



AVIATION INVESTIGATION REPORT

A07C0106



IN-FLIGHT COCKPIT FIRE

NORTHWEST AIRLINES INC.

BOEING 747-251B N632NW

WINNIPEG, MANITOBA, 150 nm N

19 JUNE 2007

Canada

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

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Summary

Northwest Airlines Inc. Flight 909, a Boeing 747-200 freighter (registration N632NW, serial number 23112) was en route from Wilmington, Ohio, to Anchorage, Alaska, United States, with a crew of three on board when the crew noticed smoke and fire emanating from a cockpit circuit breaker panel located behind the second officer's position. The crew completed the related emergency cockpit checklist procedures and declared an emergency with air traffic control. The fire self-extinguished during the action of the checklist procedures. The aircraft diverted to Winnipeg, Manitoba, landing safely at 0649 central daylight time with airport rescue and fire-fighting vehicles standing by. There were no injuries.

Ce rapport est également disponible en français.

Other Factual Information

A special aerodrome weather report was issued for Winnipeg at 0622 central daylight time.¹ The weather was as follows: wind 320° true (T) at 12 knots, visibility 15 statute miles with a few clouds at 1100 feet, broken clouds at 2200 and 9500 feet, and a temperature of 12°C. The weather, both at cruise altitude and at landing, did not play a factor in this occurrence.

At the time of the occurrence, the aircraft was in cruise flight at flight level 360. At approximately 0625, the second officer noticed a fluctuation in the number four engine fire-detection loop "A" nacelle temperature indicator. The fluctuation increased in intensity, followed by a blinking fault light on the engine fire-detection panel. The fault light eventually illuminated steady, along with a master fire-detection light in the cockpit annunciator panel. The crew accomplished the "Engine Fire Detection Light and/or Fault Light Illuminated" company operations manual (COM) Section 2.26.32 checklist in the emergency/abnormal procedures manual.

The fire-detection loop was selected from the loop "A" to the loop "B" position and the fault light extinguished. Soon after the completion of the checklist, an electrical smell was detected. The second officer confirmed that the smell was coming from behind the P6 panel located at the rear of the cockpit. The second officer looked through the designed viewing ports and saw flames and smoke within the panel. The crew members donned their oxygen masks and smoke goggles and control of the aircraft was given to the first officer. The first officer declared an emergency and requested a direct clearance to Winnipeg.

The captain and second officer began the "Electrical Fire or Smoke" COM Section 2.26.6 checklist, during which time the Engine Fire Detect 3A-4A circuit breaker on the P6 panel popped. The fire began to increase in intensity and stopped only after the crew tripped the number one and number two generator breakers in accordance with the checklist instructions. The fire damage was contained within the interior of the P6 panel and the visibility inside the cockpit was normal at all times. When the fire was out, the crew members removed their oxygen masks and smoke goggles. The captain took control of the aircraft and approximately 10 000 pounds of fuel was dumped to bring the aircraft down to its maximum landing weight. The fuel dump was terminated above 10 000 feet above sea level and a visual approach was made to Runway 36 at the James Armstrong Richardson International Airport in Winnipeg, where a safe landing was accomplished.

¹ All times are central daylight time (Coordinated Universal Time minus five hours).

The aircraft was inspected and the fire was found to originate from within the number four engine loop "A" (A4) circuit board warning card mounted in the fire-detection control electronics box located on the aft side of the P6 circuit breaker panel (see Photo 1). The fire had spread to both the adjoining A3 and A5 circuit cards, as well as to a major aircraft wiring bundle located above the control box. Maintenance personnel replaced the control box and the circuit cards and repaired the damaged wiring bundle. The number four engine was started and the number four engine fire-detection loop "A" nacelle temperature indicator again began to fluctuate as in the original



Photo 1. P6 panel fire damage

occurrence. The fault light on the engine fire-detection panel illuminated and the engine was shut down. The A4 circuit card was again found to be damaged, indicating that both card faults were likely caused by stray voltage entering the wiring harness from outside the control box, causing the cards to overheat. There is no circuit breaker protection in the circuit between the circuit board warning card and the engine fire loop. The number four engine fire-detection system electrical firewall disconnect plug was removed. The inner rubber insulator, used to isolate the individual wiring pins, was found to be deteriorated and saturated with Skydrol hydraulic fluid. The electrical plug was replaced and all systems tests and engine ground runs were considered normal.

