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NFPA 422
Guide for Aircraft Accident Response
1994 Edition

NFPA®

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

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NFPA 422

Guide for

Aircraft Accident Response

1994 Edition

This edition of NFPA 422, *Guide for Aircraft Accident Response*, was prepared by the Technical Committee on Aircraft Rescue and Fire Fighting and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 16-18, 1994, in San Francisco, CA. It was issued by the Standards Council on July 14, 1994, with an effective date of August 5, 1994, and supersedes all previous editions.

The 1994 edition of this document has been approved by the American National Standards Institute.

Origin and Development of NFPA 422

Originally a manual, development of NFPA 422M was initiated in 1963, and it was submitted to the Association for adoption at the 1972 Annual Meeting. The document was revised in 1979 and 1984 and the 1989 edition was a reconfirmation of the 1984 edition.

The title for this 1994 edition was changed from *Manual for Aircraft Fire and Explosion Investigators* to the current title. The document was completely revised to provide a framework for the accumulation of data relative to the effectiveness of aircraft accident emergency response services in the application of principles found in the standards and guides developed by the Technical Committee on Aircraft Rescue and Fire Fighting.

This document is intended to assist the committee in collecting significant data that may be utilized to facilitate revisions to the NFPA aircraft rescue and fire fighting documents.

The work of revising this document was accomplished by a task group appointed by the chairman. The following is a list of members of the task group.

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

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

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

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

Information on referenced publications can be found in Chapter 3 and Appendix C.

Chapter 1 Introduction

1-1 Scope. This document provides a framework for the collection of data that provides information on the effectiveness of aircraft accident emergency response services. This standard applies the principles of those standards and guides developed by the Technical Committee on Aircraft Rescue and Fire Fighting.

1-2* Purpose. The purpose of this document is to outline a format for a comprehensive emergency response analysis and the collection of significant data that can be utilized to facilitate revisions to applicable NFPA documents.

1-2.1 Part 2 of this guide also may be effectively used to record and critique airport emergency disaster exercises.

1-3 Arrangement. This guide contains two separate reports that are intended to provide a comprehensive emergency response analysis when completed. These report forms can be photocopied from this guide if they are not available elsewhere.

1-3.1 The forms should be completed by persons with knowledge of the pertinent subject matter.

1-3.2 No obtained information should be released to the news media or to any person unless permission has been obtained first from the chief of the official investigating team. The successful collection of information is related directly to its judicious treatment.

1-3.3 These forms may be used by any person or organization for their internal use. However, when released, copies should be sent to the Committee on Aircraft Rescue and Fire Fighting for entry into the NFPA data bank.

1-4 Units. This guide uses metric units of measurement in accordance with the modernized metric system known as the International System of Units (SI). The liter unit, which falls outside of but is recognized by SI, is used commonly in international fire protection.

1-4.1 If a measurement value provided in this guide is followed by an equivalent value in other units, the first stated value should be regarded as the recommendation. The equivalent value might be approximate.

1-4.2 SI units have been converted from U.S. values by multiplying the U.S. value by the conversion factor and rounding the result to the appropriate number of significant digits.

Chapter 2 Aircraft Accident/Emergency Response Data

2-1 Reports on incidents and accidents that involve fires should include information on the origin of the fire, the method by which it was spread and fed, the type and effectiveness of extinguishing agents used, and whether any equipment malfunctioned. Methods for fighting fires that follow crashes and for forced entry into burning aircraft have been the subject of much research. All available facts should be reported to improve safety to life.

2-2 It should be noted if escape from the burning plane was successful and whether emergency exits were able to be used or were blocked due to the fire's intensity and location. Information and data should be solicited from flight crew, passengers, and witnesses.

2-2.1 It is important to verify the weather conditions that existed at the time of the fire, particularly the wind direction and velocity. This information, combined with information on the location and use of emergency exits, can provide data on fire spread in the cabin interior.

2-3 Reports should indicate the type of ground fire fighting equipment available and used, including the response time and effectiveness of each responding vehicle, and the quantity and type of extinguishing agents used and left unused. The level of experience and degree of training of fire fighting and rescue personnel also should be reported. The type of clothing worn by personnel involved and the degree of protection provided by this clothing is especially important. Reports should indicate any problems with communications, command and control on the scene, and problems with any emergency plans employed.

2-4 A complete report should be made on the medical findings that result from analysis of the accident. This report should differentiate between injuries and deaths due to fire and those due to impact. Pathological examinations should include toxicological analyses in order to identify all toxic products of combustion. The report also should describe the fire extinguishment and victim care procedures that were used. These reports can be completed by different persons.

2-5 Complete information on in-flight fires is essential in order to improve and develop adequate fire warning and extinguishing systems. The source of the flight crew's discovery of fire in progress and the effectiveness of extinguishment efforts should be determined. A complete, step-by-step description of the procedure used by the crew for extinguishing the fire should be recorded and compared with the approved method listed in the applicable technical manual, flight manual, and flight attendant manual. The voice recorder and the aircraft flight recorder can be most helpful to the investigator in gathering this important information.

2-6 Before completing the aircraft fire and emergency response reports, the following tasks should be completed.

2-6.1 The data collector should become familiar with the overall accident site.

2-6.2 The data collector should determine the location of the responding emergency response services at the time of response and the response routes accessed.

2-6.3 The data collector should first walk through the wreckage area to size up the layout and distribution. This provides a mental picture of the main line of distribution and is helpful for plotting and interpreting witness statements, breakup patterns, etc.

2-6.4 Upon arriving at the accident scene, the data collector should immediately contact the accident investigator in charge. For on-airport accidents, the airport authority or the FAA can provide the location of the investigator in charge. For off-airport accidents, the local enforcement authority should be contacted.

PART I INSTRUCTIONS FOR COMPLETING THE NFPA AIRCRAFT FIRE INVESTIGATION REPORT

The following instructions provide detailed information on how to complete the "Aircraft Fire Investigation Report," which is reproduced in this guide. Sample information and data and instructions for completion appear in italics.

A. GENERAL

1. Aircraft Data:

a. Type of aircraft (common name or symbol): *Boeing 727*

b. Model no.: *Series 200*

c. Manufacturer of aircraft: *Boeing Company, Seattle, Washington*

d. Type and number of engines: *3*

e. Registration no.: *N304*

f. Name of operator: *OK Airlines*

g. Purpose of aircraft use at the time: *The aircraft was on a charter flight for the World's Sport Society.*

h. Flight route: *Chicago to Los Angeles via airways*

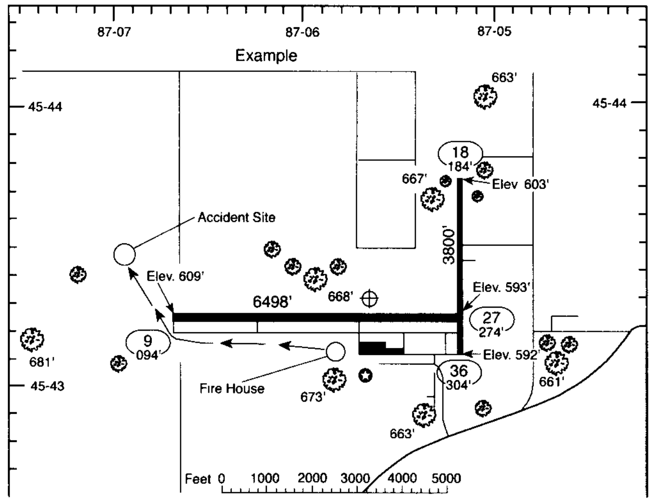
i. Other information: *Provide any additional, appropriate information regarding this aircraft or flight not indicated previously.*

2. Location of Emergency:

a. Provide name of specific airport, if applicable, or city, nearest city, or nearest airport, stating distance factors and, where applicable, compass directions: *1 mile northwest of Burbank Airport, Burbank, California.*

NOTE: In the United States, the National Transportation Safety Board (NTSB) identifies accidents by using the name of the nearest post office.

b. Prepare grid map, including terrain features: *This greatly assists in showing the exact location and helps to determine if the terrain was a factor in the accident. Use the grid map in the fire report. Please note that details of the fire scene are not included in this map but are to be entered later in the report on a separate grid map. In this sketch, show means of access to the accident site, including any perimeter roads around the airport, location of gates, etc. Indicate whether the Rescue and Fire Fighting (RFF) equipment had to travel long distances on public roads, and, if so, sketch the routing.*



3. Time Factors:

a. Date of accident: Day/Month/Year

b. Time (local and Greenwich Mean Time): Hour: minutes (local), Hour: minutes (GMT)

4. Type of Aircraft Accident: *There are eight basic types of accidents as far as the responsibilities of the aircraft fire investigator are concerned.*

a. Crash, no fire: *It is important for the investigator to determine why no fire occurred. What set of circumstances caused this crash without also causing a fire? A study of procedures that were used can be of benefit in future crashes.*

b. Crash, immediately followed by fire: *This type of accident is the opposite of item 4.a., but the object of the investigation is the same. What procedures were used?*

c. Crash, followed by fire but with delay in ignition (time interval): *What caused the delay in the ignition, and what procedures could have further delayed or prevented the ignition?*

d. Fire in air, fire extinguished in flight: *The cause of the fire should be determined, and the procedures used to extinguish the fire. How can these procedures be improved? Did the crew act rapidly enough?*

e. Fire in air, followed by crash and fire: *Crew members seldom survive this type of accident, and careful examination of the wreckage is necessary to determine the cause and location of a fire in the air. Examination of various components of the aircraft fire extinguishing system indicates the extent to which the extinguishing system was used and the procedures were completed. Remember to check the positions of components of other systems on the fire extinguishing checklist. It is possible that the procedure for manipulation of the fire extinguishing controls was positioned low on the checklist so that the crew did not have time to perform this function. Can the procedure be shortened? Why was the procedure unsuccessful in extinguishing the fire?*

f. Fire on the ground (no crash): *The cause of the fire should be determined to help prevent future fires of this type. The fire sequence should be examined carefully to determine if it is possible to reduce the time needed to extinguish a fire, the time needed to detect a fire, and the time needed to isolate a fire.*

g. Fire inside hanger (no crash): *The cause should be determined to aid in developing prevention techniques. Once the causal factor has been established, efforts to prevent this type of fire can be successful; however, since the cause of this type of fire* *usually is traced to human behavior, the procedures used and their effectiveness should be noted carefully. Can the procedures be made more effective?*

h. Fire—other (specify): *This section addresses any other type of aircraft accident. The causal factor should be determined, and the extinguishing procedures used and the extent to which they were successful should be identified. Can they be improved?*

i. In-water accident: *Determine the cause of the accident. It is important to describe the tactics, strategy, and equipment utilized to suppress fire and accomplish rescue in these circumstances. Much can be learned from this information.*

j. Other aircraft ground incidents: *It is important to describe other emergencies that necessitate an Aircraft Rescue and Fire Fighting (ARFF) response. Many times the prompt response of the ARFF prevents major aircraft damage and loss of life, and significant new response techniques are developed as a result.*

