NFPA 403

Standard for Aircraft Rescue and Fire-Fighting Services at Airports

1998 Edition

NFPA

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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Standard for

Aircraft Rescue and Fire-Fighting Services at Airports

1998 Edition

This edition of NFPA 403, *Standard for Aircraft Rescue and Fire-Fighting Services at Airports,* was prepared by the Technical Committee on Aircraft Rescue and Fire Fighting and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 18–21, 1998, in Cincinnati, OH. It was issued by the Standards Council on July 16, 1998, with an effective date of August 5, 1998, and supersedes all previous editions.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

This edition of NFPA 403 was approved as an American National Standard on August 6, 1998.

Origin and Development of NFPA 403

Committee work leading to the development of a 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, CA. 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, 1975, and 1978.

The 1988 edition comprised a complete revision to the text of the document to make it a standard and to segregate mandatory requirements from advisory material. Prior to the 1988 edition, all editions were recommended practices. The standard was revised again in 1993.

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This 1998 edition is a partial revision.

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This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of this document.

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for the criteria for aircraft rescue and fire-fighting services and equipment, procedures for handling aircraft fire emergencies, and for specialized vehicles used to perform these functions at airports with particular emphasis on saving lives and reducing injuries coincident with aircraft fires following impact or aircraft ground fires. This Committee shall also develop aircraft fire investigation procedures as an aid to accident prevention and the saving of lives in future aircraft accidents involving fire.

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

Information on referenced publications can be found in Chapter 8 and Appendix B.

Chapter 1 Administration

1-1 Scope. This standard contains the minimum requirements for aircraft rescue and fire-fighting (ARFF) services at airports. Requirements for other airport fire protection services are not covered in this document.

1-2 Purpose.

1-2.1 This standard is prepared for the use and guidance of those charged with providing and maintaining aircraft rescue and fire-fighting services at airports.

1-2.2 The principal objective of a rescue and fire-fighting service is to save lives. For this reason, the preparation for dealing with an aircraft accident or incident occurring at, or in the immediate vicinity of, an airport is of primary importance because it is within this location that the greatest opportunity to save lives exists. The possibility of, and need for, extinguishing a fire that can occur either immediately following an aircraft accident or incident, or at any time during rescue operations, must be assumed at all times.

1-2.3 The most important factors bearing on effective rescue in a survivable aircraft accident are the training received, the effectiveness of the equipment, and the speed with which personnel and equipment designated for rescue and fire-fighting purposes can be put to use.

1-3 Definitions. For the purpose of this standard, the following terms shall have the meanings given below.

ARFF Personnel. Personnel actively engaged in the pursuit of rescue and fire-fighting at the scene of an airport incident.

Actual Response Time. The total period of time measured from the time of an alarm until the first ARFF vehicle arrives at the scene of an aircraft accident and is in position to apply agent.

Aircraft Accident. An occurrence associated with the operation of an aircraft that takes place between the time any person boards the aircraft with the intention of flight and until all such persons have disembarked and in which any person suffers death or serious injury or in which the aircraft receives substantial damage.

Aircraft Fire Fighting. The control or extinguishment of fire adjacent to or involving an aircraft following ground accidents or incidents. Aircraft fire fighting does not include the control or extinguishment of airborne fires in aircraft.

Aircraft Incident. An occurrence, other than an accident, associated with the operation of an aircraft, that affects or could affect continued safe operation if not corrected. An incident does not result in serious injury to persons or substantial damage to the aircraft.

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

Airport Air Traffic Control. A service established to provide air and ground traffic control for airports.

Airport Fire Chief. The individual normally having operational control over the airport's rescue and fire-fighting personnel and equipment, or a designated appointee.

Airport Fire Department Personnel. Personnel under the operational jurisdiction of the chief of the airport fire department assigned to aircraft rescue and fire fighting.

Airport Manager. The individual having managerial responsibility for the operation and safety of an airport. The manager can have administrative control over aircraft rescue and fire-fighting services, but normally does not exercise authority over operational fire and rescue matters.

Approved.* Acceptable to the authority having jurisdiction.

Authority Having Jurisdiction.* The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

Critical Rescue and Fire-Fighting Access Area (CRFFAA). The rectangular area surrounding any runway within which most aircraft accidents can be expected to occur on airports. Its width extends 500 ft (150 m) from each side of the runway centerline and its length is 3300 ft (1000 m) beyond each runway end. *(See Figure A-1-3.)*

Fixed Base Operator (FBO). An enterprise based on an airport that provides storage, maintenance, or service for aircraft operators.

Flight Service Station (FSS). An air traffic facility that briefs pilots, processes, and monitors flight plans, and provides in-flight advisories.

Foam. An aggregation of small bubbles used to form an air-excluding, vapor-suppressing blanket over the surface of a flammable liquid fuel.

Foam, Alcohol-Resistant. Used for fighting fires involving water-soluble materials or fuels that are destructive to other types of foam. Some alcohol-resistant foams are capable of forming a vapor-suppressing, aqueous film on the surface of hydrocarbon fuels.

Foam, Aqueous Film-Forming (AFFF). A concentrated aqueous solution of one or more hydrocarbon and/or fluorochemical surfactants that forms a foam capable of producing a vapor-suppressing, aqueous film on the surface of hydrocarbon fuels. The foam produced from AFFF concentrates is dry chemical compatible and, therefore, is suitable for use in combination with that agent.

Foam Concentrate. A concentrated liquid foaming agent that is mixed with water and air in designated proportions to form foam.

Foam, Film-Forming Fluoroprotein (FFFP). A protein-based foam concentrate incorporating fluorinated surfactants that forms a foam capable of producing a vapor-suppressing, aqueous film on the surface of hydrocarbon fuels. This foam might show an acceptable level of compatibility to dry chemicals and might be suitable for use with those agents.

Foam, Fluoroprotein (FP). A protein-based foam concentrate with added fluorochemical surfactants that forms a foam showing a measurable degree of compatibility with dry chemical extinguishing agents and an increase in tolerance to contamination by fuel.

Foam, Protein (P). A protein-based foam concentrate that is stabilized with metal salts to make a fire-resistant foam blanket.

Foam Solution. The solution that results when foam concentrate and water are mixed in designated proportions prior to aerating to form foam.

Fuselage. The main body of an aircraft.

International Civil Aviation Organization (ICAO). An international body charged with matters dealing with the development, coordination, and preservation of international civil aviation.

Movement Area. Those parts of the airport used for taxiing, takeoff, and landing of aircraft, exclusive of parking areas.

Mutual Aid. Reciprocal assistance by emergency services under a prearranged plan.

Rapid Response Area (RRA).* A rectangle that includes the runway and the surrounding area extending to but not beyond the airport property line. Its width extends 500 ft (152 m) outward from each side of the runway centerline, and its length is 1650 ft (500 m) beyond each runway end. *(See Figure A-1-3.)*

Shall. Indicates a mandatory requirement.

Should. Indicates a recommendation or that which is advised but not required.

Table-Top Training. A workshop style of training involving a realistic emergency scenario and requiring problem-solving participation by personnel responsible for management and support at emergencies.

Chapter 2 Organization of Aircraft Rescue and Fire-Fighting (ARFF) Services

2-1 Administrative Responsibilities.

2-1.1 The airport management shall be responsible for the provisions of ARFF services on the airport.

2-1.2 Regardless of the functional control of ARFF services on the airport, a high degree of mutual aid shall be prearranged between such services on airports and any off-airport fire or rescue agencies serving the environs of the airport.

2-1.3 The aircraft owner or operator shall ensure that provisions have been made for the security of the aircraft until such time as a legally appointed accident investigation authority assumes responsibility. The airport manager or authority having jurisdiction can assist or assume the authority in the absence of the aircraft owner or operator.

2-2 Emergency Preparedness.

2-2.1 Airports shall prepare and maintain in current status an airport/community emergency plan. The plan shall assign specific duties and responsibilities and include all airport and community resources necessary to cope with a major aircraft emergency.

2-2.2* Airport/community emergency plans shall be tested at least every two years in the form of a full-scale exercise. In addition, table-top training shall be conducted at least annually.

2-2.3 Airport management and resource agencies shall participate in annual table-top training exercises that encompass their duties and responsibilities depicted in the emergency plan.

2-3 Categorizing Airports for ARFF Services.

2-3.1* The authority having jurisdiction shall determine the level of protection based on the largest aircraft scheduled into the airport. Airports shall be categorized for ARFF services in accordance with Table 2-3.1.

Table 2-3.1 Airport Category by Overall Length and Width of Aircraft

Airport Category U.S.			Overall Length of Aircraft up to but Not Including		Maximum Exterior Width up to but Not Including	
NFPA	FAA	ICAO	ft	m	ft	m
1	GA-1	1	30	9	6.6	2
2	GA-1	2	39	12	6.6	2
3	GA-2	3	59	18	9.8	3
4	A	4	78	24	13.0	4
5	A	5	90	28	13.0	4
6	B	6	126	39	16.4	5
7	C	7	160	49	16.4	5
8	D	8	200	61	23.0	7
9	E	9	250	76	23.0	7
10			300	91	25.0	8

Airport categories are used in the calculations to eliminate the need for calculating specific quantities of extinguishing agents for each type of aircraft.

