U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: Firefighting of General and High-Energy In-Flight Fires

Date: 3/16/23 **AC No:** 120-80B
Initiated by: AFS-200 **Change:**

1 PURPOSE OF THIS ADVISORY CIRCULAR (AC). This AC provides information on the hazards and risks of in-flight fires on transport category aircraft. The information includes recommended crewmember procedures and training for combating general and high-energy fires (HEF) caused by lithium batteries. This AC is applicable to operators conducting operations under Title 14 of the Code of Federal Regulations (14 CFR) parts 91, 91 subpart K (part 91K), 121, 125, and 135. The contents of this document do not have the force and effect of law and are not meant to bind the public in any way, and the document is intended only to provide information to the public regarding existing requirements under the law or agency policies.

1.1 General. This AC addresses the following:

1. The importance of flightcrew member initial and recurrent hands-on training, including:
   - The use of operable oxygen mask/goggle sets, the use of the regulator's emergency selector, and the venting of smoke goggles.
   - Aircraft-specific training on establishing and maintaining internal flight deck communications when flightcrew members don oxygen masks.
2. The importance of flightcrew members stowing their oxygen masks set to 100 percent.
3. Guidance for operators' smoke, fire, or fumes checklists to include, as the first step, that flightcrew members don their oxygen masks and verify that the regulator is set to 100 percent.
4. Guidance for operators on addressing the unique characteristics of lithium battery fires through procedures and training.
5. The dangers of in-flight fires with particular emphasis on hidden fires that may not be visible or easily accessed by the flight or cabin crewmembers. This AC discusses the importance of recognizing and quickly assessing the conditions that may be associated with hidden fires and the importance of taking immediate action to gain access to fires that are located behind interior panels.
6. Guidance on how to deal with in-flight fires by emphasizing the importance of flight and cabin crewmembers taking immediate and aggressive action in response to signs of an in-flight fire while stressing the effectiveness of halon extinguishing agents.

7. The importance of appropriate crewmember training in dealing with hidden fires, the effective application of fire extinguishing agents behind interior panels, and the urgency of the crew's action in dealing with such fires.
8. Guidance that complements previously developed guidance for crewmembers concerning the proper use of cabin fire extinguishers (the current edition of AC 20-42, Hand Fire Extinguishers for Use in Aircraft, and National Fire Protection Association (NFPA) 408, Standard for Aircraft Hand Portable Fire Extinguishers) and the most effective means of extinguishing fires that are readily accessible.
9. Information from research conducted by the Federal Aviation Administration (FAA) William J. Hughes Technical Center (WJHTC). As additional information becomes available, it will be published in future revisions to this AC.
10. Information on and the use of fire containment kits/bags designed to contain lithium battery fires.
11. Guidance for crewmembers faced with a portable electronic device (PED) powered by a lithium battery that is overheating, expanding, smoking, or burning.
12. Identifies procedures that incorporate risk mitigation guidance from the International Air Transport Association (IATA), International Civil Aviation Organization (ICAO), and civil aviation authorities (CAA).

2 AUDIENCE. Air carriers, Directors of Operations (DO), Directors of Maintenance (DOM), Directors of Safety (DOS), Chief Pilots, Chief Inspectors, directors of in-flight/cabin safety training, training center curriculum designers, and others involved in the development of crewmember training programs as well as crewmembers and others involved in flight operations under part 121 should be familiar with the contents of this AC. This AC may also be valuable to operators associated with operations conducted under parts 91, 125, and 135.

3 WHERE YOU CAN FIND THIS AC. You can find this AC on the FAA's website at https://www.faa.gov/regulations_policies/advisory_circulars and the Dynamic Regulatory System (DRS) at https://drs.faa.gov.

4 WHAT THIS AC CANCELS. AC 120-80A, In-Flight Fires, dated December 22, 2014, is canceled.

5 USING THIS AC. When tailored to specific aircraft and operators' procedures, the suggested guidelines presented in this AC provide a good framework for mitigating the risk of and combating general and high-energy in-flight fires. However, approved aircraft manufacturer procedures should take precedence over the information presented in this AC. The importance of crewmembers taking immediate and aggressive action to locate the source, gain access, and effectively apply extinguishing agents to hidden fires cannot be overstressed. The multitude of cabin configurations that are currently in use throughout the industry complicates this task. For this reason, there is no single formula for fighting and extinguishing in-flight fires.

6 RELATED REGULATIONS (14 CFR).

- Part 25, § 25.851.
- Part 91, § 91.513.
- Part 121, §§ 121.215, 121.221, 121.273, 121.275, 121.308, 121.309, 121.337, and 121.703.
- Part 135, §§ 135.170, 135.331, and 135.415.

7 DEFINITIONS.

7.1 Aggressively Pursue. Aggressively pursuing a fire means taking immediate action to determine the source of hot spots, smoke, and/or flames. The crew should quickly evaluate the situation, gain access to the fire, and attack the fire using all available resources, which may include deadheading crewmembers or able-bodied persons (ABP).

7.2 Aqueous-Based Extinguishing Agents. Aqueous agents provide a heat absorption (cooling) effect on the burning material to extinguish the fire. Aqueous film-forming foam (AFFF) and film-forming fluoroprotein (FFFP) fire extinguishers are rated for use on Class A and B fires. Aqueous-based extinguishing agents sprayed on the PED to cool the cells in the battery have been demonstrated to be effective to prevent the propagation of TR.

7.3 Cheek Area. The area just below the floor, outboard of the cargo compartment areas. In narrow and wide body aircraft, this area houses wire bundles, hydraulic lines, and other electrical components (see Appendix C, Typical Wide Body Cross-Section).

7.4 Circuit Breaker. Circuit breakers are designed to open an electrical circuit automatically at a predetermined overload of current.

7.5 Electrical Arc. An electrical breakdown of a gas that produces a prolonged electrical discharge.

7.6 Halon. A liquefied gas that extinguishes fires by chemically interrupting a fire's combustion chain reaction rather than physically smothering it. This characteristic is one of the main reasons that halon extinguishers are effective when the exact source of the fire cannot be positively determined. Halon fire extinguishing agents that have been approved for use in aircraft include Halon 1211, Halon 1301, and a combination of both (Halon 1211/1301). Both Halon 1211 and Halon 1301 are typified as "clean agents," which leave no agent residue after discharge. Approved halon-type extinguishers are three times as effective as carbon dioxide (CO_2) extinguishers with the same weight of extinguishing agent.

7.6.1 Halon 1211. The chemical name is bromochlorodifluoromethane. Halon 1211 is a multipurpose, Class A, B, and C-rated agent that is effective against fires fueled by flammable liquids (see Appendix E, Information on Using Hand Fire Extinguishers, for definitions of the classes of fires). Halon 1211 fire extinguishers discharge in an

85 percent liquid stream, giving the agent a range of 9 to 15 feet, which offers a significant advantage in fighting fires in large aircraft cabins.

7.6.2 Halon 1301. The chemical name is bromotrifluoromethane. Halon 1301 has Class A, B, and C capability in total flooding systems;[1] however, Halon 1301 has limited Class A capability when used in portable fire extinguishers. The useable range of a Halon 1301 extinguisher is slightly less than that of a Halon 1211 extinguisher.

7.7 Halotron BrX. The chemical name is 2-bromo-3,3,3-triflouro-1-propene and commonly referred to as 2-BTP. Halotron BrX has been approved for use in aircraft as noted in AC 20-42. Halotron BrX is a multipurpose, Class A, B, and C-rated clean agent that has both a low global warming potential and a near zero ozone depletion potential while being highly effective at fighting fires fueled by liquid combustibles. It extinguishes a fire through the removal of heat as a result of the chemical reaction taking place between the agent and the fire.

7.8 Hidden Fires. "Hidden" fires are not readily accessible, may be difficult to locate, and are more challenging to extinguish. Some examples of hidden fires would be fires behind sidewall paneling or in overhead areas.

