

# **NFPA<sup>®</sup>**

# **403**

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**Standard for Aircraft Rescue  
and Fire-Fighting Services  
at Airports**

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**2018**



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## NFPA® 403

### Standard for

## Aircraft Rescue and Fire-Fighting Services at Airports

### 2018 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. It was issued by the Standards Council on August 1, 2017, with an effective date of August 21, 2017, and supersedes all previous editions.

This edition of NFPA 403 was approved as an American National Standard on August 21, 2017.

### 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 (USA) 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. 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.

The 1998 edition was a partial revision.

The major change to the 2003 edition was the addition of staffing requirements.

The 2009 edition modified some definitions. Additional cleanup of the document was made by moving nonmandatory language to Annex A. The FAA Airport Category column in Table 4.3.1 was updated.

For the 2014 edition, the committee made several changes to various requirements and sections within the document. The committee updated the definitions pertaining to foam and extracted several definitions from other NFPA standards for document and project consistency. Most of the updates and changes in the 2014 edition revolved around response times and response capabilities for ARFF departments. The committee invested a significant amount of time looking at existing science and data along with currently accepted practices and adjusted the response time requirements accordingly. Along with adjusting response times and capabilities, the committee also developed requirements that would allow for a risk analysis to be conducted by the AHJ in order to determine what would best meet the needs and demands of each ARFF department, recognizing the fact that each department and airport are different and have different needs. The committee also made adjustments to the minimum number of ARFF vehicles required based on airport category. Annex B, which is related to agent qualities, was also revised.

For the 2018 edition, the committee updated the reference sections of the document as well as updated and included new definitions in the document. Some of the newly included definitions are pertaining to special events, specifically air shows occurring at airports. There are now definitions for the three categories pertaining to the aircraft showline. This had been included because the committee has added a new chapter pertaining to special events and airport-based air shows. The committee also made changes to the requirements pertaining foam with the intent of limiting variation due to potential confusion and increased complication in testing. The committee also re-evaluated the staffing levels within the document, and in doing so they added new text to ensure that the levels can be modified based on the AHJ completing a task and resource analysis based on the airport's individual needs and demands. The committee also added clarification to the distinction between the terms *arriving* and *responding*, with the intent to reduce and eliminate confusion. The committee also included response times relating to passenger boarding areas of the airport, such as jet bridges.

## Technical Committee on Aircraft Rescue and Fire Fighting

**Robert C. Mathis**, *Chair*  
The Boeing Company, WA [M]

**John W. McDonald**, *Secretary*  
U.S. General Services Administration, MD [U]  
Rep. U.S. General Services Administration

**Keith W. Bagot**, U.S. Federal Aviation Administration, NJ [RT]  
Rep. U.S. Federal Aviation Administration

**Ralph Colet**, JRI Inc., CA [M]

**Bradford Colton**, American Pacific Corporation, NV [M]  
Rep. Fire Equipment Manufacturers' Association

**Howard Costa**, Massport Fire Rescue, MA [U]

**Ross A. Davidson**, U.S. Department of the Navy, CA [E]  
Rep. U.S. Department of the Navy

**Graeme Day**, LHR Airports Limited, United Kingdom [U]

**Hanh Deniston**, Metropolitan Washington Airports Authority, VA [L]  
Rep. International Association of Fire Fighters

**Martin Gravel**, Department of National Defence, Canada, Canada [E]

**Neil Gray**, United Kingdom Civil Aviation Authority, United Kingdom [E]

**Michael A. Greenup**, Los Angeles Fire Department, CA [U]

**Ronald E. Jones**, E-One, Inc., FL [M]

**D. Scott Lanter**, Blue Grass Airport, KY [C]  
Rep. Airports Council International-North America

**Stephen Listerman**, Cincinnati/Northern Kentucky International Airport Fire Department, OH [E]

**John Anderson Maddox**, Lakeland Fire Department, FL [U]

**Douglas C. Mangels**, Denver Fire Department, CO [SE]  
Rep. Aircraft Rescue & Fire Fighting Working Group, Inc.

**Graydon L. Matheson**, King County Sheriff's Office-ARFF Division, WA [U]

**Kevin J. Petit**, Akron Brass Company, OH [M]

**Pam L. Phillips**, Port Authority of New York & New Jersey, NJ [C]  
Rep. American Association of Airport Executives

**Danny M. Pierce**, ARFF Solutions, CA [SE]

**James E. Podolske, Jr.**, U.S. Department of the Air Force, FL [E]

**Paul W. Powell**, Rosenbauer America, TX [M]  
Rep. Fire Apparatus Manufacturers Association

**Joseph L. Scheffey**, JENSEN HUGHES, MD [SE]

**Jason Shively**, Oshkosh Corporation, WI [M]

**Jeremy Souza**, Rhode Island Airport Corporation, RI [U]

**Marc S. Tonnacliff**, U.S. Federal Aviation Administration, DC [E]  
Rep. U.S. Federal Aviation Administration

**Christopher A. Toten**, U.S. Marine Corps, TX [E]

### Alternates

**Gerard G. Back**, JENSEN HUGHES, MD [SE]  
(Alt. to Joseph L. Scheffey)

**Daniel Buckingham**, U.S. General Services Administration, DC [U]  
(Alt. to John W. McDonald)

**Ralph B. Colet**, JRI Inc., CA [M]  
(Alt. to Ralph Colet)

**Robert L. Darwin**, Engility Corporation, VA [C]  
(Alt. to Ross A. Davidson)

**Richard Gentry**, Indianapolis Airport Authority, IN [E]  
(Alt. to Stephen Listerman)

**Fred B. Goodnight**, Amerex Corporation, AL [M]  
(Alt. to Bradford Colton)

**William D. Gordon**, BWI Fire Rescue Department, MD [L]  
(Alt. to Hanh Deniston)

**Al Gulamali**, Lee County Port Authority, FL [C]  
(Alt. to D. Scott Lanter)

**Denny J. Heitman**, U.S. Department of the Air Force, IL [E]  
(Alt. to James E. Podolske, Jr.)

**Elizabeth A. Hendel**, Phoenix Fire Department, AZ [E]  
(Voting Alt.)

**Duane F. Kann**, Rosenbauer, MN [M]  
(Alt. to Paul W. Powell)

**Ronald J. Krusleski**, Houston Fire Department ARFF, TX [SE]  
(Alt. to Douglas C. Mangels)

**Dana Larsen**, Los Angeles City Fire Department, CA [U]  
(Alt. to Michael A. Greenup)

**Thomas W. Littlepage**, Evansville Airport Authority, IN [U]  
(Alt. to John Anderson Maddox)

**William K. Major**, Buffalo Niagara International Airport Fire Department, NY [L]

**James Price**, U.S. Department of Transportation, GA [E]  
(Alt. to Marc S. Tonnacliff)

**Steven Schwartz**, Oshkosh Corporation, WI [M]  
(Alt. to Jason Shively)

**Darrell Sooter**, The Boeing Company, SC [M]  
(Alt. to Robert C. Mathis)

**Leroy Stephens**, E-One, FL [M]  
(Alt. to Ronald E. Jones)

**Jonathan Torres**, SRA International, A CSRA Company, NJ [RT]  
(Alt. to Keith W. Bagot)

**Justin M. Towles**, American Association of Airport Executives, VA [C]  
(Alt. to Pam L. Phillips)

**Tim Vanfleet**, Akron Brass Company, OH [M]  
(Alt. to Kevin J. Petit)

**Nonvoting**

**Francois Villard**, Fire Safety Security Crisis Management Training,  
Switzerland [SE]

**Thomas J. Lett**, Albuquerque Fire & Safety Associates, NM [SE]  
(Member Emeritus)

**L. M. Krasner**, Medfield, MA [SE]  
(Member Emeritus)

**Ken Holland**, NFPA Staff Liaison

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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 documents on aircraft rescue and fire-fighting services and equipment, for 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 also shall have responsibility for documents on aircraft hand fire extinguishers and accident prevention and the saving of lives in future aircraft accidents involving fire.

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**NFPA 403****Standard for****Aircraft Rescue and Fire-Fighting Services at  
Airports**

2018 Edition

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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 Annex A.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex F. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex F.

**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.

**1.2.2.1** The preparation for dealing with an aircraft accident/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.

**1.2.2.2** The need for extinguishing a fire can occur either immediately following an aircraft accident/incident, or at any time during rescue operations, and 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 Equivalency.**

**1.3.1** Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard.

**1.3.2** Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

**1.3.3** The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

**Chapter 2 Referenced Publications**

**2.1 General.** The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

**2.2 NFPA Publications.** National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 10, *Standard for Portable Fire Extinguishers*, 2017 edition.

NFPA 405, *Standard for the Recurring Proficiency of Airport Fire Fighters*, 2015 edition.

NFPA 412, *Standard for Evaluating Aircraft Rescue and Fire-Fighting Foam Equipment*, 2014 edition.

NFPA 414, *Standard for Aircraft Rescue and Fire-Fighting Vehicles*, 2017 edition.

NFPA 1003, *Standard for Airport Fire Fighter Professional Qualifications*, 2015 edition.

**2.3 Other Publications.**

**2.3.1 Military Specifications.** Department of Defense Single Stock Point, Document Automation and Production Service, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 1911-5094.

U.S. Military Specification MIL-F-24835, *Fire Extinguishing Agent, Aqueous Film-Forming Foam (AFFF), Liquid Concentrate, for Fresh and Sea Water*.

**2.3.2 Other Publications.**

*Merriam-Webster's Collegiate Dictionary*, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

ICAO Doc 9137, *Airport Services Manual*, Part 8, Level B.

**2.4 References for Extracts in Mandatory Sections.**

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2016 edition.

## Chapter 3 Definitions

**3.1 General.** The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

### 3.2 NFPA Official Definitions.

**3.2.1\* Approved.** Acceptable to the authority having jurisdiction.

**3.2.2\* Authority Having Jurisdiction (AHJ).** An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

**3.2.3 Shall.** Indicates a mandatory requirement.

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

**3.2.5 Standard.** An NFPA Standard, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase "standards development process" or "standards development activities," the term "standards" includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

### 3.3 General Definitions.

**N 3.3.1\* Aerobatic Box.** The Federal Aviation Administration (FAA) defines the aerobatic box as the airspace at an air show where participating aircraft are authorized to perform aerobatic maneuvers appropriate to their category (CAT).

**N 3.3.2 Air Boss.** The individual who has the primary responsibility for air show operations on the active taxiways, runways, and the surrounding air show demonstration area.

**N 3.3.3 Air Show Waiver.** An official document issued by the FAA that authorizes certain operations of aircraft to deviate from a regulation but under conditions that ensure an equivalent level of safety.

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

**3.3.5 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.

**3.3.6\* Aircraft Fire Fighting.** The control or extinguishment of fire adjacent to or involving an aircraft following ground accidents or incidents.

**3.3.7\* 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.

**3.3.8\* Aircraft Rescue.** Action taken to save or set free persons involved in an aircraft accident/incident by safeguarding the integrity of the aircraft fuselage from an external/internal fire, to support self-evacuation, and to undertake the removal of injured and trapped persons.

### N 3.3.9 Aircraft Showline Categories.

**N 3.3.9.1 Category I Showline.** A Category I showline must be not less than 1500 ft from the primary spectator area (minimum showline distances are measured from the crowd line to the center of the aircraft closest to any spectator area). Reciprocating engine-powered aircraft with a speed of 245 knots indicated air speed (KIAS) or higher in straight and level flight at 75 percent power at standard temperature and pressure (15°C at sea level) shall not perform aerobatic maneuvers closer than the Category I showline. Turbine engine-powered aircraft with a speed of 245 KIAS or higher in straight and level flight at 85 percent power at standard temperature and pressure shall not perform aerobatics closer than the Category I showline.

**N 3.3.9.2 Category II Showline.** A Category II showline must be not less than 1000 ft from the primary spectator area. Reciprocating engine-powered aircraft with a speed of more than 156 KIAS and less than 245 KIAS in straight and level flight at 75 percent power at standard temperature and pressure shall not perform aerobatic maneuvers closer than the Category II showline. Turbine engine-powered aircraft with a speed higher than 156 KIAS and less than 245 KIAS in straight and level flight at 85 percent power at standard temperature and pressure shall not perform aerobatics closer than the Category II showline.

