NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

July 28, 1999

SYSTEMS GROUP CHAIRMAN FACTUAL REPORT ADDENDUM FOR AIRCRAFT WIRE INSPECTIONS AND HISTORICAL REPORTS

A. ACCIDENT: DCA96MA070

Location : East Moriches, New York

Date : July 17, 1996

Time : 2031 Eastern Daylight Time

Airplane : Boeing 747-131, N93119
Operated as Trans World Airlines (TWA) Flight 800

B. SYSTEMS SUB-GROUP

MAY 19-20, 1997

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JANUARY 31, 1999; MARCH 29, 1999

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C. SUMMARY

On July 17, 1996, at 2031 EDT, a Boeing 747-131, N93119, crashed into the Atlantic Ocean, about 8 miles south of East Moriches, New York, after taking off from John F. Kennedy International Airport (JFK). All 230 people aboard were killed. The airplane was being operated as a Code of Federal Regulations (CFR) Part 121 flight to Charles De Gaulle International Airport (CDG) at Paris, France, as Trans World Airlines (TWA) Flight 800. Wreckage from the airplane was recovered from more than nine square miles of ocean. Reconstruction of portions of the wreckage found evidence of an explosion in the center wing fuel tank (CWT).

Various Systems Group members examined wiring in a total of 18 transport category airplanes from May 19, 1997, through July 29, 1998, and Safety Board representatives took part in the examinations of more than 25 airplanes. The largest single group consisted of 16 airplanes at Pinal Airpark, near Marana, Arizona, that were inspected from February 21-25, 1998. Other airplanes were inspected at airports in Arizona, California, Missouri, Virginia, and London, England.

NOTE: Individual airplanes are identified by identification numbers that were assigned for this report. Operators, airplane registrations, and some airports have been deleted due to operator concerns regarding publicity about potential discrepancies that were found while assisting the investigation.

The group began by inspecting B-747 airplanes; then inspections of other types were accomplished as the airplanes became available. The airplanes were built by Boeing, Douglas,[1] and Airbus and flown by operators in America, the Middle East, and Asia. The Boeing group included 13 "Classic" B-747s,[2] an undelivered 747-400, 2 undelivered B-737s, a B-757, and a B-767. A DC-9 and a MD-90 were inspected and at the time they were 25-years-old and 8-months-old, respectively. One 22-year-old Airbus A300B4 was examined. The ages of the airplanes

[1] Douglas Airplane Company subsequently became the Douglas Products Division of the Boeing Commercial Airplane Group.

[2] The "Classic" Boeing 747 airplanes include variations on the B-747-100, B-747-200, B-747-300, B-747-SP, and B-747-SR.

ranged from new to 27 ½ years old. The flight times of the airplanes ranged from 4 to 102,712 flight hours.[3]

The group agreed that the general condition, contamination, and workmanship of wiring in the TWA B-747s was similar to the wiring examined in the B-747s of other operators with similar flight times. The visual inspections conducted by the Systems Group found physical (mechanical) damage to wire insulation. Metal shavings were found both on and between wires in bundles, as well as next to the cooling holes on the tops of avionic boxes. The group found accumulations of foreign materials on wires that included lint (fiber particles and dust), hardware, structural corrosion preventive compound, grease, blue and brown fluid stains, and paper. Wire bundles were found adhered into solid masses with added wires strapped to the existing bundle. Wires shown segregated into separate parrellel bundles in Boeing 747 Production Illustrations were contacting each other in airplanes that were inspected. Crumbled rubber cushions were found in clamps, cracked o-rings were found, and cracks were found in the insulation of wires in five airplanes. The group found wire installations (workmanship) that did not comply with standards contained in the Boeing Standard Wiring Practices Manual (SWPM, D6-54446).

This report contains the results of wire examinations that were conducted during this investigation and records of prior accidents and incidents that involved electrical systems in transport airplanes. The total number of records cited in this report identify 71 airplanes[4] and 34 safety recommendations. These records included:

Investigations that the Safety Board conducted during the period that involved electrical systems,
Boeing 747 records of reported short-circuits and wire fire reports in 1996,
FAA Service Difficulty Records for B-747 wire and connector problems in 1996,
Previous Safety Board air transport airplane accident/incident records (1983-1998) that cited wiring involvement.

Boeing inspected wiring in high-time B-747 airplanes and described discrepancies found in Service Letter 747-SL-20-048 (attached). The Service letter also cites what "Boeing believes [what] are the principal causes of wiring degradation," areas that merit special attention during wiring inspections, and locations could be included in a special inspection of high time 747 airplane wiring.

[3] Flight times rounded to nearest whole numbers.

[4] Includes those inspected by the Systems Groups, but does not count the results of fleet inspections that some records cite. For example, airplane 19 is a single entry for a B-767 wiring fire of January 9, 1998. The FAA issued Airworthiness Directive (AD) 98-07-26 to call for inspections of wiring in other B-767 airplanes and discussion material was released with the issuance of the AD. The FAA stated that150 other B-767 airplanes were inspected and that damaged insulation was found in 13 airplanes before the AD was released.

D. DETAILS OF THE INVESTIGATION

AIRCRAFT INSPECTIONS OF FEBRUARY 21-25, 1998:

The majority of airplanes inspected were B-747 models and the same general areas were inspected in each (when accessible). The black areas in the following graphic show the areas, which are located forward of the wing spar, in the Main Equipment Center[5] (E/E), and behind the cockpit flight engineer station. The group inspected inside cockpit circuit breaker (C/B) panels when available. The group inspected the E/E located beneath the cockpits of other transport airplane models, as well as other areas. The list of airplanes that follows is sorted by age, with the newest airplanes first.

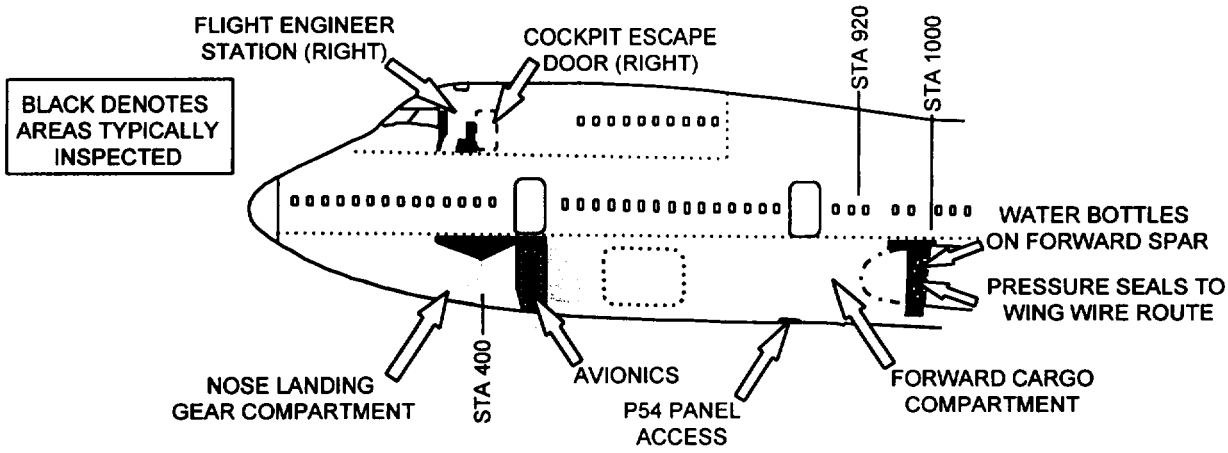


Illustration 1. Boeing 747 Inspected Areas[6]

AIRPLANE # 1

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
737	Undelivered	2/25/98	1/31/98	Not Applicable	1/30/98 (M)	4 (Pre-Delivery)

Condition : This new airplane had not yet been delivered to a customer. Only about 10-15 minutes were spent to inspect one area, the E/E.

Metal Debris : In the E/E center located forward of the nose landing gear were metal shavings in the bilge, but none were found on wires. Only

[5] The term used is from the September 1990 Boeing 747 Systems Handbook for a compartment that contains avionics and electrical distribution components is located aft of the nose landing gear. Boeing and TWA documents contain multiple descriptions for the compartment and areas within it. The compartment is widely known as the "E and E" (written as E/E).

[6] Station numbers (STA) denote inches aft of a reference datum to the cited location. Butt-lines (LBL or RBL) denote a number of inches to the left or right of the center of the airplane.

one metal shaving was found on wiring in the rest of the E/E, but otherwise the inspected area was clean.

Other : In the E/E center behind the nose landing gear, water was leaking from the forward R1 door drain. In the parked attitude, the water fell within an inch of a wire bundle.

AIRPLANE # 2

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
737	Undelivered	2/25/98	1/31/98	Not Applicable	1/30/98 (M)	4 (Pre-Delivery)

Condition: This new airplane had not yet been delivered to a customer. Only about 10-15 minutes were spent to inspect one area, the E/E.

Metal Debris : In the E/E behind the nose landing gear were two washers, a small nut, and metal shavings in the bilge. The largest fore-aft raceway in the left side was enclosed in a covering. Metal shavings were found on the cover, but no metal shavings were seen on wiring.

AIRPLANE # 3

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
747-400	Undelivered	2/25/98	1/26/98	Not Applicable	1/5/98 (M)	8 (Pre-Delivery)

Condition : This new airplane had not yet been delivered to a customer.

Metal Debris : A metal drill shaving was found in the fuselage on the right wing FQIS wires at the wing/fuselage pressure seal (where the wires pass from the fuselage into the right wing) and the shaving measured 2.7 inches long. A second shaving was seen between the wires at the wing/fuselage seal in the forward lower bundle.

The B-747-400 FQIS is different than in the "Classic" 747 series and the FQIS computer was found in an enclosed and covered area beneath the forward cargo compartment. The wires were routed aft to the wing/fuselage area through the bilge area located beneath the

forward cargo compartment with other wire bundles. The wires were exposed and vulnerable to possible foot traffic. Chips were not found in the bilge area beneath the forward cargo compartment and the bilge area was clean.

Forward of the upper deck left passenger door was a small connector panel near the deck, outboard of the compartment side walls. Under the panel were metal drill shavings and a coaxial cable with an adhesive anchor that had pulled from the deck.

Other : Wires in the E/E were fastened into bundles with different colors of plastic straps (panduits[7]), as described in the SWPM (20-10-19, page 14) for system segregation.

AIRPLANE # 4

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
MD-90	Eastern Mediterranean	2/25/98	11/13/97	Not Applicable	3/97 (D)	1488

Condition : An owner's representative said that the airplane had about 1300 hours and that it had been manufactured in May 1997.

Metal Debris : The group briefly inspected the E/E, behind the nose landing gear, and behind a small area of the C/B panel in the cockpit, through an access panel. During the brief inspection of the E/E, metal shavings were only seen on yellow cables located behind the left avionics boxes and on a connector.

Lint : Light fuzz was found only in a constricted area behind the left avionics rack.

[7] Plastic straps in Boeing airplanes are typically identified as BACS38K() and are also refered to as panduits. The Boeing SWPM describes replacement of BMS13-54 lacing tape with the BACS38K() plastic straps in section 20-10-11 and both methods of tying wires into bundles were seen in the inspected airplanes.

AIRPLANE # 5

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
A300B4	Asian	2/25/98	6/15/97	Unknown (*)	4/16/76 (M)	Unknown (*)

(*) Records unavailable.

Condition : Retired but complete. Doors, windows, and other openings were sealed and covered with foil. Airline magazines were found with August 1997 dates.

Metal Debris : The group found an extensive accumulation of metal drill shavings along the left sidewall of the E/E, outboard of the avionics racks that are located behind the nose landing gear. The drill shavings coated numerous wires and components. The shavings and black residues penetrated foam raceway clamps. Also found on wires and clamps were portions of drilled rivets, a screw, and an unused rivet. Aft of the nose landing gear structure in the E/E was a central wiring area for each of the avionics box connectors. Metal shavings were found on some wires and terminal blocks in the connector area.

A washer was found in cockpit C/B panel 124VU on the power side of one 3 ampere C/B. The washer was covered by lint and was on top of the C/B with the panel closed. When the C/B panel was opened, the washer was on the (vertical) side of the C/B and did not slip off.

Lint : In the forward left and right corners of the E/E were bundles retained by foam clamps. The lint, bundles, and upper portions of the clamps were encased in black syrup-like debris and dirt.

Lint accumulations were found in the C/B panels. The lint crossed between the backs of C/Bs, wires, and electrical connections. After removal of a small instrument panel cover, lint accumulations were seen behind the flight engineer station and the amounts were similar to lint in the C/B panel. Lint in the E/E area located beneath the cockpit were a dark gray and obscured the wires of some wire bundles.

Scraps of paper and other materials were found in the lint and between wires.

Other : The back of the flight engineer panel was closed preventing sunlight from the aft-right cockpit window reaching the inside of the panel. Wiring over the forward instrument panels had been painted with the color of the instrument panels. Paint was found on wiring in the E/E, located beneath the cockpit.

An abraded shielded wire found in the forward right corner of the E/E had exposed woven shielding.

AIRPLANE # 6

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
747	U.S. Based	2/25/98	1/15/97	12/31/93	2/25/76 (D)	55,218

Condition : Retired. None of the engines were completely cowled. The airplane doors and windows were intact and found closed. Magazines in airline jackets were found dated January 1997. On the flight deck, a Certificate of Airworthiness was found from a foreign country, dated 11 April 1995, with the airplane's serial number and registration number.