7.9 High-Energy Fire (HEF). A fire involving a battery or other energy storage device that has components or materials with the potential to release a significant amount of additional energy that would further fuel the fire. This results in a heat release and rate of heat release that is higher than a typical Class A fire, can more easily harm nearby individuals, and can be characterized as relatively unpredictable.

7.10 Knock Down. To reduce the flame or heat on the more vigorously burning part of a fire edge.

7.11 Lithium Battery. Batteries commonly used to power consumer PEDs, including those used to power authorized Electronic Flight Bags (EFB) supplied by the operator. There are two types of lithium batteries: lithium metal (typically nonrechargeable) and lithium ion (rechargeable).

7.12 Overhead Area. The area within the aircraft fuselage located above the ceiling panels. This area ranges in volume depending on the aircraft type. In a narrow body transport aircraft, this area may be only several inches high running the length of the fuselage. However, in wide body aircraft, this volume is much larger and may range in height from 2 to 4 feet or more. A typical overhead area contains components of the aircraft's entertainment system, numerous wiring bundles, control surface cables, portions of the air conditioning system, the passenger emergency oxygen system, and other systems (see Appendix C).

[1] Total flooding systems are generally designed to fully discharge their contents upon being activated.

7.13 Recirculation Fan. These units are typically located in the overhead area and recirculate air in this space to prevent elevated temperatures and remove stagnant air.

7.14 Return Air Grills. Vents located along the baseboard area of each sidewall of the passenger cabin. Most transport category aircraft have air conditioning systems that supply conditioned air near the cabin ceiling. This air flows in a top-to-bottom direction, exiting through the return grills, and eventually out the fuselage via the outflow valve(s).

7.15 Smoldering Fire. Combustion without a visible flame and a slow combustion rate are characteristics of a smoldering fire. A smoldering fire left unattended or an incompletely extinguished fire can ignite and grow into a larger, uncontrollable fire in a short time period.

7.16 Suppressed Fire. A partially extinguished fire that may or may not have visible flames. A suppressed fire, if not extinguished, may reestablish itself and grow into a larger, uncontrollable fire in a short time period.

7.17 Thermal Runaway (TR). Rapid self-sustained heating of a battery cell driven by a chemical reaction of the materials within the cell where energy is released in the form of light or heat. TR is generally evidenced by a sharp increase in temperature and pressure and a drop in cell voltage.

7.18 Water Extinguisher. An extinguisher containing water that is designed with a CO_2 cylinder in the handle to pressurize the water inside so it can be propelled from the extinguisher.

8 RESOURCES (current editions).

8.1 FAA Documents:

- AC 20-42, Hand Fire Extinguishers for Use in Aircraft.
- AC 25-9, Smoke Detection, Penetration, and Evacuation Tests and Related Flight Manual Emergency Procedures.
- AC 25-16, Electrical Fault and Fire Prevention and Protection.
- AC 120-48, Communication and Coordination Between Flightcrew Members and Flight Attendants.
- AC 120-76, Authorization for Use of Electronic Flight Bags.
- Safety Alerts for Operators (SAFO) 09013, Fighting Fires Caused by Lithium Type Batteries in Portable Electronic Devices.
- FAA Order 8900.1, Flight Standards Information Management System, chapters and sections that address cabin safety issues and emergency procedures.

8.2 Related Research Material:

- A Benefit Analysis for Enhanced Protection From Fires in Hidden Areas on Transport Aircraft, DOT/FAA/AR-02/50, CAA Paper 2002/01, report prepared by R G W Cherry and Associates.
- In-Flight Aircraft Seat Fire Extinguishing Tests (Cabin Hazard Measurements), DOT/FAA/CT-82/111, Hill, R.G., and Speitel, L., December 1982.
- Effectiveness of Flight Attendants Attempting to Extinguish Fires in an Accessible Cargo Compartment, DOT/FAA/AR-TN99/29, Blake, D., April 1999.
- Halon Extinguishment of Small Aircraft Instrument Panel Fires, DOT/FAA/CT-86/26, Slusher, G.R., Wright, J.A., and Speitel, L.C., December 1986.
- ICAO Doc 9284, Technical Instructions for the Safe Transport of Dangerous Goods by Air.
- IATA Dangerous Goods Regulations (DGR).
- IATA Lithium Battery Risk Assessment Guidance for Operators, "Cargo Operations" and "Passenger Operations" sections.
- IATA Cabin Operations Safety Best Practices Guide.
- NFPA 408, Standard for Aircraft Hand Portable Fire Extinguishers.
- NFPA 1971, Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting.

9 SUBTLE CAUSES OF IN-FLIGHT FIRES.

9.1 Wiring Failures. A majority of hidden in-flight fires are the result of electrical arcs along wire bundles. In most cases, the electrical arc acts as the initiating event, igniting other surrounding materials. The surface of insulation materials is often a conveyer of these initiating events, as contamination from spillage, accumulated dirt/dust, lubrication, or corrosion inhibitors on these surfaces can promote flame spread (uncontaminated insulation materials are generally very fire resistant). In other instances, the resetting of a tripped circuit breaker can overheat wiring, ultimately leading to failure and arcing, causing the same chain of events.

9.2 Electronically Adjustable Seats. Operator procedures should address crew communication, safe operating instructions, and precautions to prevent PEDs from being crushed. Event reports have identified overheating and battery damage as hazards associated with extreme pressure or crushing a lithium battery-powered PED in an electronically adjustable seat. Crew reports indicate that passenger seat mechanisms have damaged PEDs that have slipped beneath the passenger seat.

9.3 Electrical Component Failures. Electrical motors can overheat, bind, fail, and possibly ignite surrounding materials. An accumulation of contaminants in the immediate area exacerbates the spread of fire in these instances.

9.4 Lightning Strikes. Although very infrequent, there have been instances in which a lightning strike has initiated a fire. In these instances, faulty or contaminated insulation material contributed to the fire.

9.5 Bleed Air Leaks. Aircraft with systems that use air from the engine (bleed air) depend on a series of pneumatic lines to deliver the air supply. A failure of any of these supply lines, if left unchecked, can cause high temperatures in the surrounding area and damage to the aircraft's equipment, wiring, and associated components. High-temperature bleed air leaks have caused in-flight fires and structural damage.

9.6 Faulty Circuit Protection. A malfunctioning circuit breaker that does not open (trip) when it detects an abnormally high current draw may cause the affected unit or associated wiring to overheat and ignite.

9.7 Lithium-Ion Batteries. Lithium-ion batteries are rechargeable batteries that are being installed in newer-design aircraft to power multiple systems or equipment, and these batteries are capable of overheating. This can lead to a process called TR, which can cause the sudden release of the contents of the battery as a flaming jet, heavy smoke, or unburned hydrocarbons. In some cases, the battery can explode or rocket. Once one cell in a battery pack goes into TR, it produces enough heat to cause adjacent cells to go into TR. The resulting fire can flare repeatedly as each cell ruptures and releases its contents.

10 INDICATIONS OF HIDDEN FIRES.

10.1 Abnormal Operation or Disassociated Component Failures. Failure or uncommanded operation of an aircraft component may indicate a developing fire. Electrical connections and the components themselves may have had damage from a fire in the area of the component or at any point along its power supply line. For this reason, cabin crewmembers should report all failures of electrical items to the flightcrew members in accordance with company policy and procedures.

10.2 Circuit Breakers. Circuit breaker(s) tripping, especially multiple breakers, such as entertainment systems or coffee makers, may be an indication of damage occurring in a hidden area common to the affected components.

10.3 Hot Spots. Hot spots on the floor, sidewall, ceiling, or other panels should be immediately investigated.

10.4 Fumes. This may be one of the first indications of an impending fire. Never ignore a strange odor; crewmembers need to identify its source as soon as possible.

10.5 Visual Sighting of Smoke. Smoke coming from vents or seams between interior panels, especially from the ceiling area, is an indicator of a problem, and crewmembers should take immediate action to determine the source.

11 RESOURCES AVAILABLE FOR FIGHTING IN-FLIGHT FIRES. The available resources depend on the aircraft's specific cabin configuration, which may vary within types. Therefore, crewmembers should include this subject in crew briefings as suggested in AC 120-48.

