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Updating Airport Emergency Capabilities

Present standards for airport quantities of fire extinguishing materials are questioned, and recommendations are made to increase them.

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Prior to World War II, airport fire and rescue services were seldom based at airports except at military fields, and even then the equipment was not very effective. The main problem was getting the fire truck manned and started to reach the fire as quickly as possible. After war broke out, the rapid influx of larger and faster aircraft, often full of fuel and explosives and flown by recently trained airmen, forced military authorities to take a serious look at crash/fire/rescue (CFR) facilities and equipment.

Unfortunately, after hostilities ended, very little of the expertise and equipment developed during the war filtered down to the commercial airports of the world. The U.S. Civil Aeronautics Board (CAB) was very concerned about this situation and in 1948 asked the National Fire Protection Association (NFPA - U.S.) for its guidance on the subject. NFPA formed a study committee of aviation representatives who were experts about aircraft but knew very little about crash fires. Within two years, the committee produced the first CFR manual. This was not ratified by the membership of the NFPA, however, due to objections from airport representatives. The initial effort was sent back to the committee, and an approved manual, NFPA 403, was issued in 1951. The manual has been revised frequently since that time, upgrades being based on recent past experience of the quantities of agents required to extinguish aircraft fires and on political considerations.

In 1968, the International Civil Aviation Organization (ICAO) Rescue and Firefighting Panel decided, because it was using the same system as the NFPA guidelines, that it was time for improvements to be made. The panel spent two years developing a mathematical formula that has received international acceptance for 21 years.

This formula is based on the criterion that fuselage integrity must be maintained to ensure survival of the occupants. Fire tests conducted by the U.S. Federal Aviation Administration (FAA) and other ICAO panel members indicated that it was essential to keep the fire at least 50 feet away from the aircraft fuselage in order to maintain a survivable atmosphere inside the cabin. This distance was used for large aircraft more than 65 feet in length; a distance of 20 feet was considered adequate for smaller aircraft. This distance/aircraft length criterion became what is known as the theoretical critical area (TCA).

The TCA became the basis for all extinguishing agent computations. However, the required quantities were considered economically unfeasible for some countries to maintain. Further, it was brought to the attention of the panel that, in one study, 99 of 106 fires required only two-thirds of the agent that would be required by the new formula. Based upon this statistic, the panel decided to reduce the TCA requirement by one-third, and called the lower requirement the practical critical area (PCA), a reduced area that was then used for agent quantity computations. Subsequently, it was discovered that the statistic upon which the lower requirement was based had reflected the results of training fires, and not actual crash fires; however, the lower requirement was left unchanged.

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Fire tests conducted by several participating ICAO members also indicated that, to ensure survival, control of the fire must be obtained in one minute or less. This required an application rate for protein foam of 2.0 gallons per minute (gpm) per square foot. An application rate of 1.3 gpm per square foot was allowed for aqueous film-forming foam (AFFF). In retrospect, this may have been an over-generous adjustment.

The total amount of agent required was determined by the use of the formula Q = Q1 + Q2, Q1 being the amount required to control the fire and establish an escape path and Q2 is the quantity of extra agent required to maintain the escape path and extinguish the fire. Q1 was determined from the potential fire area and application rate, and Q2, the amount of extra agent required for extinguishment, was determined to be a percentage of Q1 based on four factors — maximum gross weight of the aircraft, maximum fuel capacity, maximum passenger capacity and past experience.

To aid airport authorities in determining the agent quantities required for their operations, it was necessary to divide aircraft into groups; each one containing aircraft of similar size and operating characteristics. Aircraft were divided into nine groups, or categories, with fuselage length used as the determining factor. Once again, in order to keep agent requirements as low as possible to meet economic considerations, the quantity recommended was based on the median length of the aircraft in each category instead of the longest.

