NFPA 403
Aircraft Rescue and Fire Fighting Services at Airports
1978 Edition

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National Fire Protection Association   Batterymarch Park, Quincy, MA 02269

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

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Recommended Practice for

Aircraft Rescue and Fire Fighting Services at Airports and Heliports

NFPA 403-1978

1978 Edition of NFPA 403

This document was prepared by the Technical Committee on Aircraft Rescue and Fire Fighting and this present edition was adopted by the Association on November 15, 1978, at its Fall Meeting in Montreal, Quebec, Canada. It was released by the Standards Council on December 4, 1978.

This edition of NFPA 403 supersedes the 1975 edition.

This 1978 edition of NFPA 403 represents a major revision to the 1975 edition. It has been rewritten in conformance with the NFPA Manual of Style and SI Units have been added.

The 1975 edition was approved by the American National Standards Institute.

Origin and Development of NFPA 403

Committee work leading to the development of this recommended practice by the Association commenced in 1947 following a request from the Civil Aeronautics Board (U.S.A.) for information on what constituted "adequate" ground fire fighting equipment and personnel for airports served by air carrier aircraft.

NFPA Committee work continued during 1948 and in 1949 the Association adopted a tentative text at its Annual Meeting held in San Francisco, California. In 1952 a revised text was submitted for adoption by the Association, and unanimously accepted. Since its original adoption, this text has been revised periodically with editions issued in 1954, 1955, 1956, 1957, 1958, 1959, 1960, 1961, 1962, 1965, 1966, 1967, 1970, 1971, 1972, 1973, 1974, and 1975.

In June 1948, the International Civil Aviation Organization distributed ICAO Circular 4 — AN-3 which contained the recommendations on this subject. In February 1955, the ICAO reproduced the 1954 editions of this text and NFPA 402 in ICAO Circular 41 — AN — 36. These publications are now obsolete. During December 1956, the ICAO sponsored a meeting of a specially constituted international "Panel on Aircraft Rescue and Fire Fighting Services at Aerodromes" to develop "specifications or further guidance material" on the subject.

Subsequent ICAO Panel Meetings were held in 1962, 1968, 1970, and 1972. The current recommendations of ICAO are contained in "Annex 14" (Aerodromes) to the Convention on International Civil Aviation (available from ICAO, International Aviation Building, 1080 University Street, Montreal 3, Quebec, Canada, and from their Regional Offices in France, Peru, Senegal, Thailand, and the United Arab Republic) in English, French, and Spanish editions. ICAO Aerodrome Manual, Part 5 (Equipment, Procedures, and Services), contains an extensive chapter on Rescue and Fire Fighting, and a Supplement on Aircraft Data for Fire Fighting and Rescue Crews. Part 6 (Heliports) discusses Rescue and Fire Fighting as practiced in the United Kingdom and U.S.A. Each of these publications is available in the same languages from the same source. In addition, ICAO has published a Training Manual for Aerodrome Fire Services Personnel (Part 16), available for 75 cents per copy. (*See also Appendix B herein.*)

The Federal Aviation Administration (U.S.A.) has issued Federal Aviation Regulation, Part 139 which gives *minimum* levels of the scale of protection to be provided at land airports serving Civil Aeronautics Board-certificated air carriers operating large aircraft (other than helicopters). FAA Advisory Circular 150/5210-6B dated 26 Jan. 1973 ("Aircraft Fire and Rescue Facilities and Extinguishing Agents") with CH I (8-22-73) gives the *recommended* levels (as compared to the *minimum* level specified in Part 139.49) and additional information on this subject.

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Recommended Practice for
Aircraft Rescue and Fire Fighting Services at Airports and Heliports

NFPA 403-1978

Chapter 1 General

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

1-1 Scope. This recommended practice contains guidance on the protection considered essential to establish and maintain an adequate aircraft rescue and fire fighting capability at airports and heliports.

1-2 Purpose. This recommended practice is prepared for the use and guidance of those charged with providing and maintaining aircraft rescue and fire fighting services at airports and heliports.

1-3 Application.

1-3.1 This recommended practice applies to aircraft rescue and fire fighting services at airports and heliports; it does not include fire protection facilities for airport structures (i.e., hangars, shops, terminals, other airport buildings, etc.), although the equipment and manpower made available to perform these services might constitute valuable fire protection for such structures and their contents in many instances. Vehicles designed for aircraft rescue and fire fighting services are covered in the *Standard for Aircraft Rescue and Fire Fighting Vehicles*, NFPA 414 (ANSI); their recommended use is outlined in *Aircraft Rescue and Fire Fighting Operational Procedures for Airport Fire Departments*, NFPA 402; and methods for on-site testing of certain of these vehicles are given in the *Standard for Evaluating Foam Fire Fighting Equipment on Aircraft Rescue and Fire Fighting Vehicles*, NFPA 412 (ANSI). Any consideration given to the structural fire fighting capability of these vehicles may be only to the extent that any design features or equipment added do not detract from their primary purpose. (*See Appendix B.) The Recommended Practice for Airport/Community Emergency Planning*, NFPA 424, provides guidelines on an integrated program for dealing with major emergencies. (*See Appendix B.*)

1-3.2 Heliports designed *exclusively* for handling helicopter operations are generally limited in area and are separately evaluated as regards helicopter rescue and fire fighting services. For the purposes of this text, the term "heliport" should include all areas exclusively used for commercial and/or high frequency helicopter operations. Unattended low frequency landing areas referred to as "helistops" are exempt from these requirements. Heliports may be located at ground level, on platforms constructed specifically for the purpose, or on the roofs of buildings. The degree of fire protection recommended depends on the size of the helicopters, the number of occupants, the maximum operational fuel load of the helicopters using the facility, personnel available for rescue and fire fighting purposes and the frequency of operations (*see 3-1.4 and Table 2*).

1-4 Definitions and Units.

1-4.1 Definitions. For the purpose of clarification the following general forms used with special technical meanings in this recommended practice are defined:

Aircraft Fire Fighting. The control or extinguishment of aircraft fires following ground accidents incident to aircraft rescue and thereafter. Aircraft fire fighting, as used in this text, does not include the control or extinguishment of airborne fires in aircraft.

Aircraft Rescue. As used in this text, means the fire fighting action taken by an emergency crew to prevent, control, or extinguish fire involving or adjacent to an aircraft, for the purpose of providing maximum fuselage integrity and an escape area for its occupants. The emergency crew, to the extent possible, will assist in evacuation of the aircraft using normal and/or emergency means of egress. Additionally, emergency crews will, by whatever means necessary, enter the aircraft and provide all possible assistance in the evacuation of the occupants.

Airport Control. A service established to provide air traffic control for airports.

Airport Manager. The individual having managerial responsiblity for the operation and safety of the airport, whether he represents a governmental agency, a private corporation, or an individual. The airport manager may have administrative control over aircraft rescue and fire fighting services operating on the movement area of the airport (*see Section 1-7 for details*). He should not normally be required to exercise authority over operational matters at the time of emergency, said responsibility normally being that of a duly appointed chief.

Chief of Airport Fire Department. As used in this text, means the individual normally having operational control over the airport's aircraft rescue and fire fighting equipment and manpower specifically made available for aircraft rescue and fire fighting activity on the airport, or his designated assistant. He has both the authority and responsibility for decisions affecting rescue and fire fighting activity and is normally in sole command of such operations at times of emergency.

Conventional Airports. All airports except those completely unattended or exclusively for the private use by the owner thereof or temporarily established to serve operations conducted with complete cognition of the total lack of ground support protection.

Airport Fire Department Personnel. Personnel under the operational jurisdiction of the Chief of the Airport Fire Department assigned to aircraft rescue and fire fighting duties.

Movement. As used herein, a movement means a landing or a take-off of an aircraft at an airport.

Mutual Aid. Prearranged exchanged of aid and assistance between various fire defense organizations within a given area, as, for instance, the mutual aid which might be provided between aircraft rescue and fire fighting organizations and local public fire departments for an "area" defense of the community, the airport, and surrounding territories. (*See Recommended Practice for Airport/Community Emergency Planning, NFPA 424, for further information.*)

Response Time. The time taken for the emergency vehicles to reach the accident site. The time is measured from the time of initial alarm to the time of the first discharge of extinguishing agent at the accident site. (*For more details see Section 9-4.*)

1-4.1.1*ICAO Definitions. The International Civil Aviation Organization (ICAO) utilizes certain basic definitions. These are contained in Appendix A.

1-4.2 Units.

1-4.2.1 Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI). Two units (litre and bar), outside of but recognized by SI, are commonly used in international fire protection. These units are listed in Table 1-4.2 with conversion factors.

1-4.2.2 If a value for measurement as given in this standard is followed by an equivalent value in other units, the first stated is to be regarded as the requirement. A given equivalent value may be approximate.

Table 1-4.2 Metric Conversion Factors

Name of Unit	Unit Symbol	Conversion Factor
litre	L	1 gal = 3.785 L
cubic decimeter	dm^3	1 gal = 3.785 dm^3
pascal	Pa	1 psi = 6894.757 Pa
bar	bar	1 psi = 0.06895 bar
bar	bar	1 bar = 10^5 Pa

For additional conversions and information see ASTM E380, *Standard for Metric Practice*. (*See Appendix B.*)

1-5 Type of Aircraft Operations Safeguarded.

1-5.1 The threat of fire is ever present and may occur at any time when an aircraft is involved in either operational or servicing accidents. Experience has shown that severe problems of rescue are encountered when fire occurs incident to operational accidents. Fire is especially apt to occur immediately following ground impact in operational accidents but may occur at any time during rescue operations. Because of the nature of the aircraft fuel and lubricants used, rupture or damage to the fuel containing structures or associated plumbing can result in a fire reaching maximum intensity immediately on ignition. Ignition sources include the latent heat of operating aircraft engines, exhaust flames and hot gases, the possibility of sparks being created through disturbance of electrical circuits or from friction, or the discharge of accumulated electrostatic charges at time of ground contact. This presents a severe hazard to the lives of those involved in the accident and anyone attempting their rescue.

1-5.2 All aircraft do not have identical crash impact fire dangers. Aircraft design features which tend to improve the "crashworthiness" of the aircraft should be considered. Opportunities to assist in the rescue of aircraft occupants involved in an aircraft accident will vary with virtually every accident. In addition, the opportunities for effective rescue will depend on the nature and extent of the impact injuries sustained by the occupants, the adequacy of the aircraft exit facilities available and in service, the extent of the fire conditions prevailing at the time rescue efforts are initiated, the availability of properly trained and equipped personnel to achieve the rescue and fire control mission, and other factors. In addition, the aircraft rescue and fire fighting services provided at each airport will differ somewhat due to the types of aircraft operations, the extent of such operations, and other special factors. Each individual airport should consider the application of these recommendations to its own needs. The application of these recommendations to airports is thus subject to discriminating use. Experience has indicated that the recommendations contained herein will provide a reasonable degree of protection in most situations.

1-6 Location of Accidents.

1-6.1 The possibility of aircraft accidents is constantly present throughout the extent of air routes. The accident potential is greatest, however, on the movement areas of airports or heliports and in their immediate vicinity due to the concentration of air traffic found in the described areas and the operational hazards associated with aircraft landings, takeoffs, and taxiing and the servicing of aircraft (fueling operations and aircraft maintenance). For this reason, the provision of special means to deal with incidents on and in the immediate vicinity of such movement areas is of primary importance. It is within such limits that there are the greatest opportunities of saving life and property.

1-7 Administrative Control.

1-7.1 Aircraft rescue and fire fighting on the movement area of an airport should be under the administrative control of airport management for policy determination. Functional operations of the Airport Fire Department should be under the direct control of a member of the Airport Manager's Staff having this responsibility, or under a Command Officer of a non-military entity supplying this service. Appreciation of this command designation is vital for judicious coping with operations during emergencies. Close liaison with airport management is essential in order to integrate fire department and aircraft operations to assure effective and safe response of emergency equipment on the movement area of the airport.

1-7.2 Regardless of the functional control of aircraft rescue and fire fighting services on the airport, a prearranged high degree of mutual aid (joint defense measures) is desirable between such services on airports and any municipal (or similar regional) fire or rescue agencies serving the environs of the airport. An Airport/Community Emergency Plan should be in force and effect. (*See Recommended Practice for Airport/Community Emergency Planning, NFPA 424.*) Airport management should encourage and offer instruction to cooperating departments in aircraft rescue and fire fighting. See Chapter 8 herein and *Aircraft Rescue and Fire Fighting Operational Procedures for Airport Fire Departments*, NFPA 402 (*see Appendix B*).

1-7.3 The services of other available airport personnel not assigned for aircraft rescue and fire fighting should be utilized to perform specific duties during an emergency, such as: aircraft evacuation; scene security; first aid assistance; escort duty; transportation; etc. These special crews should operate during an emergency under the direction of the officer in charge of the rescue and fire fighting services. Training should be under the auspices of airport management or the authority having administrative jurisdiction of the aircraft rescue and fire fighting services. Insurance coverage for such personnel while assisting in emergencies should be considered in the planning. After evacuation and completion of fire and rescue operations, the operator is responsible for the security of the aircraft unless a legally appointed accident investigation authority assumes responsibility.

Chapter 2 Basis for Recommendations on Extinguishing Agents

2-1 Types of Extinguishing Agents.

2-1.1 In order to establish the types of extinguishing agents recommended for aircraft rescue and fire fighting, it is desirable to consider certain basic principles concerning the various agents available for the purpose. These principles are summarized in 2-1.2 through 2-1.6.

