



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 8, 2009

In reply refer to: A-09-43 through -53
A-07-100 (Reiteration)

The Honorable J. Randolph Babbitt
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On June 28, 2008, about 2215 Pacific daylight time, an ABX Air Boeing 767-200, N799AX, operating as flight 1611 from San Francisco International Airport (SFO), San Francisco, California, experienced a ground fire before engine startup. The captain and the first officer evacuated the airplane through the cockpit windows and were not injured, and the airplane was substantially damaged. The cargo flight was operating under the provisions of 14 *Code of Federal Regulations* (CFR) Part 121. At the time of the fire, the airplane was parked near a loading facility, all of the cargo to be transported on the flight had been loaded, and the doors had been shut.

The National Transportation Safety Board (NTSB) determined that the probable cause of this accident was the design of the supplemental oxygen system hoses and the lack of positive separation between electrical wiring and electrically conductive oxygen system components. The lack of positive separation allowed a short circuit to breach a combustible oxygen hose, release oxygen, and initiate a fire in the supernumerary compartment that rapidly spread to other areas.¹ Contributing to this accident was the Federal Aviation Administration's (FAA) failure to require the installation of nonconductive oxygen hoses after the safety issue concerning conductive hoses was initially identified by Boeing.²

Background

The pilots reported that, while performing the engine start checklist, they heard loud "pop" and "hissing" sounds. The first officer reported that, less than 1 minute before he and the captain heard the pop and hissing sounds, he had been in the supernumerary compartment with

¹ The supernumerary compartment, which is present on some cargo airplanes, is located directly aft of the cockpit and forward of the main deck cargo compartment. This area was where the lavatory, galley, and three non-flight crew seats (in a bench configuration) were located.

² For more information, see *Ground Fire Aboard Cargo Airplane, ABX Air Flight 1611, Boeing 767-200, N799AX, San Francisco, California, June 28, 2008*, Aircraft Accident Summary Report NTSB/AAR-09/04/SUM (Washington, DC: NTSB, 2009).

no fire or smoke present at the time. Within 15 seconds after hearing the sounds, the first officer opened the cockpit door and saw black smoke in the supernumerary compartment at ceiling height; through the smoke, he saw fire near the ceiling above the top of the right-most occupant seat and above the location of the weight and balance computer.³

The supernumerary compartment was constructed with low-flammability materials, in accordance with Federal regulations. The enclosure above the supernumerary occupant seats, the top right of which was consistent with the location where the first officer initially observed the fire, included panel material, an aluminum subframe, and three oxygen mask stowage boxes. The brief time during which the fire developed, the intensity of the fire, and the pop and hissing noises heard by the flight crew indicated that pressurized oxygen was involved in the fire.

Each of the three oxygen mask stowage boxes (in the enclosure above the supernumerary occupant seats) included an oxygen mask assembly, a flexible hose that was primarily made of polyvinyl chloride (PVC),⁴ and rigid stainless steel supply tubing. The manufacturer of the PVC flexible oxygen hoses installed a stainless steel coil spring in the hoses to prevent bends from collapsing the hose and disrupting the oxygen supply. The stainless steel coil was loosely attached to the aluminum fittings at each hose end, making the hoses electrically conductive.

Conductivity of Oxygen Hoses

After receiving reports that electrical energy (in one case, from a short circuit) had caused leaks in oxygen hoses installed on its airplanes,⁵ Boeing changed the design requirement for flexible oxygen hose assemblies and began installing nonconductive hoses on new-production airplanes. The nonconductive hoses included insulators that were installed between the internal coil spring and the fitting at each hose end. According to Boeing, the new hoses were designed to help prevent damage if they were subjected to an electrical current. The first 767 (the accident airplane model) with the new hose design was delivered in August 1999.

In addition, Boeing issued alert service bulletins (SBs) to operators of its 737, 747, 757, and 767 airplanes to replace existing oxygen hoses in the cockpit with the new nonconductive hoses. The SB for the accident airplane model, 767-35A0034, was issued in September 1999.⁶ However, the FAA did not mandate compliance with the SBs. Although SB 767-35A0034 was not initially accomplished on the accident airplane,⁷ after the accident, ABX Air accomplished the SB on all of its 767 airplanes. In addition, ABX Air replaced the oxygen hoses in the airplanes' supernumerary compartment with nonconductive hoses.

³ The weight and balance computer was located below the right end of the supernumerary enclosure and to the right of the supernumerary occupant seats.

⁴ PVC is a plastic.

