93	3.85
70	8.09	7.93	7.47	6.48	4.90	3.82
71	8.09	7.93	7.45	6.45	4.88	3.79
72	8.09	7.92	7.44	6.43	4.85	3.77
73	8.09	7.91	7.42	6.40	4.83	3.74
74	8.09	7.91	7.40	6.38	4.80	3.72
75	8.08	7.90	7.38	6.35	4.78	3.70
76	8.08	7.89	7.37	6.33	4.75	3.67
77	8.08	7.89	7.35	6.30	4.73	3.65
78	8.08	7.88	7.33	6.28	4.70	3.63
79	8.08	7.87	7.32	6.26	4.68	3.61
80	8.08	7.86	7.30	6.23	4.66	3.58
81	8.07	7.86	7.28	6.21	4.64	3.56

TABLE A-1. HALON 1211 DIFFUSION MODEL OUTPUT (CONTINUED).

	Concentration v/v Halon 1211					
Time,	Nozzle No.					
s	1	2	3	4	5	6
82	8.07	7.85	7.26	6.19	4.62	3.54
83	8.07	7.84	7.25	6.17	4.59	3.52
84	8.07	7.83	7.23	6.14	4.57	3.50
85	8.06	7.82	7.21	6.12	4.55	3.48
86	8.06	7.81	7.20	6.10	4.53	3.46
87	8.06	7.81	7.18	6.08	4.51	3.44
88	8.06	7.80	7.16	6.06	4.49	3.43
89	8.05	7.79	7.15	6.04	4.47	3.41
90	8.05	7.78	7.13	6.02	4.45	3.39
91	8.05	7.77	7.11	6.00	4.43	3.37
92	8.04	7.76	7.10	5.98	4.41	3.36
93	8.04	7.75	7.08	5.96	4.40	3.34
94	8.04	7.74	7.06	5.94	4.38	3.32
95	8.03	7.73	7.05	5.92	4.36	3.31
96	8.03	7.72	7.03	5.90	4.34	3.29
97	8.02	7.71	7.02	5.88	4.32	3.27
98	8.02	7.70	7.00	5.86	4.31	3.26
99	8.01	7.69	6.98	5.84	4.29	3.24
100	8.01	7.68	6.97	5.82	4.27	3.23
101	8.01	7.67	6.95	5.80	4.26	3.21
102	8.00	7.66	6.94	5.79	4.24	3.20
103	8.00	7.65	6.92	5.77	4.22	3.18
104	7.99	7.64	6.91	5.75	4.21	3.17
105	7.99	7.63	6.89	5.73	4.19	3.16
106	7.98	7.62	6.87	5.71	4.18	3.14
107	7.98	7.61	6.86	5.70	4.16	3.13
108	7.97	7.60	6.84	5.68	4.15	3.12
109	7.96	7.59	6.83	5.66	4.13	3.10
110	7.96	7.58	6.81	5.65	4.12	3.09
111	7.95	7.57	6.80	5.63	4.10	3.08
112	7.95	7.56	6.78	5.61	4.09	3.06
113	7.94	7.54	6.77	5.60	4.07	3.05

TABLE A-1. HALON 1211 DIFFUSION MODEL OUTPUT (CONTINUED).

Concentration v/v Halon 1211						
Time,	Nozzle No.					
s	1	2	3	4	5	6
114	7.93	7.53	6.75	5.58	4.06	3.04
115	7.93	7.52	6.74	5.57	4.05	3.03
116	7.92	7.51	6.72	5.55	4.03	3.01
117	7.91	7.50	6.71	5.53	4.02	3.00
118	7.91	7.49	6.69	5.52	4.01	2.99
119	7.90	7.48	6.68	5.50	3.99	2.98
120	7.89	7.47	6.67	5.49	3.98	2.97
121	7.89	7.46	6.65	5.47	3.97	2.96
122	7.88	7.45	6.64	5.46	3.95	2.95
123	7.87	7.44	6.62	5.44	3.94	2.94
124	7.87	7.42	6.61	5.43	3.93	2.92
125	7.86	7.41	6.60	5.41	3.92	2.91
126	7.85	7.40	6.58	5.40	3.90	2.90
127	7.84	7.39	6.57	5.39	3.89	2.89
128	7.84	7.38	6.55	5.37	3.88	2.88
129	7.83	7.37	6.54	5.36	3.87	2.87
130	7.82	7.36	6.53	5.34	3.86	2.86
131	7.81	7.35	6.51	5.33	3.85	2.85
132	7.80	7.34	6.50	5.32	3.83	2.84
133	7.79	7.32	6.49	5.30	3.82	2.83
134	7.79	7.31	6.47	5.29	3.81	2.82
135	7.78	7.30	6.46	5.28	3.80	2.81
136	7.77	7.29	6.45	5.26	3.79	2.80
137	7.76	7.28	6.43	5.25	3.78	2.80
138	7.75	7.27	6.42	5.24	3.77	2.79
139	7.74	7.26	6.41	5.22	3.76	2.78
140	7.74	7.25	6.39	5.21	3.75	2.77
141	7.73	7.24	6.38	5.20	3.74	2.76
142	7.72	7.22	6.37	5.18	3.73	2.75
143	7.71	7.21	6.36	5.17	3.71	2.74
144	7.70	7.20	6.34	5.16	3.70	2.73
145	7.69	7.19	6.33	5.15	3.69	2.73

TABLE A-1. HALON 1211 DIFFUSION MODEL OUTPUT (CONCLUDED).

Concentration v/v Halon 1211						
Time,	Nozzle No.					
s	1	2	3	4	5	6
146	7.68	7.18	6.32	5.14	3.68	2.72
147	7.67	7.17	6.31	5.12	3.67	2.71
148	7.66	7.16	6.29	5.11	3.66	2.70
149	7.65	7.15	6.28	5.10	3.66	2.69
150	7.64	7.14	6.27	5.09	3.65	2.68

HALON 1211 REQUIREMENTS MODEL

```
c The purpose of this program is to determine the Halon 1211
c discharge rate necessary to obtain a specific concentration
c of agent in an aircraft within a specific period of time.
c The current configuration of the program represents the situation
c of a C-130 aircraft with the personnel door open.  Algorithms
c for this code were obtained from the NFPA NFC No. 12B.
c
c
c    NMERI/APT   1986   Ric Calhoun
c
c
c
      dimension r(50),c(50)
      character*64 outfile
      write (*,7)
c Note: The Output file for this program is called "DUMP"
7     format(' Enter The Name Of The Output File: (dump) ' )
      read(*,'(a)') outfile
      open (4,file=outfile)
c
c x=The Halon 1211 discharge rate
      x=10.0
c
c S=Specific Volume of Halon 1211 at 70 deg. F.
      s=2.248
c
c v=Volume of the aircraft
      v=5000.0
c
c del=The desired accuracy of the calculation
      del=0.005
c
c it=The time at which the desired halon concentration should
c    be achieved.
      it=10
```

```
c
c con=The desired Halon 1211 concentration
       con=5.0
c
c h=The height of the aircrafts open door.
       h=5.00
c
c wi=The width of the aircrafts open door
       wi=2.80
c
c ww=The total amount of Halon 1211 that remains inside the aircraft.
       ww=0.0
c
c iflag=The number of iterations that the program has done.
       iflag=0
c
c jflag=This limits the number of iterations of the program.
c      By increasing this quantity, the program will run longer.
       jflag=1000
c
c
50          do 100 i=1,it,1
            ww=ww+x
c
c cc=The concentration of the Halon 1211 inside the aircraft.
            cc=(100.0*ww*s)/(v+ww*s)
c
c r(i)=The diffusion rate of Halon 1211 out of the aircraft.
            r(i)=0.00145*(h**1.53)*(cc**1.51)*wi
            ww=ww-r(i)
            c(i)=(100.0*ww*s)/(v+ww*s)
100         continue
c
```

```
c
      a=abs(c(it)-con)
      if(a.lt.del)go to 200
      if(c(it).lt.con) x=1.5*x
      if(c(it).gt.con) x=0.5*x
      iflag=iflag+1
      ww=0.0
      if(iflag.gt.jflag) go to 150
      go to 50
c
c
150   write(4,175)jflag
175   format(1x,'"iflag" must be increased')
200   write(4,250)x
250   format(1x,'Halon Discharge Rate =',f6.3,/,/)
      write(4,300)
300   format(1x,'Time',3x,'Concentration',3x,'Diffusion Rate',/)
      write(4,350)(i,c(i),r(i),i=1,it,1)
350   format(3x,i2,6x,f5.3,13x,f6.3)
c
c
      stop
      end
```

TABLE A-2. HALON 1211 DISCHARGE REQUIREMENTS

Time, s	Concentration v/v	Diffusion rate, lb/s
1	0.534	0.018
2	1.060	0.052
3	1.579	0.095
4	2.091	0.146
5	2.594	0.202
6	3.090	0.263
7	3.579	0.329
8	4.059	0.398
9	4.532	0.470
10	4.997	0.544

Note: Halon Discharge Rate =11.951

Table A-3 contains the corrected data for Channel A and B from the Perco Analyzer collected during a dump test of 142 pounds of Halon 1211 in a C-131 aircraft. These data represent the halon concentration in cell 5, 18 inches from the ceiling of the aircraft (See Figure 7).

TABLE A-3. PERCO ANALYZER TEST 1 DATA.

Time, s	Channel A Concentration, %	Channel B Concentration, %
5	0.252	0.758
10	2.400	3.281
15	4.886	6.729
20	5.424	9.997
25	8.060	11.36
30	8.913	11.70
35	8.853	11.94
40	8.683	12.29
45	8.414	12.17
50	7.809	11.32
55	6.796	10.28
60	5.958	9.580
65	5.298	8.409
70	4.766	7.489
75	4.101	6.868
80	3.681	6.235
85	3.523	5.834
90	3.089	5.302
95	2.885	4.496
100	2.569	4.079
105	2.235	3.934
110	1.781	3.631
115	1.708	3.366
120	1.644	3.105
125	1.547	2.965
130	1.445	2.821
135	1.341	2.603
140	1.236	2.483

TABLE A-3. PERCO ANALYZER TEST 1 DATA (CONCLUDED).