2-1.2 Foam.

2-1.2.1 Foam is particularly suited for aircraft rescue and fire fighting because the basic ingredients, water and foam liquid concentrate, can be carried in bulk to the scene of the accident and brought into operation with a minimum of delay. The most serious limitation of foam for aircraft rescue and fire fighting is the problem of quickly supplying large quantities of foam to the fire in a gentle manner so as to form an impervious fire-resistant blanket on large flammable liquid spills. The hazards of disrupting established foam blankets by turbulence, water precipitation, and heat baking can be minimized by firemen's training and the purchase of a good quality of the basic foam ingredient. Foams used for controlling aircraft fires involving fuel spills are produced by the physical agitation of a mixture of water, air, and a foam-liquid concentrate. The foam produced should be able to cool hot surfaces, flow over a burning liquid surface, and form a long-lasting, air-excluding blanket that seals off volatile flammable vapors from access to air or oxygen. Good quality foam should be homogeneous, resisting disruption due to wind and draft or heat and flame attack. It should be capable of resealing in the event of mechanical rupture of an established blanket.

2-1.2.2 Foam-liquid concentrates of different types or different manufacturers should not be mixed unless it is established that they are completely interchangeable. The concentrates should be stored so as to comply with the manufacturers' instructions. There are four major types of foam-liquid concentrate now used for aircraft rescue and fire fighting, namely:

(a) Aqueous-Film-Forming-Foam (AFFF) Concentrate. These concentrates utilize fluorinated surfactants and current formulations at recommended nominal concentrations of 3 percent or 6 percent. The foam formed acts both as a barrier to exclude air or oxygen and to develop an aqueous film on the fuel surface capable of suppressing the evolution of fuel vapors. The foam blanket produced should be of such thickness as to be visible before fire fighters assume it to be capable of suppressing fuel vapors. The blanket should not be relied on to be permanent and should be renewed from time to time as the rescue operation proceeds. AFFF concentrates listed as such by a nationally recognized testing laboratory have been found to be satisfactory for extinguishing fires, including aircraft fuel fires. AFFF concentrates are normally used in conventional foam-making devices suitable for producing protein foams as described in 2-1.2.3 (*see also 2-1.2.7*). Vehicles using in-line compressed air systems may require modifications. The foam produced with AFFF concentrate is dry-chemical-compatible and thus is suitable for combined use with dry chemicals. Protein and fluoroprotein foam concentrates are incompatible with AFFF concentrates and should not be mixed, although foams separately generated with these concentrates are compatible and can be applied to a fire in sequence or simultaneously. It should be noted that 3-1.1.4 allows a lower application rate and 3-1.2.1 permits a ⅓ reduction in the amount of water for foam production when using AFFF concentrates rather than protein or fluoroprotein concentrates. This is in recognition of the fact that AFFF reduces control and extinguishment times significantly, although other factors (such as foam blanket stability, burnback rate, and wicking action) modify the relative degree of efficiency of AFFF on open spill fires between the concentrates.

(b) Fluoroprotein-Foam Concentrates. These concentrates are very similar to protein-foam concentrates as described in 2-1.2.2(c) with a synthetic fluorinated surfactants additive. They form an air-excluding foam blanket and may also deposit a vaporization-inhibiting film on the surface of a liquid fuel. These concentrates are used at recommended nominal concentrations of 3 percent and 6 percent of the water discharge. Both types can be used to produce a suitable mechanical foam, but the manufacturer of the foam-making equipment should be consulted as to the correct concentrate to be used in any particular system (the proportioners installed must be properly designed and/or set for the concentrate being used). Compatibility of the foams produced using fluoroprotein-foam concentrates with any dry chemical agent programmed for use on a fire in sequence or simultaneously should be established by test.

(c) Protein-Foam Concentrates. These concentrates consist primarily of products from a protein hydrolysate, plus stabilizing additives and inhibitors to protect against freezing, to prevent corrosion of equipment and containers, to resist bacterial decomposition, to control viscosity, and to otherwise assure readiness for use under emergency conditions. Current formulations are used at recommended nominal concentrations of 3 percent and 6 percent of the water discharge. Both types can be used to produce a suitable mechanical foam, but the manufacturer of the foam-making equipment should be consulted as to the correct concentrate to be used in any particular system (the proportioners installed must be properly designed and/or set for the concentrate being used).

NOTE: Where other than nominal concentrations of 3 percent or 6 percent foam-liquid concentrate are used, proportioner adjustments should be made.

(d) Other Synthetic Foams. There are other synthetic foaming agents, generally based on hydrocarbon surface active agents, which are capable of extinguishing flammable and combustible liquid fires under specific conditions. Some of these are listed or approved as wetting agents, and others as foaming agents at extraordinary application rates. Since there is little recorded and reported test and experience data for this type of foam, no specific recommendations for its use can be made. Its use is usually limited to portable nozzle application to spill fires where generous rates can be used. Such foams are usually rapid draining and do not demonstrate the rapid control and extinguishment rates of the AFFF agents, nor the resistance to petroleum fuel attack of the AFFF and fluoroprotein foams, nor the good backburn resistance of protein foams.

2-1.2.3 Foam may be produced in a number of ways. The methods of foam production selected should be carefully weighed considering the techniques of employment best suited to the equipment concerned, the rates and patterns of discharge desired and the manpower needed to properly dispense the foam capabilities of the vehicles. The principal methods of foam production are:

(a) Nozzle Aspirating Systems. Foam is produced by pumping a proportioned solution of water and foam liquid concentrate under pressure into a specialized discharge appliance or nozzle which draws in atmospheric air and mixes it with the solution. Various devices are used to shape the discharge pattern between a straight stream and a spray.

(b) In-Line Compressed Air Systems. Air under pressure is injected into the proportioned solution of water and foam liquid concentrate, where it is mixed with the solution to form foam within the system piping. The air is supplied by a compressor on the vehicle. Nozzles serve only to distribute the foam in various patterns.

(c) In-Line Foam Pump Systems. A proportioned solution of water and foam liquid concentrate is injected at atmospheric or higher pressure into a positive displacement type pump which draws in atmospheric air and mixes it with the solution to generate foam. The foam is formed in the discharge piping as in the in-line compressed air systems. Nozzles serve only to distribute the foam in various patterns.

(d) In-Line Aspirating Systems. An inductor in the pump discharge line receives a proportional solution of water and foam liquid concentrate under pressure, or water only if the inductor is designed also to draft the correct amount of foam liquid concentrate. The liquid, in passing through the inductor, draws in atmospheric air which is mixed with the solution to form foam in the discharge lines. Nozzles serve only to distribute the foam in various patterns.

(e) Non-Aspirating Fog Nozzles. Certain conventional variable pattern fog nozzles used in structural fire fighting have been found effective for use with AFFF agents. Foam characteristics will differ from those produced when using aspirating nozzles.

2-1.2.4 Foam is currently applied in two principal pattern configurations — solid stream and dispersed patterns. Normally both methods of application are available using variable nozzles. Training and experience will determine the best method of application under a given set of circumstances. Foam, when dispersed in wide, uniformly dispersed patterns (sometimes called "fog-foam"), is used principally for direct application to a large area of burning fuel or while securing the rescue area. It falls very gently on the surface, giving radiation protection to the fire fighter and cooling and smothering the fire in a short time. Solid streams of foam are used principally for fire situations requiring long distance reach or where the foam may be deflected from a solid barrier to facilitate gentle application. Solid stream foam is not recommended for close-in rescue operations.

2-1.2.5 The quality of water used in making foam may affect foam performance. Locally available water may require adjustment of the proportioning device to achieve optimum foam quality. No corrosion inhibitors, freezing point depressants or any other additives should be used in the water supply without prior consultation and approval of the foam liquid concentrate manufacturer.

2-1.2.6 Where foam and dry chemical are used as supplementary agents, it is important to establish that the two agents are reasonably compatible when used simultaneously (e.g., that the foam qualifies as dry chemical-compatible and that the dry chemical is foam-compatible).

2-1.2.7 Caution. Converting aircraft rescue and fire fighting vehicles utilizing foam from one type of concentrate system to another type of concentrate system should not be accomplished without consultation with the equipment manufacturer and without a thorough flushing of the agent tank and the complete foam delivery system. Particular attention should be given to assuring that system component materials are suitable for the particular concentrate being substituted and that, where necessary, the proportioning equipment is recalibrated and reset.

2-1.3 Dry Chemicals.

2-1.3.1 There are a number of chemical compounds offered on a proprietary basis which are referred to as "dry chemical" fire extinguishing agents. Historically, sodium bicarbonate based compounds were initially so described, but in recent years a number of other chemicals have been tested and found as, or more, effective (e.g., potassium-bicarbonate base, potassium-chloride base, monoammonium-phosphate base, etc.). Such chemicals have proven effective as a means of quickly "knocking-down" flammable liquid fires when applied with the proper technique at an adequate rate and in sufficient quantity. They have good "flooding" characteristics and can penetrate to otherwise inaccessible areas. They have good shielding effects against radiant heat and good range under *normal* outdoor conditions. However, particularly during during rescue operations, it is necessary to guard against the reignition of flammable vapors. The permanency of extinguishment with dry chemical may also be affected by atmospheric conditions, particularly where air currents or wind conditions are adverse, but fire fighter's training has a great influence on this contingency.

2-1.3.2 Dry chemicals as currently used in aircraft rescue and fire fighting service may be employed in one of the following ways:

(a) When foam is the principal agent utilized, *regular* (meaning not necessarily foam-compatible) dry chemicals are employed as a supplementary medium (usually in relatively small quantities) before the foam is applied and when the fires are in their incipient stages. *Regular* dry chemical may also be used subsequently to control or extinguish fires in concealed or inaccessible locations, or to check "running" fires where foam is *not* being used simultaneously. Care should be taken when using *regular* dry chemical in conjunction with foam to avoid deleterious effects on the foam as somewhat greater quantities of foam may be needed to overcome the tendency of the foam to breakdown due to the admixture. It is therefore important that the compatibility of foam and dry chemical be established if it is intended that they be used simultaneously.

(b) Some limited use has been made of large quantities of dry chemicals [quantities of over 1,000 lbs (450 kg)] discharging the agent through turrets at rates of 1,000 lbs (450 kg) per minute or more, but experience to date has not established this technique or the equipment requirements.

2-1.4 Carbon Dioxide.

2-1.4.1 Carbon dioxide is normally used in aircraft rescue and fire fighting service as a supplementary agent, either initially (before foam is applied), when the fires are in their incipient stages, or subsequently, to control or extinguish fires in concealed or inaccessible locations or to check "running" fires. Carbon dioxide has excellent flooding characteristics and penetrates to otherwise inaccessible areas. It leaves no agent residue. As atmospheric conditions (particularly wind direction and velocity) may interfere with the smothering effect of carbon dioxide, and as the cooling effect may not always be sufficient to prevent reignition of flammable vapors by hot or burning materials, a supplementary cooling and blanketing agent (foam or water) is normally necessary. Fire fighter training has a great influence on the effective use of carbon dioxide. When liquid carbon dioxide is discharged to the atmosphere, a small portion is converted to "dry ice" at minus 110°F (-78°C).

2-1.4.2 The following subparagraphs define "high pressure" and "low pressure" carbon dioxide:

(a) "High pressure" carbon dioxide is carbon dioxide stored in pressure containers at atmospheric temperatures. At 70°F (21°C) the pressure in this type of storage is 850 lbs per sq in. (58.6 bars). On airports, "high pressure" carbon dioxide is preferably limited to portable extinguishers and small cylinder systems used for standby protection on ramps and flight lines. The use of "high pressure" carbon dioxide cylinders manifolded together has not proved to be as effective for aircraft rescue and fire fighting work as "low pressure" equipment.

(b) "Low pressure" carbon dioxide is carbon dioxide stored in an insulated pressure container at controlled low temperatures, usually at 0°F (18°C). At this temperature the pressure in this type of storage is 300 lbs per sq in. (20.7 bars). Low pressure is used where large storage capacity and high discharge rates are required, as in aircraft rescue and fire fighting operations. The lower liquid temperature and higher discharge rate combine to produce greater cooling effect and longer reach.

2-1.4.3 As a combined agent with foam, "low pressure" carbon dioxide is applied in large quantities [1,000 lbs (450 kg) or more] at a minimum discharge rate of 1,000 lbs (450 kg) per minute. Table 1B indicates that "low pressure" carbon dioxide may be used in lieu of foam-compatible dry chemical to effect the quickest fire control or extinguishment with foam as the principal agent. Quantitatively, 2 lbs (0.90 kg) of "low pressure" carbon dioxide should be provided for every 1 lb (0.45 kg) of foam-compatible dry chemical recommended in the table.

2-1.5 Water.

2-1.5.1 Water is recognized as the best cooling agent universally available for the control of fire and for personnel protection from heat, but the ability of water to effect extinguishment is limited on large flammable liquid based fires of the type usually encountered in accidents involving aircraft. Therefore, it is not recommended as the sole agent available for this type of fire fighting on airports. See *Guide for Aircraft Rescue and Fire Fighting Techniques for Fire Departments Using Conventional Fire Apparatus and Equipment*, NFPA 406M, where specialized equipment is not available. (*See Appendix B.*)

2-1.5.2 Water spray may be used effectively for the protection of trapped personnel in aircraft accidents involving fire and for the protection of rescue and fire fighting personnel from severe radiant heat conditions, and its availability is therefore considered desirable.