5. Flight Factors: *Observation of various flight factors prior to, during, and subsequent to initiation of an aircraft fire can supply information that leads to possible changes in procedures, structures, etc., that might prevent reoccurrence. Some pertinent flight factors include:*

a. Crash at takeoff: *Indicate the point in the takeoff roll at which the crash occurred. Had power been reduced? What was the configuration of the flaps, gear, etc.?*

b. Crash immediately after takeoff: *Indicate the approximate maximum altitude reached. Record the configuration of the flaps, gear, etc. Had power been reduced? What were the changes in the heading (if any) of the aircraft? Was any smoke or flame emitting from the aircraft? If so, from where and at what point in time?*

c. Aircraft in flight, power stall: *Was the aircraft involved in any abrupt pull-up? Was power still being applied?*

d. Aircraft in flight, explosion in air: *Was there any explosion while in the air? If so, when? Take care to differentiate between explosions and other sounds. A breaking spar can sound exactly like an explosion.*

e. Aircraft in flight, fire in air: *If a fire during flight is suspected, what indications, such as smoke or flame, are present? From what portion of the aircraft? The location of the smoke emissions from an aircraft often can provide a valuable clue to that checklist procedure last performed by the crew before fire occurred. What color and how intense is the smoke? Describe the color of the smoke as it relates to everyday items (e.g., white as a bed sheet, gray as newsprint, etc.).*

f. Aircraft in flight, structural failure: *In which phase of flight was the aircraft (takeoff, initial climb, cruise, etc.)? Which structure failed and when? In what manner? Was fire present? Did the fire occur before or after the structural failure?*

g. Collision with other aircraft while airborne: *In this situation, the main focus of attention should be the relative angle between the two aircraft as they approached each other.*

h. Collision with structure: *At what phase of flight did the collision occur (takeoff, initial climb-out, landing, etc.)? At what altitude above the ground did the collision occur?*

i. Collision with ground: *In which phase of flight was the aircraft? What was the angle of impact? Describe the type of terrain and surface characteristics (e.g., ditches, embankments).*

j. Crash while landing: *Did the crew give any warning of any unusual condition? Was any unusual condition evident from the ground? At what phase of the landing did the collision occur (e.g., prior to touchdown, during rollout, during taxi, etc.)?*

k. Crash while making emergency landing: *What were the indications regarding the type and nature of the emergency? In what type of terrain was the landing attempted? In what phase of the landing did the crash occur?*

l. Other:

6. Weather Factors:

a. General weather conditions: *Rain, fog, ice, snow*

b. Surface visibility, miles: *Runway visibility (RVR)*

c. Wind direction and velocity in knots:

d. Ambient temperature and dew point in °F or °C: *Specify measurement used.*

e. Ice, snow, fog, dry, wet:

f. Visibility distance:

B. FIRE FACTORS

1. Aircraft Fuel (Class B Fire):

a. Estimated amount of fuel on board at time of accident: *The quantity of fuel carried by the aircraft at the time of the incident/accident and an accounting of its status during and after the time of impact (if any) and fire (if any) are important in evaluating the effectiveness of the fuel tank construction and installation in minimizing fire hazard factors. Provide the quantities in gallons, pounds, kilos, or liters, specifying the unit used.*

b. Describe type of fuel spill and effect of terrain and soil conditions on fuel spill: *The dimensions of the fuel spill area in sq ft at time of ignition should be estimated, and the sequence of fire growth should be recorded from that time of ignition. This should include the rate of fuel leakage from tanks or broken fuel lines and the rate of growth of fuel spill area. (See NFPA 407, Standard for Aircraft Fuel Servicing, Section 3-2, for spill prevention and control.) Did the scope of the terrain affect fuel runoff?*

2. Other Flammable Liquids (Class B Fire): *Yes/No.*

Comments: Describe the part that engine oil, hydraulic fluid, alcohol, etc., played in the fire (pertinent only when original combustible or primary amount of fuel is involved): *It is common knowledge that other special purpose liquids carried aboard aircraft are not only combustible but can be destructive to foams that are likely to be used to extinguish the main fuel fire. Although the quantities of these liquids are small in comparison with the quantity of fuel load, their presence should be treated as a clue to any effectiveness deficiency in the extinguishing agents used.*

3. Combustible Metals (Class D Fire): *Yes/No.*

Comments: Describe the role of combustible metals as possible ignition source or continuing source of ignition (list types of metals involved): *What was the effect on fire control? Magnesium and titanium are the only metals likely to be encountered as factors in an aircraft fire. Metals usually are not the cause of large fires; however, they can create severe problems in a fire situation, since not only are they difficult to extinguish, but the usual agents, water and water-containing agents (e.g., foam), aggravate and often spread the burning metal. The metals themselves rarely self-ignite, but friction sparks resulting from their contact with the runway surface usually ignite fuel from any leaks in their vicinity. Metal fires usually are due to prolonged heating by the flames of liquid fuel fires or are the result of the friction of metals in contact with the runway. Titanium fires rarely occur.*

4. Ordinary Solid Combustibles (Class A Fire): *Yes/No.*

Comments: Baggage, cargo, personal effects, cabin interior furnishings, etc.: *Describe the role of solid combustibles as the original ignition source, the original combustible involved, or in terms of their effect on fire control. Fires burning in ordinary materials of construction, such as wood, cotton, rubber, synthetics, etc., are Class A fires. These fires normally are extinguished by water or foam and pose no special problem, except that they might be hidden and inaccessible to the fire fighter and, therefore, can constitute a constant reignition point for the flammable vapors.*

NOTE: Special attention should be given to radioactive substances carried in cargos under restricted conditions. See NFPA 402M, *Manual for Aircraft Rescue and Fire Fighting Operations,* Appendix C.

5. Other Combustibles Not Part of Aircraft: *Yes/No.*

Comments: Trees, grass, brush, vehicles, structures, etc.: *Describe the role of other combustibles as the original ignition source, the original combustible involved, or in terms of their effect on fire control.*

6. Oxygen Involvement: *Yes/No.*

7. Hazardous Materials/Dangerous Goods: *Yes/No.*

Comments: *Include any hazardous materials carried on the aircraft and their effect on the fire. Etiological factors should be covered in Part II.*

C. IGNITION SOURCE

1. General Location of Probable Original Ignition Source: *Ignition factors can be divided into four basic groups, as follows:*

a. Impact — frictional sparks, striking power lines, etc.: *The source of original ignition quite frequently is other than the aircraft itself. Ignition can result from a friction spark that occurs on impact or possibly from power lines or the landing area lighting system. When conducting investigations, a serious effort should be made to determine the cause of ignition. Each aircraft accident exhibits evidence of several ignition sources and usually more than one fire factor. The sources and factors of greatest concern are those that cause sustained fire progression. A close examination of the ground that runs from the aircraft back along the skid path, and even beyond the point of initial ground contact, is necessary to determine the point at which ignition occurred. This also helps determine whether fire was present prior to actual touchdown. Discoloration or charred material found in this area should be examined closely to attempt to determine the type of material burned and its possible location relative to the construction of the aircraft. Such material might consist of cabin furnishings, gear components, engine components, etc. Unlike structural buildings, where fire loads are somewhat static, the original ignition source in aircraft fires is not found necessarily in the areas where the most severe burning occurs. Information included in the report should describe the point of sustained ignition in relation to its position on or in the aircraft.*

b. Power plants: *In aircraft accidents where impact forces are extremely excessive, the aircraft power plants generally provide the initial ignition of aircraft fuel loads. For this reason, every attempt should be made to determine the damage to, as well as any movement of, the engines during and after initial impact. Ignition generally takes place when engines become torn loose, severing fuel and electrical power lines. This is especially true of the turbine engine, as it remains extremely hot internally and continues to rotate for a period of time after impact.*

c. Aircraft electrical circuits: *The next most common fire ignition results when electrical lines are severed in a fuel vapor atmosphere. Every effort should be made to examine broken wires and circuit breaker panels to discover possible causes of ignition, keeping in mind that there should be a source of flammable vapor or exposed combustibles in the area of the arcs, sparks, or heat if a fire was caused by such an ignition source. Examination of aircraft batteries also should be included in this investigation.*

d. Electrostatic sparks: *These often can be the cause of the original ignition source, since the aircraft itself, or portions of the aircraft that become separated during impact, builds up an electrostatic charge while moving through the air and might discharge this residual energy upon contact with the ground.*

e. Other sources of ignition not covered previously:

2. Progress of the Fire:

a. Describe the progress of fire from ignition through extinguishment: *Once the point of sustained ignition is determined, a close examination of the burn pattern, together with a study of the aircraft construction, should provide a fairly clear picture of how the fire propagated prior to fire extinguishment action. In many cases, the fire fighting efforts themselves cause fire extension in unusual patterns. These patterns generally can be distinguished from normal fire progression by the presence of extinguishing agent residue in the burn deposit. Note that normal fire behavior causes upward extension of the fire more rapidly than it causes lateral extension. Most materials, when burned or heated, become subject to air currents, and a close examination of the burn area provides an indication of fire travel by the manner in which the charred material is curved. At this point in the investigation, it is especially helpful to have an understanding of the temperature at which different metals melt or support combustion. It also is important to understand that fire can progress by radiation, convection, and conduction. Due to the aircraft construction, fire progression usually occurs by all three of the above methods. The most accurate account of fire progression usually can be obtained from eyewitnesses; however, during questioning, it is important to remember that each witness is likely to provide a different version of any given circumstance. No assumptions should be made until statements from several eyewitnesses have been received. Reported information then should be based on those facts most strongly supported by all of the accounts. When filling out the report form, chart the fire progression as closely as possible from the time of initial touchdown or sustained ignition. The progression should be recorded in minutes and seconds. This provides a more complete accounting of the fire progression. Also, attempt to determine any unusual problems encountered during fire extinguishment operations.*

b. Describe path and speed of flame spread; also the effect of structural breakup on flame spread; effect of open exits on flame spread; identify who opened exits and when they were opened: *These items are somewhat self-explanatory, and the answers can be obtained during the normal course of the investigation. Interrogation of survivors and eyewitnesses is the most reliable source of this information, but care should be taken in evaluating this information from individuals who are closely involved. Where possible, the most satisfactory method of determining time factors for specific conditions is to have persons furnishing factual information recreate their actions, as most people lose the awareness of time during emergency situations. If possible, survivors should recreate their actions during the accident while inside an aircraft of identical type and configuration. In reporting on this phase of the investigation, it is best to furnish a sketch of the aircraft and identify exits and other points of reference by use of a numbering system or other suitable means.*

c. Describe extent and length of time of fuselage survivability after impact: *This factor is subject to many variables, such as toxic gases, extent of carbon monoxide contamination, percentage of oxygen in the cabin, and temperature gradients. A complete laboratory analysis should be done on burn tests of the cabin interior materials to determine the toxicity of fumes. It is especially helpful to furnish a diagram of the cabin configuration showing those seats occupied at the time of impact. The diagram also should show the location of any fatalities and indicate those found in their original seat location. The survivors and flight attendants are the best source of this information, and an attempt should be made to determine how much time elapsed after impact before the last known survivor evacuated the aircraft. Investigation of fire origin and progression through the cabin also are very helpful in determining this time lapse. Examination of the items that follow will be beneficial in determining the above factors.*

(1) Inspection of metal parts: *A close investigation of metal parts involved in the fire area provides information on the severity and temperature of the fire. A basic knowledge of melting temperatures of various metals is necessary to establish temperatures. Since most aircraft metals are lightweight, they become subject to air currents when they are heated or reach the fluid state.*

(2) Fuel odors: *During the investigation, check all areas of the aircraft for residual fuel odors to determine the extent of fuel spread. This is especially important in the baggage and cabin areas. Regardless of the extent of burnout, if fuel was present, the charred remains will have produced some trace of fuel odor.*

(3) Pressurized containers: *Many types of pressurized containers can be found in the personal effects aboard the aircraft as well as in the ordinary furnishings in the cabin area. Where pressure has been released during fire, unusual burn patterns can be detected. These provide an indication of free-burn areas as well as excessive temperatures that can cause exterior venting.*

(4) Oxygen systems: *Both fixed systems and walk-around oxygen bottles contribute greatly to cabin burnout. These systems should be located and identified before a full appraisal of the fire behavior is reported.*

(5) Smoke deposits: *During the investigation, various types of smoke and ash deposits will be encountered. Any unusual deposits of these materials should be inspected carefully and analyzed to determine the type of material that caused the burn. Foreign material deposits in these areas also should be noted.*

D. AIRCRAFT SAFETY SYSTEMS

1. Did aircraft have any fixed fire extinguishing systems? *All transport category aircraft, as well as some light twin aircraft, have such systems. Most single-engine types do not.*

2. What type of system?

3. Specify extinguishing agent employed: *Most modern aircraft are equipped with bromotrifluoromethane (halon 1301) systems, which discharge by remote control from the cockpit into the fire zone of each engine by selection. Some aircraft also discharge agent into baggage bins, but most do not. Other agents that might be used are carbon dioxide (CO_2), chlorobromomethane (CB or CBM), or bromochlorodifluoromethane (halon 1211-BCF). The investigator should obtain all necessary details of the system installed from the fire extinguishing equipment manufacturer.*

4. Was it used? What effect did it have on fire? *If possible, determine sequence of events and the answers to these questions from conversation with crew. Sequence should include the time from fire alarm or detection to discharge of agent and the effect of agent on fire. Was entire quantity of airborne agent used on fire? If fire continued, indicate time from discharge to landing or impact. Describe airborne progression of fire. If crew is not available, determine from examination of aircraft or remains the position of the fire discharge controls, whether or not extinguishing agent cylinders are empty, etc.*

5. Were aircraft hand-operable fire extinguishers available? Were they used?

6. State effectiveness: *These questions apply only to fire originating in a cabin or in accessible baggage bins.*

7. Did the aircraft have fire alarm and detection equipment installed?

8. What type? Did it operate?

9. Other information: *Any other information pertinent to the aircraft fire detection and extinguishing system.*

E. EMERGENCY NOTIFICATION

1. How long after the accident occurred was it discovered? *If there was uncontrolled ground fire, the investigator's job is made more difficult by destruction of possible evidence and the obscuration and masking of existing evidence. If exact time is not available, a close approximation later in the investigation helps significantly in determining burn times and effect on the evidence.*

2. Who discovered the accident? *The time lapse between the occurrence of an accident and its discovery is a factor of some importance to the investigating team. Many aircraft accidents are discovered after it is too late. The reasons vary: weather conditions, aircraft out of fuel, isolated areas, and loss of communication with the aircraft. The discovery of an accident by other aircraft notification or by survivors ultimately can be of great value to the investigator.*

3. Who dispatched the fire alarm? *Agency that ordered ARFF equipment to respond.*

4. How was the fire alarm transmitted? *Box, telephone, radio, observed, other (specify). It is important for the investigator to find out from reliable sources who initiated the alarm and how it was transmitted. Many airports have a mutual aid agreement with local fire authorities whereby alarms are transmitted by a "hot line" connected directly to the fire department alarm station for use in the event that outside help is needed by the airport crash and rescue crew.*

5. Was location of accident accurately described? *If not, indicate the reason and describe the effect of any related delay in fire and rescue service. The investigator should be informed of the accuracy or inaccuracy of the original description of the accident location. In cases where an inaccurate location has been provided, valuable response time has been lost. It is then necessary to investigate the reason for the delay in the response.*

6. Consequences of erroneous response information:

7. What were the fire and evacuation conditions at the time of arrival of the rescue and fire fighting equipment? *The fire and evacuation conditions at the time of the arrival of the rescue units are highly significant in the final analysis of the accident. These conditions can indicate the extent of fire, complete engulfment by fire, presence of interior or exterior fires, type of odors, smoke, and evacuation status of passengers. Were passengers evacuating, not evacuating, or was evacuation complete on arrival of rescue equipment?*

8. Time factors: *Time factors should be determined as precisely as possible from the records, flight crew, fire department, air traffic control tower, and Air Traffic Control (ATC), etc. After analysis, the investigator should be able to determine the effectiveness of each phase of the operation. Include response time of ARFF vehicles, from alarm to arrival at the scene, and number of vehicles with VHF communications. Also include response interference factors (e.g. weather, traffic, terrain) and those that affected the response time of the ARFF vehicles such as: weather, distance from fire house, terrain, and access roads.*

9. Remarks: *Include all conclusions drawn by the data collector after analysis of the detection and alarm system used and the time factors involved. If any time factors seem implausible, the data collector should request a simulation or rerun.*

F. AIRCRAFT RESCUE AND FIRE FIGHTING (ARFF) SERVICES

1. Vehicles and Manpower Table. *This table should be filled out carefully by the investigator working in coordination with the fire department. It provides information on the effectiveness of particular vehicles and the physical details of the operation and is useful not only in assessing effectiveness for the particular fire but serves as documented experience for study by all RFF services. Make certain to note condition of each vehicle in the "Remarks" section. Note any injuries to RFF personnel during this operation as well as details of the use of any airport-based medical vehicles. The quantities provided in tables should be expressed in national units of measure of state involved.*

2. Fire Extinguishing Agents Used and Techniques Employed: *This table should be filled out carefully by the investigator working in coordination with the fire department. This table is used to assess the overall effectiveness of the fire department by determining quantities of agents used, discharge rates and time, and order of agent use. In the "Remarks" section, note any effect agents have had on one another. Note specifications and type of agents used and the quality of agent produced. Fire fighters on duty during the operation should be questioned regarding any deleterious effects on the foam blanket due to any other agents used. The quantities provided in tables should be expressed in national units of measure of state involved.*

a. *In the past, agent quantities were determined from fire ground tests and previous experience, since detailed accident data was unavailable.*

In order to justify the agent quantity formula, $Q = Q_1 + Q_2 + Q_3$, *it is essential that the following data be available:*

Q_1 - *water quantity for control of the fire*

Q_2 - *water quantity used for extinguishment*

Q_3 - *water used by handlines, water used for maintenance (overhaul) operations.*

3. Fire Fighting Operations: *Describe conduct of fire fighting operations after arrival of equipment. After questioning the fire department, reconstruct the operational details in chronological order. Briefly describe the extent of the blaze, effect of the fire fighting operation, start of evacuation, and completion of rescue and control of the fire situation. If the fire attack was interrupted by a lack of replenishment water, note the reason for the delay. Include a description of problems encountered and lessons learned.*

a. Training: It is important to ensure adequate and proper training by maintaining records on the type and frequency of training and the most recent training evolution employing hot drills, cabin interior drills, and aircraft pre-fire planning. Lack of sufficient training is a significant factor in the improper use of existing ARFF equipment.

b. Clothing: The type of protective clothing utilized for fire suppression is significant, since NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program,* mandates a minimum level of personal protective equipment for ARFF.

c. Self-Contained Breathing Apparatus (SCBA): Recording the use of SCBA and the type utilized establishes statistics that define the levels of personal protective equipment used to suppress ARFF fires.

