National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: September 19, 2000

In reply refer to: A-00-105 through -108

Honorable Jane F. Garvey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On July 17, 1996, about 2031 eastern daylight time, Trans World Airlines, Inc. (TWA) flight 800, a Boeing 747-131, N93119, crashed into the Atlantic Ocean near East Moriches, New York. TWA flight 800 was operating under the provisions of 14 *Code of Federal Regulations* (CFR) Part 121 as a scheduled international passenger flight from John F. Kennedy International Airport (JFK), New York, New York, to Charles DeGaulle International Airport, Paris, France. The flight departed JFK about 2019, with 2 pilots, 2 flight engineers, 14 flight attendants, and 212 passengers on board. All 230 people on board were killed, and the airplane was destroyed. Visual meteorological conditions prevailed for the flight, which operated on an instrument flight rules flight plan.[1]

The National Transportation Safety Board determined that the probable cause of this accident was an explosion of the center wing fuel tank (CWT) resulting from ignition of the flammable fuel/air mixture in the tank. The source of ignition energy for the explosion could not be determined with certainty, but, of the sources evaluated by the investigation, the most likely was a short circuit outside of the CWT that allowed excessive voltage to enter it through electrical wiring associated with the fuel quantity indication system (FQIS). Contributing factors to the accident were the design and certification concept that fuel tank explosions could be prevented solely by precluding all ignition sources, and the design and certification of the Boeing 747 with heat sources located beneath the CWT with no means to reduce the heat transferred into the CWT or to render the fuel vapors in the tank nonflammable.[2]

[1] For more detailed information, see National Transportation Safety Board. 2000. *In-flight Breakup Over the Atlantic Ocean, Trans World Airlines (TWA) Flight 800, Boeing 747-131, N93119, Near East Moriches, New York, July 17, 1996*. Aircraft Accident Report NTSB/AAR-00/03. Washington, DC.

[2] Additional safety recommendations resulting from this accident investigation were addressed to the Federal Aviation Administration (FAA) in safety recommendation letters dated December 13, 1996 (Safety Recommendations A-96-174 through -177), February 18, 1997 (Safety Recommendation A-97-11), and April 7, 1998 (Safety Recommendations A-98-34 through -39).

Electrical bonding of components inside fuel tanks

In an attempt to determine what ignited the flammable vapors in the CWT, Safety Board investigators evaluated numerous potential ignition sources,[3] including static electricity. Investigators theorized that electrically isolated parts in the CWT[4] could become so highly charged from static electricity (generated by fuel striking the part or from fuel moving through the fuel lines) that a discharge between such a part and a nearby grounded fuel tank component could create a spark of sufficient energy to ignite the fuel/air vapor in the tank. The Board contracted with the U.S. Air Force (USAF) Research Laboratory (AFRL) at the Wright Patterson Air Force Base and with the Naval Research Laboratory to conduct tests to assess the electrostatic charging capabilities of several electrically isolated components commonly found in aircraft fuel systems. This testing revealed that unbonded Teflon-cushioned wire clamps (found in the 747 CWT and inboard main fuel tanks) were particularly susceptible to electrostatic charging. However, the highest voltage potential attained in testing that used fuel similar to that used on the accident flight was 650 volts, which it was estimated would produce a discharge energy of only about 0.0095 millijoule (mJ).[5] Even assuming the clamp could attain a voltage of 1,150 volts (which was produced in tests using fuel of a higher conductivity than the fuel in the CWT on TWA flight 800), the highest discharge energy that voltage could produce was estimated to be about 0.030 mJ, which is still well below the 0.25 mJ minimum ignition energy for Jet A fuel vapor. Therefore, on the basis of the evidence from the TWA flight 800 investigation and research and testing to date, it is very unlikely that static electricity ignited the fuel/air vapor in the CWT. Nonetheless, the Board recognizes that the discharge of static electricity has resulted in prior fuel tank explosions[6] and cannot rule out the possibility that, under some conditions, static electricity could produce sufficient energy to ignite the flammable vapor in a fuel tank.

