NFPA No.

403

AIRCRAFT RESCUE & FIRE FIGHTING SERVICES AT AIRPORTS 1973

NFPA

$2.00

NATIONAL FIRE PROTECTION ASSOCIATION
International
470 Atlantic Avenue, Boston, MA 02210

5M-6-73-FP
Printed in U.S.A.

Official NFPA Definitions

Adopted Jan. 23, 1964: Revised Dec. 9, 1969. Where variances to these definitions are found, efforts to eliminate such conflicts are in process.

SHALL is intended to indicate requirements.

SHOULD is intended to indicate recommendations or that which is advised but not required.

APPROVED means acceptable to the authority having jurisdiction. 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 or 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 nationally recognized testing laboratories,* i.e., laboratories qualified and equipped to conduct the necessary tests, in a position to determine compliance with appropriate standards for the current production of listed items, and the satisfactory performance of such equipment or materials in actual usage.

*Among the laboratories nationally recognized by the authorities having jurisdiction in the United States and Canada are the Underwriters' Laboratories, Inc., the Factory Mutual Research Corporation, the American Gas Association Laboratories, the Underwriters' Laboratories of Canada, the Canadian Standards Association Testing Laboratories, and the Canadian Gas Association Approvals Division.

LISTED: Equipment or materials included in a list published by a nationally recognized testing laboratory that maintains periodic inspection of production of listed equipment or materials, and whose listing states either that the equipment or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.

LABELED: Equipment or materials to which has been attached a label, symbol or other identifying mark of a nationally recognized testing laboratory that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling is indicated compliance with nationally recognized standards or tests to determine suitable usage in a specified manner.

AUTHORITY HAVING JURISDICTION: The organization, office or individual responsible for "approving" equipment, an installation, or a procedure.

Statement on NFPA Procedures

This material has been developed in the interest of safety to life and property under the published procedures of the National Fire Protection Association. These procedures are designed to assure the appointment of technically competent Committees having balanced representation from those vitally interested and active in the areas with which the Committees are concerned. These procedures provide that all Committee recommendations shall be published prior to action on them by the Association itself and that following this publication these recommendations shall be presented for adoption to the Annual Meeting of the Association where anyone in attendance, member or not, may present his views. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accepts any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

Recommended Practice for

Aircraft Rescue and Fire Fighting Services at Airports and Heliports

NFPA No. 403 — 1973

ANSI Z213.1

1973 Edition of No. 403

This Recommended Practice, prepared by the NFPA Sectional Committee on Aircraft Rescue and Fire Fighting and submitted to the Association through the NFPA Committee on Aviation, was adopted by the Association at its 77th Annual Meeting on May 16, 1973 in St. Louis, Mo. This edition supersedes all previous editions of NFPA No. 403.

The changes this year revise the 1972 text to accomplish two basic goals: (1) to recognize the superiority of aqueous film-forming foam (AFFF) concentrates in controlling flammable liquid spill fires over standard protein foam type concentrates, and, (2) to harmonize these recommendations to the maximum feasible extent with those under development in the International Civil Aviation Organization and those promulgated by the Federal Aviation Administration, U.S. Dept. of Transportation, following the adoption of Part 139 of Federal Aviation Regulations. These revisions have resulted in changes to Paragraphs 212.–217.; 311. b.–e.; 312. a.–e.; 313. a.; 314. a. and b.; 412; deletion of 487–488; and a revised Section 490. In addition Tables 1A, 1B, 1C, and C–1 have been revised. Reference material has also been updated.

The 1971 edition of this standard was approved by the American National Standards Institute under date of January 28, 1972 and designated ANSI Z213.1 — 1972. This 1973 edition is being submitted for similar approval. The ANSI designation and date of approval will be printed on the front cover of copies of the pamphlet edition of this text after approval has been received.

Origin and Development of No. 403

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

NFPA Committee work continued during 1948 and in 1949 the Association adopted a tentative text at its Annual Meeting held in San Francisco, California. In 1952 a revised text was submitted for adoption by the Association, and unanimously accepted. Since its original adoption, this text has been revised periodically with editions issued in 1954, 1955, 1956, 1957, 1958, 1959, 1960, 1961, 1962, 1965, 1966, 1967, 1969, 1970, 1971, and 1972, prior to this edition.

In June, 1948, the International Civil Aviation Organization distributed ICAO Circular 4 — AN/3 which contained the recommendations on this subject. In February 1955, the ICAO reproduced the 1954 editions of this text and NFPA No. 402 in ICAO Circular 41 — AN/36. These publications are now obsolete. During December 1956, the ICAO sponsored a meeting of a specially constituted international "Panel on Aircraft Rescue and Fire Fighting Services at Aerodromes" to develop "specifications or further guidance material" on the subject.

(*Continued on Page* 403–4)

Committee on Aviation

Jerome Lederer,† *Chairman,*
Flight Safety Foundation, 1800 North Kent St., Arlington VA 22209

Harvey L. Hansberry, *Vice-Chairman,*
U.S. Dept. of Transportation, Federal Aviation Administration, NAFEC, Atlantic City, NJ 08405

George H. Tryon†, *Secretary,*
National Fire Protection Association, 470 Atlantic Ave., Boston, MA 02210

J. C. Abbott, British Overseas Airways Corp.

H. J. Badger, The Boeing Co.

J. J. Brenneman, Chairman, NFPA Sectional Committee on Aircraft Rescue and Fire Fighting

William L. Collier, International Federation of Air Line Pilots Assns.

F. P. DeGiovanni, Vice-Chairman, NFPA Sectional Committee on Aircraft Hangars & Airport Facilities

D. G. Dumper, American Airlines

P. M. Fitzgerald, Chairman, NFPA Sectional Committee on Aircraft Hangars and Airport Facilities and rep. Factory Mutual Research Corp.

W. Harris, Australian Dept. of Civil Aviation

B. V. Hewes, Vice-Chairman, NFPA Sectional Committee on Aircraft Rescue and Fire Fighting and rep. Air Line Pilots Assn.

Lt. Col. G. A. Hope, Canadian Forces Headquarters

R. L. Jackson, American Petroleum Institute

John E. Lodge, Department of Trade and Industries (United Kingdom)

A. J. Mercurio, Factory Insurance Association

J. A. O'Donnell, Chairman, NFPA Sectional Committee on Aircraft Fuel Servicing

H. B. Peterson, U. S. Naval Research Laboratory

Capt. Reuben P. Prichard, Jr., National Aeronautics & Space Administration

Victor B. Robinson, Jr., U.S. Dept. of the Air Force

John H. Sellers, Chairman, NFPA Sectional Committee on Aircraft Maintenance and Servicing and rep. American Insurance Association

John T. Stephan, American Assn. of Airport Executives

Kenneth A. Zuber, Vice Chairman, NFPA Sectional Committee on Aircraft Maintenance & Servicing and rep. Compressed Gas Association

Alternates.

Wm. L. Hanbury, National Aeronautics & Space Administration (Alternate to Capt. Reuben P. Prichard, Jr.)

D. A. Heine, Air Line Pilots Association (Alternate to B. V. Hewes)

Thomas A. Raffety, American Assn. of Airport Executives (Alternate to John T. Stephan)

Richard Southers, American Petroleum Institute (Alternate to R. L. Jackson)

Nonvoting Members

J. G. W. Brown, British European Airways

Stanley J. Green, General Aviation Manufacturers Association

V. Kidd, Ministry of Defence, Air Force Dept. (United Kingdom)

C. Hayden LeRoy, National Transportation Safety Board

Gene I. Martin, Aerospace Industries Association of America, Inc.

C. M. Middlesworth, Federal Aviation Administration, National Aviation Facilities Experimental Center

John A. Pope, National Business Aircraft Assn., Inc.

A. F. Robertson, National Bureau of Standards.

Dr. R. R. Shaw, International Air Transport Association

Edwin L. Thomas, Air Transport Association

Chief of the Aerodromes, A.G.A., International Civil Aviation Organization

†Nonvoting.

This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

Sectional Committee on Aircraft Rescue and Fire Fighting

J. J. Brenneman, *Chairman,*
Fire Protection Engr., United Air Lines, Inc., P.O. Box 6 100, Chicago, IL. 60666

B. V. Hewes, *Vice Chairman,*
Air Line Pilots Association, 3581 N. Main St., College Park, GA 30337

J. C. Abbott, British Overseas Airways Corp.

Lt. George Augusto, Denver Fire Dept.

H. J. Badger, The Boeing Co.

Chief Harry V. Burbridge, Seattle-Tacoma International Airport

John J. Byrne, Battalion Chief, Los Angeles City Fire Dept.

Robert C. Byrus, Beltsville, Md.

Martin P. Casey, U.S. Dept. of the Air Force, AFSC

George R. Cooper, Jr., Walter Motor Trucks of Canada, Ltd.

Emmett T. Cox, International Assn. of Fire Fighters

Dan De Coursin, Fire Apparatus Manufacturing Div., Truck, Body and Equipment Assn.

Alfred W. DuBrul, U. S. Coast Guard

D. G. Dumper, American Airlines

Frederick H. Flagg, Airport Operators Council International

Capt. J. N. Pierre Gagne, Canadian Airline Pilots' Assn.