⁵ Boeing had received a report from a 737 operator (the date of which is unknown) and from a 757 operator (in August 1997) indicating that cockpit flexible oxygen hoses had developed leaks after an electrical current had shorted and heated the internal coil spring, causing the PVC hose material to melt and rupture.

⁶ Boeing SB 737-35A1053, 747-35A2101, and 757-35A0015 were issued for the other affected airplane models.

⁷ Even though maintenance records showed that the SB had not been accomplished on the accident airplane, the NTSB found that three of the four oxygen hoses in the cockpit were the nonconductive hose type.

The manufacturer of the flexible oxygen hoses noted that the general hose design was based on military standards but that the lengths, diameters, and other features were established by the airplane manufacturer. The hose manufacturer also noted that, in addition to Boeing, conductive hoses were installed on airplanes manufactured by Bombardier, Douglas, Cessna, Gulfstream, Hawker, Embraer, and others. The NTSB examined the conductive hoses in some of those airplane models and verified that the hose design was similar to that of Boeing.

The NTSB recognizes the logistical challenge of replacing all of the conductive oxygen hoses that are currently installed on airplanes. However, Boeing has already made nonconductive hoses available for its airplanes, and similar action by other airplane manufacturers would help prevent the circumstances of this accident from recurring. The NTSB's oxygen system hose tests⁸ demonstrated that the internal coil spring in the flexible hose assembly became an ignition source when the spring was electrically energized, causing it to heat up, and that the PVC hose material, when heated by the spring, would generate combustible gases, which, when combined with the oxygen and the heated spring, resulted in fire. As a result, the NTSB concludes that combustible oxygen hoses with an electrically nonconductive design would prevent the internal coil spring from becoming electrically energized, mitigating the possibility that the hoses would melt and ignite. Therefore, the NTSB recommends that the FAA require operators to replace electrically conductive combustible oxygen hoses with electrically nonconductive hoses so that the internal hose spring cannot be energized. Because Boeing continues to stock conductive hoses (they are still a certified part) and provide them to customers who request the original part number for the hose, and because other manufacturers may have the same practice, the NTSB further recommends that the FAA prohibit the use of electrically conductive combustible oxygen hoses unless the conductivity of the hose is an intentional and approved parameter in the design.

Airworthiness Directive Process

After manufacturers provide draft SBs to the FAA for approval, the FAA routinely uses the opportunity to create airworthiness directives (ADs) that require implementation of the SBs as a means for removing parts from service when those previously approved parts are found to be no longer airworthy. According to the FAA, ADs are legally enforceable rules to correct an unsafe condition in an aircraft, engine, propeller, or appliance.⁹ However, the FAA's review of Boeing's SBs (recommending the replacement of conductive cockpit oxygen hoses with nonconductive ones) missed the importance of this safety issue for undetermined reasons and thus did not result in the issuance of ADs.

After the ABX Air accident, the FAA recognized the significance of this safety issue and began its rulemaking process. In June 2009, the FAA began issuing notices of proposed

⁸ The NTSB performed tests on PVC flexible oxygen hose assemblies that had been removed from the accident airplane and other ABX Air 767 airplanes to evaluate whether electrically energized hoses could cause a fire. Additional tests involved igniting a pressurized PVC flexible oxygen hose with an external heat source.

⁹ According to 14 CFR 1.1, "General Definitions," an appliance is "any instrument, mechanism, equipment, part, apparatus, appurtenance, or accessory, including communications equipment, that is used or intended to be used in operating or controlling an aircraft in flight, is installed in or attached to the aircraft, and is not part of an airframe, engine, or propeller."

rulemaking for ADs that would require the use of nonconductive hoses in the cockpit for each of the affected Boeing airplane models in production.

Because the intent of an FAA AD and a manufacturer's SB is frequently the same, many ADs simply instruct airplane operators to comply with the provisions of a specific SB. As a result, this instruction would only address specific uses of an unsafe part. For example, the FAA's expected ADs on conductive oxygen hoses will only address specific part numbers in specific applications that Boeing cited in its SBs. However, the expected ADs will not likely address the same part numbers used in other applications, including a supplemental type certificate for a postmanufacture modification (as was the case with the accident airplane). Also, because the FAA planned to issue ADs for Boeing 737, 747, 757, and 767 models only, the ADs will not address oxygen hoses from the same hose manufacturer that have a similar electrically conductive design but are used by other airplane manufacturers and may have different part numbers.

