U.S Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: AIRCRAFT FIRE AND RESCUE FACILITIES AND EXTINGUISHING AGENTS

Date: 1/28/85 **Initiated by:** AAS-100

AC No: 150/5210-6C **Change:**

1. PURPOSE;- This advisory circular (AC) outlines scales of protection considered as the recommended level compared with the minimum level in Federal Aviation Regulation Part 139.49 and tells how: these levels were established from test and experience data; to apply a systems approach in determining the overall needs for various airports; and to use conversion factors for estimating the equivalency between various fire extinguishing agents.

2. CANCELLATION. Advisory Circular 150/5210-6B, Aircraft Fire and Rescue Facilities and Extinguishing Agents, dated January 26, 1973, is cancelled.

3. RELATED READING MATERIAL.

a. AC 150/5000-4A, Announcement of Availability, Airport Research and Technical Reports, FAA-AS-71-1, Minimum Needs for Airport Firefighting and Rescue Services, current edition.

b. AC 150/5210-7B, Aircraft Fire and Rescue Communications, current edition.

c. AC and Rescue Equipment Building Guide, current edition.

d. AC 150/5210-12, Fire and Rescue Service for Certificated Airports, current edition.

e. AC 150/5220-10, Guide Specification for Water/Foam Type Aircraft Fire and Rescue Trucks, current edition.

f. AC 150/5220-14, Airport Fire and Rescue Vehicle SpecificationGuide, current edition.

g. AC 150/5325-5B, Aircraft Data, current edition.

h. FAR Part 139, Certification and Operations: Land Airports Serving Certain Air Carriers.

4. HOW TO ORDER.

a. Copies of FAR Part 139 may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

b. Copies of National Fire Protection Association (NFPA) Standard No. 412, Evaluating Foam Fire Equipment Aircraft Rescue and Fire Fighting Vehicles, may be ordered from the National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269.

c. Report No. FAA-RD-71-57, Evaluation of Aircraft-Ground Fire Fighting Agents and Techniques, is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

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CHAPTER 1. BACKGROUND AND RESEARCH WORK

1. GENERAL. Chapter 1 contains information on research work done by the FM and the evolvement of criteria on the scales of protection developed by the ICAO Rescue and Fire Fighting Panel (RFFP II). Chapters 2 and 3 outline a systems approach to airport fire fighting and rescue services. Chapter 4 contains guidance on fire extinguishing agents, equivalency ratings of extinguishing agents, information on substitution of agents and suggestions on quality control.

2. THE THEORETICAL CRITICAL FIRE AREA. From research and experimental work done by the FAA at NAFEC, a "theoretical critical fire area" has been determined (AC 150/5210-12). This theoretical area is defined as the area adjacent to the fuselage extending outward in all directions to those points beyond which a large fuel fire would not melt an aluminum fuselage regardless of the duration of the fire exposure time.

   a. On the basis of the NAFEC work, the ICAO RFFP II has also developed what is considered as a working definition of the theoretical fire area as being the area adjacent to an aircraft in which fire must be controlled. This refers to control of the fire within an area determined from the formulas in paragraph b. below to ensure temporary fuselage integrity and provide an escape area for aircraft occupants.

   b. The theoretical critical area serves as a means for categorizing aircraft in terms of the magnitude of the potential fire hazard in which they may become involved. It is not intended to represent the average, maximum or minimum spill fire size associated with a particular aircraft. The formulas for calculating the theoretical critical fire area for different sizes of aircraft are given below and the results of these calculations for the various indexes are presented in paragraphs 6 and 17.

      TC = L x (100' + w) when L is more than 65 feet, and

      TC = L x (40' + w) when L is less than 65 feet

      where TC = the theoretical critical area

      L = the average length of the aircraft and

      w = the average width of the aircraft fuselage

3. THE PRACTICAL FIRE AREA.

a. From a study made for the FM by an independent engineering consulting firm (AC 150/5000-4A), it was determined that in survivable aircraft. crashes, a "practical fire area" should be considered which was smaller than the theoretical area. As a result, RFFP II developed-material indicating the practical area to be approximately two- thirds the theoretical area.

b. Details of the practical fire area and the related quantities of extinguishing agents are based'& criteria formulated during the Second Meeting of the ICAO Rescue and Fire Fighting Panel (RFFP II) in June 1972. Work of the Panel in developing their material included a study of extinguishing agents used on actual aircraft fires. In 99 out of 106 such fires, the quantities of agents used were less than those previously recommended by RFFP I, substantiating the requirement for the reduced quantities recommended in this circular compared with those previously considered by RFFP I.

4. DATA ON QUANTITIES OF EXTINGUISHING AGENTS.

a. Control and Extinguishment Time. The quantities of extinguishing agents, application rates, etc., in this circular were based on consideration of the following:

(1) Control Time. Time required from arrival of the first fire fighting vehicle and the beginning of agent discharge to reduce the initial intensity of the fire by 90 percent. It is considered that the equipment and techniques to be used should be capable of controlling the fire in the practical critical area in one minute. A control time not exceeding one minute has been achieved in the majority of the aircraft accidents as noted in reports collected by the Rescue and Fire Fighting Panels.

(2) Extinguishment Time. Time required from arrival of the first fire fighting vehicle to extinguish the fire completely.

(3) Actual Control or Extinguishment. Complete extinguishment of the fire is a highly desirable objective because of the possibility of occupants being trapped inside the aircraft. However, from a practical standpoint it is considered necessary that substantial control of the fire be achieved in order for occupants to escape or be rescued.

b. Application Rates.