Harvey L. Hansberry (ex-officio), U.S. Dept. of Transportation

R. A. Harley, Dept. of Transport (Canada)

G. H. Hawes, Jr., Lochkeed-Georgia Co., Marietta, GA 30060

D. A. Heine, Air Line Pilots Association

Franklyn P. Kellogg, Chief, Fire Dept. Burke Lakefront Airport (Cleveland)

Chief Paul Kowall, Firemen's Training Center, (Nassau County, New York)

L. M. Krasner, Factory Mutual Research Corp.

Philip J. Landi, Helicopter Association of America

John E. Lodge, Department of Trade and Industries (United Kingdom)

Maj. W. G. MacDonald, Canadian Forces Training

Carl E. McCoy, International Fire Service Training Assn.

William J. McNamara, U. S. Army Mob. Equipment Research & Development Center

H. B. Peterson, U. S. Naval Research Laboratory

S. Harry Robertson, Arizona State University

W. D. Robertson, Seattle-Tacoma Airport.

Robert R. Rogers, Long Island MacArthur Airport

Capt. William T. Schmidt, Indiana Firefighters Association

Chief Arthur Scott, Metropolitan Transportation Authority

L. A. Simms, Apple Valley, Calif.

John T. Stephan, American Assn. of Airport Executives

H. R. Wesson, University Engineers, Inc.

Murray M. White, Jr., National Pilots Association

E. T. Williams, British Airports Authority

E. D. Zeratsky, Fire Equipment Manufacturers Association

Alternates.

William L. Collier, International Federation of Air Line Pilots Assns. (Alternate to B. V. Hewes)

T. L. Cowick, Dept. of Transport, (Alternate to R. A. Harley)

Lt. Col. G. A. Hope, Canadian Forces Headquarters

Herb Leppke, Air Line Pilots Association, (Alternate to D. A. Heine)

Frederick Newman, Fire Equipment Manufacturers Association (Alternate to E. D. Zeratsky)

Thomas A. Raffety, American Association of Airport Executives (Alternate to John T. Stephan)

(Continued)

Nonvoting Members

Ray Alexander, Flextrac Nodwell.

Robert R. Burford, 3M Company

Jack Carroll, National Transportation Safety Board (Alternate to C. Hayden LeRoy)

J. P. Dunne, O'Hare International Airport

Nicolas J. Gabriel, Civil Aviation Safety Centre

George B. Geyer, Federal Aviation Administration, NAFEC

Philip R. Haught, Fire Control Engineering Co.

Earl W. Keegan, Federal Aviation Administration, Airports Services (Alternate to John M. Mobley)

Jerome Lederer (ex-officio), Flight Safety Foundation

C. Hayden LeRoy, National Transportation Safety Board

H. W. Marryatt, Australian Fire Protection Assn.

J. H. Mathison, Australian High Commission, Malaysia

D. N. Meldrum, National Foam System, Inc.

John M. Mobley, Federal Aviation Administration, Airport Services

Walter J. Mussoni, Rockwood Firefighting Products

James F. O'Regan, Feecon Corporation.

K. R. Pollard, Laurentian Concentrates, Limited

Samuel F. Powel III, Walter Motor Truck Co.

L. E. Rivkind, Mearl Corporation.

Jose L. Santamaria, International Civil Aviation Organization

Marvin C. Tyler, Aircraft Ground Fire Suppression and Rescue Systems Program, U.S. Dept. of Defense

H. V. Williamson, Cardox, Division of Chemetron Corp.

J. H. Yankie, Fire-X Corp.

Subcommittee on NFPA No. 403

Frederick H. Flagg, *Chairman*
Port Authority of New York and New Jersey, One World Trade Center, Room 655, New York, N.Y. 10048

John J. Byrne, Battalion Chief, Los Angeles Fire Department

Martin Casey, U.S. Dept. of the Air Force, AFSC

D. G. Dumper, Director, Safety Administration, American Airlines.

George B. Geyer, FAA National Aviation Facilities Experimental Center.

R. A. Harley, Canadian Dept. of Transport.

B. V. Hewes, Airline Pilots Association.

Maj. W. G. MacDonald, Canadian Forces Training

Carl McCoy, International Fire Service Training Association.

John M. Mobley, Federal Aviation Administration (Liaison)

Robert R. Rogers, Long Island MacArthur Airport.

Jose L. Santamaria, International Civil Aviation Organization.

Marvin C. Tyler, Aircraft Ground Fire Suppression and Rescue Systems Program, U.S. Dept. of Defense.

Murray M. White, Jr., National Pilots Association.

(*Continued from Page* **403–1**)

Subsequent ICAO Panel Meetings were held in 1962, 1968, 1970, and 1972. The current recommendations of ICAO are contained in "Annex 14" (Aerodromes) to the Convention on International Civil Aviation (available from ICAO, International Aviation Building, 1080 University Street, Montreal 3, Quebec, Canada, and from their Regional Offices in France, Peru, Senegal, Thailand, and the United Arab Republic) in English, French, and Spanish editions. ICAO Aerodrome Manual, Part 5 (Equipment, Procedures, and Services), contains an extensive chapter on Rescue and Fire Fighting, and a Supplement on Aircraft Data for Fire Fighting and Rescue Crews. Part 6 (Heliports) discusses Rescue and Fire Fighting as practiced in the United Kingdom and U.S.A. Each of these publications is available in the same languages from the same source. In addition, ICAO has published a Training Manual for Aerodrome Fire Services Personnel (Part 16), available for 75 cents per copy. (See also page 403–57 herein.)

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

Table of Contents

Recommended Practice for

Aircraft Rescue and Fire Fighting Services at Airports and Heliports*

NFPA No. 403 — 1973

ANSI Z213.1

Article 100. Introduction

110. Application

111. This recommended practice applies to aircraft rescue and fire fighting services at airports and heliports; it does not include fire protection facilities for airport structures (*i.e.*, hangars, shops, terminals, other airport buildings, etc.), although the equipment and manpower made available to perform these services might constitute valuable fire protection for such structures and their contents in many instances. Vehicles designed for aircraft rescue and fire fighting services are covered in the NFPA Standard for Aircraft Rescue and Fire Fighting Vehicles (No. 414; ANSI B128.1); their recommended use is outlined in NFPA Standard Operating Procedures, Aircraft Rescue and Fire Fighting (No. 402); and methods for on-site testing of certain of these vehicles are given in the NFPA Standard for Evaluating Foam Fire Fighting Equipment on Aircraft Rescue and Fire Fighting Vehicles (No. 412). Any consideration given to the structural fire fighting capability of these vehicles may be only to the extent that any design features or equipment added do not detract from their primary purpose.

112. Heliports designed *exclusively* for handling helicopter operations are generally limited in area and are separately evaluated as regards helicopter rescue and fire fighting services. For the purposes of this text, the term "heliport" shall include all areas exclusively used for helicopter operations, including such areas referred to as "helipads" and "helistops." Heliports may be located at ground level, on platforms constructed specifically for the purpose, or on the roofs of buildings. The degree of fire protection recommended depends on the size of the helicopters, the number of occupants, the maximum operational fuel load of the helicopters using the facility, personnel available for rescue and fire fighting purposes and the frequency of operations (see Paragraph 314 and Table 2).

*See Appendix for a bibliography of other helpful information on aircraft rescue and fire fighting and airport fire safety.

120. Type of Aircraft Operations Safeguarded

121. The threat of fire is ever present and may occur at any time when an aircraft is involved in either operational or servicing accidents. Experience has shown that severe problems of rescue are encountered when fire occurs incident to operational accidents. Fire is especially apt to occur immediately following ground impact in operational accidents (but may occur at any time during rescue operations) because of the nature of the aircraft fuel and lubricants used, rupture or damage to the fuel containing structures or associated plumbing, the latent heat of operating aircraft engines, exhaust flames and hot gases, the possibility of sparks being created through disturbance of electrical circuits or from friction, or the discharge of accumulated electrostatic charges at time of ground contact. The outstanding characteristic of aircraft fires is their tendency to reach lethal intensity within a very short time after outbreak. This not only handicaps rescue efforts but also presents a severe hazard to the lives of those involved in the accident and anyone attempting their rescue.

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

130. Location of Accidents

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

140. Nature of Recommendations

141. These recommendations give guidance on the amount and type of services to provide a reasonable degree of aircraft rescue and fire fighting protection for aircraft operations at civil airports and heliports. The recommendations are based on providing effective control of aircraft fires to achieve any needed rescue of personnel likely to be involved in "survivable" types of aircraft accidents and to provide a reasonable degree of mobile fire protection for airport ramp and movement areas.

150. Administrative Control

151. Aircraft rescue and fire fighting on the movement area of an airport should be under the administrative control of airport management *except* where the aircraft rescue and fire fighting services at airports are organized as a part of a municipal (or similar regional) or a federal fire service and are thus under the *direct* administrative jurisdiction of the Chief of the municipal, regional, or federal Fire Department. Under the latter conditions close liaison with airport management is essential to integrate fire department and aircraft operations to assure effective and safe response of emergency equipment on the movement area of the airport.

152. Where aircraft rescue and fire fighting services are not under the direct administrative jurisdiction of the Chief of a municipal, regional or federal fire service, airport management should exercise administrative control whether such management is a governmental agency, a private corporation or an individual, and irrespective of how the aircraft rescue and fire fighting services are financed and/or organized. Airport management should also have administrative duties in connection with aircraft rescue and fire fighting services within the reasonably accessible environs of the airport movement area *where* there is no conflict with the administrative jurisdiction of suitably organized and equipped municipal, regional, or federal fire services.