Although Boeing's SB specified the replacement of the oxygen hoses only in the cockpit, this accident demonstrates that electrically conductive oxygen hoses in any airplane installation are a safety hazard. Because the design of the hose originated with a military specification that could be used by any manufacturer, and this hose manufacturer provides similar hoses to numerous airplane manufacturers, the problem with conductive hoses is not restricted to Boeing or even this particular hose manufacturer.

The hoses are examples of a part (that is, appliance) that is used by more than one airplane manufacturer. If the FAA can determine which airplane models include the part, multiple ADs can be issued against each of the airplane models at the same time. If the FAA were uncertain about the specific airplane models that might include the part, the FAA could then issue an AD citing the part manufacturer or the base model identifier from that manufacturer. For example, AD 94-06-04, which was an appliance AD issued against oxygen mask regulators, stated that the mask regulators were "installed on but not limited to" a list of multiple airplane models. The AD described the general series for the part along with empty brackets ("EROS series MF10-[]-[] full face quick donning mask regulators") to represent the various part numbers used by the different airplane manufacturers. In either case, the most effective way for the FAA to have parts that are no longer airworthy removed from service is to ensure that the AD process coordinates with part manufacturers as well as airplane manufacturers.

The accident airplane was approved to be converted from a passenger to a cargo configuration, and Israel Aerospace Industries (IAI) modified the accident airplane in 2004. For this modification, IAI used a design that adapted original Boeing-numbered parts, including the flexible hoses for the supernumerary supplemental oxygen system. Because IAI is not a Boeing operator, it was not aware of Boeing's SB regarding the replacement of conductive oxygen hoses in the cockpit. Even if IAI had been so aware, the SB addressed only Boeing installations, and the supernumerary compartment had been a postmanufacture design created by IAI.¹⁰ However,

¹⁰ After the accident, IAI representatives indicated that the company would be installing nonconductive hoses in future 767 conversions. Also, in September 2008, IAI issued SB 368-35-094, which recommended replacing conductive-style hoses in airplanes that IAI had previously modified. (ABX Air owned 18 of the 30 IAI-modified airplanes.)

airplane modifiers, including IAI, review pertinent ADs to ensure the airworthiness of all parts used in a postmanufacture modification. As a result, the NTSB concludes that it is likely that the modifier of the accident airplane would have recognized the use of a part that was potentially combustible before releasing the airplane to the operator if the FAA had issued an appliance AD that cited the part manufacturer as well as the airplane model. Therefore, the NTSB recommends that the FAA formalize the AD process so that, when an aircraft manufacturer or other source identifies an airworthiness issue with an appliance, coordination with the appliance manufacturer occurs to ensure that the possible safety risks to all products using the appliance are evaluated and addressed.

Proximity of Oxygen System Components to Electrical Wiring

Boeing guidance stated that oxygen installations should include a minimum of 2 inches between oxygen lines (that is, hoses and tubing) and electrical wiring. The guidance also advised securing the wiring so that it could not reach oxygen lines and installing the wiring beneath oxygen lines in case the wiring sagged over time. During postaccident inspections of other ABX Air 767 airplanes that were modified by IAI, some installations were found to have electrical wiring in proximity to the stainless steel oxygen supply tubing. Other installations (both in the cockpit and supernumerary compartment) were found to have electrical wiring that was routed above and in direct contact with the oxygen tubing, even though the supplemental type certificate provided for positive separation. This routing created the potential for electrical short circuits to reach the flexible oxygen hoses. The investigation of the fire aboard the accident airplane found that a short circuit from electrical wiring was the most likely source to energize the coil spring inside a supernumerary oxygen system hose, causing the hose material to ignite.

On January 15, 1998, the NTSB issued Safety Recommendations A-98-1 and -2 to the FAA as a result of an April 1997 in-flight fire aboard a Cessna Citation 650 airplane. The investigation found that the fire was caused by arcing between electrical wiring and a hydraulic tube, and postaccident inspections found wiring that interfered with oxygen hoses. Safety Recommendations A-98-1 and -2 asked the FAA to do the following:

Review the design, manufacturing, and inspection procedures of aircraft manufacturers, and require revisions, as necessary, to ensure that adequate clearance is specified around electrical wiring, in accordance with published FAA guidelines. (A-98-1)

Review the existing designs of all transport-category airplanes to determine if adequate clearance is provided around electrical wiring, in accordance with published FAA guidelines. If deviations are found, require that modifications be made to ensure adequate clearance. (A-98-2)

The published FAA guidelines referred to in the recommendations were Advisory Circular (AC) 43.13-1A, "Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair," and AC 65-15, "Airframe and Powerplant Mechanics Airframe Handbook." These guidelines stated that no electrical wire should be located within 1/2 inch of any combustible fluid or oxygen line and that, if the separation was less than 2 inches, back-to-back clamps or a polyethylene sleeve should be installed to ensure positive separation. On June 28, 2002, the

NTSB stated that the FAA's actions fully addressed the recommendations.¹¹ As a result, the NTSB classified Safety Recommendations A-98-1 and -2 "Closed—Acceptable Action." However, these actions did not prevent the wiring problems that were found on the ABX Air airplanes. The NTSB was unable to determine whether the wiring problems were the result of the IAI design or ABX Air's maintenance.