2-1.5.3 The use of straight water streams discharged at high velocity is not considered desirable for aircraft rescue and fire fighting except where it is desired to "sweep" fuel spills from the area.

2-1.5.4 Some wetting agents added to water improve its extinguishing efficiency of flammable liquid based fires but care should be exercised to assure compatibility if foam is a supplementary agent.

2-1.6 Other Agents. Several vaporizing liquid fire suppression agents have recently been developed that hold promise of having superior effectiveness for airport-type fire situations under proper conditions of usage. Some experimental mixtures of halogenated agents with foams have also been tried. Inadequate technical data, at this time, prevents making positive recommendations as to the formulations, quantities, or application techniques to be utilized. A factor of concern with these agents is to assure that no toxic or irritating vapors from these agents in their original state, or following pyrolyzation, will constitute a problem during emergency operations. In addition, there have been some notable developments in formulating new dry chemical agents. Field experience is being gathered on which future recommendations can be based.

2-1.7 Summary on Agents.

2-1.7.1 The information given in 2-1.2 through 2-1.6 indicates that no single agent has all the qualities needed to accomplish speedy and permanent extinguishment of all aircraft fires. Foam, applied as discussed in 2-1.2.4, is, however, the most effective medium found to date and is therefore the principal extinguishing agent upon which reliance is placed for this service. For further recommendations, see Chapter 3.

2-1.7.2 The type and quantities of extinguishing media recommended in Tables 1B and 2 are based on the conclusions indicated in 2-1.7.1, except for heliports and Category H-1 of Table 2.

2-2 Magnesium Fire Control.

2-2.1 The presence of magnesium alloys in aircraft structures introduces an additional problem to fire extinguishment in cases where this metal becomes involved in an aircraft fire. None of the agents available for this application (*see 2-1.2 through 2-1.6*) is capable of securing positive extinguishment of burning magnesium under all conditions, and experience proves that a definite reignition hazard to flammable liquid vapors exists from burning magnesium following almost complete control over other ignited materials. The only practical methods of overcoming this difficulty are: (1) by the removal of the magnesium from the fire area where accessible and identifiable; (2) by the localized application of special magnesium extinguishing agents or covering with dry sand or dirt; (3) by cooling with water or foam (this process is liable to temporarily intensify flame spread until the application is sufficient to produce the degree of cooling required); or (4) by blanketing the exposed flammable liquids with foam and allowing the magnesium to burn itself out.

2-2.2 The form and mass of magnesium in normal airframe components of conventional aircraft is such that ignition does not normally occur until it has been subjected to considerable flame exposure (as from a fire involving aviation fuels or ordinary combustibles). This fact indicates that the problems with magnesium fire control on such aircraft normally occur following, rather than preceding, rescue opportunities. Exceptions include thin forms of magnesium frequently employed in rotary aircraft airframes, powerplant magnesium components which may be ignited by powerplant fires, and magnesium wheels or landing gear components which may be ignited following friction heating or brake fires.

2-2.3 Magnesium fires attacked in their incipient stages may be controlled under some conditions by the application of special magnesium fire extinguishing agents as indicated in 2-2.1, but generally, where a mass of magnesium becomes involved, the application of large volumes of coarse water streams provides the best ultimate control method. Attacking magnesium fires this way, however, is undesirable where the primary fire control technique is with foam as the coarse water streams would have the effect of breaking down foam blankets in the area. Thus, volume application of foam is indicated during the critical period when flammable liquid spills present the primary hazard, with the aim to so cover exposed flammable liquid spills as to prevent or eliminate their vapor hazard. Following completion of rescue and all possible salvage, it is, however, frequently advisable to apply coarse water streams to still-burning magnesium components, even if the immediate result might be a localized intensification of flame and considerable sparking. In this connection it is sometimes feasible to segregate burning magnesium components from the main fuel spill area with shovels or cranes to permit separate fire control treatment of this material.

Chapter 3 Recommendations for Protection of Aircraft Operations at Airports and Heliports

3-1 Protection for Aircraft Operations.

3-1.1 Basis for Recommendations.

3-1.1.1 These recommendations are based upon the concept that, within a specifically defined area around the fuselage of an aircraft, it is feasible to extinguish or control a fire, and thus provide opportunity to effect rescue of any trapped or immobilized occupants within a given period of time by utilizing the extinguishing media and equipment detailed herein.

3-1.1.2 The area described in 3-1.1.1 is that of a rectangle, whose longitudinal dimension is the overall length of a particular aircraft (or the average length for a group of similar aircraft) and whose width is normally 100 ft (30.5 m), plus the width of the fuselage. Where the overall length (or average length for a group of similar aircraft) is less than 65 ft (19.8 m), the width dimension may be reduced to 40 ft (12.2 m) plus the width of the fuselage. The resulting areas may be further modified by a ⅔ factor which then will reflect the difference between the calculated and the actual (probable) involvement based upon extensive studies of aircraft accidents throughout the world.

3-1.1.3 Foam, as explained in 2-1.7.1 is the principal extinguishing agent upon which reliance is placed for this service. The use of dry chemicals (*as described in 2-1.3*) or low-pressure carbon dioxide (*see 2-1.4*) to effect a "combined-agent" attack is recommended to achieve maximum speed in fire control.

3-1.1.4 Using foam produced with aqueous film-forming foam concentrates, fire control can be established within one minute when the area described in 3-1.1.2 is covered with foam at an application rate of 0.13 gal per minute per sq ft (5.5 L per minute per sq m). Using foam produced with protein- or fluoroprotein-foam concentrates, fire control can be established within one minute when the area described in 3-1.1.2 is covered with foam at an application rate of 0.20 gal per minute per sq ft (8.6 L per minute per sq m).

3-1.1.5 Some present-day transport aircraft can carry 500 or more passengers and may be involved in a fire accident when carrying in excess of 40,000 gal (152000 L) of fuel. The recommendations contained herein recognize that a situation could develop where evacuation and rescue would have to proceed over a prolonged period of time during which the threat of fire could be continuous. To maintain effective fire control under these circumstances may require intermittent application of additional foam (normally achieved by the use of hand lines) at reduced discharge rates. This may be particularly necessary where rescue operations may result in disruption of an established foam blanket or where heat and flame attack from perimeter fires or burning combustible metals cause gradual disintegration of the foam blanket. It is thus recommended that a supplementary supply of foam and water be carried which exceeds the quantity required to achieve control. This supplementary quantity is included in the quantities recommended in Table 1B, calculated on a percentage factor incorporating gross weight, passenger and fuel capacity, and previous operational experience. The percentage factor ranges from a low of 2 percent to a high of 170 percent in proportion to the size of the aircraft.

3-1.2 Extinguishing Agent Recommendations.

3-1.2.1 Water for foam production assumes the use of aqueous, film-forming foam, fluoroprotein foam, or protein foam concentrate through appropriate proportioning equipment. As indicated by Table 1B the amount of water required for foam production may be reduced ⅓ when AFFF concentrate is used rather than protein or fluoroprotein foam concentrate with corresponding reductions in the required discharge rates and amounts of concentrate required. The minimum quantities of foam concentrate recommended are twice the quantities required for the minimum water gallonage specified, so as to permit a water refill operation to be undertaken at least once. The quantities shown in Table 1B are based upon 6 percent concentrates; adjustments must be made where other than 6 percent concentrates are used. All discharge rates, as specified in Table 1B, are expressed in gallons or litres of water (not expanded foam) and are the total from all available major fire fighting vehicle discharge nozzles combined. Turret application should comprise not less than 75 percent of this total for all discharge devices. Quantities and rates of discharge are based upon agents being carried on properly designed, operated, and maintained fire fighting vehicles stationed on the airport (*see Sections 4-1 to 4-4*). At airports falling into Indexes 5 through 8 (*see Table 1B*), it is preferable to divide the total recommended quantity of water for foam production into at least two fire fighting vehicles to permit operational flexibility (for instance, to allow attacking the fire from more than one vantage point), and to provide for greater opportunity for uninterrupted fire control operations (*see 4-1.2*). When tank vehicles are employed to carry a portion of the total quantity of water recommended, their response capability should be such as to provide timely transfer to the fire fighting vehicles causing no interruption in the latter's ability to utilize the total quantities if so required. It is further recommended that water hydrants be strategically located on the airport to refill tank and fire fighting vehicles readily.

3-1.2.2 Where dry chemicals are used in conjunction with foam, chemical compatibility should be assured between the two agents to secure the maximum beneficial use of the combined-agent technique. The rates of discharge recommended in Table 1B for dry chemicals indicate the minimum rates, in lbs (kg) per minute, discharged from hand line nozzles [*see 2-1.3.2(b)*]. The amounts and discharge rates of dry chemicals are based upon having these agents immediately available for application from properly designed and maintained vehicles.

3-1.2.3 Although Table 1B recommends specific quantities and rates of discharge for dry chemical agents, it is permissible to substitute "low pressure" carbon dioxide at a ratio of 2 lbs (0.90 kg) of carbon dioxide to 1 lb (0.45 kg) of dry chemical for both the amounts of agent available and the minimum designed discharge capability. Whenever used, carbon dioxide should be carried on properly designed and maintained vehicles.

3-1.2.4 At Index 1, 2 and 3 airports (*see Table 1A*) and at airports where special climatic conditions exist (such as in arid deserts or in near-arctic cold), dry chemical may be used to replace water on the basis of 8 lbs (3.6 kg) of dry chemical to 1 gal (3.785 L) of water.

3-1.2.5 Extinguishing agents (except water for foam production) should be carried in stock to resupply vehicles in sufficient amounts commensurate with the delivery schedules of suppliers. A minimum of one additional charge for all vehicles should be maintained, and where delivery time for suppliers exceeds 24 hrs, supplies should be increased accordingly. This condition will vary at different airports, and no definitive quantities can thus be recommended. Care should be exercised in stocking agents to assure that stocks are rotated on a "first-in, first-out" basis. Consideration should be given to having on hand additional quantities of extinguishing agents for the purpose of training. Where it is anticipated that runways will be foamed for aircraft emergency landings, still further protein foam liquid concentrate should be carried in stock to assure that the supplies reserved for fire fighting are not affected. (*See also Chapter 11 of NFPA 402, Recommended Practice for Aircraft Rescue and Fire Fighting Operational Procedures for Airport Fire Departments.*)

3-1.3 Protection of Operations at Conventional Airports.

3-1.3.1 The minimum amounts of extinguishing agents recommended for the protection of operations at conventional airports are given in Table 1B based on the airport indexes established by Table 1A (using aircraft overall lengths as the criteria), and the type foam concentrate used. Table C-1 in Appendix C lists representative aircraft by the length categories.

3-1.3.2 Determination of the largest aircraft to be protected should be made by the authority having jurisdiction. In making this determination, consideration may be given to frequency of operation, to probable future expansion of traffic, and the introduction of larger aircraft.

Table 1A Airport Indexes by Overall Length of Aircraft

Airport Index (See NOTE)	Overall Length of Aircraft: Minimum Length Metres	Feet	Up to But not Including	Maximum Length Metres	Feet
1	—	—		9	30
2	9	30		12	39
3	12	39		20	66
4	20	66		28	92
5	28	92		39	128
6	39	128		49	161
7	49	161		61	200
8	61	200		76	249

NOTE: See Appendix C, Table C-1, for representative aircraft in each overall length category.

Table 1B Recommended Amounts of Extinguishing Agents

AIRPORT INDEX	Water for AFFF Production (Note 1)				or Water for Protein-Fluoroprotein Foam Production (Note 1)				Dry Chemical (Note 2)			
(See Table 1A)	Gals (U.S.)	Litres	Discharge Rates GPM	Litres/Min	Gals (U.S.)	Litres	Discharge Rates GPM	Litres/Min	Lbs	Kgs	Discharge Rates Lbs/Min	Kgs/Min
1	100	380	35	130	150	570	50	200	100	45	100	45
2	200	760	100	380	300	1 140	150	570	200	90	200	90
3	335	1 265	200	760	500	1 900	300	1 140	300	135	300	135
4	1,335	5 065	665	2 530	2,000	7 600	1,150	4 350	300	135	300	135
5	2,000	7 600	1,065	4 030	3,000	11 400	1,600	6 055	500	225	500	225
6	3,335	12 665	1,400	5 300	5,000	19 000	2,100	8 000	500	225	500	225
7	5,000	19 000	1,935	7 335	7,500	28 500	2,900	11 000	1,000	450	500	225
8	6,665	25 225	2,400	9 100	10,000	38 000	3,600	13 650	1,000	450	500	225

NOTE 1: The gallons (litres) of water specified should be on at least 2 fire fighting vehicles (see 3-1.2.1) for Indexes 5 through 8. The design minimum discharge rates are in gallons (litres) of water (not expanded foam) from all available discharge nozzles.

The minimum quantities of foam concentrate carried on each vehicle should be twice the quantities required for the water provided, to permit continued operation of the vehicle if refilled with water once.

When a premix foam-water system is used on a vehicle, recharge quantities shall not be required to be carried on the vehicle.

NOTE 2: When used with protein or fluoroprotein foam, approved foam-compatible type dry chemical is required. Alternate use is authorized of low-pressure carbon dioxide (*see 2-1.4.3 and 3-1.2.3*).