Metal Debris : No metal shavings were found near the CVR and FDR installations in the upper aft fuselage.

In the E/E there were few floor repairs and the metal chips seen were difficult to find, other than in the 3rd stanchion area. In the 3rd stanchion area, there was a coating of fine metal chips.

Near the floor behind the flight engineer station was dirt, debris and metal shaving accumulation on wiring in the bundles that obscured the definition of individual wires.

Lint : Very light lint accumulations were found near the CVR and FDR.

Very little lint was seen in the E/E.

Wire installation: In addition to wires found stretched by fallen insulation blankets that were near the CVR and FDR, individual wires were found stretched tightly between raceway clamps and the direction of the

wires sharply changed at the clamps. Wires were found resting against the hard nylon sides of the raceway clamps.

Other : Torn insulation was found that had fallen over wires and stretched them taut, near the CVR and FDR in the aft fuselage.

An extensive amount of new wiring was in the E/E. Some foam clamps in the E/E were in almost new condition, but the foam in clamps near the #1 (left) stanchion were crumbling. Worn wire insulation was found at contact points with the hard nylon sides of raceway clamps after moving the wires.

Sunlight coming through the aft windshield on the right side shone on the wiring in the rear of the flight engineer panel. The group found cracks in the insulation of the N2 tachometer wiring in this area. Also found was an inch of loose uninsulated wire (as used to secure some switch guards) that laid across the wire bundles. Above the battery, behind the flight engineer station were two bundle chafes that had removed the white insulation top coat from individual wires. Wires attached to connector D1588J were pulled to one side and the backs of the pins could be seen.

AIRPLANE # 7

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
747-200	U.S. Based	2/25/98	6/24/97	5/31/93	6/21/73 (D)	86,552

Condition : The airplane was parked with the #1 engine sealed, #2 & # 3 uncowled, and #4 engine missing. The airplane doors and windows were intact and closed. The left nose landing gear door was marked with three letters that the representative of the American-based airline noted were the initials of a European airline where the airplane had been maintained for most of the service life. A flight plan dated 24 June 1997 was found in the upper deck. In-flight magazines with 1997 dates were in the cabin.

Metal Debris: Forward of the wing, metal shavings were found between generator cables on the left side of the airplane. Metal shavings were found between other wires and a soda can tab was on the left raceway wires near droppings of grease.

A repair to the main deck floor structure was visible at the top of the E/E. The repair was located to the left of the E/E access ladder and toward the left end of the STA 400 bulkhead. The metal and fasteners were bright in color and had a different appearance than others in the area. Wires immediately beneath the repair were covered with sharp curled metal shavings.

To the right of the nose landing gear housing (looking forward) were metal shavings on the routing that contained the W350/W1360 bundles. There were metal shavings on wiring behind the E3 and on the other E/E avionic racks beneath a large drip shield.

Behind the flight engineer panel were metal shavings on connectors and on floor-mounted wires.

Lint : At the area of the forward spar to STA 980 frame, more lint and less metal shavings were found than in the airplanes 11 and 17. The lint at the left wing/body area obscured the individual wires in the bundles.

Wires at STA 400 were slightly browned and sticky and the light lint found was only a fuzz on the surface. Lint obscured individual wires in numerous places in the E/E, including where the W350 and W1360 come through the main deck floor near STA 360.

Wiring bundles along the cockpit floor behind the flight engineer station had no individual wire definition due to lint and dirt obscuration. Wires behind the forward edge of the flight engineer panel were coated with a light fuzz.

Wire Installation: Behind the forward outboard area of the flight engineer panel were wires rubbing a horizontal support bracket, and the topcoats of the wires were missing.

Miscellaneous: Abraded insulation was found on numerous wires that were held by foam clamps along the top of the E/E. None of the abrasions at the edges of the clamps exposed the core conductors of the wires, but the insulation of the wires were worn through the top coatings and into the inner brown layers.

AIRPLANE # 8

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
DC-9-30	U.S. Based	2/25/98	8/7/97	Unknown (*)	6/4/73 (M)	Unknown (*)

(*) Records not available.

Condition : The visible edge of data plate in L1 door had manufacturing date of 6-4-73. The airplane doors and windows were intact and closed. The windows and fuselage openings had been sealed with silver material, darkening the interior. In general, the airplane had much new wire and the condition was generally cleaner than in other airplanes inspected on February 25, 1998. A Fuel Distribution Form was found in the cockpit, dated 8/7/97.

Lint : Some metal shavings and lint of slightly more than ½ inch in depth were found on wiring.

Metal Debris : In the cockpit, a small triangular access panel was opened in the C/B panel behind the captain seat. Metal shavings were on the lint and on relays. In the E/E, metal shavings and other debris were found on wires at the top of the STA 160 LEFT junction panel and on wires located behind the left avionics racks.

Other : A syrup-like material adhered wires outboard of the left avionics boxes.

AIRPLANE # 9

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
747	U.S. Based	2/25/98	1/16/97	8/16/94	8/31/71 (D)	80,787

Condition : The airframe was intact and the doors and windows were closed. Seats and cowling stored in the forward cargo compartment blocked access to the left wing/body area.

Lint : At the right wing/body area was a light layer of lint "fuzz" on the wiring. Near the forward wing spar was more than ¾ inches of lint accumulated on wires. Between the E/E avionics rack stanchions,

the lint obscured individual wires and contained a mixture of fine metal chips.

Metal Debris : Fewer metal shavings were found in general than in the majority of the B-747 airplanes inspected on February 25, 1998. Less floorboard repairs were noted, as well.

A coating of metal chips was found on wires and connectors in the 3rd stanchion area of the E/E. Metal drill shavings were on the floor beneath these areas.

Below the right cockpit windows, wire bundles at the floor level had hardware, metal shavings, and other debris on and between strands. Metal shavings, lint, paper debris, and dirt were on wires routed beneath the cockpit (right) escape door sill.

Wire Installation : At one passage through the left side of the STA 400 frame, a foam clamp was missing the foam padded retention bracket and the weight of the bundles was hanging from the adjacent brackets. The bundles passing through the passage contained many fresh white-colored wires that contrasted with wires that had Boeing wire numbers and when the bundles were pressed up into the nylon portion of the raceway clamp, the amount of wires were too great to install a retention bracket.

The side panels of the upper deck passenger compartment were not installed when the airplane was seen and the wiring was visible. The W480 bundle that contains the CWT FQIS wiring was found laying against galley power cables in the W1246 bundle at two locations (STA 770 and 810). The installation did not resemble the Production Illustration (PI 61B70103) in routing, clamping, or in how the wiring sagged between clamps. According to the airline representative, the airplane had been acquired from another airline and an upper deck galley had been added before entering the airline's service. Clamped above the dirty wires was a 3-wire bundle of clean white wires and clean new (BACC10*) loop clamps.[8] On the structure behind the W480 wire bundle route to the left of the upper deck cabin were runs of tacky brown liquid, which was similar to anti-corrosion spray[9] seen beneath the main deck. The end of a wire in an adjacent bundle had a crimped and insulated cap splice.

[8] Wires are routed through the airplane in the eyes of "P"-shaped BACC10* loop clamps, as described in SWPM 20-10-12.

[9] Boeing describes the material in the 747 Structural Repair Manual (SRM) as BMS3-23.

AIRPLANE # 10

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
747	Mid-Eastern	2/25/98	Unknown (*)	Unknown (*)	6/25/71 (M)	Unknown (*)

(*) Records either destroyed or unavailable.

Condition : The airplane was found in poor condition, with the forward cargo door missing, holes in the fuselage, and wind blowing through the E/E. Wing leading and trailing edge devices were missing, as were numerous fairings, windows, doors, and other parts. Due to the poor condition of the airframe, the wiring and cracked insulation were not closely examined, except in enclosed and covered areas.

Lint : The left wing/body wire bundles were covered with lint deposits (and metal shavings) that obscured individual wires and some bundle features. The sidewalls of the cargo compartment were not installed, revealing about 1/2 to 3/4 inch thick lint accumulations near the main deck floor.

Wire Installation: Three blackened rub marks were found chafed through the woven insulations on two wire bundles that were above the location of the previously removed C/B panel on the flight deck.

Other : The P54 panel was missing.

AIRPLANE # 11

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
747	U.S. Based	2/25/98	4/24/91	1/31/90	6/19/71 (M)	80,759

Airplane Condition: The airframe rested on fixed pylons, rather than on landing gear and was missing the wing leading and trailing edge devices, numerous fairings, windows, and doors (including frames). Due to the poor condition of the airframe, the wiring was only examined in enclosed and covered areas. The floor structure over the forward

wing spar had fasteners and bright green sheet metal components that contrasted with the paint-oversprayed surroundings. The forward cargo compartment liner was in place. The flight engineer panels and (right) cockpit escape door were missing, exposing the flight engineer station to the weather.

Metal Debris: Forward of the wing spar were a washer and a screw in the left raceway wiring. Wiring in the area had numerous metal shavings on wire bundles and between wires, with more in the right raceway.[10] Some shavings were visible between wires at the bottom of the harness. A portion of a drilled rivet was found in one harness. A metal dinner knife marked with an airline logo was found lodged next to the wing/body wiring at the left side of the forward spar.

Lint : The wiring in the area of the forward wing spar to the STA 980 floor beam was found covered with black lint of 1/4 to 1/2 inch depth. The accumulations were thicker where the raceways went over the forward spar.

At the back of the flight engineer station on wires were lint, dirt, and other debris. The flight engineer panels and (right) cockpit escape door were missing, exposing the aft outboard portion of the flight engineer station to the weather.

Wire Installation: The group found wires stretched tightly between clamps at the forward spar.

Miscellaneous: The P54 Panel was found to have blackened soot-like deposits on the green paint at the diode/resistor area that was at the lower forward corner. The diodes had visible printing and were not discolored. Black residue covered the exterior (lower) surface of the wing and flow patterns were seen around obstructions, such as structure and fasteners.

[10] Raceway designations are shown on Boeing/TWA Electrical Electronic Wiring Raceway Identification (91-00-00).

AIRPLANE # 12

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
747	U.S. Based	1/12/98	10/92	Removed from service in 1992; previous records not available.	5/24/71 (D)	77,415

Condition : The airplane was removed from service in October 1992 and no records were available. The fuselage had large holes where the passenger doors had been, large components (such as wing flaps and leading edge devices) were missing, no engines were installed, and the cockpit was empty of instrumentation. The left wing pressure refueling panel components were missing. The floorboards over the center wing fuel tank wires on the left side were intact. Wire was cut for removal and coiled into a 3 foot diameter for shipment to Calverton.

Metal Debris : After the floor panels were removed from over the center wing fuel tank, wires in the raceway were exposed and metal shavings were found. Wire bundle W186 from behind the flight engineer station contains metal shavings and flakes.

Lint : After the floor panels were removed from over the center wing fuel tank, wires in the raceway were exposed and light lint deposits were found. More than ¼ inch of lint was found to be thickest over the forward spar at the airflow constriction and obscured some smaller wires. Cockpit lint obscured individual wires in at least one bundle.

Wire Installation: At about STA 960-980, the wire bundle coming forward from over the CWT sagged and contacted a wire bundle that was routed down the forward spar. Wires were found stretched tightly between two wire bundles near the bottom of the STA 980 floor beam. Wires in the raceway over the center wing fuel tank were not tied into individual bundles, but were randomly laid into a tray. Individual wires crossed from one side of the tray to the other and back. Generator and galley power cables were not routed in the tray, but were clamped to structure next to it. Wires in raceway clamps were found against the hard nylon at the sides of the clamps. Loose loop clamps (both nylon and rubber cushioned metal) were

found on a wire bundle with no screw or adjacent point to fasten the clamp to.

CWT : The center wing fuel tank access panels were not installed and the tank was entered. The scavenge pump inlet screen held an approximately one inch long uninsulated wire fragment that resembled safety wire. A vertically routed FQIS wire chafed on a horizontal structural flange that it was routed past and a horizontally routed FQIS wire chafed on a vertical row of rivets between two supporting clamps.

CWT Probes : The center tank was open and the fuel probes (both Series 3 and Series 4) had been removed with about 2 to 3 inches of wire. The following conditions were noted:

Probe:	Mfg. Date	Terminal block series:	Sulfide deposits on bare wire ends and terminal sleeves:	Wires loose under clamp:
F36 (Comp-ensator)	Mar 70	1, nylon clamp	Yes	Yes.
F38	May 70	5, nylon clamp		Firm, but slide with finger pressure.
F39	Jul 69	3, metal clamp. Set screws (not captive screws shown in IPC)	Yes	Striation marks near pigtail resemble jaw marks of wire stripper tool.
F40	Dec 69	3	Yes	Yes. Wires can slide slightly.
F41	Aug 69	3	Yes	Yes
F42	Nov 69	3, metal clamp.	Yes	
F43	Jun 70	6, nylon clamp	Yes	No. Striation marks near pigtail resemble jaw marks of wire stripper tool.
F44	Jun 70	6, nylon clamp	Yes, but less on lugs.	Yes

AIRPLANE # 13

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
747	U.S. Based	2/25/98	1/13/97	2/21/94	11/10/70 (D)	92,141

Condition : The #1 and #4 engines were not installed and #3 was partially cowled. The airplane doors and windows were intact and found closed. At the forward spar to STA 980 frame area, water was found standing in the fuselage stringers on the left side and the wing/body area wires had a washed look. Flight plan found dated January 13, 1997, and magazines in airline jackets were found with December 1996 and January 1997 dates.