Although only water is normally necessary for interior handline attack, logistically and tactically it should be discharged as foam and is therefore added to the quantities of water necessary for foam production in Tables 3-3.1(a) and 3-3.1(b).

2-3.2* The airport category for a given aircraft shall be based on the overall length of the aircraft or the fuselage width. If, after selecting the category appropriate to the aircraft's overall length, the aircraft's fuselage width is greater than the maximum width given in Table 2-3.1, then the category for that aircraft shall be the next one higher.

Chapter 3 Extinguishing Agents

3-1 Primary Agents.

3-1.1* One or more of the following types of primary agents shall be used for aircraft fire fighting involving hydrocarbon fuels.

(a) Aqueous film-forming foams (AFFF)

(b) Fluoroprotein foam (FP) or film-forming fluoroprotein foam (FFFP)

(c) Protein foam (P)

3-1.2* All foam concentrates shall be listed based on the following performance test requirements.

3-1.2.1* Aqueous film-forming foam agents shall meet the requirements of U.S. Military Specification MIL-F-24385.

3-1.2.2 Film-forming fluoroprotein foam (FFFP), protein foam (P), and fluoroprotein foam (FP) agents shall meet the applicable fire extinguishment and burnback performance requirements of Underwriters Laboratories Inc. Standard UL-162 (Type 3 application).

3-1.2.3 Any primary agent used at the minimum quantities and discharge rates for AFFF in Tables 3-3.1(a) and 3-3.1(b) shall meet the applicable fire extinguishment and burnback performance requirements of 3-1.2.1.

3-2 Complementary Agents. Either one or both of the following complementary agents shall be available for aircraft fire fighting:

(a)* Potassium bicarbonate or potassium bicarbomate dry chemical

(b)* Halon 1211.

3-3 Quantity of Agents.

3-3.1* The minimum amounts of water for foam production, and the minimum amounts of complementary agents necessary shall be as specified in Tables 3-3.1(a)or 3-3.1(b) based on the system of categorizing airports listed in Table 2-3.1.

3-3.2 Sufficient foam concentrate shall be provided to proportion, at the prescribed percentage of foam concentrate to water, into double the quantity of water specified in Table 3-3.1(a) or 3-3.1(b).

3-3.3* Water equal to 100 percent of that required by 3-3.1 shall be available to replenish the primary fire-fighting vehicle(s).

3-4* Compatibility of Agents. Chemical compatibility shall be ensured between foam and complementary agents where used simultaneously or consecutively.

3-5* Combustible Metal Agents. Extinguishing agents for combustible metal fires shall be provided in portable fire extinguishers that are rated for Class D fires in accordance with Section 1-4 of NFPA 10, *Standard for Portable Fire Extinguishers.* At least one nominal 20-lb (9.1-kg) extinguisher shall be carried on each vehicle specified in Table 4-1.1.

3-6 Agent Discharge Capabilities.

3-6.1 The discharge capabilities of extinguishing agents shall not be less than the rates specified in Table 3-3.1(a) or 3-3.1(b), and 2-15.6, 3-13.9, and 4-13.9, as applicable, of NFPA 414, *Standard for Aircraft Rescue and Fire-Fighting Vehicles.*

3-6.2 Other than at Category 1, 2, and 3 airports, where the handline nozzles can be used, the discharge rates for foam shall be met using only the ARFF vehicle turret(s).

Table 3-3.1(a) Minimum Extinguishing Agent Quantities and Discharge Rates

	AFFF		Fluoroprotein or Film-Forming Fluoroprotein Foam		Protein Foam		Potassium Bicarbonate or Potassium Bicarbomate		Halon 1211*	
	Water	Discharge Rate	Water	Discharge Rate	Water	Discharge Rate	Discharge Rate		Discharge Rate	
Airport Category	U.S. gal	gpm	U.S. gal	gpm	U.S. gal	gpm	lb	lb/sec	lb	lb/sec
1	118	60	163	75	181	85	100	5	100	5
2	195	130	270	180	300	195	200	5	200	5
3	670	230	812	310	869	335	300	5	300	5
4	1335	390	1618	530	1731	575	300	5	300	5
5	2762	825	3344	1135	3575	1230	450	5	450	5
6	3744	1100	4704	1480	5087	1620	450	5	450	5
7	4877	1440	6272	1970	6830	2150	450	5	450	5
8	7778	1900	9808	2600	10620	2845	900	10	900	10
9	9570	2400	12289	3300	13377	3480	900	10	900	10
10	11764	3100	15326	4100	16752	4600	900	10	900	10

*Or other approved halon alternatives

Table 3-3.1(b) Minimum Extinguishing Agent Quantities and Discharge Rates

	AFFF		Fluoroprotein or Film Forming Fluoroprotein Foam		Protein Foam		Potassium Bicarbonate or Potassium Bicarbomate		Halon 1211*	
	Water	Discharge Rate	Water	Discharge Rate	Water	Discharge Rate	Discharge Rate		Discharge Rate	
	L	L/min	L	L/min	L	L/min	kg	kg/min	kg	kg/min
1	446.63	225	616.96	290	685.085	322	45	2.25	45	2.25
2	738.08	500	1021.95	680	1135.50	738	90	2.25	90	2.25
3	2535.95	800	3073.42	1165	3289.17	1268	135	2.25	135	2.25
4	5052.97	1500	6124.13	2000	6551.84	2176	135	2.25	135	2.25
5	10454.17	3000	12657.04	4300	13531.38	4656	205	2.25	205	2.25
6	14171.04	4000	17804.64	5600	19254.30	6132	205	2.25	205	2.25
7	18459.45	5500	23739.52	7450	25851.55	8138	205	2.25	205	2.25
8	29439.73	7000	37123.28	9850	40196.70	10768	410	4.5	410	4.5
9	36222.45	9000	46513.87	12500	50631.95	13172	410	4.5	410	4.5
10	44526.74	11700	58008.91	15500	63406.32	17411	410	4.5	410	4.5

*Or other approved halon alternatives

Chapter 4 Aircraft Rescue and Fire-Fighting (ARFF) Vehicles

4-1 Rescue and Fire-Fighting Vehicles.

4-1.1* The minimum number of ARFF vehicles provided at each airport shall be as specified in Table 4-1.1.

Table 4-1.1 Minimum Number of ARFF Vehicles

Airport Category	1	2	3	4	5	6	7	8	9	10
Number of Vehicles	1	1	1	1	2	2	3	3	4	4

4-1.2* ARFF vehicles shall be constructed to comply with the provisions of NFPA 414, *Standard for Aircraft Rescue and Fire-Fighting Vehicles*, and Table 3-3.1(a) or 3-3.1(b).

4-1.3 Consideration shall be given to the provision of an additional vehicle or vehicles in order that minimum requirements are maintained during periods when a vehicle is out of service.

4-1.4 All foam-producing ARFF vehicles shall be tested at least annually in accordance with NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire-Fighting Foam Equipment.*

4-2* Tools and Equipment. Vehicles shall be provided with tools and equipment to effectively support rescue and fire-fighting operations.

Chapter 5 Airport Emergency Communications

5-1 Communications and Alarms.

5-1.1 Airport ARFF services communications shall have a capability that is consistent with the airport's operational needs.

5-1.2* The operational communications system shall provide a primary and, where necessary, an alternate effective means for direct communication between the following, as applicable:

(a) Alerting authority such as the control tower or flight service station, airport manager, fixed-base operator, or airline office and the airport ARFF service
(b) Air traffic control tower or flight service station and ARFF vehicles enroute to an aircraft emergency or at the accident or incident site
(c) Fire department alarm room and ARFF vehicles at the accident or incident site
(d) Airport ARFF services and appropriate mutual aid organizations located on or off the airport, including an alert procedure for all auxiliary personnel expected to participate
(e) ARFF vehicles

5-1.3 To ensure that the communications system is operational under a variety of airport emergency conditions, provisions shall be made for an emergency standby power source or alternate backup communication system.

5-1.4 A preventive maintenance program shall be carried on to keep all communications equipment in a fully serviceable condition.

5-1.5 The functional performance of all communications systems shall be tested at intervals not exceeding 24 hours.

Chapter 6 ARFF Personnel, Protective Clothing, and Equipment

6-1 Personnel.

6-1.1 A person shall be appointed to direct the airport ARFF services. The responsibilities of this person shall include overall administrative supervision of the organization, effective training of personnel, and operational control of emergencies involving aircraft within the airport jurisdiction.

6-1.2 During flight operations, sufficient trained personnel shall be readily available to staff the rescue and fire-fighting vehicles and to perform fire-fighting and rescue operations. These trained personnel shall be deployed in a way that ensures that minimum response times can be achieved and that continuous agent application at the appropriate rate can be fully maintained.

6-1.3 Responding units shall include personnel trained and equipped for cabin interior fire fighting.

6-1.4* All ARFF personnel shall meet the requirements of NFPA 1003, *Standard for Airport Fire Fighter Professional Qualifications.*

6-1.5 All ARFF and other authorized personnel shall be given suitable uniforms or identifying insignia to prevent any misunderstanding as to their right to be in the fire area or the aircraft movement area of an airport during an emergency.

6-2 Protective Clothing.