Time, s	Channel A Concentration, %	Channel B Concentration, %
145	1.193	2.164
150	1.148	2.066
155	1.035	1.981
160	1.015	1.880
165	1.000	1.712
170	0.976	1.670

TABLE A-4. SAMPLE BOTTLE TEST 1 DATA.

Sample label	Concentration, percent volume
2B1	3.48
2B2	4.63
2B3	3.01
2C1	10.85
2C2	10.41
2C3	1.52
5C2	3.09
5C3	1.99

Sample Label--2B1 where: 2--Cell the sample was taken from (Figure 7).

B--Elevation of sample.

Note: A-18 inches from ceiling of aircraft.

B-Between locations A and C.

C-18 inches from floor of aircraft.

1--Time at which the sample was taken.

Note: 1-Five seconds after discharge.

2-Thirty-five seconds after discharge.

3-Sixty-five seconds after discharge.

APPENDIX B

AFS SYSTEM COMPONENTS

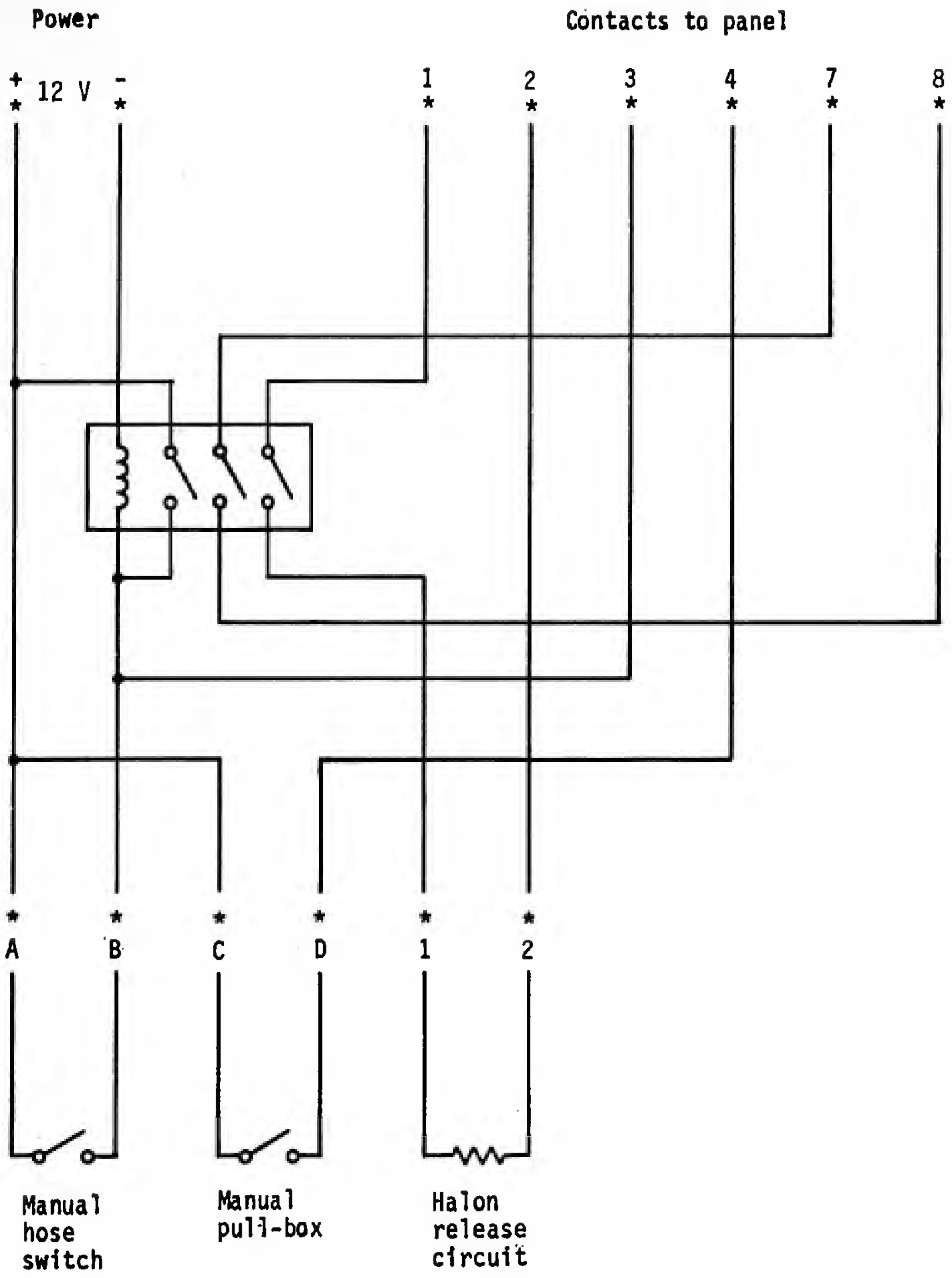
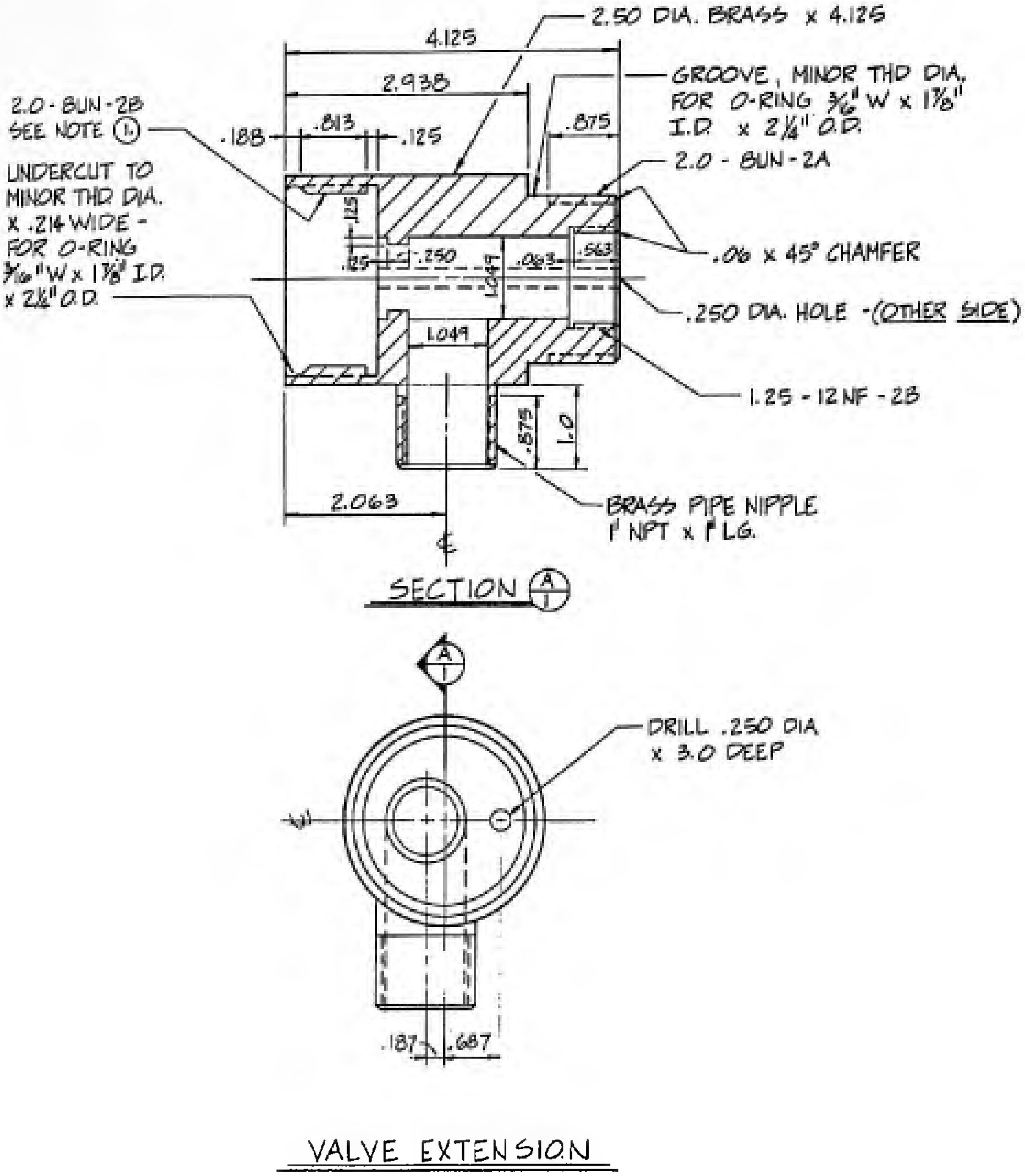


Figure B-1. Relay Card Schematic.



NOTES:

- (1.) BEGIN & END THREADS TO ALLOW FOR PROPER ORIENTATION OF EXISTING VALVE ("AMEREX CORP." DWG NO. 03550).
- DEBURR & CLEAN CHIPS FROM VALVE.

Figure B-2. Valve Extension.