153. Regardless of the administrative control of aircraft rescue and fire fighting services on the airport, a prearranged high degree of mutual aid (joint defense measures) is desirable between such services on airports and any municipal (or similar regional) fire or rescue agencies serving the environs of the airport. An "area emergency plan" is desirable and airport management should encourage and offer instruction to cooperating departments in aircraft rescue and fire fighting. See Paragraph 221.c. of NFPA No. 402.*

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

---

*See Standard Operating Procedures, Aircraft Rescue and Fire Fighting, NFPA No. 402.

Article 200. Basis for Recommendations on Extinguishing Agents

210. Types of Extinguishing Agents

211. In order to establish the types of extinguishing agents recommended for aircraft rescue and fire fighting, it is desirable to consider certain basic principles concerning the various agents available for the purpose. These are summarized in Paragraphs 212 through 216.

212. Foam

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

b. There are four major types of foam-liquid concentrates now used for aircraft rescue and fire fighting, namely:

(1). Protein-Foam Concentrates: These concentrates consist primarily of products from a protein hydrolysate, plus stabilizing additives and inhibitors to protect against freezing, to prevent corrosion of equipment and containers, to resist bacterial decomposition, to control viscosity, and to otherwise assure readiness for use under emergency conditions. Current formulations are used at recommended nominal concentrations of 3 percent and 6 percent of the water discharge. Both types can be used to produce a suitable mechanical foam but the manufacturer of the foam-making equipment should be consulted as to the correct concentrate to be used in any particular system (the proportioners installed must be properly designed and/or set for the concentrate being used). Mixing foam liquids of different types or different manufacture should not be done unless it is established that they are completely interchangeable [see Paragraphs 212.b.(2) and (3)].

(2). **Aqueous-Film-Forming-Foam (AFFF) Concentrate.** This concentrate consists of a fluorinated surfactant with a foam stabilizer which is diluted with fresh water in either a 3 percent or a 6 percent solution. (For use with salt water, consult the agent manufacturer.) The temperature of the AFFF concentrate must be above 32°F. when used, as otherwise the material may become more viscous and this could adversely affect proportioning. The foam formed acts both as a barrier to exclude air or oxygen and to develop an aqueous film on the fuel surface capable of suppressing the evolution of fuel vapors. The foam blanket produced should be of such thickness as to be visible before fire fighters place reliance on its permanency as a vapor suppressant. AFFF concentrates listed as such by a nationally recognized testing laboratory have been found to be satisfactory for extinguishing fires, including aircraft fuels. AFFF concentrates are normally used in conventional foam-making devices suitable for producing protein foams as described in Paragraph 212.b.(1), [See note following Paragraph 212.b.(4)]. Vehicles using in-line compressed air systems may require modifications. The foam produced with AFFF concentrate is dry-chemical-compatible and thus is suitable for combined use with dry chemicals. Protein and fluoroprotein foam concentrates are incompatible with AFFF concentrates and should not be mixed, although foams separately generated with these concentrates are compatible and can be applied to a fire in sequence or simultaneously. It should be noted that Paragraph 311.d. allows a lower discharge rate and Paragraph 312.a. permits a one-third reduction in the amount of water for foam production when using AFFF concentrates rather than protein or fluoroprotein concentrates. This is in recognition of the fact that AFFF reduces control and extinguishment times significantly, although other factors (such as foam blanket stability, burnback rate, and wicking action) modify the relative degree of efficiency of AFFF on open spill fires between the concentrates.

(3). **Fluoroprotein-Foam-Concentrates.** These concentrates are very similar to protein-foam concentrates as described in Paragraph 212.b.(1) with a synthetic fluorinated surfactants additive. They form an air-excluding foam blanket and may also deposit a vaporization-inhibiting film on the surface of a liquid fuel. These concentrates are used at recommended nominal concentrations of 3 percent and 6 percent of the water discharge. Both types can be used to produce a suitable mechanical foam, but the manufacturer of the foam-making equipment should be consulted as to the correct concentrate to be used in any particular system (the proportioners installed must be properly designed and/or set for the concentrate being used). Mixing foam liquid concentrates of different types or different manufacture should not be done unless it is established that they are completely interchangeable (see Paragraphs 212.b.(1) and 212.b.(2)). Compatibility of the foams produced using fluoroprotein-foam concentrates with any dry chemical agent programmed for use on a fire in sequence or simultaneously should be established by test.

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

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

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

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

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

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

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

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

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

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

213. Dry Chemicals

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

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

(1). When foam is the principal agent utilized, *regular* (meaning not necessarily foam-compatible) dry chemicals are employed as a supplementary medium (usually in relatively small quantities) before the foam is applied and when the fires are in their incipient stages. *Regular* dry chemical may also be used subsequently to control or extinguish fires in concealed or inaccessible locations, or to check "running" fires where foam is *not* being used simultaneously. Care must be taken when using *regular* dry chemical in conjunction with foam to avoid deleterious effects on the foam and somewhat greater quantities of foam may be needed to overcome the tendency of the foam to breakdown due to the admixture. Foam-compatible dry chemicals are now available and have been "listed" by nationally recognized fire testing laboratories. Foam-liquid concentrates "listed" by these same laboratories are tested to assure they will meet these compatibility features. It is thus important that where protein-concentrate types of foam are used and dry chemical is to be employed as a companion agent simultaneously, only "listed" foam-compatible dry chemical be used.

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

214. Carbon Dioxide

a. Carbon dioxide provides a means of quickly "knocking down" flammable liquid fires when applied at a proper rate and in sufficient quantity. It has excellent flooding characteristics and penetrates to otherwise inaccessible areas. It leaves no residue. As atmospheric conditions (particularly wind direction and velocity) may interfere with the smothering effect of carbon dioxide and as the cooling effect may not always be sufficient to prevent reignition of flammable vapors by hot or burning materials, a supplementary cooling and blanketing agent (foam or water) is normally necessary. Fireman's training has a great influence on the effective use of carbon dioxide. When liquid carbon dioxide is discharged to the atmosphere a portion is converted to "dry ice" at minus 110° F.

b. The following subparagraphs define "high pressure" and "low pressure" carbon dioxide:

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

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

c. Carbon dioxide is normally used in aircraft rescue and fire fighting service in one of the following ways:

(1). When foam is the principal agent, carbon dioxide, preferably "low pressure," is employed as a supplementary agent, either initially (before foam is applied) when the fires are in their incipient stages, or, subsequently to control or extinguish fires in concealed or inaccessible locations or to check "running" fires.

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

215. Water

a. Water is recognized as the best cooling agent universally available for the control of fire and for personnel protection from heat but the ability of water to effect extinguishment is limited on large flammable liquid based fires of the type usually encountered in accidents involving aircraft. Therefore, it is not recommended as the sole agent available for this type of fire fighting on airports.

NOTE: See the NFPA Guide for Aircraft Rescue and Fire Fighting Techniques for Fire Departments Using Conventional Fire Apparatus and Equipment (No. 406M) where specialized equipment is not available.

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

c. The use of straight water streams discharged at high velocity is not considered desirable for aircraft rescue and fire fighting except where it is desired to "sweep" fuel spills from hazardous areas.

d. Wetting agents added to water improve its extinguishing efficiency on flammable liquid based fires but care must be exercised to assure compatibility if foam is a supplementary agent.

216. Other Agents: Several vaporizing liquid extinguishing agents effective on flammable liquid fires under proper conditions have been used and others have been proposed for aircraft rescue and fire fighting but inadequate technical data prevents making any positive recommendations on their use up to this time. Where it is deemed advisable to use vaporizing liquid extinguishing agents care should be taken to assure that any toxic vapors produced will not constitute a hazard during rescue operations.

217. Summary on Agents

a. The information given in Paragraphs 212–216 indicates that no single agent has all the qualities needed to accomplish speedy and permanent extinguishment of all aircraft fires. Foam, applied as discussed in Paragraph 212.d. is, however, the most effective medium found to date and is therefore the principal extinguishing agent upon which reliance is placed for this service. For further recommendations, see Article 300.

b. The type and quantities of extinguishing media recommended in Tables 1B, 1C, and 2 are based on the conclusions indicated in Par. 217.a., except for heliports and Catagory H-1 of Table 2.

220. Magnesium Fire Control

221. The presence of magnesium alloys in aircraft structures introduces an additional problem to fire extinguishment in cases where this metal becomes involved in an aircraft fire. None of the agents available for this application (see Paragraphs 212–216) is capable of securing positive extinguishment of burning magnesium under all conditions and experience proves that a definite reignition hazard to flammable liquid vapors exists from burning magnesium following almost complete control over other ignited materials. The only practical methods of overcoming this difficulty are: (1) by the removal of the magnesium from the fire area where accessible and identifiable; (2) by the localized application of special magnesium extinguishing agents or covering with sand or dirt; (3) by cooling with water or foam (this process liable to temporarily intensify flame spread until the application is sufficient to produce the degree of cooling required);

or (4) by blanketing the exposed flammable liquids with foam and allowing the magnesium to burn itself out.