Table 2 Heliport — Recommended Amounts of Extinguishing Agents

Heliport Category	Water for AFFF Production				Water for Protein Fluoroprotein Foam Production				Dry Chemical*			
			Discharge Rates				Discharge Rates				Discharge Rates	
	Gals (U.S.)	Litres	GPM	Litres/Min	Gals (U.S.)	Litres	GPM	Litres/Min	Lbs	Kgs	Lbs/Min	Kgs/Min
H-1	**	**	**	**	**	**	**	**	100	45	100	45
H-2	200†	760†	100	380	300†	1140†	150	570	200	90	200	90
H-3	335†	1265†	200	760	500†	1900†	300	1140	300	135	300	135

*When used with protein or fluoroprotein foam, foam compatible type dry chemical is required. Dry chemical in containers weighing in excess of 50 lbs (22.5 kgs) should be equipped with auxiliary wheeled carriers. See 3-1.2.3 when alternate use of carbon dioxide is to be used. (*See also Standard on Installation of Portable Fire Extinguishers, NFPA 10 [ANSI]*.)

**Many times a water supply meeting the recommendations for Category H-2 may be readily available. In such cases, it should be made available assuming personnel are *assigned* to utilize the equipment in the event of an emergency.

†This amount of water should be immediately available from a hydrant (standpipe), pressurized tank, reservoir, cistern, or mobile vehicle so that it can be dispensed at the discharge rate indicated and at a satisfactory pressure. Additional water should be available to provide a continuing rescue and fire fighting capability wherever feasible.

3-1.4 Protection at Heliports.

3-1.4.1 Table 2 indicates the quantities of water for foam production (using protein or fluoroprotein foam concentrates) and the quantities of dry chemical that are recommended for heliports categorized as follows. The quantities of water may be reduced one-third when aqueous film-forming foam concentrate is used.

H-1 — This category includes all heliports where the helicopters using the facility carry less than 6 persons, have operational fuel loads of less than 100 gal (380 L).

H-2 — This category includes all heliports where the helicopters using the facility normally carry more than 6 and less than 12 passengers and have operational fuel loads of less than 200 gal (760 L).

H-3 — This category includes all heliports where the helicopters using the facility normally carry 12 or more passengers and have operational fuel loads of more than 200 gal (760 L).

3-1.4.2 For effective use of the fire protection recommended for heliports in categories H-2 and H-3, it is important that the extinguishing equipment be capable of discharging the agents at the rates indicated. The foam rates (using protein or fluoroprotein concentrates) are those which provide the maximum nozzle flow rate capable of being handled by one man. The amount of agents and rates recommended should be sufficient in the hands of trained operators to provide initial fire control, thus permitting occupants to evacuate or be rescued, assuming that they are not incapacitated or killed on impact. Additional water is recommended to permit complete extinguishment.

NOTE: Where a standpipe or other continuous water supply of sufficient pressure and volume is available, it should be used to supply the foam system. If a continuous water supply of adequate volume but insufficient pressure is available, an automatic booster pump should be provided.

3-1.4.3 Fire extinguishers, foam nozzles, hose reels, etc., located on heliports should, where necessary, be in weatherproof, abovegrade cabinets, clearly marked as to their contents. Cabinets shall be located beyond but not in excess of 20 ft (6.1 m) of the boundary line defining the landing and take-off area and shall not protrude into the normal approach-departure paths. These cabinets should be located diametrically opposite each other.

3-1.4.4 Foam nozzles should be light in weight and capable of discharging foam, dispersed pattern foam, or water spray.

3-1.4.5 The requirements of NFPA 418, *Standard on Roof-Top Heliport Construction and Protection*, should be followed, including construction, drainage and separators, landing deck egress, and fire protection for the structure.

3-1.4.6 Fueling on elevated heliports should be arranged and handled in accordance with the recommendations contained in Chapter 6 of NFPA 407 (ANSI), *Standard for Aircraft Fuel Servicing*.

3-1.4.7 An automatic alarm should be provided to indicate foam system operation and to summon aid.

Chapter 4 Aircraft Rescue and Fire Fighting Vehicles and Personnel for Protection of Aircraft Operations

4-1 Major Fire Fighting Vehicle Recommendations.

4-1.1 These vehicles should be constructed to comply with the provisions of Part B of NFPA 414 (ANSI), *Standard for Aircraft Rescue and Fire Fighting Vehicles*. Where climatic or geographic conditions exist that considerably reduce the effectiveness of wheeled vehicles, it is often necessary to carry extinguishing agents in a specialized vehicle such as track, amphibious, air cushion units, etc. At least 75 percent of the agents required should be carried on vehicles conforming to the requirements of NFPA 414 (ANSI) unless exceptional circumstances dictate otherwise.

4-1.2 It is desirable to have more than one such vehicle available to facilitate attacking aircraft fires from more than one point or quarter, as an aid to expedite rescue, to reduce the potential seriousness of a vehicle breakdown and to minimize the "out of service" consequences when a vehicle is in need of repair. This applies particularly to the protection at conventional airports in Indexes 5 through 8 (*see Table 1A*). At airports in Indexes 5 and 6 (*see Table 1A*) consideration should be given to providing the total quantity of water for foam production on two fire fighting vehicles; for Indexes 7 and 8, three fire fighting vehicles are preferred to two such vehicles with supplemental tank vehicles. The latter recommendation provides the advantage of reducing the number of vehicles and the manpower requirements.

NOTE: Having at least two fire fighting vehicles available is particularly important when dealing with transport type aircraft because: (1) of the need to cover rapidly any burning fuel spill and thus protect the aircraft and its occupants from radiated heat during the evacuation and rescue period, and (2) the need to make and maintain the area around the fuselage (*see 3-1.1.2*) to permit the safe evacuation and rescue of the occupants. An analysis should be made to determine procedural policies for rescue, fire control and extinguishment prior to making a decision on the number of vehicles required, being realistic, at the same time, as to how the number of vehicles will influence manpower requirements and vehicle maintenance.

The fire control efficiency of each fire fighting vehicle is generally proportional to the foam-producing capacity of the unit and the duration of the foam discharge. As an example, when using aqueous film-forming foam (AFFF) concentrates for foam production, Table 1B specifies 5,000 gal (19,000 L) of water capacity for the fire fighting and tank vehicles in Index 7; two fire fighting vehicles each carrying 2,500 gal (9,500 L) would be preferable to two 1,500-gal (5,700-L) capacity fire fighting vehicles supplemented by a 2,000-gal (7,600-L) capacity tank vehicle.

4-1.3 The "payload" capacity (fire fighting and rescue equipment and manpower) of the vehicles used in this service should be compatible with the desired performance characteristics established for vehicles in the various weight classes specified in NFPA 414 (ANSI), *Standard for Aircraft Rescue and Fire Fighting Vehicles*. It is particularly important that the vehicle not be so overloaded as to reduce the required acceleration, speed, or vehicle flotation (as measured by weight distribution on the tires) below the acceptable minimums set forth in the referenced document.

4-1.4 The off-pavement performance of each specialized vehicle should be established by tests at each airport during the various weather and terrain conditions experienced at each airport, to establish, prior to an actual emergency, the capabilities and limitations of the vehicle for off-pavement response to accident sites. In addition, periodic tests should be run to assure that the other performance requirements of the vehicle are as originally designed, and that the skill levels of the driver-operators remain high.

4-1.5 All essential vehicles (those designated to reach the scene first and the major units) should be provided with two-way radio facilities to assure positive communication with airport control (*see Section 4-6*).

NOTE: "Positive" communication means a highly reliable communication system to guarantee radio contact between the vehicles and airport control.

4-1.6 Overall vehicle dimensions should be within practical limits with regard to local standard highway practices, width of gates and height and weight limitations of bridges, and other local considerations.

4-1.7 Simplicity of vehicle operation (particularly operation of extinguishing agent discharge devices) is highly important because of the time restrictions imposed upon successful aircraft rescue and fire fighting operations and the need to keep to the minimum the crew required. It should be remembered that fast blanketing of the fire area is essential while using no more agent than is necessary to gain the objective. Hand hose lines are usually not enough for fires involving larger types of aircraft due to their limited discharge rate. To overwhelm an aircraft fire it is necessary to apply extinguishing agents at a rate higher than the fire is capable of destroying the control effort. For this reason elevated turrets, remotely controlled extension boom turrets, or similar devices having large discharge capacities are needed to quickly blanket the fire and knock down the bulk of the flames (*see 3-1.2.1*). Hand lines are used primarily for protecting rescue parties, for maintaining control of the fire in the rescue area, and for spot cooling.

4-1.8 Improvements in vehicle and equipment designs over recent years have increased the fire fighting efficiency of such units and have made many older aircraft fire fighting vehicles comparatively less efficient. Before procuring any used vehicle for this service, the possible saving in initial cost should be carefully weighed against the lower maintenance cost, the reduced manpower requirements, and the greater fire fighting efficiency that can be expected from new equipment built in accordance with NFPA 414 (ANSI), *Standard on Aircraft Rescue and Fire Fighting Vehicles*. Secondhand vehicles may have been subjected to abusive service, components may have been overstressed, and repair parts may be impossible to obtain. Foam fire fighting equipment purchased for this service should be tested in accordance with NFPA 412 (ANSI), *Standard for Evaluating Foam Fire Fighting Equipment on Aircraft Rescue and Fire Fighting Vehicles*.

4-2 Rapid Intervention Vehicle (RIV) or Light Rescue Vehicle Recommendations.

4-2.1 The rescue vehicle(s) recommended in Table 1B should comply with Part C of NFPA 414 (ANSI), *Standard for Aircraft Rescue and Fire Fighting Vehicles*. Operationally, the rescue vehicle should be the first unit to reach an accident site. (*See 4-8.3.1.* "NOTE".) It is considered extremely important that this vehicle be so designed that it can be operated and handled by one man, and that this one man can place in operational readiness the extinguishing equipment while enroute, so that there will be no delay in placing the vehicle in service upon arrival. Experience has proven that the availability of such a vehicle has been most valuable in attacking fires in their incipient stages; in many cases, extinguishment or control has been achieved by this single unit prior to the arrival of the larger fire fighting vehicles, and in other cases, a successful holding action has been accomplished. The amount of agent carried on this light vehicle will depend on its load capacity, but extreme care should be exercised to prevent overloading the vehicle and thus detracting from its acceleration, speed, flotation and traction capabilities. The agent discharge rate should be high to permit quick knockdown of any existing fire; the duration of such discharge will be short because of the limited agent supply but the speed of the vehicle is intended to buy time pending arrival of major units. (*See 4-1.5 and Section 4-6 with regard to communications equipment.*)

4-2.2 Rescue tools [see NFPA 414 (ANSI), *Standard for Aircraft Rescue and Fire Fighting Vehicles*] should be carried by this vehicle. Caution should be exercised in connection with this recommendation, however, that the addition of the rescue tools does not overload the vehicle or interfere with the vehicle's performance. In the cases where it is not possible to carry all the desired rescue tools on this vehicle without overloading the unit, it is recommended that provisions be made to transport that portion of the desired rescue tools on other vehicles comprising the full response group or by auxiliary vehicles capable of responding within the desired period.

4-3 Water Tank Vehicle Recommendations.

4-3.1 Water tank trucks (sometimes referred to as "Nurse Trucks") although not specified in NFPA 414 (ANSI), *Standard for Aircraft Rescue and Fire Fighting Vehicles*, can be used to augment the quantity of water available on the fire fighting vehicles. The operational purpose of these vehicles will dictate their performance needs in each instance with the overall concept being their ability to maintain the fire fighting capability of the fire fighting units(s) without interruption at the discharge rates of the latter equipment as long as the water supply permits.

4-3.2 Water tank trucks should be equipped with a pump, or pumps and hose, for relaying water to the fire fighting equipment, or for direct application on the fire. It is desirable that pumps have sufficient capacity to replenish the fire fighting vehicle having the largest rate of discharge when that vehicle is operating at maximum capacity. Proper type and sufficient quantity of hose should be provided to quickly transfer the water content of the tank vehicle to the major rescue and fire fighting vehicle, so that the tanker can be resupplied in a shuttle-type operation while the fire control effort is being maintained.

4-3.3 Auxiliary supplies of foam compounds, combination straight- and dispersed-pattern foam nozzles, and water spray nozzles may also be carried on the tank truck.

4-4 Combined Agent Vehicle Recommendations.

4-4.1 This type of vehicle should be constructed to comply with the provisions of Part D of NFPA 414 (ANSI), *Standard for Aircraft Rescue and Fire Fighting Vehicles*. It is primarily designed to serve as the prime fire fighting vehicle for Index 2 airports (*see Tables 1A and 1B*) but may be suitable as an alternate for a light rescue vehicle (*see Section 4-2*) for airports in higher indexes.

4-4.2 The fire fighting systems employed on the vehicle may be of several different types. Protein, fluoroprotein and aqueous-film-forming foam (AFFF) systems consist of tanks holding water and the foam concentrate, a proportioner for mixing the two, a pump, and a roof-mounted turret nozzle and hand lines for applying the foam. A pressurized foam system utilizes gas pressure reduced down from high pressure cylinders to expel the materials from their respective containers in lieu of pumps. The devices for applying foam to the fire are usually identical for either system. Dry chemical systems and carbon dioxide systems are always applied by pressurized-type equipment. [*See NFPA 414 (ANSI).*]

4-5 Recommendations for Fire Fighting Equipment on Vehicles.