[3] Other potential ignition sources that were considered and deemed to be very unlikely were: a lightning or meteorite strike; a missile fragment; a small explosive charge placed on the CWT; auto ignition or hot surface ignition, resulting from elevated temperatures produced by sources external to the CWT; a fire migrating to the CWT from another fuel tank via the vent (stringer) system; an uncontained engine failure or a turbine burst in the air conditioning packs beneath the CWT; a malfunctioning CWT jettison/override pump; and a malfunctioning CWT scavenge pump. The Safety Board also concluded that the ignition energy was not the result of electromagnetic interference (EMI) from radio frequency sources external to TWA flight 800 or of EMI from personal electronic devices.

[4] Certification standards only require that "major components" of the powerplant installation be electrically bonded to the other parts of the airplane. See 14 CFR 25.901(b)(4). According to a June 2, 2000, letter to the Safety Board, Boeing design practices permit parts that are less than 3 inches long in any direction (including some types of clamps and connectors installed in fuel tanks) to be electrically unbonded, presumably because such parts are not believed to have enough capacitance to retain hazardous levels of static electricity under expected operating conditions.

[5] A volt is the basic unit of measurement of electromagnetic force (the force that causes electrons to flow through a conductor). A mJ is a unit of measurement equaling one-thousandth of a joule (J), which is a measurement of electrical work or energy. Power (watts or J/seconds) is related to voltage through V^2/R, or the square of the voltage divided by the resistance, measured in ohms.

[6] The July 23, 1998, report of the Aviation Rulemaking Advisory Committee Fuel Tank Harmonization Working Group and American Petroleum Institute Recommended Practice 2003, "Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents," fifth edition, December 1991, cite several previous fuel tank explosions believed to have been caused by static electricity.

The findings from this investigation raised concerns regarding the adequacy of bonding protection against high-energy discharges, such as from lightning (or perhaps from refueling). The Safety Board is concerned about the Boeing design practice that permits parts that are less than 3 inches long in any direction (including some types of clamps and connectors installed in fuel tanks) to be electrically unbonded. Tests conducted by Boeing after two fuel tank explosions in 1970 found that a single unbonded clamp could store up to 5 mJ of energy during the increased fuel flow rates associated with ground refueling.[7] Further, according to the Federal Aviation Administration's (FAA) *Aircraft Lightning Protection Handbook*, unbonded clamps could present an ignition hazard in the event of a lightning strike. The Safety Board concludes that Boeing's design practice that permits parts less than 3 inches long in any direction to be electrically unbonded may not provide adequate protection against potential ignition hazards created by static electricity generated by lightning or other high-energy discharges. Because the Board is concerned that other manufacturers' design practices may not be adequate, the Safety Board believes that the FAA should examine manufacturers' design practices with regard to bonding of components inside fuel tanks and require changes in those practices, as necessary, to eliminate potential ignition hazards.

Separation of wires

In connection with its investigation into possible short circuit energy transfer mechanisms on TWA flight 800, the Safety Board evaluated the adequacy of existing circuit protection systems to determine whether they could provide adequate protection to FQIS wiring circuits by preventing short circuits to those wires from resulting in potential fuel tank ignition hazards. Among the methods evaluated was shielding and/or physical separation of wires.[8]

As discussed in the Safety Board's April 7, 1998, safety recommendation letter to the FAA, shielding and physical separation of FQIS wires from other wires can be an effective means of preventing the transfer of potentially hazardous levels of energy to FQIS wires from higher-voltage wiring. In that letter, the Board issued Safety Recommendation A-98-38, which asked the FAA to

> Require in Boeing 747 airplanes, and in other airplanes with FQIS wire installations that are corouted with wires that may be powered, the physical separation and electrical shielding of FQIS wires to the maximum extent possible.