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

223. Magnesium fires attacked in their incipient stages may be controlled under some conditions by the application of special magnesium fire extinguishing agents as indicated in Paragraph 221 but generally where a mass of magnesium becomes involved the application of large volumes of coarse water streams provides the best ultimate control method. Attacking magnesium fires this way, however, is undesirable where the primary fire control technique is with foam as the coarse water streams would have the effect of breaking down foam blankets in the area. Thus volume application of foam is indicated during the critical period when flammable liquid spills present the primary hazard with the aim to so cover exposed flammable liquid spills to prevent or eliminate their vapor hazard. Following completion of rescue and all possible salvage, it is, however, frequently advisable to apply coarse water streams to still-burning magnesium components, even if the immediate result might be a localized intensification of flame and considerable sparking. In this connection it is sometimes feasible to segregate burning magnesium components from the main fuel spill area with shovels or cranes to permit separate fire control treatment of this material.

Article 300. Recommendations for Protection of Aircraft Operations at Airports and Heliports

310. Protection for Aircraft Operations

311. Basis for Recommendations

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

b. The area described in Paragraph 311.a. is that of a rectangle, whose longitudinal dimension is the overall length of a particular aircraft (or the average length for a group of similar aircraft) and whose width is normally 100 feet (30.5 meters), plus the width of the aircraft. Where the overall length (or average length for a group of similar aircraft) is less than 65 feet (19.8 meters), the width dimension may be reduced to 40-feet (15.2 meters) plus the width of the fuselage. The resulting areas may be further modified by a two-thirds factor which then will reflect the difference between the calculated and the actual (probable) involvement based upon extensive studies of aircraft accidents throughout the world.

c. Foam, as explained in Paragraph 217.a., is the principal extinguishing agent upon which reliance is placed for this service. The use of dry chemicals (as described in Section 213) or low-pressure carbon dioxide (see Paragraph 214.c.) to effect a "combined-agent" attack is recommended to achieve maximum speed in fire control.

d. Using foam produced with protein or fluoroprotein foam concentrates, fire control can be established within one minute when the area described in Paragraph 311.b. is covered with foam at a discharge rate of 0.20 gallons per minute per square foot (8.2 liters per minute per square meter). Using foam produced with aqueous film-forming foam concentrates, fire control can be established within one minute when the area described in Paragraph 311.b. is covered with foam at a discharge rate of 0.13 gallons per minute per square foot (5.5 liters per minute per square meter).

e. Some present-day transport aircraft can carry 300 or more passengers and may be involved in a fire accident when carrying in excess of 40,000 gallons (152,000 liters) of fuel. The recommendations contained herein recognize that a situation could develop where evacuation and rescue would have to proceed over a prolonged period of time during which the threat of fire could be continuous. To maintain effective fire control under these circumstances may require intermittent application of additional foam (normally achieved by the use of hand lines) at reduced discharge rates. This may be particularly necessary where rescue operations may result in disruption of an established foam blanket or where heat and flame attack from perimeter fires or burning combustible metals cause gradual disintegration of the foam blanket. It is thus recommended that a supplementary supply of foam and water be carried which exceeds the quantity required to achieve control. This supplementary quantity is included in the quantities recommended in Tables 1B and 1C, calculated on a percentage factor incorporating gross weight, passenger and fuel capacity, and previous operational experience. The percentage factor ranges from a low of 2 percent to a high of 170 percent in proportion to the size of the aircraft.

312. Extinguishing Agent Recommendations

a. Water for foam production assumes the use of protein foam, fluoroprotein foam, or an aqueous film-forming foam (AFFF) concentrate through appropriate proportioning equipment. As indicated by comparing Tables 1B and 1C, the amount of water required for foam production may be reduced one-third when AFFF concentrate is used rather than protein or fluoroprotein foam concentrate with corresponding reductions in the required discharge rates and amounts of concentrate required. The minimum quantities of foam concentrate recommended are twice the quantities required for the minimum water gallonage specified so as to permit a water refill operation to be undertaken at least once. The quantities shown in Tables 1B and 1C are based upon 6 percent concentrates; adjustments must be made where 3 percent concentrates are used. All discharge rates, as specified in Tables 1B and 1C, are expressed in gallons of water (not expanded foam) and are the total from all available major fire fighting vehicle discharge nozzles combined. Turret application should comprise not less than 75 percent of this total for all discharge devices. Quantities and rates of discharge are based upon agents being carried on properly designed, operated, and maintained fire fighting vehicles stationed on the airport (see Section 410–440). At airports falling into Indexes 5 through 8 (see Tables 1B and 1C), it is preferable to divide the total recommended quantity of water for foam production into at least two fire fighting vehicles to permit operational flexibility (for instance, to allow attacking the fire from more than one angle), and to provide for greater opportunity for uninterrupted fire control operations (see Paragraph 412). When tank vehicles are employed to carry a portion of the total quantity of water recommended, their response capability should be such as to provide timely transfer to the fire fighting vehicles causing no interruption in the latter's ability to utilize the total quantities if so required. It is further recommended that water hydrants, strategically located on the airport, be provided to refill tank and fire fighting vehicles readily.

b. Where dry chemicals are used in conjunction with foam, reasonable chemical compatibility should be assured between the two agents to secure the maximum beneficial use of the combined-agent technique. The rates of discharge recommended in Tables 1B and 1C for dry chemicals indicate the minimum rates, in pounds (kilograms) per minute, discharged from hand line nozzles [see Paragraph 213.b.(2)]. The amounts and discharge rates of dry chemicals are based upon having these agents immediately available for application from properly designed, equipped, and maintained vehicles of the light rescue type (see Section 420) or the combined-agent type (see Section 440).

c. Although Tables 1B and 1C recommends specific quantites and rates of discharge for dry chemical agents, it is permissible to substitute "low pressure" carbon dioxide at a ratio of two pounds (0.90 kilograms) of carbon dioxide to one pound (0.45 kilograms) of dry chemical for both the amounts of agent available and the minimum designed discharge capability. Whenever used, carbon dioxide should be carried on properly designed, equipped, and maintained fire fighting vehicles of the type specified in Section 410.

d. At Index 1, 2 and 3 airports and at airports where special climatic conditions exist, dry chemical may be used to replace water on the basis of 8 pounds (3.6 kilograms) of dry chemical to one gallon (3.785 liters) of water.

e. Extinguishing agents (except water for foam production) should be carried in stock to resupply vehicles in sufficient amounts commensurate with resupply times from suppliers. A minimum of one additional charge for all vehicles should be maintained, and where delivery time for suppliers exceeds 24 hours, supplies should be increased accordingly. This condition will vary at different airports, and no definitive quantities can thus be recommended. Care should be exercised in stocking agents to assure that stocks are rotated on a "first in, first out" basis. Consideration should be given to having on hand quantities of extinguishing agents for the purpose of training in addition to that reserved for fire suppression. Where it is anticipated that runways will be foamed for aircraft emergency landings, additional foam liquid concentrate should be carried in stock to assure that the supplies reserved for fire fighting are not affected. (See also Section 1100 of NFPA No. 402, Standard Operating Procedures, Aircraft Rescue and Fire Fighting.)

313. Protection of Operations at Conventional Airports.

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

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

Continued on page **403-25**

Table 1A — Airport Indexes by Overall Length of Aircraft

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

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

314. Protection at Heliports

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

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

H-2 — This category includes all heliports where the helicopters using the facility normally carry passengers (less than 12), have operational fuel loads of less than 200 gallons (760 liters), and where the number of movements exceeds an average of 4 movements per day over any 3-month period. (Where the frequency of movements is less than that specified, the decision as to whether to apply these suggestions should be based on a judgment of the heliport management and any regulatory agency having jurisdiction.)

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

NOTE: Where an airport is also used as a heliport the fire and rescue protection suggested by Table 1 would apply.

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

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

c. Fire extinguishers, foam nozzles, hose reels, etc., located on heliports should, where necessary, be in weatherproof above-grade cabinets, clearly marked as to their contents. Cabinets shall be located beyond but within 5 feet (1.5 meters) of the boundary line defining the landing and take-off area and shall

Table 1B
Recommended Amounts of Extinguishing Agents by Airport Indexes Based on Using 6% Solutions of Protein or Fluoroprotein Foam Concentrates for Foam Production

AIRPORT INDEX (see Table 1A)	Water for Protein-Fluoroprotein Foam Production (Fire Fighting — Tank Vehicles) (Note 1)				Foam Concentrate (Note 2)		Dry Chemical (Light Rescue Vehicle) (Note 3)			
			Discharge Rates						Discharge Rates	
	Gals (U.S.)	Liters	GPM	Liters/Min	Gals (U.S.)	Liters	Lbs.	Kgs.	Lbs/Min	Kgs/Min
1	150	570	50	200	30	140	100	50	100	50
2	300	1,140	150	600	60	230	200	90	200	90
3	500	1,900	300	1,000	120	460	300	135	300	135
4	2,000	7,600	1,150	4,400	240	910	300	135	300	135
5	3,000	11,400	1,600	6,100	360	1,360	500	225	500	225
6	5,000	19,000	2,100	8,000	600	2,300	500	225	500	225
7	7,500	28,500	2,900	11,000	900	3,400	1,000	450	500	225
8	10,000	38,000	3,600	13,700	1,200	4,600	1,000	450	500	225

NOTE 1. The gallons (liters) of water specified should be on at least 2 fire fighting vehicles (see Paragraph 312.a.) for Indexes 5 through 8. The design minimum discharge rates are in gallons (liters) of water (not expanded foam) from all available discharge nozzles. See Table 1C for aqueous film-forming foam concentrate applications.

