National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: October 26, 1998
In reply refer to: A-98-113 through -118

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

On June 18, 1998, a Swearingen SA226-TC Metroliner II airplane,[1] Canadian registry C-GQAL, operated by PropAir, Inc., crashed after the left wing separated during an attempted emergency landing at Mirabel Airport, Montreal, Quebec, Canada. The flight was operating as a charter from Montreal to Peterborough, Ontario, Canada. The airplane had departed from Montreal's Dorval Airport and was climbing through 12,500 feet when the flightcrew reported a loss of hydraulic pressure and a fire on the left side of the airplane. The pilot then shut down the left engine and declared an emergency. The flightcrew lost control of the airplane at low altitude during the final approach for landing. The airplane was destroyed, and the two flightcrew members and all nine passengers were killed.

The National Transportation Safety Board is participating in the Transportation Safety Board (TSB) of Canada's ongoing investigation under the provisions of Annex 13 to the Convention on International Civil Aviation. On the basis of the preliminary findings of the investigation, the Safety Board has concluded that the Federal Aviation Administration (FAA) should address several safety issues.

The airplane involved in the Montreal accident was equipped with B.F. Goodrich part number (P/N) 2-1203 wheel brake assemblies (see figure 1).[2] The left wheel well included the

[1] Swearingen Aviation Corporation was the original manufacturer of SA226 and SA227 series airplanes. Fairchild Aircraft, Inc., subsequently acquired Swearingen and continued the production of these airplanes.

[2] The B.F. Goodrich P/N 2-1203 series brake assembly is a floating-type, single-disk assembly. The steel disk has smooth sides, expansion slots, and tangs around the outer diameter. The tangs are keyed into the wheel so that both rotate together. The disk floats in and out of the wheel to prevent binding during brake application. The cast-aluminum alloy housing, which is bolted to the landing gear strut, has six cylinders, aluminum alloy pistons, and O-rings to prevent leakage. Each piston is protected from the brake pad by an asbestos piston insulator to minimize heat transfer from the disk to the piston. During brake application, hydraulic fluid is forced into the cylinder, and the piston pushes against the insulator, movable brake pad, disk, and opposing brake pad and torque plate to clamp the rotating disk. The airplane involved in the Montreal accident had the original design P/N 2-1203 wheel brake assembly. Subsequent P/N 2-1203 brake assemblies have suffixes of -1 through -4.

hydraulic power pack, a main landing gear (MLG) assembly, aluminum fuel and hydraulic lines and fittings, an overheat sensor, and a rubber fuel crossover line. The overheat sensor illuminates the L WING OVHT (left wing overheat) warning light on the pilot's annunciator panel when temperatures in the wheel well reach 350°F.[3] Although the heavier Fairchild/Swearingen model SA227 airplanes (and other commuter and corporate airplanes of the approximate weight) incorporate in the MLG wheels fuse plugs that melt when hot, causing a gradual release of nitrogen pressure and preventing a tire burst, the SA226 does not incorporate such fuse plugs.