6-2.1* A complete set of approved personal protective clothing and equipment shall be provided, maintained, and readily available for use by each person required to perform duties in the immediate area of an aircraft accident.

6-2.2* All personnel engaged in operations within the immediate emergency area of an aircraft accident shall wear approved personal protective clothing and equipment commensurate with their level of involvement and shall not remove any portion of such clothing and equipment until in a declared safe area or directed to do so by the Incident Commander or his representative.

Chapter 7 Airport Fire Station Location and Response Capability

7-1 Siting and Response.

7-1.1* ARFF vehicles shall be garaged at one or more strategic locations as needed to meet required response times.

7-1.2* Emergency equipment shall have immediate and direct access to critical aircraft movement areas and the capability of reaching all points within the rapid response area (RRA) in the time specified. Therefore, the location of the airport fire station shall be based on minimizing response time to aircraft accident and incident high-hazard areas. Locating the airport fire station for structural fire-fighting utility shall be of secondary importance.

7-1.3* The demonstrated response time of the first responding vehicle to reach any point on the operational runway shall be 2 minutes or less and to any point remaining within the on-airport portion of the rapid response area shall be no more than 2½ minutes, both in optimum conditions of visibility and surface conditions. Other ARFF vehicles necessary to achieve the agent discharge rate listed in Table 3-3.1(a) or 3-3.1(b) shall arrive at intervals not exceeding 30 seconds.

Chapter 8 Referenced Publications

8-1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix B.

8-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers*, 1998 edition.

NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire-Fighting Foam Equipment*, 1998 edition.

NFPA 414, *Standard for Aircraft Rescue and Fire-Fighting Vehicles*, 1995 edition.

NFPA 1003, *Standard for Airport Fire Fighter Professional Qualifications*, 1994 edition.

NFPA 1975, *Standard on Station/Work Uniforms for Fire Fighters*, 1994 edition.

NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for the Fire Service*, 1997 edition.

8-1.2 Other Publications. *Fire Extinguishing Agent, Aqueous Film-Forming Foam (AFFF), Liquid Concentrate, for Fresh and Sea Water,* Revision F, January 7, 1992, U.S. Military Specification MIL-F-24385, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

Standard for Foam Equipment and Liquid Concentrates, 6th edition, March 7, 1989, Underwriters Laboratories Inc., Standard UL-162.

Appendix A Explanatory Material

Appendix A is not a part of the requirements of this NFPA document but is included for informational purposes only. This appendix contains explanatory material, numbered to correspond with the applicable text paragraphs.

A-1-3 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-3 Authority Having Jurisdiction. The phrase ''authority having jurisdiction'' is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A-1-3 Rapid Response Area (RRA). Approximately 85 percent of the accidents as historically recorded in the CRFFAA occurred within the boundary of the RRA. Response time to the on-airport portion of the RRA should meet the times specified in 7-1.3. *(See Figure A-1-3.)*

A-2-2.2 Information on airport/community emergency plans and full-scale exercises is provided in NFPA 424, *Guide for Airport/Community Emergency Planning*.

A-2-3.1 Background.

Area Concept. The first meeting of the Rescue and Fire-Fighting Panel (RFFP-I) was convened by the International Civil Aviation Organization (ICAO) in Montreal, Canada, from March 10 to 20, 1970.

At that time, the method contained in Annex 14, Attachment C (5th edition), for the determination of the level of protection (agent quantities and number of vehicles) to be provided at airports for fixed wing aircraft was based on the fuel load and passenger capacity of the aircraft. As a result of correspondence exchanged among the Panel members there was general agreement that a new or revised method for specifying the quantity of extinguishing agents and rescue equipment to be provided was needed.

The Panel unanimously agreed that the concept for determining the level of protection should be the "critical area." This was an area to be protected in any post-accident situation that would permit the safe evacuation of the aircraft occupants. The purpose of the critical area concept was not to define fire attack procedures. Instead, it was to serve as the basis for calculating the quantities of extinguishing agents necessary to achieve protection within an acceptable period of time.

Based on the logic that passenger capacity was related to length, the Panel also unanimously agreed that the critical area should be a rectangle having as one dimension the length of the fuselage. However, a wide division of opinion existed as to what width should be used. The RFF Panel's report documents five proposed means of defining the width of the critical area.

It was finally agreed that there was no single system that could be used to express the area to be protected for all sizes of aircraft. In the end, the Panel agreed that the critical area should be a rectangle, having as one dimension the overall length of the aircraft and as the other dimension the overall length of the aircraft for aircraft with wing spans of less than 30 m (100 ft) and to be 30 m (100 ft) for aircraft with wing spans of 30 m (100 ft) or more. A standard fuselage width of 6 m (20 ft) was assumed. Using this approach, the aircraft in service at that time were grouped into a series of eight categories. Beginning with category one, each successive category represented a logical progression in aircraft length (Hewes 1970, p. 2-1).

The concept of using graduated aircraft categories as a means of assessing fire protection needs has survived to the present time with only minor revisions to reflect changes in the operating aircraft fleet. This general concept has been adopted worldwide by both consensus standard-writing organizations and national regulatory authorities.

By correspondence following RFFP-I, the members agreed that the use of the area concept for determining the level of fire-fighting agents and equipment needed to combat an aircraft accident fire was based on the following facts:

(a) The quantity of agent necessary to control or cover the fire area could be relatively accurately determined.

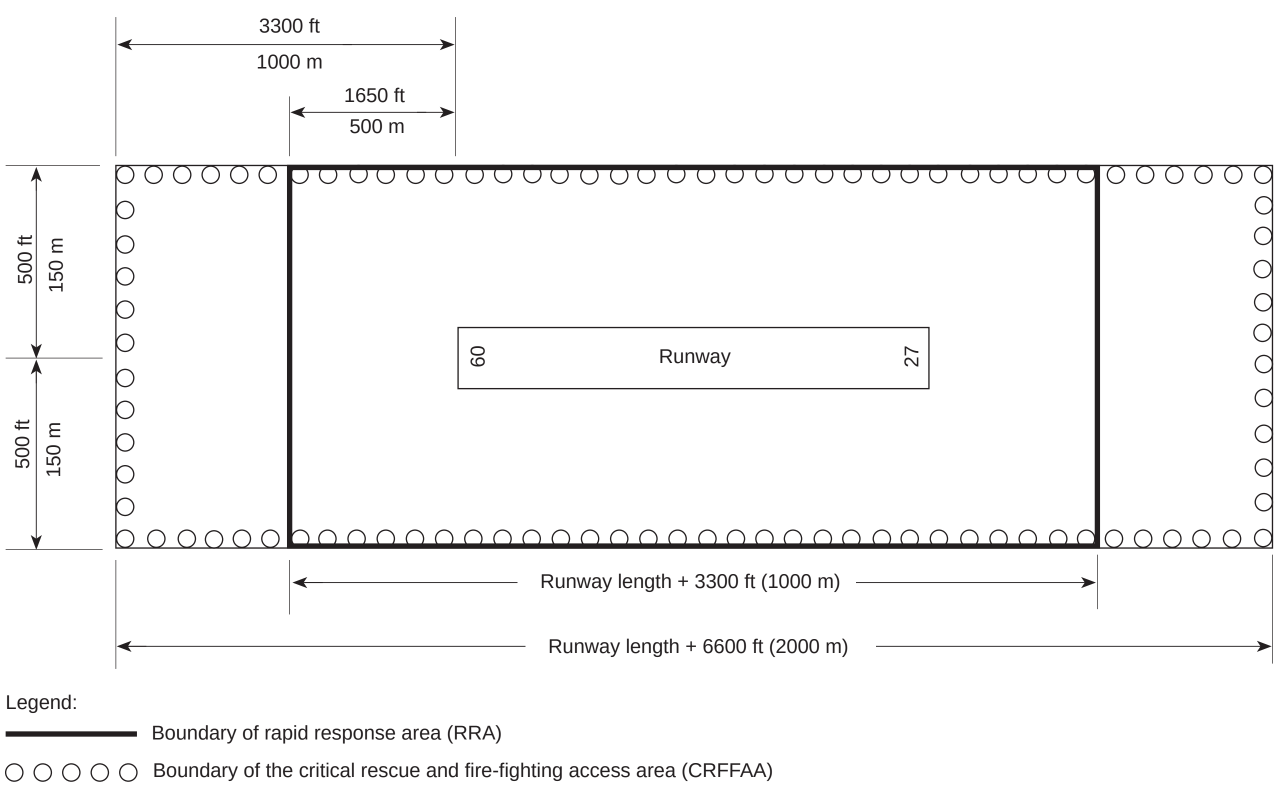

Figure A-1-3 Response and access areas.

(b) The rate of application of the agents to control the fire in the most effective time period could also be determined.

Hence, when RFFP-II convened in 1972, the Panel confirmed the critical area concept where one dimension of the area would be the length of the aircraft. However, there was no consensus as to length of the other side. In addition, the Panel concluded that there was a need to distinguish between the ''theoretical critical area'' within which it might be necessary to control a fire and a ''practical critical area'' that was representative of actual aircraft accident conditions. Although the Panel had not agreed on the dimensions, it did agree that the theoretical critical area should be defined as follows:

Theoretical Critical Area. The theoretical area adjacent to an aircraft in which fire must be controlled for the purpose of ensuring temporary fuselage integrity and providing an escape area for its occupants.