The involvement of oxygen in a fire can significantly expedite its growth and severity. In its report on the May 11, 1996, accident involving ValuJet Airlines flight 592, the NTSB determined that the accident was the result of an in-flight fire that began with the actuation of oxygen generators, which were being improperly carried as cargo. The NTSB's report on this accident stated, "the oxygen generators would have initially fed the fire with an abundance of oxygen ... resulting in a very rapidly developing fire," which prevented the airplane from returning safely to land on the runway from which it had departed about 10 minutes earlier.¹² Also, in its report on the September 2, 1998, accident involving Swissair flight 111, which crashed into water while the pilots were attempting an emergency landing after detecting an in-flight fire, the Transportation Safety Board of Canada (TSB) found that an aluminum cap assembly used on an oxygen tube above the cockpit ceiling was susceptible to leaking or fracturing when exposed to the fire-related temperatures that were likely occurring in that area during the last few minutes of the flight. The TSB stated that it could not determine whether leaking or fracturing had occurred but that such a failure would have exacerbated the fire.¹³

The energy in a short circuit could perforate the rigid stainless steel supply tubing and become an ignition energy source or allow oxygen to reach other fuel and ignition sources. The NTSB concludes that protecting oxygen system tubing from inadvertent short circuits is important because of the proximity between the tubing and electrical wiring in a compressed area as well as the potential severity of a fire involving oxygen. Because the general wire routing guidelines in AC 43.13-1A and AC 65-15 were advisory only and specific installations can deviate from airplane manufacturer wiring guidance, the NTSB recommends that the FAA require airplane manufacturers and modifiers to provide positive separation between electrical wiring and oxygen system tubing according to, at a minimum, the guidance in AC 43.13-1A and AC 65-15. The NTSB further recommends that the FAA require airplane manufacturers and operators to ensure that oxygen system tubing in proximity to electrical wiring is made of,

¹¹ On April 3, 2002, the FAA stated that it conducted audits on wire separation installation practices used at Cessna, Boeing, Raytheon, and Learjet and did not find any systemic wire separation problems that would warrant review of existing designs of all transport-category airplanes. The FAA also stated that it produced two training aids to increase awareness of wire installation and separation requirements and address wiring maintenance practices. In addition, the FAA stated that it published a policy statement in the *Federal Register* that addressed wire installation drawings, safety analyses of wiring and wire bundles, and continued airworthiness considerations for wiring. The FAA further stated that it had initiated a program to enhance wire system safety through better design, inspection, maintenance, and training. Last, the FAA indicated that it was proposing improved wire separation design and instructions for continuing airworthiness requirements.

¹² National Transportation Safety Board, *In-Flight Fire and Impact With Terrain, ValuJet Airlines Flight 592, DC-9-32, N904VJ, Everglades, Near Miami, Florida, May 11, 1996*, Aircraft Accident Report NTSB/AAR-97-06 (Washington, DC: NTSB, 1997).

¹³ Transportation Safety Board of Canada, *In-Flight Fire Leading to Collision with Water, Swissair Transport Limited, McDonnell Douglas MD-11, HB-IWF, Peggy's Cove, Nova Scotia 5 nm SW, 2 September 1998*, Aviation Investigation Report A98H0003 (Quebec, Canada: TSB, 2003).

sleeved with, or coated with nonconductive material or that the tubing is otherwise physically isolated from potential electrical sources.

Electrical Grounding of Oxygen System

Examination of the supplemental oxygen system found that it was supported by rubber clamps so that the system was grounded to the airplane structure through the PVC flexible hoses and a stainless steel convoluted oxygen hose¹⁴ that was routed to an overpressure port. Although the convoluted oxygen hose and its fittings were metal, they were not designed or evaluated to be a potential ground path for the electrical wiring that was routed nearby. However, the investigation determined that the path of least resistance between the supplemental oxygen system and the airplane structure was through the hoses.