(1) Protein Foam. Insofar as protein foam is concerned, an application rate of 0.20 U.S. gal/min/ft^2 has been established as the rate for single agent attack at which control can be achieved within one minute under a wide variety of simulated accident conditions. Experiments on dual agent attack with simultaneous discharge of both a primary agent (foam) and a supplementary agent (dry chemical powder, or halocarbon (vaporizing liquid agents)) have shown that the total agent requirement by weight to obtain a one-minute control time, is essentially the same as that for a single agent attack. Therefore, it has been established that the combined agent application rate by weight for dual agent attack should be the same as that for single agent attack with foam.

(2) Aqueous Film Forming Foam (AFFF). The application rate for AFFF to obtain fire control within one minute has been determined to be 0.13 U.S. gal/min/ft^2 under a wide variety of simulated accident conditions.

C. Discharge Rate. The discharge rates (gallons per minute) in paragraph 7 were calculated to obtain a one-minute control time on the practical fire area. The discharge rate for each airport index was therefore determined by multiplying the practical area by the application rate.

d. How Quantities of Foam Extinguishing Agents Were Determined. Consideration of experience and test data indicate the t 'the quantities of agents needed to control and extinguish the fire should be determined separately. The first quantity (Q_1) is the amount of foam required to 'obtain a one-minute control time in the practical critical area, while the second quantity (Q_2) is that required for continued control of the fire after the first minute of application and/or for complete extinguishment of the fire. Thus, the quantity (Q) as shown in Table 2, page 7, and Table 4, page 15, was found by the formula: $Q = Ql + Q_2$.

(1) Quantity (Q_1). This quantity of solution has been calculated by multiplying the practical critical area by the foam solution application rate and by one minute. As previously noted, the practical critical area was computed as two-thirds of the theoretical area..

(2) Quantity (Q_2). This amount of additional foam solution is needed in order to maintain the established foam blanket and/or to extinguish the fire in the practical critical fire area. Q_2 depends upon several factors such as state of the fire after the initial attack, the appropriate application rate for the fire area and the duration of the containment phase. Since numerous variables are involved, this quantity has been determined from test data and analyses of actual aircraft rescue and fire fighting operations to be a percentage factor of Q_1 as listed below:

(a) For the General Aviation Indexes, listed under paragraph 18, the percentage factors for determining Q_2 are: 22 percent for Index 1; and 37 percent for Index 2.

(b) For Airport Indexes "A" through "E"[1/] listed under paragraph 7, percentage factors for determining Q_2 are: 66 percent for Index A; 100 percent for Index B; 129 percent for Index C; 152 percent for Index D; and 170 percent for Index E.

(3) As an example, in determining the Quantity (Q) needed for Index B, note that in paragraph 4b(2) 1) the application rate for protein foam is 0.20 gal/min/ft^2 and the practical critical area is 7,959 square feet. Therefore, the quantity of water for,protein foam solution was determined as follow::

7,959 practical fire area
.20 solution application rate gal/min/ft^2
1591.80 = Q_1 x 1 minute
1.00 percentage factor for Q2
1591.80 = Q_2

Thus, Q = 1592
+1592
3184 gallons

[1/] The index is established by consideration of the longest aircraft used by an air carrier at an airport.

CHAPTER 2. AIRCRAFT FIRE FIGHTING AND RESCUE SYSTEM NEEDS FOR AIRPORTS SERVING CAR-CERTIFICATED AIR CARRIERS

5. ITEMS COMPRISING THE SYSTEM. The items in this chapter are recommended for a complete and workable system. It is intended that they be considered in overall planning, initial purchasing of equipment or in purchasing equipment to complement that already owned by airports. The systems approach to airport fire fighting and rescue services should assure that complete and workable "turnkey" units are specified and provided on airports. The items in this sys tern include:

   a. The quantities of extinguishing agents suggested for the applicable airport index;

   b. The fire trucks as needed to support the system, based on factors outlined in paragraph 8; and

   c. The materials and equipment needs which comprise a sub-system on the trucks such as tanks and cylinders full of extinguishing agents, plus miscellaneous safety equipment, communications equipment, and fire fighter protective clothing.

6. TABLE 1. AIRCRAFT DIMENSIONS, THEORETICAL[1] AND PRACTICAL FIRE AREAS FOR INDEX "A" THROUGH "E" AIRCRAFT.

1 [2] Index	2 Overall Length Lower Limit (Ft.)	3 Overall Length Upper Limit (Ft.)	4 Average Length (Ft.)	5 Average Fuselage Width (Ft.)	6 Theoretical Area (Sq. Ft.) /Col. 4 x (100 + Col.5)/	7 Practical Area (Sq. Ft.) (.67 x Col.6)
A	60	90	75	10	8,250	5,527
B	90	126	108	10	11,880	7,959
C	126	160	143	10	15,730	10,539
D	160	200	180	20	21,600	14,472
E	200	--	225	20	27,000	18,090

[1] As previously noted, the formula for the theoretical critical area is:

TC = L x (100' + w) when L is more than 65 feet, and

TC = L x (40' + w) when L is less than 65 feet

where TC = the theoretical critical area

L = the average length of the aircraft and

w = the average width of the aircraft fuselage

Using this formula, the theoretical critical area for Index B was arrived at as follows:

TC = L x (100 + w)

where the constant = 100; L = 108; and

w = 10.

Thus, TC = 108 x (100 + 10) =

108 x 110 = 11,880.

[2] Indexes A through E in this Table refer to those identified in Part 139.49 and AC 150/5210-12.

7. **TABLE** 2. QUANTITIES OF FIRE EXTINGUISHING AGENTS FOR AIRPORTS.