In response to this recommendation, the FAA initiated two notices of proposed rulemaking (NPRM) that subsequently led to the issuance of airworthiness directives (AD) to require shielding and separation of FQIS wiring on 747 and 737 airplanes.[9] Regarding other

[7] These test results were reported to the FAA during a March 11, 1971, meeting regarding electrostatics during refueling and were summarized in a March 16, 1971, FAA memorandum that documented the results of that meeting.

[8] The other methods evaluated included circuit breakers (both the standard, thermally activated type and the recently developed processor-based arc-fault circuit breakers); electrical resistors; and transient suppression devices (TSD), such as surge protection systems.

[9] The NPRMs proposed the installation of TSDs as an optional or additional requirement. Although the final ADs did not include TSDs as an alternative, the FAA indicated in correspondence related to Safety Recommendation A-98-39 that it will nonetheless permit TSDs as an alternate means of compliance.

airplane types, the FAA indicated that advisory material being developed in connection with the fuel tank design reviews proposed in NPRM 99-18, "Transport Airplane Fuel Tank System Design Review, Flammability Reduction, and Maintenance and Inspection Requirements,"[10] would include information "describing the use of wire separation and electrical shielding to protect FQIS wiring from short circuits…and other failures and malfunctions that could induce high electrical energy on FQIS wires that enter fuel tanks." In its February 9, 1999, response letter, the Safety Board expressed concern about the adequacy of Boeing's wire separation standard (discussed further below) and stated that, pending receipt of further details regarding this separation standard and planned activities for other airplane models, Safety Recommendation A-98-38 was classified "Open—Acceptable Response."

Although airplane manufacturers generally provide protection for certain critical electrical circuits, there is no FAA regulation that specifies wire separation criteria or identifies which circuits must be protected. In their evaluation of the adequacy of the wire separation that would be required by the two ADs, Safety Board investigators reviewed the general wire separation standards and practices of several airplane manufacturers and found that these standards are not uniform. For example, Douglas Aircraft Company specified that wiring for certain systems (including FQIS and other fuel system wiring, fire warning system wiring, primary generator feeder cables, and electro-explosive devices) must be separated by at least 3 inches from other electrical wiring. In contrast, Boeing specifications do not require protection for some of the systems specified by Douglas (such as the FQIS), and, for those systems that are designated as protected, the required separation distance is only 1/4 inch in pressurized areas and 1/2 inch in unpressurized areas.

The potential for short circuits to damage nearby wiring (more than 1 1/2 inches away) has been documented in Safety Board investigations of numerous accidents and incidents.[11] The Safety Board concludes that existing standards for wire separation may not provide adequate protection against damage from short circuits. Therefore, the Safety Board believes that the FAA should review the design specifications for aircraft wiring systems of all U.S.-certified aircraft and (1) identify which systems are critical to safety and (2) require revisions, as necessary, to ensure that adequate separation is provided for the wiring related to those critical systems.

[10] This NPRM proposed a Special Federal Aviation Regulation (SFAR) that would require transport airplane type certificate (TC) holders for transport airplanes and holders of supplemental type certificates (STC) that affect the transport airplane's fuel system to conduct a safety review of the fuel tank system that is designed to show that fuel tank fires or explosions will not occur. If the design does not meet the specified requirements, the SFAR would require the TC or STC holder to develop the necessary corrective design changes. The SFAR would also require TC and STC holders to develop all maintenance and inspection instructions necessary to maintain the design features required to preclude the existence or development of an ignition source within the fuel tank system. (The NPRM proposed to add a new subsection [c] to 14 CFR Section 25.981, which would require that fuel tank installations in newly designed airplanes include a means to minimize the development of flammable vapors in fuel tanks, or to mitigate the effects of an ignition of fuel vapors within fuel tanks, such that no damage caused by an ignition will prevent continued safe flight and landing.) For more information, see 64 *Federal Register* 586644 (October 29, 1999).