Lint: Lint obscured individual wires of some bundles behind the aft side of the flight engineer's station. The face of the forward spar was covered by a light coat of lint.

Metal Debris : The E/E had drill shavings on numerous wires and connectors in the #1 stanchion area. Metal shavings were found resting in the areas, as well. Three loose screws and parts of drilled sheetmetal fasteners were found with metal shavings to the left of the nose landing gear structure, forward of the STA 400 bulkhead.

Wire Installation: A raceway clamp was missing the entire foam retainer bracket and the wires were hanging from the clamps located forward and aft of the open clamp. The clamp was located at the STA 400 frame center rectangular opening, to the left of the nose landing gear.

Other : Near the right wing/fuselage pressure seals was a Spanish customs declaration form between the generator cables. The form was dated May 17, 1996.

The lower fire extinguisher container mounted on the forward spar was found with both top supports broken; the bottle was hanging by a braided stainless steel hose. Wiring attached to the bottom of the container led toward a connector and the wires had a tag marked FWD PRESS. The wires had been pulled from the connector. The four wires of a nearby bundle were found loosely tied and strayed more than an inch from each other.

The wires were slightly moved from the STA 400 left side lower foam clamp for inspection. The black jacket was found worn from a twisted wire set, exposing the wires within the jacket. The abraded depth in the insulation of other wires in the clamp penetrated the top coatings.

At STA 400, the top and middle layers of insulation were missing from numerous wires routed next to each other. The wires were marked in green ink with W42A (BMS13-42A).

At least 4 wires were found with cracked insulation behind the flight engineer panel. The wires were found in the corner near the right cockpit windows. Each wire was marked with green lettering that began with W42A (BMS13-42A). One wire was attached to the T721 terminal track and one to the T249. The wires were single, having split out of the grouped wires of the bundles.

Cracked wire insulation was found in 2 places behind the aft side of the flight engineer station and above the battery. One wire was kinked about 1/4 inch from a connector that had no visible marking. One wire with cracked insulation was on the side of a 3/4 inch diameter bundle.

AIRPLANE # 14

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
747-100	U.S. Based	2/25/98	1/13/97	4/9/93	5/23/70 (D)	102,712

Condition : All 4 engines were found partially cowled and the cowls were in the forward cargo compartment, obstructing access to the forward spar area. The airplane doors and windows were intact and found closed. A jumpseat authorization form was found with a date of 1/13/97 and magazines in airline jackets were found with January 1997 dates.

Metal Debris : In the CVR/FDR area of the aft fuselage, no visible metal shavings were found.

A floor panel near the L2 door was not installed and the wiring beneath the floor was visible over the forward cargo compartment.

In this area was a coating of anti-corrosion spray and metal shavings on wires.

In the E/E at the #4 (right) stanchion, metal shavings were found beneath the drip shield. The #1 stanchion connectors and nearby wires were found covered with metal shavings. Metal chips and a metal drill spirals were found on wires at the left end of STA 400 (aft side).

Wiring routed along the cockpit floor and aft of the first officer's cup holder, beneath the aft-right cockpit window, was in the midst of brown stains. The PI (61B70102) showed the wires routed to the first officer instrument panels. The floor bundles were adhered into a single mass with inclusions of dirt, metal chips, and other debris that obscured individual wire features. The mass of wires contained dust, metal chips, and other debris. Strapped to the mass with plastic panduits (Ty-wraps) was a loose bundle of bright white wires.

Lint : In the CVR/FDR area of the aft fuselage was about 1/8 inch thickness of lint on wiring and extensive nicotine-colored film on most features.

The E/E contained lint and sheetmetal repairs (with metal shavings) similar to those seen in previous airplanes, but the accumulations were more localized to individual areas, including under drip shields.

Wire Installation: On the aft side of STA 400, to the left of the main deck ladder, horizontal bundles routed together rubbed against vertically mounted power cables. The horizontal bundles included W500, W634, W9410, and the vertical power cables were the W254 bundle.

The STA 400 bulkhead had riveted reinforcements. The rivets did not match the surrounding painted structure and pencil markings were next to each of the fasteners.[11]

[11] FAA Advisory Circular (AC) 43.13-1B, ACCEPTABLE METHODS, TECHNIQUES, AND PRACTICES - AIRCRAFT INSPECTION AND REPAIR, (Ch 6, Sect 6, para c & d) states that graphite pencils and other sharp pointed instruments should not be used to mark any metal surface and that "Graphite is cathodic to all structural metals and will generate cathodic corrosion in the presence of moisture, especially if the graphite is applied in dry form."

Wires behind the flight engineer station were found cut off and tied into a knot around the bundle with the exposed conductor at the end. Some of the sunlit wires had cracked insulation and the core conductors were visible.

Other : Toward the left end of the STA 400 frame at about LBL 45, bundles W500/W404/W450 were found in a P-shaped nylon clamp that had broken from a stand-off.

An abraded wear pattern crossed the woven sleeve of a twisted wire set at the edge of the nylon portion of a raceway clamp. The clamp was located at the right of the STA 400 frame.

AIRPLANE # 15

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
747-100	U.S. Based	2/25/98	1/13/97	6/26/96	5/13/70 (D)	83,477

Condition : The airplane was painted in a logo adopted by the airline within the previous year. The #1 engine inlet and exhausts had been sealed, the #2 & #3 engines were uncowled, and the #4 engine was not installed. The airplane doors and windows were intact and found closed. A flight plan was found dated 1/13/97 and in-flight magazines were dated 1997.

Metal Debris : Avionics in the P54 compartment, beneath the forward cargo hold, could be seen from the cargo hold and black grime was in the screw holes for the missing P54 compartment cover. Metal shavings rested on the tops of the avionics boxes, next to cooling holes. Circuit cards within the boxes could be seen through the ventilation holes. Oily drippings were on adjacent sheetmetal. Wires and the general features of the area were darkened with a dirty coating of residue and lint.

Metal shavings and lint obscured individual wires of bundles. Metal chips were found between wires of a bundle within a foam clamp.

Behind the flight engineer panel were metal shavings on connectors and on floor-mounted wires.

Lint : Lint and dirt obscured the definition of wire routings on cockpit floors.

Wire Installation: At STA 400, at least one chafe between wire bundles penetrated to the middle layer of wire insulation. Foam clamps were found with plastic ties (a.k.a. ty-raps or panduits) holding the legs together.

Behind the forward area of the outboard side of the flight engineer panel were wires rubbing a horizontal support bracket and the outer wire insulation was rubbed off.

Other : Foam was found degraded from raceway clamps and the wires rested on the metal bracket. At the STA 980 floorbeam above the right potable water tank were blue stains in the yellow foam of a raceway clamp. The foam of the adjacent clamp had crumbled and the wires were nearly in contact with the metal bracket. Anti-corrosion material was on the wires and seen as brown and black hardened drips from the STA 980 floorbeam.

Resistors and other electrical components in the P54 panel were blackened with a soot-like residue. The residue could be wiped off and the component markings were visible.

AIRPLANE # 16

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
747	U.S. Based	2/25/98	10/6/97	6/5/96	4/29/70 (D)	102,709

Condition : The #1 and #4 engines were cowled and sealed. The #2 and #3 engines were partially cowled and exposed. The airplane doors and windows were intact and found closed. Magazines in airline covers were found dated 10/6/97. Insulation blankets were found dated 8/14/69.

Metal Debris : Near FDR/CVR units in aft fuselage was a wire bundle (W1324) mounted to a beam with small metal chips on the wires. In E/E, metal shavings and debris were found on top of fuselage STA 400 wire bundles in foam clamps.

The #1 (left) stanchion area at the left end of the E/E racks had metal shavings covering most of the wires and connectors.

Metal shavings, lint, and dirt obscured wires routed beneath the cockpit (right) escape door sill.

Lint: At least a quarter inch of lint was on wires and connectors behind the flight engineer panel.

Other : Foam clamps in the aft fuselage near the FDR/CVR area looked new.

The wires and connectors had a wet look and some harness wires were adhered into a single unit with a syrup-like coating beneath the circular stair and the L1 door area.

In the dark area behind the flight engineer panel was connector D1799J. A wire in bundle W668 entered connector pin 19 and was browned at both the plug and the receptacle sides of the connector. The copper conductor outboard of the plug was visible for at least 1/8 inch. The insulation was browned and split for more than another inch beyond the exposed conductor. An identification marker on the wire was darkened. Closer examination of electrical connectors in the area revealed that the connector pins could be seen, where wires bent to the side of the connectors and stretched the rubber connector grommets.

Wires behind the forward portion of the flight engineer panel (nearest cockpit windows) had extensive cracks in the insulation, but most cracks only penetrated the top coat. Cracks were found in the wire insulation of bundle W186.

Wire insulation (BMS13-42A) was found cracked in an interphone bundle for the upper deck flight attendant station, above the E11 avionics rack. The bundle was W1368 and the area was enclosed so that daylight did not reach it. The wire was marked W42A in green ink.

Electrical Test: A hand-cranked megohm meter was used in the E/E to measure surface resistance with the meter leads about 3/8 to 1/2 inch apart.[12] On what appeared to be new white wire, the resistance was above 500 to 1000 megohms, but accuracy at the high end of the scale varied with meter movement during cranking. Placing the leads on

[12] The tests were for comparative values and were not conducted to a specification. The test method consisted simply of attaching alligator clips to the surface of wiring with about .25-.5 inch spacing between the clips and then applying an electrical load by use of a hand-cranked megohm meter.

the surface of wires with dirt and oil gave measurements of as low as 12 megohms.[13]

AIRPLANE # 17

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
747	U.S. Based	2/25/98	11/27/90	9/26/86	4/25/70 (M)	76,776

Airplane Condition: Similar poor condition as airplane #11. Due to the poor condition of the airframe, wiring was only documented in enclosed areas.

Metal Debris: At the forward wing spar, numerous metal chips and drill shavings were found on wire bundles and between wires. A rusted nutplate was found on forward wing spar flange, less than two inches beneath the W480 harness. Similar nutplates fastened wire bundles to a metal bracket above the loose part. The lint and metal chips were not as extensive as in airplane #11.

Metal shavings, lint, and dirt were on wires routed beneath the cockpit (right) escape door sill.

Lint: The group found extensive lint accumulations on wires near the forward spar and STA 980 floor beam. The lint was black and grimy.

Above the rear of the flight engineer panel extensive lint deposits were on the wiring.

Wire Installation: Wires were checked for type near the forward wing spar and were found to be BMS13-42A, with some -42B and -38.

A bundle containing at least 13 wires (semi-legible wires marked WP026?) above the forward cargo compartment ended near a foam cushioned raceway clamp at STA 980. The ends of the wires were not covered and the copper conductors were visible. An open-ended wire splice was in the bundle.

Wires routed vertically along the 920 frame passed the main deck cabin windows.

[13] One megohm is one million ohms of electrical resistance.

A wire routed near the cockpit floor was found stretched tightly between a raceway clamp and a plastic panduit (Ty-wrap). Wire bundles crossed each other at an angle within the raceway clamps.

Chafes were found between wire bundles above the P6 C/B panel, between bundles W940 and W418. This area was the subject of Alert Service Bulletin 747-24A2186 and AD 94-05-07. Bundle W6 was found riding on two woven bundles, about six inches from connector D1805J.

Other: The yellow foam of a raceway clamp at STA 980 had blue stains. The floor/seat supports over the forward spar appeared to have newer fasteners that did not match other fasteners in the area.

The insulation blankets were found torn and laying across the generator cables and other wiring at the wing/body pressure seals.

The lower forward corner of the P54 Panel had blackened soot-like residue on the green paint of the diodes, resistors, and metal. The diodes had visible printing and were not discolored.

The Boeing Engineering Quality Assurance (EQA) Laboratory performed an examination of four connectors removed from the airplane. The EQA Report (Chem 6743, see attachment "AIRPLANE 17") Conclusions Section stated that in addition to dust and dirt, three connectors were "contaminated with ester oil, azelaic acid, and mixtures of oil and acid. Engine turbine oils (such as MIL-L-23699 or MIL-L-7808) and ester greases are known to degrade to form azelaic acid. Although the presence of azelaic acid was identified on all three connectors, the extent of degradation varied among the connectors with the D1990P having the lowest amount of acid and D1769 having the largest amount of acid."

AIRPLANE # 18

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
747	U.S. Based	May 19-20, 1997	Unknown	Unknown	Unknown	Unknown

Airplane Condition: The airplane was a retired 747 and was missing all four engines. The center wing fuel tank was open and most interior panels had

been removed. The purpose of the visit was to photograph the installation of the fuel quantity indication system and wiring from the tank to the flight engineer station. The group did not search for or document metal debris or lint.

In CWT: An o-ring from the cross-feed manifold was examined and found to have numerous radial cracks. The bottom of the fuel probes measured from .37 to .6 inches from the tank floor, except the center probe, which measured 1.5 inches. The center probe tube had dents above the level of the scavenge pump inlet tube, which also had dents.