NOTE 2. When a premix foam-water system is used on a vehicle, recharge quantities shall not be required to be carried on the vehicle, but where a premix is not used, the minimum quantities of foam concentrate carried on each vehicle should be twice the quantities required for the water provided to permit continued operation of the vehicle if refilled with water once.

NOTE 3. *Approved foam-compatible types.* Alternate use is authorized of low-pressure carbon dioxide [see Paragraphs 214.c.(2) and 312.c.].

Table 1C

Recommended Amounts of Extinguishing Agents by Airport Indexes Based on Using 6% Solutions of Aqueous Film-Forming Foam (AFFF) Concentrates for Foam Production

AIRPORT INDEX (See Table 1A)	Water for AFFF Production (Fire Fighting — Tank Vehicles) (Note 1)				Foam Concentrate (Note 2)		Dry Chemical (Light Rescue Vehicle)			
	Gals (U.S.)	Liters	Discharge Rates		Gals (U.S.)	Liters	Lbs.	Kgs.	Discharge Rates	
			GPM	Liters/Min					Lbs/Min	Kgs/Min
1	100	380	35	134	20	105	100	50	100	50
2	200	760	100	400	40	155	200	90	200	90
3	335	1,265	200	665	80	310	300	135	300	135
4	1,335	5,065	665	2,935	160	605	300	135	300	135
5	2,000	7,600	1,065	4,067	240	905	500	225	500	225
6	3,335	12,665	1,400	5,335	400	1,535	500	225	500	225
7	5,000	19,000	1,935	7,335	600	2,265	1,000	450	500	225
8	6,665	25,335	2,400	9,135	800	3,065	1,000	450	500	225

NOTE 1. The gallons (liters) of water specified should be on at least 2 fire fighting vehicles (see Paragraph 312.a.) for Indexes 5 through 8. The design minimum discharge rates are in gallons (liters) of water (not expanded foam) from all available discharge nozzles. See Table 1B for protein and fluoroprotein foam concentrate applications.

NOTE 2. When a premix foam-water system is used on a vehicle, recharge quantities shall not be required to be carried on the vehicle, but where a premix is not used, the minimum quantities of foam concentrate carried on each vehicle should be twice the quantities required for the water provided to permit continued operation if the vehicle is refilled with water once.

Table 2 — Heliport Fire Protection Recommendations

Heliport Category	Water for Foam Production Using Protein or Fluoroprotein Foam Concentrates††				Foam Compatible Dry Chemical (Rating)*	Additional Water for Foam if Heliport Is Elevated	
	Amount of Water		Total Rate of Discharge				
	Gallons	Liters	GPM	Liters		Gallons	Liters
H-1	None**	None**	None**	None**	2–80B:C Extinguishers	None**	None**
H-2	500†	1,900†	100	380	2–80B:C Extinguishers **or** 1–160B:C Wheeled Extinguisher	1000†	3,800†
H-3	1500†	5,700†	200 from two 100 gpm nozzles or from one mobile unit with a turret	760	2–80B:C Extinguishers **and** 1–160B:C Wheeled Extinguisher	1500†	5,700†

*See Standard on Installation of Portable Fire Extinguishers (NFPA No. 10; ANSI Z112.1).

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

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

††The quantity of water may be reduced one-third when aqueous film-forming foam concentrate is used.

not protrude into the normal approach-departure paths. These cabinets should be located diametrically opposite each other.

d. Foam nozzles shall be light in weight and capable of discharging foam, dispersed pattern foam, or water spray.

e. NFPA Standard on Roof-Top Heliport Construction and Protection (NFPA No. 418) should be followed, including construction, drainage and separators, landing deck egress, and fire protection for the structure.

f. Fueling on elevated heliports should be arranged and handled in accordance with the recommendations contained in Part VIII of the Standard for Aircraft Fuel Servicing (NFPA No. 407; ANSI Z119.1).

g. An automatic alarm should be provided to indicate foam system operation and to summon aid.

Article 400. Aircraft Rescue and Fire Fighting Vehicles and Personnel for Protection of Aircraft Operations

NOTE: Where climatic or geographic conditions exist that considerably reduce the effectiveness of wheeled vehicles, it is often necessary to carry extinguishing agents in a specialized vehicle such as track, amphibious, air cushion units, etc. At least 75 per cent of the agents required shall be carried on vehicles conforming to the requirements of NFPA No. 414 (ANSI B128.1) unless exceptional circumstances dictate otherwise.

410. Major Fire Fighting Vehicle Recommendations

411. These vehicles should be constructed to comply with the provisions of Part B of the Standard for Aircraft Rescue and Fire Fighting Vehicles (NFPA No. 414; ANSI B128.1).

412. It is desirable to have more than one such vehicle available to facilitate attacking aircraft fires from more than one point or quarter, or as an aid to expedite rescue. This applies particularly to the protection at conventional airports in Indexes 5 through 8 (see Table 1A). At airports served by only one vehicle extreme care should be taken to keep the vehicle in top operating condition and available at all times. At airports in Indexes 5 and 6 (see Table 1A) consideration should be given to providing the total quantity of water for foam production on two fire fighting vehicles; for Indexes 7 and 8, three fire fighting vehicles are preferred to two such vehicles with supplemental tank vehicles. The latter recommendation provides the advantage of reducing the number of vehicles and the manpower requirements.

NOTE: Having at least two fire fighting vehicles available is particularly important when dealing with transport type aircraft because: (1) of the need to cover rapidly any burning fuel spill and thus protect the aircraft and its occupants from radiated heat during the evacuation and rescue period, and (2) the need to make and maintain the area around the fuselage (see Paragraph 311) to permit the safe evacuation and rescue of the occupants. An analysis should be made to determine procedural policies for rescue, fire control and extinguishment prior to making a decision on the number of vehicles required, being realistic, at the same time, as to how the number of vehicles will influence manpower requirements and vehicle maintenance.

The fire control efficiency of each fire fighting vehicle is generally proportional to the foam-producing capacity of the unit and the rates of foam discharge available. As an example, in Index 7 two 2,500 gallon

(9,500 liter) capacity fire fighting vehicles would be preferable to two 1,500 gallon (5,700 liter) capacity units supplemented by a 2,000 gallon (7,600 liter) capacity tank vehicle.

413. The "payload" capacity (fire fighting and rescue equipment and manpower) of the vehicles used in this service should be compatible with the desired performance characteristics established for vehicles in the various weight classes specified in NFPA No. 414 (ANSI B128.1). It is particularly important that the vehicle not be overloaded to reduce the required acceleration, speed, or vehicle flotation (as measured by weight distribution on the tires) below the acceptable minimums set forth in the referenced document.

414. The off-pavement (runway or taxiway) performance of each specialized vehicle should be established by test at each airport during the variable weather and terrain conditions experienced at each airport to establish, prior to an actual emergency, the capabilities and limitations of the vehicle for off-pavement response to accident sites. In addition, periodic tests should be run to determine the maintenance of the other performance requirements of the vehicle as originally designed.

415. All essential vehicles (those designed to reach the scene first and the major units) should be provided with two-way radio facilities to assure communication opportunities with Airport Control. (See Section 460.)

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

417. Simplicity of vehicle operation (particularly operation of extinguishing agent discharge facilities) is highly important because of the time restrictions imposed upon successful aircraft rescue and fire fighting operations and the need to keep to the minimum the crew required. It must be remembered that fast blanketing of the fire area is essential. Hand hose lines are thus usually not enough for fires involving larger types of aircraft; elevated turrets, remotely controlled extension boom turrets, or similar devices having large discharge capacities are needed to quickly blanket the fire and knock down the bulk of the flames (see Par. 312.a.). Hand lines are used primarily for protecting rescue parties, for controlling the fire in the rescue area, and for spot cooling of the fuselage.

418. Improvements in vehicle and equipment designs over recent years have increased the fire fighting efficiency of such units and have made many older aircraft fire fighting vehicles comparatively less efficient. Before procuring any used vehicle for this service, the possible saving in initial cost should be carefully weighed against the lower maintenance cost, the reduced manpower requirements, and the greater fire fighting efficiency that can be expected from new equipment built in accordance with the Standard on Aircraft Rescue and Fire Fighting Vehicles (No. 414; ANSI B128.1). Foam fire fighting equipment purchased for this service should be tested in accordance with the NFPA Standard for Evaluating Foam Fire Fighting Equipment on Aircraft Rescue and Fire Fighting Vehicles (No. 412).

419. See also Section 450.

420. Light Rescue Vehicle Recommendations

421. The rescue vehicle(s) recommended in Table 1B should comply with Part C of NFPA No. 414 (ANSI B128.1). Operationally, the rescue vehicle should be the first unit to reach an accident site. It is considered extremely important that this vehicle be so designed that it can be operated and handled by one man and that this one man can place in operational readiness the extinguishing equipment while en route so that there will be no delay in placing the vehicle in service upon arrival. Experience has proven that the availability of such a vehicle has been most valuable in attacking fires in their incipient stages; in many cases, extinguishment or control has been achieved by this single unit prior to the arrival of the larger fire fighting vehicles and in other cases, a successful holding action has been accomplished. The amount of agent carried on this light vehicle (normally foam-compatible dry chemical) will depend on its load capacity, but extreme care should be exercised to prevent overloading the vehicle and thus detracting from its acceleration, speed, flotation and traction capabilities. (See Paragraph 415 and Section 460 with regard to communications equipment.)