1	2	3	4	5	6
Index 1/	Primary Agents				Supplementary Agent
	Protein Foam OR		Aqueous Film Forming Foam (AFFF)		
	Water for Foam Production (gal.) (Q)	Solution Application Rate(g.p.m.) (Q_1)	Water for AFFF Production (gal.) (Q)	Solution Application Rate (g.p.m.) (Q_1)	Dry Chemical Powders (lb.)
A	1,830 2/	1,100	1,190	720	500
B	3,180	1,590	2,070	1,050	750
C	4,820	2,110	3,140	1,370	1,000
D	7,290	2,890	4,740	1,880	1,500
E	9,770	3,620	6,350	2,350	1,500

8. AIRPORT FIRE TRUCKS.

a. For.Index B and above, the number of trucks should be based on protecting both sides of the aircraft fuselage at the same time.

b. Each airport should be provided with one light-weight truck and additional trucks as needed to haul the quantities of agents shown in Table 2. However, in addition to considering the quantitative capability of the trucks, the total number should be based upon the operational needs and performance characteristics outlined below and determined on a case-by-case basis.

(1) Meeting the response time requirements;

(2) Attaining the solution application rate specified for the applicable index;

(3) Providing sufficient trucks so that if one is out-of-service, the capability will not be reduced more than 50 percent; and

(4) Considering the general range of turret streams in relation to the applicable index-aircraft. (Reference paragraph 53, AC 150/5220-10.)

c. With further reference to the range of turret streams, the limitations imposed by short foam reach are not entirely overcome by design features that permit the fire pump to be used while the truck is being maneuvered.

d. Water tank trucks of up to 2000 gallons capacity may be substituted for water/foam trucks in Indexes C through E, provided they can deliver water foam solution at a comparable discharge rate.

9. AIRCRAFT RESCUE AND SAFETY EQUIPMENT. The list of equipment below is arranged so that an airport can be more selective in the purchase of items that are compatible with the general design of its crash trucks. The list is in tended to permit a "sponsor-designer choice." This involves equippage of trucks having built-in features which permit the use of fixed electric extension lights, for example, or trucks of a design which will permit the mounting of portable electric generators having extension lights. (The use of portable equipment is considered as an advantage because it can be transferred from one truck to another.) Where equipment is purchased as a part of a truck, it should be included in the truck specification. Compartments, holders, brackets, etc., should be designed so that the equipment will be held firmly in place under operating conditions and be readily removed for use.

a. Miscellaneous Tools and Accessories. At least one set of the following items per fire department: Sledge hammer, 8-pound size; shovel, D-handle type with round point; pike pole, 12-feet long; crowbar, pinch point type, 5-feet long; adjustable type hydrant wrench; spanner wrench and hose coupling wrench; and an extension ladder, 2-section type, capable of being extended 18 feet; or a flat type step ladder 18 feet long preferably of light-weight alloy, 24-inches wide.

b. Forcible entry equipment.

(1) A set per fire department containing one[1/] each of the following forcible entry tools securely packaged for easy identification and ready access to each item: Bolt cutter, 36 inches long, 9/16 inch cutting capacity; wrecking bar, gooseneck type with claw; cold chisel, 8x1 inch; cutter, aircraft cable (Aircraft Tool Company AT-501C, or equal; screwdriver, blade type 8x3/16 inch; screwdrivers, phillip type, sizes 2 or 3 (two); screwdriver, double grip type, 18x1/2 inch; hacksaw, pistol grip type, 12-inch with one dozen assorted blades; sheetmetal shears; fastening tools (DZUS keys) for aircraft acces-s panels (two); "V" blade rescue knife (W.S. Darley & Co., #RN-2 or equal); spare blades for rescue knife (six); axe, hand type, metal cutting with insulated handles; pliers, lineman's type, 8 inches long, insulated handles; a ball peen hammer, 1½ pound size; six repair plugs--wood and/or rubber; and felt pads 30 inches x 30 inches x 1/4 inch (two).

(2) Air operated metal chisel--may be operated by the use of bottles designed for breathing equipment (one per fire department).

(3) Hydraulic rescue kit (forcing tool) (one per fire department).

(4) Portable, metal-cutting, circular type saw, of gasoline-driven engine type (at least one per fire department).

c. Emergency Lighting Equipment. Lantern, electric hand type with 6-volt dry cell battery (two per crash truck); flashlight, 2-cell explosion proof type (one per crash truck); portable, electric generator/alternator unit gasoline engine driven, having features similar to the following: 3,000 watt, 25 ampere rating, output of 120 and 240 volts, 60 cycle, single phase; 120 and 240 volt outlets; governor; radio interference suppression device; two, portable 500 watt, 115 volt floodlights, each equipped with extension cables 100 feet long with reels (one unit per fire department.)

[1/] Unless a different number is shown in parenthesis following the item.

d. Safety and Extinguishing Equipment. Breathing equipment, preferably of compressed air type (one for each crew position on each crash truck); dry chemical extinguishers having a minimum UL rating of 80:BC (two per crash truck); smoke ejector, designed for exhausting smoke from enclosed spaces, and usable for cooling hot aircraft brakes (one per fire department); first-aid kit, appropriate for crash truck crews, lo-person unit size (one per crash truck).

10. SUPPLIES OF EXTINGUISHING AGENTS,

a. Each truck, when purchased, should be equipped with its design capacity of extinguishing agents,

b. For operating and training purposes, airports should also provide:

(1) Twice the quantity of agents carried on each truck-- available in the fire station.

(2) A supply of protein foam liquid concentrate where the foaming of runways is contemplated.

(3) A supply of agents to be used for training.

11. COMMUNICATIONS EQUIPMENT. Each airport fire truck when purchased, should be provided with a two-way radio equipped for conununicating with the FAA control tower or other authority as indicated in AC 150/5210-7B.