Title 14 CFR 25.1441, “Oxygen Equipment and Supply,” paragraph (b), states that an oxygen system must be free from hazards in itself. However, the existing method of grounding the oxygen system could allow inadvertent contact from adjacent electrical wiring to energize oxygen system components.

Specific electrical grounding requirements would ensure that an electrical current has a path for reaching airplane structure without energizing oxygen system components. These requirements could include the use of electrical ground straps, which generally consist of a braided wire with an eyelet at each end; one eyelet is connected to a system component, and the other is connected to the airplane structure. (These straps are commonly used to electrically bond numerous flight control and fuel control system components to an airplane structure.) Ground straps would also provide redundancy in case the method used to physically isolate electrical and oxygen system components experiences a fault or if the design requirements for the isolation of oxygen system components become compromised after in-service modifications and maintenance.

No electrical ground straps were found in the cockpit and the supernumerary compartment oxygen system installations and near the oxygen supply bottles (below the cockpit) on the ABX Air 767 airplanes that were examined. (It is important to note that the cockpit was an original airplane installation and was not part of the airplane’s modification to a cargo configuration.) If ground straps had been installed on the accident airplane, the short circuit that energized the supernumerary oxygen hose internal spring might have been directed away from the spring. Because undesirable potential electrical ground paths exist with the current grounding method for the 767 oxygen system components, electrical ground straps or another method of electrical grounding would help protect system components. Other Boeing airplane models and other manufacturers’ airplanes may have similar undesirable potential electrical ground paths because the design of their oxygen system is similar to that of the Boeing 767 oxygen system.

The NTSB concludes that an effective method of electrically grounding the supplemental oxygen system to the airframe would help ensure that oxygen system components are protected from short circuits. Therefore, the NTSB recommends that the FAA develop minimum electrical grounding requirements for oxygen system components and include these requirements as part of

¹⁴ Convoluted hoses have ridges or folds (similar to a vacuum cleaner hose).

the certification process for new airplanes and approved supplemental type certificate modifications to existing airplanes. The NTSB further recommends that, once electrical grounding requirements for oxygen system components are developed, as requested in Safety Recommendation A-09-48, the FAA require airplane operators and modifiers to inspect their airplanes for compliance with these criteria and modify those airplanes not in compliance accordingly.

Aging Oxygen Hoses

The investigation of this accident determined that no life limits were established for supplemental oxygen system hoses and that some hoses had been in service for more than 40 years. The hoses on the accident airplane were consumed by the fire, so no evidence was available to show whether an aging hose contributed to the fire. Examination of supplemental oxygen system hoses on other ABX Air 767 airplanes found that older hoses were stiffer than newer ones. It is likely that the older and stiffer hoses would be more prone to cracking than the newer and more flexible hoses. Also, cracked hoses can lead to oxygen leaks.

Because the hoses are common to several airplane manufacturer models, it is possible for an operator to remove an aging hose from an older in-service airplane and install the hose on a newer airplane, including one that has been newly delivered. However, oxygen system hoses are inspected only as part of general maintenance inspections; there are no detailed hose inspections or tests for plastic parts that have been in service for long periods. Oxygen hose inspections are also important because the PVC hose material can be degraded over time by pressure, temperature, light, and some chemicals used in normal airplane maintenance and operations (including cleaning agents, hydraulic fluid, oils, and greases).

The NTSB concludes that, because aging PVC flexible hoses are more likely than newer hoses to be cracked or otherwise degraded, aging hoses are more likely to leak oxygen, which, along with an ignition source, could result in a fire. As a result, the NTSB recommends that the FAA develop inspection criteria or service life limits for flexible oxygen hoses to ensure that they meet current certification and design standards. The NTSB further recommends that, once inspection criteria or service life limits for flexible oxygen hoses have been developed, as requested in Safety Recommendation A-09-50, the FAA require airplane operators to replace those hoses that do not meet the inspection criteria or that exceed the service life limits.

Potential for Reading Lights to Become Ignition Source

Passenger service unit (PSU) assemblies were installed in the supernumerary compartment of ABX Air's 767 airplanes. The PSU assemblies included reading lights and their electrical push-button switches, which were typically installed near the supplemental oxygen system.¹⁵

During the investigation of this accident, ABX Air found that the sockets containing the reading lights could be rotated so that the grounded socket housings could touch the electrical

¹⁵ Many transport-category passenger airplanes have oxygen generators, so the electrical parts of the PSU assembly are not installed near a source of gaseous oxygen.

contacts for the switches. To prevent such contact from occurring, the manufacturer of the lights provided rubber boots for the switch assembly and the lighting socket assembly. These boots isolated the electrical parts of the light assembly. However, many of the rubber boots were missing from the ABX Air 767 airplanes that were examined as part of this investigation. The rubber boots are reportedly difficult to install, so it is possible that the boots were not put on the assemblies during the cargo conversion or that the boots were taken off but not properly put back on the assemblies during maintenance.