[11] For example, during postincident inspection of a shorted wire bundle after a January 9, 1998, incident aboard a United Airlines 767 en route from Zurich, Switzerland, to Washington Dulles International Airport in which the flight crew made a precautionary landing at London Heathrow International Airport after experiencing multiple display errors and tripped circuit breakers, power was inadvertently reapplied and arcing resumed, but it did not trip any additional circuit breakers. However, this event damaged dozens of wires, some more than 1 1/2 inches away, and also burned printed circuit tracks from cards located in another section of the electronics compartment.

Silver-sulfide deposits in fuel tanks

Research and testing conducted during this investigation found that silver-coated copper parts inside fuel tanks, such as those used in the FQIS, can develop silver-sulfide deposits[12] that are semiconductive and, therefore, can reduce the resistance between electrical connections and permit arcing. Such deposits can become a potential ignition mechanism inside a fuel tank.[13]

Silver-sulfide deposits were found on FQIS probes, compensators, and wiring from the accident airplane. Similar deposits have been discovered on FQIS parts from other airplanes, both military and civilian (including other 747s). Research by the Safety Board, the FAA, and the AFRL has found that deposits accumulate over time as a result of the part's exposure to jet fuel and fuel vapors, which contain sulfur. (It should be noted that the FQIS design for the 747 classic includes exposed conductors at terminal blocks.) In addition, laboratory research by the University of Dayton Research Institute conducted as a result of this investigation found that increased temperatures enhanced the formation of silver-sulfide deposits and that fuel washing could slow the accumulation of these deposits. This finding is significant with regard to CWTs because they are less frequently filled with fuel to the top than wing tanks, and, therefore, the terminal block at the top of the CWT fuel probes is less often covered by fuel (which would subject it to fuel washing) than would be the case in a wing tank.[14]

The AFRL concluded that the accumulation of silver-sulfide deposits "is most likely the result of a long-term degradation or corrosion process…[and that] as the probes age, more probe failures [calibration errors] can be expected." However, the problem is not solely limited to older airplanes; silver-sulfide deposits that were significant enough to cause FQIS anomalies[15] were found in a 757 airplane with only 750 hours.

The existence of silver-sulfide deposits on FQIS components from both the accident airplane and numerous other airplanes raises the possibility that sulfide deposits could have provided an energy release mechanism at the point of ignition in the CWT. The accident airplane's recent maintenance history, which indicates FQIS anomalies, is consistent with silver-sulfide deposits interfering with FQIS operation. Accordingly, sulfide deposits were considered as a possible ignition mechanism for the TWA flight 800 CWT explosion.[16]

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[12] These deposits are sometimes also referred to as copper-sulfide deposits, sulfides, or sulfidation.

[13] Ignition of vapors in an AFRL trainer fuel probe in 1990 during electrical bench tests (when test voltages higher than normal fuel system voltages were applied) was attributed by the AFRL to sulfide deposits. Subsequent AFRL testing for the Safety Board indicated that the deposits could break down and result in arcing when exposed to a 170-volt pulse. Also, during the investigation of the TWA flight 800 accident, the Board became aware that in 1988, Boeing found evidence of silver-sulfide deposits at the location of arcing in 18 fuel pump motors. In addition, during FAA-sponsored testing at Arizona State University in connection with this investigation, application of direct current voltage to silver-sulfide deposits created in a laboratory ignited Jet A fuel vapors.

[14] Only two of the many FQIS components from other airplanes examined during this investigation that contained silver-sulfide deposits had been removed from the airplane because of FQIS anomalies; both were terminal strips from the top of 747 CWTs.

[15] Research by BFGoodrich, an FQIS manufacturer, conducted after the AFRL vapor ignition incident in 1990 found that silver-sulfide deposits could permit leakage of electrical currents and, therefore, cause FQIS anomalies.

[16] Although silver-sulfide deposits were considered as a possible ignition mechanism, the probable energy release mechanism inside the CWT could not be determined from the available evidence.