11.1 Firefighting Tools. In addition to aircraft emergency equipment required under 14 CFR parts, crewmembers should also consider those items not normally thought of as firefighting aids. For example, the crewmember may pour nonalcoholic liquid, such as coffee, soda, juice, or water, onto a fire.[2] When extinguishing a suspected electronic device fire, douse the device with water, an aqueous-based extinguishing agent, or other nonalcoholic liquids to cool the device and prevent additional battery cells from reaching TR. For example, crewmembers have used a carbonated beverage as a fire extinguisher by shaking up the can or bottle, opening the top, and spraying the contents at the base of the fire. Any of these suggestions may prove to be effective as possible firefighting methods. These examples are not meant to be all-inclusive, and crewmembers should consider what other items might be useful.

11.2 Containment Products Used for Firefighting. There are various firefighting kits and containment products marketed for in-flight use. The FAA does not prohibit the use of the various commercially manufactured containment products. The FAA-sponsored High-Energy Firefighting Training Enhancement (HEFTE) working group presented questions on the effectiveness of fire containment devices to FAA researchers.[3] The researchers emphasized the dangers associated with picking up the PED while the device is in an unstable condition (i.e., the fire is still actively burning, the device is unstable, or the device is hot). A fire in one cell of a battery may not have propagated to other cells, but if the device is hot, the potential for propagation exists. Therefore, the device should be cooled before it is moved to a containment device.[4]

11.2.1 On December 10, 2020, the Underwriters Laboratories (UL) announced a new standard for fire containment bags: ANSI/CAN/UL 5800, the Standard for Safety for Battery Fire Containment Products. The new standard includes testing and certification and should reduce the risk of in-flight TR events in the future.

11.2.1.1 ANSI/CAN/UL 5800 was developed by UL with input from a Standards Technical Panel made up of international representatives from airlines, shipping companies, and other aviation-related organizations along with government bodies (including the FAA) and containment product developers.

11.2.1.2 The standard provides test methodology and performance criteria and sets construction, testing, marking, instruction, and packaging requirements. It has been nationally accepted by the American National Standards Institute (ANSI)

[2] As mentioned below in paragraph 12.1.1, crewmembers should not use water if the fire is of aircraft electrical system origin.
[3] Refer to FAA Air Carrier Training Aviation Rulemaking Committee (ACT ARC) Recommendation 18-5, Guidance on Fighting High-Energy Fires (2018).
[4] *Id.* at 32 (citing ICAO Doc 9481, Emergency Response Guidance for Aircraft Incidents Involving Dangerous Goods, 3.3.1, Battery/Portable Electronic Device (PED) Fire/Smoke (2021–2022)).

and the Standards Council of Canada (SCC), increasing consistency in the safety of battery containment products across both countries and jurisdictions.

11.2.2 Manufacturers may have stated in their advertisement and marketing videos that their products are "FAA certified," "successfully tested by the FAA," or "meet FAA standards." However, the Fire Safety Branch of the FAA WJHTC and the Aircraft Certification Service (AIR) emphasize that no FAA test standards exist for these containment products nor does the FAA have a mechanism in place for the approval of these products. The FAA has no objection to the use of the various commercially manufactured containment products.

11.2.3 With the advent of these commercially marketed containment products, operators may have amended or may be considering amending their firefighting procedures and training programs to align with procedures suggested by the manufacturers of these containment products. Through continuous research and evaluation by the Fire Safety Branch of the FAA WJHTC and the Transport Airplane Directorate (TAD), the FAA finds the procedures as set forth in this AC provide the best means to address fires or overheating caused by lithium batteries.

11.3 Firefighting Gloves. Federal regulations do not require firefighting gloves. However, many carriers have used their Safety Risk Management (SRM) process to justify having these protective tools on board. Operators should consider proper fit, dexterity, and protection, as stated by the NFPA,[5] when considering firefighting gloves. Firefighting glove ratings are based on the Thermal Performance Protective (TPP) scale. Firefighting gloves should have a TPP of at least 35.0 with a second-degree burn time of no less than 10.0 seconds and a pain time of no less than 6.0 seconds to comply with NFPA 1971, Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting.

11.4 Able-Bodied Passengers. Crewmembers should consider deadheading crewmembers and able-bodied passengers as additional resources when combating a fire. The ability to enlist the help of qualified individuals, especially on a single flight attendant (F/A) operation, might be very valuable in combating a fire and communicating with the flightcrew members. Regardless of the type of operation, crewmembers should consider using all available resources when faced with an in-flight fire.

12 FIRE EXTINGUISHERS.

12.1 Type of Fire Extinguisher to Use. Immediate and aggressive action when confronted with a potential fire is much more important than delaying while you attempt to classify a particular fire. As a general rule, halon fire extinguishers are the best choice since halon is classified as a multipurpose (Class A, B, and C fires) agent.

[5] NFPA 1971 provides minimum levels of protection for professional firefighters.

12.1.1 Initial Focus. Upon discovering a fire, the initial focus should be on aggressively extinguishing the fire with a readily available extinguisher (which will likely be halon); however, crewmembers should not use water if the fire is of aircraft electrical system origin. Generally, consider using the first available extinguisher rather than delaying firefighting efforts while locating a particular extinguishing agent for a Class A, B, or C fire. After initially suppressing the fire or exhausting the first fire extinguisher, use the preferred extinguishing agent for the class of fire to maintain control or extinguish the fire (see Appendix E).

12.1.2 Exceptions. There are a few exceptions to this general guidance. Crewmembers should not discharge a water fire extinguisher directly into a circuit breaker panel or an electrical outlet. Water should also not used to combat a liquid fire (e.g., grease or fuel) pooled or collected on a nonporous surface. The use of a water extinguisher on a fire fueled by flammable liquids is acceptable if the surface has absorbed the liquid, such as gasoline poured on a seat or other absorbent material.

12.2 Handheld Fire Extinguishers Should Be Held Upright. Handheld fire extinguishers are designed for use in the upright position. Most extinguishers have been designed with a center siphon tube that extends to the bottom of the canister. Placing a fire extinguisher on its side or upside down prevents the agent from flowing through the tubing, which has been designed to collect the agent from the bottom of the canister. Laying the extinguisher on its side or turning it upside down to aim at the ceiling may limit the amount of extinguishing agent that is available to be discharged, thereby reducing the extinguisher's firefighting capacity. Consequently, fire extinguishers equipped with flexible discharge hoses and nozzles are better suited to handle fires that may necessitate discharging the agent in an upward direction or in any other situation requiring flexibility. The installation and use of fire extinguishers with flexible hoses is highly desirable for these reasons.

13 HALON EXPOSURE. Various publications, including AC 20-42, caution against exposure to "high levels" of halon in confined spaces, citing the possibility of dizziness, impaired coordination, and reduced mental sharpness. AC 20-42 also provides guidelines that describe what is meant by the term "high level" and further states that these levels should not be exceeded in ventilated or nonventilated passenger compartments on aircraft. However, studies have shown that discharging all of the handheld halon extinguishers required by regulation[6] in the passenger cabin of an aircraft will not exceed the maximum concentration levels of halon vapor specified in AC 20-42 or NFPA 408 guidelines.

13.1 National Transportation Safety Board (NTSB) Recommendation. The NTSB has expressed concern that crewmember training programs have overemphasized the risks of exceeding the maximum recommended levels of halon gas, especially when compared to the risks of an in-flight fire. The NTSB emphasizes "…that the potential harmful effects on passengers and crew [of Halon] are negligible compared to the safety benefits

[6] Hand fire extinguishers are required under 14 CFR § 25.851(a)(l); part 29, §§ 29.851(a)(l) and 29.853(e) and (f); § 91.513(c); part 119, § 119.25; § 121.309(c); and § 135.155.

achieved by fighting in-flight fires aggressively."[7] The toxic effects of a typical aircraft seat fire, for example, far outweigh the potential toxic effects of discharging a halon fire extinguisher.