4. Grid Map of Accident: *Sketch the details suggested in the fire report on a separate sheet of paper. When satisfied that all details are included, transfer the sketch to the grid map. In the explanatory remarks, explain all details of the diagram that are necessary.*

G. HUMAN FACTORS. *It is vitally important when analyzing an aircraft accident involving fire to obtain as much information as possible on the occupants of the aircraft. Improved aircraft structures and rescue techniques can result. Therefore, as many details as possible should be obtained by investigators. The coordinated effort of the entire investigation team should be used in this area.*

1. Personnel Table: *After consultation with those who participated in the rescue of personnel, the investigator should fill out this table carefully. If possible, a seating arrangement showing the location of passengers and crew prior to the accident (including gender and whether child or adult) should be obtained.*

2. Number of Casualties: *The investigator should create a seating arrangement chart indicating the status of passengers and crew during and after the accident, e.g., injury, burns, fatality, (provide cause, e.g., burns, asphyxiation, impact), escaped unaided, rescued by fire and rescue personnel.*

3. Describe Evacuation, Number of Rescue Personnel, Exits Used, Break-in Areas Used: *Extensive questioning of flight crew and passengers should help the investigator in this description. Include the extent of briefing and preplanning, if known.*

a. *Had occupants begun evacuation or were they waiting to be rescued?*

b. *Had flight crew been able to complete emergency shutdown drills?*

c. *Were passengers or crew able to operate escape hatches satisfactorily?*

d. *Was sufficient marking and lighting available to facilitate evacuation?*

e. *Describe in detail any difficulties encountered in evacuation.*

4. Time Required to Accomplish Rescue and Removal of Occupants:

a. *Did occupants respond to orders from rescue crews?*

b. *Which emergency exits were used during evacuation? Did they function properly, or were they damaged by impact or fire?*

c. *Were aircraft crew able to assist in the rescue? If so, to what extent?*

d. *How many persons used each means of egress?*

5. Time Required to Control Fire? Time Required to Extinguish Fire? *Describe in detail if passenger and crew evacuation delayed extinguishing of fire. Smoldering and small spot fires not affecting rescue should not be included in this time factor.*

Copies of each report should be sent to the appropriate government authorities involved in the investigation.

When released by these authorities, reports should be sent to the following organizations:

International Civil Aviation Organization
1000 Sherbrooke Street, W
Montreal, PQ, Canada H3A 2R2

Fire Analysis Department
National Fire Protection Association
1 Batterymarch Park
P.O. Box 9101
Quincy, MA 02269-9101 U.S.A.

Other concerned qualified authorities such as the U.S. Air Force, U.S. Navy, U.S. Flight Safety Foundation, etc.

NATIONAL FIRE PROTECTION ASSOCIATION
AIRCRAFT FIRE INVESTIGATION REPORT

Report # **Date of Report**

A. GENERAL

1. Aircraft Data

a. Type of aircraft ____________________

b. Model no. ____________________

c. Manufacturer of aircraft ____________________

d. Type and number of engines ____________________

e. Registration no. ____________________

f. Name of operator ____________________

g. Purpose of aircraft use ____________________

h. Flight route ____________________

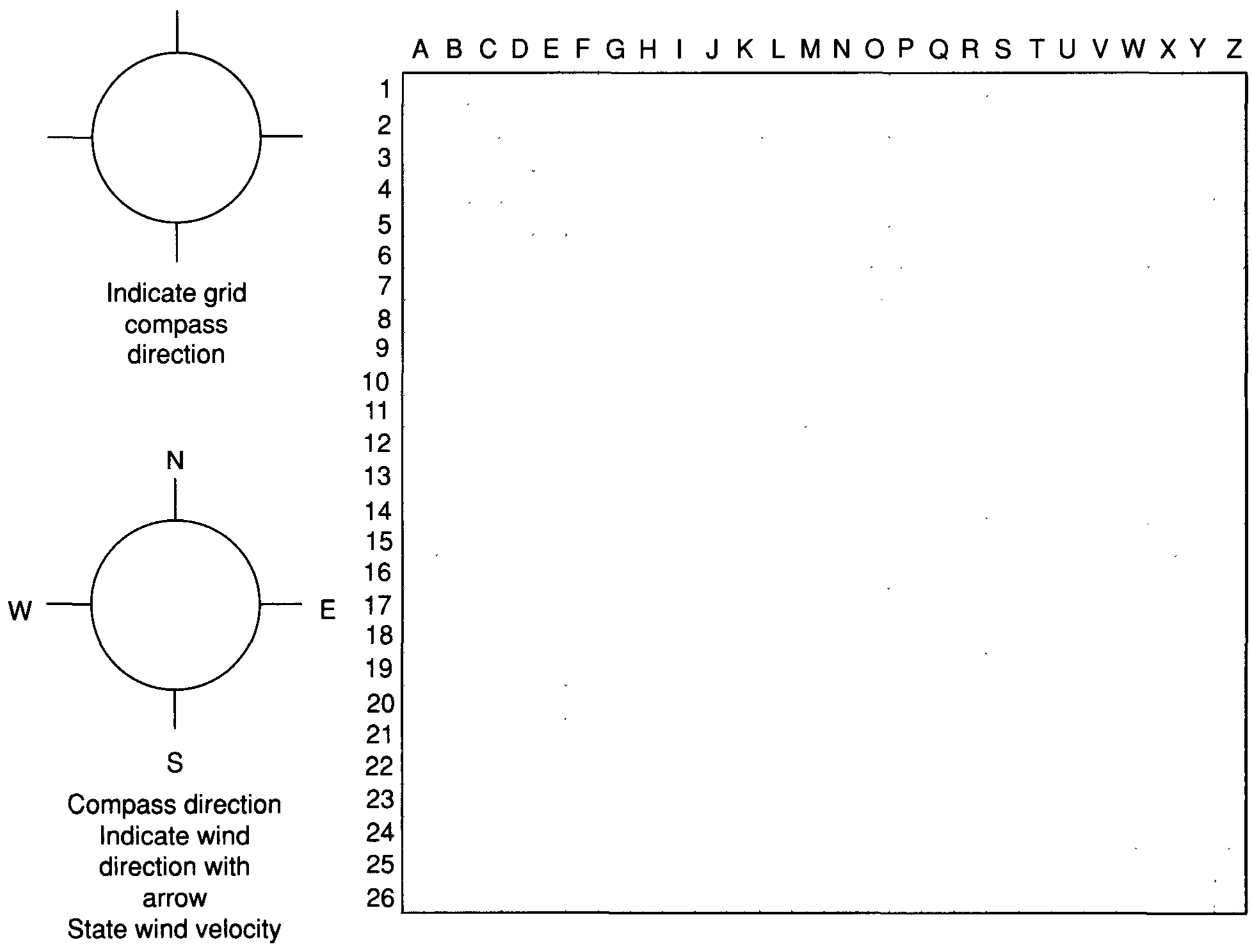
i. Other information ____________________

j. Other ____________________ Name of operator ____________________

2. Location of Emergency

a. Provide name of specific airport, if applicable, or city, nearest city, or nearest airport, stating distance factors and, where applicable, compass directions.

b. Prepare grid map showing location of the accident site in relation to the fire station, the access route taken, and any significant features, such as runways, taxiways, aprons, roads, and water area. Include relationship of crash site to city or airport.



3. Time Factors

a. Date of accident ____________

b. Time—Local ____________

4. Type of Aircraft Accident (check the appropriate items)

a. Crash, no fire ____________

b. Crash, immediately followed by fire ____________

c. Crash, followed by fire but with delay in ignition ____________
Time interval ____________ minutes

d. Fire in air, fire extinguished in flight ____________

e. Fire in air, followed by crash and fire ____________

f. Fire on the ground (no crash) ____________

g. Fire inside hangar (no crash) ____________

h. Fire—other (specify) ____________

i. In-water accident ____________

j. Other aircraft ground incidents ____________

5. Flight Factors (check the appropriate items)

On airport ____________ Off airport ____________

a. Crash at takeoff ____________

b. Crash immediately after takeoff. Altitude obtained ____________

c. Aircraft in flight, power stall ____________

d. Aircraft in flight, explosion in air ____________

e. Aircraft in flight, fire in air. Designate origin ____________

f. Aircraft in flight, structural failure. Designate structure ____________

g. Collision with other aircraft while airborne ____________

h. Power on, collision with structure ____________ Type of structure ____________

i. Power on, collision with ground ____________ Type of ground ____________

j. Crash while landing (runway) ____________

k. Crash while making emergency landing (off runway) ____________

Type of terrain ____________

l. Other (specify) ____________

6. Weather Factors

a. General weather conditions ____________

b. Surface visibility ____________ miles/feet

c. Wind direction ____________ Wind velocity/knots ____________

d. Ambient temperature ____________ °F ____________ °C Dewpoint ____________ °F ____________ °C

e. Ice ____________ Snow ____________ Fog Dry ____________ Wet ____________

f. Visibility distance ____________

B. FIRE FACTORS

1. Aircraft Fuel (Class B Fire)

a. Quantity of fuel ____________ Type of fuel ____________

b. Describe type of fuel spill.

(1) Dimensions ____________

(2) Rate of fuel leakage ____________

(3) Terrain ____________

(4) Soil conditions ____________

2. **Other Flammable Liquids (Class B Fire)** Yes ____________ No ____________

   Comments: ____________

3. **Combustible Metals (Class D Fire)** Yes ____________ No ____________

   Comments: ____________

4. **Ordinary Solid Combustibles (Class A Fire)** Yes ____________ No ____________

   Comments: ____________

5. **Other Combustibles Not Part of Aircraft** Yes ____________ No ____________

   Comments: ____________

6. **Oxygen Involvement** Yes ____________ No ____________

   Liquid ____________ Gaseous ____________ Solid (Generator) ____________

7. **Hazardous Materials/Dangerous Goods** Yes ____________ No ____________

   Type and location ____________

   Comments: ____________

C. IGNITION SOURCE

1. **General Location**

   a. Impact ____________

   b. Power plants ____________

   c. Aircraft electrical circuits ____________

   d. Electrostatic sparks ____________

   e. Other sources ____________

2. **Progress of the Fire**

   a. Describe the progress of the fire from ignition to extinguishment. ____________

   b. Describe the path and speed of flame spread; also the effect of structural breakup on flame spread, effect of open exits on flame spread; identify who opened exits and when they were opened. ____________

   c. Describe the extent and length of time of fuselage survivability after the impact.