12. FIRE FIGHTER PROTECTIVE EQUIPMENT.

a. Proximity suits have both insulation and heat reflective qualities. The reflective material is designed to protect the wearer against infra-red light given off by fire and are thus recommended as preferable items. Proximity suits are costly, but they provide effective protection against the radiant heat of aircraft fires and consist of:

(1) Coat

(2) Trousers

(3) Boots

(4) Gloves

(5) Helmet and hood

b. Entry suits are designed. for an extreme environment such as that existing within flames. There has been general agreement among users that rescue operations could not be executed under such extreme conditions, and therefore the entry suits are not considered appropriate for airport fire departments.

c. As the name implies, proximity suits are intended to protect crash crews in close proximity to flames and heat given off by aircraft fuel fires. The proximity coats and trousers are designed to be worn over other clothing, such as dungarees. Experience indicates that crash crews should wear the complete suits during aircraft fire fighting operations. In addition, to assure adequate heat protection, these suits should never be worn without the liners. Each crew member should, however, realize the limitations of this or any other clothing so that he will not expose himself to an unsafe environment within a fire.

d. The value of proximity suits in rescue operations should also be realized. From studies of persons in situations surrounded by fire, it was noted that the feeling of facial pain was apparently strong enough to delay individuals from taking preventive measures to escape from the fire. From such circumstances, it has been assumed that protection of the skin against pain is as important as protection against burns.

e. The proximity trousers are designed to be worn over regular firemen's rubber boots. The trousers should not be tucked into these boots. Normal wear subjects this clothing to grease stains, foam and various chemicals used in fire extinguishing agents. Therefore, proximity suits should be cleaned after use to maintain their reflectivity and they should be replaced if torn, cracked or damaged beyond being patched or mended according to the manufacturers' instructions.

(1) Overall ranges of garment sizes. 1/

Item	Lower Range		Upper Range	
	Small	Medium	Large	Extra Large
Coats	34-36	38-40	42-44	46-48
Trousers	28-31	32-35	36-39	40-43
Gloves	x	X	X	

1/ The proximity hoods are adjustable and the regular firemen's rubber boots are comparable with shoe sizes.

(2) These sizes are regarded by the garment industry as standard for aluminized proximity clothing. The lower range sizes are generally found to be interchangeable between crew members of small and medium build - so that persons who work on alternate shifts can use one suit. It is also assumed that large and extra large, crew members can alternately use one suit in the upper range size. However, for hygienic reasons, it is not considered good practice to exchange boots.

CHAPTER 3. AIRCRAFT FIRE FIGHTING AND RESCUE SYSTEM NEEDS FOR AIRPORTS SERVING GENERAL AVIATION AIRCRAFT

13. SCOPE. This chapter contains recommended scales of protection for a system of airport fire fighting and rescue services for general aviation.

14. SYSTEM NEEDS. Similar to that outlined in Chapter 2, this system is comprised of communications equipment, fire trucks and extinguishing agents, miscellaneous safety equipment and fire fighter protective clothing. Therefore, airport fire trucks should be purchased on a basis of obtaining a complete and workable system including:

a. The quantities of extinguishing agents specified for the applicable index; and

b. The aircraft rescue and safety equipment needs to comprise a subsystem on the crash trucks such as those outlined in paragraphs 9 through 12.

15. AIRPORT CATEGORIES.

a. These airports are divided into two indexes as described in paragraph 16.

b. These airport indexes were arrived at basically by using the method described in Part 139.49. Differences have been made between the two methods by considering annual departures in this guidance whereas the Part 139.49 indexes are based on daily departures. Annual departures were used because this chapter deals primarily with aircraft operations which are not generally recorded. This method gives a broader basis for the estimation of departures.

c. The ICAO RFFP II used a slightly different method than the U.S. for determining the index and the principle aircraft, but the results are similar. The departure factor used to establish indexes is only indirectly related to the total operations at airports, it is not a method of determining a risk factor. It indicates the most representative type of aircraft using the airport, upon which the level of protection can be based.

16. GENERAL INDEXES.

Airport Departure Situations	Applicable Index 1/ 1	2
a. Airports having at least 1825 annual departures of aircraft more than 30 feet but not more than 45 feet long.	X	
b. Airports having at least 1825 annual departures of aircraft more than 45 feet but not more than 60 feet long.		X

Note 1/ On general aviation airports having operations involving aircraft more than 60 feet long, the scales of protection should be determined by using the applicable information in Chapter 2, and the aircraft index breakdown in AC 150/5210-12, Fire and Rescue Service for Certificated Airports.

17. TABLE 3. AIRCRAFT DIMENSIONS THEORETICAL CRITICAL AND PRACTICAL FIRE AREAS FOR GENERAL AVIATION AIRCRAFT.

	Data on Aircraft Length					
1	2	3	4	5	6	7
Index	Lower Limit (Ft.)	Upper Limit (Ft.)	Average Length (Ft.)	Average Width of Fuselage (Ft.)	Theoretical 1/ Critical Fire Area (Sq. Ft.) /Col. 4 x 740 + Col.5)7	Practical Fire Area (Sq. Ft.) (.67 x Co1.6)
1	30	45	38	6	1,748	1,171
2	45	60	53	10	2,650	1,775

1/ Based on the following formula:

TC = L x (40 + w) when L is less than 65 feet

where TC = the theoretical critical fire area

L = the average length of the aircraft

w = the average width of the aircraft fuselage

18. TABLE 4. SCALES OF PROTECTION FOR GENERAL AVIATION AIRCRAFT.

	Primary Agents				Supplementary Agent	
	AFFF		OR Protein Foam			
1	2	3	4	5	6	7
Index	Water for foam production (gal.) (Q)	Solution application rate (g.p.m.) (Q_1)	Water for foam production (gal.) (Q)	Solution application rate (g.p.m.) (Q_1)	Dry Chemical Powders (Pounds)	Number of Vehicles
1 1/	190	150	290	230	300	1
2	310	230	490	350	400	1

1/ Rounded off to the nearest 10 gallons. For practical application, the quantities in Columns 2 and 4 should be adjusted to coincide with conventional water tanks of 200, 300 and 500 gallon capacities.