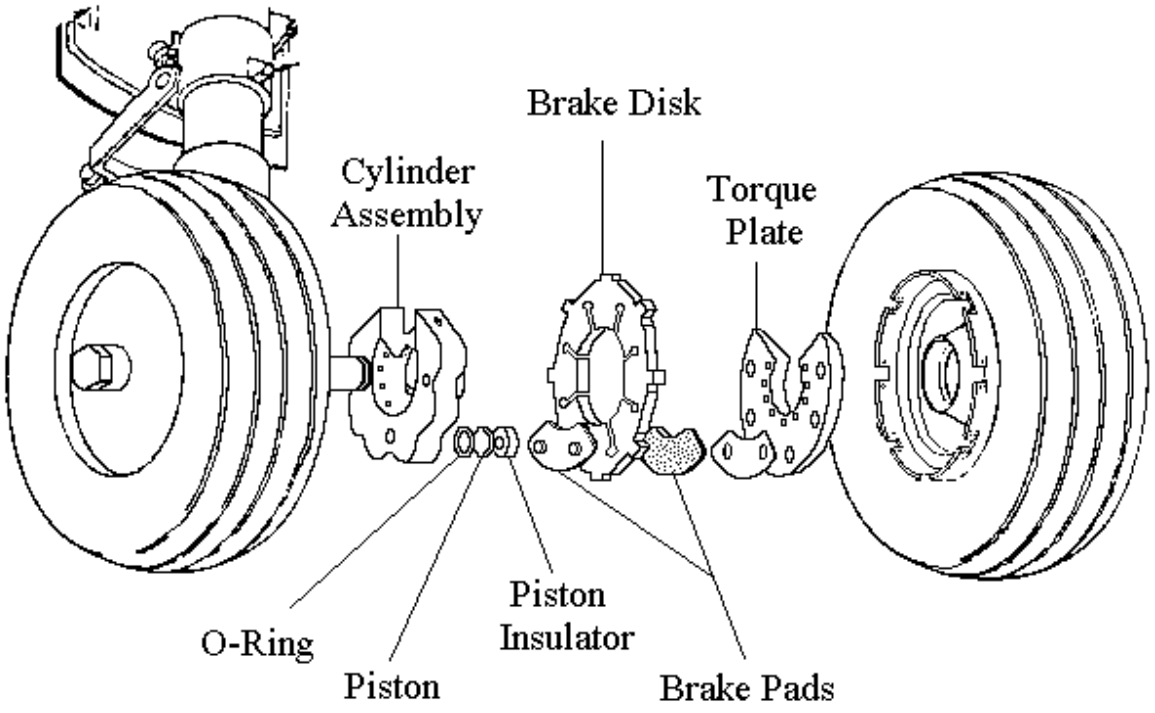

Figure 1. B.F. Goodrich 2-1203 Disk Brake Assembly

The preliminary results of the investigation revealed that, during the takeoff roll, the flightcrew applied the right rudder because the airplane was apparently veering toward the left side of the runway. Approximately 13 minutes after takeoff, the flightcrew noted a loss of hydraulic pressure and the illumination of multiple warning lights, including the left wing overheat warning light. Meanwhile, a passenger reported that the left engine was on fire. The captain later reported that the fire was extinguished and that the back of the engine appeared to have exploded. However, while executing the instrument approach, approximately 1 minute before impact, the flightcrew reported that the fire had resumed. The flightcrew manually extended the landing gear after descending through 1,000 feet, shortly before the left wing failed.

Examination of the wreckage at TSB's facility in Ottawa revealed extensive fire damage to the left MLG wheel well, overheated left MLG brake assemblies, burned tires, melted aluminum

[3] A similar sensor is installed in the right wheel well.

hydraulic and fuel lines and fittings, and a burned rubber fuel crossover line. Witness marks on the inside of the brake cylinders and on the outside of the piston insulators indicated that the pistons were cocked within their respective cylinders. Most of the brake pads were worn unevenly, exposing the base metal. The piston insulators and brake disks were also worn unevenly; however, the wear on the disks was within the minimum thickness requirements specified in the airplane's maintenance manual. Although the airplane's main and brake hydraulic systems had a placard specifying MIL-H-83282, analysis of the fluid in both systems revealed a mixture of MIL-H-83282 and MIL-H-5606 hydraulic fluids.[4] The mixed fluids had a flash point of approximately 237°F.

The investigation thus far indicates that the flightcrew applied the right rudder during the takeoff roll probably to compensate for a dragging left wheel brake and then raised the landing gear, with overheated brakes, into the left wheel well. Although the precise cause of the wheel well fire has not yet been determined, the investigative findings indicate that the ensuing fire in the left wheel well may have been caused by either (1) leaking low flash point brake system hydraulic fluid from a brake cylinder or (2) leaking fluid from damaged lines in the wheel well from an exploding tire coming in contact with and being ignited by the hot brake disk. The fire became hotter as additional flammable liquids from the brake, hydraulic, and fuel systems were introduced. This fire likely led to the wing failure. Leaking brake cylinders could have been caused by the cocked pistons, which appear to have resulted from the combined effects of excessive and uneven brake pad wear, uneven disk wear, and unevenly worn piston insulators on the outboard brake.

Use of Lower Flash Point Hydraulic Fluid

The accident and incident history of Fairchild/Swearingen SA226 and SA227 series airplanes revealed two previous cockpit fire accidents that involved the lower flash point MIL-H-5606 hydraulic fluid. On October 15, 1982, a Sun Aire Swearingen SA226-TC Metroliner II caught fire in Palm Springs, California, when an electrical arc from the copilot's panel light rheostat ignited wires, contaminated with hydraulic fluid from the right brake line, underneath the side panel. Additionally, on August 27, 1983, a Scheduled Skyways Swearingen SA226-TC Metroliner II caught fire in Hot Springs, Arkansas, when an electrical arc ignited wires, contaminated with hydraulic fluid, underneath the instrument panel.[5]

After the investigations of these two accidents, the Safety Board issued Safety Recommendation A-83-59, which asked the FAA to require operators to comply with Fairchild Service Bulletin (SB) 32-018 and use fire-retardant hydraulic fluid. As a result, the FAA issued Airworthiness Directive (AD) 83-19-02 on September 29, 1983,[6] which required operators of

[4] According to Air Force Aero Propulsion Laboratory Report AFAPL-TR-85-2057, MIL-H-5606 is a mineral oil product with a flash point of approximately 194°F, and MIL-H-83282 is a synthetic hydrocarbon with a flash point of approximately 390°F. Although the fluids are chemically compatible, mixing MIL-H-83282 with as little as 5 percent of MIL-H-5606 can render the first fluid's fire-retardant feature ineffective.