      (1) Inspection of metal parts ____________

      (2) Fuel odors ____________

      (3) Pressurized containers ____________

      (4) Oxygen systems ____________

      (5) Smoke deposits ____________

D. AIRCRAFT SAFETY SYSTEMS

1. **Did the aircraft have any fixed fire extinguishing systems?** ______
2. **What type of system?** ______
3. **Specify extinguishing agent employed** ______
4. **Was it used?** ______ **What effect did it have on the cabin, lavatory, cargo, or engine fire?** ______

______

5. **Were aircraft hand-operable fire extinguishers available?** ______
   Were they used? ______
6. **State effectiveness** ______
7. **Did the aircraft have fire alarm and detection equipment installed?** ______
8. **Which type?** ______
   Did they operate? ______
9. **Other information** ______

E. EMERGENCY NOTIFICATION

1. **How long after the accident occurred was it discovered?** ______
2. **Who discovered it?** ______
3. **Who dispatched the fire alarm?** ______
4. **How was the fire alarm transmitted?** ______
   Box ______ Telephone ______ Radio ______ Observed ______ Other ______
5. **Was the location of the accident accurately described?** ______
6. **If not, indicate the reason and describe the effect of any related delay in the response of the ARFF.** ______

______

7. **What were the fire and evacuation conditions at the time of arrival of the ARFF?** ______

______

8. **Time Factors**
   a. If emergency preannounced, from announcement to touchdown (impact), ______ minutes
   b. If emergency not preannounced, from accident/incident to alert of the ARFF services, ______ minutes
   c. From alert to the arrival of the major vehicles, ______ minutes
   d. From arrival of the ARFF to fire under control, ______ minutes
   e. From arrival of the ARFF to rescue operations commencing, ______ minutes
   f. From arrival of the ARFF to rescue operations terminated, ______ minutes
   g. From arrival of the ARFF to extinguishment of the fire, ______ minutes
   h. From extinguishment of fire to return to service, ______ minutes
   i. List any factors that affected the response time of the ARFF ______

   ______

9. **Remarks** ______

______

______

______

F. RESCUE AND FIRE FIGHTING (ARFF) SERVICES

1. Vehicles and Manpower

a. Were any vehicles out of service at the time of accident? ____________________

List type and reason for lack of availability

(1) ____________________

(2) ____________________

(3) ____________________

VEHICLE AND STAFFING TABLE

		Vehicle 1	**Vehicle 2**	**Vehicle 3**	**Vehicle 4**	**Vehicle 5**
Brand Name and Manufacturer						
Date of Procurement						
Model/Year of Manufacture						
Agent Capacity Check One Gallons ______ Liters ______	Foam					
	Water					
	Dry Chem.					
	Halon					
	Other					
Agent Discharged Check One Gallons ______ Liters ______	Foam					
	Water					
	Dry Chem.					
	Halon					
	Other					
Manpower Assigned						
Number of Turrets						
Turret Flow Rate(s) and Pattern	1					
	2					
Time Vehicle Dispatched						
Response Time to Scene						
Distance Traveled						
Time Returned to Service						
Terrain Conditions	Ice					
	Mud					
	Snow					
	Steep Slopes					
	Sand					
	Other					
Communication Equipment	Radio					
	Cellular Phone					
	Fax					
	Aircraft Headphones					
	Bullhorn					

Remarks: ____________________

____

____

2. Fire Extinguishing Agents Used

Table 2(a) Total Agents and Quantities Applied

Check One: Gallons ________ Liters ________

Type	Control – Q1	Extinguish – Q2	Handlines Overhaul – Q3
Dry Chemical			
Halon			
Foam			
Other			

Table 2(b) Handline Utilization

	Number of Lines	Size of Lines	Flow Rate Hoseline(s) Check One GPM _____ LPM _____			Handline Size Hoseline(s)			Nozzle Type Hoseline(s)			Manpower Hoseline(s)		
			#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3
External Use														
Interior Use														

3. Fire Fighting Operations

Were vehicles replenished with water? No ____________ Yes ____________

Source: Tankers ____________ Hydrants ____________ Drafting ____________ Relay pumping ____________

Describe details or resupply operation: ____

____

Were vehicles replenished with foam? No ____________ Yes ____________

Source: 5-gallon cans __________ Barrels __________ Tanker on-site __________ Tanker at firehouse __________

Was agent replenishment a factor that impaired the fire suppression operation? If yes, explain ____________

____

Describe the fire fighting strategy and tactics in detail ____

____

Problems encountered ____

____

Lessons learned and verified by experience ____

____

a. Training

(1) Training to NFPA 1001, *Standard for Fire Fighter Professional Qualifications*, and NFPA 1003, *Standard for Airport Fire Fighter Professional Qualifications* ____

(2) Date of last live fire ____

(3) Date of last cabin interior drill ____

(4) Date of last aircraft pre-planning exercise on affected aircraft ____

b. Clothing

(1) Type of protective clothing used.

(NFPA 1976, *Standard on Protective Clothing for Proximity Fire Fighting*) Proximity________________________

(NFPA 1971, *Standard on Protective Clothing for Structural Fire Fighting*) Structural ________________________

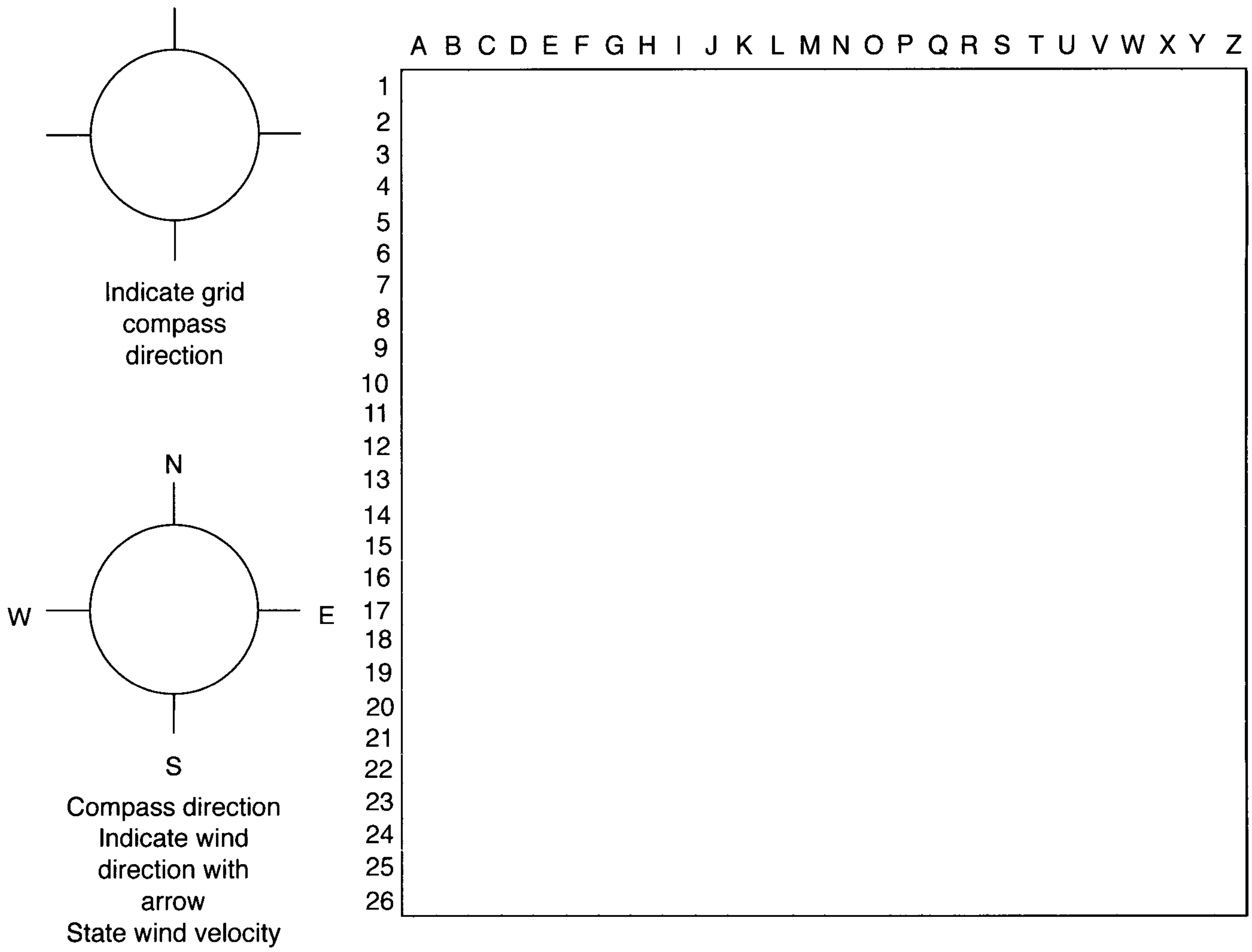
c. Self-contained breathing apparatus (SCBA)

(1) Which type? ____

(2) Was it used? ____

4. Grid Map of the Accident

a. Draw a diagram showing the positioning of the ARFF equipment in relation to the aircraft and including significant features such as fuel spills, escape routes, unusual terrain, water supplies, and buildings.