**N 3.3.9.3 Category III Showline.** A Category III showline must be not less than 500 ft from the primary spectator area. Reciprocating engine-powered aircraft with a speed of 156 KIAS or less in straight and level flight at 75 percent power at standard temperature and pressure shall not perform aerobatic maneuvers closer than the Category III showline. Turbine engine-powered aircraft with a speed higher than 156 KIAS or less in straight and level flight at 85 percent power at standard temperature and pressure shall not perform aerobatics closer than the Category III showline.

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

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

**3.3.12 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.

### 3.3.13 Area Classifications.

**3.3.13.1 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. (See Figure A.3.3.13.3.)

**3.3.13.2 Movement Area.** That part of an airport to be used for the takeoff, landing, and taxiing of aircraft, and the apron(s).

**3.3.13.3\* Rapid Response Area (RRA).** A rectangle that includes the runway and the surrounding area extending to a width of 500 ft (150 m) outward from each side of the runway centerline and to a length of 1650 ft (500 m) beyond each runway end, but not beyond the airport property line. (See Figure A.3.3.13.3.)

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

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

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

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

**3.3.17.1\* Aqueous Film-Forming Foam Concentrate (AFFF).** A concentrate based on fluorinated surfactants plus foam stabilizers to produce a fluid aqueous film for suppressing hydrocarbon fuel vapors and usually diluted with water to a 1 percent, 3 percent, or 6 percent solution. [11, 2016]

**3.3.17.2\* Film-Forming Fluoroprotein Foam Concentrate (FFFP).** A protein-foam concentrate that uses fluorinated surfactants to produce a fluid aqueous film for suppressing hydrocarbon fuel vapors. [11, 2016]

**3.3.17.3 Fluorine-Free Synthetic Foam (FFSF).** Foam concentrate based on a mixture of hydrocarbon surface active agents that are fluorine free.

**3.3.17.4\* Fluoroprotein Foam Concentrate (FP).** A concentrate very similar to protein-foam concentrate but with a synthetic fluorinated surfactant additive. [11, 2016]

**3.3.17.5\* Protein Foam Concentrate (P).** Concentrate consisting 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 ensure readiness for use under emergency conditions. [11, 2016]

**3.3.18\* Foam Concentrate.** A concentrated liquid foaming agent as received from the manufacturer. [11, 2016]

**3.3.19 Fuselage.** The main body of an aircraft.

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

**3.3.21 Mutual Aid.** A written intergovernmental agreement between agencies, jurisdictions, or both, that they assist one another on request by furnishing personnel, equipment, expertise, or a combination in a specified manner.

**3.3.22 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/incident and is in position to apply agent.

**3.3.23 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 4 Organization of Aircraft Rescue and Fire-Fighting (ARFF) Services

### 4.1 Administrative Responsibilities.

**4.1.1** The airport management shall be responsible for the provisions of ARFF services on the airport.

**4.1.2** Mutual aid shall be prearranged between such services on airports and any off-airport fire or rescue agencies serving the environs of the airport.

**4.2\* Emergency Preparedness.** The airport shall develop a risk management plan for fire emergency scene strategy.

**4.2.1** Airports shall prepare and maintain in current status an airport/community emergency plan.

**4.2.1.1** The plan shall assign specific duties and responsibilities and include all airport and community resources necessary to cope with a major aircraft emergency and other potential emergencies requiring ARFF resources.

**4.2.2\* Airport/community emergency plans** shall be tested at least every 3 years in the form of a full-scale exercise.

**4.2.2.1** In addition, tabletop training shall be conducted at least annually.

**4.2.3** Airport management and resource agencies shall participate in annual tabletop training exercises that encompass their duties and responsibilities depicted in the emergency plan.

### 4.3 Categorizing Airports for ARFF Services.

**4.3.1** 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 4.3.1. (See Annex B.)

**4.3.2\*** The airport category for a given aircraft shall be based on the overall length of the aircraft or the fuselage width.

**4.3.2.1** 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 4.3.1, then the category for that aircraft shall be the next one higher.

**Table 4.3.1 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                     | A*  | 1    | 30                                                 | 9  | 6.6                                            | 2 |
| 2                     | A*  | 2    | 39                                                 | 12 | 6.6                                            | 2 |
| 3                     | A*  | 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                    | E   | 10   | 295                                                | 90 | 25.0                                           | 8 |

Notes:

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

(2) Although only water is normally necessary for interior handline attack, logistically and tactically it should be discharged as foam and is therefore included in the quantities of water necessary for foam production in Table 5.3.1(a) and Table 5.3.1(b).

\*It is FAA Category A if the airport has scheduled service with aircraft that have more than nine passenger seats.

## Chapter 5 Extinguishing Agents

### 5.1 Primary Agents.

**5.1.1\*** One or more of the following types of primary agents shall be used for aircraft fire fighting involving hydrocarbon fuels:

- (1) Aqueous film-forming foams (AFFF)
- (2) Fluoroprotein foam (FP) or film-forming fluoroprotein foam (FFFP)
- (3) Protein foam (P)
- (4) Fluorine-free synthetic foam

**5.1.2\*** All foam concentrates shall be listed.

**5.1.2.1** Any primary agent used at the minimum quantities and discharge rates in Table 5.3.1(a) and Table 5.3.1(b) shall meet the applicable fire extinguishment and burnback performance requirements of the performance tests specified.

**5.2 Complementary Agents.** All ARFF vehicles responding shall carry either one or both of the following categories of complementary agents:

- (1)\* Potassium-based dry chemical
- (2)\* Halogenated agent

### 5.3 Quantity of Agents.

**5.3.1** The minimum amounts of water for foam production and the minimum amounts of complementary agents necessary shall be as specified in Table 5.3.1(a) or Table 5.3.1(b), based on the system of categorizing airports listed in Table 4.3.1.

**5.3.2** Sufficient foam concentrate shall be provided on each vehicle to proportion, at the prescribed percentage of foam concentrate to water, into double the quantity of water specified in Table 5.3.1(a) or Table 5.3.1(b) at the maximum tolerance specified in NFPA 412.

**5.3.3\*** Each airport shall conduct and document a needs analysis to determine a minimum 100 percent water resupply capability within the critical rescue and fire-fighting access area and shall ensure that local arrangements fulfill that capability.

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

### 5.5\* Combustible Metal Agents.

**5.5.1** Extinguishing agents for combustible metal fires shall be provided in portable fire extinguishers that are rated for Class D fires in accordance with 5.2.4 of NFPA 10.

**5.5.2** At least one nominal 20 lb (9.1 kg) extinguisher shall be carried on each vehicle specified in Table 6.1.1.

### 5.6 Agent Discharge Capabilities.

**5.6.1** The discharge capabilities of extinguishing agents shall not be less than the rates specified in Table 5.3.1(a) or Table 5.3.1(b) of this standard and Table 4.1.1(c) and Table 4.1.1(d) of NFPA 414.

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



**Table 5.3.1(a) Extinguishing Agents, Discharge, and Response Capability in U.S. Customary Units**

| Airport Category | Response Phases   | Response Capability (sec) | MIL-F-24835 and ICAO C    |                            | ICAO B                    |                            | ICAO A                    |                            | Complementary Agents <sup>a</sup> |                    |
|------------------|-------------------|---------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|-----------------------------------|--------------------|
|                  |                   |                           | Required Water (U.S. gal) | Discharge Capability (gpm) | Required Water (U.S. gal) | Discharge Capability (gpm) | Required Water (U.S. gal) | Discharge Capability (gpm) | Quantity (lb)                     | Discharge (lb/sec) |
| 1                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 120                       | 120                        | 160                       | 160                        | 180                       | 180                        | 100                               | 5                  |
|                  | Q2 <sup>c</sup>   |                           | 0                         |                            | 0                         |                            | 0                         |                            |                                   |                    |
|                  | Q3 <sup>d</sup>   |                           | 0                         |                            | 0                         |                            | 0                         |                            |                                   |                    |
| TOTAL            |                   |                           | 120                       |                            | 160                       |                            | 180                       |                            |                                   |                    |
| 2                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 157                       | 157                        | 213                       | 213                        | 236                       | 236                        | 200                               | 5                  |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 43                        |                            | 57                        |                            | 64                        |                            |                                   |                    |
|                  | Q3 <sup>d</sup>   |                           | 0                         |                            | 0                         |                            | 0                         |                            |                                   |                    |
| TOTAL            |                   |                           | 200                       |                            | 270                       |                            | 300                       |                            |                                   |                    |
| 3                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 285                       | 285                        | 392                       | 392                        | 438                       | 438                        | 300                               | 5                  |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 85                        |                            | 118                       |                            | 132                       |                            |                                   |                    |
|                  | Q3 <sup>d</sup>   | 240 <sup>d,e</sup>        | 300                       | 60                         | 300                       | 60                         | 300                       | 60                         |                                   |                    |
| TOTAL            |                   |                           | 670                       |                            | 810                       |                            | 870                       |                            |                                   |                    |
| 4                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 468                       | 468                        | 646                       | 646                        | 715                       | 715                        | 300                               | 5                  |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 272                       |                            | 374                       |                            | 415                       |                            |                                   |                    |
|                  | Q3 <sup>d</sup>   | 240 <sup>d,e</sup>        | 600                       | 60                         | 600                       | 60                         | 600                       | 60                         |                                   |                    |
| TOTAL            |                   |                           | 1,340                     |                            | 1,620                     |                            | 1,730                     |                            |                                   |                    |
| 5                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 863                       | 863                        | 1,194                     | 1,194                      | 1,331                     | 1,331                      | 450                               | 5                  |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 647                       |                            | 896                       |                            | 999                       |                            |                                   |                    |
|                  | Q3 <sup>d</sup>   | 240 <sup>d,e</sup>        | 1,250                     | 125                        | 1,250                     | 125                        | 1,250                     | 125                        |                                   |                    |
| TOTAL            |                   |                           | 2,760                     |                            | 3,340                     |                            | 3,580                     |                            |                                   |                    |
| 6                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 1,245                     | 1,245                      | 1,725                     | 1,725                      | 1,920                     | 1,920                      | 450                               | 5                  |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 1,245                     |                            | 1,725                     |                            | 1,920                     |                            |                                   |                    |
|                  | Q3 <sup>d</sup>   | 240 <sup>d,e</sup>        | 1,250                     | 125                        | 1,250                     | 125                        | 1,250                     | 125                        |                                   |                    |
| TOTAL            |                   |                           | 3,740                     |                            | 4,700                     |                            | 5,090                     |                            |                                   |                    |
| 7                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 1,585                     | 1,585                      | 2,192                     | 2,192                      | 2,437                     | 2,437                      | 450                               | 5                  |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 2,045                     |                            | 2,828                     |                            | 3,143                     |                            |                                   |                    |
|                  | Q3 <sup>d</sup>   | 240 <sup>d,e</sup>        | 1,250                     | 125                        | 1,250                     | 125                        | 1,250                     | 125                        |                                   |                    |
| TOTAL            |                   |                           | 4,880                     |                            | 6,270                     |                            | 6,830                     |                            |                                   |                    |
| 8                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 2,095                     | 2,095                      | 2,901                     | 2,901                      | 3,222                     | 3,222                      | 900                               | 10                 |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 3,185                     |                            | 4,409                     |                            | 4,898                     |                            |                                   |                    |
|                  | Q3 <sup>d</sup>   | 240 <sup>d,e</sup>        | 2,500                     | 250                        | 2,500                     | 250                        | 2,500                     | 250                        |                                   |                    |
| TOTAL            |                   |                           | 7,780                     |                            | 9,810                     |                            | 10,620                    |                            |                                   |                    |
| 9                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 2,619                     | 2,619                      | 3,626                     | 3,626                      | 4,030                     | 4,030                      | 900                               | 10                 |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 4,451                     |                            | 6,164                     |                            | 6,850                     |                            |                                   |                    |
|                  | Q3 <sup>d,f</sup> | 240 <sup>d,e</sup>        | 2,500                     | 250                        | 2,500                     | 250                        | 2,500                     | 250                        |                                   |                    |
| TOTAL            |                   |                           | 9,570                     |                            | 12,290                    |                            | 13,380                    |                            |                                   |                    |
| 10               | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 3,195                     | 3,195                      | 4,424                     | 4,424                      | 4,915                     | 4,915                      | 900                               | 10                 |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 6,069                     |                            | 8,405                     |                            | 9,338                     |                            |                                   |                    |
|                  | Q3 <sup>d</sup>   | 240 <sup>d,e</sup>        | 5,000                     | 500                        | 5,000                     | 500                        | 5,000                     | 500                        |                                   |                    |
| TOTAL            |                   |                           | 14,260                    |                            | 17,830                    |                            | 19,250                    |                            |                                   |                    |

<sup>a</sup>The minimum quantity is based on ISO qualified potassium bicarbonate. Powder can be substituted by a listed agent exceeding the performance of potassium bicarbonate.