[5] For more detailed information on these two accidents, see Briefs of Accident DCA83AA037 and LAX83FA002 (enclosed).

[6] A similar directive was issued by the Canadian government's aviation regulatory authority, Transport Canada.

certain Swearingen SA226 series airplanes, including the airplane involved in the accident in Montreal, to drain and purge the main hydraulic and brake system reservoirs and refill them with MIL-H-83282 hydraulic fluid.[7] The AD also required that operators change the placards on both reservoirs to specify that only MIL-H-83282 fluid be used. On February 21, 1984, the Safety Board classified this recommendation "Closed—Acceptable Action."

Although AD 83-19-02 and Fairchild's airplane maintenance manual required the use of MIL-H-83282 hydraulic fluid in the main and brake hydraulic systems in Swearingen SA226 and SA227 series airplanes, respectively, the Safety Board is concerned that the use of the lower flash point MIL-H-5606 or the mixing of MIL-H-5606 with MIL-H-83282 may be occurring. Therefore, the Safety Board believes that the FAA should require principal maintenance inspectors to notify operators of Fairchild/Swearingen SA226 and SA227 series airplanes of the Montreal accident and the requirement to use only the higher flash point MIL-H-83282 hydraulic fluid in all B.F. Goodrich P/N 2-1203 series brake systems.

Brake Assembly Overheating

The accident and incident history of Fairchild/Swearingen SA226 and SA227 series airplanes also revealed two previous wheel well fire accidents. On July 27, 1988, a Peninsula Airways Fairchild SA227-AC Metroliner III experienced a loss of hydraulic pressure, wheel well and wing overheat indications, exploded tires, and substantial fire damage in the left wheel well.[8] The flightcrew made a successful emergency landing at Anchorage International Airport in Alaska. Additionally, on February 10, 1990, a Perimeter Airlines Swearingen SA226-TC Metroliner II similarly experienced a loss of hydraulic pressure, wheel well and wing overheat indications, exploded tires, and substantial fire damage to the left wheel well. The flightcrew shut down the left engine and made a successful emergency landing at Winnipeg International Airport in Canada.[9]

As a result of its investigation into the Anchorage incident, the Safety Board issued Safety Recommendation A-89-101, asking the FAA to conduct a directed safety investigation of the Fairchild SA226 and SA227 wheel braking systems that utilize the B.F. Goodrich P/N 2-1203-3 wheel brake assembly to (1) determine the potential for brake lockups or overheating as a result of piston insulator cocking and (2) evaluate the current wear limits for proper brake operation at the maximum wear allowed. The FAA reviewed the 5-year history of service difficulty reports regarding B.F. Goodrich brake malfunctions and discovered that 75 reports, including 9 incidents of MLG brake or wheel well fires, had been filed. On October 26, 1989, B.F. Goodrich issued Service Letter (SL) 1498 to clarify the proper location to take wear measurements for all P/N 2-1203 series brake assemblies and revise the maximum allowable clearance for brake assembly P/N 2-1203-3 to reduce the brake lining wear allowed before required overhaul. The FAA issued a special notice to FAA inspectors to alert them that SL 1498 revised the method of determining brake wear and the brake wear limit for P/N 2-1203 brake assemblies, and Fairchild

[7] The Fairchild/Swearingen SA227 series airplane maintenance manual already specified the use of MIL-H-83282 in the main and brake hydraulic systems.
[8] For more detailed information, see Brief of Accident ANC88FA100 (enclosed).
[9] For more detailed information, see Aviation Occurrence Report synopsis A90C0024 (enclosed).

revised its maintenance manual accordingly. On June 18, 1990, the Safety Board classified this recommendation "Closed—Acceptable Action."

Also, the Safety Board issued Safety Recommendation A-89-102, asking the FAA to take appropriate action to prevent brake binding and overheating of B.F. Goodrich P/N 2-1203-3 brake assemblies. On January 16, 1992, the FAA issued AD 92-01-02, which required that operators of SA226 and SA227 airplanes equipped with B.F. Goodrich P/N 2-1203-3 brakes inspect and conduct wear measurements in accordance with SL 1498 and that operators of certain SA226 and SA227 airplanes modify the parking brake system in accordance with Fairchild SBs 227-32-017 and 226-32-049.[10] On March 24, 1992, the Safety Board classified this recommendation "Closed—Acceptable Action."