In response to AFRL's findings from the 1990 vapor ignition incident, BFGoodrich eliminated the use of silver-plated components in the FQIS and began using nickel-plated wire, gold-plated ring connectors, and sealant. Those improved components have been used in military airplanes since about 1993. According to BFGoodrich, since that time, there has been a large reduction in the FQIS anomalies that had been associated with silver-sulfide deposits (such as FQIS inaccuracies). Although a Boeing 1991 engineering report indicated that silver should never contact sulfur-containing liquids because of the susceptibility to sulfidation, and Boeing uses nickel-plated (instead of silver-plated) wiring in its newly manufactured 777 and 737-NG airplanes, Boeing indicated in a December 7, 1999, letter to the Safety Board that it does not recommend replacing silver-plated FQIS components in existing airplanes.

In an April 7, 1998, letter to the FAA, the Safety Board expressed concern that sulfide deposits on FQIS wires could become an ignition source in fuel tanks and issued Safety Recommendation A-98-37, which asked the FAA to

> Require research into sulfide deposits on FQIS parts in fuel tanks to determine the levels of deposits that may be hazardous, how to inspect and clean the deposits, and when to replace the components.

In response to this recommendation, the FAA convened a team of specialists from Government, academia, and industry to conduct research. According to the FAA's May 17, 2000, response to the Safety Board, the team has studied the properties of sulfide deposits created in a laboratory environment but has not found indications of significant levels of deposits occurring in in-service airplanes for comparison. The FAA indicated that the research program had been extended from its original 12-month timeframe so that the team could complete its evaluation.

The FAA indicated in NPRM 99-18 that it anticipates that the proposed fuel tank safety review will identify critical areas of the fuel tank system that will require maintenance actions to account for the effects of aging, wear, corrosion, and possible contamination of the fuel system. Specifically, the FAA noted that it might be necessary to provide maintenance instructions to identify and eliminate silver-sulfide deposits.[17]

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[17] In NPRM 98-NM-163-AD, issued July 24, 1998, the FAA proposed that silver-plated copper FQIS wiring in 747 CWTs be replaced with nickel-plated copper FQIS wiring within 20 years of the airplane's manufacture. Although the FAA acknowledged that there was little technical basis for this time limit, and the proposed replacement requirement was not included in the final rule (AD 98-08-02), the Safety Board is concerned that this proposal indicates a belief on the part of the FAA that silver-sulfide deposits do not pose a significant risk for airplanes less than 20 years old. As previously discussed, potentially hazardous deposits can accumulate in younger airplanes as well as on older airplanes, and such deposits can pose a significant risk.

The Safety Board concludes that silver-sulfide deposits on FQIS components inside fuel tanks pose a risk for ignition of flammable fuel/air vapor. Although precluding operations with flammable fuel/air vapor (as the Board recommended in Safety Recommendation A-96-174)[18] would eliminate this risk, flammable fuel/air vapors will not likely be eliminated in all fuel tanks or during all phases of flight. Therefore, although the Board is pleased that the FAA is continuing to support research into sulfide deposits, the Safety Board believes that the FAA should require the development and implementation of corrective actions to eliminate the ignition risk posed by silver-sulfide deposits on FQIS components inside fuel tanks. (In its final report on this accident, the Safety Board classified Safety Recommendation A-98-37 "Closed—Acceptable Action—Superseded.")

Aging non-structural systems

Several potentially unsafe conditions were found in and near the electrical wiring from the accident airplane, including cracked wire insulation, metal shavings adhered to a floor beam along which FQIS wires would have been routed,[19] other debris, and sulfide deposits. In addition, evidence of several repairs that did not comply with the guidelines in Boeing's Standard Wiring Practices Manual (SWPM) were found on the accident airplane. Noncompliant repairs included the use of an oversized strain relief clamp on the terminal block of the No. 1 fuel tank compensator, which did not adequately secure the wires; numerous open-ended (rather than sealed) wire splices, which exposed conductors to possible water contamination; several wire bundles containing numerous wire splices on adjacent wires at the same location; and excessive solder on the connector pins inside the fuel totalizer gauge, which had connected the pins/wires from the right wing main fuel tank and the CWT FQIS.

