Many pilots and maintenance technicians don't realize that routine tire-pressure checks are crucial to safe operations.

Pressure Check

BY LINDA WERFELMAN

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Some operators are unaware of appropriate tire-pressure check intervals and, as a result, are flying airplanes with dangerously under-inflated tires, the U.S. National Transportation Safety Board (NTSB) says, citing the fatal crash of a Bombardier Learjet Model 60 that was attributed to poor tire maintenance ("Thrust Into an Overrun," p. 24).[1]

Tire pressures on the accident airplane had not been checked for about three weeks before the Sept. 19, 2008, accident in Columbia, South Carolina, U.S., the NTSB said. Multiple tire failures — a result of "severe under-inflation" — occurred during the takeoff roll, prompting the crew to reject the takeoff, but the airplane overran the runway safety area and crashed. Both crewmembers and two passengers were killed; the other two passengers were seriously injured, and the airplane was destroyed.

The accident investigation found that the four main landing gear tires — Goodyear Flight Eagle, part no. 178K43-1 — had been installed in December 2007 and, at the time of the accident, had accumulated 20 landings. Their rated tire inflation pressure was 220 psi (15.2 bar).

According to tire performance criteria outlined in a number of documents, including U.S. Federal Aviation Administration (FAA) Technical Standard Order TSO-C62c, the maximum allowable tire pressure loss is 5 percent per day; Goodyear tests showed that the type of Flight Eagle tire installed on the accident airplane had a documented daily pressure loss of 2.2 percent.

The accident report said maintenance logs for the Learjet indicated that, during the 12 days preceding the accident, the airplane had been flown on five days.

"Interviews with personnel from all facilities that handled the accident airplane during that time period revealed that none had serviced or received a request to service the MLG [main landing gear] tires," the report said.

Subsequent tests showed that the MLG tires were under-inflated by about 36 percent. The NTSB report noted that the aircraft maintenance manual called for a tire to be replaced if it was operated with a pressure deficit of 15 percent or more.

Excess Heat Hurts

The tires of transport category airplanes typically are made from rubber, flexible nylon ply or some similar material, and steel bead wires, and are filled with nitrogen. They operate with high inflation pressures and are designed to withstand the heavy load requirements and high speeds that prevail during takeoff and landing.

As the tires rotate, they produce heat, largely because of the friction generated during tire deflection — the shifting of the axle-to-ground distance after a tire is installed.[2] Tires function properly when they are correctly inflated and not overloaded. However, when they are under-inflated or overloaded, tires tend to over-deflect.

"When a tire's sidewalls over-deflect at the bottom of each rotation, the excessive flexing of the rubber can result in fatigue of the reinforcing fibers and the generation of higher internal temperatures at a faster rate than would be generated in a properly inflated, properly loaded tire," the report said. "High temperatures can degrade the physical properties of the tire's rubber compounds and melt the nylon threads in the plies; such damage can lead to tire failure."

Instructions for "daily or regular" checks of tire pressure are included in many aircraft maintenance manuals and tire maintenance documents, and the accident report cited such instructions in the Learjet 60 maintenance manual and other Learjet and Goodyear tire maintenance publications, as well as FAA Advisory Circular (AC) 20-97B, *Aircraft Tire Maintenance and Operational Practices*.[3]

On the Learjet 60, checking tire pressure is considered a job for maintenance personnel, not flight crewmembers, and requires the technician to "crouch or crawl under the wing of the airplane to gain access to the MLG tire pressure valves," the report said. "The landing gear doors may conceal the valves for the outboard tires, requiring a person to lie on the ground to gain access."

The accident report quoted Global Exec Aviation's director of operations as saying that the Learjet 60 airplane flight manual (AFM) did not specify that daily tire pressure checks were necessary and that the company's pilots did not check the tire pressure and were not required to do so. At the time of the accident, the company's preflight procedures called for the flight crew to "check" the main landing gear wheels, tires and brakes, and the AFM prescribed a check of their "condition"; neither instruction called specifically for a check of tire pressure.

The report said that Learjet 60 pilots and instructors interviewed by accident investigators said that "preflight tasks involved visually inspecting the tires for general condition, such as excessive wear, sidewall bulges or visible tire cord. All but one pilot interviewed stated that tire under-inflation would be difficult to determine visually (one thought that 'significant' under-inflation could be visually detected). All but one of the Learjet 60 pilots and instructors interviewed stated that checking tire pressure was a maintenance function and that they were neither trained nor expected to check tire pressure at any time."

The director of maintenance at Global Exec Aviation told investigators that he did not know how often the pressure of the tires on the Learjet 60 was to be checked and that there was no requirement to maintain a written record of the checks. He said that he referred to the aircraft maintenance manual to determine when such maintenance items were to be performed.

5 Percent

The NTSB said, in its accident report and accompanying safety recommendations, that even if the tires on transport category airplanes lose 5 percent pressure every day, the pressure loss is not visible and can be detected only with tire pressure checks.

Because of the rapid pressure loss, "It may take only a few days for such tires to reach an under-inflation level below what the aircraft maintenance manual specifies for tire replacement," the NTSB said.

The NTSB recommended that the FAA tell pilots and maintenance personnel about the potential for tire pressure loss and its consequences. Other NTSB recommendations called on the FAA to require all air carriers, commuter and on-demand operators, and fractional-ownership operators to "perform tire pressure checks at a frequency that will ensure that the tires remain inflated to within aircraft maintenance manual–specified inflation pressures."