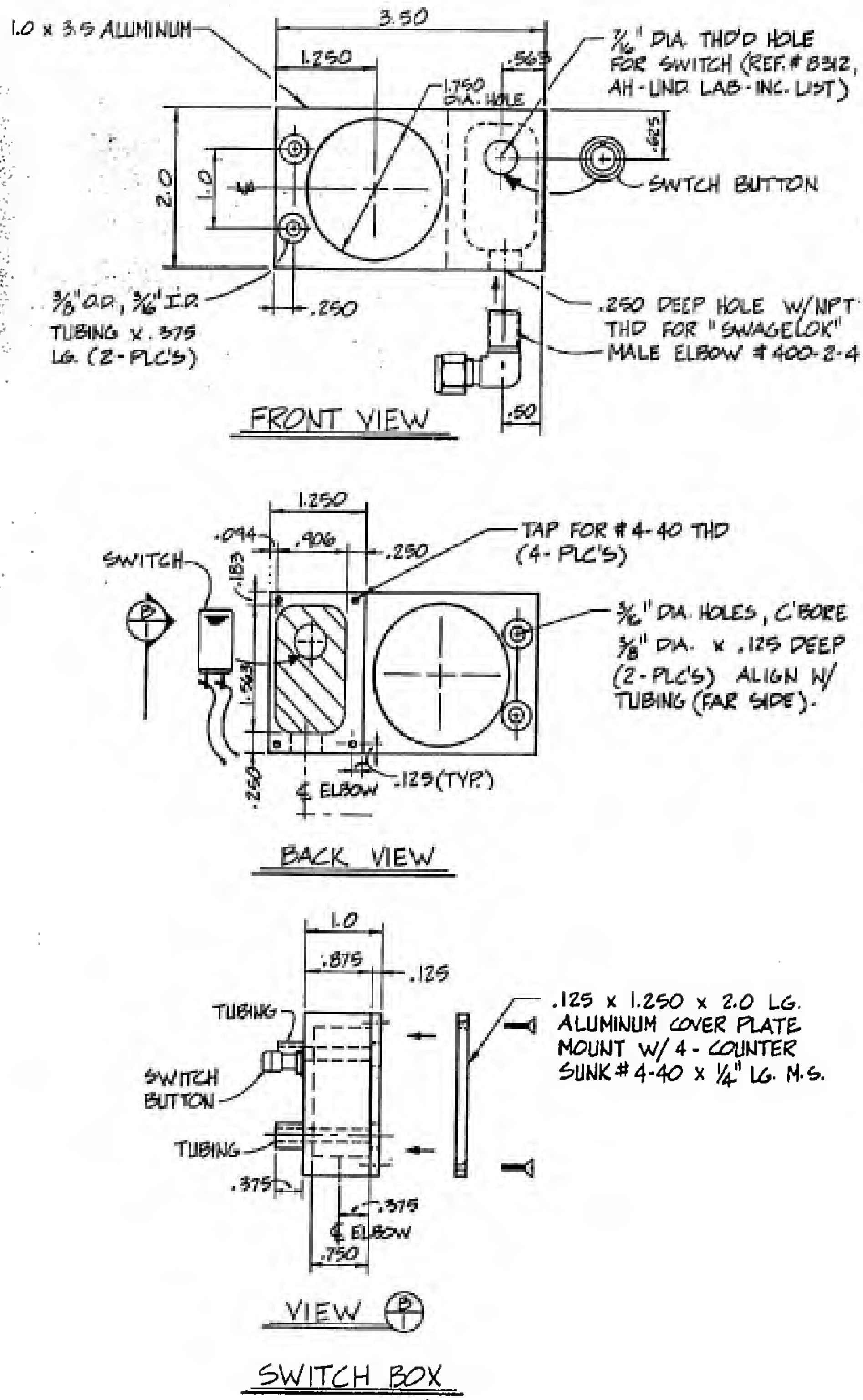


Figure B-3. Switch Box.

APPENDIX C
RADIO TRANSMITTERS

Many bases use an RF signal system in conjunction with facility security and fire alarms. The RF transmitter used with the AFS system will be required to interface with signaling systems. Three such RF signaling systems are manufactured by Ademco, Monaco, and King-Fisher. Information on each of these systems is included below. Other systems could be used with the AFS system; however, it is impractical to include information on all applicable systems.

The descriptions below are partial quotes from information provided by the manufacturer (Reference C-1).

A. ADEMCO, NO. 7620 REMOTE SUBSCRIBER EQUIPMENT

--Operates on installer's exclusive 900-MHz channel.

--May be backed up by redundant phone line.

--12 VDC (volts direct current) power or powered by AC transformer with battery backup.

--Fully compatible with existing installations, including all of Ademco's popular control panels.

--Supervision via periodic automatic status report.

--Automatic low battery report.

--Uses Ademco High Speed Report Format for compatibility with Ademco's No. 685 Receiver.

--Incorporates Ademco communicator features, including: delay, inverted operation, restore--all by channel and open/close reporting.

--Selectable status report periodicity for various levels of security.

--Rapid transmission of alarms.

--Microprocessor-based with built-in self test diagnostics.

--All options PROM programmable, no jumpers insert or cut.

--Crystal-controlled transmitter for truly stable operation.

--Inexpensive compared to competitive transmitters.

True eight-channel long range radio communicator with separate test channel. 12 VDC powered or powered from built-in power supply for use with an external transformer. Tandem radio and phone line operation provides higher security. Supervision achieved via periodic status messages.

PROM-defined option selections by channel: inverted channel input (trigger on "low"), 16-second delay, open/close report, zone restoral report. Alarm is transmitted multiple times to assure reception. Thirteen-digit alarm and status message. Activated by 4.5-14.5 VDC input, dry closure application or removal. Built-in LEDs indicate transmission and AC operation. The Ademco No. 7620 Remote Subscriber Equipment is that part of the 7600 alarm communication system that provides the radio link between the subscriber and the central station. By converting incoming alarm messages into a radio signal, the No. 7620 enables the alarm control to communicate with the monitoring agency. The No. 7620 equipment consists of the No. 7621 Transmitter Interface, the FCC approved No. 7622 Transmitter and the No. 7625 Antenna.

The No. 7621 Transmitter Interface converts individual parallel input triggers into a serial data message and is located between the alarm control and the transmitter. It may be powered from a standard Ademco 16 VAC (volts alternating current) secondary plug-in transformer with a battery backup or may, as an alternative, receive 12 VDC power directly form the alarm control (the presence of power is indicated by a green LED on the P.C. board). Each interface channel is activated by a 4.5-14.5 VDC input, a dry closure application or removal. Upon receiving an alarm input from the alarm control, the transmitter interface is then activated. After a selectable 150-millisecond or 16-second delay, the interface processes the incoming alarm and then switches on the transmitter.

The No. 7622 Long Range Radio Transmitter is a crystal-controlled FCC listed, FM transmitting device which transmits the signal between the subscriber site and the master site antenna. Generally mounted indoors (or outdoors for remote locations), the No. 7622 receives its power from the No. 7621 Transmitter Interface. Upon being activated, the transmitter sends the signal to the master site antenna via the No. 7625 Antenna. The No. 7622 is constantly monitored by the No. 7621, in case the No. 7622 fails by continuing to transmit constantly.

The No. 7625 Antenna is an omnidirectional antenna which can be mounted indoors, connected directly to the transmitter, or outdoors, using preassembled coaxial cable.

The system sends both alarm and status messages. Alarm messages signal zone fault situations and/or battery failure. Status messages periodically notify the central station of system operational fitness. The alarm message is sent to the master site antenna on a carrier frequency of 928 MHz. Each alarm message is repeated several times to ensure reception by the master site antenna, in spite of the ongoing "traffic" between other transmitters and the antenna master site. The alarm message consists of an account number, individual zones status messages and a battery status indicator.

The status message informs the central station that the system is functioning properly. Both the Status Timing and Reporting formats are programmed by the installer. When programmed to transmit in the short format, transmission may occur every 15 minutes, 30 minutes, 1 hour, 2 hours. The long format reports every hour, 6 hours, 8 hours, or 24 hours. The long format message includes the same information as the short format plus the status of the eight zones and an additional battery status message.

The signal is then received and stored by the master site, which is subsequently polled by the central station. The master site antenna then relays the message (on a carrier frequency of 952 MHz) to the central station. In order to facilitate the master site will record the number of transmissions received from the No. 7620, signal strength, frequency and modulation deviation and will transmit that information ot the Central Station upon request.

B. MONACO, BUILDING TRANSCEIVER BT2-3 (Reference C-2)

Monaco's Building Transceiver (BT2-3) provides the communication link between the local fire alarm system and the D-500 II central station CTR (Central Transmitter/Receiver). The BT2 detects alarm and trouble conditions on zone inputs from the protected area equipment and transmits coded signals identifying the condition and address to the CTR, In addition to zone input troubles, the BT2 monitors three internal operating conditions: low battery, AC power failure and tamper. If any of these conditions occur, a trouble signal will be transmitted. An alarm message is transmitted three times and a trouble message is transmitted twice. Upon completion of the alarm or trouble transmission, the BT2 automatically returns to normal scanning of zone inputs.

The BT2 also accepts and replies to supervisory interrogations from the CTR to ensure communication integrity. An interrogation cycle of all BT2's in a D-500 II ?System occurs automatically at intervals of one to 24 hours as programmed by the customer. A manual test of all BT2's or individual BT2's may be initiated at the CTR at any time.

The last in Monaco's line of Building Transceivers, the BT2-3 is microprocessor controlled. This allows more sophisticated monitoring and reporting capabilities. The "Features" list outlined these capabilities. This list is parallel to the list of features for the BT2-2 for easy comparison when deciding which model Building Transceiver meets your needs.

BT2-3 Features

--Provides VHF-FM radio link to eliminate expensive land lines.

--Provides alarm and trouble monitoring of up to 5 zones.

--Each zone may be selected for fire or security reporting.

--Selectable 2 to 15 second transmission delay.

--Zone and transceiver are customer addressable.

--Enclosure tamper, low battery and AC power failure are monitored and reported with the BT2 address.

--Transmission of AC fail trouble may be inhibited to prevent multiple trouble reports.

--LED's identifying tamper, low battery, AC fail and zone alarm and trouble conditions.

--Remote test or auxiliary function relay built in.

--Test and reset switches aid in installation and maintenance.

--Continued operation with a single ground fault and the fault is reported as a trouble.

--Integral backup battery provides for up to 24 hours of operation n case of AC power failure.

--On board battery charger.

--4 watts RF output power.

--Microprocessor controlled.

--Diagnostic tests included in software to assist maintenance personnel.

--Carrier detect prevents simultaneous from several BT2s.

--Transmits "return to normal" messages for zone alarm and troubles.

--Provides current status reply to specific BT2 test call.

--Selectable 115 or 230 VAC input.

C. KING-FISHER, RADIO ALARM TRANSMITTERS (Reference C-3)

The solid state electronic circuitry modules are interchangeable between all King-Fisher call box transmitter housings, including the King-Fisher combination transmitter/interface enclosure.