4-5.1 No attempt is made here to detail water pump capacities, pump inlet and outlet plumbing, foam proportioners and controls, the location of elevated nozzles and their operation, hose reel locations, or other design details of foam or supplementary agent equipment mounted on the equipment provided. It is recognized that all these items require careful engineering and that the details of the fire control equipment must be compatible with the discharge rates recommended in the tables, the manpower available in each instance, and the objective of providing maximum capability for the vehicles in their primary function of rescue. [See NFPA 414 (ANSI), *Standard for Aircraft Rescue and Fire Fighting Vehicles, for fire fighting equipment recommendations.*]

4-5.2 Vehicles provided for this service should be designed to permit uninterrupted pump discharge even when maneuvering the vehicle during the rescue operation. This may be accomplished by providing an independent pumping engine(s), or, if the vehicle engine(s) is (are) also used for pumping, by providing a specially designed transmission or engine-powered take-off. Use of such a transmission or power take-off should not result in more than a slight decrease in pump pressure, as well as not interrupting extinguishing agent discharge while vehicle movement is being accomplished. [*See Section 31 of Part B of NFPA 414 (ANSI).*]

4-5.3 Optimum benefits are normally achieved with mobile equipment by approaching aircraft fires from the windward position but this is not always possible. This dictates that turrets and hand lines should be so located and operable over such a range as to be of maximum utility and not conflict with each other. [*See Sections 335 and 336 of NFPA 414 (ANSI) for details.*]

4-5.4 At airports adjacent to water or swampy areas or where snow, ice, or unusual terrain may affect fire and rescue activities, special consideration should be given to these factors (*see Chapter 6 — Water Rescue Facilities*).

4-5.5 Elevated platform devices or aerial water towers may be needed at some airports to allow fire fighters to reach elevations above the normal range of other ground fire fighting vehicles. (*See also NFPA 402, Aircraft Rescue and Fire Fighting Operational Procedures for Airport Fire Departments, on handling aircraft cabin fires.*)

4-6 Communications and Alarms Recommended.

4-6.1 The provision of two-way radio communication, special telephone and general alarm systems is recommended between airport control and the airport fire station. Dependable transmission of essential emergency signals is a vital necessity. All such equipment should be tested at least every 24-hour period, although experience may prove more frequent testing is desirable, i.e., each new shift, after severe electrical storms, etc. Mobile vehicles considered essential for the effective rescue and fire fighting service should be provided with two-way radio equipment (*see 4-1.5*). Consistent with the individual situations at each airport, communication and alarm equipment should serve the following purposes:

4-6.1.1 Provide for direct communication between airport control and the airport fire station to ensure the prompt alerting and dispatch of rescue and fire fighting vehicles and personnel in event of an alert or incident.

4-6.1.2 Provide for emergency signals to ensure the immediate summoning of auxiliary personnel not on standby duty at the airport fire station (*see 1-5.3, herein, and NFPA 402 and NFPA 424*).

4-6.1.3 As necessary, in accordance with the Airport/Community Emergency Plan (*see NFPA 424*), provide for the summoning of cooperating public protective agencies (public fire departments, ambulance and medical services, police or security personnel) and others located on or off the airport.

4-6.1.4 Radio equipment should be available to allow for tactical communications between the fire officer in charge and fire fighters engaged in rescue and fire fighting operations at the accident site.

4-7 Related Airport Features.

4-7.1 The installation of underground water service mains with either conventional or flush-type hydrants along aprons and adjacent to administration and service areas is recommended. Underground water service mains for aircraft landing areas are also desirable.

4-7.2 Consideration should be given at all airports, depending on local conditions, to provide for ready access to such natural water supplies (lakes, ponds, streams, etc.) as may be available in the immediate vicinity. Provision should be made for drafting and pumping from such water supplies to augment the capabilities of the aircraft rescue and fire fighting vehicles. The construction of ramps, cisterns, docks, or settling basins to permit utilization and access to natural water sources available should not be overlooked. Wherever feasible, provision for drafting and pumping should be incorporated on a structural fire fighting unit which is either based at or located in the vicinity of the airport.

NOTE: For further guidance on airport water supplies, see NFPA 419, *Recommended Practice for Master Planning Airport Water Supply Systems for Fire Protection.*

4-7.3 Depending on the location of the airport and local topography, consideration should be given to the provision of suitable quick exits around the perimeter of the airport for aircraft rescue and fire fighting vehicles and to provide good approaches to access roads beyond the airport boundary for as far a distance as is necessary or practical. Particular attention should be given to the provision of ready access to the undershoot and overrun areas. (*See Figure 2-2.2 of NFPA 402.*)

4-7.4 Aircraft rescue and fire fighting vehicles normally should be garaged at one or more strategic locations (*see also Chapter 9 herein and NFPA 402*). The station apparatus section should be heated (where necessary) to assure immediate starting of garaged vehicles and should be located so:

4-7.4.1 That access to the movement area is unobstructed.

4-7.4.2 That vehicle running distance to active runways is the shortest possible consistent with regulations regarding clearances of structures from landing areas.

4-7.4.3 That observation of both flight line activity and landing area is unobstructed to the greatest extent possible.

4-7.4.4 That auxiliary personnel, trained for aircraft rescue and fire fighting, will be able to reach their stations without unnecessary delay.

4-8 Personnel Recommendations.

4-8.1 All personnel provided for aircraft rescue and fire fighting duties should be fully schooled in the performance of their duties under the direction of a designated airport fire department training officer. (*See Chapter 8 herein.*)

4-8.2 Personnel. Men recruited for aircraft rescue and fire fighting services should be of a high physical and mental standard, resolute, possess initiative, competent to form an intelligent assessment of a fire situation and, above all, must be well trained and fully qualified. Ideally, every man should be capable of sizing up changing circumstances at an aircraft accident and taking the necessary action without detailed supervision. The officer responsible for the organization and training of the fire service should be an experienced, qualified and competent leader.

4-8.3 In the interest of providing immediate response capabilities of all vehicles recommended in Table 1B, the following *minimum* manpower should be provided during flight operations:

4-8.3.1 A fully trained driver-operator for the light rescue vehicle or the combined agent vehicle.

NOTE: It is anticipated that this vehicle will be the first unit to arrive. It is recommended that the officer in charge respond with this vehicle. This will allow an early appraisal of conditions in order that he can better direct fire fighting operations.

4-8.3.2 A fully qualified driver-operator for each of the other vehicles provided to meet the recommendations in Table 1B for airports in Indexes 4 through 8.

4-8.3.3 A fully trained turret operator for each major fire fighting vehicle recommended in Table 1B for airports in Indexes 3 through 8.

NOTE: In 3-1.2.1 it is recommended that not less than 75 percent of the recommended discharge rates appearing in Table 1B be from turrets. In the event that the combined turret discharge capacity for all vehicles required to carry the specified quantities of water for foam making exceeds 75 percent of the total discharge recommended, then fully trained turret operators to man the additional turrets is a matter for the local jurisdiction to decide. Example: If four fire fighting vehicles provide the 10,000 gal (37,850 L) of water for protein foam making recommended for Airport Index 8 in Table 1B and each vehicle has an individual turret capacity of 900 GPM, fully trained turret operators are essential on only three of the four vehicles (3 x 900 GPM = 75% of 3,600 GPM).

Other fully trained fire fighting personnel should be readily available* to provide handline operation capabilities of the major fire fighting vehicles. At airports falling into Indexes 5 through 8 of Table 1B, serious consideration should be given to providing this additional personnel on an immediate response basis.

4-8.3.4 In order to determine training and qualifications of the fire fighting personnel, refer to training procedures outlined in Chapter 8.

4-8.4 Movement and utilization of aircraft rescue and fire fighting equipment and of other emergency equipment at the time of emergency should be governed by the principles set forth in NFPA 402, *Aircraft Rescue and Fire Fighting Operational Procedures for Airport Fire Departments.*

4-8.5 It is recommended that equipment be manned and placed at predetermined emergency stations on the movement area prior to any landing or take-off attempted under any abnormal flight or weather conditions which might increase the accident potential during such operations. (*See NFPA 402 for further information.*)

4-8.6 All authorized personnel should be given suitable identifying insignia to prevent any misunderstanding as to their right to be in the fire area or on the movement area of an airport during an emergency. (*See NFPA 424 for further information.*)

4-9 Protective Clothing.

4-9.1 It is essential that adequate protective clothing and equipment be provided, maintained, and readily available for use. There are two types of protective

*"Readily available fire fighting personnel" are personnel trained in and assigned to fire fighting duties but who may have other duties on the airport and respond to an emergency upon call.

clothing available for use by airport fire departments which are:

4-9.1.1 Entry Suits. Fire entry suits have been tried experimentally but are not recommended for civil airport application. Although entry through the flames may be possible with such protection, evacuation of crew and passenger personnel in this same environment is not possible unless they are outfitted with similar clothing. Rapid fire control afforded by present fire fighting equipment and short times for survival without fire control make the fire entry suit impractical.

4-9.1.2 Proximity Suits. There are two kinds:

(a) Reflective Suit. The primary source of heat to fire fighting personnel in an aircraft fire environment is from radiant heat. Reflective fire fighting suits are available. They generally include coats, trousers, hood/helmet, gauntlet-type gloves and boots. The coat and trousers are sometimes replaced with a one-piece coverall-type garment.

(b) Bunker Suit. The bunker suit is the same as worn for structural fire fighting. It is generally nonreflective and consists of coat, trousers, helmet, gloves and boots. It does not provide the radiant heat protection afforded by the reflective clothing; therefore, fire control must be well established prior to approaching the flame while wearing this type suit.

4-9.2 Although there is seldom need for the fire fighter to enter the flames, he should be provided with clothing that will withstand radiant heat and occasional direct flame contact. The suit should, therefore, provide thermal insulation, be noncombustible, waterproof, lightweight, free of bulky incumberances, provide freedom of movement, be comfortable, easily donned without the aid of a second person, and compatible with self-contained-type breathing equipment. The fabrics used should be lightweight, not bulky, and flexible with tear-resistant qualities. They should be abrasion-resistant and have high-temperature resistance. All seams should be waterproof. If pockets are provided, a small hole should be left in the bottom corners for water drainage. Fastenings should be heat and flame resistant and not yield under stress. They should be easily accessible under emergency conditions and capable of being operated while wearing gloves. Protective clothing may have to be worn for a protracted period of time under a hot sun or in extreme cold. Therefore, the balance between protection of various thicknesses and densities of material should be selected with considerable judgment and should be proven by rigorous practical testing before the clothing is purchased.

4-9.3 Gloves. Gloves should be of the gauntlet type with heat protective lining. They should have a closure at the wrist and provide maximum dexterity for the operation of switches, fastenings and hand tools.

4-9.4 Head Protection. A helmet with a wide-vision face shield should provide the wearer with the best ocular and aural awareness and some heat sensitivity. A helmet should minimize a sense of isolation to the wearer; should provide adequate protection from impact; should be resistant to penetration and electric shock; should be adaptable for one- or two-way radio communication; and should provide thermal stability. An abrasion- and impact-resistant movable visor is advisable. If the helmet incorporates radio equipment, an identification number should be applied on the helmet exterior in a contrasting color to facilitate communication under operational conditions. If a conventional fire hood is used in lieu of a helmet, it should be vented. Some hoods can be dangerous because of entrapment and rebreathing of used air.

4-9.5 Boots. Uppers should be of tough, flexible, heat resistant material. Soles should be of no-slip material, resistant to heat, oil, aircraft fuel, and acid, and be puncture resistant. Toe caps should be reinforced with steel. The entire boot should be insulated for heat protection and resistant to static charges.

4-9.6 Undergarments. Some suits require special underwear to complete their protective function. Due to climatic conditions, it is often not practical to provide these garments for continuous wear. In this case, the additional protection must be provided in the outer suit, or fire fighters must wear complete work clothing, including long sleeve shirts.

4-9.7 Protection Requirements.

4-9.7.1 Each component of the protective clothing and the entire assembly, when worn and used correctly, should provide protection from the following:

(a) Occasional flame contact.

(b) Radiant heat of 0.7 cal/cm^2/sec for two minutes.*

(c) Radiant heat of 1.9 cal/cm^2/sec for one minute.*

(d) Impact resistance from sharp objects.

(e) Water.

(f) Electric Shock.

4-9.7.2 The entire suit should be capable of being cleaned without deterioration of the properties listed in 4-9.7.1

4-9.8 Respiratory Protection Equipment. Recent tests have shown that many toxic gases are produced when aircraft cabin interior finish materials are burned or charred. These gases include carbon monoxide, hydrogen chloride, chlorine, hydrogen cyanide and other cyanogen compounds, and carbonyl chloride (phosgene). A principal cause of difficulty lies in the fact that the supply of breathing air is greatly reduced by combustion of these cabin finish materials. It is, therefore, necessary that fire fighters and rescue men who enter an aircraft during the fire sequence be equipped with self-contained breathing equipment. Their helmets or hoods should be designed to accommodate this equipment without interference; most existing proximity hoods do not have this provision. Self-contained breathing equipment should be of the type approved by the U. S. Bureau of Mines and must meet the requirements of NFPA 19B, *Standard on Respiratory Protective Equipment for Fire Fighters.* Those utilizing the principle of canister generation of

*Radiant heat emittance should cover the spectrum of 0.6n to 6.0n wavelength range.

oxygen are sometimes unsatisfactory in atmospheres containing high concentrations of fuel vapor. Self-contained breathing equipment should contain an audio/visual warning device to actuate when the air supply is nearing exhaustion. It should be compatible with the hood or helmet and be capable of rapid actuation.