A further adjustment allowed economic factors to affect required quantities of firefighting material. Agent quantities were based on the largest category of aircraft using the airport on a regular or scheduled basis. However, both ICAO and the FAA allow a remission factor to a lower category based on the number of movements of the largest aircraft at an airport. ICAO uses a number of 700 movements of the largest aircraft within the busiest three-month period. If this number is not met, the quantity of agent required could be reduced by one category. If this 700 number could not be attained by adding together the number of movements of the two largest aircraft, then the category cold be further reduced one category lower for a total of two categories lower than required by the original formula. The FAA bases its remission factor on five departures of the largest aircraft per day for a reduction of one category only.

Recently, the ICAO Rescue and Firefighting Panel voted unanimously to recommend elimination of the remission factor. The Air Line Pilots Association (ALPA-U.S.) recently petitioned the FAA to do likewise in U.S. Federal Aviation Regulation (FAR) Part 139 which applies to airport certification.

Relating the potential size of an aircraft fire to the number of movements is not valid, and represents a compromise with safety that further serves to reduce the extinguishing agent requirements below those necessary to contain the fire. It can result in airport firefighters battling an aircraft fire with a less than optimum chance of extinguishing the fire.

It has been the policy of the NFPA and ICAO committees to study accidents that have occurred in recent years. Within the past 13 years, there have been a number of major aircraft accidents and crash fires which have shown that the decisions to reduce agent quantities below those required by the original concept have not been justified. Accidents, where statistics are available, are listed in Table 1.

All of the quantities of agent presented in Table 1 are approximate and were obtained from accident reports and, where possible, contact with the firefighters involved. Where actual quantities of agent are missing,

Table 1

			Water for foam production		Type of Agent
			Recommended (NFPA 403)	Used (U.S. gal.)	
DC-10	Los Angeles	January 3, 1978	4,800	7,800	AFFF
DC-8-61	Athens	October 7, 1979	4,800	12,000+	
L-1011	Riyadh	August 19, 1980	4,800	20,000	AFFF
Boeing 747	Seoul	November 18, 1980	6,500	UNK	*
Boeing 727	Yap Island	November 21, 1980	3,300	3,500	AFFF *
Boeing 737	Orange County	February 17, 1981	2,200	3,000	AFFF
Boeing 737	Orange County	February 17, 1981	2,200	13,000	HX
DC-10	Malaga	September 13, 1982	4,800	7,500	Prot. *
DC-9	Barquisimeto	March 11, 1983	2,200	7,925	Prot. *
DC-9	Cincinnati	June 2, 1983	2,200	7,400	P/AFFF
DC-9/Boeing 727	Madrid	July 12, 1983	5,400	18,000+	
Boeing 727	Chicago	November 11,1983	3,200	15,000+	
Boeing 737	Calgary	March 22, 1984	2,200	12,000	AFFF
Boeing 707	Edwards AFB	December 1, 1984	3,300	24,000	AFFF
Convair 880	March AFB	July 17, 1985	3,300	59,000	AFFF
L-1011	Dallas	August 2, 1985	4,800	16,400	AFFF
Boeing 737	Manchester	August 22, 1985	2,200	10,000	AFFF
L-1011	Columbo	May 3, 1986	4,800	2,000	FFFP
Piper Aztec	Tampa	November 6, 1986	60	500	AFFF
CASA C-212	Detroit	March 4, 1987	315	5,800	AFFF
CASA C-212	Mayaguez	May 8, 1987	315	1,000	AFFF
DC-9	Detroit	August 16, 1987	2,200	19,900	AFFF
DC-9	Denver	November 15, 1987	2,200	940	AFFF
DH-8	Seattle	April 15, 1988	600	6,000	AFFF
Boeing 727	Dallas	August 31, 1988	3,300	15,000	AFFF
Boeing 737	E. Midlands	January 8, 1989	2,200	670	FP
DC-10	Sioux City	July 19, 1989	4,800	15,000	AFFF
Boeing 727	Salt Lake City	October 14, 1989	3,300	3,000	AFFF
A320	Bangalore	February 14, 1990	4,800	UNK	*
DC-9/Boeing 727	Detroit	December 3, 1990	5,500	8,500+1,500	
Boeing 737/Swearingen Metroliner	Los Angeles	February 6, 1991	2,800	8,000+9,000	
DC-9	Cleveland	February 17, 1991	2,200	15,000	AFFF
DC-8	New York	March 12, 1991	4,800	16,000	AFFF
Boeing 727	Bradley	May 3, 1991	3,300	36,000	AFFF