Although some of these conditions may suggest the need for improved maintenance, the Safety Board found that deterioration, damage, and contamination of aircraft wiring and related components, and noncompliant repairs, such as those found on the accident airplane, were common in the airline transport airplanes of numerous operators (especially in the older airplanes) inspected in connection with this accident investigation.[20] Therefore, the Safety Board concludes that the condition of the wiring system in the accident airplane was not atypical for an airplane of its age and that it was maintained in accordance with prevailing industry practices.

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[18] In Safety Recommendation A-96-174, the Safety Board recommended that the FAA require the development and implementation of design and operational changes that would preclude the operation of transport-category airplanes with explosive fuel/air mixtures in the fuel tanks. The recommendation further stated that significant consideration should be given to the development of airplane design modifications, such as nitrogen-inerting systems and the addition of insulation between heat-generating equipment and fuel tanks, and that appropriate modifications should apply to newly certificated airplanes and, where feasible, to existing airplanes. The FAA's actions in response to this recommendation are discussed in the Board's final report on this accident.

[19] The presence of metal shavings is consistent with maintenance records that described compressed air being used to blow metal shavings off avionics units.

[20] The widespread existence of such conditions was also corroborated by Boeing's Service Letter (SL) 747-SL-20-048 (dated January 25, 1995), which detailed similar conditions found in numerous 747s. In that SL, Boeing also stated that it "believe[d] that the wiring on high time 747 airplanes is holding up exceptionally well" and noted that "[w]iring damage is hard to predict but some areas of wiring experience degradation more frequently."

Nonetheless, the Safety Board was concerned about the damage and contamination found on electrical wiring and components during its examinations of transport airplanes, including the accident airplane. These conditions were especially disturbing because it was apparent from those examinations that a large portion of aircraft wiring is difficult, if not impossible, to inspect and/or test because of its inaccessibility (as a result of being confined in wire bundles or blocked by other obstructions). Moreover, the general nature of current visual wiring inspection criteria is such that wire damage or other potentially unsafe conditions may not be detected even on visible and accessible portions of aircraft wiring. The Safety Board concludes that, until recently, insufficient attention has been paid to the condition of aircraft electrical wiring, resulting in potential safety hazards.

However, this accident investigation has resulted in a heightened awareness of the importance of maintaining the integrity of aircraft wiring, and the FAA has now recognized that current maintenance practices may not adequately or proactively address aging non-structural systems. In its July 1998 Aging Transport Non-Structural Systems Plan (which was developed after the FAA received the recommendation of the White House Commission on Aviation Safety and Security and had participated in Safety Board airplane inspections), the FAA described the results of its evaluation of five transport-category airplanes deemed representative of the "aging" fleet of transport airplanes. The FAA found conditions similar to those found by the Board during airplane inspections in connection with this investigation, including deterioration of wiring and related components; stiff and easily cracked wire; contamination of wire bundles with metal shavings, dust, and fluids; cracked insulation; corrosion on connector pins; and improper wire installation and repairs. The FAA also found, as had Board investigators, that wires contained in wire bundles could be difficult to inspect.