A PSU reading light without rubber boot protection has the potential to short circuit, causing sparks. In fact, during this investigation, ABX Air personnel demonstrated that visible sparks could be produced when the electrical components of the light assembly contacted each other.¹⁶ Such a spark could ignite a combustible material, such as lint accumulations or, with minor oxygen leakage, the PVC material of a supplemental oxygen system hose.

The PSU reading lights can be eliminated as a possible cause for the fire aboard the accident airplane for two reasons. First, the first officer had turned off the PSU lights, thus eliminating a potential ignition source. Second, the flight crew heard a loud popping noise before discovering the fire, and the NTSB's oxygen hose tests showed that an external ignition source, which would include a spark from a PSU light, did not produce a popping sound once the hose was ignited, as did the internal ignition source.¹⁷ However, any spark in the enclosure above the supernumerary occupant seats, whether the result of an internal or external ignition source, could be generated in an oxygen-rich environment if a concurrent oxygen leak existed, creating a safety hazard.

Both IAI and ABX Air took action to correct the lack of rubber boots for the PSU reading lights. The companies' efforts focused initially on inspections to ensure that the boots were in place. However, in February 2009, IAI issued SB 368-25-025 to allow operators the option of using common heat-shrinkable tubing to cover the electrical contacts.

Although the PSU reading light assemblies on the ABX Air airplanes had a specific part number from the PSU manufacturer, the light assemblies were similar to those that are found in the passenger cabin of some transport-category airplanes or the supernumerary compartment of other cargo airplanes. The NTSB concludes that PSU reading lights with exposed electrical contacts have the potential to move to positions that create inadvertent short circuits and produce sparks near combustible materials. Therefore, the NTSB recommends that the FAA require transport-category airplane operators to (1) perform a one-time inspection of all PSU reading lights installed on their airplanes to ensure that they include rubber boots or use other means to isolate the electrical parts of the assembly and (2) include, in maintenance manuals or other maintenance documentation, information about the importance of this electrical protection.

¹⁶ In other installations, it is also possible for the lights to be rotated until their electrical components contact grounded structure.

¹⁷ Each hose ignition that resulted from heating the internal spring was preceded by a loud pop sound (similar to that of a firecracker), and the sustained burning of the pressurized flexible hose was accompanied by a loud hissing sound. For each hose ignition that resulted from an external heat source, the oxygen hose did not ignite with a loud pop sound, but a loud hissing sound was heard.

Smoke Detection System

No smoke detection system was present in, or required for, the supernumerary compartment. Given that the flight crew was alerted to the fire by the loud pop and hissing sounds, the rate at which the fire developed, and the intensity of the fire, a smoke detector would not have helped prevent the fire damage that occurred during this accident. However, in other situations, a smoke detector could alert flight crewmembers of a fire and allow them to address it while the fire was still at a stage at which it could be suppressed. For example, smoke detectors would alert a flight crew to a smoldering fire, which would produce smoke for a prolonged period of time before generating flames. This type of fire could originate in electrical devices, such as a coffee maker, within the supernumerary compartment.

Passenger cabins are regularly occupied areas that do not have smoke detectors. As such, flight crewmembers of these transport-category airplanes rely on the passengers and flight attendants to report any smoke in the cabin. For transport-category cargo airplanes, smoke detectors were required in the lavatory and the cargo compartments.¹⁸ However, because the supernumerary compartment is not a regularly occupied area, a smoke detector in the compartment would provide additional safety for cargo operations.

Even though a smoke detector was required for the lavatory, the door to the lavatory is usually closed. As a result, the detection of smoke emanating from elsewhere in the supernumerary compartment would be delayed, especially if no one were occupying the supernumerary seats (as was the case with this accident). The NTSB recognizes the possibility for a smoke detector to produce a false alarm. However, if this situation were to occur and the supernumerary compartment were unoccupied, the false alarm could easily be detected by the nonflying pilot.