422. Rescue tools (see NFPA No. 414; ANSI B128.1) should be carried by this vehicle. Caution should be exercised in connection with this recommendation, however, that the addition of the rescue tools does not overload the vehicle or interfere with the vehicle's performance. In cases where it is not possible to carry the desired rescue tools on this vehicle without overloading the unit, it is recommended that a separate vehicle having the same performance capability be provided, equipped with the rescue tools and equipment designed to aid in the evacuation of crews and passengers from aircraft in distress.

423. See Paragraph 418 and Section 440.

430. Water Tank Vehicle Recommendations

431. Water tank trucks (sometimes referred to as "Nurse Trucks") are designed to augment the quantity of water available on the fire fighting vehicles. Since the function of water tank vehicles is to replenish the water supplies of the fire fighting vehicles, tank vehicles should be designed in accordance with Part D of the Standard for Aircraft Rescue and Fire Fighting Vehicles (NFPA No. 414; ANSI B128.1). The operational purpose of these vehicles will dictate their performance needs in each instance with the overall concept of their being able to maintain the fire fighting capability of the fire fighting unit(s) without interruption at the discharge rates of the latter equipment as long as the water supply permits.

432. Water tank trucks should be equipped with a pump or pumps and hose for relaying water to the fire fighting equipment or for direct application on the fire. It is desirable that pumps have sufficient capacity to replenish the fire fighting vehicle having the largest rate of discharge when that vehicle is operating at maximum capacity. Proper type and sufficient quantity of hose should be provided to transfer the water content of the tank vehicle to the major rescue and fire fighting vehicle.

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

434. See also Section 450 and Paragraph 418.

440. Combined Agent Vehicle Recommendations

441. This type vehicle should be constructed to comply with the provisions of Part E of the Standard for Aircraft Rescue and Fire Fighting Vehicles (No. 414; ANSI B128.1). It is primarily designed to serve as the prime fire fighting vehicle for Index 2 airports (see Table 1B) but may be suitable as an alternate for a Light Rescue Vehicle (see Section 420) for airports in higher Indexes.

442. The fire fighting systems employed on this type vehicle may be of several different types. In most cases, such vehicles are designed to carry approximately 300 gallons (1,140 liters) of water for foam production and 300 pounds (135 kilograms) of foam-compatible dry chemical. When used as the sole rescue and fire fighting unit on an airport, the provision of a foam or twinned-agent turret is recommended; when used as a Light Rescue Vehicle, such a turret is not required.

450. Recommendations for Fire Fighting Equipment on Vehicles

451. No attempt is made here to detail water pump capacities, pump inlet and outlet plumbing, foam proportioners and controls, the location of elevated nozzles and their operation, hose reel locations, or other design details of foam or supplementary agent equipment mounted on the equipment provided. It is recognized that all these items require careful engineering and that the details of the fire control equipment must be compatible with the discharge rates recommended in the Tables, the manpower available in each instance, and the objective of providing maximum capability for the vehicles in their primary function of rescue. [See Standard for Aircraft Rescue and Fire Fighting Vehicles (NFPA No. 414; ANSI B128.1) for fire fighting equipment recommendations.]

452. Vehicles provided for this service should be designed to permit uninterrupted pump discharge even when maneuvering the vehicle during the rescue operation. This may be accomplished by providing an independent pumping engine(s), or, if the vehicle engine(s) is (are) also used for pumping, by providing a specially designed transmission or engine-powered take-off. Use of such a transmission or power take-off should not result in more than a slight decrease in pump pressure, as well as not interrupting extinguishing agent discharge while vehicle movement is being accomplished. (See Section 31 of Part B of NFPA No. 414; ANSI B128.1.)

453. Optimum benefits are normally achieved with mobile equipment by approaching aircraft fires from the windward position but this is not always possible. This dictates that turrets and hand lines should be so located and operable over such a range as to be of maximum utility and not conflict with each other. (See Sections 335 and 336 of NFPA No. 414; ANSI B128.1 for details.)

454. At airports adjacent to water or swampy areas or where snow, ice or unusual terrain may affect fire and rescue activities, special consideration should be given to these factors (see Article 600 — Water Rescue Facilities).

460. Communications and Alarms Recommended

461. The provision of two-way radio communication, special telephone and general alarm systems is recommended between Airport Control and the Airport Fire Station. Dependable transmission of essential emergency signals is a vital necessity. Mobile vehicles considered essential for the effective rescue and fire fighting service should be provided with two-way radio equipment (see Paragraph 415). Consistent with the individual situations at each airport, communication and alarm equipment should serve the following purposes:

a. Provide for direct communication between Airport Control and the Airport Fire Station to ensure the prompt alerting and despatch of rescue and fire fighting vehicles and personnel in event of an alert or incident.

b. Provide for emergency signals to ensure the immediate summoning of auxiliary personnel not on stand-by duty at the Airport Fire Station (see Paragraph 154 and NFPA No. 402).

c. As necessary, provide for the summoning of cooperating public protective agencies (public fire departments, ambulance and medical services, police or security personnel) and others located on or off the airport. (See NFPA No. 402.)

d. Provide for communication by means of two-way radio on all aircraft rescue and fire fighting vehicles.

470. Related Airport Features

471. The installation of underground water service mains with either conventional or flush type hydrants along aprons and adjacent to administration and service areas is recommended. Underground water service mains for the movement area are also desirable.

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

NOTE: For further guidance on Airport Water Supplies, see NFPA Recommended Practice for Master Planning Airport Water Supply Systems for Fire Protection (No. 419 — 1969).

473. Depending on the location of the airport and local topography, consideration should be given to the provision of suitable quick exits around the perimeter of the airport for aircraft rescue and fire fighting vehicles and to provide good approaches to access roads beyond the airport boundary for as far a distance as is necessary or practical. Particular attention should be given to the provision of ready access to the undershoot and overrun areas.

474. Aircraft rescue and fire fighting vehicles normally should be garaged at a central station. (See also Article 100 of NFPA No. 402.) The station apparatus section should be heated (where necessary) to assure immediate starting of garaged vehicles and should be located so:

a. That access to the movement area is unobstructed.

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

c. That visibility of flight activity is normally obtainable.

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

e. That direct communication with Airport Control be available.

480. Personnel Recommendations

481. All personnel provided for aircraft rescue and fire fighting duties should be fully schooled in the performance of their duties under the direction of a designated Chief of Emergency Crew.

482. Personnel: Men recruited for aircraft rescue and fire fighting services should be of a high physical and mental standard, resolute, possess initiative, competent to form an intelligent assessment of a fire situation and, above all, must be well trained and fully qualified. Ideally, every man should be capable of sizing up changing circumstances at an aircraft accident and to take the necessary action without detailed supervision. Where, of necessity, the available manpower displays limited capacity to use initiative, the deficiency must be made good by the provision of additional supervisory staff of a superior grade who will be responsible for exercising control of their crews. The officer responsible for the organization and training of the fire service should be an experienced, qualified and competent leader.

483. In the interest of providing immediate response capabilities of all vehicles recommended in Table 1B or 1C, the following *minimum* manpower shall be provided during flight operations:

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

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

b. A fully qualified driver-operator for each of the other vehicles provided to meet the recommendations in Table 1B or 1C for airports in Indexes 3 through 8.

c. A fully trained turret operator for each major fire fighting vehicle recommended in Table 1B or 1C for airports in Indexes 3 through 8.

NOTE: Where all the water requirements recommended in Table 1B or 1C are carried on fire fighting vehicles, it is not considered necessary to furnish a separate turret operator for each such vehicle beyond those scheduled for immediate response requirements.

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

d. In order to determine training and qualifications of the fire fighting personnel, refer to Training Procedures outlined in Article 800.

484. Movement and utilization of aircraft rescue and fire fighting equipment and of other emergency equipment at the time of emergency should be governed by the principles set forth in "Standard Operating Procedures, Aircraft Rescue and Fire Fighting" (NFPA No. 402).

485. It is recommended that equipment be manned and placed at predetermined emergency stations on the movement area

---

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

prior to any landing or take-off attempted under any abnormal flight or weather conditions which might increase the accident potential during such operations.

486. All authorized personnel should be given suitable identifying insignia to prevent any misunderstanding as to their right to be in the fire area or on the movement area of an airport during an emergency.

490. Protective Clothing.

491. It is essential that adequate protective clothing and equipment be provided, maintained and readily available for use. There are two types of protective clothing available for use by airport fire departments which are:

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

b. Proximity Suits. There are two kinds:

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

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

492. Although there is seldom need for the fire fighter to enter the flames, he must be provided with clothing that will withstand radiant heat and occasional direct flame contact. The suit should, therefore, provide thermal insulation, be noncombustible, waterproof, lightweight, be free of bulky incumberances, provide freedom of movement, be comfortable, easily donned without the aid of a second person, and be compatible with self-contained type breathing equipment. The fabrics used should be lightweight, not bulky, and flexible with tear-resistant qualities. They should be abrasion-resistant and have high-temperature resistance. All seams should be waterproof. If pockets are provided, a small hole should be left in the bottom corners for water drainage. Fastenings should be heat and flame resistant and not yield under stress. They should be easily accessible under emergency conditions and capable of being operated while wearing gloves.