<sup>b</sup>Quantity of water for foam production for initial control of the pool fire.

<sup>c</sup>Quantity of water for foam production to continue control or fully extinguish the pool fire.

<sup>d</sup>Water available for interior fire fighting.

<sup>e</sup>The 240-second requirement begins after arrival of the first ARFF apparatus.

<sup>f</sup>For multiple passenger deck aircraft within this category, the Q3 discharge capability should be increased to 375 gpm (1420 L/min) and required water increased to 3750 gal (14,195 L).

Table 5.3.1(b) Extinguishing Agents, Discharge, and Response Capability in SI Units

| Airport Category | Response Phases   | Response Capability (sec) | MIL-F-24385 and ICAO C |                              | ICAO B             |                              | ICAO A             |                              | Complementary Agents <sup>a</sup> |                    |
|------------------|-------------------|---------------------------|------------------------|------------------------------|--------------------|------------------------------|--------------------|------------------------------|-----------------------------------|--------------------|
|                  |                   |                           | Required Water (L)     | Discharge Capability (L/min) | Required Water (L) | Discharge Capability (L/min) | Required Water (L) | Discharge Capability (L/min) | Quantity (kg)                     | Discharge (kg/sec) |
| 1                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 450                    | 450                          | 600                | 600                          | 700                | 700                          | 45                                | 2.25               |
|                  | Q2 <sup>c</sup>   |                           | 0                      |                              | 0                  |                              | 0                  |                              |                                   |                    |
|                  | Q3 <sup>d</sup>   |                           | 0                      |                              | 0                  |                              | 0                  |                              |                                   |                    |
| TOTAL            |                   |                           | 450                    |                              | 600                |                              | 700                |                              |                                   |                    |
| 2                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 591                    | 591                          | 787                | 787                          | 906                | 906                          | 90                                | 2.25               |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 159                    |                              | 213                |                              | 244                |                              |                                   |                    |
|                  | Q3 <sup>d</sup>   |                           | 0                      |                              | 0                  |                              | 0                  |                              |                                   |                    |
| TOTAL            |                   |                           | 750                    |                              | 1,000              |                              | 1,150              |                              |                                   |                    |
| 3                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 1,077                  | 1,077                        | 1,500              | 1,500                        | 1,692              | 1,692                        | 135                               | 2.25               |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 323                    |                              | 450                |                              | 508                |                              |                                   |                    |
|                  | Q3 <sup>d</sup>   | 240 <sup>d,e</sup>        | 1,100                  | 110                          | 1,100              | 110                          | 1,100              | 110                          |                                   |                    |
| TOTAL            |                   |                           | 2,500                  |                              | 3,050              |                              | 3,300              |                              |                                   |                    |
| 4                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 1,772                  | 1,772                        | 2,468              | 2,468                        | 2,722              | 2,722                        | 135                               | 2.25               |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 1,028                  |                              | 1,432              |                              | 1,578              |                              |                                   |                    |
|                  | Q3 <sup>d</sup>   | 240 <sup>d,e</sup>        | 2,250                  | 225                          | 2,250              | 225                          | 2,250              | 225                          |                                   |                    |
| TOTAL            |                   |                           | 5,050                  |                              | 6,150              |                              | 6,550              |                              |                                   |                    |
| 5                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 3,257                  | 3,257                        | 4,514              | 4,514                        | 5,029              | 5,029                        | 205                               | 2.25               |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 2,443                  |                              | 3,386              |                              | 3,771              |                              |                                   |                    |
|                  | Q3 <sup>d</sup>   | 240 <sup>d,e</sup>        | 4,750                  | 475                          | 4,750              | 475                          | 4,750              | 475                          |                                   |                    |
| TOTAL            |                   |                           | 10,450                 |                              | 12,650             |                              | 13,550             |                              |                                   |                    |
| 6                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 4,700                  | 4,700                        | 6,525              | 6,525                        | 7,250              | 7,250                        | 205                               | 2.25               |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 4,700                  |                              | 6,525              |                              | 7,250              |                              |                                   |                    |
|                  | Q3 <sup>d</sup>   | 240 <sup>d,e</sup>        | 4,750                  | 475                          | 4,750              | 475                          | 4,750              | 475                          |                                   |                    |
| TOTAL            |                   |                           | 14,150                 |                              | 17,800             |                              | 19,250             |                              |                                   |                    |
| 7                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 5,983                  | 5,983                        | 8,297              | 8,297                        | 9,214              | 9,214                        | 205                               | 2.25               |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 7,717                  |                              | 10,703             |                              | 11,886             |                              |                                   |                    |
|                  | Q3 <sup>d</sup>   | 240 <sup>d,e</sup>        | 4,750                  | 475                          | 4,750              | 475                          | 4,750              | 475                          |                                   |                    |
| TOTAL            |                   |                           | 18,450                 |                              | 23,750             |                              | 25,850             |                              |                                   |                    |
| 8                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 7,937                  | 7,937                        | 10,992             | 10,992                       | 12,202             | 12,202                       | 410                               | 4.5                |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 12,063                 |                              | 16,708             |                              | 18,548             |                              |                                   |                    |
|                  | Q3 <sup>d</sup>   | 240 <sup>d,e</sup>        | 9,450                  | 945                          | 9,450              | 945                          | 9,450              | 945                          |                                   |                    |
| TOTAL            |                   |                           | 29,450                 |                              | 37,150             |                              | 40,200             |                              |                                   |                    |
| 9                | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 9,907                  | 9,907                        | 13,722             | 13,722                       | 15,259             | 15,259                       | 410                               | 4.5                |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 16,843                 |                              | 23,328             |                              | 25,941             |                              |                                   |                    |
|                  | Q3 <sup>d,f</sup> | 240 <sup>d,e</sup>        | 9,450                  | 945                          | 9,450              | 945                          | 9,450              | 945                          |                                   |                    |
| TOTAL            |                   |                           | 36,200                 |                              | 46,500             |                              | 50,650             |                              |                                   |                    |
| 10               | Q1 <sup>b</sup>   | 180 <sup>b</sup>          | 12,103                 | 12,103                       | 16,759             | 16,759                       | 18,603             | 18,603                       | 410                               | 4.5                |
|                  | Q2 <sup>c</sup>   | 210 <sup>c</sup>          | 22,997                 |                              | 31,841             |                              | 35,347             |                              |                                   |                    |
|                  | Q3 <sup>d</sup>   | 240 <sup>d,e</sup>        | 18,900                 | 1,890                        | 18,900             | 1,890                        | 18,900             | 1,890                        |                                   |                    |
| TOTAL            |                   |                           | 54,000                 |                              | 67,500             |                              | 72,850             |                              |                                   |                    |

<sup>a</sup>The minimum quantity is based on ISO qualified potassium bicarbonate. Powder can be substituted by a listed agent exceeding the performance of potassium bicarbonate.

<sup>b</sup>Quantity of water for foam production for initial control of the pool fire.

<sup>c</sup>Quantity of water for foam production to continue control or fully extinguish the pool fire.

<sup>d</sup>Water available for interior fire fighting.

<sup>e</sup>The 240-second requirement begins after arrival of the first ARFF apparatus.

<sup>f</sup>For multiple passenger deck aircraft within this category, the Q3 discharge capability should be increased to 375 gpm (1420 L/min) and required water increased to 3750 gal (14,195 L).

## Chapter 6 Aircraft Rescue and Fire-Fighting (ARFF) Vehicles

### 6.1 Rescue and Fire-Fighting Vehicles.

**6.1.1\*** The minimum number of ARFF vehicles provided at each airport shall be as specified in Table 6.1.1.

△ **Table 6.1.1 Minimum Number of ARFF Vehicles**

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

**6.1.2\*** Vehicles with sufficient collective capacities shall be constructed to comply with the provisions of NFPA 414 and Table 5.3.1(a) or Table 5.3.1(b).

**6.1.3** 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.

△ **6.1.4** All foam-producing ARFF vehicles shall be tested annually in accordance with NFPA 412.

**6.1.5** The equipment delivering the complementary extinguishing agent shall be tested annually, and the authority having jurisdiction shall determine the test procedure.

### 6.2\* Tools and Equipment.

**6.2.1** Tools and equipment to effectively support ARFF services shall be available at the incident or accident scene within the required response time.

## Chapter 7 Airport Emergency Communications

### 7.1 Communications and Alarms.

**7.1.1** Airport ARFF services communications shall have a capability that is consistent with the airport's operational needs.

**7.1.2** The operational communications system shall provide a primary and, where necessary, an alternate effective means for direct communication between the following, as applicable (*see Annex C*):

- (1) Alerting authority such as the air traffic control tower or flight service station, airport manager, fixed-base operator, or airline office and the airport ARFF service
- (2) Air traffic control tower or flight service station and ARFF vehicles en route to an aircraft emergency or at the accident or incident site
- (3) Fire department alarm room and ARFF vehicles at the accident or incident site
- (4) 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

- (5) ARFF vehicles
- (6) Responding vehicles and an aircraft in a situation of emergency using an established discreet VHF frequency

**7.1.3** 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 communications system.

**7.1.4** A preventive maintenance program shall be carried on to keep all communications equipment in a fully serviceable condition.

**7.1.5** The functional performance of all communications systems shall be tested at intervals not exceeding 24 hours.

## Chapter 8 ARFF Personnel, Protective Clothing, and Equipment

### 8.1 Personnel.

**8.1.1** A person shall be appointed to direct the airport ARFF services.

**8.1.1.1** 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.

**8.1.2\*** During flight operations and 15 minutes prior and 15 minutes following, ARFF personnel shall be readily available to staff the rescue and fire-fighting vehicles and to perform fire-fighting and rescue operations.

△ **8.1.2.1** Staffing levels shall be established through a task resource analysis based on the needs and demands of the airport, but shall not be lower than the values specified in Table 8.1.2.1 for the minimum total number of ARFF-trained personnel responding to an initial alarm, based on the minimum response times in Chapter 9 and extinguishing agent discharge rates and quantities required in Chapter 5.

**8.1.2.2** A task and resource analysis shall be performed to determine additional staffing requirements.

**8.1.2.2.1** This analysis shall be documented.

**8.1.2.2.2** Under no circumstances shall the minimum required staffing be less than those values appearing in Table 8.1.2.1. (*See Annex D.*)

△ **Table 8.1.2.1 Minimum Required ARFF Personnel at Airports**

| Airport Category | ARFF Personnel |
|------------------|----------------|
| 1                | 2              |
| 2                | 2              |
| 3                | 2              |
| 4                | 3              |
| 5                | 6              |
| 6                | 9              |
| 7                | 9              |
| 8                | 12             |
| 9                | 15             |
| 10               | 15             |

Note: See also Annex D.

**8.1.3** Responding units shall include personnel trained and equipped for cabin interior fire fighting.

**8.1.3.1** The responding units and personnel shall demonstrate the ability to apply extinguishing agent to the interior of the aircraft within 4 minutes of arrival at the accident/incident location.

**▲ 8.1.4** All ARFF personnel shall meet the requirements of NFPA 1003.

**▲ 8.1.4.1** All ARFF personnel shall undertake recurrent training meeting the requirements of NFPA 405. (*See Annex E.*)

**8.1.5** 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.

**8.1.6** Wherever possible, at international airports, the incident commander (IC) shall have a reasonable command of the English language to facilitate communication with the flight crew.

## **8.2 Protective Clothing.**

**8.2.1\*** 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.

**8.2.2\*** 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 IC or his or her representative.

## **Chapter 9 Airport Fire Station Location and Response Capability**

### **9.1 Siting and Response.**

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

**9.1.2\*** 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.

**9.1.2.1** Therefore, the location of the airport fire station shall be based on minimizing response time to aircraft accident and incidents.

#### **9.1.3\* Response Time.**

**9.1.3.1\*** The response time of the first-arriving ARFF vehicle to reach any point on the operational runway and begin agent application shall be within 3 minutes of the time of the alarm.

**9.1.3.2\*** The response time of the first-arriving ARFF vehicle to reach any point remaining within the on-airport portion of the RRA with improved surface conditions shall be within 4 minutes from the time of the alarm.