Chapter 5 Ambulance and Medical Facilities

NOTE: See *Recommended Practice for Airport/Community Emergency Planning*, NFPA 424, for comprehensive guidance.

5-1 Provision for Ambulances.

5-1.1 The availability of ambulance and medical facilities for the removal and after-care of casualties arising from an aircraft accident should receive the careful consideration of airport managements and should form part of the overall emergency plan established to deal with such emergencies as recommended in NFPA 424, *Recommended Practice for Airport/Community Emergency Planning*.

5-1.2 The extent of the facilities to be provided should be determined by the type of traffic and the maximum number of passengers likely to be involved in the largest aircraft normally using the airport.

5-1.3 Any decision regarding the provision of ambulances on the airport proper should consider the ambulance facilities available in the proximity of the airport and the possibility of assembling this equipment to meet within a reasonable period of time a sudden demand for assistance of the scale envisaged. It is also important to consider the suitability of such ambulances for movement on the terrain in the vicinity of the airport. Where it is decided that the provision of an ambulance or ambulances on the airport is necessary, then consideration should be given to the following:

5-1.3.1 The vehicle to be provided should be of a type suitable for movement on the terrain over which it may reasonably be expected to operate, and should provide adequate protection for the casualties.

5-1.3.2 As a measure of economy, the vehicle may be one which is used for other purposes, provided such other uses will not interfere with its availability in the event of an accident. Any dual purpose vehicle should be easily modified to permit the carriage of stretchers and other medical equipment. In a case where auxiliary personnel are relied on for fire fighting and rescue purposes the ambulance vehicle could be used for the transport of such personnel to the scene of the accident and then assume its role as an ambulance.

5-2 Organization of Medical Assistance Program.

5-2.1 The provision of a first aid room or medical clinic on the airport for the reception and treatment of casualties may be desirable. Such a room or clinic should be equipped to the standard considered necessary to meet the local requirement, which will, of course, take into account the availability and proximity of hospital services with which predetermined arrangements should exist for the reception and handling of casualties arising from an aircraft accident as recommended in NFPA 424.

5-2.2 The emergency plan should provide for the summoning of physicians in the event of an accident and for the recruitment and training in first aid or higher level of emergency medical training (paramedic or EMT) of as many people as possible from the airport staff who may be prepared to undertake such duties either on a voluntary basis or on such other basis as may be determined locally. It is especially desirable that personnel manning ambulances should be trained to the extent recommended in NFPA 424.

5-2.3 The usefulness and efficiency of any ambulance and first aid organization to be provided on an airport may be greatly assisted if it is used to deal with incidents, whether of a minor or major character, arising during the normal routine working of the airport. By so doing, a situation is avoided whereby trained personnel and a useful organization may be left untried and unused over very long periods.

Chapter 6 Water Rescue Facilities

NOTE: See also NFPA 402, *Recommended Practice for Aircraft Rescue and Fire Fighting Operational Procedures for Airport Fire Departments*, for comprehensive recommendations.

6-1 Provisions for Rescue Service.

6-1.1 Airports adjacent to large bodies of water should assure availability of facilities capable of rescuing occupants of any aircraft that may come down in the water in the proximity of the airport.

6-1.2 Many aircraft do not carry personnel flotation devices on board, especially those not engaged in extensive over-water operations. Such flotation devices should be available in numbers sufficient to meet the needs of the maximum passenger capacity of the largest aircraft in regular service at the airport. Where the largest aircraft is in scheduled over-water operation and all other operations are over-water in character, the airport may reduce the amount of personnel flotation devices by 50 percent.

6-1.3 Consideration of unusual terrain and water conditions, such as tidal flats, swamps and the like, may dictate the choice of the particular type vehicle most suitable to these conditions. Helicopters, air cushion, and amphibious vehicles as well as conventional watercraft may be found to provide this specialized service.

NOTE: In developing the water rescue service, consideration should be given to private or public services (such as military search and rescue units, harbor police, or fire departments) and private rescue services (such as rescue squads, power and communication companies, pipeline or oil field operators, lumbering industry, or shipping and waterway operators) which may be available and are capable of rendering assistance. A signal system for alerting private or public services in time of emergency should be prearranged.

6-2 Rescue Boats.

6-2.1 Rescue boats should be capable of shallow water operations. Boats powered by jet-type propulsion eliminate the dangers of propellers puncturing inflatable equipment or injuring survivors during rescue operations. Boats powered by conventional propellers may diminish the hazards of puncture and injury by being equipped with fan-type guards or cowls.

6-2.2 Boats and other rescue vehicles should be so located that they can be brought into action in minimum time. Special boathouses or launching facilities should be provided when such will contribute materially to the rapidity of the launching process.

6-2.3 The boats should be of such size as to efficiently carry the flotation equipment required with adequate space for the crew and sufficient working space to permit rapid dispersal of the flotation devices. Inflatable life rafts should be the prime flotation equipment carried, and there should be an adequate number of life rafts to accommodate the largest aircraft occupancy served by the airport (*see 6-1.2*). Once this flotation equipment has been dispensed, the space in the boat used to carry it should be such that it would accommodate a limited number of litter cases brought aboard in the process of rescue.

6-2.4 In order to permit communications with other rescue units, such as helicopters, air cushion or amphibious equipment and with water-land based units, adequate two-way radio equipment should be provided in all rescue boats.

6-2.5 A minimum of two floodlights should be provided for night operations.

Chapter 7 Reports

7-1 NFPA Reports.

7-1.1 Each operation of aircraft rescue and fire fighting equipment should be carefully reported and analyzed and one copy of each such report should be sent to the National Fire Protection Association. Copies of the NFPA's Aircraft Fire Report form are available from the Association.

7-1.2 To guide those studying aircraft accidents, the *Aircraft Fire Investigators Manual*, NFPA 422M, should be secured and the techniques recommended therein utilized.

Chapter 8 General Principles for Training of Aircraft Rescue and Fire Fighting Personnel

8-1 Introduction.

8-1.1 The objectives of a training program for aircraft rescue and fire fighting personnel at airports are:

8-1.1.1 To assure the application of recognized practices and safe procedures that are universally accepted as contributing to the survival and/or permitting the rescue of those involved in aircraft accidents;

8-1.1.2 To develop and maintain competency of the individuals and of the crews working as a team assigned to the airport fire department by developing confidence in themselves and their equipment;

8-1.1.3 To instill the concept of professionalism among people making this service a career;

8-1.1.4 To serve as a technically qualified source of information whereby the lessons gained from aircraft accidents or incidents may be analyzed and properly disseminated to others technically concerned with related fire safety and rescue problems;

8-1.1.5 To enhance the esprit-de-corps of aircraft rescue and fire fighting personnel by creating an appreciative awareness of the hazard and dangers they may face in carrying out their duties.

8-1.2 Instances at airports when aircraft rescue and fire fighting personnel are called upon to face a serious situation involving major rescue and fire fighting operations are fortunately infrequent. There are, however, many needs to stand by as a precautionary measure to assure the immediate availability of fire prevention and protection services during many different types of aircraft movements and aircraft servicing and maintenance operations. Under these conditions, aircraft rescue and fire fighting personnel are seldom called upon to put their full knowledge to a supreme test under stress conditions, and thereby gain "experience." It follows, therefore, that only by means of carefully planned and executed programs of training can there be any assurance that both the men and the equipment will be competent to deal with a major aircraft accident/incident should the necessity arise.

8-1.3 A training program oriented specifically to meet the needs of aircraft rescue and fire fighting personnel that can result in achieving and maintaining the desired proficiency levels may involve a considerable financial burden to the airport.

NOTE: As an indication of the financial realities involved in vocational skill/development programs for aircraft rescue and fire fighting personnel that may be anticipated, the following recommendations of Transport Canada Air may be used as a guide:

"Annual training material requirements for fire fighting should be calculated using the following quantities:

(a) Training materials for one year to *reach* the required level:

Foam concentrate per man (6%)	200 gal (900 L)

Fuel per man	2000 gal (9000 L)
Dry chemical per man	2000 lb (900 kg)
(b) Training materials for one year to *maintain* the required level:	
Foam concentrate per man (6%)	100 gal (450 L)
Fuel per man	1000 gal (4500 L)
Dry chemical per man	1000 lb (450 kg)"

Under the distressful real-life fire conditions that can be visualized as occurring on an airport, inept or ineffectual operations by aircraft rescue and fire fighting personnel would be tragic. Only by training experiences of a seriously challenging nature can there be assurance of individual and team proficiency, essential conservation of extinguishant resources through judicious application, and occupational safety for those involved. A training budget should also include provisions for sending personnel to schools, conferences, demonstrations, and similar gatherings for their personal and professional development.

8-1.4 Training of aircraft rescue and fire fighting personnel falls into three broad categories:

(a) Indoctrination training for probationary members;

(b) Technical and tactical training to firmly establish knowledge and skills levels, possibly increasing the survival time of those involved in aircraft accident/incidents through optimum utilization of the resources available; and

(c) Fire/rescue leadership training.

Training in the three phases is as important for support personnel as for career aircraft rescue and fire fighting personnel; because of the factor of time-availability for schooling, the depth into which subjects are covered will vary, but the scope should not be materially reduced for non-career support personnel crew members.

8-2 Basic Training and Educational Programs.

8-2.1 The complete training and educational program for aircraft rescue and fire fighting personnel should be under the direction of *one* officer of the airport fire department for planning, development, implementation, and supervision. Classes may be taught by other officers or crew members particularly qualified in one or more subject areas, but the training provided all should be in accordance with the airport fire department's master training plan. In addition to possessing professional attributes in the subject being covered, each instructor should possess personal attributes that will assure maintaining the interest and enthusiasm of the department members.

8-2.2 A successful training program at an airport should overcome numerous obstacles, including:

8-2.2.1 The monotony of preparing for eventualities that seldom happen;

8-2.2.2 The difficulty of duplicating on the training ground the psychologically disturbing factors of massive human injury and suffering that may be prevalent at an actual accident/incident;

8-2.2.3 The vagaries encountered in long-range planning due to work schedules, weather, and unforeseen occurrences; and,

8-2.2.4 The objections raised by realistic-type training such as hot fire drills.

8-3 Indoctrination Training.

8-3.1 Orientation. An early understanding by new aircraft rescue and fire fighting personnel of the factors affecting and/or concerned with their new assignment is important in the making of satisfactory craftsmen. It is basic human nature to desire to know what an individual may expect to get out of an activity, as well as what is expected of him. It is during the probationary period involved in orientation that the potential capability of the individual for service should be determined, Those not possessing the desired attributes should be directed to other employment. The new recruit is entitled to know:

8-3.1.1 The department rules and regulations.

8-3.1.2 The airport policies and procedures that affect his conduct.

8-3.1.3 His individual benefits, such as: retirement, promotions, sickness coverage, social security, union representation, and other conditions of service.

8-3.1.4 Knowledge of his basic duties and responsibilities and those of his co-workers.

8-3.1.5 Emergency turnout procedures.

8-3.1.6 The command structures for administration and for operations.

8-3.1.7 The importance of safety to himself and his co-workers.

8-3.1.8 The roles and missions of such government bodies and organizations* as:

(a) Air Line Pilots Association (ALPA)

(b) Air Transport Association of America (ATA)

(c) American Association of Airport Executives (AAAE)

(d) Airport Operators Council International (AOCI)

(e) Federal Aviation Administration (FAA)

(f) Fire Equipment Manufacturers Association (FEMA)

(g) Helicopter Association of America (HAA)

(h) International Association of Fire Chiefs (IAFC)

(i) International Association of Fire Fighters (IAFF)

(j) International Air Transport Association (IATA)

(k) International Civil Aviation Organization (ICAO)

(l) International Federation of Air Line Pilots Associations (IFALPA)

*The agencies listed are those of significance in the U.S.A.; in other countries, similar organizations normally exist and can be substituted, except for the international bodies.

(m) International Fire Service Training Association (IFSTA)

(n) National Fire Protection Association (NFPA)

(o) National Transportation Safety Board (NTSB)

(p) Society of Fire Protection Engineers (International) (SFPE), and state and local organizations representative of the above, or other related interests.

8-3.2 Fire Behavior and Fire Extinguishment. Aircraft rescue and fire fighting personnel need to have sound knowledge of the behavior of fire if they are to become proficient in fire suppression. A factor that makes aircraft fire fighting unlike structural fire fighting is that the objective of safeguarding the lives of those involved may entail control of the heat produced by the fire in a designated area in proximity to those portions of the aircraft containing survivors, or likely to contain survivors, rather than to attempt *complete* extinguishment. To increase the survival time of persons within an aircraft surrounded by fire, it thus may be necessary to concentrate the expenditure of the usually limited amount of agents within the immediate vicinity of the occupied areas of the fuselage, while disregarding fires burning in other areas (e.g., scattered wreckage, power plants dislodged, etc.). A mistake frequently made by unskilled persons is to immediately attack the *nearest* fire encountered on approaching a fire scene. This results in a severe drain on the limited resources of extinguishant carried by the response vehicles, without any fruitful accomplishment of the major mission.

8-3.3 Basic Knowledge of Fire Suppression. Previous experience in fire fighting is essential to understanding the rigors of fire suppression work. Instruction in this category should include:

8-3.3.1 The principles of combustion, with emphasis on the types of fuels prevalent on an aircraft.

8-3.3.2 How fire propagates through conduction, convection, and radiation effects.

8-3.3.3 The impact of fuel arrangement on heat production.