The RFFP-II had the benefit of large test fire experiments conducted by a member country aimed at estimating the size of the theoretical critical fire area (Geyer 1972). This study paid particular attention to the width on each side of the fuselage that would have to be secured to protect the aircraft's skin from melting under severe fire conditions. On the basis of the data presented in this report, the Panel agreed that the theoretical critical area should be a rectangle having as one dimension the overall length of the aircraft, and the other dimension determined by the following:

(a) For aircraft with an overall length of less than 20 m (65 ft), 12 m (40 ft) plus the width of the fuselage

(b) For aircraft with an overall length of 20 m (65 ft) or more, 30 m (100 ft) plus the width of the fuselage (Harley 1972, p. 3-1f)

The theoretical critical area serves only as a means for categorizing aircraft in terms of the magnitude of the potential fire hazard in which they may become involved. It is not intended to represent the average, maximum, or minimum spill fire size associated with a particular aircraft. The original formula for the maximum theoretical critical area, as presented in the RFFP-II report, was given as follows (Harley 1972, p. 3-16):

$$A_T = L \times (30 + w) \text{ where } L > 20 \text{ m}$$

or

$$A_T = L \times (100 + w) \text{ where } L > 65 \text{ ft, and}$$
$$A_T = L \times (12 + w) \text{ where } L < 20 \text{ m}$$

or

$$A_T = L \times (40 + w) \text{ where } L < 65 \text{ ft}$$

where:
L = overall length of the aircraft
w = width of the aircraft fuselage
A_T = theoretical critical area (TCA)

The data analyzed by RFFP-II in its effort to respond to the issue of TCA versus practical critical area (PCA) appeared to indicate that the PCA was approximately two-thirds of the TCA. This had been verified by a study conducted by one of the member countries of actual spill fire sizes and aircraft accidents (Ansart 1970). Another analysis of aircraft rescue and fire-fighting operations had not included the study of the PCA as compared to the TCA (Harley 1972, p. 1-1). However, that study did compare the actual amount of water used for foam at those accidents with the amounts recommended by RFFP-I. It was found that out of 106 accidents for which this information was available, in 99 cases or 93 percent the amounts recommended by the Panel were in excess of those required in the actual aircraft accident. In light of the above, the Panel decided to use two-thirds of the TCA as the PCA (Harley 1972, p. 3-3). [*See Figure A-2-3.1(a) for a graphic display of this concept.*] The formula for the PCA developed by RFFP-II for fixed-wing aircraft can be expressed as

$$PCA = (0.67) \times (TCA)$$

Control Time. After defining the critical area to be protected and developing a system of fire protection categories, RFFP-I turned its attention to the issues of discharge rates and the extinguishing agents to be applied to the critical area. The Panel concluded that fire control time and fire extinguishment time within the critical area should be considered individually and defined as follows:

(a) Control time is the time required from the arrival of the first fire-fighting vehicle to the time the initial intensity of the fire is reduced by 90 percent.

(b) Extinguishment time is the time required from arrival of the first fire fighting vehicle to the time the fire is completely extinguished (Hewes 1970, p. 2-2).

RFFP-II confirmed these definitions and, based on an analysis of accident data furnished by member countries, it considered that the equipment and techniques to be used should be capable of controlling the fire in the PCA in 1 minute (Harley 1972, p. 3-4). This concept has not only survived to the present time, but it has, with minor revisions from time to time to update changes in the operating aircraft fleet, been adopted worldwide by both consensus standards-making organizations and national regulatory authorities.

RFFP-II was unable to identify a recommended time period for the extinguishment time. This was due to the numerous variables involved at each aircraft accident such as the size of the aircraft, area of fire, and three-dimensional fires (Harley 1972, p. 3-4).

Discharge Rate. At RFFP-I, the Panel agreed that discharge rates should be designed to achieve the lowest possible fire control time that is consistent with the objective of pre-

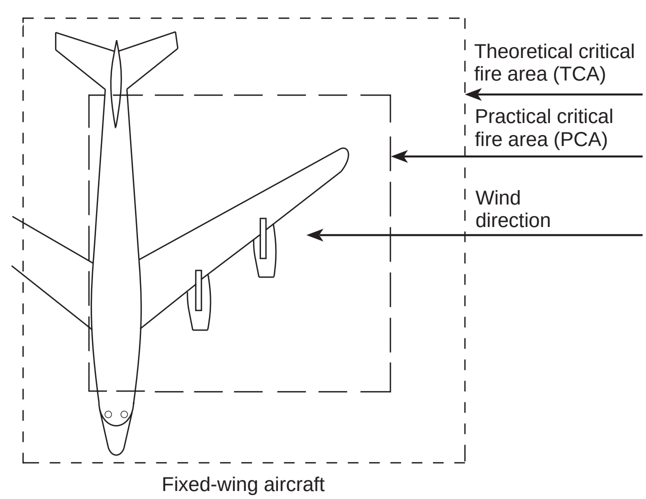

Figure A-2-3.1(a) Theoretical critical fire area (TCA) relative to practical critical fire area (PCA).

venting the fire from melting through the fuselage or causing an explosion of the fuel tanks. The Panel also agreed that the equipment and techniques to be used should be capable of controlling the fire in the critical area in 1 minute and of extinguishing the fire within another minute. Using available fire extinguishment test data based on protein foam, the Panel concluded that for a single agent attack an application rate of 8.2 (L/ min)/m^2 (0.2 U.S. gpm/ft^2) for 2 minutes would be sufficient to meet the fire control and fire extinguishment time requirements. The Panel also agreed that when dual agent attack techniques were used (foam and dry chemical, CO_2, or a halocarbon), a reduced application rate could be used. A minimum of 6.1 (L/min)/m^2 (0.15 U.S. gpm/ft^2) was recommended.

Based on the consideration that the lighter construction of small aircraft increased their vulnerability to fire penetration, the Panel also recommended that the same discharge rates be used for small aircraft.

All of the discussions and recommendations at RFFP-I were based on the performance of protein foam only. The Panel's report recognized the existence of both fluoroprotein and aqueous film-forming foams and indicated that some member countries were starting to use them. However, the Panel generally agreed that there was insufficient documentation of performance upon which to base recommendations. The report also indicated a general understanding among Panel members that the suitability of other agents and their relationship with protein foam would be considered later (Hewes 1970, p. 2-2).

At RFFP-II, the Panel confirmed the application rate for protein foam recommended by RFFP-I and agreed that an application rate of 5.3 (L/min)/m^2 (0.13 U.S. gpm/ ft^2) for aqueous film-forming foam was suitable. The Panel could not agree on a suitable recommendation for fluoroprotein due to the wide variety of foams. However, it did recognize them as useful aircraft fuel fire-fighting foams and left the application rate to the authority having jurisdiction, to be based on test data for the individual foams (Harley 1972, p. 3-4f).

Quantities of Agent to Be Provided. By multiplying the TCA corresponding to the upper limit of the airport category times the recommended protein foam application rate, times a factor of two for the recommended discharge time, RFFP-I produced a table of recommended water quantities for foam production. The table also included recommended weights for complementary agents and the recommended discharge rates for both single and dual agent attack for eight airport categories (Hewes 1970, p. 2-17).

At RFFP-II, the Panel agreed that when determining the amounts of extinguishing agents to be provided, the amounts required to control and to extinguish a fire should be determined separately. The quantities were named and defined as follows:

Quantity Q_1.The quantity required to obtain a 1-minute control time in the PCA.

The formula for the water required for control (Q_1) in the PCA can be expressed as:

$$Q_1 = \text{PCA} \times R \times T$$

where:

PCA = practical critical area
R = rate of application for the specific foam
T = time of application

Quantity Q_2.The quantity required for continued control of the fire after the first minute or for complete extinguishment of the fire or for both.

The Panel concluded that the amount of water required for Q_2 could not be calculated exactly, as it depended on a number of variables. Those variables considered of primary importance by the Panel were the following:

(a) Maximum gross weight
(b) Maximum passenger capacity
(c) Maximum fuel load
(d) Previous experience (analysis of aircraft rescue and fire-fighting operations)

These factors were used by RFFP-II to generate Q_2 values for each airport category where $Q_2 = f \times Q_1$. The values of f ranged from 3 percent for Category 1 airports through 170 percent for Category 8 airports (Harley 1972, p. 3-16ff).

Today's Situation. The basic concepts developed by the ICAO RFFPs are still considered valid. However, the variables mentioned above that are used to develop the f factor for Q_2 have been refined over time and are now expressed as follows:

(a) *Aircraft Size.* Aircraft size reflects the potential level of risk. This risk factor is a composite of the passenger load, the potential internal fire load, flammable liquid fuel capacity, and the fuselage length and width. Careful consideration of all these factors allows the identification of a meaningful operational objective, that is, the area to be rendered firefree (controlled or extinguished).

(b) *Relative Effectiveness of Agent Selected.* This is accounted for by the specific application rate identified for each of the common generic foam concentrate types.

(c) *Time Required to Achieve PCA Fire Control.* Information from reliable large-scale fire tests, empirical data from a wide variety of sources, and field experience worldwide indicates that 1 minute is both a reasonable and a necessary operational objective.