All King-Fisher radio box transmitters can transmit Fire, Police, Road Aid, Medical Aid, etc. As many as 10 different types of messages, including a test message, are possible. The specific emergency message to be transmitted can be either through selection of the push button labeled with that particular emergency (Fire, Police, Medical Aid, etc.) and/or automatically through the King-Fisher radio master box circuitry which is programmed to automatically transmit any preprogrammed message. A wide variety of specific emergencies can be transmitted when the King-Fisher radio call box transmitter is connected to a King-Fisher radio interface panel.

The King-Fisher radio call box transmitter automatically transmits a low battery signal when the battery voltage in the call box (measured under transmission) drops below a specified limit. The average remaining life of the battery charge after a low battery signal is received is approximately 2 weeks.

The battery should be recharged every 6 months or less depending on climatic conditions. Recharging the radio call box transmitter is reduced to once a year when wired to King-Fisher radio interface panel. The interface panel has a built-in battery charger that can maintain a charge on the call box battery.

The test message is transmitted at least daily to verify that the King-Fisher radio call box transmitter is operational. The King-Fisher radio call box transmitter automatically transmits tamper/knockdown signals in the event of any abnormal tilting or knockdown of the call box. The tamper signal circuitry is dampened to eliminate false signals.

Features

--Self-contained long-life 12V rechargeable sealed lead acid batteries.

--Meets and exceeds N.F.P.A. 1221 and 72B.

--F.C.C. Type accepted.

--One-piece weatherproof cast metal housing.

--Automatic self-testing.

--AM tone.

--FM-FSK.

--Number assignment capacity up to six digits for 1,000,000 box numbers.

--CMOS components and 100 percent solid state circuitry.

--All electronics interchangeable.

--Tamper/Knockdown feature.

--Adjustable automatic low-battery signal.

--Adjustable automatic low battery shutoff.

--Clock-set button/Test button.

--Operating temperature range -40 F to +140 F (-40 C to +60 C).

--Transmitter frequency range: 72-76 MHz, 138-174 MHz (Gov. Use Only).

REFERENCES

C-1 Ademco Brochure No. 7620, **Ademco Long Range Radio Remote Subscriber Equipment**, 165 Eileen Way, Syosset, NY 11791.

C-2 Monaco Enterprises, Inc., **Equipment Catalog, D863,** P.O. Box 141 Spokane, WA 99214.

C-3 King-Fisher Co. Brochure, **Radio Transmitters (Boxes)**, 2350 Foster Ave., Wheeling, IL 60090-6574.

APPENDIX D

SAMPLE CALCULATIONS FOR HALON 1211 FLOOD SYSTEM

The series of calculations below describe the recommended method for designing a Halon 1211 total flood system as described in Reference 5. The properties are as follows:

1. Halon 1211 available - 150 pounds
2. Fill ratio of Halon 1211 cylinder - 52 percent
3. Overpressure of Halon 1211 cylinder - 220 lb/in^2
4. Average Halon 1211 liquid density - 114 lb/ft^3

Important equations necessary to design a Halon 1211 total flood system are as follows:

1. Flow through pipes.

$$h/L = (1.03+1.8D+9.0(D/R)^{0.25})(R^2/D^5)(10^{-3}) \qquad \text{(D-1)}$$

where

h = Pressure drop in lb/in^2.
L = Length of pipe in feet.
D = Internal diameter of pipe in inches.
R = Halon 1211 mass flow rate in lb/s.

2. Flow through nozzles.

$$G = C_d(2GrqP_n^{1/2}) \qquad \text{(D-2)}$$

where

G = Mass flow rate per unit area of nozzle orifice.
Gr = Gravitational Acceleration (Gr = 32.2 ft/s^2).
q = Density of liquid Halon 1211 (Use q = 0.79 lb/in^3).
P_n = Pressure of halon at the nozzle (30 lb/in^2 min).
C_d = Nozzle Discharge Coefficient (Use C = 0.30)

Experimental measurements were performed by Imperial Chemical Industries (ICI) on several types of nozzles. It was found that the flow could be represented by the above equation provided that the discharge coefficient was expressed as a function of the pressure ratio P_n/P_r where P_r is the total pressure in the storage vessel, and P_n is the pressure at the nozzle. C_d is an empirical quantity and must be determined independently for each nozzle. A more detailed description of this can be found in Reference 5. The example calculations shown use information found on the graphs contained within Reference 5. For type 'a' nozzles, C_d can be found from the equation: $\log(C_d) = 0.526 \log(P_n/P_r) - 0.070$

A. PROBLEM STATEMENT

Design a Halon 1211 distribution system for a fictitious C-130 aircraft with the dimensions: Width: 10.3 feet, Height: 9.2 feet, Length: 41 feet.

The following assumptions shall be used in the solution of the problem.

1. Assumptions

a. Assume that six nozzles will be used to disperse the Halon 1211.

b. Assume that 1-inch piping will be used throughout the aircraft for the halon distribution system.

c. Assume that the distribution system is a balanced system. In other words, the distribution system is composed of a primary header which is fed by a single supply line intersecting the header at its geometric center. The halon nozzles are located on the header and are equally spaced on either side of the supply line.

d. Assume that the nozzles used in the system perform in a fashion similar to type 'a' nozzles as described in Reference 5 with a 0.45-inch diameter orifice.

e. Assume that the system is to be designed to meet the minimum average delivery rate of 11.9 lb/s, per the data contained in Table A-2.

B. PROBLEM SOLUTION

See Figure D-1 for a graphic depiction of the proposed system.

Names: The Variables

- P - Pressure at a point.
- G - Nozzle time-mass flow rate.
- W - Nozzle mass flow rate.
- h - Pressure head loss between nozzles.

Calculate the mass flow rate and pressure loss in pipe section b-a.

P_a = 30 lb/in

From Figure A-6b of Reference 5: G_2 = 12.3 lb/in^2-s

A = Area of orifice. A = 0.159 in^2

W_a = Discharge through each nozzle = G x A = 1.96 lb/s

From Figure A-2b of Reference 5: h/L = 0.040 lb/in^2-ft

L_{a-b} = 7 feet

h_{b-a} = (0.058)(7) = 0.28 lb/in^2

Calculate the mass flow rate and pressure loss in pipe section c-b.

$P_b = P_a + h_{a-b}$ = 30.28 lb/in^2

G_b = 12.4 lb/in^2-s

W_b = (12.5)(0.159) = 1.97 lb/s

$W_{Total} = W_a + W_b$ = 3.93 lb/s

h/L = 0.15 lb/in^2-ft

L = 7 feet

h_{c-b} = (0.15)(7) = 1.05 lb/in^2

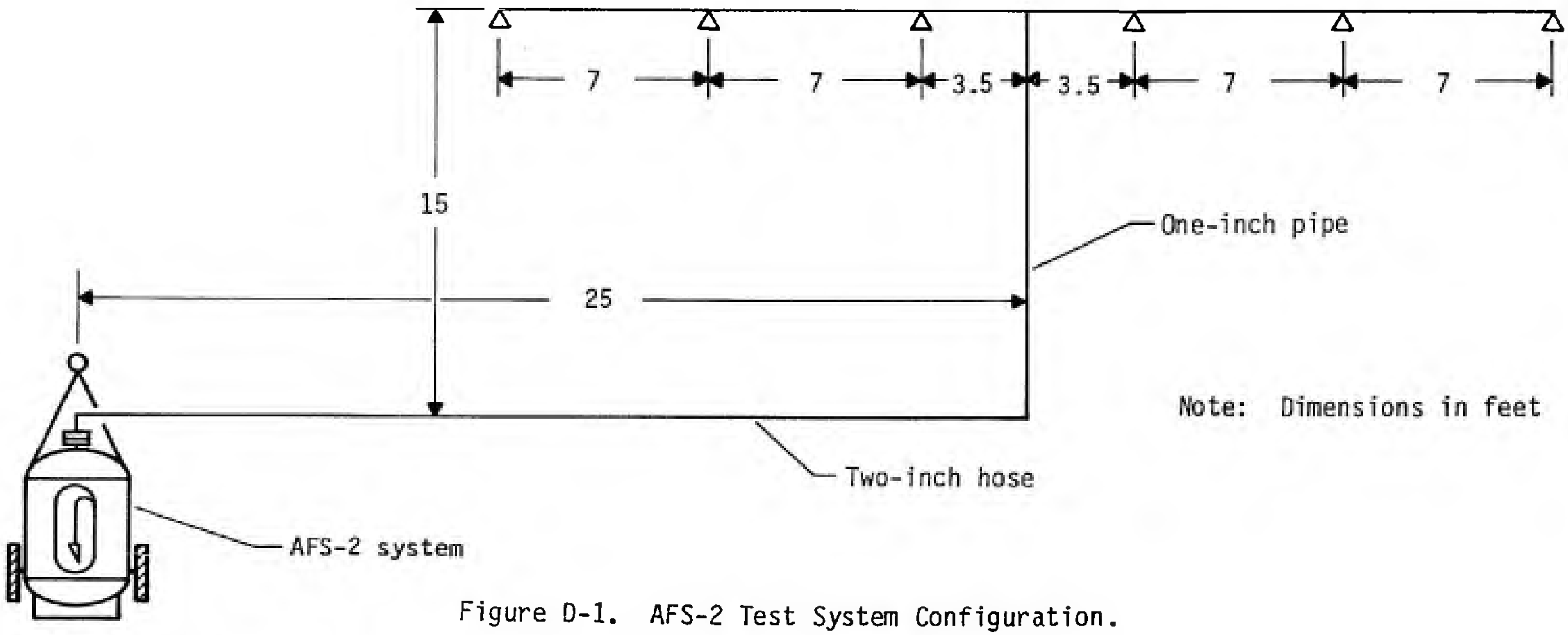


Figure D-1. AFS-2 Test System Configuration.