14 QUESTIONS FOR OPERATORS TO CONSIDER WHEN DEVELOPING PROCEDURES AND TRAINING.

14.1 How Critical Are Small In-Flight Fires? In-flight fires left unattended, particularly those that are not readily accessible, may lead to catastrophic failure and result in the complete loss of airplanes. Fire tests conducted by various regulatory authorities have shown that fires allowed to spread into the aircraft's overhead area may become uncontrollable in as few as 8 to 10 minutes. Studies have also shown that a flightcrew member may have as few as 15 to 20 minutes to get an aircraft on the ground if the crew allows a hidden fire to progress without any intervention. Appendix D, Time to Becoming Nonsurvivable, provides various illustrations of the time from the first indication to the crew of the presence of a hidden fire until it becomes catastrophically uncontrollable. These studies and other experiences indicate that flightcrew members should begin planning for an emergency landing as soon as possible after the first indication of fire. Delaying the aircraft's descent by only a couple of minutes might make the difference between a successful landing and evacuation and the complete loss of an aircraft and its occupants.

14.2 What Should Crewmembers Do If They Suspect a Hidden Fire? In accordance with company policies and procedures, coordinate with other crewmembers, as applicable, and take immediate and aggressive action to locate and extinguish the fire.

14.3 Is It Necessary to Locate the Exact Source of a Fire Before Applying Extinguishing Agent? It is not necessary in all circumstances. There have been several incidents where fires have been extinguished with a stream of halon by discharging the fire extinguisher into the air return grills (for fires beneath floor) or into the overhead area. Some aircraft (e.g., ATR-72) have cargo compartments that are locked by ground personnel prior to door closure and unlocked at destination. F/As do not have access to these compartments; however, there is an opening where an F/A can discharge a fire-extinguishing agent if a fire occurs in flight.

14.4 Should Holes Be Cut or Punched in an Aircraft Cabin Wall, Ceiling, or Floor Panel in Order to Gain Access to a Fire? If this is the only way to gain access to the fire, yes. In this situation, crewmembers should weigh the risk of damaging equipment behind the paneling and the possibility of creating a bigger problem against the catastrophic potential of in-flight fires left unattended. F/As should quickly and accurately describe to a flightcrew member the location where the crash axe will be used so a flightcrew member can determine the risk involved.

[7] NTSB Safety Recommendation Letter, dated January 4, 2002.

14.5 What Resources Can Be Used to Access Hidden Fires? Consider all available resources to access a hidden fire. Items found in carry-on baggage might be useful, nontraditional resources, such as a shoehorn, knitting or crocheting needles, walking canes, and fairly rigid items that could pry apart paneling. One of the best defenses is to be familiar with the interior configuration of the specific aircraft. This familiarity provides clues as to what tools would be most effective when trying to gain access to hidden areas of the aircraft. For example:

1. Some aircraft are equipped with a manual release tool that is designed to open the oxygen compartments. Crewmembers may use this device to separate or pull apart sidewall panels to permit access to a hidden fire.
2. Some aircraft have cabin ceiling speaker covers that are removable by simply snapping them out of their fixture. The removal of these covers provides access to the overhead area in the immediate area of the speaker fixture.
3. Equipment located in raft survival kits that are not an integral part of a survival raft may be useful for gaining access to hidden fires.
4. Galley equipment such as casserole or ice tongs, metal cutlery, or similar items may be useful in separating interior panels.
5. One of the most important elements in successfully combating an in-flight fire is an individual's own resourcefulness and determination in accessing hidden areas within the aircraft.

14.6 What Is the Best Way to Locate Hot Spots on a Door or Interior Panel Before Attempting to Open or Remove It? While there is no single best method, using the back of one's hand (instead of fingers or palms) is recommended because:

14.6.1 The skin on the back of the hand is more sensitive to temperature variations than palms or fingertips. Using the back of one's hand allows for more sensitivity to temperature fluctuations while running one's hand along a panel, making it easier to locate hot spots on the panel.

14.6.2 Using the back of the hand protects one's palm and fingers from injuries. For example, there is a possibility of being burned if one was to grasp a hot door handle (e.g., lavatory door) using the palm and fingers of the hand. A burned hand would make firefighting activities more difficult and could cause a delay in extinguishing the fire and conducting an evacuation of passengers.

14.7 What Should Crewmembers Do If They Suspect a Fire in a Lavatory?

14.7.1 If you suspect a fire in a lavatory, immediately notify another crewmember, get the closest fire extinguisher, and check the door for heat.

14.7.2 Cautiously and slowly open the lavatory door. Try to locate the source of the fire and discharge the fire extinguisher at the base of the fire. If you cannot clearly identify the source of the fire, aggressively attempt to locate the cause of the smoke and extinguish the fire. If the base of the flames or the source of the fire is not readily identifiable,

crewmembers should not discharge the agent with the intent of suffocating the smoke. There are some lavatory doors with air vent grills. (When developing fire in a lavatory procedures, the operator should compare their procedures to the aircraft manufacturers' procedure recommendations for this unique type of lavatory door design feature as part of their SRM process.) It is possible that the fire-extinguishing agent could be discharged through the air vent grill, or, in some cases, it may be advantageous to cover the air vent grill to prevent smoke and fumes from escaping into the cabin. All efforts should be used to fight a fire and not waste valuable extinguishing agent on smoke.

14.7.3 It is critically important to protect oneself from the effects of smoke and fumes while attempting to fight a fire. Crewmembers should not enter an enclosed area or begin to battle a fire that is generating heavy smoke without first donning Protective Breathing Equipment (PBE). A small fire can quickly grow to be large and uncontrollable. Time is critical when combating an in-flight fire; every available resource to locate and extinguish it should be used. Research has shown that a fire left uncontained can destroy an aircraft in as few as 20 minutes, and a smoke-filled cabin can be completely consumed by fire in as few as 6 to 10 minutes.

14.8 What Are The Recommended Procedures for Fighting an HEF? The public's use of PEDs is increasing. According to the FAA Air Traffic Organization (ATO), part 121 operators transport approximately 2.5 million passengers per day in the National Airspace System (NAS). Assuming each passenger carries two to three lithium-ion battery-powered PEDs, this translates to approximately 2.3 billion lithium-ion battery-powered devices brought into aircraft passenger cabins per year in the NAS. This means the likelihood of encountering an overheat or HEF event has also increased. Crewmembers should exercise extreme caution when approaching an electronic device that is overheating, smoking, deforming, or on fire. The following procedures are recommended for mitigating the risk of an HEF on board an aircraft. Operator procedures and training should include the following three basic concepts:

- Recognizing overheat indicators and actions necessary to prevent a device from starting an HEF or going into TR.
- Extinguishing an HEF fire with the appropriate extinguisher.
- Cooling, containing, and monitoring procedures as the final steps.

14.8.1 Recognizing the Early Warning Signs of PED Overheating. Early recognition of a possible overheat situation of a PED by a crewmember may be able to prevent a potential/imminent TR from causing an HEF. The objective is to stop the device from overheating, thereby preventing the introduction of smoke, flames, or fire in the aircraft environment. HEFs are unique and may not present or progress in the same manner as other fires. In some situations, an HEF can start quickly, but in other situations, the buildup to an HEF can take a little longer. For example, devices prior to TR may show signs of overheating. The overheat can manifest in different ways depending on the device, including warning statements, discoloration of screens, smoking, expanding or swelling of the device, or simply being hot to the touch.

14.8.2 Extinguishing an HEF. The steps to extinguish an HEF are similar to fighting other fires in the aircraft cabin with the exception of the possible volatile nature of an HEF. Quick and aggressive action is necessary to determine the source of hot spots, smoke, and/or flames. The crew should quickly evaluate the situation, gain access to the fire, and attack the fire using all available equipment and resources, which may include deadheading crewmembers or ABPs. Procedures for extinguishing an HEF include:

1. Clearing occupants from the area around the device.
2. Donning personal protective equipment (PPE) (e.g., gloves or PBE).
3. Obtaining appropriate firefighting equipment (a halon or water extinguisher or another acceptable extinguishing product).
4. Approaching the device with appropriate caution and only getting as close as necessary to effectively extinguish flames and mitigate smoke generation.