Explanatory Remarks

____

____

____

____

G. HUMAN FACTORS

1. Personnel Table

Occupants	Total on Board	Evacuated Unaided	Extricated	Medical Priority 1	Medical Priority 2	Medical Priority 3	Fatalities
Passengers							
Crew							
Other							

2. Number of Casualties

a. Number who died as a result of this accident? ____________________

b. Number who died as result of burns? ____________________

c. Number who died from suffocation? ____________________

d. What special factors are important regarding occupants (e.g., number thrown clear of the wreckage, rescue difficulties due to location of occupants, type of injuries, etc.)? ____________________

3. Describe Evacuation, Number of Rescue Personnel, Exits Used, Break-in Areas Used ____________________

____

____

4. Time Required to Accomplish Rescue and Removal of the Occupants ____________________

____

____

5. Time Required to Control the Fire, __________ minutes

6. Time Required to Extinguish the Fire, __________ minutes

PART II

INSTRUCTIONS FOR COMPLETING THE NFPA DISASTER RESPONSE REPORT

PURPOSE

The purpose of Part II is to provide the information associated with an accident that can be used to update and refine disaster plans for other airports and communities involved in aviation operations. It also is used to provide data for the revision of NFPA 424M, *Manual for Airport/Community Emergency Planning*. Both the positive and negative consequences of the operation should be emphasized with the objective of improving safety to life in future accidents.

1. Data Collection

The information needed to complete this report can be obtained from the FAA, airline owner, or aircraft owner or their representatives and from representatives of the responding services.

2. Disaster Plan

A copy of the plan should be obtained. This provides the investigator with access to the telephone contacts necessary for obtaining details on the effectiveness of the response and a critique of the most recent exercise.

3. How Was the Alarm Received?

4. Response Times

Response times have a direct bearing on the entire rescue operation. They usually are reported to the Chair of the NTSB Human Factors Group during interviews with the responding agencies. Response times often are recorded on tapes maintained by the airport tower, fire departments, and emergency services. Where recorded times are not available, more than one source should be used for verification.

5. Responding Agencies

5.1 Mutual Aid Fire Services

The number of vehicles used for response and their function during the rescue operation are vital pieces of information that can affect future operations. Vehicle type should be recorded and identified as pumper, ladder, hose layer, etc. The arrival time of each vehicle and its effectiveness to the operation also should be recorded. Were the vehicles used to fight the fire or to replenish the ARFF vehicles? Were they used to maintain airport protection while the ARFF vehicles were fighting the fire? Were personnel used to extricate the victims? Only mutual aid off-airport vehicles should be included. DO NOT include airport ARFF crash trucks.

5.2 Helicopters

Include any helicopters that participated in the location or evacuation of survivors. Also include helicopters for news reporting that did not participate in the evacuation but aided traffic control.

5.3 Civil Defense

Include the vehicles responding and their part in the operation. Did they provide radio communications with other responders? What was their relationship to the command post?

5.4 Military

Include any military assistance provided at the scene, such as hazardous material control, helicopter response, etc. Provide the names of those units that assisted.

5.5 Police

Include local police responsible for maintaining ready access for emergency vehicles and crowd control.

5.6 Sheriff/State Patrol

Include any local security services that were involved. Was their participation effective, or did they interfere with the operation?

5.7 Airline/Airport Personnel

The first responders to an accident often are airport personnel who are working at the time of the accident. They provide help in any way they are able, from extrication of victims to personal care of the survivors. Include the number of responders, their affiliation, and the function they performed during the accident response.

5.8 Ambulance Services

It is often difficult to verify the identity of the first ambulance service to arrive at the scene, the number of survivors that service transported, and the medical facility to which survivors were taken. This section should include the names of the responding ambulance services, their approximate response times, and the number of patients whom they transported. Information on whether or not the ambulances were used also should be recorded.

5.9 Other Responders

Other responders should include the Red Cross, clergy, coroner, postal authorities, customs and immigration officials, and any additional participants not previously identified.

6. Rescue Operation

6.1 Mobile Command Post

Identify the operator of the command post and describe the type of vehicle. Was the vehicle self-propelled? Was it equipped with full emergency communication equipment? Is the vehicle owned by the airport authority, fire department, civil defense, or police? Approximately how long after the accident was the command post ready to assume control of the operation?

6.2 There usually is a change of on-scene commander during the course of operation. The first fire chief to arrive at the scene usually assumes command until replaced by the command post. Both persons should be identified.

6.3 Describe the type of command post (e.g., van, converted bus, trailer). How was it equipped (e.g., radio, VCR, mobile telephones)?

6.4 Was the command post easily recognizable while all responding vehicles were on the scene? How was it recognized?

6.5 Describe any problems encountered with communication procedures. These should include frequency congestion, incorrect frequencies, etc.

6.6 If an emergency operations center was used, describe its location and the effectiveness of its operation.

7. Triage

7.1 The triage operation may be permitted to be initiated by the airport EMTs, fire fighters, or the first responding medical unit.

7.2 The full triage operation usually is conducted by the medical authority identified in the disaster plan and usually is the medical facility located nearest the accident scene.

7.3 The location of the triage operation is of major importance. Its location relative to the accident, wind direction, and ambulance routing should be noted. How was the triage site marked?

7.4 Were emergency medical supplies available at the site? Where were they located, and how were they transported to the scene?

7.5 What were the terrain conditions at the site (e.g., swamp, trees, hills, level ground, etc.)? Did they affect efforts to set up the triage operation or the movement of the ambulances?

7.6 Were the ambulance movements controlled or did blockages result?

7.7 Note the approximate arrival times of doctors, nurses, and EMTs in relation to the time of the accident.

7.8 Note any reported obstacle to the triage operation, such as hypothermia, heat, and rain. Note the weather conditions at the time of the accident, such as temperature, precipitation, and visibility.

7.9 How were the victims tagged?

8. Medical Services

8.1 Identify the hospitals used during the emergency, the types of hospitals, such as eye, burn, trauma, etc., their distance from the accident site, and the number of casualties taken to each.

8.2 Were those who were injured but ambulatory taken to hospitals or first aid stations? Who cared for them before their release?

8.3 What provisions were made for the uninjured? Were they transported from the site? Where where they held? Were they separated from the news media? Were they provided with food and drink?

8.4 What provisions were made for the fatalities? Were there enough body bags? Where was the morgue set up? Was it set up using refrigerated trucks or other means?

8.5 Self-explanatory.

9. Police Security

9.1 At major airports, airport police are responsible for any airport emergency. They might, however, be a part of the city or county police. In the case of off-airport accidents, the security of the scene is under the control of the local authority.

9.2 The increase in airport security has resulted in several cases where the response of the emergency services was delayed by locked gates or restricted areas. Such interference with emergency response should be documented fully.

9.3 Were the emergency services delayed by highway traffic conditions?

9.4 Was the news media access controlled, or did they reach the site without authorization?

9.5 How was the general public restrained from access to the accident site?

9.6 For accidents that occurred on the airport premises, was an escort provided for mutual aid responders? Who provided the escort?

9.7 How long after the accident was the crash site secured? How was it secured (e.g., ropes, barriers, police protection)?

9.8 How were the mutual aid responders informed of the stage areas? Were they effective?

10. General

10.1 Which types of shoring materials, such as railway ties, were available to aid in extraction of the victims? Was heavy machinery, such as cranes or bulldozers, necessary for the operation?

10.2 If there were any problems with hazardous materials at the accident site, record the type of material and how it was handled.

10.3 Were all responders easily identified? How (e.g., baseball hats, armbands, vests, uniforms)?

11. Water Accidents

11.1 Many recent accidents have occurred in the water adjacent to the airport property. Identify all responding water rescue agencies, such as Coast Guard or police, and also record any water rescue equipment maintained by the airport authorities.

11.2 Some aircraft carry only floatable seat cushions. Others carry only life vests, while still others carry full overwater equipment, including rafts and life vests.

11.3 Was any additional flotation equipment transported to the scene? How was it used?

11.4 Record the water and weather conditions at the time. Both air and water temperatures should be recorded. Was visibility restricted by fog or darkness?

11.5 Describe any problems locating aircraft.

11.6 Underwater search and recovery

11.7 Any resuscitation of victims of hypothermia due to near-drowning in cold water?

PART II NATIONAL FIRE PROTECTION ASSOCIATION DISASTER RESPONSE REPORT

Aircraft no. ____________ Flight no. ____________

Type of aircraft ____________

Aircraft operator ____________

Date of accident ____________

1. Data Collection

Number of occupants:

Cockpit crew ____________

Cabin crew ____________

Passengers ____________

Other persons involved and location

____

____

Number occupants escaped unaided, uninjured ____________

Number occupants escaped unaided, ambulatory, injured ____________

Number rescued ____________

Number of trauma-related fatalities ____________ Fire-/smoke-related fatalities ____________

Other fatalities ____________

Time last survivor was evacuated ____________

2. Disaster Plan

Date of last revision ____________

Date of last inspection ____________

Is plan current? ____________

IF NOT, WHY? ____________

Incorrect telephone numbers ____________

Incorrect radio frequencies ____________

Incorrect agencies, names, etc. ____________

Date of last full-scale exercise ____________

Date of last table top exercise ____________

Did all responding agencies participate in the exercises? ____________

IF NOT, EXPLAIN ____________

Dates of any mini exercises in last two years ____________

Review of mutual aid agreements ____________

3. How Was Alarm Received? ____________

____

____

4. Response Times Local

	Local
Time of accident	________
Initial notification of ARFF	________
Arrival of ARFF	________
Disaster plan activation	________
Triage initiated	________
First casualty transported to hospital	________
Arrival of mobil command post	________
Arrival of first medical services	________
Arrival of transportation for uninjured	________
Arrival of first ambulances	________
Arrival of police/security services	________
Arrival of mutual aid fire services	________
First casualty transported to hospital	________
First and last vehicle arrival at hospital	________
Last casualty transported to hospital	________
Response terminated	________

5. Responding Agencies

5.1 Mutual Aid Fire Services

Mutual Aid Fire Services

			Amount of Agent Carried Check One Gallons ______ Liters ______		
Agency	**Vehicle Type**	**Time of Arrival**	**Water**	**Foam**	**Other**

Other ______________________________

Use extra sheet if number exceeds ten.