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

494. Head Protection. A helmet with a wide-vision face shield should provide the wearer with the best ocular and aural awareness and some heat sensitivity. A helmet should not produce a sense of isolation to the wearer; should provide adequate protection from impact; should be resistant to penetration and electric shock; should be adaptable for one- or two-way radio communication; and should provide thermal stability. An abrasion- and impact-resistant movable visor is advisable. If the helmet incorporates radio equipment, an identification number should be applied on the helmet exterior in a contrasting color to facilitate communication under operational conditions. If a conventional fire hood is used in lieu of a helmet, it should be vented. Some hoods can be dangerous because of entrapment and rebreathing of used air.

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

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

497. Protection Requirements.

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

(1) Occasional flame contact.
(2) Radiant heat of 0.7 cal/cm²/sec for two minutes.*
(3) Raidant heat of 1.9 cal/cm²/sec for one minute.*
(4) Impact resistance from sharp objects.
(5) Water.
(6) Electric Shock.

b. The entire suit should be capable of cleaning without deterioration of the properties listed in 497.(a).

498. Respiratory Protection Equipment. Recent tests have shown that many toxic gases are produced when aircraft cabin interior finish materials are burned or charred. These gases include carbon monoxide, hydrogen chloride, chlorine, hydrogen cyanide and other cyanogen compounds, and carbonyl chloride (phosgene). A principal cause of difficulty lies in the fact that the supply of breathing air is greatly reduced by combustion of these cabin finish materials. It is, therefore, necessary that fire fighters and rescue men who enter on aircraft during the fire sequence be equipped with self-contained breathing equipment. Their helmets or hoods should be designed to accommodate this equipment without interference; most existing proximity hoods do not have this provision. Self-contained breathing equipment should be of the type approved by the U.S. Bureau of Mines and must meet the requirements of the NFPA Standard on Respiratory Protective Equipment for Fire Fighters (No. 19B). Those utilizing the principle of canister generation of oxygen are sometimes unsatisfactory in atmospheres containing high concentrations of fuel vapor. Self-contained breathing equipment should be designed for an average operational time of thirty (30) minutes and should contain an audio/visual warning device to actuate when the air supply is nearing exhaustion. They should be compatible with the hood or helmet and be capable of rapid actuation. Each face mask must provide an air-tight seal on the wearer's face, be comfortable to wear, and provide clear vision through the lens. Facial hair, particularly side-burns and beards, may interfere with proper mask fit, resulting in wasted air, and possible inflow of toxic gas. Spectacles may also interfere. As a standard procedure, each individual wearing a mask should be required to don the mask, seal off the air supply tube, and by inhaling for at least 10 seconds assure that the face piece seals properly.

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

Article 500. Ambulance and Medical Facilities

510. Provision for Ambulances

511. The availability of ambulance and medical facilities for the removal and after-care of casualties arising from an aircraft accident should receive the careful consideration of airport managements and should form part of the overall emergency plan established to deal with such emergencies.

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

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

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

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

520. Organization of Medical Assistance Program

521. The provision of a first aid room on the airport for the reception and treatment of casualties may be desirable. Such a room should be equipped to the standard considered necessary to meet the local requirement which will of course take into account the availability and proximity of hospital services with whom predetermined arrangements should exist for the reception and handling of casualties arising from an aircraft accident.

522. The emergency plan should provide for the summoning of doctors in the event of an accident and for the recruitment and training in first aid of as many people as possible from airport staffs who may be prepared to undertake such duties either on a voluntary basis or on such other basis as may be determined locally. It is especially desirable that personnel manning ambulances should be trained in medical first aid (see Paragraph 154).

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

Article 600 — Water Rescue Facilities

610. Provisions for Rescue Service

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

612. Many aircraft do not carry flotation devices on board, especially those not engaged in extensive overseas operations. Facilities should be provided, in this instance, for the maximum number of passengers in the largest scheduled aircraft serving the airport. Where the largest aircraft is in scheduled overseas operation and all other operations are overseas in character, the airport may reduce the amount of flotation devices by 50 percent.

613. Special rescue vehicles are available such as helicopters, boats, air cushion or amphibious vehicles. Consideration of unusual terrain and water conditions, such as tidal flats, swamps and the like, may dictate the choice of the particular type vehicle most suitable to these conditions.

620. Rescue Boats

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

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

623. The boats should be of such size as to efficiently carry the flotation equipment required with adequate space for the crew and sufficient working space to permit rapid dispersal of the flotation devices. Inflatable life rafts should be the prime flotation equipment carried, and there should be an adequate number of life rafts to accommodate the largest aircraft occupancy served by the airport (see Paragraph 612 herein). Once this flotation equipment has been dispensed, the space in the boat used to carry it should be such that it would accommodate a limited number of litter cases brought aboard in the process of rescue.

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

625. A minimum of two floodlights should be provided for night operations.

Article 700. Reports

710. NFPA Reports

711. Each operation of aircraft rescue and fire fighting equipment should be carefully reported and analyzed and one copy of each such report should be sent to the National Fire Protection Association, 470 Atlantic Ave., Boston, Ma 02210. Copies of the NFPA's Aircraft Fire Report form are available from the Association.

712. To guide those studying aircraft accidents, the NFPA Aircraft Fire Investigators Manual (NFPA No. 422M) should be secured and the techniques recommended therein utilized.

Article 800. Training Procedures
Aircraft Rescue and Fire Fighting Personnel at Airports

810. Introduction

811. Instances when personnel whose protection duties consist solely of the rescue and fire fighting services for aircraft movements are actually called upon to face a serious situation involving major rescue and fire fighting operations are relatively infrequent. Normally, they will experience numerous standbys to cover ramp and other aircraft movements and servicing operations (under circumstances where the possibility of a serious accident may reasonably be anticipated) plus a few actual minor incidents. Under such conditions they are seldom called upon to put their full knowledge and experience to a supreme test. It follows, therefore, that only by means of a most carefully planned, and rigorously followed program of training can there be any assurance that both men and equipment will be able to deal with a major aircraft fire should the necessity arise.

812. Training of aircraft rescue and fire fighting personnel falls into two broad categories: (1) basic training in the use and maintenance of equipment (see Section 830); and (2) tactical training which covers the deployment of men and equipment to accomplish control of a fire to permit rescue operations to proceed (see Section 840). In addition, training of "mutual aid" support personnel is essential (see Section 850).

820. The Training Program

821. The officer responsible for the training program must endeavor to maintain the interest and enthusiasm of his crews at all times. In certain respects this will not be too difficult. There are so many factors affecting aircraft rescue and fire fighting procedures which, as far as possible, must be anticipated, staged and practiced, that the officer has an opportunity of sustaining the interest of his students indefinitely. Each new type of aircraft using the airport brings with it new problems which must be assessed and incorporated into the training program. Other more routine aspects of training become less interesting over a long period and here it is essential that the officer should ensure that each man realizes to the full the need of such training. For example, it is a fundamental practice in the rescue and fire fighting service that each man satisfies himself, when on duty, that the equipment he may be called upon to use is serviceable. This particular aspect of a man's duty could deteriorate after a long period of comparative inaction unless the man is really convinced of the importance of this task. The entire training program must be designed to ensure that both men and equipment are at all times fully efficient. This represents a very high standard to achieve but anything less than full efficiency is not only not good enough but may be dangerous both to those in need of aid and those who are seeking to give such aid.

830. Basic Training

831. Fire and Fire Extinguishment: All rescue and fire fighting personnel should have a general knowledge of the causes of fire, the factors contributing to spread of fire and the principles of fire extinguishment. Only when armed with such simple knowledge can they be expected to take intelligent action when confronted with a serious fire situation. It must be known, for instance, that certain types of fire require a cooling agent while others need blanketing or smothering action, and equally, that certain of the media used extinguish by cooling, while others blanket or smother a fire (see Article 200). The scope of instruction will vary with the intelligence of the trainees. In most cases, the simpler this instruction is kept, the more successful it is likely to be. In no case should enthusiasm, engendered by the interest value of the subject, be allowed to carry the instruction beyond its practical application.

832. Types of Extinguishing Agent Employed: It is essential that the agents employed shall be thoroughly understood. In particular, every opportunity should be given to use the agents on actual fires to understand by experience not only the virtues but also the limitations of each agent. Each routine equipment test should be used as a training exercise in the proper handling of the equipment and the correct application of the particular agents involved. [See Standard for Evaluating Foam Fire Fighting Equipment on Aircraft Rescue and Fire Fighting Vehicles (NFPA No. 412).]

833. Handling of Equipment: All rescue and fire fighting personnel must be capable of handling their equipment, not only under drill ground condition, but also in rapidly changing circumstances. The aim must always be to ensure that every man is so well versed in the handling of all types of equipment that, under stress conditions, he is able to operate it in an automatic manner. This can be accomplished in the initial state of training by employing the "change-round" technique during standard drills, and later by training involving the use of two or more pieces of equipment simultaneously. Particular attention should be paid to actual operation. This form of training is, of course, a continuing commitment.