Wire Installation: The CWT FQIS was found routed along the left side of the upper deck with the coaxial cables for the VOR antenna. The wires for the right wing FQIS were bundled with the No. 3 VHF antenna coax.

Other: An electrical signal generator was connected to a CWT FQIS wire (wire identification was not noted) at the flight engineer station, and a hand-held receiver emitted a warbling sound when placed next to the wire.[14] The receiver was used to trace the wire route. Although the signal generator was only connected to the CWT FQIS wire, the warbling was also heard when the probe was brought near FQIS wiring for other fuel tanks. The warbling sound from the receiver was not as loud as when near CWT FQIS wire.

The Boeing Engineering Quality Assurance (EQA) Laboratory performed an examination of black film deposits that were on wiring removed from the P14 (power distribution) panel. The EQA Report (Chem 6304, see attachment "AIRPLANE 18") Conclusions Section stated that "The deposits were identified as a complex mixture of organic and inorganic environmental debris...[which] likely contains silicates, sulfates, and phosphates." "The deposits contain water-soluble elements, suggesting that the material may have been deposited from water."

[14] The signal generator is ground test equipment that electrically energizes an isolated wire with an alternating current. The tip of the hand-held receiver is a radio antenna. When the antenna is near the wire and the frequency of the alternating current is detected, the hand-held unit will generate an audible warbling tone.

Table 1. SUMMARY OF AIRCRAFT EXAMINED DURING TWA 800 INVESTIGATION
Listed By Age

NTSB ID# (See Note 1)	Model	Airline or Operator Location (See Note 1)	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
1	737	Undelivered	2/25/98	1/31/98	Not Applicable	1/30/98 (M)	4 (Pre-Delivery)
2	737	Undelivered	2/25/98	1/31/98	Not Applicable	1/30/98 (M)	4 (Pre-Delivery)
3	747-400	Undelivered	2/25/98	1/26/98	Not Applicable	1/5/98 (M)	8 (Pre-Delivery)
4	MD-90	Eastern Mediterranean	2/25/98	11/13/97	Not Applicable	3/97 (D)	1488
5	A300	Asian	2/25/98	6/15/97	Unknown	4/16/76 (M)	Unknown
6	747	U.S. Based	2/25/98	1/15/97	12/31/93	2/25/76 (D)	55,218
7	747-200	U.S. Based	2/25/98	6/24/97	5/31/93	6/21/73 (D)	86,552
8	DC-9-30	U.S. Based	2/25/98	8/7/97	Unknown	6/4/73 (M)	Unknown
9	747	U.S. Based	2/25/98	1/16/97	8/16/94	8/31/71 (D)	80,787
10	747	Mid-Eastern	2/25/98	Unknown	Unknown	6/25/71 (M)	Unknown
11	747	U.S. Based	2/25/98	4/24/91	1/31/90	6/19/71 (M)	80,759
12	747	U.S. Based	1/12/98	10/92	Removed from service in 1992	5/24/71 (D)	77,415
13	747	U.S. Based	2/25/98	1/13/97	2/21/94	11/10/70 (D)	92,141
14	747	U.S. Based	2/25/98	1/13/97	4/9/93	5/23/70 (D)	102,712
15	747-100	U.S. Based	2/25/98	1/13/97	6/26/96	5/13/70 (D)	83,477
16	747	U.S. Based	2/25/98	10/6/97	6/5/96	4/29/70 (D)	102,709
17	747	U.S. Based	2/25/98	11/27/90	9/26/86	4/25/70 (M)	76,776
18	747	U.S. Based	May 19-20, 1997	Unknown	Unknown	Unknown	Unknown

RECORDS OF OTHER NTSB INSPECTIONS DURING THE INVESTIGATION:

AIRPLANE # 19

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
767-300	U.S. Based	1/11/98	1/9/98	Unknown	10/27/92 (M)	24,743

The Safety Board participated in an United Kingdom Air Accidents Investigation Branch (AAIB) examination of this airplane. Numerous systems had reportedly become inoperative after the airplane took off from Zurich, Switzerland, for a flight to Washington, DC, and a precautionary landing was made at London Heathrow International Airport.

Molten wires and charred insulation were found near the sharp corner of the galley chiller unit in the E/E, located beneath the cockpit and forward right galley. Foam on the side of the chiller had burned. The heaviest wire damage was found in a wire bundle that contained BMS13-51 (aromatic polyimide) and BMS13-48 (XL-ETFE) wire insulation. The burned bundle included a sub-bundle that was contained in a woven fabric (Varglass) sleeve. The insulation of wires that had been against the sleeve were black and crispy. Balls of copper from the arced wires melted holes in the XL-ETFE insulation of wires that were more than an inch from the site of the electrical arc and exposed the copper conductors.

While the AAIB Systems investigator was in the E/E, a mechanic inadvertently put electrical power on the airplane and wiring located aft of the galley chiller began to arc without popping C/Bs.

The chiller had been replaced before the previous day's flight. Water was found collected on a thermal insulation blanket beneath the chiller and wire bundle. Metal shavings, coins, screws, copper wire, locking wire, plastic cable ties, and dust/dirt were found on or beneath wire bundles in the incident airplane and in other airplanes inspected at London Heathrow during this investigation.

Note: The FAA issued Airworthiness Directive (AD) 98-07-26 following the incident to require both wire inspections and wrapping the wires for protection. Discussion material that was released with the issuance of the AD stated that examination of similar wiring near the chillers in 150 other 767 airplanes found damage to the same area of wiring in 13 airplanes before the AD was released.

AIRPLANE # 20

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
747-100	European	1/12/98	Previous month	In process	1970 (M), April 1974 (D)	100,000+

During the investigation into the January 9, 1998, precautionary landing made by airplane #19 (B-767-300), the E/E wiring in a European 747 was also examined at London Heathrow International Airport on January 12, 1998. The examination was made by the investigators from the National Transportation Safety Board and Air Accidents Investigation, with an inspector from the operator. The group found materials on the wiring that included metal shavings, a screwdriver, hair comb, coins, lint, and sticky anti-corrosive spray.

A hand-cranked megohm meter was used in the E/E to measure surface resistance with the meter leads about 3/8 to 1/2 inch apart.[15] The measured resistance varied between more than 500 megohms on clean wires to less than three megohms on oily looking wires that were covered with lint. The group did not determine why the oily looking wires had lower resistance than the clean wires.

AIRPLANE # 21

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
757	U.S. Based	7/29/98	May 1998	1994	March 1982 (M)	24,225

Safety Board investigators examined an experimental fuel quantity indication system (FQIS) that was installed in parrellel with an existing (Honeywell) FQIS system in airplane #21. Wires inside the fuel tanks were found attached to nylon loop clamps that were dated JAN 1988 and the free space in the clamps was filled with rubber o-rings, some of which had split.[16] Wires attached to the Honeywell FQIS probes and compensator were flat or kinked where pressed beneath metal clamping bars. Chafed wires were found at the corner of the Honeywell compensator and at rivets installed along the wire route. Dark sulfidation residues were seen at the ring connectors on the ends of

[15] Similar test described in entry for airplane #16.

[16] The SWPM (20-10-12, page 6) states that free space within clamps can only be filled with BACP20BA filler plugs, RT-876 heat shrink sleeve, Scotch 70 tape, or E125-2 film strip (or equivalent) and warns against the use of other materials. The SWPM also states: CAUTION: DO NOT USE FILLER PLUGS, FILLER RODS, INSULATION TAPE, OR FILM STRIPS WITH THE CLAMPS IN THE FUEL CELLS. IF ANY OF THESE MATERIALS COMES FREE, THE FUEL FILTERS CAN BECOME CLOGGED.

wiring attached to the fuel probes and the darkened residues streamed down the plastic insulation from the exposed metal. The end of a fuel fill tube was gouged where it contacted an electrical bonding strap. Fuel tank sealant was found on FQIS parts and on wiring.

After inspecting the center and inboard right fuel tanks, general airplane wire was examined. The airplane had a large percentage of wiring that was marked by the dot-matrix method and the wires did not have the Boeing BMS13-51 markings. These wires did not appear to be original wiring. The wiring was generally clean, except in corners and enclosed areas. The airplane had extensive modifications within the four years before the inspection and minor amounts of lint were found between original avionic installations. Although the airplane was cleaner than contemporary or older transport airplanes, trash found in the lowest (bilge) areas included hardware, lint, dirt, and liquid stains, Woven sleeving that contained wire sets was found damaged and the wires could be seen. Small metal chips and drill shavings were found on some wire harnesses and between the wires of some bundles. Mechanical damage to wire insulation in the E/E exposed the copper of some wires. The white insulation topcoat on other wires was damaged and the copper conductor appeared to be exposed, but closer examination revealed that the polyimide wire insulation was intact. Removal of the topcoat did not exceed the damage tolerance limits specified by Boeing in the SWPM.

The operator had replaced the CWT FQIS compensator and gave the removed compensator to the NTSB for failure analysis. The removed compensator was given to the Air Force Research Laboratory (AFRL) Electrical Laboratory at Wright-Patterson Air Force Base, in Dayton, Ohio, for examination into potential failure causes. The compensator did not include the FQIS wiring from the fuel tank. Wright Patterson found no short circuits or causes for the failure, but found a square-edged hole poked through the outer layer of shielded wire insulation. The hole punctured the woven shielding inside the compensator and had cut partially through the internal insulation, between the wire conductor and the shielding. The hole had inward deformation at one end, outward deformation at the other end, and was coated with copper/silver sulfide deposits. (Report AFRL/MLSA 99-10, see attachment "AIRPLANE 21")

AIRPLANE # 22

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
L-1011	U.S. Based	11/9/98	11/9/98	Unknown	Unknown	Unknown

NTSB Identification for this incident is DCA99SA043, see attachment "AIRPLANE 22"

About 140 miles west of San Francisco International Airport, during a flight from Honolulu, the flight engineer saw white smoke, arcing, and sparks emanating from a C/B panel next to his cockpit station. He also reported that he saw a small flame inside the panel and extinguished it with a fire extinguisher. During the descent and landing,

multiple systems failures occurred with the autopilot, cabin pressurization, auto spoilers, and thrust reversers. After a safe landing and taxi to the gate, the crew determined that the engines were still running at flight idle instead of ground idle. Additionally, the cabin doors could not be opened because the cabin pressurization outflow valves remained in the closed position despite attempts to override them. The crew then attempted to shut down the engines with normal procedures, but were required to pull the emergency "T" handles to accomplish the shut down. The airplane was subsequently depressurized, the cabin doors were opened, and the occupants deplaned normally into the jetway.

Airline maintenance personnel inspected the airplane and found a blackened adel clamp and circuit breaker (tripped) and the circuit breaker post exhibited evidence that it had arced to the adel wiring clamp which held a bundle of wires. According to maintenance personnel from the airline, the adel clamp appeared to have been a factory installation, and should not have been installed in that location. According to maintenance records, the circuit breaker had popped during a flight on the day prior to the incident flight, had been replaced, and had popped again on a subsequent flight.

An accumulation of dust was found in the area that covered the C/Bs and wires. Additionally, the inspection found the corner of a piece of paper with flight crew hand writing on it and the corner had been partially burned by fire.

AIRPLANE # 23

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
L-1011	U.S. Based	12/22/98	12/22/98	Unknown	Unknown	Unknown

NTSB Identification for this incident is DCA99SA044, see attachment "AIRPLANE 23"

The airplane was to be pushed back from a gate at Atlanta, Georgia, when a passenger notified a flight attendant about sparks and smoke. The flight attendant reported having seen flames near the bottom of the left cabin wall. The passengers and flight crew were deplaned, the smoke ceased, and the airplane was inspected by representatives of the airline and the FAA.

Two wire bundles of about three-inch diameter were found burned in the mid-electronics-service-center (MESC[17]), beneath the aft edge of the 2L lavatory in the cabin. Examination of the area revealed blue lavatory fluid stains and dust accumulations on wire bundles and generator feeder cables. Resolidified copper indications of wire-to-wire arcs in the bundles were found and no evidence of arcing to structure or other areas was noted.

[17] Lockheed designation for an area described by Boeing as an E/E, located forward of the forward wing spar.

Airline personnel reported that there had been three or four previous occurences involving exposure of wire bundles to blue lavatory fluid below the mid lavatories on their L1011 airplanes. The airline inspected the 35 airplanes in their L1011 fleet after the incident and found 5 airplanes with evidence of lavatory fluid contamination of wires in the inspection area, 11 airplanes exhibited "some signs of feeder to bundle rubbing" in the inspection area, 17 airplanes "demonstrated excessive dirt and dust" in the inspection area, and 13 airplanes had metal shavings or paper debris" in the inspection area.

AIRPLANE # 24

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
MD-11	U.S. Based	1/31/99	1/31/99	Unknown	March 30, 1993 (D)	25,532

NTSB Identification for this incident is DCA99SA037, see attachment "AIRPLANE 24"

About 70 minutes after departing for Narita, Japan, smoke was observed in the passenger cabin and an emergency was declared. The crew found the source of smoke at the overhead bin near the R2 door as the airplane returned to Seattle-Tacoma International Airport to perform an emergency landing. A Halon fire extinguisher was discharged onto a video system control unit (VSCU) in the area, pulled cabin system circuit breakers, and the smoke dissipated.