Calculate the mass flow rate and pressure loss in pipe section d-c.

$$P_c = P_b + h_{c-b} = 31.3 \text{ lb/in}^2$$

$$G_c = 12.8 \text{ lb/in}^2\text{-s}$$
$$W_c = (12.8)(0.159) = 2.03 \text{ lb/s}$$
$$W_{Total} = W_a + W_b + W_c = 5.96 \text{ lb/s}$$

$$h/L = 0.30 \text{ lb/in}^2\text{-ft}$$
$$L = 3.5 \text{ feet}$$
$$h_{d-c} = (3.5)(0.30) = 1.05 \text{ lb/in}^2$$
$$P_d = P_c + h_{d-c} = 32.4 \text{ lb/in}^2$$

The halon distribution system is a balanced system; therefore, it can be assumed that the second half of the system performs exactly like the first half. Consequently, the total mass flow rate of halon into the distribution system header is $W = 2 \times W_{Total} = 11.9$ lb/s

The feeder which supplies the header with halon is made of 1-inch hose which is 15 feet long. Determine the minimum pressure required by the halon distribution system at the aircraft connection?

$$h/L = 1.1 \text{ lb/in}^2\text{-ft}$$
$$L = 15 \text{ feet}$$
$$h_{e-d} = (1.1)(15) = 16.5 \text{ lb/in}^2$$

Elevation Change: $P_{el} = (12 \text{ feet})(114 \text{ lb/ft}^3)(144 \text{ in}^2/\text{ft}^2) = 9.5 \text{ lb/in}^2$

$$P_e = P_d + h_{e-d} + P_{el} = 58.4 \text{ lb/in}^2$$

The hose which transports the Halon 1211 from the portable system to the aircraft is a 1 1/2-inch hose which is 25 feet long.

$$h/L = 0.18 \text{ lb/in}^2\text{-ft}$$
$$L = 25 \text{ feet}$$
$$h_{f-e} = 4.5 \text{ lb/in}^2$$
$$P_f = P_e + h_{f-e} = 62.9 \text{ lb/in}^2$$

The major sources of head loss for the AFS discharge are:

1. Entrance losses at the dip tube.
2. Friction losses in the dip tube.
3. Friction losses due to valves and hardware.
4. Friction losses in the hose which transports the halon from the AFS system to the aircraft.

Each of theses sources of head loss are examined in detail below.

1. Entrance losses at the dip tube.

Equation: $h = \frac{KV^2}{4.62G}$ (D-3)

where

K = Loss Coefficient ($K = 1$)
V = Average Fluid Velocity ($V = 19.1$ ft/s)
G = Gravitational Acceleration ($G = 32.2$ ft/s^2)
Sg = Specific Gravity of Halon 1211 Liquid (Water = 1)
(Halon 1211 $Sg = 1.82$)
$h_{(1)} = 4.5$ lb/in^2

2. Friction losses in the dip tube.

Equation: $h = (p/L)L$
Dip Tube Length: $L = 30$ inches.
Mass Flow Rate: $q = 12$ lb/sec.
$h/L = 1.1$ lb/in^2-ft
$h_{(2)} = 2.75$ lb/in^2

3. Friction losses due to valves and hardware.

Equation: $h = \frac{KV^2Sg}{4.62G}$

where:

K = Loss Coefficient ($K = 3$)

V = Average Fluid Velocity ($V = 19.1$ ft/s)

G = Gravitational Acceleration ($G = 32.2$ ft/s^2)

Sg = Specific Gravity of Halon 1211 Liquid (Halon 1211 $Sg = 1.82$)

$h_{(3)} = 13.4$ lb/in^2

Total head loss for the AFS system is the sum of all the head losses:

$$h_{(AFS)} = h_{(1)} + h_{(2)} + h_{(3)} = 20.6 \text{ lb/in}^2$$
$$P_{Total} = P_f + h_{Total} = 83.5 \text{ lb/in}^2$$

The minimum nitrogen over-pressure required to push the halon through the system has been determined to be 83.5 lb/in^2. The pressure of the system after the liquid halon has been dispensed must be equal to, or greater than this pressure. The final pressure of the system can be determined by the relationship, PV = Constant. Note the following:

Cylinder Volume (empty): $V_i = 4300$ in^3 (D-4)

Volume of hose: $V_h = 530$ in^3

Volume of empty piping: $V_p = 207$ lb/in^2

System Volume: $V_s = V_i + V_h + V_p = 5037$ in^3

System Fill Ratio: r = 52 percent

System Over-pressure: $P_i = 220$ lb/in^2

Design Pressure: $P_f = \dfrac{(1-r)V_i P_i}{V_s} = 90$ lb/in^2

This same set of calculations was done with different minimum nozzle pressures to arrive at the following data:

TABLE D-1. DISCHARGE RATES IN AN EXAMPLE AIRCRAFT.

Gage pressure, lb/in^2(gage)	Discharge rate, lb/s	Abs. pressure lb/in^2 (abs)	Discharge rate, ft^3/s
83.5	11.9	98.2	0.1044
124.5	16.0	139.2	0.1404
238.0	24.5	252.7	0.2150

The absolute pressure inside the halon reservoir and the volumetric discharge rate of the halon can be used to obtain an algorithm which describes the pressure in the tank as a function of amount of halon that has been discharged. The algorithm for the above data is:

$$R = -1.358x10^{-3} + 1.2173x10^{-3}P - 1.429x10^{-6}P^2 \qquad (D-5)$$

where

R--Total discharge rate of Halon 1211
P--Absolute pressure in the halon cylinder

The volume of the vapor above the liquid halon at the beginning of the discharge is the sum of the vapor volume in the halon tank before the discharge plus the volume of all the hoses and piping.

Volume of vapor space above liquid halon:	1.1944 ft^3
Volume of all hose and piping:	0.5795 ft^3
Total	1.7740 ft^3

The pressure in the halon cylinder at the beginning of the halon discharge can be found from the relationship PV = Constant, e.g.;

$$P = (1.1944/1.7740)(220 + 14.7) = 158\ \text{lb/in}^2\text{(abs)}$$

By using Equation (D-1), the discharge rate of the system with the above pressure can be determined. This logic can be continued to produce the following table.

TABLE D-2. DISCHARGE TIME FOR THE EXAMPLE SYSTEM.[a]

Time, s	Vapor volume, ft^3	Reservoir pressure, lb/in^2 (abs)	Discharge rate, lb/s
0	1.774	158	0.155
1	1.929	145	0.145
2	2.075	135	0.137
3	2.212	127	0.130
4	2.342	119	0.124
5	2.466	114	0.119
6	2.584	108	0.114
7	2.698	104	0.110
8	2.808	100	0.106
9	2.914	96	0.103
10	3.016	93	0.099

[a] Discharge of the system is complete after 10 seconds.

APPENDIX E

DRAFT PURCHASE DESCRIPTION

FOR AN AUTOMATIC AIRCRAFT FIRE SUPPRESSION SYSTEM

1. SCOPE

1.1 General.

This purchase description covers the details of an automatic fire suppression unit to be used in conjunction with wide-bodied aircraft while they are parked.

1.2 Equipment.

1.2.1 The system shall include the following equipment:

(a) 150-Pound Wheeled, Liquified-Gas, Fire Extinguisher, Amerex Part 03496.
(b) Valve extension.
(c) Control Panel, and enclosure.
(d) Battery.
(e) Transmitter, crystal, and antenna.
(f) Strobe and Siren.
(g) Blow-out disk assembly.
(h) Switch box.
(i) Pull-box.
(j) Signal and power cable.
(k) Electrical connectors.
(l) Quick connect coupling, 2-inch.
(m) Hose, 2-inch, 30-foot long, rubber. 350 lb/in^2 rating.
(n) Associated piping and conduit.

1.2.2 The system shall not be supplied charged with agent.

1.3 Documentation.

1.3.1 Each system is to be furnished with the following documentation:

1.3.1.1 Technical Order for the base unit fire extinguisher, T.O. 13f4-4-121.

1.3.1.2 Technical Order for the control panel.

1.3.1.3 Technical Order for the rupture disk assembly.

1.3.1.4 Technical Order for the transmitter.

1.3.1.5 Complete system parts list.

2.0 APPLICABLE DOCUMENTS

2.1 Government documents. The following documents are intended to form a part of the specifications. Unless otherwise specified, the version in effect on the date of invitation for bids or request for proposal shall apply.

(a) Specifications, Military.

MIL-P-116	Preservation-Packaging, Methods of
MIL-B-38741	Bromochlorodifluoromethane, Technical
MIL-B-26195	Boxes, Wood-Cleated, Skidded, Load-Bearing Base
MIL-C-5015	Connectors, Electrical, Circular Threaded, an Type
MIL-E-46676 MU.	Flexible Explosive.
MIL-B-38741	Bromochlorodifluoromethane, Technical.

(b) Standards, Military.

MIL-STD-100	Engineering Drawings and Practices.
MIL-STD-129	Marking for Shipment and Storage.
MIL-STD-130	Identification Marking of U.S. Military Property.
MIL-STD-831	Test Reports, Preparation of
MIL-STD-889	Dissimilar Metals.
MIL-STD-1186	Cushioning, Anchoring, Bracing, Blocking and Waterproofing; with Appropriate Test Methods.
MIL-STD-810	Environmental Test Methods and Engineering Guidelines.

2.1.1 Source of government documents. Copies of Military Specifications and Standards required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contraction officer.

3.0 REQUIREMENTS

3.1 General.

3.1.1 Description. The Aircraft Fire Suppression system (referred to as the "system") described herein is designed to provide interior fire protection to specially outfitted military cargo aircraft. The system also fulfills aircraft requirements for the presence of local fire extinguishers. The system will provide power to a fire detection system installed aboard an aircraft, monitor contacts for closure on the detection system, and release 150-pounds of Halon 1211 into an aircraft through an installed distribution system following the alarm of the detection system. The detection system and halon distribution system installed in the protected aircraft are not part of this specification. Alarm of the detection system results in an RF transmitter sending a distress signal to the fire department with system specific location information. The system can also be used as a standard flight line fire extinguisher. When used manually, the system provides 150-pounds of Halon 1211 through a standard hose line, alerts local personnel of the emergency, and calls the fire department. Finally, a pull-box located on the system provides the ability for personnel to remotely call the fire department. The system is composed of five major components:

(a)	Extinguisher unit	3.2.3
(b)	Control panel	3.2.4
(c)	Peripheral devices and hardware	3.2.5
(d)	Transmitter	3.2.6
(e)	Automatic release mechanism	3.2.7

3.1.2 Agent requirements. Where specified, the agent shall be Bromochlorodifluoromethane (Halon 1211) conforming to the requirements of MIL-B-38741.