The FAA concluded that current maintenance practices do not adequately address wiring components, wire inspection criteria are too general, unacceptable conditions are not described in sufficient detail, repair instructions and data are difficult to extract from SWPMs, wire replacement criteria may not be adequate, and current incident/maintenance reporting procedures do not allow for easy identification of failures. The Safety Board concurs with these conclusions. The FAA's plan also detailed several tasks and associated subtasks aimed at correcting these problems, including improving wiring inspection criteria and providing more detailed descriptions of undesirable conditions; improving inspector training to ensure that it adequately addresses the recognition and repair of aging wiring components; and developing methods for nondestructive testing of wiring.[21]

To assist in addressing these problems, the FAA established the Aging Transport Systems Rulemaking Advisory Committee (ATSRAC), the activities of which the Safety Board has been following with great interest. The Board is encouraged that other Government agencies, including the Navy and USAF, have increased their research into aging aircraft systems and shared the resulting information and reports with the FAA and that the White House has formed a Wire Safety Research interagency working group. Although the FAA's research is scheduled to

[21] The Safety Board has participated in demonstration tests of automated test equipment in which faults were detected that could not be visually seen. Lectromechanical Design Company (with whom the Board contracted to conduct laboratory research into short circuiting of aircraft electrical wiring) documented similar results during inspections of five Navy P-3 airplanes, finding that visual inspections revealed only 25 to 39 percent of the defects found by electrical inspections.

continue into future fiscal years, the ATSRAC charter will expire in January 2001, unless it is extended. In light of the short time remaining for the completion of the ATSRAC's work, the Board is concerned that the ATSRAC's final report and recommendations may not fully and adequately address all of the issues identified in the Aging Transport Non-Structural Systems Plan.

The Safety Board supports the FAA's ongoing efforts to address the maintenance/aging issues identified by the Aging Transport Non-Structural Systems Plan and will continue to follow the activities of the ATSRAC and other Government and industry initiatives related to aircraft maintenance and aging problems. The Safety Board concludes that the issues defined in the FAA's Aging Transport Non-Structural Systems Plan are important safety issues that must be fully addressed through appropriate changes, including rulemaking. Therefore, the Safety Board believes that the FAA should, regardless of the scope of the ATSRAC's eventual recommendations, address (through rulemaking or other means) all of the issues identified in the Aging Transport Non-Structural Systems Plan, including the need for improved training of maintenance personnel to ensure adequate recognition and repair of potentially unsafe wiring conditions; the need for improved documentation and reporting of potentially unsafe electrical wiring conditions; and the need to incorporate the use of new technology, such as arc-fault circuit breakers and automated wire test equipment. To determine whether adequate progress is being made in these areas, the Safety Board believes that, within 90 days, the FAA should brief the Safety Board on the status of its efforts to address all of the issues identified in the Aging Transport Non-Structural Systems Plan.

Therefore, the National Transportation Safety Board makes the following recommendations to the Federal Aviation Administration:

> Examine manufacturers' design practices with regard to bonding of components inside fuel tanks and require changes in those practices, as necessary, to eliminate potential ignition hazards. (A-00-105)
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> Review the design specifications for aircraft wiring systems of all U.S.-certified aircraft and (1) identify which systems are critical to safety and (2) require revisions, as necessary, to ensure that adequate separation is provided for the wiring related to those critical systems. (A-00-106)
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> Require the development and implementation of corrective actions to eliminate the ignition risk posed by silver-sulfide deposits on fuel quantity indication system components inside fuel tanks. (A-00-107)
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> Regardless of the scope of the Aging Transport Systems Rulemaking Advisory Committee's eventual recommendations, address (through rulemaking or other means) all of the issues identified in the Aging Transport Non-Structural Systems Plan, including:
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> - the need for improved training of maintenance personnel to ensure adequate recognition and repair of potentially unsafe wiring conditions;

- the need for improved documentation and reporting of potentially unsafe electrical wiring conditions; and
- the need to incorporate the use of new technology, such as arc-fault circuit breakers and automated wire test equipment.

To determine whether adequate progress is being made in these areas, the Safety Board believes that, within 90 days, the Federal Aviation Administration should brief the Safety Board on the status of its efforts to address all of the issues identified in the Aging Transport Non-Structural Systems Plan. (A-00-108)

Chairman HALL and Members HAMMERSCHMIDT, BLACK, GOGLIA, AND CARMODY concurred in these recommendations.

Original Signed

By: Jim Hall
Chairman