19. TYPICAL[1/] AIRCRAFT COMPRISING THE GENERAL AVIATION INDEX.

a. General Index #1 involving aircraft more than 30 feet, but not more than 45 feet long	Aircraft Length (Feet)	Number of Seats
Beech G50 Twin-Bonanza	32	7
Beech Queen Air	33	7-8
Beech El8 S Super 18	35	7-10
Aero, 560E Commander	35	7
Beech, King Air	35	10
de Havilland 104 Series 1	39	10-13
SC-7 Skywagon	40	19
Twin Stallion H-1201	41	18
Cessna Citation	44	8
North American Sabreliner	44	9
Beech 99	45	17
b. General Index #2 involving aircraft more than 45 feet, but not more than 60 feet long		
Jetliner 600	47	18
Learjet Model 25B	48	10
Super Turbo 18	48	7-11
de Havilland DHC-6 Twin Otter	50	16-31
Jet Commander	51	8
Jet Falcon	56	12
Merlin 4 SA226AT	59	12

[1/] For a more detailed listing see AC 150/5325-5B.

CHAPTER 4. GUIDANCE ON EXTINGUISHING AGENTS AND QUALITY CONTROL

20. CURRENTLY USED AND AVAILABLE PRIMARY AGENTS. Foam used for extinguishing aircraft fires should consist of an aggregation of bubbles of a lower specific gravity than that of hydrocarbon fuels or water with strong cohesive qualities and capable of covering and clinging to vertical or horizontal surfaces. Aqueous foam cools hot surfaces by its high water retention ability and must flow freely over a burning liquid surface to form a tough, air-excluding blanket that seals off volatile flammable vapors from access to air or oxygen. Good quality foam should be dense and long lasting, capable of resisting disruption by wind or draft and stable to intense thermal radiation and capable of re-sealing in event of mechanical rupture of an established blanket. A brief description of three types of foam is contained below:

a. Protein Foam liquid concentrates consist primarily of hydrolysis products of various proteinaceous materials. They also contain stabilizing additives and inhibitors to protect against freezing, to prevent torrosion of equipment and containers, to resist bacterial decomposition, to control viscosity and to assure readiness for use in emergencies. The manufacturer of the foam-making equipment should be consulted as to the proper setting of metering devices for the foam liquid concentrate to be used in a truck. Foam liquids of different types or different manufacturers should not be mixed unless it is determined that they are completely interchangeable. Most protein foam is not compatible with most dry chemical powders, but compatibility can be attained by using a dry chemical listed as such and intended for dual use.

b. Aqueous Film Forming Foam (AFFF) consists of a solution of perfluorinated surfactant(s) with a foam stabilizer, suitable freezing point depressants and viscosity control agents. As indicated for protein foam, the manufacturer of the foam making equipment should be consulted as to the correct setting of metering devices for dispensing the AFFF concentrate. For use of AFFF with a salt water system, the manufacturer should also be consulted. The AFFF acts both as a barrier to exclude air or oxygen and in addition produces an aqueous film on the fuel surface capable of suppressing the evolution of fuel vapors. Ideally, the foam blanket produced by the AFFF should be of sufficient thickness' so as to be visible before fire fighters place reliance on its effectiveness as a vapor suppressant. AFFF concentrates are

normally used in conventional foam-making devices suitable for producing protein foams, but the equipment should not be converted for AFFF use without consultation with the manufacturer of the equipment. In addition, the flushing procedures outlined below are suggested at the time of such a conversion:

(1) Remove all protein foam by discharging it through all turrets and nozzles of the fire fighting system;

(2) Flush the system with fresh water by discharging it through the fire system until the water is clear; and

(3) Refill the tanks with AFFF and water and place the truck in service. After about 10 days, drain the AFFF from the tank and flush the fire fighting system, then replace the AFFF and water--placing the truck back in service.

c. The compatibility of AFFF makes it suitable for use with all currently available dry chemical powders and thus adaptable for combined use. Protein and fluoroprotein foam concentrates are not compatible with AFFF concentrates and should not be pre-mixed, although foams separately generated with these concentrates are compatible and can be applied. to a fire in sequence or simultaneously.

d. Fluoroprotein Foam falls broadly into two sub-types, one of which has concentrations of a synthetic fluorinated surfactant for the purpose of providing resistance to breakdown by dry chemical powders. The other type has concentrations of a surfactant sufficient to produce an aqueous film on the surface of hydrocarbon fuels. Both types can be used to produce suitable 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). Foam liquid concentrates of different types or different manufacture should not be mixed unless it is established that they are completely interchangeable. The compatibility of these foams with any dry chemical agent intended for use on a fire in sequence or simultaneously, should be established by test, although such foams are known to be compatible with all currently available dry chemical powders.

21. CURRENTLY USED AND AVAILABLE SUPPLEMENTARY AGENTS. This class of compounds includes dry chemical powders, liquid vaporizing agents (halocarbons) and magnesium fire extinguishing agents. They are employed either singly or in combination with foam to accomplish particular jobs in aircraft fire fighting operations.

a. Dry Chemical Powders. Experimental data developed from large outdoor free burning pool fires have indicated that no-great differences exist between dry chemical powders as a group. As a result, a general equivalency of dry chemical powders and protein foam of 1:1 on a weight basis has been recommended. Although higher efficiency ratios of individual agents exist, much of this advantage is lost when used under simulated and actual rescue conditions. High wind is a particularly important factor in reducing the efficiency of powders. In view of these data, for substitution purposes, 8 pounds of dry chemical powder are considered as equivalent to 1 U.S. gallon of water for protein foam. However, an exception to this equivalency has been made as noted in AC 150/5210-12 which permits the substitution of potassium base chemical for the sodium bicarbonate base on a 9:10 ratio. In this case, equivalency of the powder to water is 7 pounds to one gallon.