(d) *Time Required to Maintain the Controlled Area Firefree or to Extinguish the Fire.* An operational objective that provides a safety factor for the initial fire attack on the PCA while waiting for the arrival of backup support or to complete extinguishment of remaining fires outside the PCA.

The quantity of water for foam production required for 1-minute fire control of the PCA is still referred to as Q_1. However, data collected in the ensuing years now permits us to specify the required application rates for three generic foam types needed to extinguish fire in 1 m^2 or 1 ft^2 of the PCA as follows:

(a) AFFF = 5.5 (L/min)/m^2 or 0.13 gpm/ft^2
(b) FP = 7.5 (L/min)/m^2 or 0.18 gpm/ft^2
(c) PF = 8.2 (L/min)/m^2 or 0.20 gpm/ft^2

Over time the changes in aircraft size factor have required revisions to the values of both Q_1 and Q_2 and the introduction of a third component, Q_3, which make up the total quantity of water (Q) required for the production of foam.

For example, Q_1 changes as a function of the accepted foam application rates and the size of the operational aircraft common to the various airport categories. And, since Q_2 is a function of Q_1, it too is impacted by changes in aircraft size and requires revision from time to time to accurately reflect the changes in the operational aircraft fleet.

The operational significance of the components making up Q is substantial in that Q relates to both the specific quantities of fire suppression agents required to control fire in the PCA and to the requirement that the specified quantity of agent be applied to the PCA within a time frame of 1 minute. In turn, Q_2 relates to the need to have sufficient fire suppression agents available to maintain conditions that do not pose a threat to life in the PCA until such time as rescue operations are completed. The secondary role of Q_2 is to extinguish all fires in and peripheral to the PCA.

The development of the requirement for these two quantities of water is based on exterior aircraft fuel spill fire control parameters. Information from actual incidents in recent years has shown that with increased aircraft crash worthiness, water for interior fire-fighting operations is also necessary. This quantity of water, called Q_3, is based on the need for handlines to be used for interior fire fighting. Hence, the total quantity of water (Q) is now defined as follows:

$$Q = Q_1 + Q_2 + Q_3$$

where:
Q_1 = water requirement for control of PCA
Q_2 = water requirement to maintain control or extinguish the remaining fire or both
Q_3 = water requirement for interior fire fighting

[See Figure A-2-3.1(b).]

1. The method for calculating the values for each component of Q are presented below.

$$Q_1 = \text{PCA} \times R \times T$$

where:
PCA = (0.67) × TCA, TCA = $L \times (K + W)$, and
L = length of aircraft
W = width of fuselage
R = application rate of selected agent
T = time of application (1 minute)
K = values shown below

Feet

K = 39 where L = less than 39
= 46 where L = 39 up to but not including 59
= 56 where L = 59 up to but not including 79
= 98 where L = 79 and over

Meters

K = 12 where L = less than 12
= 14 where L = 12 up to but not including 18
= 17 where L = 18 up to but not including 24
= 30 where L = 24 and over

2. The current values of Q_2 as a percentage of Q have been determined to be as shown:

Airport Category	Q_2% Q_1	Airport Category	Q_2% Q_1
1	0	6	100
2	27	7	129
3	30	8	152
4	58	9	170
5	75	10	190

3. The values of Q_3 are based on accepted water flow requirements for the type of fire-fighting operations to be experienced when combating an interior aircraft fire. They are determined as follows:

Airport Category	Q_3 Equals (U.S. gal)
1	0
2	0
3	60 gpm × 5 min = 300 gal
4	60 gpm × 10 min = 600 gal
5	125 gpm × 10 min = 1250 gal
6	125 gpm × 10 min = 1250 gal
7	125 gpm × 10 min = 1250 gal
8	250 gpm × 10 min = 2500 gal
9	250 gpm × 10 min = 2500 gal
10	250 gpm × 10 min = 2500 gal

Sample Calculation Using Airport Category 4 and AFFF Foam

$$\begin{aligned} \text{TCA} &= L \times (K + W) \\ &= 77.8 \times (56 + 12.9) = 5360 \text{ ft}^2 \\ \text{PCA} &= {}^2/_3 \times \text{TCA} = {}^2/_3 \times 5360 \text{ ft}^2 = 3573 \text{ ft}^2 \\ Q_1 &= 0.13 \text{ gpm/ft}^2 \times 3573 \text{ ft}^2 \times 1 = 464 \text{ gal} \\ Q_2 &= 58\% \times Q_1 = 0.58 \times 464 = 269 \text{ gal} \\ Q_3 &= 600 \text{ gal} \end{aligned}$$

now

$$\begin{aligned} Q &= Q_1 + Q_2 + Q_3 \\ &= 464 + 269 + 600 = 1333 \text{ gal} \\ &\quad \text{rounded up to 1335 gal} \end{aligned}$$

This quantity is shown in the second column of Table 3-3.1(a).

The example is given to illustrate the logic and the factors used to arrive at the quantity of water for foam production required for an airport Category 4. For example, the aircraft length (L) and the aircraft external cabin width (W) are the midpoint length and width for Category 4.

A-2-3.2 See Table A-2-3.2.

A-3-1.1 Foams used for control and extinguishment of aircraft fires involving fuel spills are produced by incorporation of air into a solution of foam concentrate and water. Their characteristics, as indicated by expansion and drainage rate, are influenced by the amount of mechanical agitation to which the water, foam concentrate, and air are subjected. They extinguish fire by physically separating the fuel vapors from the heat and oxygen necessary for combustion, spreading over the surface of the fuel to effectively suppress vaporization and secure an extinguished area by protecting it from reignition. Foam, being essentially water, cools the surface of the fuel and any metal surfaces in the fuel. The solution drainage from some foams forms an aqueous film on most aviation fuels. It is advantageous for a foam blanket to reseal if disrupted, and essential that either the foam has good thermal and mechanical stability or that provision is made to renew the foam blanket from time to time during a lengthy rescue operation.

Foam liquid concentrates of different types or from different manufacturers should not be mixed unless it is first established that they are compatible. Protein and fluoroprotein foam concentrates, in particular, are generally not compatible with AFFF concentrates and should not be mixed, although foams generated separately from these concentrates are compatible and can be applied simultaneously to a fire. All foams used as primary agents are available for use at 3 percent and 6 percent concentrations, usually in either fresh- or saltwater, and some are for use at other concentrations such as 1 percent or 5 percent.

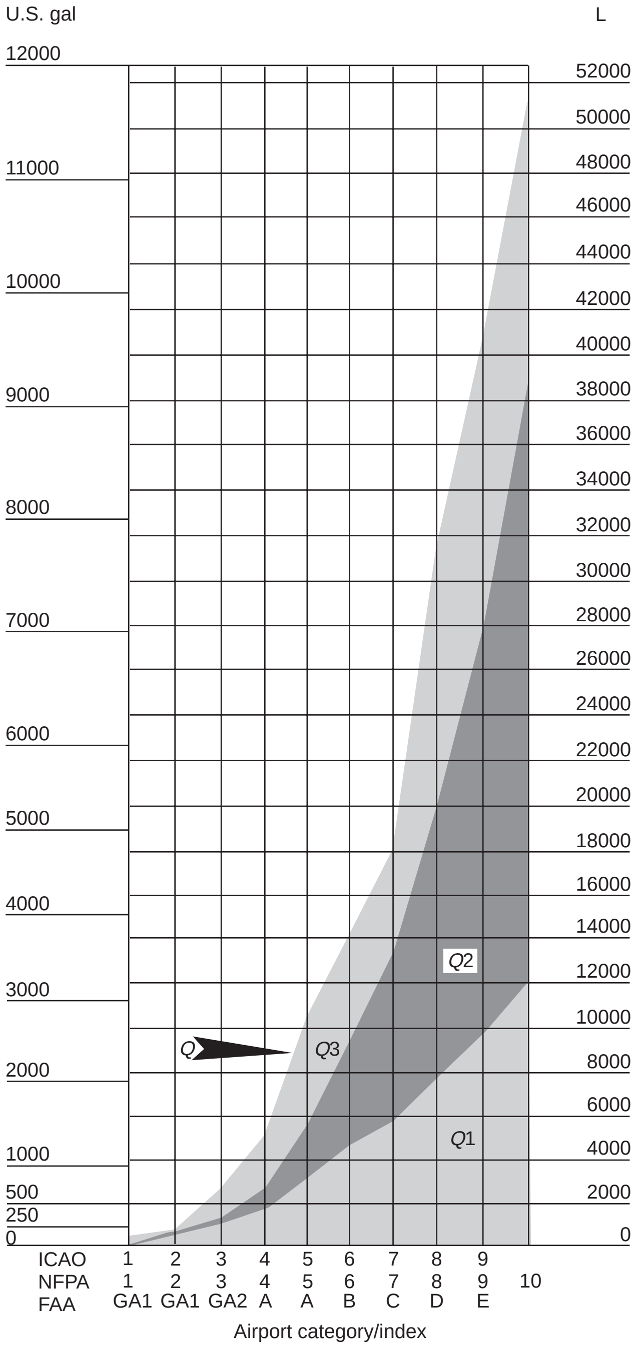

Figure A-2-3.1(b) Comparison of water by volume of Q_1, Q_2, Q_3, and Q for producing foam solution using AFFF.