3.2 Salient characteristics.

3.2.1 Materials. Materials shall be as specified herein. Materials not specifically covered by this or applicable specifications shall be suitable in every respect and of good quality. Wood shall not be used in construction.

3.2.1.1 Metals. Unless otherwise specified herein, metal components of the system in contact with the agent shall be compatible with Halon 1211.

3.2.1.2 Dissimilar metals. Unless protected against electrolytic corrosion, dissimilar metals shall not be used in intimate contact with each other. Dissimilar metals are defined in MIL-STD-889.

3.2.1.3 Nonmetals. Nonmetal components of the system in contact with the agent shall be compatible with Halon 1211.

3.2.2 Design and construction. The system shall be so designed and constructed that parts will not work loose in service. It shall be inherently capable of with standing the stresses, jars, vibrations, and other conditions incident to shipping, storage, and usage and shall provide maximum ease and safety of operation.

3.2.2.1 Functional design. The system shall be designed to operate efficiently. Meters, gages, and switches shall be accessible or readable from a standing position. Storage for hoses and fittings shall be provided as an integral part of the system. The system shall be designed to be portable.

3.2.3 Extinguisher unit. The extinguisher unit shall consist of a 150-pound Halon 1211 Flightline fire extinguisher similar to the Amerex Wheeled Stored Pressure Halon 1211 Fire Extinguisher model 600.

3.2.3.1 Valve extension. A valve extension is required to provide a port through which the system can be discharged automatically. The valve extension shall be threaded such that the manual valve orientation does not obstruct the valve operation. When assembled, the port for the automatic discharge shall be located 90 degrees from the manual discharge port on the valve (Figures E-1 and E-2).

3.2.4 Control panel. The system control panel shall provide 12 VDC power to an installed aircraft fire detection system and monitor that detection system for alarm. Alarm of the aircraft fire detection system will be indicated by the closure of contracts. Upon alarm, the control panel shall cause the release of the systems fire suppression agent, and causes a strobe, siren, and transmitter to operate. The control panel shall continuously monitor itself, and all peripheral devices.

3.2.4.1 Control panel housing. The control panel housing shall be of a weather-proof design sufficiently large to contain the control panel, the transmitter, and the system batteries. The front exterior of the control panel shall accomodate two LEDs (normal and trouble operation), a keyed latch to prevent tampering with components, a keyed switch to turn the unit on, a test button to check for proper operation, a pull-box, a siren/strobe, and the transmitter antenna. The control panel shall also accomodate a protected abort switch and a protected discharge switch. The housing shall have dimensions no greater than the following: depth: 6-inches, width: 15-inches, height: 24-inches.

3.2.4.2 System power. The system shall function in a normal configuration on a 12 volt battery pack. Batteries used with the system shall be long-duration batteries capable of providing standby power for a continuous 90-day period. The batteries shall be housed in the control panel housing, and shall be packaged in such a fashion to assure correct battery polarity. The batteries shall be packaged in such a manner that they can be easily and quickly replaced. The control panel shall be constructed in such a way that the system can be operated on 120/240 VAC, 60/50 Hz power. Electrical leads are not to be furnished with the unit.

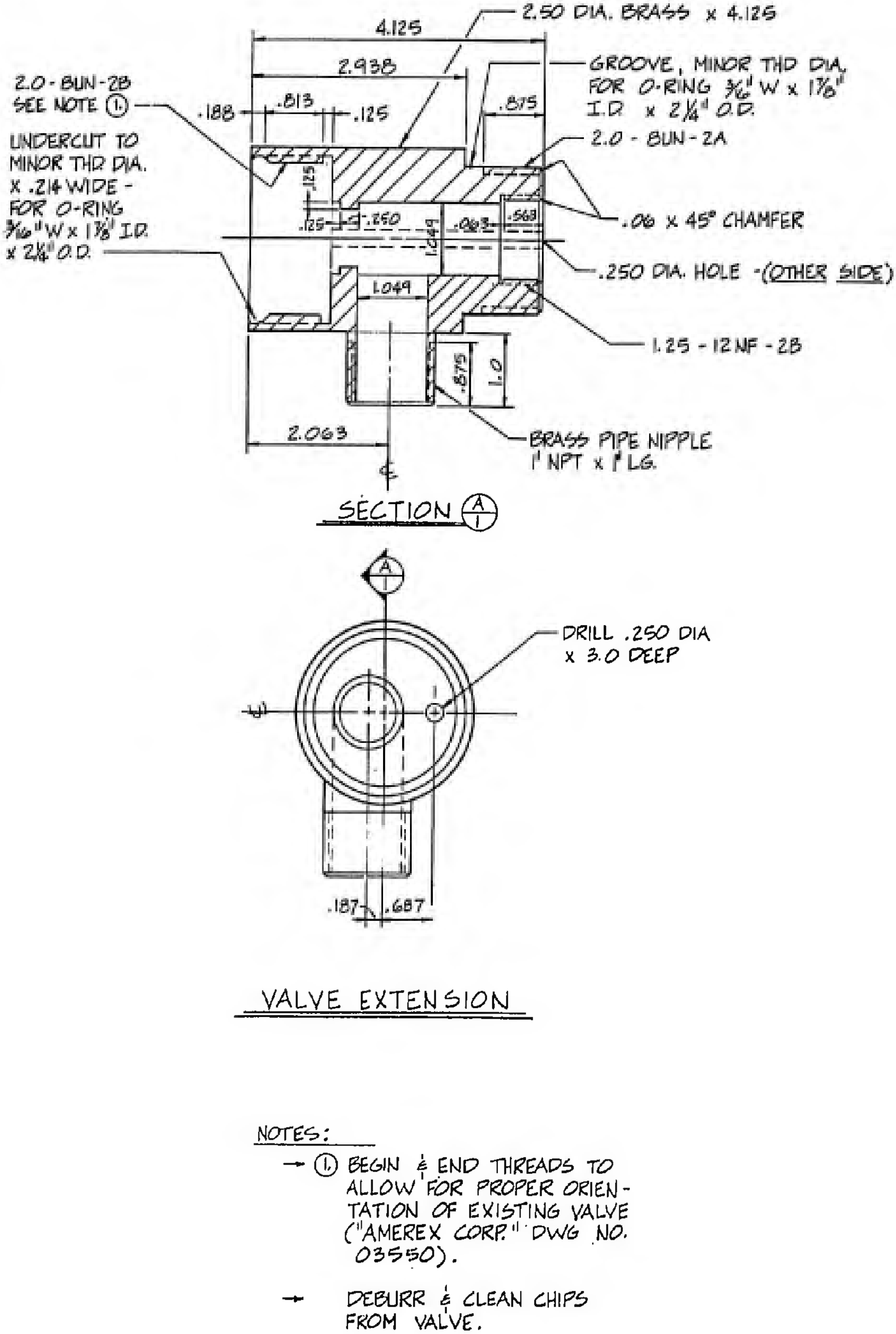


Figure E-1. Valve Extension.

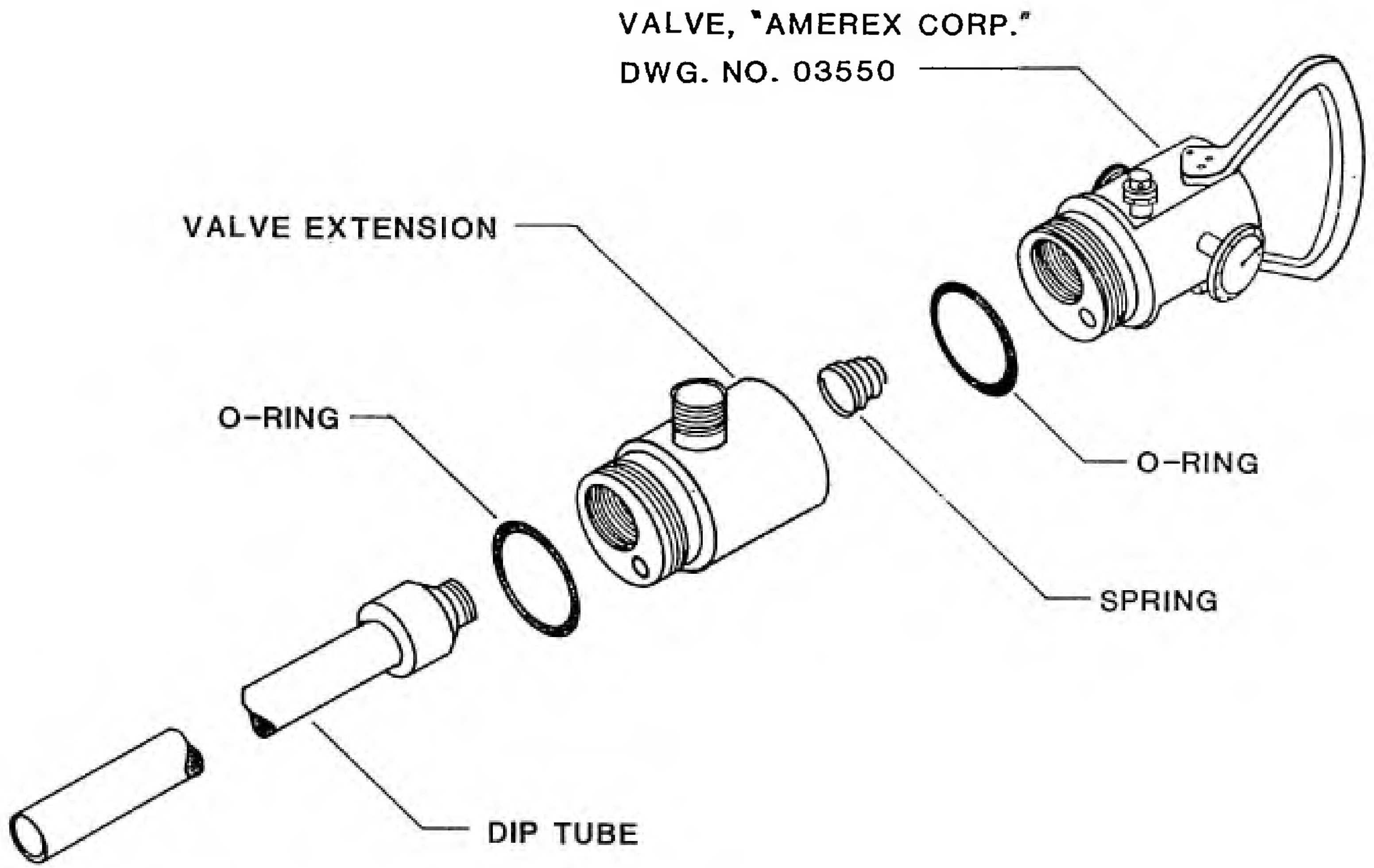


Figure E-2. Valve Extension Assembly.