AFFF - Aqueous Film-forming Foam
FFFP - Film-forming Fluoroprotein
HX - High Expansion Foam
Prot. - Protein Foam
FP - Fluoroprotein
* - Total aircraft burnout

Table 2*

Date	Carrier/Aircraft	Location	Passengers	Fatalities
March 13, 1979	Alia Boeing 727	Doha	64	44
April 26, 1979	Indian Boeing 737	Madras	67	0
February 27, 1980	China Boeing 707	Manila	135	2
November 4, 1980	TAAG Boeing 737	Benguela	134	0
July 27, 1981	Aeromexico DC-9	Chihuahua	66	30
March 17, 1982	Air France A300	Sanaa	124	0
August 26, 1982	Southwest Boeing 737	Ishigaki	138	0
July 2, 1983	Altair Caravel	Milan	89	0
December 7, 1983	Aviaco DC-9	Madrid	42	42 Collision
December 7, 1983	Iberia Boeing 727	Madrid	93	51 Collision
December 18, 1983	Malaysian A300	Kuala Lumpur	247	0
March 10, 1984	UTA DC-8	Ndjamena	23	0
August 30, 1984	Air Cameroon Boeing 737	Douala	118	2
October 13, 1984	Cyprus Boeing 707	Zurich	10	0
November 30, 1985	Mandala L-188	Medan	45	0
June 17, 1989	Interflug Il 62	East Berlin	113	50?

* Information on CFR operations for these aircraft fires is sought by the author, through FSF.

photographs indicate that the aircraft was destroyed by fire.

In only four of the reported accidents in Table 1 was less agent used than required by ICAO, NFPA 403 or FAA regulations. In most cases, higher-than-recommended amounts of agent were used; however, there are a number of factors which may or may not account for the variances, such as delayed notification of the accident, slow response due to weather conditions or poor location of the fire station. Vehicle malfunctions or inability to negotiate the terrain when some of the aircraft came to rest outside the airport boundary also hindered firefighting efforts. Most crash fires were, however, located on or in the immediate vicinity of the active runway.

Most of the fires were three-dimensional. The greatest problems encountered were the interior cabin fires and the methods available for combating them. It is estimated that an average of 5,000 gallons of extra agent have been used when combating a cabin fire. These fires resulted in known thermal deaths to more than 500 persons in at least seven of the accidents.

Many people blame the higher-than-recommended agent used on the lack of adequate practical training. There are very few aircraft fires compared with the almost daily response of the average city fire department, which offers continuing experience for firefighters. Further, many states will not allow hot (live) fire drills because of environmental restrictions.

The Los Angeles DC-10 fire in 1978, following a rejected takeoff/runway overrun accident, is considered an example of a nearly perfect response. It involved well-trained crews with excellent and appropriate equipment. Despite an excellent response time of less than 40 seconds, the amount of agent used was still in excess of ICAO/NFPA recommendations by more than 3,000 gallons.

Los Angeles, again, in February 1991, demonstrated a rapid response after the runway collision of a Boeing 737 and a Swearingen Metroliner. This was the first time that accurate information was obtained of the actual agent used and for what purpose: 5,000 gal. for control, 4,000 gal. for the interior fire and 8,000 gal. for overhaul (mop-up operations and prevention of fire re-ignition).