14.8.3 Cooling and Containing. Cool a smoking, overheating, or deforming device with water, nonalcoholic beverages, a water extinguisher, or an aqueous-based extinguisher. The most effective cooling is achieved by ensuring the liquid gets inside the device. This may necessitate discharging liquid into any openings within the unit or that may be formed as a result of a PED failure. PBE should be worn to protect the crewmember from fumes. Crewmembers should do the following:

1. All flightcrew members should wear oxygen masks with regulators set to 100 percent oxygen if a fire extinguisher is to be discharged in the flight deck.
2. Continue to cool the device and let it rest without touching it for at least 10 to 15 minutes.
3. Use protective gloves, such as oven gloves or fire gloves, if available, and place the device in a container (e.g., trash bin, galley compartment bin, containment product, or other suitable container that is capable of containing and maintaining a device submerged in water).
4. Fill the container/containment device with water or nonalcoholic liquid to completely submerge the device.
5. Place in a secured area that is accessible to the cabin crewmembers but removed from passengers and will prevent spillage.
6. Monitor the device and surrounding area for the remainder of the flight and provide status updates to the pilot in command (PIC).

WARNING 1: Picking up and moving a smoking or burning device may cause injuries.

WARNING 2: Crewmembers should not cover the device or use ice to cool the device. Ice or other materials insulate the device, increasing the likelihood that additional battery cells will reach TR.

14.8.4 Flightcrew Member Actions in the Event of a Device Overheating on the Flight Deck. PED overheat warning signs on the flight deck are similar to those in the cabin but may be easier to detect because of the close proximity of the devices to the flightcrew. If overheat is detected:

1. One flightcrew member should establish control of the aircraft and consider immediate descent and landing at the nearest suitable airport.
2. Disconnect the device from power or attempt to power off the device.
3. Douse the device with water or nonalcoholic liquids to cool the device.
4. In some cases, if necessary, remove the device from the docking station and then quickly remove it from the flight deck.
5. If practical, when the device can be safely moved, place it in a containment device filled with enough liquid to submerge the device.
6. Signal and coordinate with the cabin crewmembers to alert them to opening the flight door to quickly move the device out of the flight deck and into a secure location in the cabin.

14.8.5 Flightcrew Member Actions in the Event of an HEF on the Flight Deck.[8] Flightcrew members should take the following immediate actions:

1. One flightcrew member should establish control of the aircraft and consider immediate descent and landing at the nearest suitable airport.
2. Flightcrew members should don smoke goggles and oxygen masks at the first indication of smoke or fumes and before accomplishing any abnormal or emergency procedures associated with smoke or fume removal.
3. Flightcrew members should immediately use a fire extinguisher to fight the fire.
4. Flightcrew members should signal and coordinate with the cabin crewmembers to don PPE before assisting with the device removal process. Where applicable, F/As should prepare a makeshift containment and cooling area in accordance with HEF-approved training.
5. The most effective cooling is achieved by ensuring the liquid gets inside the device. This may necessitate discharging liquids into any openings formed by the separation of the screen from the unit.
6. Extreme caution should be exercised when handling the device. During TR, external temperatures of the device could exceed 500 °F.
7. Though tablet devices may have a lower probability of propagation of the event to other battery cells, they should be treated as though there is a risk of additional TR events until the device is adequately cooled.

[8] Refer to the Portable Electronic Device (PED) Fire Training – Flight Deck video.

8. Flightcrew members should coordinate with the cabin crewmembers the need for a containment device prior to moving the device out of the flight deck to a secure location in the cabin.

WARNING: Picking up and move a smoking or burning device may cause injuries.

15 FLIGHTCREW MEMBER ACTIONS IN THE EVENT OF AN IN-FLIGHT FIRE. Flightcrew members should:

1. Immediately don their oxygen masks and verify that the regulator is set to 100 percent.
2. Plan for an immediate descent and landing at the nearest suitable airport.
3. Not use smoke/fume elimination procedures to combat a fire.
4. Use smoke/fume elimination procedures to evacuate pollutants.
5. Not reset circuit breakers once the fire is extinguished unless required for safe flight.

15.1 Emergency Landings. Technical evaluations and actual experience indicate that flightcrew members should immediately follow company-approved emergency procedures, notify air traffic control (ATC), and begin planning for an emergency landing as soon as possible. The vast majority of events in the cabin are controlled and do not necessitate an emergency landing. In the event of a hidden fire, delaying descent by only a couple of minutes may make the difference between a successful landing and evacuation and the complete loss of the aircraft.

15.2 Notification. If there is a fire, flightcrew members should notify the F/A(s) to prepare the passengers for an emergency landing and evacuation in accordance with company procedures. If appropriate, flightcrew members should notify the F/As to assist in fighting the fire.

15.3 Checklists. Smoke, fire, or fumes checklists should include, as the first step, that flightcrew members don their oxygen masks and verify that the regulator is set to 100 percent. Flightcrew members should don smoke goggles and oxygen masks at the first indication of smoke or fumes and before accomplishing any abnormal or emergency procedures associated with smoke or fume elimination in accordance with company procedures, the manufacturer's recommendations, or both. Any delay might result in a crewmember's incapacitation.

15.4 Smoke and Fume Elimination. Smoke and fume elimination procedures are designed primarily to evacuate the cabin of foreign pollutants. These procedures are not designed to eliminate the cause of the pollutant but rather to increase the aircraft's airflow to evacuate the pollutant. If the cause of the pollutant is an unextinguished fire, using smoke and fume elimination procedures may worsen the situation by increasing airflow through the area where the fire or smoldering condition exists. For this reason, it is important to extinguish the fire first. If the original source of the fire cannot be determined, exercise caution when attempting to eliminate smoke and fumes from the aircraft. A flightcrew

member's best defense is to have a good understanding of the aircraft's ventilation and pressurization systems and the location of major components within the fuselage. Flightcrew members should not delay taking corrective action in accordance with company-approved procedures for any reason.

15.5 PBE Use. If a flightcrew member is needed to assist in fighting a cabin fire, the FAA recommends they don PBE before leaving the flight deck.

16 F/A ACTIONS IN THE EVENT OF AN IN-FLIGHT FIRE. Company procedures should specify how to handle a fire emergency.

16.1 Recommended Actions.[9] It is recommended that F/As take the following steps for general or lithium battery fires:

16.1.1 General.

1. Be aggressive; if flames are visible, fight the fire immediately.
2. Immediately notify the flightcrew members and describe the fire, smoke, smells, action being taken, etc.
3. If flames are not visible, find the base or source of the smoke.
4. Pull circuit breakers in the applicable area.
5. Do not reset circuit breakers unless instructed by a flightcrew member.
6. Relocate passengers as necessary.
7. Locate hot spots using the back of one's hand.
8. Don PBE (as necessary).

16.1.2 Fighting a Fire Involving Lithium Batteries (Disposable/Rechargeable Battery or Battery Pack).

1. Relocate passengers away from the device.
2. Utilize a halon, halon replacement, or water fire extinguisher to prevent the spread of the fire to adjacent battery cells and materials.
3. Pour water or another nonalcoholic liquid over the cells immediately after knock down or extinguishment of the fire. Only water or other nonalcoholic liquid can provide sufficient cooling to prevent reignition, propagation, or both of the fire to adjacent batteries. Water, though it may react with the tiny amount of lithium metal found in a disposable battery, is most effective at cooling remaining cells, stopping TR, and preventing additional flareups. Significant cooling is needed to prevent the spread of fire to additional cells in a battery pack.

[9] Refer to the Portable Electronic Device (PED) Fire Training – Cabin video.

16.2 Team Approach. One method that may be beneficial is to consider using a team approach to combat a fire. The team approach consists of using flightcrew members and multiple F/As to assist in combating the fire. The team approach is modifiable to fit any number of participants greater than one.

16.2.1 Firefighter. The crewmember (typically an F/A) who finds the fire is usually designated as the firefighter. The firefighter aggressively attempts to locate the source of the fire, fights the fire, and actively tries to extinguish the fire.