**N 9.1.3.3\*** The response time of the first-arriving ARFF vehicle to reach any passenger boarding areas with improved surface

conditions shall be within 4 minutes from the time of the alarm.

**▲ 9.1.3.4** All response times shall be in optimum visibility and surface conditions.

**9.1.3.5** Additional ARFF vehicles necessary to achieve the agent discharge rate shall arrive in accordance with the times specified in Table 5.3.1(a) or Table 5.3.1(b).

**9.1.4** Airport ARFF services shall develop/implement a plan for responding to an accident/incident involving any aircraft with passengers within the aircraft movement area beyond or outside the runway and RRA.

## **N Chapter 10 Special Events**

### **N 10.1\* Airport-Based Air Shows.**

**N 10.1.1** ARFF personnel shall be staged to respond immediately to any incident or accident.

**N 10.1.2\*** ARFF vehicles and crew shall be prepositioned during the period of the air show waiver in such a way that ARFF personnel can respond to an accident or incident and deploy fire-fighting agents within 60 seconds to anywhere within the aerobatic box in optimum conditions of visibility and surface conditions.

**N 10.1.3** During the period of the air show waiver, responding crew shall have personal protective equipment (PPE) donned and will be ready to respond.

**N 10.1.4** Vehicle engines shall be running throughout the entire active flying portion of the air show.

**N 10.1.5\*** ARFF vehicles assigned to an air show shall not be positioned behind the crowd line.

**N 10.1.5.1** Friends and family shall not be located in the area of ARFF vehicle positions.

**N 10.1.5.2** Folding chairs or any other obstructions shall not be positioned in front of prepositioned ARFF vehicles.

**N 10.1.6\*** Public air shows expected to include jet or turbine performances, or any air show in which the length of the aerobatic box exceeds 8,000 ft or the width of the aerobatic box exceeds 2,000 ft, ARFF vehicles and crash fire rescue (CFR) personnel shall be deployed to the right and left of the air show/open house crowd area with unimpeded access to the area in which air show flight operations are conducted.

**N 10.1.7\*** An ARFF vehicle shall be positioned at or near show center.

**N 10.1.7.1** All deployed vehicles shall be positioned so that they have an unobstructed line of sight on the whole airfield, specifically, the aerobatic box in which the majority of the air show flight operations are conducted.

**N 10.1.8** Prefire plans for specific aircraft shall be made available.

**N 10.1.8.1** A written or graphic illustration of the aerobatic box shall be presented to performers and emergency response personnel during the pre-air show safety briefing.

**N 10.1.8.2** In consultation with the air show operations officer and the air show air boss, fire fighters shall either participate in



a pre-event tabletop emergency response exercise or be available to conduct an emergency response drill on the practice/rehearsal day of the air show (typically a Friday for a Saturday/Sunday event).

**N 10.1.9** Hands on training, if available, shall be provided.

**N 10.1.9.1\*** Prior to the beginning of air show flight operations, at least one fire fighter from each ARFF vehicle deployed in support of the show shall make themselves available to meet with the pilot-in-command of each aircraft participating in the air show or open house to discuss emergency extraction, canopy release, fuel shutoff, master switch on/off switch and aircraft lift points.

**N 10.1.10\*** Prior to the air show and not later than the first safety briefing on the rehearsal or practice day of the air show (typically Friday at most shows), fire fighters shall meet with the air show operations officer, the air show air boss, and appropriate air traffic control personnel to discuss procedures and methods to establish the standard radio communications and runway/taxiway clearances required for ARFF personnel to respond to an incident or accident during the air show.

**N 10.1.11** To ensure clear lines of communications, the incident commander shall consider positioning himself or herself or a liaison with the air boss throughout the air show.

#### Annex A Explanatory Material

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

**A.3.2.1 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.3.2.2 Authority Having Jurisdiction (AHJ).** The phrase “authority having jurisdiction,” or its acronym AHJ, 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.

**N A.3.3.1 Aerobic Box.** The aerobic box is the area in which air show flight operations are conducted. The boundaries, dimensions, and parameters of the aerobic box are clearly and specifically defined as part of the application that air show organizers submit to the AHJ to receive authorization to conduct an air show.

**A.3.3.6 Aircraft Fire Fighting.** Aircraft fire fighting does not include the control or extinguishment of airborne fires in aircraft.

**A.3.3.7 Aircraft Incident.** An incident does not result in serious injury to persons or substantial damage to the aircraft.

**A.3.3.8 Aircraft Rescue.** 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.

**A.3.3.13.3 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 9.1.3. (See Figure A.3.3.13.3.)

**A.3.3.17.1 Aqueous Film-Forming Foam Concentrate (AFFF).** The foam formed acts as a barrier both to exclude air or oxygen and to develop an aqueous film on the fuel surface that is capable of suppressing the evolution of fuel vapors. The foam produced with AFFF concentrate is dry chemical compatible and thus is suitable for combined use with dry chemicals. [11, 2016]

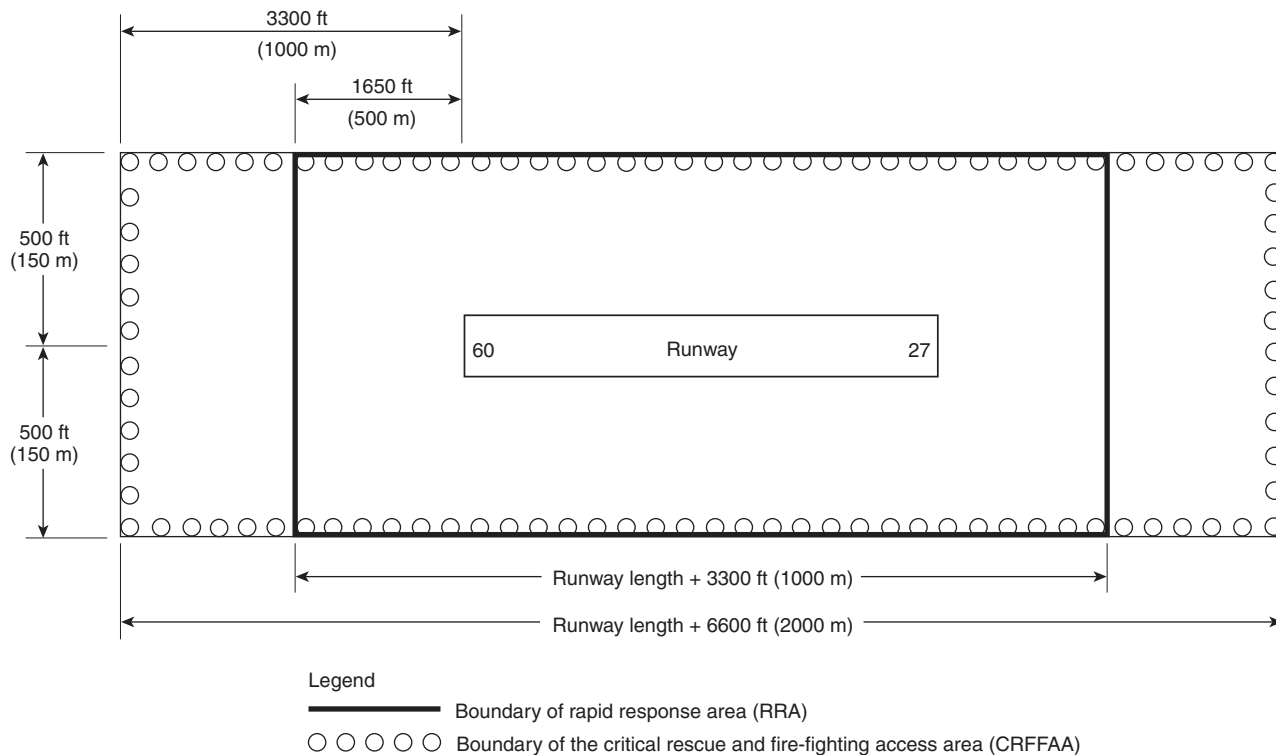
**A.3.3.17.2 Film-Forming Fluoroprotein Foam Concentrate (FFFP).** In addition to an air-excluding foam blanket, this concentrate also can deposit a vaporization-preventing film on the surface of a liquid fuel. It is diluted with water to form 3 percent to 6 percent solutions depending on the type. This concentrate is compatible with certain dry chemicals. [11, 2016]

**A.3.3.17.4 Fluoroprotein Foam Concentrate.** This type of foam utilizes a protein base plus stabilizing additives and inhibitors to protect against freezing, corrosion, and bacterial decomposition, and it also resists fuel pickup. The foam is usually diluted with water to form a 3 percent or 6 percent solution and is dry chemical compatible. [11, 2016]

**A.3.3.17.5 Protein Foam Concentrate.** These concentrates are diluted with water to form 3 percent to 6 percent solutions depending on the type. They are compatible with certain dry chemicals. [11, 2016]

**A.3.3.18 Foam Concentrate.** For the purpose of this document, “foam concentrate” and “concentrate” are used interchangeably. [11, 2016]

**A.4.2** The risk management plan should be based on an offensive and defensive policy. Strategic decisions establish the basic positioning of resources and the types of functions they will be assigned to perform at the scene of a fire or emergency incident. The level of risk to which members are exposed is driven by the strategy; offensive strategy places members in interior positions where they are likely to have direct contact with the fire, while defensive strategy removes members from interior positions and high-risk activities. The attack plan is based on



**FIGURE A.3.3.13.3 Response and Access Areas.**

the overall strategy and drives the tactical assignments that are given to individual or groups of companies/crews and the specific functions they are expected to perform. Risk identification, evaluation, and management concepts should be incorporated into each stage of the command process.

**A.4.4.2.2** Information on airport/community emergency plans and full-scale exercises is provided in NFPA 424.

**A.4.3.2** See Table A.4.3.2, which shows aircraft types and their measurements by category.

**A.5.1.1** 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.

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.

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.

**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.

Table A.4.3.2 Aircraft Data

| Aircraft<br>Type                           | Width  |       | Length |       |
|--------------------------------------------|--------|-------|--------|-------|
|                                            | ft     | m     | ft     | m     |
| Aerospatiale–British<br>Aerospace Concorde | 83.67  | 25.50 | 203.67 | 62.08 |
| Airbus                                     |        |       |        |       |
| A-318                                      | 111.87 | 34.10 | 103.10 | 31.44 |
| A-319                                      | 111.87 | 34.10 | 111.0  | 33.84 |
| A-300                                      | 147.08 | 44.83 | 177.3  | 54.05 |
| A-310                                      | 144    | 43.89 | 153.1  | 46.66 |
| A-320                                      | 111.25 | 33.91 | 123.3  | 37.57 |
| A-321                                      | 111.25 | 34.10 | 146    | 44.51 |
| A-330-200                                  | 197.83 | 60.30 | 192.9  | 58.82 |
| A-330-300                                  | 197.83 | 60.30 | 208.9  | 63.69 |
| A-340-300                                  | 197.83 | 60.30 | 208.9  | 63.69 |
| A-340-500                                  | 208.16 | 63.45 | 222.8  | 67.93 |
| A-340-600                                  | 208.16 | 63.45 | 247.2  | 75.36 |
| A-350-800                                  | 212.43 | 64.75 | 198.6  | 60.54 |
| A-350-900                                  | 212.43 | 64.75 | 219.4  | 66.89 |
| A-350-1000                                 | 211.61 | 64.50 | 242.3  | 73.88 |
| A-380                                      | 261.64 | 79.75 | 238.58 | 72.72 |
| Antonow An-22                              | 211    | 64.31 | 167    | 50.90 |
| Antonow An-225                             | 290    | 88.39 | 275.58 | 84.00 |
| ATR 72                                     | 88.58  | 27.00 | 89.08  | 27.15 |
| Beechcraft 1900                            | 54.5   | 16.61 | 57.83  | 17.63 |
| Beechcraft King Air 350                    | 57.92  | 17.65 | 46.67  | 14.23 |
| Boeing 727                                 | 108    | 32.92 | 153.17 | 46.69 |
| Boeing 737-300                             | 94.67  | 28.86 | 119.5  | 36.42 |
| Boeing 737-600                             | 112.7  | 34.30 | 102.6  | 31.20 |
| Boeing 737-700                             | 112.7  | 34.30 | 110.4  | 33.60 |
| Boeing 737-800                             | 112.7  | 34.30 | 129.6  | 39.50 |
| Boeing 737-900 ER                          | 112.7  | 34.30 | 138.2  | 42.10 |
| Boeing 747-400                             | 211    | 64.31 | 231.75 | 70.64 |
| Boeing 757                                 | 124.67 | 38.00 | 155.25 | 47.32 |
| Boeing 767-200 ER                          | 156.1  | 47.60 | 159.2  | 48.50 |
| Boeing 767-300 ER                          | 156.08 | 47.57 | 180.25 | 54.94 |
| Boeing 767-400 ER                          | 170.4  | 51.90 | 201.40 | 61.30 |
| Boeing 777-200                             | 199.11 | 60.90 | 209.1  | 63.70 |
| Boeing 777-300                             | 199.11 | 60.90 | 242.4  | 73.90 |
| Boeing 787-8                               | 197    | 60.00 | 186    | 57.00 |
| Boeing 787-9                               | 197    | 60.00 | 206    | 63.00 |
| Boeing DC 10-40                            | 165.25 | 50.37 | 180.5  | 55.02 |
| Boeing MD-11                               | 169.25 | 51.59 | 200.67 | 61.16 |
| Boeing MD-88                               | 107.67 | 32.82 | 147.75 | 45.03 |
| Casa CN-235                                | 84.5   | 25.76 | 70     | 21.34 |
| Cessna Citation 5                          | 53.42  | 16.28 | 48.67  | 14.83 |
| DeHavilland Dash 5                         | 85     | 25.91 | 73     | 22.25 |
| Grumman Gulfstream 4                       | 77.67  | 23.67 | 88.25  | 26.90 |
| Ilyushin IL-86                             | 158.5  | 48.31 | 191.75 | 58.45 |
| Lockheed L-1011-500                        | 164.25 | 50.06 | 164.17 | 50.04 |
| Short 360                                  | 74.83  | 22.81 | 70.83  | 21.59 |
| Tupolev Tu-154                             | 123.17 | 37.54 | 157.17 | 47.91 |