The aircraft was prepared for flight and, shortly after take-off, the number four engine fire-detection loop "A" nacelle temperature indicator pegged to the top of the indicator scale, and the fault light and master fire-detection light again illuminated. The aircraft returned to Winnipeg and the A4 circuit card was again found to be damaged. The aircraft was prepared for a three-engine ferry (with the number four engine inoperative) back to the operator's main base in Minneapolis, Minnesota, United States, where greater ground support could be offered.

During troubleshooting in Minneapolis, alternating current voltage (VAC) was noted to be present on the number four engine loop "A" direct current (VDC) circuit. The voltage stopped when the generator constant speed drive (CSD) was disconnected. The wiring near the generator was inspected and four wires in a wire bundle were found to be chafed; three of the wires were chafed to the conductor core. Two of the wires chafed to the conductor core originated at pins 1 and 3 at connector DG1B on the permanent magnetic generator (PMG). With the CSD coupled and the engine running, the PMG produces approximately 60 VAC. The remaining wire was a 28 VDC voltage wire (W266-W13-16R), which is part of the engine fire-detection loop.

The chafed wires were bound together with plastic tie wraps. When the tie wrap was removed, it was noted that a slack portion of the engine fire-detection wire loop had been folded back and secured to the adjacent PMG wiring harness (see Photo 2).

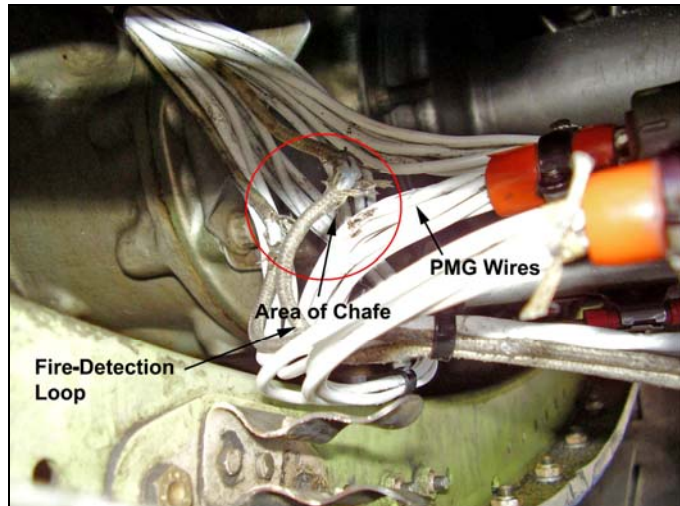


Photo 2. Area of chafe

During engine assembly, the harnesses are installed as part of the Northwest Airlines Inc. quick exchange component (QEC) shop form QEC-42. The harnesses are assembled and installed using guidelines outlined in *Northwest Airlines Publication 25092*, the *Boeing Standard Wiring Practices* (Chapter 20), and the *Boeing Powerplant Buildup* manual of standard practices (Section 71-00-00) for a level 3 high-vibration area (see Appendix A). These documents also provide guidance regarding harness routing and best assembly and installation practices. Chapter 20-10-11, paragraph 3C, specifies, in part, that if it is possible, all wires must be parallel before a wire harness tie is assembled on the wire harness.

Northwest Airlines Inc. consulted technicians who had previously worked on the engine. The technicians indicated that the wire routing configuration and bundling was at variance with QEC shop procedures (see Photo 3).

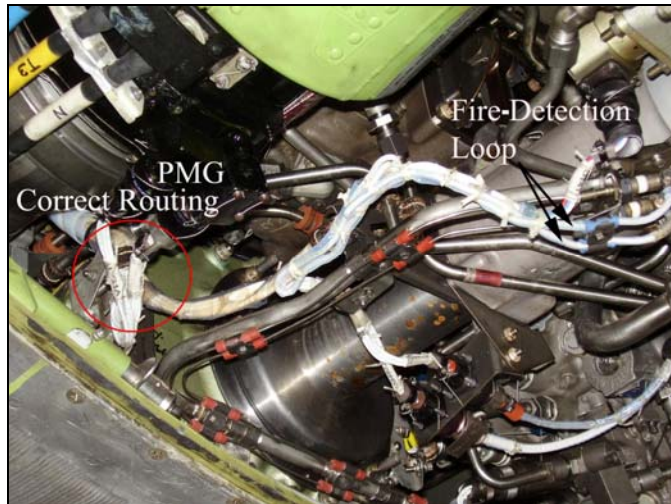


Photo 3. Example of good wire lacing and routing

When the engine is overhauled, the harness is removed for overhaul inspection as per the component maintenance manual. The general instruction is to disassemble as required to accomplish cleaning, inspection, and repair. All other shop visits would only require a visual inspection/check as installed.