16.2.2 Communicator. A second crewmember may serve as a communicator. The communicator relays factual information to the flight deck, including the location, source, and severity (e.g., the fire is under control, spreading, contained, or extinguished) of the fire, the number of fire extinguishers used, smoke conditions, and what is being done to extinguish the fire (e.g., prying apart paneling or discharging an extinguishing agent into the sidewall or overhead area). The communicator also makes announcements to keep passengers informed and calm.

16.2.3 Runner. Another crewmember may serve as a runner. The runner should assist by:

1. Obtaining additional firefighting supplies;
2. Preparing the containment area with water or nonalcoholic liquid in the appropriate container to submerge the PED, if necessary;
3. Relocating passengers;
4. Distributing towels for passengers to use to cover their noses or mouths to filter out smoke;
5. Ensuring aircraft or therapeutic oxygen bottles or both are moved out of the immediate area; and
6. Generally assisting with firefighting support activities as needed.

16.3 Single F/A Operation. In a single F/A operation, when a fire is suspected, immediate communication and coordination with the flight deck is critical. The F/A should follow established company procedures. The F/A performs a variety of tasks with the most important being aggressively pursuing and extinguishing the fire and utilizing passengers, as needed, to support the firefighting efforts (e.g., relocating passengers, runner, etc.).

17 FAA CONCERNS ABOUT RESETTING TRIPPED (POPPED) CIRCUIT BREAKERS IN FLIGHT.

17.1 Resetting Circuit Breakers in Flight.

17.1.1 The FAA reiterates its concern about resetting circuit breakers during flight. Crewmembers may create a potentially hazardous situation if they reset a circuit breaker without knowing what caused it to trip. Tripped circuit breakers should not be reset in flight unless doing so is consistent with explicit procedures specified in the approved operating manual used by the flightcrew members or unless, in the judgment of the captain, resetting the circuit breaker is absolutely necessary for the safe completion of the

flight. A detailed entry in the aircraft's maintenance log is a proven safety practice for tracking purposes and may provide maintenance personnel with key information to enable prompt troubleshooting and effective corrective action on the ground.

17.1.2 Operator manuals and training programs should contain company policies and explicit procedures regarding resetting tripped circuit breakers, both during flight and on the ground. The procedures shown in the manuals used by the operator's crewmembers, maintenance personnel, and airplane ground servicing personnel should be consistent with the airplane manufacturer's guidance. Crewmembers should be reminded not to use a circuit breaker as a switch to perform procedural functions unless doing so is specified in approved company procedures or the manufacturer's operating procedures.

17.2 Potential Hazards Associated With Tripped Circuit Breakers. The FAA previously published guidance material that states that circuit breakers are slow-acting devices and may not offer sufficient disconnect protection during events such as arc tracking or insulation flashover (refer to AC 25-16). Arc tracking is a phenomenon in which a conductive carbon path forms across an insulating surface. The carbon path provides a short circuit path through which current can flow (e.g., electrical arcing). The effects of electrical faults can include:

- Component overheating;
- Toxic fumes;
- Smoke;
- Fire;
- Damage to wires, wire bundles, or parts;
- Melting of holes in sheet metal parts by faulted, high-current feeder cables;
- Melting and burning of titanium bleed air ducts by a chafed, high-current feeder cable;
- Electromagnetic interference (EMI) with equipment; and
- The simultaneous and unreasonable loss of both engine-driven generators in a two-engine airplane.

Note: AC 25-16 contains additional information about this subject.

17.3 Using a Circuit Breaker as an On/Off Switch. Since circuit breakers are designed to open an electrical circuit automatically at a predetermined overload of current, they should not be used for day-to-day operational functions because they would not be performing their intended function, which is protection against overloads. Circuit breakers should not be used, even those suitable for frequent operation, as a switch to turn protected items on or off. An operator should publish and include in its approved maintenance programs and flight operations manuals any exceptions to this procedure.

18 RECOMMENDED TRAINING.

18.1 Training Programs. Operators' crewmember training programs should stress the importance of crewmembers taking immediate and aggressive action when confronted with smoke, fumes, and in-flight fires. It should also emphasize accessing and fighting hidden fires.

18.2 Training. Operators should include the following knowledge and skill objectives in their crewmember training programs:

18.2.1 Knowledge-Based Objectives:

1. In the event of a known or suspected in-flight fire, crewmembers should know how to take immediate and aggressive action to locate the source of the fires.
2. To assist in locating the source of the fires, crewmembers should know the various aircraft cabin configurations (e.g., overhead, sidewall, cheek, and tunnel areas) the air carrier operates.
3. Crewmembers should understand the proper methods, techniques, or both to gain access to areas that may support hidden fires and the location of any cabin panels that are removable without special tools.
4. Each flightcrew member should understand the aircraft ventilation systems, including normal and abnormal procedures, with emphasis on the potential effects of airflow on hidden fires.
5. To assist flightcrew members in maintaining internal flight deck communications when they don oxygen masks, they should know the aircraft-specific methods for establishing communication.
6. Each flightcrew member should know the importance of stowing their oxygen masks set to 100 percent.
7. To enable crewmembers to locate critical equipment components within the fuselage area, operators' manuals should contain a cross-section of the aircraft's fuselage showing the location of electrical, fuel, and hydraulic lines.
8. Crewmembers should recognize potential indications of hidden fires and the importance of not arbitrarily resetting circuit breakers.

18.2.2 Skill-Based Objectives:

18.2.2.1 Flightcrew members should practice the procedures or techniques or both methods associated with:

- Planning for an immediate descent and landing at the nearest suitable airport;
- Aggressively locating the source of smoke, fumes, and fire;
- Notifying cabin crewmembers under non-normal circumstances;

- Operating the aircraft while using PBE and smoke goggles;
- Implementing smoke and fume elimination procedures;
- Alternate means of dispersing smoke and fumes when the source of a fire is unknown; and
- Use of oxygen masks/goggle sets, including the use of the regulator's emergency selector and the venting of smoke goggles.

18.2.2.2 Cabin crewmembers should practice the procedures or techniques or both methods associated with:

- Aggressively locating the source of the fire;
- Selecting the appropriate extinguishing agent;
- Relocating passengers as necessary;
- Opening storage compartments or doors;
- Considering the location of portable oxygen bottles and considering relocating portable oxygen bottles away from the source of the fire;
- Notifying flightcrew members under non-normal circumstances; and
- Locating hot spots on interior panels.

18.2.2.3 Skill-based training should be conducted jointly (flightcrew with F/As) to emphasize Crew Resource Management (CRM). Crewmember performance should be evaluated in the following areas:

- Clear and concise communication;
- Effective decision making;
- Critical CRM skills, including situational awareness; and
- Time management.

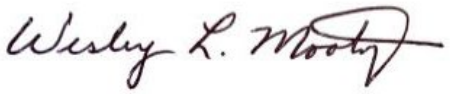
19 OBTAINING FAA PUBLICATIONS.

- This AC is available on the FAA's website at https://www.faa.gov/regulations_policies/advisory_circulars/.
- FAA handbooks and orders are available online at https://www.faa.gov/.
- The Code of Federal Regulations is available online at https://www.ecfr.gov/.

20 NOTES ON APPENDICES. The following appendices contain information about the dangers associated with in-flight fires. Operators may also use this information to develop training programs in support of the recommendations contained in this AC. The information may vary among fleets and operators and may change over time. Some of the examples may be readily adapted to an operator's training and operating manuals for

various airplane fleets. Others may apply to a certain airplane fleet and may not be adaptable apart from that fleet.

21 AC FEEDBACK FORM. For your convenience, the AC Feedback Form is the last page of this AC. Note any deficiencies found, clarifications needed, or suggested improvements regarding the contents of this AC on the Feedback Form.