After landing, representatives of the airline and manufacturer of the video system installed a replacement VSCU and that unit also began to smoke. The representatives found molten plastic and a low-resistance path between pins in the "cannon plug" electrical connector that had been attached to each of the VSCUs that had been installed. The video unit manufacturer's failure analysis of the canon plug attributed the failure to moisture and that the short circuit connected 115 VAC power to circuits that were designed for 28 volts or less. The group disassembled the original VSCU and found that beneath a cooling grill on the top were liquid stains on the top and bottom surfaces of internal circuit boards. Other than the canon plug, all external video system wiring was intact and undamaged. Inspections of similar systems in other airplanes did not find fluid stains in the canon plugs.

During the investigation, 10 airworthiness directives were found to have been issued for previously identified MD-11 wiring service difficulties that could cause smoke/fire (excludes transformers or other internal failures).

AIRPLANE # 25

Model	Airline or Operator Location	Date of Inspection	Last Known Flight	Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
MD-11	U.S. Based	3/29/99	3/29/99	Unknown	Unknown	Unknown

NTSB Identification for this incident is DCA99SA051, see attachment "AIRPLANE 25"

On March 29, 1999, maintenance personnel at San Bernardino, California, removed floorboards and found evidence of a previous fire in a MD-11. The metalized mylar insulation blanket beneath the floorboards burned in an area that measured about 60 inches by 20 inches. The investigation found a wire bundle chafe on a structural frame that damaged eight aromatic polimide-insulated wires in a larger wire bundle.

The Safety Board was involved with an earlier insulation blanket fire in the same area that was ignited by an electrical failure. On November 11, 1998, a MD-11 at Hartsfield International Airport had a fire in the center cargo compartment while parked with no passengers or crewmembers aboard. The Safety Board's investigation revealed that the fire originated directly beneath the cargo control unit (CCU), which is used to load and unload cargo containers. A connector plug had been disconnected from a floor-mounted powered roller unit and the wires had been shorted during a subsequent loading operation, electrically overloading components in the CCU.

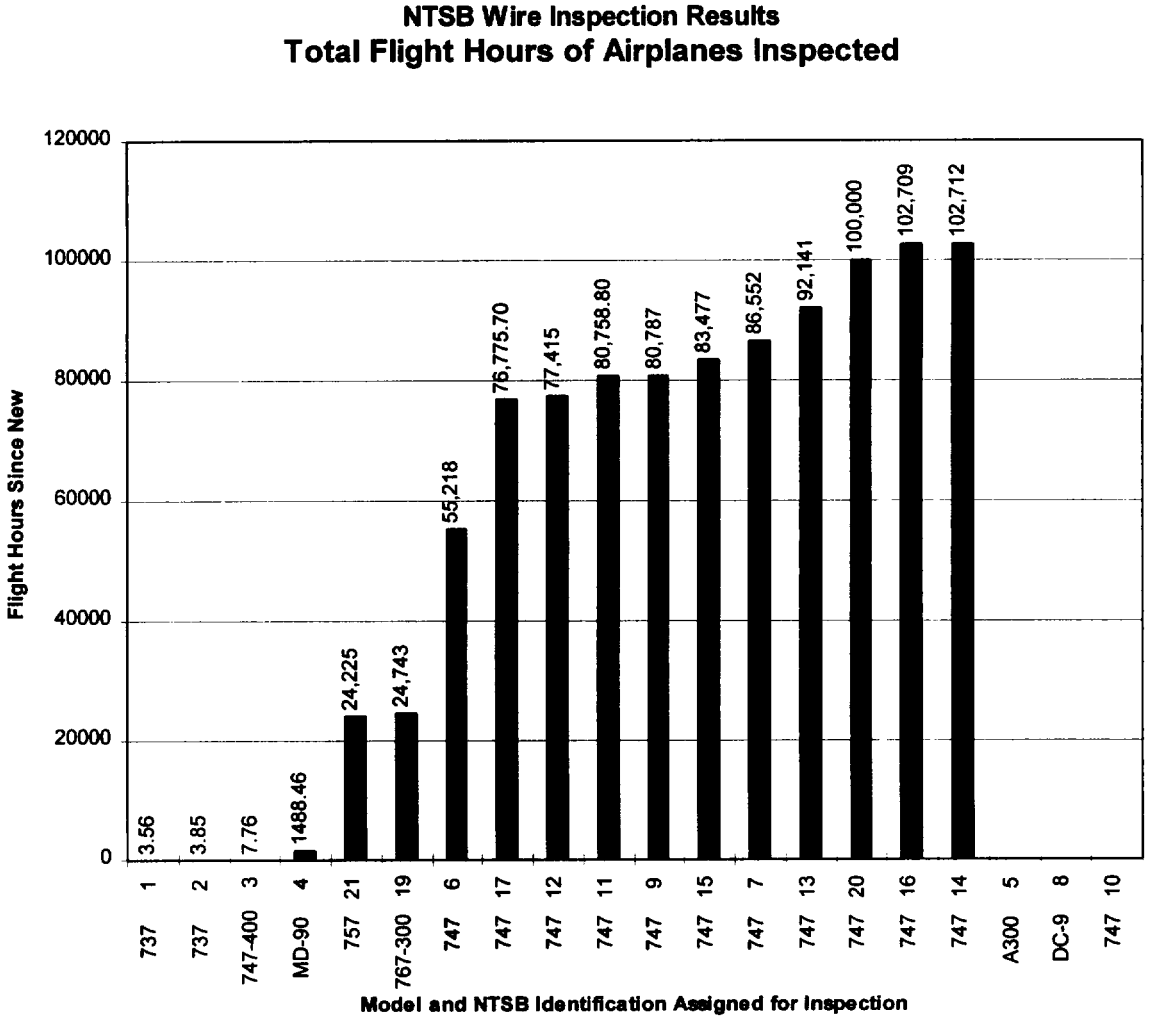
Table 2. SUMMARY OF OTHER AIRPLANE EXAMINATIONS RECORDED BY SAFETY BOARD WIRE DURING TW800 INVESTIGATION

NTSB ID# (See Note 1)	Model	Airline or Operator Location (See Note 1)	Date of Inspection	Date of Last Known Flight	Date of Last "D" Check (Or Equivalent)	Date of (D)elivery or (M)anufacture	Total Time Since New (TTSN) (hours)
19	767-300	U.S. Based	1/11/98	1/9/98	Unknown	10/27/92 (M)	24,743
20	747-100	European	1/12/98	Previous month	In process	1970 (M), April 1974 (D)	100,000+
21	757	U.S. Based	7/29/98	May 1998	1994	March 1982 (M)	24,225
22	L-1011	U.S. Based	11/9/98	11/9/98	Unknown	Unknown	Unknown
23	L-1011	U.S. Based	12/22/98	12/22/98	Unknown	Unknown	Unknown
24	MD-11	U.S. Based	1/31/99	1/31/99	Unknown	March 30, 1993 (D)	25,532
25	MD-11	U.S. Based	3/29/99	3/29/99	Unknown	Unknown	Unknown

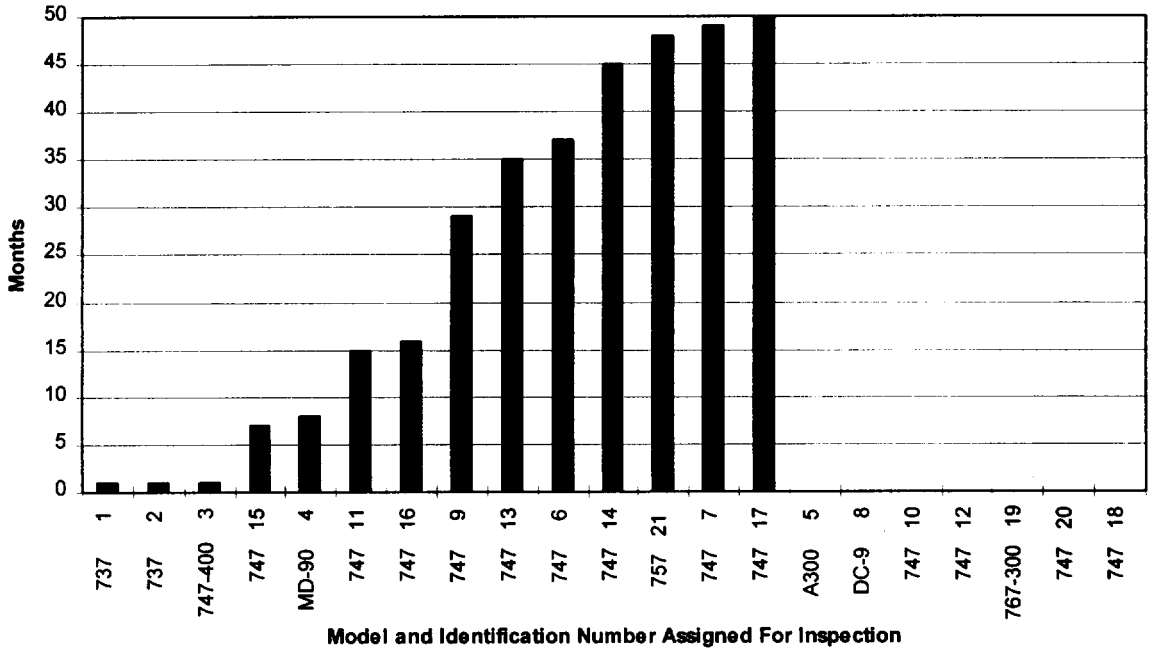
General Notes:

(1) Airlines and airplane registrations have been deleted in appreciation of their cooperation and airline concerns that the results could negatively impact competitive positions.

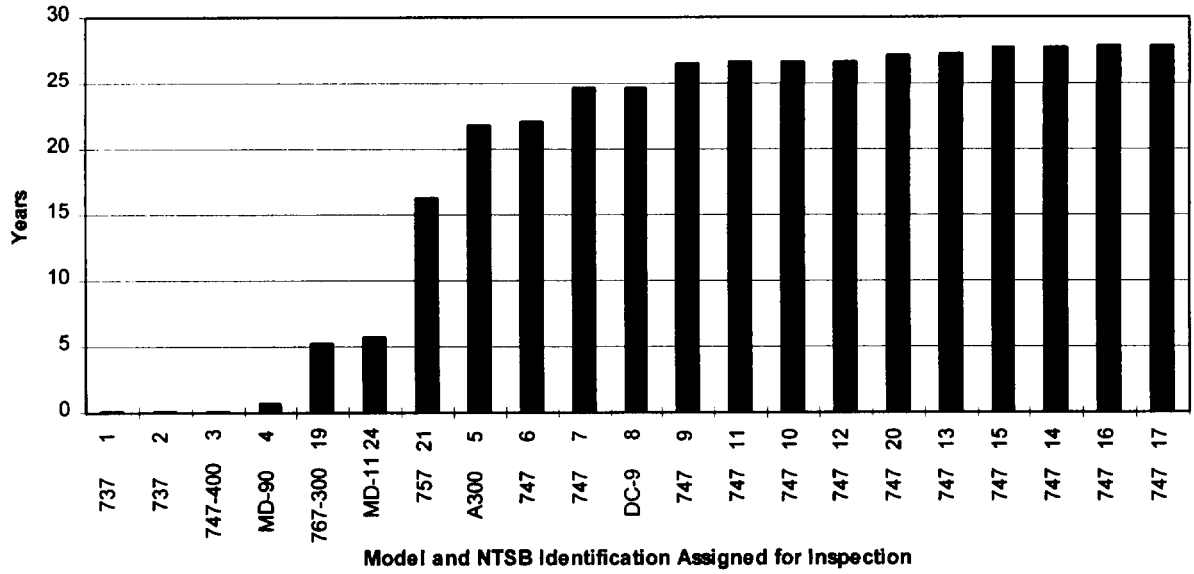
CHARTED (AVAILABLE) DATA FOR AIRPLANES 1-25:



NTSB Wire Inspection Results
Time Between D-Check and Last Flight



NTSB Wire Inspection Results
Airplane Age When Inspected



WIRE CONDITIONS NOT ATTRIBUTED TO A SINGLE AIRPLANE

The February 21-25, 1998, Systems Group made observations that were applicable to more than one airplane and made notations that did not cite the airplane that was being examined when the notes were made.

Wire insulation was found cut where metal debris was found between the individual wires in wire bundles. Chafes to wire insulation were found, including some that exposed the core conductors.[18] The damage was found between wire bundles, where wires contacted structure, at damage sites within "cushioned" loop clamps, and through holes worn in sleeves of woven material covering the wires.

The wire bundles in wheel wells were typically black and oily in texture and fluid was found on wires located near hydraulic actuators in wings. Grease was found on wires near flap drives and on landing gear struts.

Wires were routed loosely in fiber-reinforced trays[19] over the CWT without the individual bundle definition shown in Production Illustrations, such as 61B70126. The large APU and galley power cables are shown routed parrelel to the trays in Production Illustrations, such as 61B70126, and were found with this routing, immediately above the top surface of the CWT.

The Systems Group used manufacturer and airline wiring diagrams during the inspection of airplane wiring. The wiring diagrams were consistent with basic system installations, but did not reflect many post-manufacture changes. Airplane inspections found some wires that were not shown on wire diagrams and the origins of the wires were only established by searching modification (engineering) orders or vendor drawings for added systems. Wiring of disabled systems remained in the airplanes of operators after the systems were deleted from wire diagrams. Parallel small wire bundles were tied into larger wire bundles differently than shown in production illustrations.