8-3.3.4 The principles of fire suppression with the type agents utilized in aircraft fire fighting operations.

8-3.3.5 The effects of heat exposure on individuals.

8-3.3.6 Procedures for the protection of rescuees, rescuers, and spectators in a fire environment.

8-3.3.7 Procedures to be followed when using a combined agent attack on a fire using several vehicles simultaneously.

8-3.3.8 How to don, wear, and work, utilizing breathing equipment and protective clothing.

8-3.4 Knowledge of the Extinguishing Agents Employed. It is essential that the advantages and disadvantages of each agent employed be thoroughly understood by all aircraft rescue and fire fighting personnel. Every opportunity should be seized to use the agents on actual test fires. This will give opportunity for the personnel to gain knowledge not only on the capabilities of each agent, but also on its limitations. Each routine equipment test should also be used as a training exercise to provide experience in the proper handling of the equipment, and to establish the proper technique of application of each agent available.

8-3.5 Handling of Appliances. All aircraft rescue and fire fighting personnel should be capable of effective handling of the available fire and rescue appliances, not only under training conditions, but in the rapidly changing circumstances of an actual aircraft accident/incident. The aim of training is to assure that every man is so well versed in handling all types of appliances and tools that under stress conditions he is able to operate in an automatic manner. Among the items that must be covered are:

8-3.5.1 Complete knowledge of each appliance and tool available.

8-3.5.2 The location of each extinguishing device and tool carried on each vehicle.

8-3.5.3 The manner of use of each tool, with emphasis on personal safety factors.

8-3.5.4 Special handling precautions on the use of power tools.

8-3.5.5 Knowledge of and training in the use of breathing apparatus and other protective equipment.

8-3.5.6 The techniques employed in utilizing the available communication equipment.

8-3.5.7 Correct maintenance procedures to maximize the availability of the appliances and their operational efficiency.

8-3.6 Operation, Care, and Maintenance of Airport Fire Department Apparatus. A thorough knowledge of the functional operation of apparatus is essential to assure intelligent handling and to guarantee operational efficiency under all circumstances. It is, of course, vital that any piece of equipment which may be called upon for use will operate flawlessly in an emergency. Major aircraft rescue and fire fighting vehicles have motive power, driving, traction and other vehicular performance characteristics distinct from most other commercial vehicles. For this reason there must be a driver testing process that will select personnel who can handle such specialized vehicles on the varied on- and off-road conditions that must be anticipated in actual emergencies, and who, by this knowledge, can secure the optimum performance effectiveness from the vehicles available. The provisions of *Fire Apparatus Driver/Operator Professional Qualifications*, NFPA 1002, list driver/operator requirements for structural-type fire apparatus. Certain of the provisions contained therein may be adapted for aircraft rescue and fire fighting vehicles in the selection of their driver/operators, but additional skill criteria peculiar to each of the latter vehicles will have to be added based on its unique features. Aircraft rescue and fire fighting vehicle operators' abilities and talents should be regularly checked; the following are some of the skills which are particularly significant:

8-3.6.1 A competency determination procedure that includes tests for vision acuity, reaction time, side vision, depth perception, recovery from glare, and attitudes.

8-3.6.2 Knowledge of the apparatus as is, and its built-in equipment, such as: the pump and its performance capabilities vs. the specifications for same; the agents carried and their delivery systems; the function and operation of valves and gauges; and the tools and support appliances carried.

8-3.6.3 Familiarization with all vehicle controls; methods for maneuvering the vehicle under any set of circumstances; how to negotiate terrain obstacles without damaging the vehicle or causing it to get bogged-down or hung-up; methods to be employed in dispensing the agents with maximum effectiveness; control over the quantities delivered; vehicle driving techniques to maximize accuracy in agent applications; and vehicle inspection and maintenance procedures.

8-3.6.4 Knowledge of departmental policies on positioning of apparatus for tactical service at accidents/incidents under the variety of possible conditions to be encountered.

8-3.6.5 The use of communication equipment in accordance with governmental regulations, as well as those of the airport concerned.

8-3.6.6 Record keeping to measure the efficiency and effectiveness of the various vehicles utilized by the airport fire department.

8-3.7 **Local Terrain.** A thorough knowledge of the terrain of the airport and its immediate vicinity is essential. The existence of any ground areas which may from time to time become impassable because of weather or other conditions (tides, growth of brush, etc.) should be known to all crew members. Training should include instruction in primary and secondary travel routes to all parts of the airport, runway overrun areas, and all areas outside the airport boundary to which on-airport equipment may be authorized to respond in event of an aircraft accident. Experience indicates that personnel should also receive training during periods of diminished visibility. An excellent means of familiarizing aircraft rescue and fire fighting personnel with the topography surrounding the airport is to arrange surveillance flights for them in local-based aircraft. Items to be included in the instruction program include:

8-3.7.1 Locations of obstacles to direct travel to any point (both temporary and permanent).

8-3.7.2 Locations of "break-through" points (gates and/or frangible sections) in the security fence.

8-3.7.3 Location of rendezvous points for assemblage of mutual aid apparatus as planned in the Airport/Community Emergency Plan.

8-3.7.4 Areas that might become impassable in inclement weather.

8-3.7.5 Availability of helicopters, boats, swamp buggies, air cushion vehicles or other off-road conveyances for reaching otherwise inaccessible areas with the land vehicles of the types available on the airport.

8-3.7.6 The capability of each aircraft rescue and fire fighting vehicle to negotiate the existing terrain under the diverse conditions that may be anticipated.

8-3.8 **Aircraft Familiarization Training.** The importance of this aspect of training cannot be overemphasized. Aircraft rescue and fire fighting personnel may be called upon to aid in the evacuation or extrication of trapped, injured, or unconscious persons from an aircraft interior under adverse conditions in an atmosphere laden with heat, smoke, and possibly toxic fire gases. It is therefore essential that every member of the airport fire department have intimate knowledge of each type and model of aircraft normally using the airport. Such knowledge cannot be obtained solely from a study of diagrams which are issued by many operators. There is no substitute for a periodic *personal inspection* of the aircraft, paying particular attention to position and locking mechanisms of all egress means, the seating arrangements, and the configuration of the interior spaces (aisle widths, location of galleys, cargo holds, baggage racks and closets, etc.). At airports where flights do not originate or terminate, it may be necessary to arrange for the fire department personnel to visit another airport, a manufacturing plant, or a fixed-based operator to gain the desired familiarity. Some of the items that should be covered in this aspect of training include:

8-3.8.1 The availability and method of operation of escape devices.

8-3.8.2 The standard operating procedures (SOP) to be expected from the aircraft crew members under specified circumstances.

8-3.8.3 The location of aircraft batteries, and means of disconnect.

8-3.8.4 The amount and type (Jet A, Jet B, AVGAS, or mixtures) of aircraft fuel carried and the fuel storage locations in each aircraft (tanks or integral wing structures).

8-3.8.5 The location and quantity of oxygen carried (gaseous or chemical).

8-3.8.6 Access to wheel wells, engine accessory compartments, and other areas of critical concern.

8-3.8.7 The fire behavior characteristics and locations in the aircraft of combustible metals (magnesium, titanium), plastics (cabin liners, seating), combustible insulation (for electrical wiring and sound-deadening), hydraulic fluids, lubricating oil, rubber, and similar combustibles and flammable materials.

8-3.9 First Aid and EMT Training. Every member of the airport fire department should be trained and periodically requalified in advanced first aid, as a minimum. It would be very desirable for those potentially responsible for assisting in aircraft occupant rescue, evacuation, or extrication to also be instructed in organized courses leading to certificates as Emergency Medical Technicians (EMT).

8-3.10 Search, Extrication, and Rescue. The very nature of fire accident/incidents involving aircraft may require time to be measured in milliseconds if maximum survivability is to be assured. Every airport fire department crewman should thus be thoroughly competent in procedures for locating victims in need, in releasing them from any restricting environment, and in assisting them in reaching an area of refuge where additional protective measures can be taken to safeguard their well-being and initiate any needed medical or psychological attention. In addition to fire control knowledge, the personnel should thus be given optimum instructions in the following subject areas:

8-3.10.1 The locations in aircraft where victim concentration may be anticipated under accident conditions of various types.

8-3.10.2 Human behavior patterns of individuals involved in major disasters.

8-3.10.3 Means of preventing and/or minimizing panic.

8-3.10.4 Means of effecting entry through normal aircraft openings under uncomplicated and complicated circumstances.

8-3.10.5 Locations where entry may be forced at other than main access doors.

8-3.10.6 The effective use of power tools and appliances.

8-3.10.7 The requirements of setting up triage points, which should be part of the Airport/Community Emergency Plan (*see NFPA 424*).

8-3.10.8 Methods of carrying injured persons (one-man and by teams).

8-3.10.9 The necessity of recording data for future evaluation at the earliest time possible.

Chapter 9 Location of Airport Fire Stations and Response Capability

9-1 It is recommended that rescue and fire equipment meeting the recommendations of this publication be maintained and garaged in suitable fire station(s) for optimum response capability on the airport.

9-2 The location of the airport fire station is of prime importance. Emergency equipment should have:

9-2.1 Instant access to critical airport movement areas;

9-2.2 Close proximity to locations of high hazard risks; and

9-2.3 Capability of reaching the extremities of the airport and runways in minimum time.

NOTE 1: The geographical center may not be the best location. Before selecting the actual location distance-time trials should be run to determine the optimum location that assures the quickest response to all potential accident sites. Also, an evaluation should be placed on present and future usage of the airport movement areas to assure proper selection of the fire station site. (*See Section 9-3.*)

NOTE 2: For typical siting of airport fire stations see Figure 9-2.

9-3 Response time is critical. The fire equipment should be located and maintained in such position that the equipment can reach any point within the airport operational area within three minutes, but preferably two minutes, of the time of alarm, and initiate agent application within that time.

9-4 Response time factors include:

9-4.1 The means of notification of the CFR force.

9-4.2 The completeness of the information in the activation message.

9-4.3 The means of assembling the CFR crew.

9-4.4 The accessibility of the fire station.

9-4.5 The acceleration and top speed capability of the vehicles.

9-4.6 The location of the incident.

9-4.7 The degree of preparatory training.

9-5 At airports where a central location for the airport fire station cannot meet the above response criteria, it may be necessary to have two or more airport fire stations located strategically on the airport. Accident statistics show that the greatest percentage of airport accidents occur on or just off the instrument runway(s) and locations to provide the quickest response to these areas are desirable.

9-6 Aircraft occupant survival is the prime purpose of the airport fire department. Locating the airport fire sta-

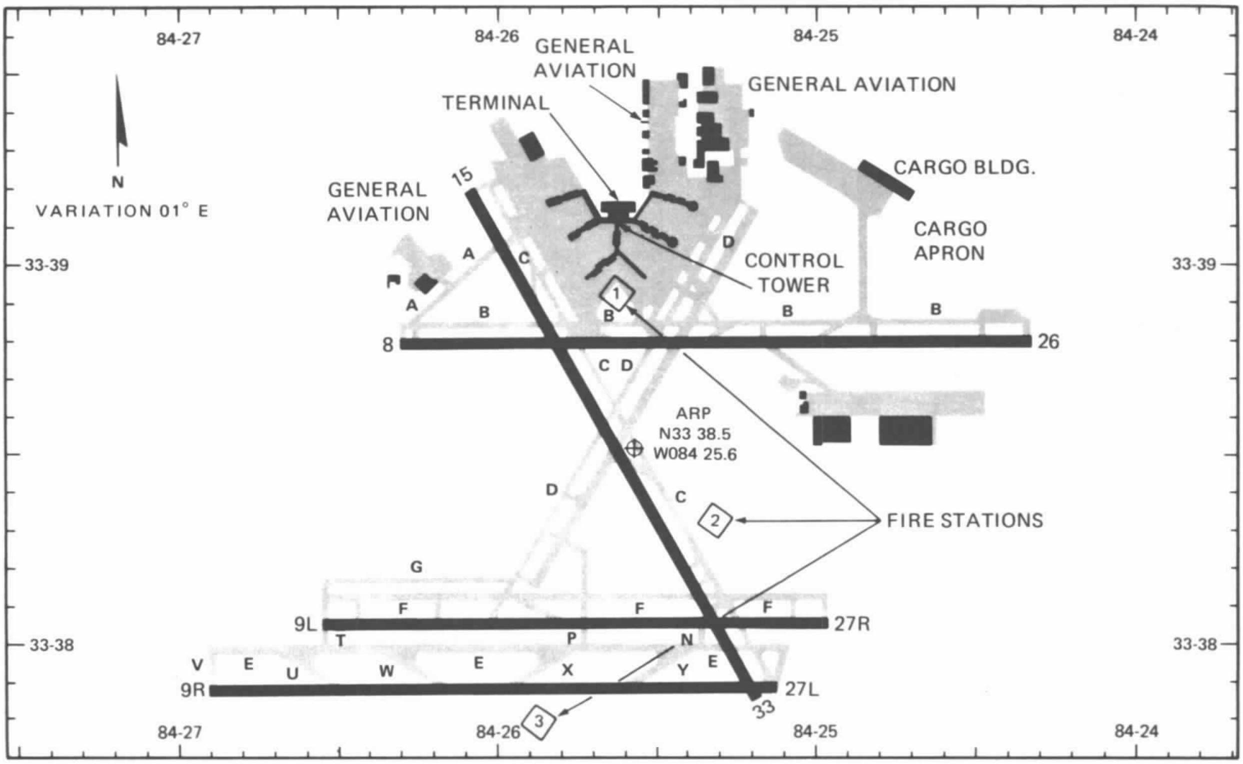

Figure 9-2

tion for structural fire fighting utility is of secondary importance.