Wesley L. Mooty
Acting Deputy Executive Director, Flight Standards Service

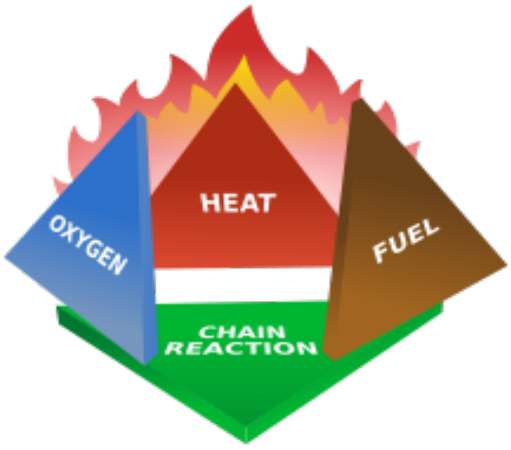
APPENDIX A. FIREFIGHTING BASICS

A.1 In order to determine the best way to approach a fire and the safest way to extinguish it, a crewmember should be able to differentiate between different types of fire situations. Learning how to fight fires involves learning the elements that are involved in creating and sustaining a fire.

A.2 The fire triangle is a model for understanding the necessary ingredients for most fires: fuel, heat, and an oxidizing agent (usually oxygen). The fire tetrahedron represents the addition of the chemical chain reaction to the three components already present in the fire triangle. Fire can be prevented or extinguished by removing any one of these elements.

Figure A-1. Fire Triangle

Figure A-2. Fire Tetrahedron



A.3 The fuel in aircraft fires is the materials used to construct the aircraft and its contents, such as insulation, carpeting, ducting, floor and ceiling panels, partitions and sidewalls, seat covers, and curtains. Heat can come from an outside source, such as a match or wire arc, and from the fire itself. The oxidizing agent is a material or substance that, when the proper conditions exist, will release gases, including oxygen. The self-sustained chemical chain reaction is the way the fire's components react to each other.

A.4 In order to extinguish a fire, and thus break the fire chain, it is necessary to eliminate one of the fire elements. The most common method is to use water, which removes heat by cooling the fire. Additionally, water acts to smother the fire by taking away oxygen. Similarly, foam fire extinguishers smother fires. Removing the fuel is another firefighting method, such as when a gas line is shut off. Another method of extinguishing fires is by inhibiting the chemical chain reaction. Fire retardant agents interrupt the combustion reaction, which halts the fire.

A.5 One of the major hazards associated with firefighting operations is the toxic environment created by combustible materials. The four major risks are smoke, oxygen deficiency, elevated temperatures, and poisonous atmospheres. Additional hazards include falls and structural collapse that can exacerbate the problems encountered in a toxic environment.

A.6 The first step in a firefighting operation is reconnaissance to search for the origin of the fire and to identify the specific risks.

A.7 A crewmember's goals when fighting a fire are to save lives, protect property, and protect the environment. A fire can rapidly spread and endanger many lives, but with consistent and appropriate firefighting techniques, catastrophe can often be avoided.

A.8 Learning how to fight fires involves both education and experience. Crewmembers should learn the science of fire, including the causes and components of the fire, and the methods of extinguishing it. They should also learn how to use the tools necessary for firefighting.

APPENDIX B. NTSB ACCIDENT REVIEWS

B.1 This AC was originally issued in part based on the National Transportation Safety Board's (NTSB) review of commercial aviation accidents involving in-flight fires. The scope of the review was limited to transport category airplanes operated by U.S. and foreign operators during the period 1983 to 2021. What follows is a brief synopsis of the events the NTSB reviewed as well as more recent in-flight fire events.

B.1.1 On June 2, 1983, a McDonnell Douglas DC-9 operated by Air Canada as flight 797 experienced an in-flight fire and made an emergency landing at Cincinnati and Northern Kentucky International Airport, Covington, KY. A passenger noticing a strange smell and an F/A seeing smoke in one of the lavatories initially detected the fire. Another F/A saw that the smoke was coming from the seams between the walls and ceiling in the lavatory. During the descent, the smoke increased and moved forward in the cabin. After the airplane landed, F/As initiated an emergency evacuation. Of the 41 passengers and 5 crewmembers on board, 23 passengers were unable to evacuate and died in the fire. The airplane was destroyed.

B.1.2 On September 17, 1999, a McDonnell Douglas MD-88 operated by Delta Air Lines as flight 2030 experienced an in-flight fire and made an emergency landing at Cincinnati and Northern Kentucky International Airport, Covington, KY. The airplane sustained minor damage. There were no injuries to the 2 flightcrew members, 3 F/As, 3 off-duty F/As, and 113 passengers during the evacuation.

B.1.3 On August 8, 2000, a McDonnell Douglas DC-9-32 operated by AirTran Airways as flight 913 experienced an in-flight fire and made an emergency landing at Greensboro Piedmont Triad International Airport, Greensboro, NC. The effects of fire, heat, and smoke substantially damaged the airplane. Of the 58 passengers and 5 crewmembers on board, 3 crewmembers and 5 passengers received minor injuries from smoke inhalation, and 5 other passengers and 1 ground crewmember received minor injuries during the evacuation.

B.1.4 On November 29, 2000, lightning struck a McDonnell Douglas DC-9-82 operated by American Airlines as flight 1683, which experienced an in-flight fire that began shortly after takeoff from Ronald Reagan Washington National Airport, Washington, DC. The flightcrew made an emergency landing at Washington Dulles International Airport and ordered an evacuation. The airplane sustained minor damage. There were no injuries to the 2 pilots, 3 F/As, and 61 passengers during the evacuation.

B.1.5 On December 18, 2020, a spare lithium battery overheated and expanded while in-flight. The F/A responded quickly to this sign of potential thermal runaway (TR) and put the battery into a containment bag.

B.1.6 On January 27, 2021, a thermal event ensued when a pair of earbuds were being charged by a passenger in-flight. The earbuds were placed in an in-flight containment bag until the smoke subsided and the flight landed.

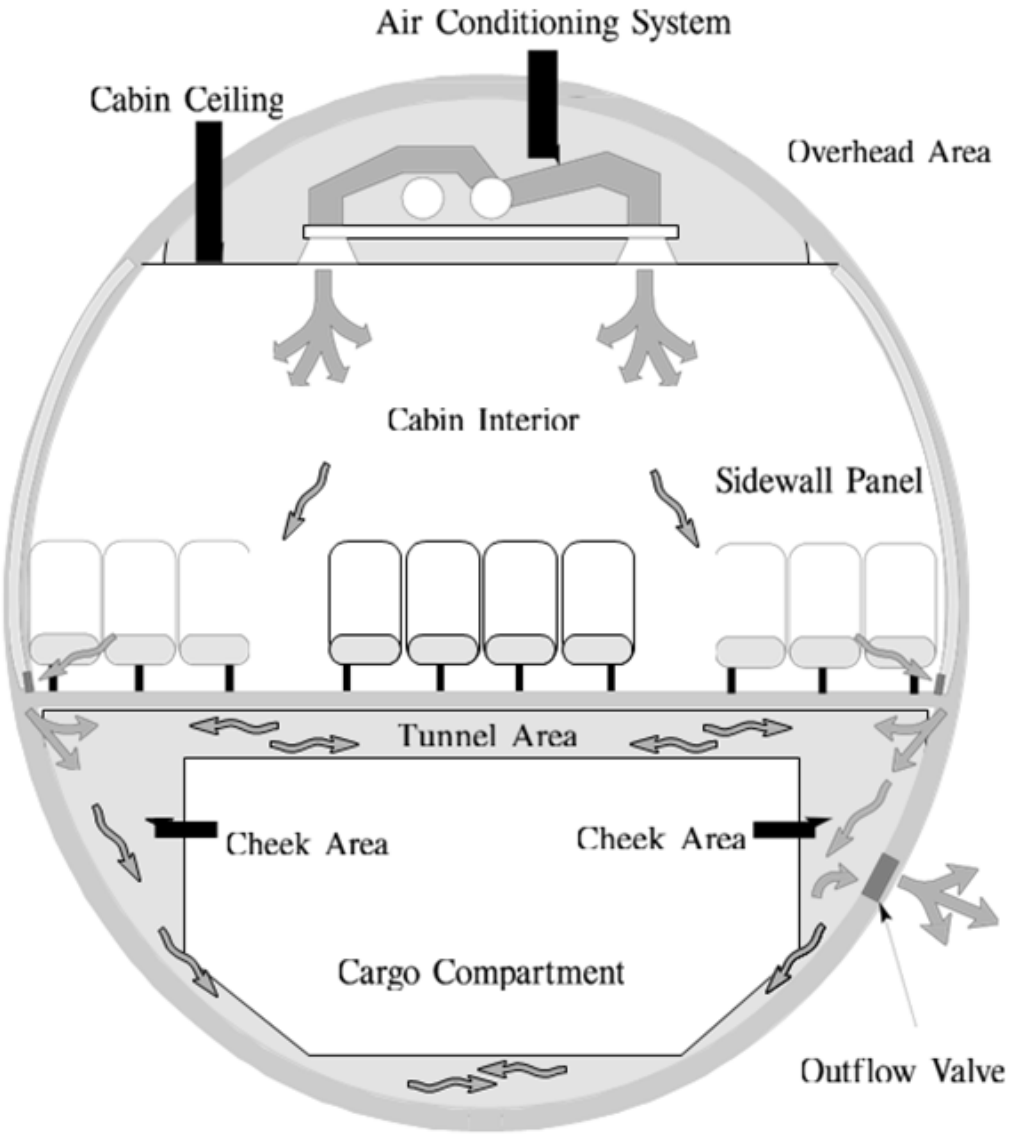
B.1.7 On March 3, 2021, a passenger's cell phone battery began to burn while in flight over the Gulf of Mexico. Airline personnel extinguished the fire and secured the phone in a thermal containment bag.