3.2.4.3 Monitor internal circuits. The control panel shall be capable of monitoring the integrity of internal circuitry and attached wiring for short and open circuits. Panel faults shall not result in alarm of the system, or release of the agent from the system. Panel faults shall be indicated by a dedicated LED on the panel. The panel shall also monitor the power supply available, and indicate low power by illumination of a dedicated LED. Any fault associated with the panel or associated connections shall result in the closure of an accessible dry contract rated for 12 VDC at 3 amperes.

3.2.4.4 Detection circuit. The control panel shall be capable of providing 0.35 milliamperes of current to a fire detection system in a Class B, four wire configuration.

3.2.4.5 Agent discharge circuit. The control panel shall have the capability to provide 1 amperes of current through an agent release circuit to actuate a blow-out disk (see Section 3.2.7). This shall occur 15-seconds after the control panel has entered an alarm mode.

3.2.4.6 Discharge abort switch. The control panel shall include an easily accessible abort switch which can prevent automatic agent discharge irregardless of other actions taken to bring about automatic discharge of the system. This switch shall be clearly marked, and protected against accidental activation. Return of the abort switch to the normal position shall restore the system to a normal operating mode.

3.2.4.7 Manual discharge. An easily accessible switch shall be located on the exterior of the control panel which, when thrown, will discharge the contents of the system. This switch shall not have the capacity to override the system abort switch. This switch shall be clearly marked, and protected against accidental activation.

3.2.4.8 Activation of strobe/siren. Alarm of the control panel shall result in the operation of a dedicated circuit which provides power to a strobe and siren. This circuit shall provide 150 milliamperes of current at 12 VDC.

3.2.4.9 Transmitter operation. Alarm of the control panel shall result in the closure of a dry contact rated for 3 amperes at 12 VDC. This contact will be used in conjunction with the operation of an RF transmitter.

3.2.4.10 Manual hose line use. The control panel shall have a circuit which monitors the manual use of the system handline. Use of the handline will result in the closure of a switch which shall result in the activation of the systems siren, strobe, and transmitter. The control panel shall inhibit the automatic discharge of the system while the switch is closed.

3.2.4.11 System pull-box. Closure of a switch on a pull-box located on the exterior of the control panel shall cause the control panel to operate the siren, strobe, and transmitter. Closure of this switch shall not prevent the system from being used in either a manual or automatic mode.

3.2.5 Peripheral devices and hardware.

3.2.5.1 Siren. The siren used with the system shall operate on 12 VDC. The siren shall produce an audible signal of 92 dB at 10 feet (minimum) in an anechoic chamber.

3.2.5.2 Strobe. The strobe shall operate on 12 VDC. The strobe shall provide a minimum of 8,000 peak candlepower.

3.2.5.3 Pull-box. The pull-box used for the system shall be similar to the Fire-Lite model BG-10.

3.2.5.4 Electrical connectors. All external electrical connectors used on the system shall meet MIL-C-5015.

3.2.5.5 Detection circuit connector. The detection system connector shall be similar to Amphenol MS-3102/7-E-18-4-P/S.

3.2.5.6 Electrical and signal cable. Cabling used to connect the system and the protected aircraft shall be 4-conductor, 16-gauge stranded wire. It shall be a minimum of 30 feet long and similar to Columbia Number 09605.

3.2.5.7.Quick-disconnect. The system discharge fitting shall be a standard 2-inch quick-disconnect constructed of stainless steel. The fitting shall be of a type similar to Swagelok model QF-32-B-32PM.

3.2.5.8 Conduit. All conduit shall be seamless, stainless steel tubing.

3.2.5.9 Conduit connectors. All conduit connectors shall be compression type tubing connectors constructed of stainless steel.

3.2.5.10 Piping. Piping associated with the system may be either seamless carbon steel or seamless stainless steel rated for this application.

3.2.6 Transmitter. The system radio shall be an autonomous unit, but housed in the cabinet of the control panel. The transmitter shall be of a type which is intended for alarm system communications. The transmitter shall function with the existing RF alarm communication system currently used at the intended base of operation. The transmitter shall meet the following specifications:

3.2.6.1 Transmitter operation. The transmitter shall operate only when activated by the control panel. There shall be no current drain by the transmitter during normal operation of the system.

3.2.6.2 Power. The transmitter shall use 12 VDC power obtained from the control panel. During periods of transmission, the current draw shall not exceed 1.25 amperes.

3.2.6.3 Frequency. The frequency used by the transmitter shall be modulated by replaceable crystals. The transmitter shall operate between 902 MHz and 928 MHz, depending on the crystal installed in the transmitter, or compatible with the frequency assigned by the base frequency manager.

3.2.6.4 Tone. The transmitter shall broadcast a tone which can be altered in the field that uniquely identifies the system in alarm or trouble. These tones shall be altered through a dip-switch. Each system shall be capable of broadcasting a minimum of 100 unique tones.

3.2.6.5 Antenna. The transmitter antenna shall be no longer than 18 inches, and shall be an omnidirectional outdoor type.

3.2.7 Automatic release mechanism. The automatic release mechanism shall consist of an electrically actuated blow-out disk and associated piping and conduit. Additionally, this portion of the system includes a switch and switch box which monitor use of the manual hose line.

3.2.7.1 Blow-out disk detonator. The disk detonator shall not fire when subjected to a current of 0.2 amperes or less. The detonator shall have a minimum all-fire current of 0.6 amperes. The minimum electrical energy required for firing shall be 0.02 Joules using a 40 microfarad capacitor. The detonator shall adhere to MIL-E-46676 MU.

3.2.7.2 Blow-out disk. The blow-out disk assembly shall be composed of a stainless steel, nonfragmenting rupture disk housed in a factory sealed casing. The blow-out disk shall have a minimum ANSI rating of 300 lb/in^2.

3.2.7.3 Blow-out disk housing. The housing for the blow-out disk shall be factory sealed. It shall be composed of stainless steel. The housing shall have female threads on both ends. It shall be clearly marked as to its orientation.

3.2.7.4 Switch box. The switch box must be designed such that it will securely hold a momentary switch and protect the pressure gage mounted on the manual discharge valve from mechanical damage (see Figure E-3).

3.2.7.5 Manual use switch. The switch mounted in the enclosure described in 3.2.7.4 shall be a normally closed, momentary switch rated for outdoor service. It shall have a stoke sufficiently long to reliably monitor the operation of the manual discharge valve.

3.3 <u>Environmental requirements</u>.

3.3.1 Elevation. The system shall operate satisfactorily at all elevations ranging between sea level and 10,000 feet above sea level.

3.3.2 High temperature. According to method 501.2, MIL-STD-810.

3.3.3 Temperature shock. According to method 503.2, MIL-STD-810.

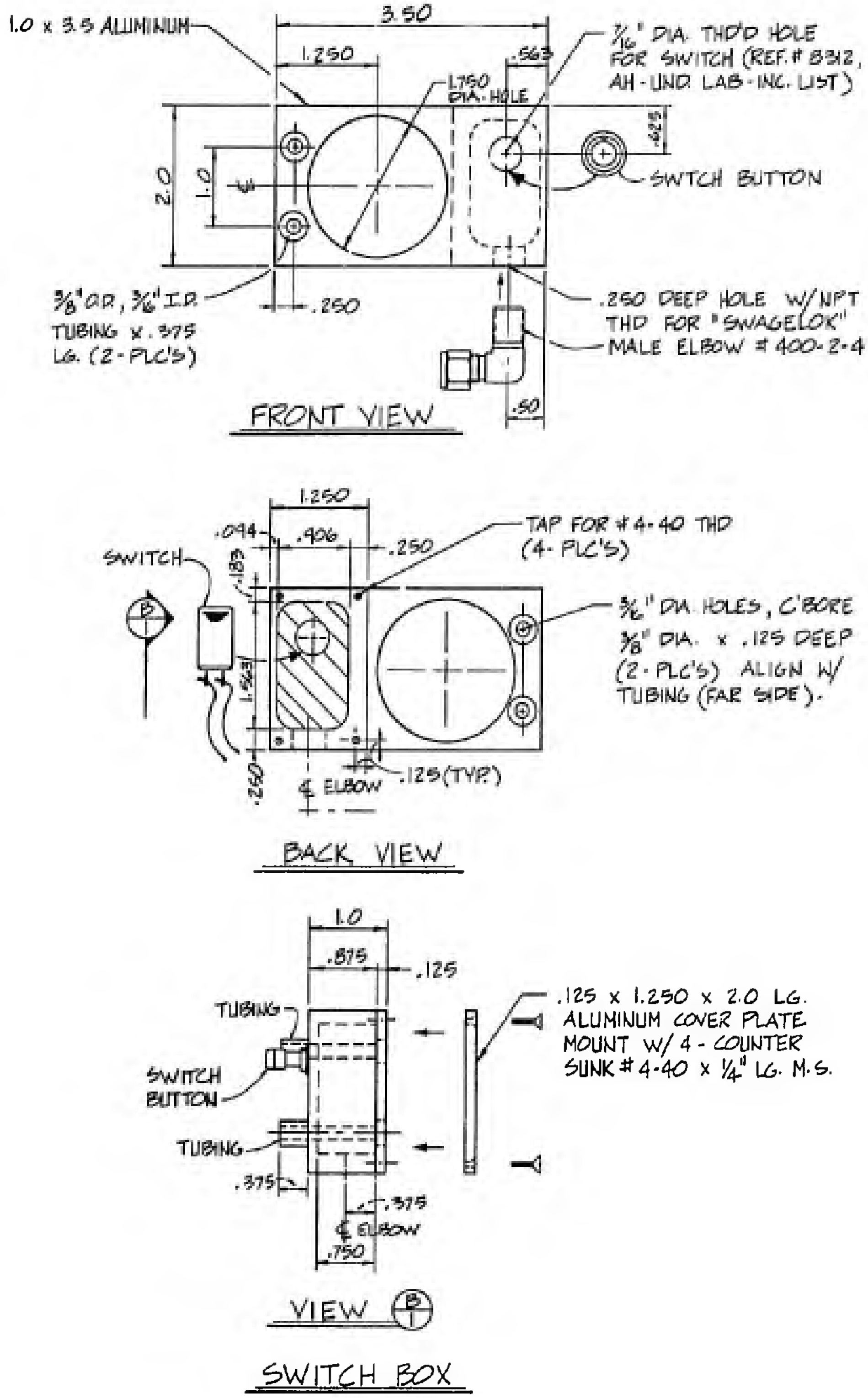


Figure E-3. Switch Box.