How were these vehicles utilized? ______________________________

____

____

Primary fire fighting ________ Tankers ________ Rescue ________

Standby for continuing flight operations ______________________________

Other ______________________________

5.2 Helicopters

Were helicopters used during the emergency? ______

To locate accident site? ______

To control traffic? ______

To transport casualties to hospital? ______

Record the owner and/or operator of each helicopter

(a) Arrival time ______

______

(b) Arrival time ______

______

(c) Arrival time ______

______

(d) Arrival time ______

______

5.3 Civil Defense ______

5.4 Military ______

5.5 Police ______

5.6 Sheriff/State Patrol ______

5.7 Airline/Airport Personnel ______

5.8 Ambulance Services ______

Ambulance Services

Owner/Operator	Number Medical Personnel Provided	Patient Capacity	Arrival Time at Scene	Used/Not Used

Medical Personnel

Doctors ______

Nurses ______

EMTs ______ ALS ______ BLS ______

5.9 Other Responders ______

6. Rescue Operation
   6.1 Mobile command post ______
   How long after the accident was the command post ready to assume control of the operation? ______
   6.2 Who was the on-scene commander? ______
   Was the incident command system (ICS) used? ______
   Problems with the ICS? ______
   6.3 Was the mobile command post (MCP) power-driven or trailer? ______
   6.4 Was the MCP easily recognizable? ______
   How? Lights ______ Balloon ______ Other ______
   6.5 Was communication with responding agencies adequate? ______
   Radio ______ Telephone ______ Land/cellular ______ Fax ______ Other ______
   Problems with communication ______
   ______
   6.6 Was an emergency operations center available? ______
7. Triage
   7.1 Who initiated triage operations? ______
   7.2 Who conducted the triage operation? ______
   7.3 Where was triage operation set up in relation to the accident?
   Describe location showing ambulance arrival and departure routes ______
   ______
   ______
   7.4 Were emergency medial supplies available at the site? ______
   7.5 Was terrain or weather a problem? If so, describe. ______
   ______
   7.6 Were ambulance arrivals/departures controlled in an orderly manner? ______
   7.7 Arrival time of first Doctors ______ EMTs ______ Nurses ______
   7.8 What were the weather conditions at the accident site?
   Temperature ______ Wind Direction ______ Wind Velocity ______ Precipitation ______ Visibility ______
   7.9 How were the victims tagged? ______
8. Medical Services ______
   8.1 Hospital distribution

Name of Hospital	Type	Distance from Incident	Arrival Time	Number of Casualties

8.2 How were the injured but ambulatory treated?
First aid at site ____________ Transported to hospital ____________

8.3 What provisions were made for the uninjured/ambulatory?
Transported to the terminal by bus ____________ Other ____________
Provided with telephones ____________ Food ____________ Drink ____________

8.4 What provisions were made for the fatalities?
Body bags available ____________ Temporary morgue ____________
Other ____________

8.5 Were the services of the following available?
Coroner ____________ Clergy ____________ Post office ____________
Customs ____________ Red Cross ____________

9. Police/Security

9.1 Who provided the police services?
Airport ____________ County ____________ State ____________ City ____________

9.2 Describe problems encountered regarding airfield/site access in detail ____________

9.3 Was highway traffic control adequate for the responding agencies? ____________

Were there any street closure plans implemented? ____________

9.4 Was the news media access coordinated? ____________ How? ____________

9.5 Was crowd control maintained? ____________ How? ____________

9.6 Who provided vehicle escort for accidents on the airport premises?
Airport police ____________ Airport authority ____________ Other ____________

9.7 How long after the accident was the crash site secured? ____________
How? ____________

9.8 Were off-airport emergency services informed of staging areas and rendezvous points? ____________

10. General

10.1 Which types of heavy equipment and shoring materials were available for extrication purposes? ____________

10.2 If a hazardous materials team was needed, describe problem involved ____________

10.3 Were all responders easily identified? ____________
How? Vests ____________ Hats ____________ Armbands ____________ Uniforms ____________

11. Water Accidents

11.1 What was the method of response to the accident?
Boats ____________ Amphibious vehicles ____________ ARFF vehicles ____________ Swamp buggies ____________
Time and distance to reach the accident scene ____________

Water Rescue Equipment

Agencies	Type	Size	Response Time	Passenger Capacity

11.2 Were survivors equipped with aircraft floatation equipment?
Life vests ____________ Slides ____________ Rafts ____________ Seat cushions ____________

11.3 What flotation equipment was transported to the scene?
Rafts ____________ Platforms ____________ Life vests ____________

11.4 Indicate weather and water conditions
Water: Smooth ____________ Choppy ____________ Rough ____________ Temperature ____________
Air temperature ____________ °F ____________ °C
Other factors affecting rescue operations ____________

11.5 Describe any problems locating aircraft ____________

11.6 Underwater search and recovery ____________

11.7 Any resuscitation of victims of hypothermia due to near-drowning in cold water? ____________

COMMENTS ____________

Name ____________

Representing ____________

Telephone contact ____________

Date ____________

Chapter 3 Referenced Publications

3-1 The following documents or portions thereof are referenced within this guide and should be considered part of the recommendations of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

3-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 407, *Standard for Aircraft Fuel Servicing*, 1990 edition.

NFPA 424M, *Manual for Airport/Community Emergency Planning*, 1991 edition.

NFPA 1001, *Standard for Fire Fighter Professional Qualifications*, 1992 edition.

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

NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program*, 1992 edition.

NFPA 1971, *Standard on Protective Clothing for Structural Fire Fighting*, 1991 edition.

NFPA 1976, *Standard on Protective Clothing for Proximity Fire Fighting*, 1992 edition.

Appendix A Explanatory Material

This appendix is not a part of the recommendations of this NFPA document but is included for informational purposes only.

A-1-2 State and International Documentation. The purpose of preparing these reports is NOT to investigate the cause of this accident, but is to provide data that can be used to prevent injury and loss of life in future accidents.

Appendix B

This appendix is not a part of the recommendations of this NFPA document but is included for informational purposes only.

The following information may be of use to persons investigating the fire.

B-1 Fire.

B-2 In most cases where there is evidence that a specific temperature has been attained, a time-temperature relationship exists, so that it is not always possible to determine a precise temperature. A temperature of 1,500°F (816°C) sustained for a few minutes can create the effect of fire that has burned at a lower temperature for a longer duration. There are sometimes specific points at which a temperature change occurs, in which case temperature ranges can be defined more closely. Laboratory analysis sometimes is needed, but investigators usually can trace or plot a fire pattern to a source point by studying the relative temperatures and the position of the burned or overheated area.

B-3 Fire resistance is not a property of a particular material but is a characteristic of a particular system comprising material, oxidant, ignition source, and environmental conditions. For example, ordinary steel at room air temperature is not ignitible with an ordinary match — unless the steel is in the form of loosely packed steel wool. Such a distinction in the form of a material often is overlooked when interpreting fire data.

B-4 Most aluminum sheet and forging ingots used for aircraft components are from the 2000 and 7000 series. The 2000 series is an alloy that uses copper as the major alloy material (approximately 4 to 5 percent); the 7000 series uses zinc as its major alloy (approximately 5 to 6 percent). All alloys are approximately 95 percent aluminum, and most include very small percentages (in terms of chemical content) of other metals, such as titanium, silicon, manganese, magnesium, etc. The melting point of the sheet used generally is around 1,180°F (639°C), but a few alloys can melt at temperatures as low as 980°F to 1,000°F (527°C to 538°C). Very few forgings or castings melt at temperatures as low as 950°F (510°C). The letters used with aluminum series numbers designate temper and strain hardening. For example, 7075-T-6 contains 5.1 to 6.1 percent zinc plus small amounts of eight other elements, is solution heat-treated, and is artificially aged.

B-5 Certain types of heat treatment and strain hardening often change the basic characteristics of metal (e.g., from ductile to brittle), and these changes can cause alterations in appearance. Plating also tends to change characteristics.

B-6 When aluminum alloys are heated to the melting range, they wrinkle and pull apart, leaving bright cracks and fissures. If heated sufficiently to form droplets, they appear as little wrinkled bags. By comparison, iron alloys tend to burn when heated to the red range, forming oxides at the edges and in thin sections.

B-7 Fire damage to metal is manifested mainly in loss of strength. For example, 7075-T-6 alloy loses 10 percent of its strength when heated for 30 minutes at 400°F (204°C); 10 minutes at 450°F (232°C); 3 minutes at 550°F (288°C); or 2 minutes at 600°F (316°C). Hardness tests can be used to determine the amount of temperature exposure, but an estimate of the length of exposure is necessary to determine the maximum temperature.

B-8 Titanium changes color from tan to light blue to dark blue to grey as the temperature increases. It reacts strongly to gases when heated, and a scale begins to form at approximately 1,100°F (593°C). This scale increases in thickness with time and turns bluish in color. At approximately 1,200°F to 1,500°F (649°C to 816°C), a grey or yellowish shade appears. At approximately 1,300°F (704°C), an appreciable oxide scale forms, which flakes off. At approximately 1,620°F (882°C), titanium undergoes an allotropic transformation (from alpha type to beta type), and the oxidation rate increases significantly. Titanium fires in turbine engines have been a cause of concern for some time; they start quickly, are difficult to detect, and are nearly impossible to extinguish. They can occur in the total absence of hydrocarbon or other fuel sources, a fact that, in itself, is evidence of a titanium fire. The mechanism of titanium (Ti) fires is complex. The scenario for a fire caused by titanium rotor blades might involve the following sequence:

(a) A Ti rotor blade can rub against the engine case and, because of the low thermal conductivity of Ti, the temperature of the blade can increase rapidly;

(b) Ti melts at about 3,100°F (1704°C);

NOTE: Steel melts at about 2,700°F (1482°C).

(c) Molten Ti absorbs O_2 to form TiO_2, which boils, burns, and stabilizes at approximately 5,600°F (3093°C);

(d) The TiO_2 continues to form and burn as long as there is an air supply. Molten Ti at very high temperatures melts through steel engine cases rapidly. (For this reason, engine design should avoid routing fuel and oil lines in the lower sector of the engine.)

B-9 Stainless steel changes color from tan to light blue to bright blue to black starting at 800°F to 900°F (427°C to 482°C). When examining stainless steel after heating, the investigator should check both sides; the lighter blue side is the side that was positioned opposite the heat source, and the heated area will be smaller in circumference.