834. Care of Equipment: A thorough knowledge of all equipment is essential in order to ensure its intelligent handling and to ensure thorough maintenance which is essential to guarantee operational efficiency under all circumstances. It is important that every fire fighter shall satisfy himself that any pieces of equipment which he may be called upon to use will work satisfactorily and, in the case of auxiliary equipment, that it is in its correct storage position. The importance of correct storage of small equipment to ensure that it can be instantly located cannot be overstressed. Officers responsible for training are advised to hold periodic compartment drills when individual crew members are required to produce immediately a particular item. All rescue and fire service equipment must be regularly tested or inspected and careful records must be maintained of the circumstances and results of each test. Some items of equipment can be repaired locally and training in such subjects should be provided.

835. Local Terrain: A thorough knowledge of the airport and its immediate vicinity is essential. Training should include instruction in the use of alternative routes where obstacles, natural or artificial, may be encountered. The existence in any part of the area of ground which may from time to time become impassable should be known to all crew members and, where these features are not permanent, arrangements should be made for the current circumstances to be made widely known. Each man must have a complete knowledge of the availability of local water supplies.

836. Aircraft Familiarization Training: The importance of this aspect of training cannot be overemphasized. Rescue and fire fighting personnel may be called upon to effect a rescue from an aircraft interior under adverse conditions, working in an atmosphere heavily laden with smoke and fumes. (If self-contained breathing apparatus is supplied careful training in its use is essential.) It is also essential that every man should have an intimate knowledge of all types of aircraft normally using the airport. This knowledge cannot be acquired solely from a study of diagrams which are issued by many operators. There is no substitute for a periodic inspection of the aircraft, paying particular attention to position and locking mechanism of all exits, both normal and emergency, and to the internal layout and seating arrangements. So far as is practicable, fire fighters should be allowed to operate the emergency exits and certainly should be fully conversant with the method of opening all the main doors. An elementary knowledge of aircraft construction is highly desirable since such knowledge is invaluable if, as a last resort, forcible entry is necessary. The cooperation of the engineering staff of the aircraft operators should be sought on this aspect of training.

837. First Aid: Every member of the rescue team should be trained and periodically requalified in first aid. The prime reason for this qualification is to insure that casualties are intelligently handled so that injuries are not needlessly aggravated.

838. Search and Rescue

a. The training program should provide instruction in search procedures, not only in enclosed spaces of an aircraft, but also for procedures for systematic searching of the area in the immediate vicinity of an aircraft accident and also in the path of the aircraft.

b. As a broad principle, it should be taught that the persons involved in a fire are most frequently found near an exit, *i.e.*, doors and windows, or in lavatories and compartments, etc.

c. Rescue is always best effected by way of a normal channel, if available. For example, it is easier to carry a person through a doorway than to manipulate him through a window. The main cabin door of an aircraft should always be attempted first. Should the door be jammed it will usually be found quicker to force it by applying leverage at the right spot than to achieve entry and rescue through another form of opening. Success in this form of operation requires a full knowledge of the locking mechanism and direction of travel of the door concerned. Forcible entry through other than normal channels should only be attempted when it is obvious that regular means cannot be employed. Pressurized cabins offer tough resistance to penetration by an axe or even power-operated saws. Properly designed axes and power saws are of value in making forcible entry, in some cases, but expert knowledge in handling such tools is a prime requisite to successful use in an actual emergency.

d. All fire fighters should be trained in rescue procedures. The working space inside a cabin is necessarily somewhat restricted and it will generally be found advisable to restrict the number of rescuers working inside the aircraft and work on a chain or "buddy" principle.

e. Where possible, the airport emergency organization should provide for the availability of personnel other than rescue and fire fighting personnel, for the handling of casualties from the moment they are removed from the aircraft (see Section 154).

f. All rescue personnel should be trained in fireman's lift and other forms of rescue.

840. Tactical Training

841. When personnel are well versed in the handling of fire fighting equipment they should receive training in tactics to be adopted at aircraft fires. Teamwork is a primary essential.

842. This training is a continuing commitment and must be absorbed to the point where compliance with the initial action called for is automatic, in the same sense that hose-laying to a well-trained fire fighter is automatic and will, therefore, follow even when working under stress. Only when this is achieved, will the officer-in-charge be in a position to assume complete control of the situation.

843. Tactical training is designed to deploy men and equipment to advantage in order to establish conditions in which people may be rescued from an aircraft which is involved in, or liable to become involved in, fire. The object is to isolate the fuselage from the fire, cool the fuselage, establish and maintain an escape route and achieve the degree of fire control necessary to permit rescue operations to proceed. This is fundamental and must be stressed in the training program. The service to be provided is primarily life saving but the personnel must be trained in fire fighting because aircraft involved in a serious accident frequently are involved in fire simultaneously. Until all the occupants of the aircraft are accounted for, fire fighting operations must be directed to those measures which are necessary to permit rescue to be carried out. This includes fire precautionary measures at those incidents where no fire has broken out. When the life saving commitment has been met it is necessary, of course, to utilize all available resources to secure protection of property.

844. The main attack on the fire will normally be by means of mass application of foam or, alternately, by the combined use of foam-compatible dry chemical or carbon dioxide and foam. Where foam alone is used as the principal agent a suitable back-up agent must be available to deal with pockets of fire which may be inaccessible to direct foam application. This will generally be provided in the form of dry chemical or carbon dioxide extinguishing agents to be used on running liquid fuel fires or in enclosed spaces, such as wing voids, in an engine nacelle, or wheel well. (See Article 200.)

845. The following points should be covered in the tactical training program:

a. The Approach: Equipment should approach the incident by way of the fastest route in order to reach the incident in the shortest possible time. This is quite frequently not the shortest route as, speaking generally, it is preferable where possible to travel on a paved surface than to approach over rough ground or grassland. Equipment recommended for this service is basically designed for on- and off-pavement service* but speed is vital and the quickest route, rather than necessarily the most direct route, is the one to be selected. When nearing the scene of the incident a careful watch must be maintained for occupants who may be dashing away from the aircraft or who may have been thrown clear and are lying injured in the vicinity. This applies particularly at night, of course, and calls for intelligent use of spot or floodlights.

b. Positioning of Equipment: The positioning of equipment, both airport and assisting equipment, is important in many respects and regard should be had to the following factors: The equipment operator must be in a position to view the fire ground; the equipment must not be placed in a position of hazard due to spillage of fuel or due to slope of ground or wind direction; no one unit should deny approach to the scene for other emergency vehicles, such as ambulances; equipment must be positioned to operate effectively on the fire, particularly as regards rescue operations, but not be so positioned that it might be trapped by fire.

c. Positioning of Light Rescue Vehicle(s):

(1). Normally, the light rescue vehicle (see Section 420) reaches the accident site first and is used to initiate rescue and fire fighting at the earliest possible moment. Hopefully, the mission of its crew is to prevent fire outbreak and initiate rescue operations, to control or extinguish the fire in its incipient stage to permit rescue, or, alternately, to try to secure a rescue path, to size up the rescue and fire fighting problem and to be in a position to direct the positioning of the major vehicles upon arrival.

(2). The light rescue vehicle should be positioned to permit the most rapid access to the principal egress route from the aircraft in distress except when it is obvious that occupants are evacuating safely without assistance and the fire or threat of fire is otherwise located.

(3). Since the light rescue vehicle has limited extinguishing capability, caution must be taken to avoid placing the vehicle in untenable locations in event of sudden extension of the flame

*See Standard for Aircraft Rescue and Fire Fighting Vehicles (No. 414; ANSI B128.1).

front or an explosion. After the vehicle's extinguishing capacity has been exhausted and assuming incomplete control, the vehicle should be withdrawn from a position which might be subsequently occupied to advantage by later-arriving fire fighting equipment.

d. Position of Major Fire Fighting Vehicles:

(1). Major units equipped with turrets for the mass application of the extinguishing media should be positioned as to make effective use of the turret streams. It is vitally important to avoid wastage of the limited amounts of agent available so that turrets should be used only when they are being effective. Frequently, hand lines control the rescue paths so it is equally important to locate equipment to permit the effective employment of these lines. Proper positioning of apparatus is, in fact, often the key to successful operations.

(2). The main initial object is to safeguard the escape routes. The type and number of nozzles available will vary with the type and the scope of the equipment provided. NFPA Standard Operating Procedures, Aircraft Rescue and Fire Fighting (No. 402), Appendix A, illustrates some useful techniques.

(3). The initial discharge of foam should cover and be along the line of the fuselage and then directed to drive the fire outwards. When selecting the best position to accomplish this purpose, always remember that the wind has considerable influence upon the rate of fire and heat travel. The position should be chosen with this in mind, thus utilizing the wind, whenever possible, to assist in the main objective. Except in unusual circumstances hose streams should not be directed towards the fuselage at right angles as this may tend to drive burning fuel toward the occupied areas handicapping survival of trapped occupants. Similarly, care must be exercised to avoid the possibility of disturbing a foam blanket by the careless application of additional foam or any other agent. Foam should always be laid on a liquid fuel fire so that it gently forms a blanket with the least possible turbulence to the fuel surface.

(4). There are two basic methods of applying foam. One involves the use of a straight stream which can be applied directly or indirectly on a surface at some distance. The second is to use a spray or diffused stream at close range. This has the advantage of simultaneously insulating the fuselage by building up a foam cover. Whenever foam equipment is being subjected to a periodic routine check the opportunity should be taken to train crew members in these methods of application.