Foam can be produced in a number of ways. The method of foam production selected should be carefully weighed, considering the techniques best suited for the equipment concerned, the rates and patterns of discharge desired, and the manpower needed to properly utilize the foam capabilities of the vehicles. The principal methods of foam production are given in NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire-Fighting Foam Equipment.*

The quality of water used in making foam can affect the foam performance. Locally available water might 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 concentrate manufacturer.

Table A-2-3.2 Representative Aircraft by Airport Categories

Airport Category	Aircraft Type	Overall Fuselage Length ft	Overall Fuselage Length m	External Fuselage Width ft	External Fuselage Width m
1	Beech Bonanza 35	26.33	8.01	3.05	1.07
	Cessna 206	26.90	8.20	4.00	1.22
	Mooney M-20	24.90	7.60	3.70	1.13
2	Cessna 414	36.30	11.06	4.70	1.43
	Piper Aerostar	34.80	10.60	3.90	1.19
	Piper Cheyenne 2	34.70	10.60	4.30	1.31
3	Beech 1900	57.90	17.65	4.60	1.40
	Beech Kingaire 200	43.80	13.35	5.80	1.77
	Lear 55	55.20	16.80	5.20	1.58
4	D.H. Dash 8	73.00	22.25	8.83	2.69
	Fokker F-27 2000	77.30	23.56	8.86	2.70
	Short 360	70.90	21.60	6.40	1.95
5	ATR 72	89.10	27.16	9.40	2.87
	D.H. Dash 7	80.70	24.60	8.50	2.59
	Gulfstream 3	83.10	25.30	7.40	2.71
6	BAE 146-200	93.67	28.55	11.68	3.56
	Airbus A-320 300	123.27	37.57	12.96	3.95
	Boeing 737-300	109.60	33.40	12.34	3.76
7	Boeing 727-200	156.16	46.68	12.34	3.76
	Boeing 757	155.30	47.34	13.00	3.96
	M.D. 88	147.90	45.10	10.96	3.34
8	Airbus A-300	175.90	53.61	18.50	5.64
	Boeing 767-300	180.30	54.96	16.50	5.03
	D.C. 10-40	182.23	55.54	19.75	6.02
	Lockheed L-1011	178.62	54.44	19.59	5.97
9	Airbus A-340 300	208.90	63.67	18.50	5.64
	Boeing 747-200	230.99	70.40	21.40	6.50
	Concorde	203.75	62.10	9.42	2.87
	M.D. 11	200.90	61.24	19.90	6.07
10	Antonov AN-225	275.70	84.10	20.90	6.40

CAUTION

Converting aircraft crash fire-fighting and rescue vehicles to use a type of foam concentrate other than that for which they were initially designed should not be accomplished without consultation with the equipment manufacturer and without a thorough flushing of the agent and the complete foam delivery system. Particular attention should be given to ensuring that the system component materials are suitable for the particular concentrate being substituted and that, where necessary, the proportioning equipment is recalibrated and reset.

CAUTION

Any salvageable aircraft that comes in contact with foam agents during fire-fighting or fuel spill-securing operations should be thoroughly flushed with fresh water as soon as practicable. Both the foam manufacturer and the airframe manufacturer should be contacted for any additional requirements that may be associated with specific foam agents or aircraft components.

A-3-1.2 The two test methods cited in 3-1.2 have wide application in North America but may not be recognized in other areas of the world. In particular, ICAO has developed guidance that references foam evaluation methods having significantly different test parameters such as test fuel, application rate, and extinguishment density. The intent of this standard is that primary foam agents meet minimum performance criteria. It is the intent that aqueous film-forming foams achieve a level of performance consistent with the MIL-F-24385, when the lowest discharge rates/ quantities in Tables 3-3.1(a) and 3-3.1(b) are used. The national (ICAO State) civil aviation authority having jurisdiction can adopt or reference standards recognized in that particular part of the world. It is incumbent on the national (ICAO State) authority to determine that alternate test methods are consistent with the minimum agent rates/quantities they have adopted. The national (ICAO State) civil aviation authority having jurisdiction should make this determination to prevent inconsistencies at the local or regional level.

A-3-1.2.1 Aqueous film-forming foam agents meeting all of the criteria of the U.S. Military Specification MIL-F-24385 appear on the Qualified Products List (QPL-24385-28). Other standards organization have fire test criteria comparable to the U.S. Military Specification MIL-F-24385. The authority having jurisdiction should obtain from their foam manufacturer, certification documentation on the foam fire performance equivalency. Freshwater or seawater can be used for the fire test.

A-3-2(a) There are a number of chemical compounds offered on a proprietary basis that 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 potassium bicarbonate-based powders have proven most effective as a means of quickly extinguishing flammable liquid fires when applied with a proper technique and at an adequate rate. Potassium bicarbonate has good flooding characteristics and can penetrate to otherwise inaccessible areas. Dry chemicals, as currently used in aircraft rescue and fire fighting, can be used to extinguish three-dimensional liquid fuel or running fires where foam is present on the ground.

A-3-2(b) Halogenated extinguishing agents are hydrocarbons in which one or more hydrogen atoms have been replaced by atoms from the halogen series—fluorine, chlorine, bromine, or iodine. This substitution confers not only nonflammability but flame extinguishment properties to many of the resulting compounds. Halogenated agents are used both in portable fire extinguishers and in extinguishing systems. The three halogen elements commonly found in extinguishing agents are fluorine (F), chlorine (Cl), and bromine (Br).

The extinguishing mechanism of the halogenated agents is not clearly understood. However, there is undoubtedly a chemical reaction that interferes with the combustion processes. Halogenated agents act by chemically interrupting the continuing combination of the fuel radicals with oxygen in the flame chain reactions. This process is known as *chain breaking*.

The discharge of Halon 1211 may create hazards to personnel such as dizziness, impaired coordination, reduced visibility, and exposure to toxic decomposition products. In any proposed use of Halon 1211 where there is a possibility that people may be trapped in or enter into atmospheres made hazardous, suitable safeguards should be provided to ensure prompt evacuation of and to prevent entry into such atmospheres and also to provide means for prompt rescue of any trapped personnel. Breathing apparatus should be worn.

Halon 1211 is a liquefied gas discharged as an 85 percent liquid stream that forms a vapor cloud when in contact with the fire, which permits penetration of obstructed and inaccessible areas. Halon 1211 leaves no agent residue and is the preferred agent for aircraft tire fires, engine fires, interior aircraft fires, electrical component fires, and flightline vehicle or equipment engine fires. Halon agent is, however, included in the Montreal Protocol on Substances that Deplete the Ozone Layer, signed September 16, 1987. The protocol permits continued availability of halongenated fire extinguishing agents at reduced production levels until the year 1994. Halon use should be limited to extinguishment of unwanted fire and should not be used for routine training of personnel.

A-3-3.1 See Tables A-3-3.1(a) and (b).

Table A-3-3.1(a) Conversion Table

Convert from	Into	Multiply by
Imp. Gallons	Liters	4.546
Imp. Gallons	U.S. Gallons	1.2009
Kilograms	Long Tons	0.00098
Kilograms	Metric Tons	0.001
Kilograms	Pounds	2.20462
Kilograms	Short Tons	0.001102
Liters	Imp. Gallons	0.21997
Liters	U.S. Gallons	0.26417
Long Tons	Kilograms	1016.05
Long Tons	Metric Tons	1.01605
Long Tons	Pounds	2240
Long Tons	Short Tons	1.12
Metric Tons	Kilograms	1000
Metric Tons	Long Tons	0.98421
Metric Tons	Pounds	2204.62
Metric Tons	Short Tons	1.1023
Pounds	Kilograms	0.4536
Pounds	Long Tons	0.0004464
Pounds	Metric Tons	0.0004536
Pounds	Short Tons	0.0005
Short Tons	Kilograms	907.185
Short Tons	Long Tons	0.89286
Short Tons	Metric Tons	0.90718
Short Tons	Pounds	2000
U.S. Gallons	Imp. Gallons	0.83267
U.S. Gallons	Liters	3.7854

A-3-3.3 Fire-fighting vehicles meeting the requirements of 3-3.2 carry a sufficient quantity of foam concentrate for one refill; therefore, rapid water resupply is of prime importance. The reserve water supply can be maintained in tankers or structural equipment. Hydrants may be considered if they are adequately located. Mutual aid services can be considered for this purpose if they are capable of responding in the critical time required to maintain the fire attack.

A-3-4 It is important that the compatibility of the foam and dry chemical agents be established if they are to be used together. Halon 1211 is compatible with all foams.

Table A-3-3.1(b) Fuel Weight Conversions at 59°F

From/To	Pounds Avgas	Pounds JetA Jet A-1 Jet A-2 Artic Diesel	Pounds Jeb B JP-4 F-40	Pounds JP-6 JP-8
Gallons Avgas	6.01			
Gallons Jet A Jet A-1 Jet A-2 Artic Diesel		7.00		
Gallons Jet B JP-4 F-40			6.68	
Gallons JP-6 JP-8				6.50

A-3-5 A variety of metals burn when heated to high temperatures by friction or exposure to external heat; others burn from contact with moisture or in reaction with other materials. Because accidental fires can occur during the transportation of these materials, it is important to understand the nature of the various fires and hazards involved. The most common combustible metals used in aircraft are magnesium and titanium.