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

**A.5.1.2** Acceptable standards for foam concentrates vary from country to country. In the U.S., the AHJ is the U.S. FAA, which requires foam concentrates be aqueous film-forming foam agents meeting all of the criteria of the U.S. Military Specification MIL-F-24835, *Fire Extinguishing Agent, Aqueous Film-Forming Foam (AFFF), Liquid Concentrate, for Fresh and Sea Water*. Freshwater or seawater can be used for the fire test. Concentrates that successfully pass this testing appear on the Qualified Products List (QPL-24385-28). This U.S. military specification standard contains a variety of physical property requirements that allow these concentrates to be interchangeable and still function properly if the proportioning system is not operating at the proper rate. This is in comparison to ICAO requirements, which do not require a specific surfactant type. Foam concentrates that have passed the ICAO Level A, B, or C performance tests will have varying viscosities affecting proportioning and nozzle type (aspirating or nonaspirating) and are not considered interchangeable. The ICAO and U.S. military specification standards contain performance tests that are specific to the requirements for airport hazards, and concentrates should be tested by an authorized body to conduct and certify compliance. Certification documentation from the foam concentrate manufacturer should be made available to the AHJ. NFPA 412 contains additional foam quality and drainage time requirements along with the test methods for these properties.

**A.5.2(1)** A number of chemical compounds are 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.5.2(2)** 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).

Extinguishing mechanisms vary for halogenated extinguishing agents. The primary extinguishing mechanism for Halon 1211 acted by chemically interrupting the continuing combination of the fuel radicals with oxygen in the flame chain reactions. This process is known as *chain breaking*. Halogenated agents that have replaced Halon 1211 primarily act by increasing the heat capacity of the air within the fire zone. This results in a cooling of the fire by removing heat that the reaction needs to sustain the flame.

The discharge of halogenated agents can create hazards to personnel such as dizziness, impaired coordination, reduced visibility, and exposure to toxic decomposition products. In any proposed use of halogenated agents where there is a possibility that people might 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.

Halogenated agents leave no agent residue and are the preferred agent for aircraft tire fires, engine fires, interior aircraft fires, electrical component fires, and flightline vehicle or equipment engine fires. Due to its ozone-depleting properties, production of new Halon 1211 stopped in 1994 and discharge of agent for training was no longer allowed. In June 1995, the FAA certified HCFC Blend B as an acceptable alternate agent to Halon 1211 for ARFF, FAA Cert-Alert 95-03. Like Halon 1211, HCFC Blend B is a clean extinguishing agent effective on Class A, B, and C hazards. It does not leave a residue after application, and therefore minimal or no collateral damage occurs from the agent itself to equipment and other assets in the area where it is employed.

**A.5.3.3** Fire-fighting vehicles meeting the requirements of 5.3.2 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 can 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.5.4** 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.

**A.5.5** 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 types of 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.6.1.1** 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.6.1.2** 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. 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 ARFF 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 practical critical area (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, and combating fires in aircraft interiors. For these reasons, turrets are needed to rapidly knock down 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 ARFF 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. Secondhand vehicles might have been subjected to abusive service, components might 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.

Specialized vehicles might be needed to allow fire fighters to safely reach elevations that are above the efficient range of ground ladders and the normal range of ARFF vehicles. Fire fighters should have the ability to access any level of the aircraft to effectively perform their mission with an aircraft interior access vehicle as described in Chapter 5, Aircraft Interior Access Vehicle, of NFPA 414.

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.

At least one elevated boom and where specified, a cabin skin penetration device, should be provided at airports of Category 6 through 9; Category 10 should have two.

▲ **A.6.2** A comprehensive and up-to-date list of tools is provided in NFPA 414. Consideration should be given to the addition of a vehicle termed as a *rescue truck* for the purpose of carrying a wide range of rescue equipment suited for conditions and aircraft utilizing the Category 7 or larger airports.

**A.8.1.2** The personnel required for the initial alarm is based on the information in Table A.8.1.2.

▲ **A.8.2.1** Personal protective clothing and equipment should meet the requirements of NFPA 1981 and NFPA 1975.

**Table A.8.1.2 ARFF Personnel Based on Airport Category**

| Airport Category | ARFF Personnel                                                                                                                                                                                           |
|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1–3              | 2 ARFF trained personnel                                                                                                                                                                                 |
| 4                | 3 ARFF trained personnel including an Incident Commander                                                                                                                                                 |
| 5                | 6 ARFF personnel including an IC and 2 trained personnel for rapid intervention                                                                                                                          |
| 6–10             | The minimum total number of trained personnel responding should be based on the equivalent of 3 per ARFF vehicle. Additionally, an IC and 2 trained personnel for rapid intervention should be provided. |

Canadian references for personal protective equipment are as follows:

- (1) Fire fighter protective clothing: CAN/CGSB-155-1, *Fire-fighters' Protective Clothing for Protection Against Heat and Flame*, April 1998
- (2) Fire fighter protective boots: CAN/BNQ 1923-410, *Fire Fighting — Protective Helmets*

U.K. references for personal protective equipment are as follows:

- (1) Helmets for fire fighting in buildings and other structures with full-face visor: EN 443 (2008), *Helmets for fire fighting in buildings and other structures*
- (2) Tunic/overtrousers (i.e., turnout gear): EN 469, *Protective clothing for firefighters. Performance requirements for protective clothing for firefighting* (2014)
- (3) Gloves: EN 659, *Protective gloves for firefighters* (2003)
- (4) Footwear (i.e., safety footwear): EN ISO 20345: *Personal protective equipment. Safety footwear*, (including footwear for fire fighters)
- (5) Conspicuous clothing: EN ISO 20471, *High-visibility warning clothing — Test methods and requirements*, (2013)
- (6) Flash hoods: EN 13911, *Protective clothing for firefighters*, (2004)

Guidance and proximity of protective clothing can be found in FAA Advisory Circular 150/5210-14B, *Airport Rescue Firefighting Equipment, Tools, and Clothing*.

Fire entry suits are not recommended for civil airport application. Rapid fire control afforded by present fire-fighting equipment and short times for survival without fire control make the fire entry suit unnecessary and inappropriate.

**A.8.2.2** 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 components, 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 ARFF personnel who enter or operate in the vicinity of an aircraft during the fire sequence be equipped with self-contained breathing equipment. Helmets or hoods should be designed to accommodate the SCBA facepiece without interference; most existing proximity hoods do not have this provision.

**A.9.1.1** Factors that influence response time include the following:

- (1) Means of notification of the ARFF force
- (2) Completeness of the information in the activation message
- (3) Location of the fire station
- (4) Acceleration, top speed, on-road handling, and off-road mobility characteristics of the vehicles
- (5) Degree of preparatory training
- (6) Provision of emergency access roads
- (7) Climatic conditions
- (8) ARFF personnel expeditious response to vehicles in the fire station
- (9) 45 and 90 degree turns

Fire house garage doors should be wide enough to provide adequate clearance to permit drivers to easily back into the garage without damaging either the vehicle or the garage.

The minimum size of the firehouse garage door(s) for a major fire-fighting vehicle should be at least 18 ft (5.5 m) wide by 18 ft (5.5 m) high.

**A.9.1.2** The geographical center of an airport might not be the best location for siting the airport fire station. Locating the airport fire station for structural fire-fighting utility should be of secondary importance. Before selecting the actual location, time trials should be run to determine the optimum location that would ensure 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 ensure proper selection of the fire station site. [See Figure A.9.1.2(a) and Figure A.9.1.2(b).]

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

Airport fire stations located close to taxiways and runways or adjacent to flight patterns should have soundproof training rooms, living quarters, and an alarm room. The high noise level of turbine engines can cause damage to hearing; accordingly, 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 might be necessary to supplement audible signals with visual signals, such as flashing lights, to alert fire fighters.

Where airport response plans call for response outside the airport fences, suitable exits should be provided around the

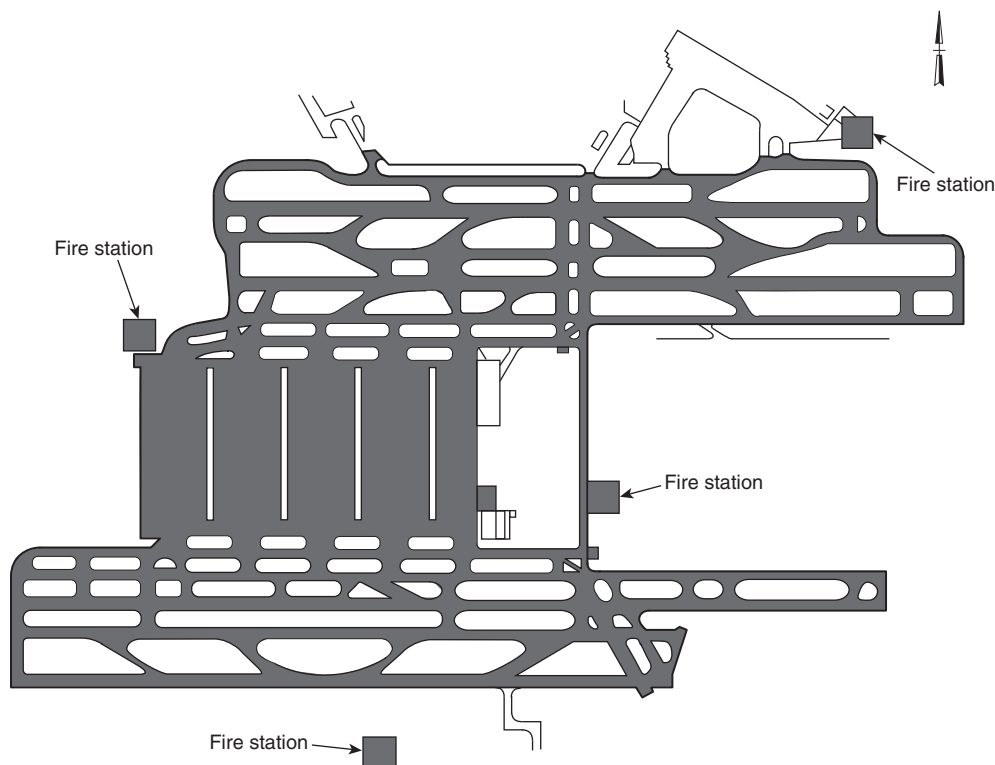
perimeter of the airport for ARFF vehicles. Particular attention should be given to the provision of ready access to the rapid response area (RRA) and critical rescue and fire-fighting access area (CRFFAA). The CRFFAA is the rectangular area surrounding any given runway. Its width extends 500 ft (150 m) outward from each side of the runway centerline, and its length is 3300 ft (1000 m) beyond each runway end. This is the area where accidents historically have occurred. [See Figure A.9.1.2(b).]