b. Halocarbons. The fire fighting effectiveness of the halocarbons is dependent to a large extent on the boiling point of the liquid agent. Current usage of the halocarbons includes bromochloromethane (CB) (Halon 1011), bromochlorodifluoromethane (Halon 1211), dibromotetrafluoroethane (Halon 2402) and bromotrifluoromethane (Halon 1301). Halocarbons 1011, 1211, and 2402 are effective in outdoor environmental conditions because they can be dispensed as a liquid vapor. Gaseous agents such as Halon 1301 are most effective in confined areas or where drafts and wind conditions are minimal. Large scale fire extinguishing experiments using aircraft fuels indicate that Halons 1011, 1211, and 2402 can be given the same equivalency factor as that for dry chemical powder and protein foam namely a 1 to 1 ratio on a weight basis.

c. Carbon dioxide. Tests also show that low pressure CO_2 is more effective in aircraft rescue and fire fighting operations than high pressure CO_2. The tests further indicate that CO_2 can be

given parity with dry chemical powder on the basis of 4.4 pound.- of CO2 gas per 2.2 pounds of dry chemical. (Except'for potassium base dry chemical--requiring 10 percent less.)

22. EQUIVALENCY RATINGS OF AGENTS AND SUBSTITUTION. This chapter contains factors on equivalency which were developed for practical application to: determine the individual quantities-of agents needed when both protein foam and AFFF are used on an airport;' and determine an equivalent level of safety on airports when one agent is substituted for another.

a. The Use of both Protein Foam and AFFF. When both-of these agents are to be used at the same airport, the total quantity of water to be provided should first be based on the quantity needed if only protein foam was used--then reduce this quantity on a ratio of 3 to 2 gallons of water to be provided for AFFF. (Multiply by 0.67 as shown in paragraph d(9) below.)

b. Units.

(1) Water weighs 8.33 pounds per gallon.

(2) Chlorobromomethane weighs 16.1 pounds per gallon.

(3) CO_2 (carbon dioxide) and dry chemical powders are listed in pounds.

c. Examples of Equivalency.

(1) Eight pounds of dry chemical powder are equivalent to 1 gallon of water for protein foam.

(2) 'One gallon of CB is equal to 2 gallons of water, or 16 pounds of dry chemical powder.

(3) Sixteen pounds of CO_2 equals 8 pounds of dry chemical powder, or 1 gallon of water for protein foam.

(4) The most common CB units are provided on U.S. Air Force trucks in 20 or 40-gallon sizes. Using the figures in paragraph (2) above, a 40-gallon CB unit would be equivalent to 640 pounds of dry chemical powder.

(5) The most common CO_2 trucks in current use are those owned by the Air Force which carry 4000 pounds of this agent. Using the figures in paragraph (3) above, this quantity of agent would be equivalent to-2000 pounds of dry chemical powder.

d. Table. 5. Factors for Estimating Equivalent Levels of Safety between Agents. /Across the board substitution not implied, Ref. FAR Part 139.49(c)/.

To convert from	Multiply by		To determine the equivalent in
(1) pounds of dry chemical powder	0.125	=	gallons of water for protein foam
(2) gallons of water for protein foam	8.	=	pounds of dry chemical powder
(3) pounds of CO2	0.0625	=	gallons of water for protein or fluoropro tein foam
(4) gallons of water for protein foam	16.	=	pounds of CO_2
(5) pounds of dry chemical powder	2.	=	pounds of CO_2
(6) pounds of CO_2	0.5	=	dry chemical powder
(7) gallons of Halon 211	16.	=	pounds of dry chemical powder
(8) pounds of dry chemical powder	0.0625	=	gallons of CB
(9) gallons of water for protein foam	0.67	=	gallons of water for AFFF
(10) gallons of water for AFFF	1.50	=	gallons of water for protein foam

23. TABLE 6. EXTINGUISHING AGENTS IN USE FOR AIRCRAFT FIRES.

Situation	Agents
a. Spill of Fuel without Fire	AFFF or Protein or Fluoroprotein Foam Blanket Water Spray Flushing
b. Spill Fire	AFFF Dry Chemical Powder Protein or Fluoroprotein Foam
c. Nacelle	Dry Chemical Powder Halocarbons CO_2
d. Wheel Fire	Dry Chemical Powder Halocarbons
e. Magnesium Fire	TEC Magnesium Extinguishing Agent Met-L-X extinguishers
f. Fires in Unoccupied enclosed spaces	CO_2 Halocarbons 1/ Water Spray
g. Fires in Occupied enclosed spaces	Water Spray
h. 3-D Exterior Fires with Spilling Fuel	AFFF, Protein Foam or Fluoroprotein Foam in combination with dry Chemical Powder or Halocarbons

1/ Primarily intended for application outdoors, they are, however, recognized as being effective on fires in unoccupied enclosed spaces such as nacelles. However, because of their TOXICITY, these agents require training in use and application.

24. QUALITY CONTROL AND PERFORMANCE. This information is intended to assure that airport fire trucks with mounted equipment and extinguishing agents are obtained on a systems approach basis to quality control--with the emphas is on performance. The intent being further to assure that overall performance is emphasized in truck specifications and purchase documenta and that tests are made to assure such performance. In this connect ion, the established requirements for crash trucks are that they meet the performance requirements of FAR Part 139.49. This involves discharge rates and response time acceleration rates. While it is recognized that acceptance testing of extinguishing agents is necessary, the technical characteristics, quality, stability compatibility, etc., cannot be determined during such system tests or demons trations. Therefore, airport management should request that prospective bidders, or suppliers of fire extinguishing agents furnish indication of tests on performance and quality by a recognized testing labora tory. Technical data concerning evaluation of agents and information on the characteristics of foam extinguishing agents and equipment are contained in NFPA No. 412.