In its report on the Swissair flight 111 accident, the TSB concluded that the fire started above the ceiling on the right side of the cockpit near the cockpit rear wall and that the fire “spread and intensified rapidly to the extent that it degraded aircraft systems and the cockpit environment, and ultimately led to the loss of control of the aircraft.” The report also concluded, in part, that no built-in smoke detection devices were in the area where the fire started and that the lack of such devices delayed the identification of the existence of the fire. However, unlike the Swissair pilots, who could not access the location where the fire initiated, pilots of cargo airplanes can access the supernumerary compartment; as a result, they could detect and extinguish a smoldering-type fire if they were provided with a warning of the fire’s existence.

After the accident, ABX Air initiated efforts to install a smoke detector in the supernumerary compartment of its airplanes. (The project is still ongoing.) The NTSB concludes that installing smoke detectors in supernumerary compartments would help flight crews identify the existence of a fire in an accessible, possibly unoccupied space and initiate suppression of the fire before it could propagate and become uncontrollable. Some cargo airplanes have an area between the cockpit and the main deck cargo compartment that is similar to the one in the accident airplane but is not specifically referred to as a supernumerary compartment by the

¹⁸ See 14 CFR 25.854, “Lavatory Fire Protection,” and 14 CFR 25.858, “Cargo or Baggage Compartment Smoke or Fire Detection Systems.”

operator. Therefore, the NTSB recommends that the FAA require operators of transport-category cargo airplanes to install smoke detectors in the supernumerary or similar compartment of their airplanes.

Emergency Response

The first aircraft rescue and firefighting (ARFF) vehicle to arrive on scene was Rescue 49, which had a high-reach extendable turret (HRET) with a skin-penetrating nozzle (SPN). The HRET/SPN was visually positioned by the driver using controls in the cab of the vehicle.

The driver of Rescue 49 reported that he tried to insert the SPN through the right cockpit window but that the extinguishing agent had sprayed outside, rather than inside, the airplane. The driver also reported that he was unaware of this situation until other firefighters told him. Once Rescue 49 was repositioned near the L1 entry door, the driver used the SPN to apply extinguishing agent onto the fire through the burn-through areas above the supernumerary compartment.

In its report on the February 7, 2006, United Parcel Service flight 1307 accident in Philadelphia, Pennsylvania, the NTSB stated that ARFF personnel who used the HRET/SPN during the emergency response experienced problems penetrating the fuselage with the device and had to reposition the tip of the SPN a few times before successfully piercing the airplane's fuselage.¹⁹ The NTSB also stated that the FAA and the International Fire Service Training Association²⁰ had acknowledged the importance of HRET/SPN training but that the FAA's AC 150/5210-17A, "Programs for Training of Aircraft Rescue and Firefighting Personnel," did not specifically address this training. The NTSB concluded that some ARFF personnel were not adequately trained on the use of this device, which reduced its effectiveness in fighting interior aircraft fires.²¹ As a result, on December 17, 2007, the NTSB issued Safety Recommendation A-07-100, which asked the FAA to do the following:

Provide guidance to aircraft rescue and firefighting personnel on the best training methods to obtain and maintain proficiency with the high-reach extendable turret with skin-penetrating nozzle.

On September 8, 2008, the FAA stated that, in July 2008, it had issued a CertAlert to all airport certification and safety inspectors and operators of Part 139 airports. According to the FAA, the CertAlert highlighted the availability of airport improvement program funding for

¹⁹ The NTSB's investigation found that ARFF personnel responding to a runway overrun accident in Teterboro, New Jersey, experienced similar problems. For more information, see National Transportation Safety Board, *Runway Overrun and Collision, Platinum Jet Management, LLC, Bombardier Challenger CL-600-1A11, N370V, Teterboro, New Jersey, February 2, 2005*, Aircraft Accident Report NTSB/AAR-06/04 (Washington, DC: NTSB, 2006).

²⁰ According to its website, this association identifies needed training materials for the fire service and related areas and fosters the development and validation of such training materials.

²¹ National Transportation Safety Board, *Inflight Cargo Fire, United Parcel Service Company Flight 1307, McDonnell Douglas DC-8-71F, N748UP, Philadelphia, Pennsylvania, February 7, 2006*, Aircraft Accident Report NTSB/AAR-07/07 (Washington, DC: NTSB, 2007).

training aids that would allow ARFF personnel to practice piercing an aircraft structure with an HRET/SPN. The FAA also stated that it would revise AC 150/5210-17A to highlight the importance of this training for ARFF personnel. The FAA expected to complete the revision by September 30, 2008. On February 4, 2009, the NTSB classified this recommendation “Open—Acceptable Response” pending the issuance of the revised AC.