**A.9.1.3** Two or more airport fire stations should be strategically located on the airport where a centrally located fire station cannot meet the response criteria given in 9.1.3.

When creating the response roadways from the firehouse to the incident area(s), the airport designer should consider the information in Table A.9.1.3(a) and Table A.9.1.3(b) when sizing the radius of curves. ARFF vehicles accelerate much faster than over-the-road vehicles and are very capable of obtaining higher speeds in a very short distance. The total response time from the time of alarm to the time ARFF vehicles arrive on scene and begin agent application is the cumulative time for notification, reflex time for ARFF personnel to don protective clothing and start ARFF vehicles, and the actual travel time to the accident/incident location.

**N A.9.1.3.1** The operational objective of the first-responding ARFF vehicle should be to reach any point on the operational runway and begin agent application within 2 minutes of the time of the alarm, in optimum visibility and surface conditions.

**N A.9.1.3.2** The operational objective of the first-arriving ARFF vehicle to reach any point remaining within the on-airport portion of the RRA should be within 3 minutes from the time of the alarm, in optimum visibility and surface conditions.



**FIGURE A.9.1.2(a) Example of Category 9 Airport Fire Station Locations.**





agent to protect the aircraft fuselage, control the fire endangering escaping occupants, establish a safe area for continued operations, perform final extinguishment, and prevent re-ignition.

**B.2 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 March 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 RFFP-I report documents five proposed means of defining the width of the critical area.

It was finally agreed that no single system 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 100 ft (30 m) and should be 100 ft (30 m) for aircraft with wing spans of 100 ft (30 m) or more. A standard fuselage width of 20 ft (6 m) 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:

- (1) The quantity of agent necessary to control or cover the fire area could be relatively accurately determined.
- (2) 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 covered in B.2.1.

**B.2.1 Theoretical Critical Area (TCA) — Definition.** 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 TCA should be a rectangle having as one dimension the overall length of the aircraft, and the other dimension determined by the following:

- (1) For aircraft with an overall length of less than 65 ft (20 m): 40 ft (12 m) plus the width of the fuselage
- (2) For aircraft with an overall length of 65 ft (20 m) or more: 100 ft (30 m) plus the width of the fuselage (Harley 1972, p. 3-1f)

The TCA serves only as a means for categorizing aircraft in terms of the magnitude of the potential fire hazard in which they might 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):

[B.2.1a]

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

or

[B.2.1b]

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

$$A_T = L \times (12 + w) \text{ where } L > 20 \text{ m}$$

or

[B.2.1c]

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

where:

$A_T$  = theoretical critical area (TCA)

$L$  = overall length of the aircraft

$w$  = width of the aircraft fuselage

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 ARFF 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 findings, the Panel decided to use two-thirds of the TCA as the PCA (Harley 1972, p. 3-3). (See Figure B.2.1 for a graphic display of this concept.) The formula for the PCA developed by RFFP-II for fixed-wing aircraft can be expressed as follows:

[B.2.1d]

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

**B.3 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:

- (1) *Control time:* 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.
- (2) *Extinguishment time:* 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

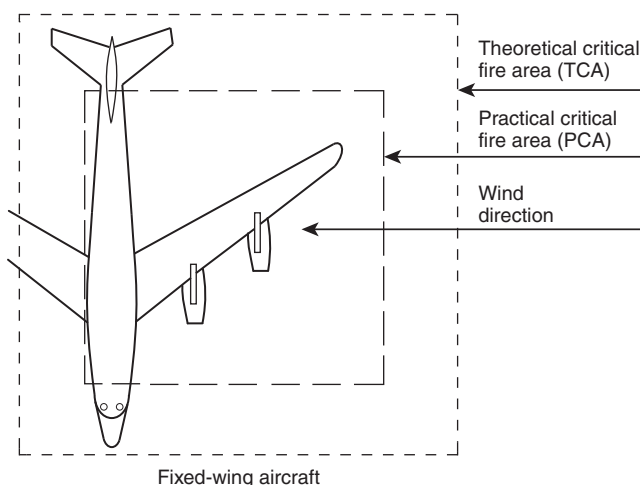


FIGURE B.2.1 Theoretical Critical Fire Area (TCA) Relative to Practical Critical Fire Area (PCA).

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).

**B.4 Discharge Time.** 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 preventing 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 0.2 U.S. gpm/ft<sup>2</sup> (8.2 L/min/m<sup>2</sup>) 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<sub>2</sub>, or a halocarbon), a reduced application rate could be used. A minimum of 0.15 U.S. gpm/ft<sup>2</sup> (6.1 L/min/m<sup>2</sup>) 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 0.13 U.S. gpm/ft<sup>2</sup> (5.3 L/min/m<sup>2</sup>) 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).

**B.5 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 2 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 in B.5.1 and B.5.2.

**B.5.1 Quantity  $Q_1$  — Definition.** 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 follows:

$$Q_1 = \text{PCA} \times R \times T \quad [\text{B.5.1}]$$

where:

PCA = practical critical area

R = rate of application for the specific foam

T = time of application

**B.5.2 Quantity  $Q_2$  — Definition.** 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:

- (1) Maximum gross weight
- (2) Maximum passenger capacity
- (3) Maximum fuel load
- (4) 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).

**B.6 Application Rates and Amounts.** The basic concepts developed by the ICAO RFFPs are still considered valid. However, the variables previously mentioned that are used to develop the  $f$  factor for  $Q_2$  have been refined over time and are now expressed as follows:

- (1) *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 fire free (controlled or extinguished).
- (2) *Relative Effectiveness of Agent Selected.* This variable is accounted for by the specific application rate identified for each of the common generic foam concentrate types.
- (3) *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 indicate that 1 minute is both a reasonable and a necessary operational objective.
- (4) *Time Required to Maintain the Controlled Area Fire Free or to Extinguish the Fire.* This time is 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 has permitted specifying the required application rates for three generic foam

types needed to extinguish fire in 1 ft<sup>2</sup> or 1 m<sup>2</sup> of the PCA as follows:

- (1) AFFF = 0.13 gpm/ft<sup>2</sup> or 5.5 L/min/m<sup>2</sup>
- (2) FP = 0.18 gpm/ft<sup>2</sup> or 7.5 L/min/m<sup>2</sup>
- (3) PF = 0.20 gpm/ft<sup>2</sup> or 8.2 L/min/m<sup>2</sup>

These application rates were based primarily on full-scale studies conducted by Geyer (1972) using both high volatility JP4 fuel and lower volatility fuel such as JP5 and Jet A. Over the years, NFPA 403 expanded the use of the FP application rate to other surfactants, such as FFFP and FFSF foams, which could meet ICAO B level foam tests. The fourth edition, 2014 of the *ICAO Airport Services Manual, Part 1, Rescue and Fire Fighting*, introduced a more difficult performance test — Level C. The intent of the new ICAO Level C foam performance test was an attempt to match test parameters to those in MIL-F-24835, *Fire Extinguishing Agent, Aqueous Film-Forming Foam (AFFF), Liquid Concentrate, for Fresh and Sea Water*, while keeping the test in line with the ICAO Level A and B test procedures. During the development process, under sponsorship from the CAA, 27 foams from eight manufacturers were tested by CNPP (CNPP-Vernon, 2008). The result is a test that is rigorous, but in certain aspects does not quite match to the performance of the Mil-Spec foams, which are required to contain film-forming fluorinated surfactants. Fire test differences relate to pan size, fuel (gasoline versus Jet A), manual versus fixed foam application, and the allowance of 99 percent control versus full extinguishment at 1 minute. However, it has been shown that few foams have the ability to pass ICAO C, reflecting the difficulty of this test procedure. There has been limited full-scale testing of ICAO C foams, but tests to date have reflected extinguishments on Jet A within 1 minute at the ICAO application rate of 0.092 gpm/ft<sup>2</sup> (3.75 L/min/m<sup>2</sup>). The 0.13 gpm/ft<sup>2</sup> (5.5 L/min/m<sup>2</sup>) application rate requirement for AFFF meeting Mil-Spec in NFPA 403 is 40 percent higher. ICAO Level C foams will have a safety margin when used at the 0.13 gpm/ft<sup>2</sup> (5.5 L/min/m<sup>2</sup>) application rate. It was concluded, for purposes of this standard, that ICAO Level C foam application rates could be set as equivalent to Mil-Spec foam.

When considering the ICAO C foams, the committee also considered the classification designations used in NFPA 403 for application rates. Historically, these related to the constituents of the foam, (e.g., protein fluoroprotein, and fluorinated surfactants) used in AFFF. There was a desire by the committee to eliminate the designation of foams by constituents, and use a performance-based approach. The ICAO Levels A, B, and C provide such an approach. Foams are evaluated based on fire performance, not physical or chemical attributes. This allows future modifications of foam formulations (e.g., for environmental improvement) without changing the fire performance criteria.

It was recognized that there are some limitations to this approach that users of ICAO C should be aware of. The intent of the MIL-F-24835 standard is to create AFFF foam concentrates that have similar physical properties and will be interchangeable between various manufacturers. The Mil-Spec also requires fire performance tests of the foam concentrate proportioned incorrectly, either too low or too high. It is noted that the ICAO tests are primarily fire performance tests and foams between manufacturers are not considered interchangeable. There are no requirements for testing of incorrectly proportioned foam. Airports adopting ICAO foam concentrates should evaluate equipment requirements any time a



switch to a new manufacturer of foam concentrates is considered.

Therefore, starting with the 2018 edition of NFPA 403, the following application rates by test standard are used:

- (1) MIL-F-24835 and ICAO Level C = 0.13 gpm/ft<sup>2</sup> or 5.5 L/min/m<sup>2</sup>
- (2) ICAO Level B = 0.18 gpm/ft<sup>2</sup> or 7.5 L/min/m<sup>2</sup>
- (3) ICAO Level A = 0.20 gpm/ft<sup>2</sup> or 8.2 L/min/m<sup>2</sup>

UL 162, *Standard for Foam Equipment and Liquid Concentrates* and EN 1568, *Specification for Low Expansion Foam Concentrates for Surface Application to Water-Immiscible Liquids*, have been recognized in past revisions of NFPA 403. In the move toward classification by performance testing, these referenced test standards were deleted since they were not developed with a focus of aircraft rescue and fire-fighting applications.

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, because  $Q_2$  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  $Q_3$  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:

[B.6]

$$Q = Q_1 + Q_2 + Q_3$$

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 B.6.)

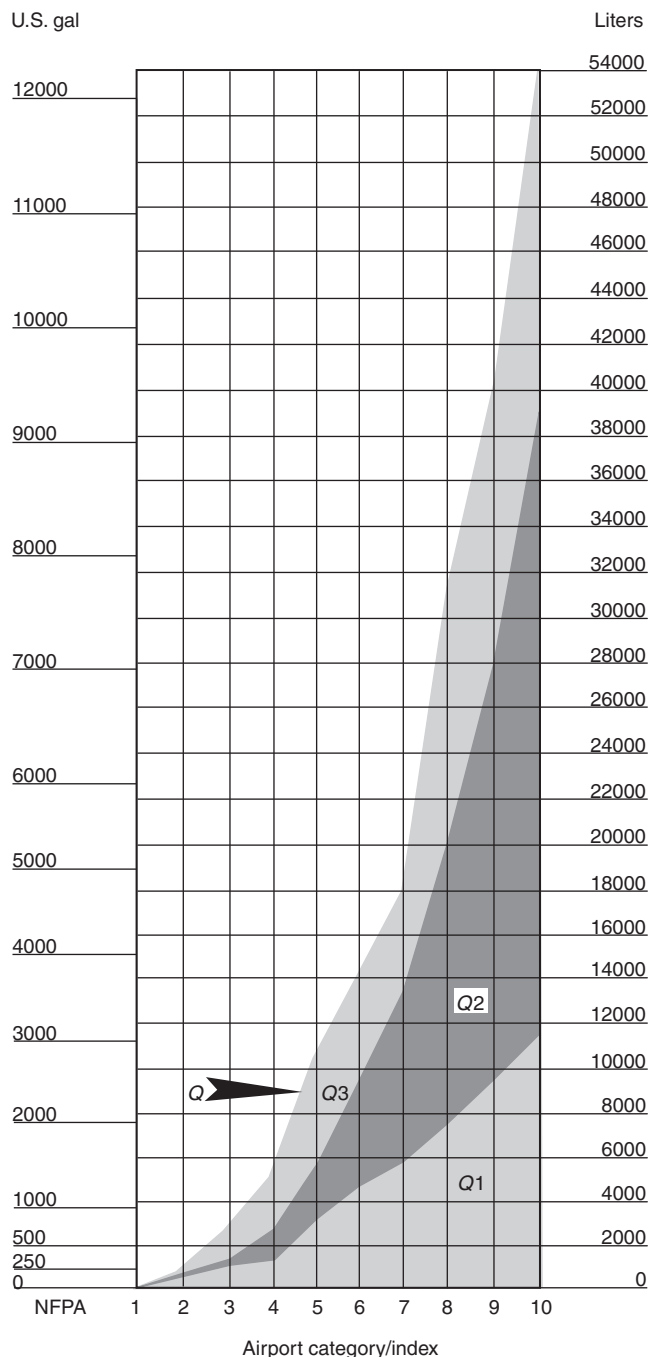


FIGURE B.6 Comparison of Water by Volume of  $Q_1$ ,  $Q_2$ ,  $Q_3$ , and  $Q$  for Producing Foam Solution Using AFFF.