In addition, the NTSB said that the FAA should require aircraft maintenance manuals to specify, "in a readily identifiable and standardized location, required maintenance intervals for tire pressure checks, as applicable to each aircraft."

Pilots of aircraft operating under U.S. Federal Aviation Regulations Part 135, "Commuter and On-Demand Operations"; Part 91, "General Operating and Flight Rules"; and Part 91K, "Fractional Ownership Operations," should be permitted to check tire pressure, and tire-pressure monitoring systems should be required for all transport category airplanes, the NTSB said.

The accident report, noting that checking tire pressure was not a task assigned to the pilots of the Learjet, said that they "had no means by which to detect the accident airplane's under-inflated tires." If they had suspected that the tire pressure might have been low, they could have requested service from the same facility that was performing other maintenance before the airplane was repositioned for the accident flight, the report said.

A tire-pressure monitoring system would have provided the pilots with such information, the report said, noting that after the accident, officials from Learjet and Global Exec Aviation said that they were considering the installation of a monitoring system.

The systems consist of "a wireless pressure and temperature sensor built into the tire's inflation stem to facilitate the ease, accuracy and automatic documentation of the aircraft daily tire pressure check," the report said. Typical monitoring systems transmit tire pressure readings to the flight deck for display and include visual and/or aural warnings in case of abnormal pressure readings.

Another recommendation said that the FAA should "require that tire-testing criteria reflect the actual static and dynamic loads that may be imposed on tires both during normal operating conditions and after the loss of one tire, and consider less-than-optimal allowable tire conditions including, but not limited to, the full range of allowable operating pressures and acceptable tread wear."

FAA Instructions

Before the release of the accident report, the FAA issued a safety alert for operators (SAFO) discussing the dangers of improperly inflated tires and providing guidance for averting such problems.[4]

"The average aircraft tire is composed of 50 percent rubber, 45 percent fabric and 5 percent steel," the FAA

said. "These tires are designed to carry heavy loads at high speeds. Problems caused by incorrect tire pressure can lead to catastrophic failure of the tire(s). Over-inflation of a tire can cause uneven tread wear, reduced traction, make the tread more susceptible to cutting, and can increase the stress on aircraft wheels. Under-inflation of a tire can cause uneven tire wear and greatly increases stress and flex heating in the tire, which shortens tire life and can lead to tire blowouts."

The FAA said that the Learjet accident was only one of a number of accidents that may have involved "malfunctioning aircraft tires" and added, "It is imperative pilots understand the dangers of improperly inflated tires."

The SAFO recommended that pilots or maintenance personnel check tire pressure according to the manufacturer's "recommended intervals and procedures." The pressure checks should be "cold" checks conducted with a calibrated pressure gauge after tires have been at rest for at least two hours, the SAFO said.

The SAFO did not alter the information provided by the FAA in AC 20-97B, which also emphasizes that "accurately maintaining the correct inflation pressure is the single most effective task in the preventive maintenance regimen for safe tire operations."

The AC prescribes daily checks of tire pressure using a calibrated gauge, with measurements accurate within plus or minus 2 percent for the tire operating range, to check "cold" tire assemblies — those that are at ambient temperature or that have not been in service for at least two hours.

During the daily pressure checks, any tire assembly with between 90 and 100 percent of the minimum loaded service pressure — service pressure is defined as "the inflation pressure needed to support the maximum operating load for a wheel position" — should be re-inflated.

However, a tire assembly should be removed from service if a pressure check indicates that it has been operated at less than 90 percent of minimum loaded service pressure, the AC says, and if an assembly has been operated at less than 80 percent of the minimum loaded service pressure, that assembly and its axle-mate should both be removed from service. Tires removed from service should either be scrapped on the site or taken to a full-service repair facility, along with written documentation of why they were removed from service.

U.S. National Transportation Safety Board

Reconstruction of a tire from the accident airplane shows outboard sidewall damage. The yellow arrows are intended to depict what the NTSB called "the generally uniform location of the damage."

Because of the high inflation pressures and high loads, the FAA said that aircraft tires "can be easily damaged when rolled over hard objects that protrude above a paved surface." In some cases, the resulting damage is superficial, but at other times, a sharp object can penetrate the tire casing and cause a loss of tread; penetration of the tread can cause "loss of inflation integrity and over-deflection of the tire," the FAA added.

Notes

1. NTSB. Safety Recommendations A-10-46 through A-10-59. April 14, 2010. Also, NTSB. *Runway Overrun During Rejected Takeoff, Global Exec Aviation, Bombardier Learjet 60, N999LJ, Columbia, South Carolina, September 19, 2008.*
2. FSF Editorial Staff. "Monitoring Aircraft-tire Pressure Helps Prevent Hazardous Failures." *Aviation Mechanics Bulletin* Volume 47 (March–April 1999): 1–13.
3. FAA. AC 20-97B, "Aircraft Tire Maintenance and Operational Practices." April 18, 2005.
4. FAA. SAFO 09012, "Dangers of Improperly Inflated Tires." June 12, 2009.

Further Reading From FSF Publications

FSF Editorial Staff. "Managing Aircraft-tire Wear and Damage Requires Adherence to Removal Limits." *Aviation Mechanics Bulletin* Volume 47 (May–June 1999): 1–12.