B-10 Zinc chromate paint primers start to tan at 450°F (232°C) and turn brown at 500°F (260°C), dark brown at 600°F (316°C), and black at 700°F (371°C). Cadmium plating begins to discolor at 500°F (260°C). Glass cloth fuses at 1,200°F (649°C). Silicone rubber blisters at 700°F (371°C). Neoprene rubber blisters at 500°F (260°C). Wire insulation is a good guide for determining lower temperature ranges if the material is known [e.g., nylon spaghetti melts at 250°F to 350°F (121°C to 177°C).]

B-11 Aircraft paints soften at 400°F (204°C), discolor at 600°F (316°C), blister at 800°F to 850°F (427°C to 454°C), and burn off completely at 900°F to 950°F (482°C to 510°C). Cutting through the paint with a sharp knife discloses the depth of overheating. Severe scorching blackens the surface without further darkening it. It is unusual to find metal beneath paint damaged if the paint is not burned through completely. It is possible to char primer beneath heat-resisting aluminum paint without apparent "surface" burning.

B-12 Temperature Limits of Selected Materials.

B-12.1 The investigator should note carefully those materials that ignited, those that melted, and those that were damaged by heat.

B-12.2 Tables B-12.2(a) and B-12.2(b) provide a list of materials and their autoignition temperatures and a list of materials and those temperature limits that damage or distort them. The materials selected usually are found in private or commercial transport aircraft.

Table B-12.2(a) Autoignition Temperature of Selected Materials

	°F	°C
Canvas	204	96
Denatured alcohol	750	399
Hydraulic hose (Buna-N-Rubber)	950	510
Leather	850	454
Nylon-covered wire	1000	538
Glass matts	950	510
Lubricating oil (MIL-1-7808)	790	421
Plywood	900	482
Rubber-covered wire	900	482
Vinyl-covered wire	900	482
Rubber-asbestos material	900	482
Styrene	914	490
Teflon	1050	566

B-12.3 Table B-12.3 provides melting points for metals and alloys used in current aircraft. It is essential that the investigator be familiar with various aircraft metals and alloys and well-informed regarding their purpose and their location in the aircraft.

Table B-12.2(b) Temperature Limits for Selected Materials

	°F	°C
Glaze or electrical porcelain	2250	1232
Enamel flakes	1200-1400	649-760
Glass softens	1400-1600	760-871
Paraffin wax melts	129	54
Zinc melts	786	419
Silver solders melt	1165-1450	629-789
Silicone rubber (considerable softening at sustained service)	425	218
Cellulose (filled melamine, heat distortion)	400	204
Nylon (polyamide), heat distortion	300-360	149-182
Melamine-formaldehyde (filled), heat distortion	266-400	130-204
Paper phenolic, delamination and distortion	250	121
Styrene elastomer, distortion at sustained service	220	104
Polystyrene, distortion	210	99
Methyl methacrylate, heat distortion	210	99
Plastic vinyl chloride, heat distortion	185	85

Table B-12.3 Melting Points of Some Aircraft Metals and Alloys

	°F	°C
Aluminum alloys	1220-1250	660-677
Brass bearings	1600-2000	871-1093
Cadmium	609	321
Chromium	3430	1889
Copper	1981-2000	1083-1093
Iron	2802	1539
Lead	621	327
Magnesium alloys	1202-1250	650-677
Manganese	2273	1243
Mercury	-39.9	-39.9
Molybdenum	4760	2627
Nickel	2651	1455
Selenium	428	220
Silicon	2605	1429
Silver	1760	960
Stainless steel	2700	1482
Tin	449	232
Titanium	3100	1704
Tungsten	6170	3410
Vanadium	3150	1732

B-13 If electrical wire breaks when no current is flowing, the break will be clean and will display a typical cup-and-cone fracture with necking down. If current is flowing, it arcs when the wire breaks, causing little balls of oxidized metal to form on the tips of the wire strands. A fire external to the wiring bundle burns the outside first, and the conductor inside will remain clean and bright, except where the insulation has burned through. Wires burned due to excess current burn from the inside out, and the conductor will be dark and oxidized, perhaps without damage to the outer cover. The tin coating on copper wire will diffuse into the copper at temperatures above its melting point of 449°F (232°C) and become rough or even disappear. On-scene examination should be only for general observation and possible conclusions. Detailed laboratory examination should be performed to confirm the mechanism of the wire faults and failures. Additionally, chemical analysis of wire breaks can reveal the presence of combustibles during the failure.

B-14 Examination of any surviving light bulbs helps in determining if electrical power was on in a particular system at the time of impact. The filaments of small bulbs will indicate if the bulb was illuminated at impact, when the bulb was shock-loaded. If the filament was hot at impact, it will stretch and distort substantially; if the filament was cold at impact, it will break but will not distort or stretch from its original shape and pattern. If the glass shattered and the filament was exposed, it will provide the information but will oxidize and discolor quickly. This entire procedure is valuable in determining the system operational status at impact, provided failure lights and warning light bulbs survive any subsequent fire in this area. (*See ICAO DOC 6920-AN/855/4, Manual of Aircraft Accident Investigation, Part III, 7.3, "Electrical Systems," for further information on fire origin.*)

B-15 All hydrocarbon fuels used in aircraft leave a similar soot residue (except when instantaneous combustion or explosion occurs, in which case no sooting is left) so that tests might not be successful in identifying or differentiating between these and various other hydrocarbon liquids that are found about aircraft. Cleaning fluids, oils, etc., can leave similar residues. Soot does not deposit or adhere to surfaces that are above 700°F (371°C).

B-16 Flammability Characteristics of Aviation Fuels.

B-16.1 There are three basic types of aviation fuels: aviation gasoline (AVGAS), the kerosene grades (JET A, JET A-1, JP-5, JP-6), and the blends of gasoline and kerosene (JET B, JP-4). The flammability characteristics of these fuels are provided in Table A-16.4, but a brief comparison is included to focus attention on their differences.

B-16.2 In order to burn, all petroleum fuels need to be vaporized and mixed with air in specified proportions. AVGAS has a strong tendency to vaporize and, as a result, the air over the surface of the liquid always is mixed with a considerable quantity of vapor. In a closed tank, so much fuel vapor is given off by AVGAS that the fuel-air mixture can be too rich to burn. When any fuel is in contact with air, it continues to evaporate until the air is saturated.

B-16.3 Kerosene grade fuel ordinarily has a low tendency to vaporize, and, in a closed tank, the fuel vapor and air mixture can be too lean to burn. However, kerosene grade fuels can be ignited by heating them above their flash point. It also is possible to ignite such fuels without heating the bulk of the fuel to flash point. This can be achieved by wicking the fuel on an absorbent material that can be heated locally (hot spot) until the fuel ignites. The hot spot on the wick furnishes sufficient vapor to sustain the flame. Such conditions can occur accidentally during crash and post-crash conditions.

B-16.4 Fuels that contain a blend of AVGAS and kerosene retain most of the worst fire characteristics of both fuels. (*See Table B-16.4.*) The vapor mixture in a closed tank normally is neither too rich nor too lean. Flammability limits include a wide temperature range, autoignition temperature is low, and flame spread is almost as fast as when using AVGAS.

Table B-16.4 Flammability Characteristics of Aviation Fuels†

Characteristics	Gasoline AVGAS	Kerosene Grades JET A, JP-5, JP-6 / JET A-1	Blends of Gasoline and Keorsene JET B and JP-4
Freeze Point	-76°F	-40°F / -58°F	-60°F
Vapor Pressure (ASTM D323)	5.5 to 7.0 lb/sq in.	0.1 lb/sq in.	2.0 to 3.0 lb/sq in.
Flash Point (by closed-cup method at sea level)	-50°F	+95°F to +145°F	-10°F to +30°F
Flash Point (by air saturation method)	-75°F to -85°F	None	-60°F
Flammability Limits			
Lower Limit	1.4%	0.6%	0.8%
Upper Limit	7.6%	4.9%	5.6%
Temp. Range for Flammable Mixtures	-40°F to +30°F	+95°F to +165°F	-10°F to +100°F
Autoignition Temperature	-825°F to +960°F	+440°F to +475°F	+470°F to +480°F
Boiling Points			
Initial	110°F	325°F	135°F
End	325°F	450°F	485°F
Pool Rate of Flame Spread*	700 ft-800 ft per min	100 ft per min or less	700 ft-800 ft per min

For SI Units: 1°C = 5/9 (°F − 32); 1 psi = 6.895 kPa; 1 ft = 0.3048 m.
† For further information, see NFPA 407, *Standard for Aircraft Fuel Servicing*.
* In mist form, rate of flame spread in all fuels is very rapid.

B-17 When heated, some hydraulic fluids vaporize into a white mist that is acrid and causes choking. When burned, the residue is first dark-colored and viscous; then it changes to a dark-charred material, and a white, fluffy deposit appears after prolonged heat. When burned, hydraulic fluids produce a yellowish flame with white smoke. If Skydrol® (a trade name hydraulic fluid commonly used in current aircraft) is heated and a piece of aluminum is placed in it, an acetylene-type odor is evident. Skydrol 500 has a flash point of approximately 440°F (227°C), and autoignition occurs at approximately 925°F (496°C). In mist form, it can ignite at room temperature.

B-18 The aging of fluids (such as oil and hydraulic fluid) is caused by an increase in their acidity over time. This acidity tends to lower the flash point, but the problem is considered negligible, since a complete fluid change by volume is performed on the average aircraft at least four times per year. The flash points provided in Table A-16.4 are based on standard sea level pressure; lower pressures reduce the flash point and increase volatility. Fuels cannot burn unless in the vapor state, and the mixture ratio determines whether a fuel can burn. Skydrol and other ester-based fluids also possess these same properties.

Appendix C Referenced Publications

C-1 The following documents or portions thereof are referenced within this guide for informational purposes only and thus are not considered part of the recommendations of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

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

NFPA 402M, *Manual for Aircraft Rescue and Fire Fighting Operations*, 1991 edition.

C-1.2 ICAO Publication. International Civil Aviation Organization, 1000 Sherbrooke Street, W, Montreal, PW, Canada 3A 2R2.

DOC 6920-AN/855/4-1970, *Manual of Aircraft Accident Investigation.*

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