**B.6.1** The method for calculating the values for each component of  $Q$  is presented here:

$$Q_1 = PCA \times R \times T \quad [\text{B.6.1}]$$

where:

$PCA = (0.67) \times TCA$ ,  $TCA = L \times (K + W)$ , and

$L$  = length of aircraft

$W$  = width of fuselage

$R$  = application rate of selected agent

$T$  = time of application (1 minute)

$K$  = values shown in Table B.6.1

(See Table B.6.1.)

**Δ B.6.2** The current values of  $Q_2$  as a percentage of  $Q$  have been determined to be as shown in Table B.6.2.

**B.6.3** 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 shown in Table B.6.3.

In December 2000, ICAO RFFP-9 met. It was agreed that to accomplish a timely interior fire suppression, all necessary equipment and personnel should be in place and the suppression activity should be in action within 5 minutes of notification of the accident event. This requirement places a premium on the need to have sufficient personnel and equipment to perform this task in the first responders group.

**Table B.6.1 K Factors**

| Feet   |                                                                                                                                                                   |
|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $K$    | = 39 where $L$ = less than 39<br>= 46 where $L$ = 39 up to but not including 59<br>= 56 where $L$ = 59 up to but not including 78<br>= 98 where $L$ = 78 and over |
| Meters |                                                                                                                                                                   |
| $K$    | = 12 where $L$ = less than 12<br>= 14 where $L$ = 12 up to but not including 18<br>= 17 where $L$ = 18 up to but not including 24<br>= 30 where $L$ = 24 and over |

**Δ Table B.6.2  $Q_2$  as a Percent of  $Q_1$**

| 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           |

**Δ Table B.6.3 Quantity of Water for Handlines**

| Airport Category | $Q_3$ Equals (U.S. gal)            |
|------------------|------------------------------------|
| 1                | 0                                  |
| 2                | 0                                  |
| 3                | 60 gpm $\times$ 5 min = 300 gal    |
| 4                | 60 gpm $\times$ 10 min = 600 gal   |
| 5                | 125 gpm $\times$ 10 min = 1250 gal |
| 6                | 125 gpm $\times$ 10 min = 1250 gal |
| 7                | 125 gpm $\times$ 10 min = 1250 gal |
| 8                | 250 gpm $\times$ 10 min = 2500 gal |
| 9                | 250 gpm $\times$ 10 min = 2500 gal |
| 10               | 500 gpm $\times$ 10 min = 5000 gal |

**B.6.4 Sample Calculation Using Airport Category 4 and AFFF Foam.**

$$TCA = L \times (K + W)$$

$$= 77.8 \times (56 + 12.9) = 5360 \text{ ft}^2$$

$$PCA = \frac{2}{3} \times TCA = \frac{2}{3} \times 5360 \text{ ft}^2 = 3573 \text{ ft}^2$$

$$Q_1 = 0.13 \text{ gpm/ft}^2 \times 3573 \text{ ft}^2 \times 1 = 464 \text{ gal}$$

$$Q_2 = 58\% \times Q_1 = 0.58 \times 464 = 269 \text{ gal}$$

$$Q_3 = 600 \text{ gal}$$

now

$$Q = Q_1 + Q_2 + Q_3$$

$$= 464 + 269 + 600 = 1333 \text{ gal}$$

rounded up to 1340 gal

This quantity is shown in Table 5.3.1(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.

**B.7 Updated Review of TCA/PCA.** A recent pair of studies performed by the U.S. Federal Aviation Administration (FAA) demonstrated that the PCA/TCA concept is still valid. The reports are: *A Technical Review of Methodologies for Calculating Fire-fighting Agent Quantities Needed to Combat Aircraft Crash Fires*, DOT/FAA/AR/11-29, U.S. Department of Transportation, Federal Aviation Administration, April 2012; and *Analysis of Suppression Effects on Aviation Fuel Fires Around an Aircraft*, Final Report, DOT/FAA/AR-11-27, U.S. Department of Transportation, Federal Aviation Administration, November 2011. These analyses addressed various factors in assessing current ARFF agent requirements. These factors included the historical development of the existing methods and the recent fire-related loss history. The recent loss history includes the effectiveness of the ARFF response. A fire hazard analysis was performed for threats to occupants in an aircraft and those who have escaped the aircraft. The NFPA 403 methodology was found to be acceptable and appropriate for establishing agent quantities.

### Annex C Operational Communications System

*This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.*

**C.1** 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 (ARFF) personnel, and the alerting/dispatching 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 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:

- (1) Control tower, flight service station, or other control point
- (2) Rescue and fire fighting

- (3) Airport police
- (4) Airport management
- (5) Airline station manager(s), as appropriate
- (6) Military units (joint-use airports)
- (7) 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 might 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, such as location of accident or incident site, type of aircraft, number of persons involved, aircraft fuel load, and 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 ARFF 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 ARFF 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 ARFF vehicles should be equipped to communicate on a frequency common with the control point.

Where practicable, the two-way radio capability on the ARFF 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 (OSCs) 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.

Additionally, direct communications can be established between the flight deck and the incident commander (IC) or ARFF personnel by use of the discrete emergency frequencies (DEF) and deck to ground lines. Normally this communication capability results from the use of a flight service headset that is plugged into a wheel well or nose interphone jack (this can be coded red on some aircraft).

The ARFF 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.

#### Annex D Task and Resource Analysis Model

*This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.*

**D.1 General.** The most appropriate approach to accurately determine the necessary levels of staffing in airports was developed by reviewing and combining several task analysis methodologies from airport regulators and fire departments. The recommended Task and Resource Analysis model for this approach is described in this annex.

**D.2 Scope.** This annex describes the stages that must be followed by an airport operator in performing a Task and Resource Analysis in order to justify the minimum number of qualified personnel required for an airport rescue and fire-fighting service (ARFF) to respond effectively to an aircraft incident/accident. If an airport operator requires the ARFF to attend to structural incidents/accidents in addition to aircraft incidents/accidents, the possibility of being unable to meet required response times must be considered.

**D.3 Purpose.** The Task and Resource Analysis uses a risk-based approach and focuses on possible worst-case scenarios. This allows it to identify the minimum number of personnel required to perform identified tasks in real time before external services are needed at the incident/accident site to effectively support the ARFF services.

The Task and Resource Analysis also should include the types of aircraft using the aerodrome and the need for personnel to use breathing apparatus, handlines, ladders, and other ARFF equipment provided at the aerodrome.

**D.4 Preliminary Information.** The airport operator should first establish the minimum number of ARFF vehicles required for delivering the extinguishing agents at the required discharge rate for the specified airport category.

**D.5 Task and Resource Analysis/Risk Assessment.** A Task and Resource Analysis should consist primarily of a qualitative analysis of the rescue and fire-fighting service (RFFS) response to a realistic, worst-case aircraft accident scenario. The purpose of this analysis is to review the current and future staffing levels of the RFFS deployed at the aerodrome. The analysis should be supported by a quantitative risk assessment to estimate risk reduction. This risk assessment could be related to risk reduction to passengers and aircrew as a result of deploying additional personnel. One of the most important elements of the assessment is determining the impact of any critical paths that were identified by the qualitative analysis.

**D.6 Qualitative Analysis.** A Task and Resource Analysis and a Workload Assessment are used to examine the effectiveness of the current staffing level and determine the level of improvement that would result from additional staffing. A worst-case accident scenario should be analyzed to assess the relative effectiveness of at least two levels of RFFS staffing: minimum level and optimum level.

**D.7 Quantified Risk Assessment.** Generally, the quantified risk assessment will be used to support the conclusions of the qualitative analysis by examining the risks to passengers and aircrew from aircraft accidents at the airport. This risk assessment allows the employment of additional RFFS staff to be evaluated in terms of reducing the risk of passenger and aircrew lives lost and expressed in monetary terms. This value can be compared with the cost of employing additional personnel. However, this comparison is of little, if any, value in determining minimum levels of personnel.

**D.8 Task and Resource Analysis.** The basic contents of an analysis are as follows:

- (1) Description of aerodrome, including the number of runways.
- (2) RFFS category (AIP).
- (3) Response criteria, such as area, number of fire stations, times.
- (4) Rate of movements — that is, remission factor.
- (5) Hours of operation.
- (6) Current structure and establishment.
- (7) Level of staffing.
- (8) Level of supervision.
- (9) RFFS competence in terms of training and facilities.
- (10) Extraneous duties such as domestic and first aid response.
- (11) Alarm system.
- (12) ARFF vehicles and extinguishing agents.
- (13) Specialized equipment such as fast-rescue craft, hovercraft, water carrier, hose line.
- (14) Role responsibilities at medical facilities.
- (15) Predetermined attendees: local police, fire fighters, and EMTs.
- (16) Worst-Case Accident Scenario Analysis/Workload Assessment. (This analysis should include personnel mobilization, deployment at the scene, scene management, fire fighting, suppression/extinguishment, complementary media, post-fire security, personal protective equipment (PPE), rescue team(s), aircraft evacuation, and media replenishment. Note: This analysis/assessment should

identify any conflicts between the current and proposed workloads.)

- (17) Appraisal of existing RFFS provision.
- (18) Future requirements, aerodrome development and expansion.
- (19) Enclosures such as maps, event trees, and so forth.
- (20) Airport certification manual, aerodrome manual, and so forth.

The preceding list is not exhaustive and should only act as a guide.

**D.9 Stage 1.** The airport operator must understand the goals and objectives of the ARFF staff services and the tasks that personnel are required to perform.

Example:

Goal: To maintain a dedicated ARFF staff of qualified and experienced fire and rescue personnel with specialized equipment to make an immediate response to an aircraft incident/accident in an airport or its immediate vicinity.

Objective: To save lives.

Tasks:

- (1) Meet the required response time.
- (2) Extinguish an external fire.
- (3) Protect exit routes.
- (4) Assist in passenger and aircrew self-evacuation.
- (5) Extinguish an internal fire.
- (6) Rescue trapped personnel.

The preceding list is not exhaustive and should only act as a guide.

**D.10 Stage 2.** The airport operator must identify a selection of representative realistic accidents that could occur at the airport. This selection can be identified by analyzing statistics of previous accidents at airports and data from both international and national sources.

(Note: All accidents/incidents are to involve fire to represent worst-case scenarios.)

Example:

- (1) Internal aircraft fire
- (2) Aircraft engine failure with a fire
- (3) Aircraft aborts and overruns with fire
- (4) Aircraft into aircraft with fire
- (5) Aircraft into terminal building(s) with a fire

**D.11 Stage 3.** The airport operator must identify the types of aircraft commonly used at the airport. This stage is important because the type of aircraft and its configuration have a direct impact on the resources required in meeting Stage 1. For ease of analysis, it might be necessary to group the types in relation to common aircraft configuration.

Example:

- (1) Long, wide-bodied aircraft with multiple passenger decks and multiple aisles
- (2) Long, narrow-bodied aircraft with single aisle, high passenger density
- (3) Short, narrow-bodied aircraft with single aisle, high passenger density and restricted over-wing exits

A representative aircraft from this example can then be chosen as one of the following:

- (1) Boeing 747
- (2) Boeing 757
- (3) Boeing 737

**D.12 Stage 4.** Every airport is unique in that the airport location, runway and taxiway configuration, aircraft movements, airport infrastructure and boundary, and so forth, could present specific additional risks to the airport operator.