In two almost identical Boeing 737 fires (Calgary, Canada,

Table 3

Category	Present (gal.)	Proposed (gal.)	Representative Aircraft	USAF
1	60	200	Cessna 310	
2	185	300	Cessna 400s	
3	315	625	Beech 99	
4	600	1175	Short 360	
5	1,450	2,450	Fokker F28	6,130
6	2,200	4,025	Boeing 737	6,130
7	3,300	5,750	Boeing 757	12,745
8	4,800	8,250	DC-10	12,745
9	6,500	11,500	Boeing 747	12,745
10	6,500	15,800	Antonov An-225	12,745

in 1984 and Manchester, England, in 1985), excellent equipment and training were involved. Both accidents exceeded the required agent quantities by 8,000 to 9,000 gallons. There were water resupply problems in both cases. In Manchester, the supply hydrants were dry and in Calgary one truck was stuck in the mud. These were replenishment problems and did not affect the quantity of agent required for the initial fire attack.

Crash fire statistics, from actual crash fires instead of the theoretical statistics obtained during the ideal conditions of fireground (live-fire practice area) tests, indicate that the quantities of extinguishing agent recommended by the FAA, ICAO and the NFPA are no longer adequate. Additional quantities of agent should be on immediate standby for post-fire operations. This additional agent need not be carried on crash trucks but must be available to replenish them promptly during an emergency.

Recommendations to ensure sufficient extinguishing agent to cope with an aircraft fire include the following:

- Base the agent quantities on the size of recent crash fires and not fireground tests.
- The agent quantities should be computed for the longest aircraft in each category, instead of the median aircraft.
- A replenishment factor should be included and, based on recent experience, should be at least 100 percent of the basic quantity recommended for extinguishment.
- Airports should base required agent quantities on the largest aircraft scheduled into the airport regardless of the number of operations.

Based on the above considerations and the fact that the U.S. Air Force has already significantly increased its requirements, it would be appropriate for quantities of water for foam production using AFFF be increased at least as indicated in Table 3.

These recommendations may not prove to be adequate in all conditions; however, they will at least give the airport firefighter a much better opportunity to succeed in extinguishing aircraft fires and rescuing survivors. ♦

About the Author

B. Victor Hewes, a retired Delta Air Lines captain, is the author of several publications and articles on airport fire and rescue, and has presented numerous papers at Flight Safety Foundation seminars. He presently is a consultant specializing in accident investigation, airport safety and security, and aircraft fire protection. Hewes is a member of the Society of Air Safety Investigators and has participated in more than 25 major accident investigations.

Hewes served more than 30 years as regional and national safety committee chairman for the U.S. Air Line Pilots Association (ALPA). Under his leadership, many advances were made in the field of accident survival that resulted in several U.S. and international regulations on aircraft cabin interior fireworthiness, evacuation, seat restraint standards, disaster exercises and airport certification.

Hewes has been associated with the National Fire Protection Association (NFPA), the International Federation of Air

Line Pilots Associations (IFALPA) and the International Civil Aviation Organization (ICAO), serving on the latter's Fire Fighting Panel for many years, during which present worldwide standards were established for airport fire services. He has received a number of air safety awards including the Flight Safety Foundation's Admiral Luis de Florez and Laura Taber Barbour Awards, the Aviation Week and Space Technology Distinguished Service Award, the IFALPA Scroll of Merit and the National Fire Protection Association Distinguished Service Award.

Hewes was born in England and in 1940 he became a pilot in the Royal Air Force (RAF), serving two combat tours flying Spitfires, Hurricanes and Mosquitoes, and as a VIP squadron commander flying Dakotas (C-47). He began his air safety activities as a pilot in the RAF and continued them after leaving the service at the end of hostilities when he joined Delta as a line pilot. He has logged more than 33,500 hours and 12 million miles in the air. He is the Dixie Wing Leader of the Confederate Air Force and regularly flies B-24s and B-29s.

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