CHAPTER 5. CRITERIA FOR ALUMINIZED PROXIMITY SUITS FOR CIVIL AIRPORT FIRE FIGHTERS

25. PURPOSE. This chapter is intended as guidance for airport operators to use in obtaining clothing from off-the-shelf design garments. It contains a general description of proximity suits and refers to Federal standards used by manufacturers in testing of the fabrics' involved.

26. CLOTHING FABRICS. Three layers of fabrics are arranged essentially in the same manner to form the basic construction for the hoods, coats and trousers. Protection is attained by a combination of heat reflection and insulation qualities of the material as explained below:

a. The outer shell has a reflective vacuum-deposited aluminized coating with a minimum reflectivity of 90 percent, maae of base material (before coating) having a minimum weight of six ounces per square yard. Typical materials used in this application include: fiberglass, Nomex, Dutettc, asbestos, rayon fire retardant treated cellulosics, Kynol and combinations of the above.

b. A vapor barrier material is provided to prevent the inward penetration of steam resulting from high thermal exposures. The vapor barrier may be an integral coating on the inside of shell fabric, or a separate layer of coated fabric located behind the shell. Neoprene coated fabrics are among the typical materials being used as vapor barriers.

c. The insulating liner should be either detachable {snap-in) or permanently attached (sewn-in). The liner provides protection against the transmission of heat from fires with appropriate design for extreme climatic conditions as recommended by the manufacturer. Typical fabrics used for liners include a quilted design of fiberglass, neoprene and flannel, neoprene and nylon, wool, Dacron and Nomex or Kynol batting.

27. CLOTHING FEATURES.

a. Suggested design features of garments include wide vision hoods equipped with a "hard cap" and adjustable headband, "storm flap' closures on coats and adjustable-waist trousers equipped with suspenders. For the purpose of general illustration, typical clothing items are shown in Figures 1 and 2 of this chapter. It is not intended that new garments be exact duplicates of those illustrated. However, the coat should be thigh length (approximately 36 inches) to provide adequate coverage while giving reasonable maneuverability.

b. Indications are that proximity suits should be loose-fitting to avoid heat transmission through the material. From the development of improved fabrics, proximity suits which are relatively lightweight and comfortable can now be obtained from several manufacturers. The manufacturing sources for this clothing may be obtained from lists in the Thomas Register and in the directory issue of Fire Engineering. (Reference paragraph 31.)

c. The facepiece of hoods are generally made in the form of a 180 degree arc. Such a design allows room for the use of a full-face breathing apparatus and the wearing of eyeglasses.

28. LABORATORY TEST DATA.

The garment manufacturer should be requested to make available for the purchaser, laboratory test data or suppliers certification to indicate that fabrics used for the outer shell and the vapor barrier have been selected for this purpose and tested for fire resistivity and waterproofing under: Federal Standard 191, "Textile Test Methods, Method 5903.2, Flame Resistance of Cloth; Vertical;" and Method 5512, "Water Resistance of Coated Cloth; High Range, Hydrostatic Method." (Reference paragraph 31.)

29. GARMENT SIZES.

Item	Range of Sizes			
	Small	Medium	Large	Extra Large
Coats	34-36	38-40	42-44	46-48
Trousers	28-31	32-35	36-39	40-43
Gloves	X	X	X	
Hoods	Adjustable			

30. MANUFACTURERS' INSTRUCTIONS.

The manufacturer should be requested to furnish instructions for storage and maintenance of garments as outlined below:

a. Storing of items for efficient use; and

b. restoring, repairing or patching garments, plus information on the source of special chemicals or materials necessary for this purpose.

c. Touch-up kits of vaporized aluminum in pressurized cans for surface renewal of worn spots on the aluminized outer shell.

31. SOURCES AND REFERENCES.

a. Manufacturing sources include:

(1) Thomas Register of American Manufacturers
Thomas Publishing Company
461'Eighth Avenue
New York, New York 10001

(2) Fire Engineering
Directory Issue
875 Third Avenue
New York, New York 10022

b. Standards involving the testing of clothing include:

(1) Federal Standard 191, Textile Test Methods, Method 5903.2, Flame Resistance of Cloth; Vertical; and

(2) Federal Standard 191, Textile Test Methods, Method 5512, Water Resistance of Coated Cloth; High Range, Hydrostatic Method, are available from the General Services Administration, Washington, D.C. 20407.