The foam pads in wire bundle (raceway) clamps were found degraded in airplanes during the inspections of February 21-25, 1998. One pad that was not visually degraded and two that visibly had no integrity to the pad material were sumitted to the Boeing Engineering Quality Assurance (EQA) Laboratory. The laboratory reported (Chem 6883, see attached "NO SINGLE AIRPLANE") that two of the submitted clamps had degradation and that the third did not. The same part marking was on the most degraded clamp and the one with the intact pad. The third pad was found to have "a good deal of deterioration." The BACKGROUND Section of the Report stated that "Exposure to fluid or overheating were suspected possible causes of the damage to the foam, which is specified in BACC10DS to be a modified closed-cell silicone foam rubber per BMS 1-68." The results of the report stated that "Optical inspection revealed that the

[18] Although the damage limits contained in the SWPM are not shown here since the limits vary by wire type, penetration to the core conductor exceeds damage limits for all wire types.

[19] Boeing stated in a letter of November 20, 1997, that the trays were constructed of BMS 8-80R or BMS 8-2K.

non-degraded yellow pad consisted of an open-cell foam material. The remains of the degraded black and yellow pads appeared to have originally consisted of solid blocks of material rather than open-cell foam. Both pads were partially liquid in character." The report further stated that the pre-polymers used to synthesize the pads were different and that the degraded pads were synthesized from polyester pre-polymers that "have poor resistance to environment in that the ester linkage is subject to hydrolysis."

WIRING EVENT RECORDS

The following records were found from events that involved airplane electrical systems (records from each are attached).

Table 3. **SUMMARY OF WIRING EVENT RECORDS REVIEWED**

NTSB ID# (See Note 1)	Model	Airline or Operator Location	Date of Incident	Summary of Events
26	B-757	European	6/22/98	In the climb out of LCA and passing FL255, loud bang and shower of sparks from overhead panel, some of which landed on Captain (the First Officer was flying). Flight instruments failed and batteries began to discharge. Overweight landing performed at LCA. Post-flight inspection of this and 3 (of 15) other B-757 airplanes revealed wires chafed to a bracket. (See attch "AIRPLANE 26.")
27	B-747	European	7/19/97	C/Bs opened while on approach to JFK in an airplane that had been converted from passenger to freight use. Investigation found burned wiring in the front cargo hold. Drill shavings were found by operator in the area of damaged wires in this and other airplanes.
28	B-747	European	4/28/97	Smoke entered the cabin while en route and sparks were seen coming from an overhead panel. The British AAIB reported finding that metal debris had damaged wire insulation. (See attch "AIRPLANE 28.")
29	B-747	Asian	10/12/96	Wire fire on forward spar during maintenance. Investigation found arcing at shield termination and either use of improper material (wire type) or improper maintenance practice. (See attch "AIRPLANE 29.")
30	B-737	European	10/22/95	Enroute with the autopilot engaged, the aircraft experienced roll/yaw oscillations which ceased when the plane was slowed from 290 knots. Evidence of fluid contamination was found bridging pins within an electrical connector. (See attch "AIRPLANE 30.")
31	MD-11	Asian	9/6/95	Fire found in E/E prior to starting engines. Eleven wires were found separated after the fire and the investigation found that the position of a clamp permitted vibration and wear. (See attch "AIRPLANES 31,33.")
32	Nimrod	European	5/16/95	The crew ditched the airplane after an in-flight fire was discovered and after receiving indications that the air start valve (ASV) opened. Evidence of arcing in a wire bundle containing the ASV control circuit was found. The investigation concluded that "the prime cause of loss of this aircraft was the uncommanded opening of the No 4 engine ASV whilst in flight, compounded by a latent defect within the ASM. This resulted in the release of the ASM turbine whilst rotating at high speed and the subsequent puncture of the No 2 fuel tank," (See attch "AIRPLANE 32.")
33	B-737-300	Asian	10/10/94	Post-landing inspection found an insulation blanket on [or evidence of?] fire beneath the E2 rack in the E/E. Examination found improper installation of a wire bundle clamp led to contact and chafing between the metal portion of the clamp and wires. (See attch "AIRPLANES 31, 33.")
34	C-130A	U.S.	8/13/94	Witnesses saw the aircraft in level flight and observed a bright orange flash near the wing root. The probable cause of the accident included listing a fuel leak and arcing of wiring. The dry bay area of the right wing contains high pressure fuel lines, unshielded and exposed electrical wiring, and is in close proximity to the No. 3 engine. (See attch "AIRPLANE 34.")
35	B-757	European	5/10/85	Both generators tripped off while en-route and smoke temporarily appeared in the passenger cabin. Fluid from the lavatory was found on a burned area of wire bundle and insulation was found damaged by improper hot stamp marking process. (See attch"AIRPLANE 35.")

General Notes:

(1) Airlines and airplane registrations have been deleted in appreciation of their cooperation and airline concerns that the results could negatively impact competitive positions.

SAFETY BOARD ACCIDENT/INCIDENT DATA BASE SEARCH

The Safety Board data base was queried for air transport airplane records and that contained the words records "wire" or "wiring." The search found fifteen records from the 1983 to 1999 period. The results of the search are shown below.

Table 4. SAFETY BOARD ACCIDENT/INCIDENT DATA BASE SEARCH

(Airplane 36)

MKC83IA116	05/27/83	KANSAS CITY,MO	L-1011-385-1

DURING DESCENT AN ELECTRIC WIRE BUNDLE SHORTED BEHIND THE FLIGHT ENGINEERS PANEL, A FIRE ERUPTED WITH SMOKE. THE FLIGHT ENGINEER USED A PORTABLE FIRE EXTINGUISHER TO PUT OUT THE FIRE.

(Airplane 37)

ANC84IA002	10/07/83	JUNEAU,AK	727-247

ACFT DEVELOPED SMOKE IN THE COCKPIT ON TAKEOFF & SUBSEQUENTLY THE SMOKE ABATED. A SECOND EPISODE OCCURRED AT THE TOP OF THE CLIMB. THE RIGHT HAND TAXI LIGHT SWITCH HAD FAILED IN AN OVERHEAT CONDITION & BURNED THE INSULATION FROM AN ADJACENT WIRE.

(Airplane 38)

CHI84IA196	05/17/84	MINNEAPOLIS,MN	DC-10-40

DURING CLIMB FROM FL330 TO FL370 THE 1ST OFFICER SAW SPARKS AND SMOKE COMING FROM THE LEFT SIDE PANEL UNDER HIS GLARE SHIELD. COCKPIT LIGHTS WERE TURNED OFF AND SMOKE STOPPED. FLT RETURNED TO MINNEAPOLIS AND LANDED WITHOUT INCIDENT. INSPECTION OF THE ACFT DISCLOSED THE FIRE WAS IN A WIRE BUNDLE LOCATED BTW CENTER OF INSTRUMENT PANEL AND THE FLORESCENT LIGHT UNDERNEATH THE 1ST OFFICER'S GLARE SHIELD. THE WIRE BUNDLE (REINSTALLED 4 DAYS BEFORE) WAS STRETCHED TIGHTLY ACROSS THE LEFT END OF THE FLORESCENT LIGHT AND WAS FORCED TO TURN AN ABRUPT ANGLE ACROSS A SHARP METAL EDGE ON THE LIGHT. INSULATION AND FABRIC SLEEVE AROUND THE WIRES WAS BURNED LEAVING THE WIRES EXPOSED. TESTING OF THE CIRCUIT BREAKERS DID NOT DETERMINE WHY THEY FAILED TO OPEN.

(Airplane 39)

SEA87IA003	10/05/86	SEATTLE,WA	DC-10-10

DURING ATTEMPT TO APPLY GROUND POWER TO ACFT, INTERNAL FEEDER CABLES SHORTED AND MELTED DOWN. INVESTIGATION REVEALED POOR WORKMANSHIP BY CONTRACTED MAINTENANCE PERSONNEL IN MODIFICATION INSTALLATION.

(Airplane 40)

NYC87IA202 07/12/87 BOSTON,MA 767-232

A BOEING 767, WAS NR THE OUTER MARKER (OM) ON AN ILS RWY 22L APCH WHEN THE FLT CONTROL SYS SENSED AN UNCOMMANDED GO-ARND. THE ACFT DRIFTED RGT OF THE LOCALIZER FOR OVR 1 MIN. AT ABT 1000' AGL, RWY 22R WAS SIGHTED TO THE LEFT & A NORMAL LANDING WAS MADE ON THAT RWY. RWY 22R WAS OFFSET 1500' TO THE RGT OF RWY 22L. A BOEING 727, WHICH PRECEDED THE INCIDENT ACFT, WAS LEARED TO CROSS THE RGT RWY. THE CONTROLLER FAILED TO OBSERVE THE PROGRESS OF THE BOEING 767 AFTER IT PASSED THE OM. THE BOEING 727 CREW SAW THE BOEING 767 LANDING LIGHTS AS THE ACFT APCHD RWY 22R & NOTIFIED THE TOWER IT WOULD HOLD SHORT OF THE RWY. THE DELTA CAPTAIN HAD A REPUTATION FOR DOMINANT BEHAVIOR WHICH TENDED TO SUPPRESS OTHERS IN THE COCKPIT. THE AIRLINE OPS MANUAL GAVE MINIMAL DIRECTION CONCERNING MISSED APPROACHES. THE UNCOMMANDED GO-AROUND MALFUNCTION WAS TRACED TO A FAULTY WIRING HARNESS IN THE THROTTLE QUADRANT.

(Airplane 41)

DCA88IA044 03/30/88 BOSTON,MA DC-10-40

DRG TAXI TO GATE AFTER LDG, CREW STARTED APU NORMALLY. WHILE TAXIING NR 3 PNEUMATIC DUCT FAIL LT ILLUMINATED. LATER, THE CENTER ACCESSORY COMPT (CAC) DOOR WARNING LT ILLUMINATED AND GND PERS SAW SMOKE EMANATING FM THE FUSELAGE OUTFLOW VALVES. AFTER ENG SHUTDOWN, SMOKE ENTERED THE CABIN AND THE APU TRIPPED OFF. FIRE DEPT PERS FND CAC OUTSIDE DOOR HOT, THEN, USING CABIN FLOOR HATCH, OBSRVED 1-2 FT HIGH FLAMES IN CAC. FIRE WAS EXTINGUISHED WITH DMG LIMITED TO CAC. INVEST REVEALED IMPROPER/LOOSE BATTERY GND CONNECTION. NORMAL CABLE MOVEMENT WOULD LOOSEN CONNECTION DRG BATT DISCONNECT. BURNED INSULATION BLANKETS MET SPEC BUT WERE COATED WITH SYNTHETIC HYD FLUID (SLAT ACTUATOR LKG) AND JET FUEL. FIRE PATTERN SUGGESTED FUEL SEEPAGE ALONG BULKHEAD FASTENER LINE. BATT GND LAST INSTALLED NOV,87. BATT LAST CHDG 2 WKS BEFORE INCIDENT. SERVICE BULLETIN PERTAINING TO BATT GND NOT COMPLIED. INOPERATIVE CAC DRAIN VALVES ALLOWED FUEL TO POOL IN CAC BILGE. NO CAC FIRE WARNING OR EXTINGUISHER SYSTEM WAS INSTALLED.

The National Transportation Safety Board determines that the probable cause(s) of this incident was:
THE IMPROPER INSTALLATION OF THE BATTERY GROUND CONNECTION THAT RESULTED IN PREMATURE LOOSENING OF THE CONNECTION AND ELECTRICAL ARC IGNITION OF POOLED FUEL IN THE CAC BILGE. THE FUEL WAS NOT DRAINED OVERBOARD DUE TO INOPERATIVE CAC BILGE AREA DRAIN VALVES. CONTRIBUTING TO THE INCIDENT WAS NORTHWEST'S NON-COMPLIANCE WITH A SERVICE BULLETIN TO MODIFY THE GROUND CABLE ATTACHMENT BRACKET TO PREVENT LOOSENING OF THE CONNECTION.

(Airplane 42)

DCA88MA052 04/15/88 SEATTLE,WA DHC-8

SHORTLY AFTER TKOF FROM SEATTLE-TACOMA INTL AIRPORT, THE CREW NOTED A RT ENG POWER LOSS AND DECIDED TO RETURN FOR A PRECAUTIONARY LNDG. AFTER LOWERING THE LNDG GEAR, A MASSIVE FIRE WAS DISCOVERED IN THE RT ENG NACELLE. AFTER LNDG, DIRECTIONAL CONTROL AND ALL BRAKING WAS LOST. THE ACFT DEPARTED THE LEFT SIDE

OF THE RWY 16L AFTER THE LEFT POWER LEVER WAS MOVED TO FLT IDLE. THE F/O ADVISED TWR THAT THE ACFT WAS OUT OF CONTROL. THE ACFT ROLLED ONTO THE RAMP AREA WHERE IT STRUCK A RWY DESIGNATOR SIGN, GROUND EQUIPMENT, AND JETWAYS B7 AND B9. THE ACFT WAS SUBSEQUENTLY DESTROYED BY FIRE. INVESTIGATION REVEALED THAT DURING OVERHAUL THE HIGH PRESSURE FUEL FILTER COVER WAS IMPROPERLY INSTALLED ON THE ENG AND THE IMPROPER INSTALLATION WAS NOT DISCOVERED DRG COMPANY INSTALLATION OF THE ENG ON THE ACFT. THIS LED TO A MASSIVE FUEL LEAK AND THE NACELLE FIRE. THE FIRE/EXPLOSION CAUSED THE LOSS OF THE ENG PANELS, REDUCING THE EFFECTIVENESS OF THE FIRE SUPPRESSION SYSTEM AND ALLOWING OTHER SYSTEMS TO BE DAMAGED. (FOR FURTHER INFORMATION-SEE NTSB/AAR-89/02.)