The hazards involved in the control or complete extinguishment of combustible metal fires include extremely high temperatures, steam explosions, hydrogen explosions, toxic products of combustion, explosive reaction with some common extinguishing agents, breakdown of some extinguishing agents with the liberation of combustible gases or toxic products of combustion, and dangerous radiation in the case of certain nuclear materials. Some agents displace oxygen, especially in confined spaces. Therefore, extinguishing agents and methods for their specific application should be selected with care. Some combustible metal fires should not be approached without suitable self-contained breathing apparatus and protective clothing, even if the fire is small. Other combustible metal fires can be readily approached with minimum protection.

Numerous agents have been developed to extinguish combustible metal (Class D) fires, but a given agent does not necessarily control or extinguish all metal fires. Although some agents are valuable in working with several metals, other agents are useful in combating only one type of metal fire. Despite their use in industry, some of these agents provide only partial control and cannot be classified as actual extinguishing agents. Certain agents that are suitable for other classes of fires should be avoided in the case of combustible metal fires, because violent reactions can result (e.g., water on sodium, vaporizing liquids on magnesium fires).

Certain of the combustible metal extinguishing agents have been in use for years, and their success in handling metal fires has led to the terms *approved extinguishing powder* and *dry powder.* These designations have appeared in codes and other publications where it was not possible to employ the proprietary names of the powders. These terms have been accepted in describing extinguishing agents for metal fires and should not be confused with the name *dry chemical,* which normally applies to an agent suitable for use on flammable liquid (Class B) and live electrical equipment (Class C) fires.

A-4-1.1 It is desirable to have more than one 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 vehicle breakdown, and to minimize the "out of service" consequences when a vehicle is in need of routine maintenance or repairs. Having at least two fire-fighting vehicles available is particularly important when dealing with transport-type aircraft due to the need to rapidly cover any burning fuel spill to protect the aircraft and its occupants from radiated heat during the evacuation and rescue period, and to maintain the secure area around the fuselage to permit the safe evacuation and rescue of the occupants.

A-4-1.2 The capacity of each vehicle with regard to fire fighting, rescue equipment, and staffing should be compatible with the desired performance characteristics established for vehicles in the various categories specified in NFPA 414, *Standard for Aircraft Rescue and Fire-Fighting Vehicles.* It is particularly important that the vehicle not be overloaded so as to reduce the required acceleration, top speed, or vehicle flotation below the acceptable minimums set forth in NFPA 414.

The off-pavement performance capability of each ARFF vehicle should be established by tests at each airport during the various weather and terrain conditions experienced at that airport to establish, prior to an actual emergency, the capabilities and limitations of the vehicle for off-pavement response to accident or incident locations. In addition, periodic tests should be conducted to ensure that the performance requirements of the vehicle are as originally designed, and that the skill levels of the driver/operator remain high.

Where climatic or geographic conditions exist that considerably reduce the effectiveness of conventional wheeled vehicles, it is often necessary to carry extinguishing agents in a specialized vehicle suitable for traveling the airport terrain, such as a tracked, amphibious, air-cushioned, or high-mobility wheeled vehicle. Where these difficult operational conditions exist, experts should be consulted to develop a vehicle specification that matches the vehicle's performance capabilities to the unique conditions present at the airport.

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

Simplicity of vehicle operation with emphasis on operation of the extinguishing agent discharge devices is extremely important due to the time restrictions imposed for successful aircraft rescue and fire-fighting operations and the need to keep the fire-fighting crew to the minimum required for safe and efficient operations. Successful control of the fire in the PCA is essential using the minimum amount of agent necessary to secure the objective. To control an aircraft fire it is necessary to apply extinguishing agents at a rate higher than the fire is capable of destroying the control effort. Hand hose lines are usually not adequate for fire involving larger types of aircraft due to their limited discharge rate and are used primarily for protection of rescue parties, maintaining control of the fire in the PCA area, and combating fires in aircraft interiors. For these reasons, turrets are needed to rapidly knockdown the fire and secure the evacuation routes.

Improvements in vehicle and equipment design over recent years have increased the fire-fighting efficiency of these units and have outdated older rescue and fire-fighting vehicles. Before procuring any used vehicle for an airport rescue and fire-fighting service, the possible savings 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 vehicles and equipment built in accordance with NFPA 414, *Standard for Aircraft Rescue and Fire-Fighting Vehicles*. Secondhand vehicles might have been subjected to abusive service, components may have been overstressed, and repair parts might be impossible to obtain. Foam fire-fighting equipment purchased for this service should be tested in accordance with NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire-Fighting Foam Equipment*.

Specialized vehicles such as elevated platform devices or aerial water towers might be needed at some airports to allow fire fighters to reach elevations above the normal range of airport ARFF vehicles. Provision of escape slides or other rapid evacuation systems on these vehicles might be invaluable in affecting a rapid rescue.

All essential vehicles should be provided with two-way radio communications with air traffic control (ATC) or the airport controlling facility, for example, air-radio, flight service station, and so forth.

A-4-2 The following equipment should be carried on each ARFF vehicle:

(a) One ladder of overall length appropriate to the aircraft using the airport. This ladder is to be of lightweight alloy, aluminum, or magnesium, 16-in. (40.6-cm) minimum width, mounted in quick-release brackets on the apparatus and readily accessible. This ladder is not intended for evacuation use.

(b) Rapid intervention vehicles and Class 1 major fire-fighting vehicles should be equipped with a ladder capable of extending to a length of at least 16 ft (4.9 m).

Class 2, 3, and 4 major fire-fighting vehicles should be equipped with a ladder capable of extending to a length of at least 20 ft (6.1 m).

(c) Two portable 6-volt electric, weatherproof, hand-held lanterns having a minimum 25,000 beam candle power rating with carrying straps.

(d) One 6-lb crash axe with a serrated cutting edge and designed to prevent full penetration.

(e) One adjustable hydrant wrench capable of accommodating up to a 1.75-in. (4.4-cm) pentagon nut and up to a 1.25-in. (3.2-cm) square nut.

(f) One set of double male and double female connectors to fit each tank fill connection size provided on the vehicle. The connector material should be specified.

(g) Appropriate coupling wrenches for each size of hose carried on the vehicle.

(h) Two approved fire extinguishers having a minimum 80B:C UL rating of either dry chemical or Halon 1211. The dry chemical extinguishers should be the external propellant cartridge type.

(i) One 36-in. (91.4-cm) crowbar.

(j) One "D" handle pike pole with a shaft of fiberglass or other nonconductive material of similar density.

(k) One rubber mallet suitable for removing long-handled pipe caps.

(l) One 36-unit first-aid kit.

(m) One general-purpose cutter with capacity to cut up to 0.38 in. diameter hardened steel (Bhn 300) bolts.

(n) Two Dzus fastener keys.

(o) One tool roll to include at least the following equipment:

1. One aircraft cable cutter, 14-in. (35.6-cm), capacity to ¼ in. (0.6 cm)
2. One lineman's pliers, heavy duty, 8 in. (20.3 cm) long
3. One grappling hook and rope sling, 40 in. (101.6 cm) long
4. One hacksaw frame, adjustable 8 in. to 12 in. (20.3 cm to 30.5 cm)
5. Three hacksaw blades, 10-in. (25.4-cm) steel
6. Six fuel line plugs: 3 hardwood, 3 neoprene
7. One rescue knife with "V" blade
8. One vise grip wrench, 10 in. (25.4 cm) long
9. One metal cutting saw, 20-in. (50.8-cm) blade
10. Two industrial grade slot-type screwdrivers [one 4-in. (10.2-cm) and one 6-in. (15.2-cm) blade]
11. Two industrial grade Phillips screwdrivers [one 4-in. (10.2-cm) and one 6-in. (15.2-cm) blade]
12. One hand axe with serrated face and insulated handle

One hydraulic rescue kit should be carried on an in-service ARFF vehicle.

A-5-1.2 At those locations where the primary alerting authority (such as a control tower) is not operational during all the hours that the airport is open to aircraft traffic, a secondary alerting authority should be designated and trained. Appropriate communications and alarm control devices should be available at the secondary alerting authority's operating location and be operational during all times that the primary alerting authority is not available.

At those locations where a city or town or county off-airport fire department furnishes the airport rescue and fire-fighting personnel, and the alerting/dispatch of those personnel for airport emergencies is handled by an emergency direct-line telephone between the airport alerting authority and the off-airport alarm room, the airport fire station alarm(s) should ring upon activation of the direct emergency line. If possible, this type of "third party" dispatching of airport fire-fighting and rescue services should be avoided.

Because the majority of the calls for aircraft ARFF services are initiated by or first received by air traffic controllers, the airport fire department alarm room and the control tower, the flight service station or other air traffic control point should be linked by two-way radio and direct-line telephone to enhance the response time of the fire and rescue crews.

The emergency direct-line telephone should not pass through any intermediate automated switchboard or operator that could subject the alert calls to delays.