9-7 Care should be taken that access to or from the airport fire station cannot and will not be blocked by taxiing or parked aircraft or airport vehicular traffic.

NOTE: Paving in front of airport fire stations should be prominently marked to prevent unauthorized use.

9-8 Airport fire stations located close to taxiways and runways or adjacent to flight patterns have a noise problem. It is thus necessary to soundproof all training rooms, living quarters, and the alarm room. The high noise level of turbine engines can cause damage to the hearing senses; at airports handling turbine powered aircraft, fire fighters on duty outside of soundproofed areas should be provided with aural protection. Where high noise levels are encountered it may be necessary to supplement audible signals with visual signals, such as flashing lights, to alert fire fighters.

Appendix A Definitions

This Appendix is not a part of this NFPA Recommended Practice but is included for information purposes only.

ICAO Definitions. The following definitions of terms are extracted from the "Lexicon" issued by the International Civil Aviation Organization (ICAO):

Aerodrome. A defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure, and surface movement of aircraft.

Aeroplane. A power-driven heavier-than-air aircraft, deriving its lift in flight chiefly from aerodynamic reactions on surfaces which remain fixed under given conditions of flight.

Air Traffic. All aircraft in flight or operating on the maneuvering area of an aerodrome.

Landing Area. That part of a movement area intended for the landing or take-off of aircraft.

Movement Area. That part of an aerodrome to be used for take-off and landing of aircraft and for the surface movement of aircraft.

Appendix B References

This Appendix is not a part of the recommendations of this NFPA document. . . but is included for information purposes only.

B-1 Reference Publications.

B-1.1 NFPA Publications. The following publications are available from the National Fire Protection Association.

NFPA 10, *Standard for the Installation, Maintenance and Use of Portable Fire Extinguishers*, 1978 (ANSI)

NFPA 19B, *Standard on Respiratory Protective Equipment for Fire Fighters*, 1971

NFPA 402, *Recommended Practice for Aircraft Rescue and Fire Fighting Procedures for Airport Fire Departments*, 1978

NFPA 406M, *Manual on Aircraft Rescue and Fire Fighting Techniques for Fire Departments Using Structural Fire Apparatus and Equipment*, 1975

NFPA 407, *Standard for Aircraft Fuel Servicing*, 1975 (ANSI)

NFPA 408, *Standard on Aircraft Hand Fire Extinguishers*, 1973 (ANSI)

NFPA 409, *Standard on Aircraft Hangars*, 1975 (ANSI)

NFPA 410A, *Recommendations on Safeguarding Aircraft Electrical System Maintenance Operations*, 1975

NFPA 410B, *Recommendations on Safeguarding Aircraft Breathing Oxygen System Maintenance Operations*, 1971 (ANSI)

NFPA 410C, *Recommendations on Safeguarding Aircraft Fuel System Maintenance*, 1972 (ANSI)

NFPA 410D, *Recommendations for Safeguarding Aircraft Cleaning, Painting, and Paint Removal*, 1971

NFPA 410E, *Recommended Safe Practices for Aircraft Welding Operations in Hangars*, 1975

NFPA 410F, *Recommendations on Safeguarding Aircraft Cabin Cleaning and Refurbishing Operations*, 1975

NFPA 412, *Standard for Evaluating Foam Fire Fighting Equipment on Aircraft Rescue and Fire Fighting Vehicles*, 1974 (ANSI)

NFPA 414, *Standard for Aircraft Rescue and Fire Fighting Vehicles*, 1978 (ANSI)

NFPA 415, *Standard on Aircraft Fueling Ramp Drainage*, 1977 (ANSI)

NFPA 416, *Standard on Construction and Protection of Airport Terminal Buildings*, 1975 (ANSI)

NFPA 417, *Standard on Construction and Protection of Aircraft Loading Walkways*, 1977 (ANSI)

NFPA 418, *Standard on Roof-top Heliport Construction and Protection*, 1973

NFPA 419, *Recommended Practice for Master Planning Airport Water Supply Systems for Fire Protection*, 1975

NFPA 422M, *Aircraft Fire Investigators Manual*, 1972

NFPA 424, *Recommended Practice for Airport/Community Emergency Planning*, 1978

NFPA 1002, *Fire Apparatus Driver/Operator Professional Qualifications*, 1976

B-1.2 Aviation Bulletins (AB).*

AB 365, *Crash Fire Hazard Rating System for Controlled Flammability Fuels*, August 1969

*This listing is partial and includes only those Aviation Bulletins related particularly to aircraft rescue and fire fighting issued since 1965. For more complete bibliography, write to NFPA. Copies available as supply lasts.

AB 366, *The 747 Evacuation System*, by Milton Heinemann, The Boeing Company, September 1969

AB 367, *Report on Accident at Heathrow Airport, London, April 8, 1968*, September 1969

AB 368, *Minutes of the Meeting of the Sectional Committee on Aircraft Rescue and Fire Fighting*, held September 30-October 1, 1969

AB 373, *Minutes of the Meeting of the Sectional Committee on Aircraft Rescue and Fire Fighting*, held February 24-25, 1970

AB 377, *Minutes of the Meeting of the Sectional Committee on Aircraft Rescue and Fire Fighting*, held September 16-17, 1970

AB 386, *The Anchorage, Alaska, Crash Fire*, by C. Hayden LeRoy, National Transportation Safety Board (Accident: May 17, 1971)

AB 387, *Air Transport Cabin Mockup Fire Experiments* by John F. Marcy, FAA National Aviation Facilities Experimental Center

AB 388, *Improvement of Fire Safety in Commercial Aircraft*, by Matthew I. Radnofsky, NASA Manned Spacecraft Center

AB 390, *Airport Certification*, by Earl W. Keegan, Airport Certification Safety Specialist, Federal Aviation Administration

AB 391, *U.S. Department of Defense Aircraft Ground Fire Suppression and Rescue System Program*, by Lt. Col. Robert B. Artz, System Program Director

AB 397, *Hickam Air Force Base Tests of Aqueous Film-Forming Foam*, Roger N. McGaha, 15th Air Base Wing Fire Dept

AB 399, *New Concepts in Crash Fire Fighting*, George B. Geyer, FAA National Aviation Facilities Experimental Center

AB 400, *Minutes of the Meeting of the Sectional Committee on Aircraft Rescue and Fire Fighting*, held September 27-29, 1972

AB 406, *Minutes of the Meeting of the Sectional Committee on Aircraft Rescue and Fire Fighting*, held September 25-27, 1973

AB 412, *Summary of U.S. Army Crashworthy Fuel Systems Accident Experience from April 1970 to April 1974*, by LTC W. T. Gabella, Transportation Corps and CPT Wade Young, Infantry, US Army Agency for Aviation Safety, 1974

AB 414, *Minutes of Meeting of Sectional Committee on Aircraft Rescue and Fire Fighting*, held October 22-24, 1974

AB 418, *Additional 1975 Proposed Revisions to NFPA Standard for Aircraft Rescue and Fire Fighting Vehicles*, (NFPA 414), May 1975

B-1.3 Aircraft Rescue and Fire Fighting Manuals.

US Navy Aircraft Firefighting and Rescue Manual, NAVAIR 00-80R-14, January 1968. (Available from Naval Air Systems Command, Code 1416C Washington, DC 20360.)

Fire Service Training Programs (2nd Edition), IFSTA 206. (Available from International Fire Service Training

Association, Oklahoma State University, Stillwater, OK 74074.)

Aircraft Fire Protection and Rescue Procedures (1st Edition), IFSTA 206. (Available from International Fire Service Training Association. Oklahoma State University, Stillwater, OK 74074.)

Aircraft Emergency Rescue Information, Technical Manual, T.O. 00-105E-9, dated 1 July 1972. (Available from Hq. NRAMA-MMSTD, Robins Air Force Base, Georgia 31093.)

B-1.4 Aircraft Rescue and Fire Fighting Test Reports.

RD-65-50, *Post-Crash Fire-Fighting Studies on Transport Category Aircraft*, May 1965. (Available from the FAA National Aviation Facilities Experimental Center, Atlantic City, NJ 08405.)

NA-68-34, *Interim Report on Foam and Dry Chemical Application Experiments*, December 1968. (Available from the FAA National Aviation Facilities Experimental Center, Atlantic City, NJ 08405).

NA-68-37, *Effect of Ground Crash Fire on Aircraft Fuselage Integrity*, December 1969. (Available from National Technical Information Service, Springfield, Virginia 22151.)

AGFSRS 70-1, *Aircraft Ground Fire Suppression and Rescue Systems — Current Technology Review*, October 1969. (Tri-Service System Program Office for Aircraft Ground Fire Suppression and Rescue, ASWF. Available from National Technical Information Service, Springfield, Virginia 22151.)

AD 739-027, *A Proposed Method for Evaluating Fire Prevention Efforts by the Airport Manager of Non-Hub Airports*, 1970. (Available from National Technical Information Service, Springfield, VA 22151.)

AS-71-1, *Minimum Needs for Airport Fire Fighting and Rescue Service*, January 1971. (Available from National Technical Information Service, Springfield, VA 22151.)

AGFSRS 71-1, *Evaluation of Aircraft Ground Firefighting Agents and Techniques*, February 1972. (Available from National Technical Information Service, Springfield, Virginia 22151.)

AGFSRS 71-2, *Fire Fighter's Exposure Study*, December 1970. (Available from National Technical Information Service, Springfield, Virginia 22151.)

AGFSRS 72-2, *Aviation Fuel Fire Behavior Study*, February 1972. (Available from National Technical Information Service, Springfield, Virginia 22151.)

DORA Report 7201, Dept. of Trade and Industry Aerodrome Fire and Rescue Services, January 1972, EASAMS Reference No. 5631-4-3. (Copies available from Her Majesty's Stationery Office, 49 High Holborn, London WCIV6HB.)

AGFSRS 72-1, *Aircraft Ground Fire Suppression and Rescue Systems — Basic Relationships in Military Fires, Phases I and II*, April 1972. (Available from National Technical Information Service, Springfield, Virginia 22151.)

ASD-TR-72-75, *Evaluation of Auxiliary Agents and Systems for Aircraft Ground Fire Suppression, Phase I*, August 1972. (Available from National Technical Information Service, Springfield, Virginia 22151.)

AFAPL-TR-73-74, *Fire and Explosion Manual for Aircraft Accident Investigations*, August 1973, Joseph M. Kuchta, Pittsburgh Mining and Safety Research Center, Bureau of Mines Report No. 4193 published by US Dept of the Air Force, Air Force Aero Propulsion Laboratory, AFAPL/SFH, Wright-Patterson Air Force Base, OH 45433.

FAA-RD-74-204, *Evaluation of a High-Capacity, Firefighting Foam-Dispensing System*, January 1975. (Available from National Technical Information Service, Springfield, Virginia 22151.)

DOD-AGFSRS-75-1, *Airfield Parameter Study and Categorization System Related to Aircraft Ground Fire Suppression and Rescue*, June 1975. (Available from National Technical Information Service, Springfield, Virginia 22151.)

DOD-AGFSRS-75-2, *Generic Airborne Fire Suppression System*, May 1975. DOD Aircraft Ground Fire Suppression & Rescue Office, Wright-Patterson Air Force Base, Ohio 45433

DOD-AGFSRS-75-3, *Aircraft Ground Fire Suppression and Rescue Systems, Basic Relationships in Military Fires, Phase IV; High Speed Dissemination of Dry Chemical Fire Suppression Agents*, May 1975. DOD Aircraft Ground Fire Suppression & Rescue Office, Wright-Patterson Air Force Base, Ohio 45433

DOD-AGFSRS-75-4, *Aircraft Ground Fire Suppression and Rescue Systems, Basic Relationships in Military Fires, Phases III, V, VI, and VII*, May 1975. DOD Aircraft Ground Fire Suppression & Rescue Office, Wright-Patterson Air Force Base, Ohio 45433.

B-1.5 Typical ICAO Publications. Available from International Civil Aviation Organization, 1000 Sherbrooke St., W, Montreal, Quebec, Canada.*

Airport Services, Manual, Part 1 — Rescue and Fire Fighting, First Edition, 1977, Doc 9137-AN/898 Part 1.

Aerodrome Manual, Part 6 — Heliports, Fourth Edition, 1971, Doc. 7920-AN/865, Part 6.

Training Manual, Aerodrome Fire Services Personnel, First Edition, 1976, Doc 7912-AN/857, Part E-2.

International Standards and Recommended Practices — Aerodromes, Annex 14, Seventh Edition, June 1976

Manual of Aircraft Accidents Investigation, Fourth Edition, 1970, Doc 6920-AN/855/4.

Aircraft Accident Digests, Numbers 1-21

B-1.6 Air Line Pilots Association Publications.

ALPA — *A Survey of Airport Fire and Rescue Facilities*, North America and Canada. (Available from ALPA, Fire and Rescue Committee, 3581 North Main St., College Park, GA 30337.)

ALPA — *Guide for Airport Standards*, First Edition July 1969, Third Printing December 1970. (Available from Air Line Pilots Association, Engineering and Air

*And other offices in Bangkok, Thailand; Cairo, Egypt; Dakar, Senegal; Lima, Peru; Mexico City, Mexico; Paris, France.