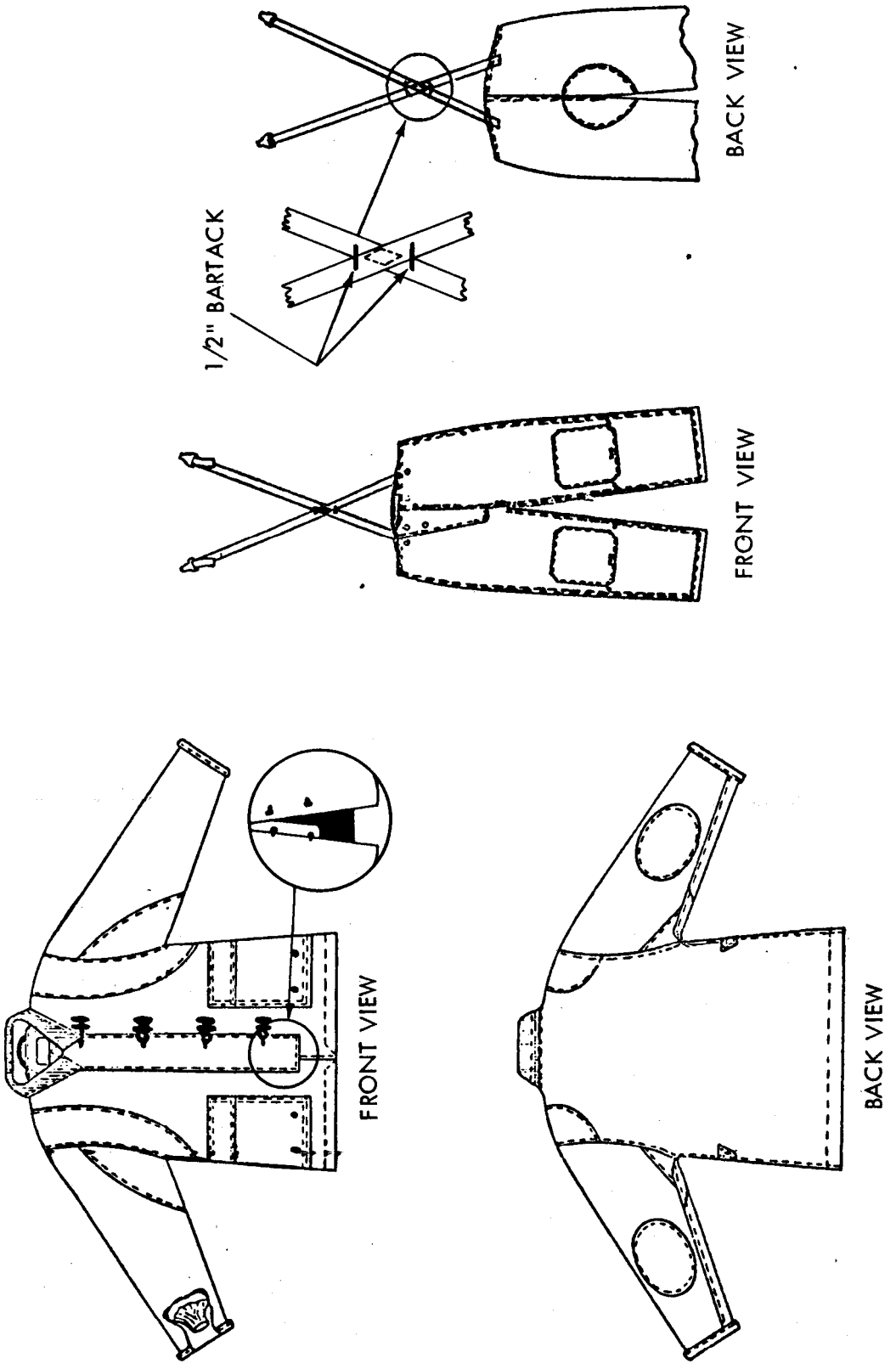
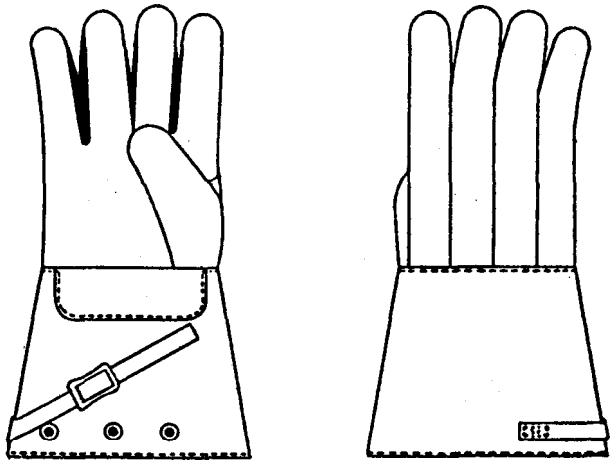
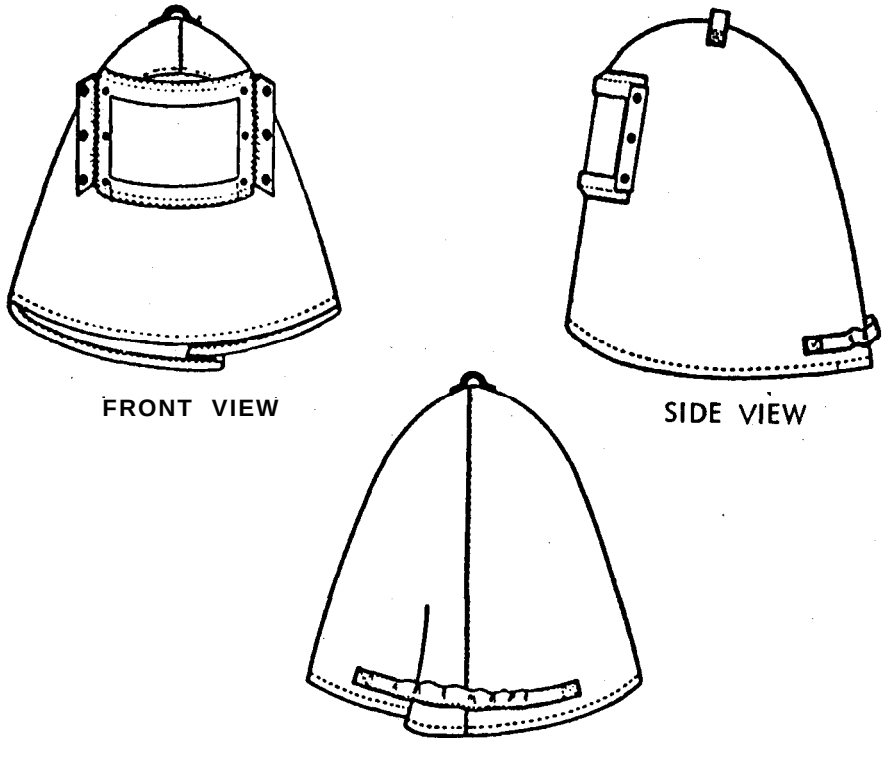


FIGURE 1. Illistration of Aluminized Proximity coats and trousers indicating suggested design



PALM VIEW BACK VIEW



FRONT VIEW SIDE VIEW

BACK VIEW

FIGURE 2. Illustration of Aluminized Proximity Gloves and Hood (shoulder length type) indicating suggested designs

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