SAE INTERNATIONAL

AEROSPACE INFORMATION REPORT

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Superseding AIR4762

(R) Compilation of Freezing Brake Experience and Potential Designs and Operating Procedures to Prevent Its Occurrence

RATIONALE

Recent freezing brake events have occurred on commercial and military aircraft and the investigation of these events has resulted in new mitigation actions. Additional laboratory testing performed by wheel and brake manufacturers has generated data that provides new insight to the phenomenon of freezing brakes and in some aspects does not support assertions made in earlier versions of the document.

1. SCOPE

This Aerospace Information Report (AIR) describes conditions under which freezing (frozen) brakes can occur and describes operating procedures which have been used to prevent or lessen the severity or probability of brake freezing.

This document also identifies design features that some manufacturers implement to minimize the occurrence of freezing brakes.

This document is not an Aerospace Recommended Practice (ARP) and therefore does not make recommendations based on a consensus of the industry. However, part of this document's purpose is to describe the design and operational practices that some are using to minimize the risk of frozen brakes.

NOTE: The following information is based upon experience gained across a wide-range of aircraft types and operational profiles, and should NOT take precedence over Aircraft Flight Manual or Flight Operations Procedures.

2. REFERENCES

Federal Aviation Administration (FAA), Special Airworthiness Information Bulletin (SAIB) NM-09-18, *Landing Gear: Tire Failure – Locked Carbon Disk Brake Due to Moisture Adsorption and Freezing*, Dated March 11, 2009

EASA Safety Information Bulletin No. 2008-89 Tire Failure – Locked Carbon Disc Brake due to Moisture Absorption and Freezing, dated 19 December 2008.

Many of the updates contained in Revision A of this document were based on information obtained from a 2009 U.S. Air Force-sponsored industry survey of brake manufacturers, airframers, and operators, and shared in SAE A5A panel meetings.

3. PROBLEM

A frozen brake is not an uncommon problem for some aircraft. For a freezing brake condition to occur the brake must be exposed to moisture and freezing temperatures for a sufficient period of time to create an ice bond. Brake freezing can occur on the ramp, between taxi stops, as well as during flight/prior to landing. The first two situations can result in an inability to move the aircraft, while the latter results in a much more serious condition which can cause a locked wheel landing with attendant damage, tire skid-throughs leading to rupture, and possible loss of directional control.

Brake freezing can occur with minimal water present. A frozen brake may occur prior to or following takeoff even though conditions prior to takeoff were not considered adverse conditions (i.e., rain, snow, or slush.) During cold weather operations when snow, slush, or wet runway departure conditions are present, it is possible for frozen brake events to occur. Precipitation and aircraft washing can contribute to a frozen brake event.

3.1 Contributing Factors

Factors which influence the potential for freezing brakes occurrences include operator awareness of conditions which may result in frozen brakes, ambient weather conditions, runway contamination (i.e., snow, slush, and water), maintenance procedures and aircraft operating procedures. Lower use of brakes prior to takeoff can also contribute to a freezing brake event, although most brake manufacturers do not recommend riding or dragging the brakes during taxi due to risks of overheating the brakes and/or of releasing wheel fusible plugs. Additionally, the design of the wheels and brakes, landing gear, and aircraft configuration can significantly infuence the propensity for frozen brake incidents. More specifically, the brake rubbed area, number of disk pairs, brake heatsink location (outside versus inside the wheel), wheel flange driven rotors versus wheel well driven rotors, multiple wheel landing gear, aircraft design (specifically whether the wheel well is heated or not), and aircraft water drain paths all influence the relative likelihood for frozen brakes.

A frozen brake can occur with both carbon and steel heatsink brakes, however the ice bond with carbon brakes is typically stronger than for steel brakes. Ice bonds created with the heatsink oriented vertically (i.e., gear extended) are typically not as strong as when ice bonds are developed when the heatsink is oriented horizontally (i.e., as with gear retracted in most aircraft). Although carbon brakes absorb moisture into the disk voids (typically a maximum of 4% by weight) and not into the carbon fibers, their susceptibility to freezing is not significantly greater than for steel brakes. Carbon brakes will typically achieve 98% of their water absorption capacity within 15 minutes and over 50% of their absorption capability within 3 minutes.

The normal or average shear strength of ice which forms between the rubbed surfaces of the brake is approximately 30 psi. This ice bond strength is strong enough to produce drag levels capable of skidding most tires on dry runways. This strength will vary depending upon the thickness of the ice and the amount of brake wear debris present on the surfaces of the brake disks. Less ice thickness generally results in increased ice shear strength. The presence of wear debris can also result in increased ice bond shear strength. Contaminated water (i.e., water with runway and aircraft de-icer fluids present) typically results in decreased ice shear strength, and these contaminants may also adversely affect carbon friction performance as well as become catalysts for carbon oxidation.

A carbon brake heatsink exposed to 100% humidity for a period of 24 hours and then exposed to freezing temperatures has not been demonstrated to result in a frozen brake condition. That is, humidity alone has not been proven to provide sufficient moisture to result in a freezing brake condition; a quantity of moisture (i.e., rain, snow, slush) is required to support a freezing brake event.

The problem of frozen brakes is most prevalent on aircraft which have unheated or open wheel wells where the landing gear doors seal around the tire OD (i.e., wheel and tire exposed to the slip stream). The resulting damage from freezing brakes is exacerbated by low aircraft sink rates where wheel load is gradually applied during landing, making tire skids-throughs leading to rupture more likely. This type of landing provides a lower tire load than generated during a normal landing and hence lower impact forces that could possibly break ice bonds that may have formed in flight.