3.3.4 Humidity. According to method 507.2, MIL-STD-810.

3.3.5 Leakage. According to method 512.2, MIL-STD-810.

3.3.6 Vibration. According to method 514.3, MIL-STD-810.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may utilize his own facilities suitable for the performance of inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and serves conform to prescribed requirements.

4.2 Workmanship. The system shall be manufactured in accordance with the specifications and standards contained in this document and to accepted commercial practices.

4.3 Acceptance inspection. Each system shall be examined as specified in 4.3.1, and tested in accordance with the test procedures in 4.3.2. Presence of one or more defects shall be cause for rejection.

4.3.1 Examination. Each system shall be examined for the following or similar defects including:

a. Missing parts.
b. Incorrect system markings.
c. Nonconformance to approved drawings.
d. Nonspecified materials of construction.
e. Damaged components or parts.
f. Non-compliance with purchase description.
g. Void area of primer, paint, or plating.

4.3.2 Test procedure.

a. Assurances shall be gained that the system is not pressurized or charged with agent. This may be done by observing that the liquid level gage on the cylinder is at zero-level, and by observing that the cylinder pressure gage reads atmospheric pressure.
b. The transmitter frequency shall be verified, and the tone for alarm and trouble shall be verified. Each test event described below shall be coordinated with the fire department. Precautions shall be taken to ensure that an unintentional alarm is not registered with the fire department or any other monitoring agency.
c. Verify that the system battery is disconnected and the system on/off switch is off. Disconnect the electrically actuated blow-out disk and install a 12-volt light across leads from the control panel. This light will be referred to as the "discharge light." Short the two lead connected of the blow-out disk to prevent inadvertent operation.
d. Connect battery to system. Plug in detection system simulator.
e. Turn the system on. Check for proper operation of the system by pressing the operations button on the front of the control panel. A green light indicates proper operation. A yellow light indicates a fault in the systems operation. If a system fault is indicated, check all internal connections pertaining to the systems detection system, transmitter connections, siren and strobe connections, and blow-out disk (discharge light) connections. An uncorrectable system fault is cause for rejection of the system.
f. Pull the handle on the pull-box. The siren, strobe and transmitter should operate. Check with the fire department to verify transmitter operation. After system has been in alarm for 10-seconds, turn the system off and reset the pull-box. Failure of the siren, strobe, or transmitter to operate properly is cause for rejection of the system. Wait approximately 60 seconds before proceeding to the next test item.

g. Turn the system on and check for proper operation, as described in part "e." Pull the pin from the manual hose valve and pull the valve handle forward so as to use the manual hose line. This action should cause the system to alarm as indicated by the operation of the siren, strobe, and transmitter. Failure of the siren, strobe, or transmitter to operate properly is cause for rejection of the system. After the system has been in alarm for 10-seconds, operate the discharge switch on the control panel. The discharge light should not illuminate. Illumination of the discharge light is cause for rejection of the system. After approximately 10-seconds, turn the system off and reset the manual valve and the discharge switch. Wait approximately 60 seconds before proceeding to the next test item.

h. Turn the system on and check for proper operation as described in part "e." Operate the abort switch. The system should enter a trouble mode, and should send a trouble signal to the fire department. Failure of the system to enter a trouble mode or transmit a trouble signal is cause for rejection of the system. Approximately 10 seconds after the abort switch has been operated, operate the system discharge switch. The system should enter an alarm mode, and the transmitter should transmit an alarm to the fire department; however, the discharge light should not illuminate. Failure of the transmitter to transmit an alarm is cause for rejection of the system. Approximately 10 seconds after the system discharge switch has been operated, return the abort switch to its normal position. The discharge light should illuminate. Failure of the discharge light to illuminate is cause for rejection. After approximately 10 seconds, turn the system off, and return the discharge switch to its normal position. Wait approximately 60 seconds before proceeding to the next test item.

i. Turn the system on and check for proper operation as described in part "e." Disconnect the detection system simulator. This action should cause the system to enter a trouble mode. The transmitter should send a trouble signal to the fire department. Failure of the system to enter a trouble mode or the transmitter to operate properly is cause for rejection of the system. After the system has been in a trouble mode for 10 seconds, turn the system off and replace the detection system simulator. Wait approximately 60 seconds before proceeding to the next test item.

j. Turn the system on and check for proper operation as described in part "e." Cause the detection system simulator to alarm. After approximately 15 seconds have elapsed, the system should enter an alarm mode as indicated by the operation of the siren, strobe, transmitter, and discharge light. Failure of any one of these four devices to operate is cause for rejection of the system. After approximately 10 seconds, operate the abort switch. The discharge light should go out. Continued illumination of the discharge light is cause for rejection of the system. After approximately 10 seconds, return the abort switch to its normal position. The discharge light should illuminate. Remove the pin from the manual discharge valve and open the valve. Again, the discharge light should go out. Continued illumination of the discharge light is cause for rejection of the system. Turn the system off and reset all peripheral devices to a normal mode. Wait approximately 60 seconds before proceeding to the next test item.

k. Turn the system on and check for proper operation as described in part "e." When proper operation of the system is verified, turn the system off, and remove the system batteries. Wait approximately 60 seconds before proceeding to the next test item.

l. Reconnect the electrically actuated blow-out disk, making sure all connections are secure. Reconnect the system batteries.

m. Turn the system on and check for proper operation as described in part "e." Once proper operation is verified, turn the system off, and remove the detection system simulator.

n. Charge the system with 150 pounds of Halon 1211 as described in the Technical Order for the system.

o. Test complete.

4.3.3 Test data. During the test specified herein, the following data, as applicable, shall be collected.

a. Transmitter frequency.
b. Transmitter tones for alarm and trouble conditions.
c. Response time of all peripheral devices for test items "f" through "k."
d. The size charge of agent for each system.
e. The pressure each system is charged to.
f. The date/time of the test, and the individuals conducting the test.
g. All corrective actions taken by individuals conducting the test.

4.3.4 Test observations. Throughout the tests specified herein, the system shall be closely observed for the following conditions which shall be considered cause for rejection.

a. Inconsistent operation of the peripheral devices.
b. Unexplained actions of the system to the test items.
c. Excessive power drain.
d. The presence of smoke or unusual odors associated with the tests.

4.3.5 Test report. The test report for each system shall contain, as a minimum, items described in 4.3.3 and 4.3.4.

4.3.6 Reliability and maintainability information. The following information shall be included as an appendix to the test report:

a. All failures, servicing, adjustments, maintenance, and irregular functioning shall be identified. Test conditions at the time of the event shall be identified and recorded.
b. Test operator and maintenance technician actions, test equipment and test facility failures, and other events that might serve as grounds for a request that an equipment failure not be counted as a reliability failure. Detailed descriptions of the events and the analysis to substantiate any such request shall be included and clearly cross-referenced to each applicable failure.
c. A summary of the engineering analysis and of any tests conducted to determine assignable causes for any failure or irregular functioning.

d. A summary of the engineering analysis leading to any corrections made to design, construction, quality control, or other procedures, or leading to any corrections to be made or proposed to be made to production items. The summary shall also include an analysis of the predicted effectiveness of other means shall be counted as reliability failures until the corrections have been both analyzed and verified by test to sufficiently substantiate the effectiveness of the corrections to the procuring activity.

5.0 PREPARATION FOR DELIVERY

5.1 Preservation and packaging. Preservation and packaging shall be level A or C as specified (see 6.2.1)

5.1.1 Level A. The system shall be prepared according to Method III, MIL-P-116. Components shall be adequately secured to prevent movement and damage in accordance with MIL-STD-1186. Accessories and disassembled parts shall be wrapped, cushioned, and packaged in a wood or cleated plywood container. The disassembled parts shall be marked as to identity and proper location on the assembled item. Exposed gages, controls, and similar items shall be wrapped with waterproof barrier and taped with waterproof tape. All openings shall be closed with plugs, caps, or waterproof barrier with tape.

5.1.2 Level C. Level C shall be the same as Level A except the containers may be of fiberboard of sufficient strength.

5.2 Packing. Packing shall be Level A or C as specified (see 6.2.1). Should Level B be specified, Level A shall apply.

5.2.1 Level A. Each system shall be packed within a container conforming to Type II, Style A, Class 1, plywood superstructure MIL-B-26195. The system shall be secured to the container base in accordance with MIL-STD-1186.

5.2.2 Level C. Each system shall be packed within a container conforming to Type I, Style C, Class 1, fiberboard superstructure MIL-B-26195. The system shall be secured to the container base in accordance with MIL-STD-1186.

5.3 Markings. Marking for shipment and storage shall be in accordance with MIL-STD-129.

6.0 NOTES

6.1 Intended use. The intended use of the system specified herein is to control interior aircraft fires during an interim period when the fire department is responding, and to satisfy requirements of aircraft for local flightline fire extinguishers.

6.2 Ordering data. Procurement documents should specify the following:

a. Title, number, and date of this specification.
b. Location and conditions for system testing.
c. Transmitter type, frequencies, and tones.
d. Level of preservation and packaging required (see 5.1).
e. Level of packing required (see 5.2).
f. Additional markings as required (see 5.3).

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