For the worst-case accident scenario to be modeled, a major factor to consider is the worst-case location for the most likely accident type that could occur.

The worst-case location should be confirmed by a facilitator using a team of experienced fire service personnel who have knowledge of the airport and the worst-case locations in which an aircraft accident could occur.

The role of the facilitator is to assist the team in reaching agreement on the worst-case locations and, by using a scoring system, to rank order these locations.

The team must determine their reasons for identifying the worst-case locations. Each team member gives each location a weighted number. The numbers for each location can then be added up to correspond to each identified location.

Example:

The team could have identified that the following factors contributed to a worst-case location:

- (1) Travel time
- (2) Route to the accident site — that is, hard or soft ground
- (3) Terrain
- (4) Crossing active runways
- (5) Aircraft congestion
- (6) Surface conditions
- (7) Communications
- (8) Supplementary water supplies
- (9) Adverse weather conditions
- (10) Additional lighting

An additional time delay that could result from any of these factors should be estimated and recorded, and the location with the highest additional response time should be identified as a worst-case location.

It is important to note that the location of an accident could have an impact on the resources and tasks required to be performed by ARFF personnel.

From this analysis, a location or a number of locations will be identified, and in agreement with the airport operator, a sample number of the top risks should be chosen as identified by the ranked score.

Example:

- 1. Taxiway leading onto Runway 06L
- 2. Runway 06R Crossing point
- 3. Runway 06L Overshoot
- 3. Aircraft Stand 33

**D.13 Stage 5.** This stage combines the accident types to be examined, as described in Stage 2, with the aircraft identified in Stage 3 and the worst-case locations as described in Stage 4.



The accident types should be correlated with the possible worst-case location. In some cases, an accident could occur in more than one location in an airport, for each of which a Task and Resource Analysis needs to be carried out.

This information is to be integrated into a complete accident scenario that can be analyzed by experienced fire fighters for the Task and Resource Analysis described in Stage 6.

Example: Scenario Number 1

Accident Type — Internal fire (Stage 2)

Aircraft Identified — Boeing 747-400 (Stage 3)

Accident Location — Taxiway leading onto Runway 06L (Stage 4)

The Boeing 747-400 is a wide-bodied multi-deck aircraft. Its typical seating configuration is 340 Economy, 23 Business, and 18 First Class passengers on the lower deck. On the upper deck, provision is made for 32 additional Business Class passengers, giving a total aircraft seating capacity of 413, excluding the crew. The aircraft typically has four exits on both sides of the lower deck and one exit on each side of the upper deck.

During the taxi-out from the terminal using the taxiway leading to Runway 06L, a small incendiary device activates within a toilet compartment situated between the rear of the Business Class section and the front of the main Economy Cabin. The fire develops rapidly. The Cabin Crew notifies the Flight Deck Crew, who halts the aircraft and orders an evacuation. Due to the noise of the device's activation, there is considerable panic and confusion onboard the aircraft, and the lower deck rapidly fills with smoke.

The Boeing 747-400 is one in a line of aircraft that is taxiing out to Runway 06L and is blocked in by the aircraft to the front and rear. The ARFF services are unable to access the aircraft along the main taxiway, and they have to leave the hard surface and cross soft ground to reach the aircraft.

Due to the fire and smoke, Emergency Exits Right 2 and Left 2 on the lower deck are not used for evacuation. The incident results in a serious internal fire from which a number of passengers will fail to self-evacuate.

**D.14 Stage 6.** By using a facilitator with teams of experienced airport fire fighters, the accident scenarios developed in Stage 5 are subject to a Task and Resource Analysis carried out in a series of table-top exercises.

When performing a Task and Resource Analysis, the objective should be to identify in *real time*, and in sequential order, the minimum number of ARFF personnel required at *any one time* to achieve the following:

- (1) Receive and dispatch ARFF response. (The dispatcher might have to respond as part of the riding strength.)
- (2) Respond and operate ARFF vehicles.
- (3) Use extinguishing agents and equipment.
- (4) Assist in passenger and crew self-evacuation.
- (5) Access aircraft to carry out specific tasks, for example, fire fighting, rescue.
- (6) Support and sustain the deployment of fire-fighting and rescue equipment.
- (7) Support and sustain the delivery of supplementary water supplies.
- (8) Replenish foam supplies.

The Task and Resource Analysis should identify the optimum time when additional resources will be available to support and replace resources supplied by ARFF services.

Note: ARFF personnel required in agreement with the airport operator to attend other airport-related incidents should be subject to a separate Task and Resource Analysis.

To start a Task and Resource Analysis, the required airport category must be identified as required by the regulatory authority. The category will confirm the number of vehicles and the minimum extinguishing agent requirements and discharge rates. This information will determine the number of personnel required to operate these vehicles.

The results of the analyses should be recorded in a table or spreadsheet format (*see Table D.14*) and should be laid out in such a way as to ensure that the following are recorded:

- (1) Time — Starts from receipt of call, and the time line continues in minutes until additional external resources arrive
- (2) List of assessed tasks and priorities
- (3) The resources (personnel and equipment) required for each task
- (4) Comments column to allow team member comments to be recorded

Example:

Major ARFF vehicles are identified as A, B, C, D, E, or F.

Existing personnel riding the major ARFF vehicles are identified as A1, A2, B1, B2, and so forth.

Stated objectives:

- (1) Respond within the required response time.
- (2) Assist in passenger and aircrew self-evacuation.
- (3) Extinguish internal fire.
- (4) Ventilate aircraft to create survivable conditions.

Table D.14 shows that 16 fire fighters and an officer in charge (O i/c) are required, supported by 6 major foam tenders. However, no additional personnel were available to assist passengers in self-evacuation.

The time line can be further verified by the use of practical exercises to establish whether the times are realistic and achievable.

Example:

- (1) How long does it take to don protective clothing?
- (2) How long does it take to don breathing apparatus?
- (3) How long does it take to slip and pitch a ladder?
- (4) How long does it take to open an aircraft door from the head of a ladder?
- (5) How long does it take to run out one, two, or three ECT lengths of hose?
- (6) How long does it take to carry any item of rescue equipment over a specified distance and get it to work?

Table D.14 also illustrates that the scenario will dictate tasks and resources to be evaluated.

The Task and Resource Analysis model can also be used to identify equipment shortages and training needs for personnel required to deal with identified tasks.



**Table D.14 Example of a Task and Resource Analysis (Qualitative Analysis)**

| Time<br>(Minutes) | Task                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Resource                                                                                   | Comments                                                                                                                                                                |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 00.00             | Call received as AGI to taxiway leading to Runway 06L, explosion and internal fire.<br>ARFF personnel mobilized by dispatcher.<br>Call made to operate the airport emergency community plan.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Dispatcher                                                                                 |                                                                                                                                                                         |
| 00.30             | With the exception of the drivers and officer in charge (O i/c), all personnel dress in PPE en route to incident.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Minimum riding strength                                                                    |                                                                                                                                                                         |
| 01.00             | Four fire fighters don breathing apparatus en route.<br>O i/c requests captain to switch to frequency 121.6 via ATC.<br><br>Priority identified as to assist in self-evacuation, and to create and maintain survivable conditions within the aircraft.                                                                                                                                                                                                                                                                                                                                                                                                                                               | A3, A4, F3, F4                                                                             | Evacuation might have already taken place.                                                                                                                              |
| 01.46             | Major ARFF vehicles in position at aircraft.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                            |                                                                                                                                                                         |
| 01.50             | O i/c and drivers dress in PPE.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                            |                                                                                                                                                                         |
| 01.52             | Assistance required for self-evacuation.<br><br>C1 nominated as the Breathing Apparatus Control Officer.<br><br>Identify access to aircraft pitch ladder to door L2 and open door.<br><br>B1 remains as Turret Operator and provides escape route protection.<br>B2 and C2 run out extended sideline and hand to A3, A4, F3, F4 and charge.<br>A1 remains A supplying water to internal crew.<br>C2 foots ladder for internal crew.<br>D2, A2 assists with charged line for BA entry team.<br>O i/c upgrades incident to Aircraft Accident and liaises with Airside Operations.<br>O i/c requests Airside Operations to assist in containing exiting passengers and crew and obtaining a head count. | C1<br><br>A3, A4, F3, F4<br><br>B, B1<br>B2, C2<br>A, A1<br>C2<br>D2, A2<br>O i/c<br>O i/c | No additional personnel available. Remains with C to provide additional water supply.<br>To slip and pitch ladder and open door and enter, four personnel are required. |
| 03.13             | O i/c requests ATC to instruct aircraft front and rear to shut down engines.<br>D1, E2, don BA and enter at door L2.<br>E, with E1 on pump to supply water to D1, E2.<br>B2 and F2 run out extended sideline and hand to D1, D2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | O i/c<br>D1, E2<br>E, E1<br>B2, F2                                                         |                                                                                                                                                                         |
| 06.30             | F, F1 supplies additional water to A.<br>C supplies additional water to E.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | F1<br>C1                                                                                   |                                                                                                                                                                         |
| 07.30             | Supplementary water is required from nearest hydrant B2, F2.<br><br>Assist in the deployment of fire ground equipment A2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | B2, F2<br><br>A2                                                                           | Hydrant number flow and pressure.                                                                                                                                       |
| 09.00             | Internal crew start to extinguish and ventilate aircraft.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                            |                                                                                                                                                                         |
| 10.00             | External supporting services arrive at scene.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                            |                                                                                                                                                                         |

## Annex E Training Program

*This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.*

**Δ E.1 ARFF Training Program Objectives.** A carefully organized training program should be developed to meet the qualification requirements of NFPA 1003 and follow the guidance within NFPA 405. The following guidelines are offered for structuring such a program.

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

- (1) Teach the safe application of recognized practices and procedures
- (2) Develop and maintain the confidence and competency of all personnel assigned ARFF duties
- (3) Instill the concept of professionalism
- (4) 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
- (5) Enhance the esprit de corps of ARFF personnel by creating an appreciative awareness of the hazards and dangers they could face in carrying out ARFF operations

**E.2 Control and Planning.** The complete training and educational program for ARFF personnel should be under the direction of one officer of the airport fire department for planning, development, and supervision.

**E.3 Resources for Training.** Training material/resources oriented specifically to meet the needs of ARFF personnel should take into consideration the provision of suitable amounts of extinguishing agents, such as foam concentrate, dry chemical, and halogenated agents, and funding for training fires.

**E.4 Phases of Training.** Training of ARFF personnel should include seven phases. Training in all phases should be conducted for support personnel used as auxiliary fire fighters and for full-time ARFF 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.

**E.4.1 Indoctrination.** Indoctrination training should include the following:

- (1) The rules and regulations applicable to ARFF services
- (2) Knowledge of the basic duties and responsibilities and those of co-workers
- (3) Emergency response procedures
- (4) The command structures for administration and operations
- (5) The importance of practicing occupational safety

**E.4.2 Operating ARFF Equipment.** All ARFF 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:

- (1) Complete knowledge of each tool and piece of equipment.
- (2) Location of each piece of equipment and tool carried on each vehicle.
- (3) Method of using each piece of equipment and tool, with emphasis on personal safety factors.
- (4) Special handling precautions for the use of power tools.
- (5) Knowledge of, and training in, the use of breathing apparatus and other protective equipment.
- (6) Techniques employed in utilizing the available communication equipment.
- (7) Knowledge of the apparatus, its built-in equipment, including the pump and its performance capabilities, the agents carried and their delivery systems.
- (8) 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.
- (9) Knowledge of departmental policies on positioning of apparatus for tactical service at accidents/incidents under the variety of possible conditions to be encountered.
- (10) Recordkeeping to document the efficiency and effectiveness of the various vehicles utilized by the airport fire department.

**E.4.3 Fire Behavior and Fire Suppression.** ARFF personnel should possess a sound knowledge of fire behavior.

Instruction in this phase should include the following:

- (1) Principles of combustion, with emphasis on the types of aircraft fuels
- (2) How fire propagates through the effects of heat conduction, convection, and radiation
- (3) Influence of fuel distribution on heat production
- (4) Principles of fire suppression by the various types of agents utilized in ARFF
- (5) Live fire exercises that include, but are not limited to, exterior fuel fires, interior fires, engine fires, wheel fires, and fires involving onboard auxiliary power units
- (6) 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.

**E.4.4 Rescue and Fire-Fighting Procedure.** Care should be taken to ensure that ARFF 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 (PCA) 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.