(Airplane 43)

LAX90FA061 12/30/89 TUCSON,AZ 737-204

DURING APPROACH, A FIRE ERUPTED IN THE WHEEL WELL OF THE 22-YR OLD AIRPLANE. THE FIRE BURNED THRU THE HYDRAULIC LINES RENDERING THE A, B, & STANDBY HYD SYSTEMS INOP. THE CREW LANDED THE AIRPLANE USING THE EMERGENCY MANUAL REVERSION FLIGHT CONTROL SYSTEM. HOWEVER, THE AIRPLANE WAS UNABLE TO STOP ON THE RUNWAY BECAUSE OF THE PREVIOUS FAILURES OF THE CHECK VALVES IN THE BACKUP HYD ACCUMULATOR PRESSURE SYSTEMS FOR THE #2 THRUST REVERSER AND THE INBOARD PAIR OF WHEEL BRAKES. DURING THE 2 MIN ROLLOUT, THE AIRPLANE TRAVERSED 14,000 FT, OVERRAN THE RWY END, AND COLLIDED WITH A CONCRETE STRUCTURE WHICH COLLAPSED THE NOSE GEAR. THE AIRPLANE HAD RECENTLY UNDERGONE A "C" CHECK DURING WHICH THE OPERATOR'S MECHANICS FAILED TO OBSERVE & REPAIR AN ELECTRIC WIRE WHICH HAD BEEN CHAFING AGAINST A HYD LINE. ON THE ACCIDENT FLT THE ENERGIZED WIRE ARCED, PUNCTURED THE LINE, & IGNITED THE ESCAPING HYD FLUID. THE HYD CHECK VALVES HAD FAILED EARLIER DUE TO MECHANICAL WEAR.

The National Transportation Safety Board determines that the probable cause(s) of this accident was:
FAILURE OF THE OPERATOR'S MAINTENANCE PERSONNEL TO DETECT AN ELECTRICAL WIRE WHICH HAD CHAFED AGAINST A HYDRAULIC LINE AND WHICH EVENTUALLY ARCED CAUSING A LEAK IN THE HYDRAULIC LINE AND SUBSEQUENT FIRE AND HYDRAULIC SYSTEM FAILURE. IN ADDITION, PREVIOUS WEAR OF CHECK VALVES IN THE BACKUP HYDRAULIC SYSTEMS PREVENTED THE AIRPLANE FROM STOPPING ON THE RUNWAY. A CONTRIBUTING FACTOR WAS THE AIRPLANE MANUFACTURER'S INADEQUATE GUIDANCE FOR MAINTAINING THE HYDRAULIC COMPONENTS.

(Airplane 44)

NYC92IA030 11/13/91 TOLEDO,OH DC-8-63

THE MAIN CARGO DOOR OPENED IN FLIGHT AND THE AIRPLANE RETURNED FOR A NORMAL LANDING. OF THE TWO CIRCUIT BREAKERS REQUIRED TO BE PULLED PRIOR TO TAKEOFF, ONE WAS FOUND STILL ENGAGED. A CONFORMITY INSPECTION ON THE CARGO DOOR INSTALLATION REVEALED SEVERAL AREAS OF NONCONFORMITY INCLUDING DOOR LOCKS OF LESS THAN REQUIRED STRENGTH, LACK OF PAINT ON DOOR LOCKS WHICH IS USED FOR VISUAL IDENTIFICATION, AND DAMAGED WIRES IN A BUNDLE. THE WIRES WERE PART OF THE DOOR CLOSING, DOOR LOCKED INDICATING SYSTEM. THE INVESTIGATION REVEALED IT WAS POSSIBLE FOR THE DOOR TO BE NOT COMPLETELY CLOSED AND HAVE THE DOOR WARNING LIGHT GO OUT, INDICATING IT WAS FULLY LOCKED.

The National Transportation Safety Board determines that the probable cause(s) of this incident was:
THE FAILURE OF THE FLIGHT ENGINEER TO CONDUCT A PROPER PREFLIGHT INSPECTION AND ENSURE THE MAIN CARGO DOOR WAS FULLY CLOSED AND LOCKED. FACTORS RELATED TO

THE ACCIDENT WERE THE DAMAGED WIRES IN THE BUNDLE, AND THE IMPROPER MAIN CARGO DOOR INSTALLATION.

(Airplane 45)

ATL92IA025 11/20/91 ATLANTA,GA MD-88

SHORTLY AFTER LIFTOFF A PASSENGER IN ROW 18 REPORTED OBSERVING FLAMES COMING FROM THE OVERHEAD AREA ON THE RIGHT SIDE OF THE AIRPLANE. THE FLIGHT ATTENDANT SUPPRESSED THE REPORTED AREA WITH A HALON FIRE EXTINGUISHER AND REPORTED THE INCIDENT TO THE FLIGHT DECK. HOWEVER, THE FLIGHT ATTENDANT DID NOT REPORT SEEING FLAMES. AN EMERGENCY LANDING WAS MADE AT THE DEPARTURE AIRPORT WITHOUT FURTHER INCIDENT. EXAMINATION OF THE OVERHEAD AREA AROUND ROW 18 REVEALED THAT THE CANNON PLUG CONNECTOR ADJACENT TO THE LIGHT ASSEMBLY HAD SHORTED. SUBSEQUENT EXAMINATIONS OF THE CONNECTOR REVEALED THAT PINS IN THE MATING HALVES OF THE CONNECTOR WERE DAMAGED, AND APPEARED TO HAVE OCCURED WHEN A PREVIOUS CONNECTION WAS ATTEMPTED. RESEARCH EFFORTS TO DUPLICATE THE CONNECTOR FAILURE MODE FAILED. A REVIEW OF THE OPERATORS MAINTENANCE RECORDS FAILED TO DISCLOSE IF ANY MAINTANANCE HAD BEEN CONDUCTED IN THE AREA OF THE CONNECTOR. HOWEVER, THE OPERATOR COULD NOT VERIFY THAT THE CONNECTOR AND AFFECTED AREAS WERE NEVER SERVICED DURING A PREVIOUS STOPOVER

The National Transportation Safety Board determines that the probable cause(s) of this incident was:
A SHORT IN AN ELECTRICAL CONNECTOR WHICH RESULTED IN ITS FAILURE. THE REASON FOR THE SHORT WAS NOT DETERMINED. A FACTOR WAS THE IMPROPER INSTALLATION OF THE CONNECTOR BY AN UNKNOWN MAINTENANCE PERSON.

(Airplane 46)

DEN92IA025 01/03/92 DENVER,CO 737-300

DURING CLIMB, THE CREW NOTED AN ELECTRICAL ARCING SOUND AND SLIGHT ELECTRICAL-TYPE BURNING ODOR WHILE PASSING THROUGH FLIGHT LEVEL 180. EMERGENCY PROCEDURES WERE COMPLIED WITH AND THE PROBLEM APPEARED TO BE SOLVED. THE CLIMB WAS CONTINUED, AND WHILE PASSING THROUGH FLIGHT LEVEL 330 A LOUD ARCING SOUND WAS AGAIN HEARD ACCOMPANIED BY FLAMES FROM THE FLIGHT DECK AFT OVERHEAD PANEL. THE FLIGHT ATTENDANTS EXTINGUISHED THE FIRE, AND THE FLIGHT RETURNED TO DENVER AND LANDED WITHOUT FURTHER INCIDENT. EXAMINATION DISCLOSED A SHORT IN A WIRE BUNDLE. THE BUNDLE WAS NOT SHIELDED OR ANCHORED AS THE OTHER MAJOR BUNDLE IN THE COMPARTMENT. THE SHORT WAS DUE TO THE BUNDLE CHAFING ON THE FLIGHT DECK ENTRY DOOR FRAME. IN ADDITION, TESTING REVEALED THAT THE WIRE GAUGE USED IN PART OF THIS APPLICATION WAS INSUFFICIENT FOR THE ELECTRICAL LOAD.

The National Transportation Safety Board determines that the probable cause(s) of this incident was:
AN ELECTRICAL SHORT CIRCUIT IN A MAIN WIRE BUNDLE DUE TO CHAFING OF THE BUNDLE ON AIRFRAME STRUCTURAL MEMBERS.

(Airplane 47)

CHI94IA095 02/25/94 MOSINEE,WI ATP

THE FLIGHT CREW SAW SMOKE IN THE COCKPIT WHILE DESCENDING FROM CRUISE AND DECLARED AN EMERGENCY. THE COPILOT DISCOVERED THE SOURCE OF THE SMOKE TO BE A RED-HOT PUSH BUTTON SELECTOR INDICATOR (PBSI) SWITCH FOR THE FLIGHT IDLE BAULK TEST. HE DISCHARGED A PORTABLE FIRE EXTINGUISHER ON THE SWITCH AND THE SMOKE

STOPPED. THE SWITCH WAS SUBSEQUENTLY REMOVED BY MAINTENANCE PERSONNEL AND FOUND TO SCORCHED AND MELTED. ADJACENT WIRING WAS ALSO HEAT DAMAGED. THE MANUFACTURER HAD PREVIOUSLY ISSUED TWO SERVICE BULLETINS WHICH DEALT WITH PBSI SWITCH MALFUNCTIONS ASSOCIATED WITH WATER INGRESS TO THE COCKPIT IN THE VICINITY OF THE SWITCHES. THE OPERATOR HAD NOT COMPLIED WITH THE VOLUNTARY SERVICE BULLETINS AT THE TIME OF THE INCIDENT.

The National Transportation Safety Board determines that the probable cause(s) of this incident was:
THE INADEQUATE DESIGN OF THE PBSI ELECTRICAL SWITCH(ES), AND THE OPERATOR'S FAILURE TO EXPEDITIOUSLY IMPLEMENT CORRECTIVE SERVICE BULLETINS.

(Airplane 48)

CHI96IA109 03/18/96 DETROIT,MI A320-211

THE CAPTAIN REPORTED THAT THE CREW LEVELED AT FLIGHT LEVEL 370 AND RECEIVED AN ELEVATOR AILERON COMPUTER (ELAC) NUMBER TWO PITCH FAULT MESSAGE. THE MESSAGE CLEARED ITSELF. A FEW MINUTES LATER THEY RECEIVED SERVO FAULT MESSAGE. THE "PITCH JUMPED +/- 100 FEET." THE CREW DESCENDED TO FLIGHT LEVEL 350. DURING THE LEVEL OFF THEY RECEIVED AN ELAC NUMBER ONE PITCH FAULT MESSAGE. THE CREW DECLARED AN EMERGENCY AND LANDED UNEVENTFULLY. THE AIRCRAFT MAINTENANCE LOG REVEALED A SIMILAR OCCURRENCE ON THE PREVIOUS FLIGHT. INVESTIGATION REVEALED AN INTERMITTENT FAULT IN THE ELEVATOR SERVO CONTROLLER ELECTROVALVE COIL AND A DEFECTIVE DIODE IN THE ELECTRONIC MODULE FOR ONE OF THE STABILIZER ACTUATORS. THE DEFECTIVE DIODE PRODUCED AN INTERMITTENT LOSS OF ELECTRICAL MOTOR POWER DURING TRANSIENT, CLOSED LOOP CONTROL OF THE ACTUATOR.

The National Transportation Safety Board determines that the probable cause(s) of this incident was:
A DEFECTIVE DIODE IN THE NUMBER TWO STABILIZER ACTUATOR THAT PRODUCED AN INTERMITTENT LOSS OF ELECTRICAL MOTOR POWER DURING TRANSIENT, CLOSED LOOP CONTROL OF THE ACTUATOR. A FACTOR WAS THE INTERMITTENT OPEN CIRCUIT IN THE ELEVATOR SERVO CONTROLLER ELECTROVALVE COIL.

(Airplane 49)

CHI97IA195 07/05/97 FLINT,MI DC-9-30

THE CAPTAIN AND FIRST OFFICER NOTICED SMOKE COMING FROM UNDERNEATH THE AIRPLANE'S INSTRUMENT PANEL GLARESHIELD WHILE AT CRUISE ALTITUDE. AFTER PUTTING ON SMOKE GOGGLES AND OXYGEN MASKS THE FLIGHT CREW PERFORMED THE EMERGENCY CHECKLIST. UPON SHUTTING DOWN THE GENERATORS, THE SMOKE CLEARED FROM THE COCKPIT IN ABOUT 4-MINUTES. THE FLIGHT LANDED AND ITS PASSENGERS DEPLANED WITHOUT INCIDENT. EXAMINATION OF THE INSTRUMENT PANEL AREA REVEALED BURNT WIRING AND A CHARRED POSITION LIGHT SWITCH. FURTHER EXAMINATION SHOWED THAT THE LEFT WINGTIP'S OSCILLATING POSITION LIGHT AUTOTRANSFORMER HAD SHORTED OUT, AND THE POSITION LIGHT CIRCUIT BREAKER WAS STUCK IN THE CLOSED POSITION.