The tone of the emergency telephone bell (or buzzer) should be distinctly different from all other communications signaling devices within hearing of personnel in the alarm room, on the apparatus floor, or in living quarters as applicable.

Protection against delays due to telephone bell or buzzer failure should be provided by use of redundant warning lights activated by the same input signal as the telephone ringer. The lights should be strategically located throughout the alarm room, the apparatus floor, and living space as dictated by the fire station design and the normal activities of the fire and rescue service personnel.

The fire station alarm should be linked to the emergency telephone so that a call on the emergency telephone circuit simultaneously actuates the audible alarm throughout the fire station.

Consideration should be given to having the alarm circuitry open the vehicle bay doors in the fire station upon sounding the alarm. However, some climatic conditions can make this impractical, or noise when doors are opened can interfere with hearing the dispatch.

The notification of all units designated to respond to an aircraft emergency on a large airport should be done through the use of a "conference" circuit that allows simultaneous notification. This "conference" circuit should include, as appropriate, the following units or offices:

(a) Control tower, flight service station, or other control point

(b) Rescue and fire fighting

(c) Airport police

(d) Airport management

(e) Airline station manager(s), as appropriate

(f) Military units (joint-use airports)

(g) Other authorities on or off the airport as required by the airport's emergency plan

At airports with several air carriers, the notification of the appropriate station manager might be accomplished more effectively by the use of individual paging devices.

Fire stations where personnel are normally present for duty, but may be preoccupied with housekeeping or training duties, should be equipped with a public address system. This is particularly important in fire stations where the alarm room, training room, and living quarters are physically separated from the apparatus floor. Such a system should significantly enhance response time and fire fighter effectiveness by providing vital details of the emergency to each fire fighter during response, for example, location of accident or incident site, type of aircraft, number of persons involved, aircraft fuel load, preferred vehicle routing, and so forth.

At airports with a main fire station and one or more substations, an interconnected public address system should be provided.

At airports employing dual function personnel or auxiliary fire fighters, an audible alarm should be installed in all areas where auxiliary fire-fighting personnel are employed to notify them of any emergency recall for fire and rescue duties. It should be a distinctly different sound and loud enough to be clearly heard above the normal noise level.

At airports equipped with ground-to-air radio, the person authorized to receive in-flight emergency messages should be provided with a device for actuating these alarms.

Alarm actuating stations should be provided near hangars, shops, fueling stations, and aircraft parking areas.

Individual paging devices, although potentially more expensive, can be used. This method has the advantage of notifying those persons with assigned rescue fire-fighting duties.

A reliable voice communications capability should be available between the airport rescue and fire-fighting service and any off-airport organizations expected to participate in the airport/community mutual aid plan.

Each emergency response vehicle on an airport should be equipped with two-way voice radio communication between the alerting authority, all other aircraft rescue and fire-fighting vehicles, and the designated command post.

On airports with a control tower the communications channel between vehicles and the tower should be on the assigned standard ground control frequency, or as designated in the Airport Emergency Plan Letter of Agreement between airport management, the control tower, and/or flight service station.

On airports without a control tower but with another means of ground-to-air communications, the rescue and fire-fighting vehicles should be equipped to communicate on a frequency common with the control point.

Where practicable, the two-way radio capability on the airport fire and rescue service vehicle(s) should not be tied into public service frequencies (city, county, or airport maintenance). This independent communications network will help ensure interruption-free communication in an emergency situation.

On-scene commanders (OSC) should have a communication capability while outside or remote from their vehicle communications systems. Portable radios can be used by the OSC for direct contact with the airport fire services and air traffic control services.

A reliable form of communication should be provided between the aircraft commander, the OSC, ARFF services, and the airport alerting authority to preclude unnecessary aircraft emergency evacuation or misunderstandings.

Direct communications can be established between the flight deck and the OSC or ARFF personnel by use of flight-deck-to-ground lines. Normally this communication capability results from the use of a ground service headset that is plugged into a wheel well or nose interphone jack.

The airport rescue and fire-fighting service alarm room should be designed and operated in such a manner that an alarm can be received, evaluated, and acted on with a minimum of activity or consultation.

For an alarm room to serve its intended function, provisions should be made to ensure that all personnel assigned to alarm room duties are trained in communication equipment operations, proper communication procedures, and local emergency plan implementation procedures.

A-6-1.4 A carefully organized training program should be developed to meet the qualification requirements of NFPA 1003, *Standard for Airport Fire Fighter Professional Qualifications*. The following guidelines are offered for structuring such a program.

The objectives of a training program for aircraft rescue and fire-fighting personnel at airports should be to accomplish the following:

(a) Teach the safe application of recognized practices and procedures

(b) Develop and maintain the confidence and competency of all personnel assigned ARFF duties

(c) Instill the concept of professionalism

(d) Serve as a source of accurate technical information whereby the lessons gained from aircraft accidents or incidents are properly analyzed and the information disseminated to others concerned with ARFF operations

(e) Enhance the esprit de corps of aircraft rescue and fire-fighting personnel by creating an appreciative awareness of the hazards and dangers they may face in carrying out ARFF operations

Control and Planning. 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, and supervision.

Resources for Training. Training material resources for a training program oriented specifically to meet the needs of aircraft rescue and fire-fighting personnel should take into consideration providing suitable amounts of extinguishing agents, such as foam concentrate, dry chemical, and Halon 1211; and fuel for training fires.

Phases of Training. Training of aircraft rescue and fire-fighting personnel should include seven phases. Training in all phases should be conducted for support personnel used as auxiliary fire fighters and for full-time 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 reduced for auxiliary fire fighters.

Indoctrination. Indoctrination training should include the following:

(a) The rules and regulations applicable to ARFF services
(b) Knowledge of the basic duties and responsibilities and those of co-workers
(c) Emergency response procedures
(d) The command structures for administration and operations
(e) The importance of practicing occupational safety

Operating ARFF Equipment. All aircraft rescue and fire-fighting personnel should be capable of effectively handling fire and rescue equipment under varied conditions of terrain and weather. The aim of training should be to ensure that every fire fighter is so well versed in handling all types of appliances and tools used in ARFF operations that under stressful conditions individual fire fighters can take effective action without the need for specific direction. Some of the items that should be covered are included in the following list:

(a) Complete knowledge of each tool and piece of equipment.
(b) Location of each piece of equipment and tool carried on each vehicle.
(c) Method of using each piece of equipment and tool, with emphasis on personal safety factors.
(d) Special handling precautions for the use of power tools.
(e) Knowledge of, and training in, the use of breathing apparatus and other protective equipment.
(f) Techniques employed in utilizing the available communication equipment.
(g) Knowledge of the apparatus, its built-in equipment, including the pump and its performance capabilities, the agents carried and their delivery systems.
(h) Actual operation of all vehicle controls and behind-the-wheel driver training under circumstances including negotiating obstacles and muddy or snow-covered soil conditions. This is done to provide a degree of assurance that the vehicle will not get bogged down or damaged during emergencies.
(i) Knowledge of departmental policies on positioning of apparatus for tactical service at accidents/ incidents under the variety of possible conditions to be encountered.
(j) Record keeping to document the efficiency and effectiveness of the various vehicles utilized by the airport fire department.

Fire Behavior and Fire Suppression. Aircraft rescue and fire-fighting personnel should possess a sound knowledge of fire behavior.

Instruction in this phase should include the following:

(a) Principles of combustion, with emphasis on the types of aircraft fuels
(b) How fire propagates through the effects of heat conduction, convection, and radiation
(c) Influence of fuel distribution on heat production
(d) Principles of fire suppression by the various types of agents utilized in aircraft rescue and fire-fighting operations
(e) Live fire exercises that include but are not limited to exterior fuel fires, interior fires, engine fires, wheel fires, and fires involving on-board auxiliary power units
(f) Effects of heat exposure on individuals

Training should be given covering the advantages and disadvantages of each fire extinguishing agent employed. Every opportunity should be taken to use the agents on realistic training fires. Each routine equipment test should 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.

Rescue and Fire-Fighting Procedure. Care should be taken to ensure that aircraft rescue and fire-fighting personnel fully understand that to achieve the objective of safeguarding the lives of those involved in an aircraft accident requires that fire in the practical critical area be controlled quickly and that this area be kept secure. Strict discipline should be maintained to ensure that fire suppression agents are not expended on fire outside the PCA until it is positively established that the immediate and long-term security of the PCA will not be jeopardized.

Personnel should be given thorough instructions in the following subject areas:

(a) Standard operating procedures (SOP) to be expected from the aircraft crew members under specified circumstances
(b) Locations within aircraft where victim concentration may be anticipated under accident conditions of various types
(c) Behavior patterns of individuals involved in major disasters
(d) Means of preventing or minimizing panic
(e) Means of gaining entry through normal aircraft openings
(f) Locations most suitable for forcible entry into the aircraft
(g) Requirements of setting up triage and treatment areas that should be part of the airport/community emergency plan *(see NFPA 424, Guide for Airport/ Community Emergency Planning)*
(h) Methods of carrying injured persons (one-person and by teams)

Familiarization with Local Terrain. A thorough knowledge of the terrain of the airport and its immediate vicinity is essential. The existence of any areas that may from time to time become impassable because of weather or other conditions (tides, growth of brush, etc.) should be known to all crew