B.1.8 On March 17, 2021, a passenger's vaping device began to overheat in his pocket while in the lavatory. F/As placed the device in a containment bag. Fire rescue met the aircrew upon landing and disposed of the device.

B.2 Brief incident summaries of events with smoke, fire, extreme heat, or explosion involving lithium batteries can be found at https://www.faa.gov/hazmat/resources/lithium_batteries/media/Battery_incident_chart.pdf.

APPENDIX C. TYPICAL WIDE BODY CROSS-SECTION

Although the following diagram represents a typical wide body aircraft, many narrow body aircraft have the same general layout and ventilation airflow. Other than the cabin height and width, the main difference between wide body and narrow body aircraft is the volume of free space in the overhead area. This free space can range from a few feet to more than 4 feet in wide body aircraft and to as little as a few inches in small regional jets. Crewmembers should understand the volume of overhead space in a particular aircraft to effectively combat hidden fires in this area.



APPENDIX D. TIME TO BECOMING NONSURVIVABLE[10]

The following chart depicts the time that various crews had from the first indication of the presence of a hidden fire to the time that fire became catastrophically uncontrollable. For aircraft with hidden fires, an approximate assessment is that only one-third will reach an airfield before the fire becomes uncontrollable.[11]

DATE	LOCATION	AIRCRAFT TYPE	TIME TO BECOME NONSURVIVABLE (MINUTES)
07-26-1969	Biskra, Algeria	Caravelle	26
07-11-1973	Paris, France	B707	7
11-03-1973	Boston, USA	B707	35
11-26-1979	Jeddah, Saudi Arabia	B707	17
06-02-1983	Cincinnati, USA	DC-9	19
11-28-1987	Mauritius, Indian Ocean	B747	19
09-02-1998	Nova Scotia, Canada	MD-11	16

[10] CAA Paper 2002/01, (FAA Reference DOT/FAA/AR-02/50), "A Benefit Analysis for Enhanced Protection From Fires in Hidden Areas on Transport Aircraft," p. 6.
[11] CAA Paper 2002/01, p. 20.

APPENDIX E. INFORMATION ON USING HAND FIRE EXTINGUISHERS

The following information has been extracted from AC 20-42, Hand Fire Extinguishers for Use in Aircraft, and presented here for your review and ease of reference. The information presented below is current as of the date of this AC. To ensure you have current information relating to hand fire extinguishers for use in the aircraft, refer to the current edition of AC 20-42.

E.1 Types of Fires. To select an appropriate extinguisher for use in an aircraft, consider the following classes of fires (as defined in the National Fire Protection Association (NFPA) 10, Standard for Portable Fire Extinguishers) that are likely to occur:

E.1.1 Class A. Fires in ordinary combustible materials, such as wood, cloth, paper, rubber, and plastics, for which the quenching and cooling effects of quantities of water or aqueous-based extinguishing agents containing a large percentage of water are of prime importance.

E.1.2 Class B. Fires in flammable liquids, oils, greases, tars, oil-based paints, lacquers, and flammable gases for which extinguishing agents having a blanket effect are essential.

E.1.3 Class C. Fires involving energized electrical equipment and where the electrical nonconductivity of the extinguishing agent is important.

E.1.4 Class D. Fires involving combustible metals, such as magnesium, titanium, zirconium, sodium, lithium, and potassium, could continue to burn unless dry powder extinguishing agents are used. You should follow the recommendations of the manufacturer for use of those extinguishers to avoid a possible chemical reaction between the burning metal and the extinguishing agent.

E.2 Extinguishing Agents Appropriate for Types of Fires. The following extinguishing agents are recommended, as appropriate, for use on the types of fires specified below and as defined in AC 20-42, Chapter 3, Selecting the Correct Hand Fire Extinguisher:

- Carbon dioxide (CO_2): Class B or C.
- Water/aqueous-based extinguishing agent: Class A.
- Dry chemicals: Class A, B, or C.
- Halogenated hydrocarbons (halon): Class A, B, or C.
- Specialized dry powder: Class D.

Note: Only “all-purpose” or Class A, B, or C dry chemical powder extinguishers containing monoammonium phosphate have a UL Class A, B, or C rating; all other powders have a Class B or C rating only.

E.3 Numeral Ratings. Extinguishers labeled for Class A and B fires use numerals with the identifying letters. The numeral indicates the relative extinguishing effectiveness of the device on a given size fire, which is dependent on the agent, the capacity of the device, discharge times, and design features. For example, an extinguisher rated as 4A should

extinguish about twice as much Class A fire as a 2A-rated extinguisher. A 2½-gallon water extinguisher is rated 2A. On an extinguisher rated for Class B fires, the numeral rating precedes the letter "B." Extinguishers labeled for Class C or D fires do not use numeral ratings. Extinguishers that are effective on more than one class of fires have multiple numeral-letter and letter classifications and ratings (e.g., 5B:C).

E.4 Helpful Hints in Extinguishing Fires.

E.4.1 Generally, you can obtain the best results in firefighting by attacking the base of the fire at the near edge of the fire and progressing toward the back of the fire by moving the fire extinguisher nozzle rapidly in a side-to-side, sweeping motion.

E.4.2 The effective discharge time of most handheld fire extinguishers ranges from 8 to 25 seconds depending on the capacity and type of extinguisher. Because of this relatively short effective timespan, the crewmember should select and use the proper fire extinguisher without delay.

E.4.3 Care should be taken not to direct the initial discharge at the burning surface at close range (less than 5 to 8 feet) because the high-velocity stream may cause splashing and/or scattering of the burning material.

E.4.4 Ventilate the compartment promptly after successfully extinguishing the fire to reduce gaseous combustion and gases produced by thermal decomposition.

Advisory Circular Feedback Form

If you find an error in this AC, have recommendations for improving it, or have suggestions for new items/subjects to be added, you may let us know by contacting the Air Transportation Division at 9-AFS-200-Correspondence@faa.gov or the Flight Standards Directives Management Officer at 9-AWA-AFB-120-Directives@faa.gov.

Subject: AC 120-80B, Firefighting of General and High-Energy In-Flight Fires

Date: _____

Please check all appropriate line items:

☐ An error (procedural or typographical) has been noted in paragraph _____ on page _____.

☐ Recommend paragraph _____ on page _____ be changed as follows:

_____

_____

☐ In a future change to this AC, please cover the following subject:
(Briefly describe what you want added.)

_____

_____

☐ Other comments:

_____

_____

☐ I would like to discuss the above. Please contact me.

Submitted by: _____ Date: _____