The National Transportation Safety Board determines that the probable cause(s) of this incident was:
AN ELECTRICAL SHORT IN THE WIRING OF THE LEFT WINGTIP OSCILLATING POSITION LIGHT AUTO TRANSFORMER AND A FAILURE OF THE SYSTEM CIRCUIT BREAKER.

(Airplane 50)

CHI98IA164 05/18/98 MINNEAPOLIS,MN 747-123

WHILE TROUBLESHOOTING A FIRE WARNING INDICATION WITH COMPANY MAINTENANCE CONTROL USING THE #2 VHF TRANSCEIVER, THE CREW EXPERIENCED SEVERAL UNCOMMANDED "KICKS" OF THE YAW DAMPER. THE CREW TURNED OFF THE UPPER YAW DAMPER, BUT NOT THE LOWER. THEY CONTINUED TO EXPERIENCE "KICKS" ALTHOUGH NOT AS SEVERE. THE FLIGHT DEPARTED TO MINNEAPOLIS WHERE IT LANDED UNEVENTFULLY. INSPECTION OF THE AIRPLANE AFTER THE INCIDENT REVEALED AN OPEN SHIELD AT THE #2 VHF COAX CONNECTOR WHICH IS LOCATED NEAR THE YAW DAMPER CONTROL BOX. THE CONNECTOR WAS REPLACED AND THE AIRPLANE WAS RETURNED TO SERVICE.

The National Transportation Safety Board determines that the probable cause(s) of this incident was:
THE OPEN SHIELDING ON THE #2 VHF TRANSCEIVER COAX CONNECTOR WHICH RESULTED IN ELECTROMAGNETIC INTERFERENCE WITH THE YAW DAMPER SYSTEM.

FAA SERVICE DIFFICULTY REPORTING (SDR) SYSTEM DATA

Table 5. SDR SEARCH FOR 747 AND "FIRE/SMOKE"

The FAA SDR data base was queried for air transport airplane records that contained the words records "fire" and "smoke." The search found 47 electrical fire/smoke records from 1987-1993. Six of the SDRs were from B-747 airplanes and these are shown below.

AIRPLANE	FAA DATE & CONTROL NUMBER	TEXT OF SERVICE DIFFICULTY REPORT
51	87061200030	ELECTRICAL FIRE STARTED AT PAX ENTERTAINMENT CONTROL BOX AT R-4 DOOR DURING LANDING AT ROME. ELECTRICAL PLUG REMOVED AND CONFIRMED SOURCE OF BURNING WAS CONTROL BOX.
52	88120200029	WIRING BURNED (ELECTRICAL FIRE) AT FLOOR LINE FS 1200 RIGHT CIRCUIT BREAKER FOR PALLET DRIVE WHEELS P13, 14, 15, 16, 17, AND 18 RIGHT TRIPPED ON P-129 PANEL. 13 WIRES BURNED IN A 6-8 INCH AREA.
53	9007200008	CREW REPORTED ELECTRICAL FIRE UNDER AFT GALLEY PERSONAL ELEVATOR. FLAMES AND SMOKE, DISCHARGE TWO FIRE EXTINGUISHERS, TURNED OFF GALLEY POWER AND PULLED CIRCUIT BREAKER.
54	90102900135	DURING CRUISE, AN ELECTRICAL FIRE OCCURRED IN UPPER CONTROL MODULE OF THE FIRST-CLASS GALLEY. PORTABLE HALON FIRE EXTINGUISHERS USED TO EXTINGUISH FIRE. FOUND CAPACITOR SPLIT IN OVEN CONTROLLER, REPLACED UPPER OVEN CONTROLLER AND BOTH HALON BOTTLES.
55	86122100013	ELECTRICAL FIRE IN CLIPPER GALLEY. FORWARD COFFEE MAKERS. USED HALON FIRE EXTIGUISHER. NO DAMAGE TO GALLEY. FOUND RIGHT COFFEEMAKER ELECTRIC WIRES DAMAGED. COFFEEMAKER PLACARDED INOPERATIVE INOPERATIVE CONNECTORS REMOVED.
56	90020200119	EN ROUTE, AN ELECTRICAL FIRE STARTED IN GALLEY NR 2, THE FIRE WAS EXTIGUISHED USING THE HALON FIRE BOTTLE LOCATED AT 1L DOOR. UPON LANDING,

		MAINTENANCE DETERMINED THE CAUSE OF THE FIRE TO BE ATTRIBUTED TO A SHORTED WIRE.

Table 6. **SDR SEARCH FOR 747 AND "WIRE/CONNECTOR"**

The SDR records were searched for the words "wire" and "connector" from 1996. The search found 15 records from B-747 airplanes and these are shown below.[20]

AIRPLANE	FAA DATE & CONTROL NUMBER	TEXT OF SERVICE DIFFICULTY REPORT
57	9603150015	WHEN LEADING EDGE DEVICES WERE EXTENDED, THE NR 2 INDICATED AMBER. AIRCRAFT RETURNED TO BLOCKS. FOUND WIRING AT THE NR 2 POSITION SWITCH WAS SHORTING TO GROUND.
58	96040500466	INSPECTION FOUND EMERGENCY LIGHTS AT R-4 DOOR INOPERATIVE. MAINTENANCE FOUND LOOSE WIRING ON CANON PLUG AT CHARGING UNIT.
59	96062000199	DURING LINE CHECK, FOUND EMERGENCY LIGHTS AT DOOR 4R AND 2L INOPERATIVE. REPAIRED PIN AND WIRING.
60	96080800263	WIRES WORN THROUGH ON NR 3 ENGINE FIRE LOOP AT HYDRAULIC BOX FORWARD BRACKET AT 3 O'CLOCK POSITION.
61	96081500572	DURING DAILY CHECK, FOUND 'E' ZONE R/S 'E' PATH LIGHT INOP. REPLACED FUSE AND REPAIRED CHAFED WIRE AT SEAT.
62	96081500662	EN ROUTE MCE TO VIS, LEFT MAIN GEAR INDICATES DOWN AND LOCKED WITH GEAR RETRACTED. AIRCRAFT DIVERTED TO FAT. MX FOUND LEFT MAIN GEAR MICROSWITCH WIRES CHAFED.
63	96081500621	DURING DAILY SERVICE, FOUND 'J' AND 'Q' LAV SMOKE DETECTOR INOP. FOUND BROKEN WIRE, REPAIRED WIRING.
64	96082900112	DURING LINE CHECK, FOUND FLOOR EMERGENCY LIGHTS INOPERATIVE AT ROWS 51-66 LEFT AND 35-43 RIGHT. SECURED WIRING FOR EMERGENCY LIGHTS.
65	96082900760	DURING DAILY CHECK, FOUND 5L MED EMERGENCY LIGHT INOP. REPAIRED WIRING.
66	96090500525	DURING DAILY CHECK, FOUND UPPER DECK ALL FLOOR EVAC LIGHTS INOP. FOUND WIRE SHORTED TO GROUND.
67	96090500231	(CAN)ARCING SOUNDS AND SPARKS COMING FROM OVERHEAD PSU AT SEAT 4B. WIRING HARNESS THAT RUNS PARALLEL WITH SIDEWALL LIGHT ASSEMBLY ABOVE 4AB BURNT THROUGH.
68	96091200405	DURING DAILY CHECK, FOUND NR 2L MAIN ENTRY DOOR UPPER DOOR BUSTLE LIGHT INOP. FOUND CHAFED WIRE

[20] Excludes entries for light ballasts, failures to light sockets, reseated electrical connectors that clear faults, coffee maker entries, and secondary damage to wires caused by failure of other components.

		AT BUSTLE LIGHT CONNECTOR.
69	96091900633	DURING LINE CHECK, FOUND FLOOR PATH EMERGENCY LIGHTS INOPERATIVE FROM ROW 27B THROUGH 3L. RECONNECTED WIRING AND INSTALLED LIGHT ASSEMBLY.
70	96092600668	DURING CRUISE, ELECTRICAL ARCING AND SMOKE WAS EMMITTED FROM WORK LIGHT WIRING AT B-GALLEY COFFEEMAKER. SHUT OFF GALLEY ELECTRICAL POWER. FOUND CHARRED ELECTRICAL WIRING INSULATION.
71	96101000747	DURING DAILY CHECK, FOUND EVAC LIGHTS HAVE A SHORTED CIRCUIT ALONG SIDE SEAT 50H. REPAIRED WIRING.

BOEING WIRING INSPECTION (Service Letter 747-SL-20-048)
INSPECTION OF WIRING ON HIGH TIME AIRPLANES

Boeing inspected B-747 airplanes and on January 25, 1995, released Service Letter 747-SL-20-048 (attached) after "requested by operators to provide guidance on areas of wiring that warrant special attention on high time 747 airplanes." The service letter contained 37 photographs of electrical system components. Boeing stated that "Overall, Boeing has found that most airplane wiring exceeds the economic design goal of the airplane."

The service letter listed what "Boeing believes [what] are the principal causes of wiring degradation." The list of principal causes were:

Vibration,
Maintenance,
Indirect Damage,
Chemical Contamination,
General Maintenance, and
Heat

The service letter stated that the following are the types of areas that merit special attention during wiring inspections:

Clamping points,
Connectors,
Terminations,
Backshells,
Sleeving and Conduits.

The service letter stated that the following locations could be included in a special inspection of high time 747 airplane wiring and that the first three are in high vibration areas. A sample for "close examination of installed wire bundles with no clamps or wire ties removed" was attached to the service letter.

Wings,
Engine and Nacelle Area
Landing Gear,
Electrical Panels,
Power Feeders.

SAFETY RECOMMENDATIONS

Attached are 34 National Transportation Safety Board safety recommendations that were found during keyword searches for the words "breaker," "circuit," "circuitry," "electrical," "wire," and "wiring." These items do not include safety recommendations that indirectly mentioned the electrical components in the discussion of other systems (such as circuit breakers in cockpit voice recorder systems). The safety recommendations are attached with brief descriptions of the accident or incident, place, date, and subsequent correspondence.

PHOTOGRAPHS

Attached are 48 photographs depicting conditions found in airplanes inspected during the investigation. Also attached is the Boeing Service Letter (SL) 747-SL-20-048, which contains photographs of wiring conditions documented by Boeing.

Robert L. Swaim
TWA 800 Systems Group Chairman

7/28/99

National Transportation Safety Board
Washington, D.C.

ATTACHMENTS

Boeing Laboratory Report (Chem 6743), dated March 26, 1998,
Subject: Analysis of Contaminants on BACC45FT Connectors
Boeing Laboratory Report (Chem 6304), dated October 31, 1997,
Subject: Identification of Deposits on Wire Bundle
Air Force Research Laboratory Report (AFRL/MLSA 99-10), dated January 26, 1999,
Subject: Honeywell 757 Fuel Tank Compensator (Failure Analysis)
NTSB Airworthiness Factual Report (DCA99SA043), dated June 15, 1999,
Lockheed L-1011 Arcing And Smoke In Cockpit
NTSB Airworthiness Factual Report (DCA99SA044), dated June 11, 1999,
Lockheed L-1011 Sparks and Smoke From Wiring Beneath Lavatory
NTSB Preliminary Report, Aviation (DCA99SA037), [event] dated January 31, 1999,
McDonnell Douglas MD-11 With Fire in Video Unit
NTSB Preliminary Report, Aviation (DCA99SA051), [event] dated March 29, 1999,
McDonnell Douglas MD-11 With Burned Wires and Thermal Insulation
AIR 2000 Air Safety Report (B98/67), [event] dated June 22, 1998,
Loud Bang and Sparks in Flight Deck - Followed by Instrument Failures and Multiple EICAS Messages.
AIR 2000 Letter from Mr. Mick Rhodes to Mr. Paul Price, dated June 24, 1998,
Subject: AIR 2000 B757 FLEET INSPECTION
Air Accidents Investigation Branch (AAIB) Bulletin 10/97, [event] dated April 28, 1997,
Overheating damage to wiring loom and furnishing behind overhead panels.
Boeing Letter, From Mr. K. B. Buchanan to Mr. D. L. Riggin, dated December 16, 1996,
FAR 21.3 Report 96-1989, Wire Bundle Fire in Forward Lower Lobe - Model 747-200 - Status Report.
AAIB Report, [event] dated October 22, 1995,
Contamination of Electrical Connector and Flight Anomaly
Civil Aviation Administration of China Investigation Report of B-737 and MD-11 on Fire, dated May 24, 1996,
AAIB Report, [event] dated May 16, 1995,
Accident to RAF Nimrod XW666 in the Moray Firth, Scotland.
NTSB Accident Brief Format Report (LAX94FA323), [event] dated August 13, 1994,
In-flight Destruction of Lockheed C-130 Near Pearblossom, California.
Boeing 757 Service Bulletin Summary (757-24A00025), dated May 10, 1985,
Electrical Power - General - Wire Bundle Routing Modification.
Boeing Letter (B-B600-16409-ASI), From Mr. John W. Purvis to Mr. R. Swaim, dated May 19, 1998, Subject: Scrapped Airplane Wire Bundle Clamp Analysis
Safety Recommendations