Maintenance records indicated that the number four JT9D-7R4G2 engine, serial number 715053, was last overhauled by Northwest Airlines Inc. in October 2002 and had accumulated 13 376 hours and 2339 cycles since install. There was no record of engine repairs since the installation. An under-cowl maintenance check was accomplished 383 hours before the occurrence, coincident with a 1A check. The time remaining until the next inspection was 216 hours. The under-cowl check calls in part for the inspection of "electrical cables for chafing, loose connections, loose back-shells, burned spots and deterioration." The occurrence aircraft was used by Northwest Airlines Inc. on cargo flights worldwide and had maintenance work completed in many cities and countries around the world.

The damaged fire-detection control electronics box along with the digital flight data recorder (DFDR) and the cockpit voice recorder (CVR) were forwarded to the TSB Engineering Laboratory in Ottawa, Ontario, for examination. The DFDR and CVR did not provide any valuable information. The DFDR only recorded a limited number of parameters, none of which related directly to the fire. The two-hour CVR recording had been overwritten by ground operations after the flight. The number four engine loop "A" (A4) circuit board warning card (part number 60B00023-96) in the fire-detection control electronics box was assessed as being the source of the fire. The power resistor (R11) on the side of the board had burnt and burst from internal overheating due to excessive current passing through the resistor.

Analysis

The wire chafing occurred as a result of relative movement between individual wires secured together in adjacent wire bundles in a non-standard way. The bundles are situated in an engine area identified as a high-vibration area. Excess wire length in the number 4 engine fire-detection loop was folded back and secured to the adjacent PMG wiring harness. The Boeing *Standard Wiring Practices* manual specifies in part that all wires must be parallel before a wire harness tie is assembled on the wire harness. The excess wire length in the number 4 engine fire-detection loop was not secured in this manner.

The wires chafed to the conductor core, which allowed the generator PMG 60 VAC to transfer to the 28 VDC "A" loop fire-detection circuit and cause a current surge back through to the fire-detection control electronics box in the cockpit. The current surge was dissipated by resistors on the A4 circuit board warning card, causing a rise in temperature in the resistors to the point of ignition. There is no circuit breaker protection in the circuit between the circuit card and the engine fire loop; thus, the system would overheat until the short occurred.

It could not be established when the subject wires were secured improperly, but it is likely that it occurred at some point at or after engine overhaul. Subsequent shop visits, and under-cowl maintenance checks did not identify the wiring discrepancy or wire chafing. Such a discrepancy would be hard to identify without disassembly of the wire harness. Ongoing maintenance checks only require a visual inspection/check of the wire harness as installed.

The following TSB Engineering Laboratory reports were completed:

LP 057/07 - DFDR/CVR Analysis, Boeing B747-200, N632NW

LP 059/07 - Fire Detection Control Box Examination, Boeing B747-200, N632NW

These reports are available from the Transportation Safety Board of Canada upon request.

Findings as to Causes and Contributing Factors

1. Adjacent wire bundles in a high-vibration area in the number four engine were secured in a non-standard way.

2. The improperly secured wire bundle was not detected by Northwest Airlines Inc. maintenance or quality control personnel during initial installation, modification of the bundle, or the subsequent under-cowl inspections.
3. The wires chafed to the conductor core, allowing a high-voltage power surge back through to the fire-detection control electronics box in the cockpit. The power surge subsequently shorted the resistors on an internal circuit card, causing the on-board fire.

Safety Action Taken

Northwest Airlines Inc. initiated a Boeing 747 fleet campaign to look for wire routing and chafing issues similar to those found on the occurrence aircraft. No similar discrepancies were found. Northwest Airlines Inc. also enhanced its maintenance program by adding a new step to the existing 600-hour "under-cowl check." The step was designed specifically to identify and correct poorly routed wiring in the area of the chafe as noted on the occurrence aircraft.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 10 January 2008.

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Appendix A – Boeing Powerplant Buildup Manual (Excerpt)