The intent of Safety Recommendation A-07-100 was for the FAA to determine the best methods for ARFF personnel to train and maintain proficiency with the HRET/SPN. The FAA’s response to this recommendation indicated that the best method would be training that allowed ARFF personnel to use the SPN to pierce an airplane structure. However, in March 2009, the FAA indicated that the AC recommending this training might be issued in August 2009, which is almost 1 year later than initially planned.

The driver of Rescue 49 stated that he received familiarization training on the use of the HRET/SPN when the vehicle was delivered to SFO (about 14 years before the accident occurred). He stated that he practiced using the SPN on cars and vans, indicating that the SPN required “lots of practice.” Although the driver of Rescue 49 had an initial problem using the SPN, he was then able to successfully use the device to penetrate the fuselage skin near the burn-through area and extinguish the fire. However, it is important for firefighters to receive training that will enable them to quickly and successfully use the SPN in an emergency response. The NTSB concludes the type of training that the driver of Rescue 49 received on the operation of the HRET/SPN was not sufficient to allow him to successfully insert extinguishing agent into the cockpit on his initial attempts. The NTSB further concludes that ARFF personnel who are not sufficiently trained on the HRET/SPN may not be able to use the device effectively when fighting aircraft fires. Therefore, the NTSB reiterates Safety Recommendation A-07-100.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Require operators to replace electrically conductive combustible oxygen hoses with electrically nonconductive hoses so that the internal hose spring cannot be energized. (A-09-43)

Prohibit the use of electrically conductive combustible oxygen hoses unless the conductivity of the hose is an intentional and approved parameter in the design. (A-09-44)

Formalize the airworthiness directive process so that, when an aircraft manufacturer or other source identifies an airworthiness issue with an appliance, coordination with the appliance manufacturer occurs to ensure that the possible safety risks to all products using the appliance are evaluated and addressed. (A-09-45)

Require airplane manufacturers and modifiers to provide positive separation between electrical wiring and oxygen system tubing according to, at a minimum, the guidance in Advisory Circular (AC) 43.13-1A, “Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair,” and AC 65-15, “Airframe and Powerplant Mechanics Airframe Handbook.” (A-09-46)

Require airplane manufacturers and operators to ensure that oxygen system tubing in proximity to electrical wiring is made of, sleeved with, or coated with nonconductive material or that the tubing is otherwise physically isolated from potential electrical sources. (A-09-47)

Develop minimum electrical grounding requirements for oxygen system components and include these requirements as part of the certification process for new airplanes and approved supplemental type certificate modifications to existing airplanes. (A-09-48)

Once electrical grounding requirements for oxygen system components are developed, as requested in Safety Recommendation A-09-48, require airplane operators and modifiers to inspect their airplanes for compliance with these criteria and modify those airplanes not in compliance accordingly. (A-09-49)

Develop inspection criteria or service life limits for flexible oxygen hoses to ensure that they meet current certification and design standards. (A-09-50)

Once inspection criteria or service life limits for flexible oxygen hoses have been developed, as requested in Safety Recommendation A-09-50, require airplane operators to replace those hoses that do not meet the inspection criteria or that exceed the service life limits. (A-09-51)

Require transport-category airplane operators to (1) perform a one-time inspection of all passenger service unit reading lights installed on their airplanes to ensure that they include rubber boots or use other means to isolate the electrical parts of the assembly and (2) include, in maintenance manuals or other maintenance documentation, information about the importance of this electrical protection. (A-09-52)

Require operators of transport-category cargo airplanes to install smoke detectors in the supernumerary or similar compartment of their airplanes. (A-09-53)

Also, the National Transportation Safety Board reiterates the following recommendation to the Federal Aviation Administration:

Provide guidance to aircraft rescue and firefighting personnel on the best training methods to obtain and maintain proficiency with the high-reach extendable turret with skin-penetrating nozzle. (A-07-100)

In response to the recommendations in this letter, please refer to Safety Recommendations A-09-43 through -53 and Safety Recommendation A-07-100. If you would like to submit your response electronically rather than in hard copy, you may send it to the following e-mail address: correspondence@ntsb.gov. If your response includes attachments that exceed 5 megabytes, please e-mail us asking for instructions on how to use our Tumbleweed secure mailbox procedures. To avoid confusion, please use only one method of submission (that is, do not submit both an electronic copy and a hard copy of the same response letter).

Acting Chairman ROSENKER and Members HERSMAN, HIGGINS, and SUMWALT concurred with these recommendations.

[Original Signed]

By: Mark V. Rosenker
Acting Chairman