The wear measurement techniques specified in the component maintenance manual, SL 1498, and AD 92-01-02 were intended to measure the amount of brake wear. However, the techniques were not designed to measure or detect the degree of uneven wear, which could lead to cocked pistons and result in dragging brakes, hydraulic fluid leakage, and wheel well fires. Therefore, the Safety Board believes that the FAA should require B.F. Goodrich to develop and implement a process for identifying and eliminating excessive uneven wear on all B.F. Goodrich P/N 2-1203 series wheel brake assemblies used on Fairchild/Swearingen SA226 and SA227 series airplanes.

Need for Improved Emergency Procedures to Address Wheel Well Fires

The SA226-TC airplane flight manual (AFM) states that, after the illumination of a wing overheat warning light, the flightcrew should secure the bleed air from the affected engine and extend the landing gear. The flightcrew involved in the Montreal accident apparently noticed a loss of hydraulic pressure and the left wheel well and wing overheat warning light but did not extend the landing gear until just before impact. In this accident, immediate extension of the landing gear might have prevented failure of the left wing.

The AFM emergency procedure to address the illumination of the wheel well and wing overheat warning light assumes that the cause is an air conditioning duct overheat and does not consider the consequences of a wheel well fire and the loss of hydraulic pressure or other airplane systems. For example, the procedure calls for shutting down the engine on the affected side of the airplane, which would be appropriate for an air conditioning duct overheat or a bleed air leak but unnecessary for a brake fire. Therefore, the Safety Board believes that the FAA should require Fairchild to (1) expand the description of the wing and wheel well overheat annunciator panel warning light in all Fairchild/Swearingen SA226 and SA227 series AFMs to note that a L or R WING OVHT annunciation may indicate a brake or wheel well fire and (2) expand the emergency procedure for a wheel well and wing overheat warning annunciation to address a wheel well fire and the consequences of other airplane system failures as a result of the fire.

[10] The requirement for the parking brake system is not relevant to the issues discussed in this safety recommendation letter.

The Safety Board is also concerned about the vulnerability of the MLG wheel well in all Fairchild/Swearingen SA226 and SA227 series airplanes to the consequences of overheated brakes and wheel well fires. In the Montreal accident, the heat from the wheel well fire consumed the rubber fuel crossover line, melted aluminum fuel and hydraulic system lines and fittings, and allowed flammable fluid to be introduced to the wheel well fire. In addition, the wheel well might have incurred damage from bursting tires. A brake temperature monitoring or overheat detection system could have provided the pilots with an earlier warning of an overheating brake. Also, the introduction of flammable fluids may have been prevented had the airplane been equipped with stainless steel, rather than aluminum, hydraulic and fuel lines; a heat-resistant fuel crossover line; or fuse plugs such as those already installed in the higher gross weight SA227 series airplanes. Therefore, the Safety Board believes that FAA should require the modification of Fairchild/Swearingen SA226 and SA227 series airplanes to (1) include the installation of a brake temperature monitoring or overheat detection system; (2) provide protection to keep tires from exploding; and (3) protect the lines, fittings, and tubing installed in the wheel wells from hazards associated with exploded tires and fire.

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

> Require principal maintenance inspectors to notify operators of Fairchild/Swearingen SA226 and SA227 series airplanes of the Montreal accident and the requirement to use only the higher flash point MIL-H-83282 hydraulic fluid in all B.F. Goodrich part number 2-1203 series brake systems. (A-98-113)
>
> Require B.F. Goodrich to develop and implement a process for identifying and eliminating excessive uneven wear on all B.F. Goodrich part number 2-1203 series wheel brake assemblies used on Fairchild/Swearingen SA226 and SA227 series airplanes. (A-98-114)
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> Require Fairchild to (1) expand the description of the wing and wheel well overheat annunciator panel warning light in all Fairchild/Swearingen SA226 and SA227 series airplane flight manuals to note that a L or R WING OVHT annunciation may indicate a brake or wheel well fire and (2) expand the emergency procedure for a wheel well and wing overheat warning annunciation to address a wheel well fire and the consequences of other airplane system failures as a result of the fire. (A-98-115)
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> Require the modification of Fairchild/Swearingen SA226 and SA227 series airplanes to
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> (1) include the installation of a brake temperature monitoring or overheat detection system; (A-98-116)
>
> (2) provide protection to keep tires from exploding; (A-98-117) and

(3) protect the lines, fittings, and tubing installed in the wheel wells from hazards associated with exploded tires and fire. (A-98-118)

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

[Original Signed]

By: Jim Hall
Chairman

Enclosures