



AEROSPACE INFORMATION REPORT

AIR5490™**REV. A**

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Superseding AIR5490

(R) Carbon Brake Contamination and Oxidation

RATIONALE

This document is intended to raise awareness of the effects of carbon brake contamination and provide recommendation for its prevention.

Rev A: Although carbon brakes had been operating for many years with only the occasional oxidation issue, the introduction of a new family of “environmentally-friendly” runway deicers in the early 1990s has resulted in dramatic increases in the occurrences and severity of carbon brake disk degradation due to catalytic oxidation. This revision contains additional information regarding the mechanism of oxidation, the role of these chemicals in promoting catalytic oxidation, and inspection techniques both on and off the aircraft.

1. SCOPE

This document provides information on contamination and its effects on brakes having carbon-carbon composite friction materials (carbon). Carbon is hygroscopic and porous, and therefore readily absorbs liquids and contaminants. Some of the contaminants can impact intended performance of the brake. This document is intended to raise awareness of the effects of carbon brake contamination and provide information on industry practices for its prevention. Although not addressed in this report, contaminants can cause problems with other landing system components including tires.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS1424 Deicing/Anti-Icing Fluid, Aircraft SAE Type I

AMS1428 Fluid, Aircraft Deicing/Anti-Icing, Non-Newtonian (Pseudoplastic), SAE Types II, III, and IV

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Documents

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AMS1431 Compound, Solid Runway and Taxiway Deicing/Anti-Icing

AMS1435 Fluid, Generic, Deicing/Anti-Icing Runways and Taxiways

AIR5567 Test Method for Catalytic Carbon Brake Disk Oxidation

2.1.2 Military Publications

Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, <http://quicksearch.dla.mil>.

MIL-PRF-83282 Hydraulic Fluid

MIL-PRF-5606 Hydraulic Fluid

MIL-PRF-87257 Hydraulic Fluid

2.1.3 Regulatory Guidance Materials

Available from the FAA, EASA, and Transport Canada respective web sites.

EASA Safety Information Bulletin 2008-19R2 Dated 23 April, 2013

FAA, Special Airworthiness Information Bulletin (SAIB) NM-08-27R1

Transport Canada, Service Difficulty Advisory (SDA) AV 2009-03

2.2 Definitions

AIRPLANE ANTI-ICING/DEICING FLUIDS: Chemical solutions applied to the exterior of an aircraft for the purpose of preventing and removing frozen deposits of frost, ice, and snow prior to take-off.

AIRPLANE HYDRAULIC FLUIDS: Oils used in struts and hydraulic systems.

AIRPLANE LUBRICANTS: Greases and oils, particularly that are applied to landing gear components.

AIRPLANE WASH FLUIDS: Cleaning solutions applied to the airplane and/or its components.

ANTIOXIDANT (AO) TREATMENTS: Treatment applied to carbon brakes to reduce oxidation.

CARBON BRAKE: A brake that uses friction material composed of a carbon-carbon composite. This is usually in the form of a carbon fiber preform densified with additional carbon as matrix.

CATALYTIC OXIDATION: Oxidation that is accelerated by a catalyst.

CLEANING SOLVENTS: Chemical degreasers and paint stripping agents.

FIRE EXTINGUISHING AGENTS: Foam, dry chemicals, and solutions used to extinguish fires.

DISINFECTANTS: Chemicals applied to aircraft to kill biological organisms for limiting the spread of diseases.

HYGROSCOPIC: Absorbs liquids.

OXIDATION: The reaction between carbon and oxygen resulting in the loss of mass.

RUNWAY ANTI-ICING/DEICING SOLIDS AND FLUIDS: Chemical solutions applied to a runway surface for the purpose of preventing and removing frozen deposits of frost and ice.

TEMPERATURE INDICATION MARKERS: Crayons with specified melting points used to determine brake temperatures.

THERMAL OXIDATION: Oxidation that is accelerated as the result of exposure to elevated temperatures.

TRIBOLOGY: The study of friction, wear, lubrication, and the design of bearings.

3. BACKGROUND

The aerospace industry has had a number of brake problems occur on different airplane models that have been traced back to carbon friction material contamination. As mentioned above, carbon is particularly susceptible to contamination. The effects of contamination can be very serious and the ability of a brake to generate torque can be significantly reduced.

These effects can occur by two distinct mechanisms:

- a. Contamination can lead to an accelerated form of carbon oxidation called catalytic oxidation. Catalytic oxidation can result in loss of mechanical strength of carbon materials and structural disk failures. Structural failure of disks reduces the number of effective friction generating interfaces in the brake and significantly reduces the brake's ability to generate torque. Loss of rubbed/friction -area through catalytic oxidation can also contribute to reduction in performance.
- b. Contamination can impact stopping performance. Certain chemical contaminants can have a temporary or permanent effect on the tribology of the friction material resulting in a change in friction level at a given set of braking conditions. Carbon brakes usually operate at temperatures higher than their steel brake counterparts. Operating temperatures may be high enough to boil off the contaminant. In this case, the impact on performance may be temporary. In other cases, the temperatures required to boil off the contaminant far exceed normal brake operating temperatures. In these cases, the impact on performance can be lasting unless there is effective maintenance intervention. Contamination has also been known to adversely affect the brake wear characteristics.

As a result of the aforementioned issues, the SAE's A5A Wheels, Brakes, and Brake Controls committee and G-12RDF committee (Working Group on carbon brake oxidation and runway de-icers) have engaged the industry and regulators through regularly scheduled meetings to both raise awareness of these issues and to identify industry needs to mitigate the impact to aircraft operators. Runway de-icing chemicals are approved with reference to specifications AMS1431 and AMS1435 which until 2010 did not consider the issue of runway de-icer compatibility with carbon-carbon composite friction materials. The major effort of the G-12RDF working group was directed towards liaison work with the SAE A-5A to create, ballot, and approve a carbon compatibility test for runway and pavement deicer products. This work has resulted in the production of AIR5567 which has been included in the AMS1431 and AMS1435 specifications. The AIR5567 test results are available from the de-icer manufacturers. Additionally, several aviation authorities have issued advisory letters to the aviation community with the intent of further raising awareness (see 2.1.3.)

4. POTENTIAL TYPES AND SOURCES OF BRAKE CONTAMINATION

4.1 Sources for Potential Carbon Brake Contamination Are:

- a. Runway anti-icing/deicing solids and fluids
- b. Airplane anti-icing/deicing fluids
- c. Airplane wash fluids
- d. Airplane lubricants

- e. Airplane hydraulic fluids including phosphate ester based fluids
- f. Fire extinguishing agents
- g. Cleaning solvents
- h. Disinfectants containing sodium, potassium, calcium, citric acid, chlorine, and other uninhibited compounds
- i. Temperature indication markers applied directly to carbon
- j. Sea water

4.2 Classifications of Contaminants Found in Service

4.2.1 Catalytic Agents

The catalysis mechanism of carbon brake disks is fairly well understood. Elements from contamination absorb into pores of unprotected carbon, which catalyze the oxidation of carbon at temperatures between 800 to 1200 °F.

Some common catalysts include:

- a. Sodium from seawater, or aircraft cleaners or anti-icers/deicers that do not contain phosphate.
- b. Potassium acetate ($\text{KC}_2\text{H}_3\text{O}_2$), potassium formate (KCO_2H), sodium formate (NaCO_2H), sodium acetate ($\text{NaC}_2\text{H}_3\text{O}_2$). Acetates and Formates are contained in alkali metal runway deicers. AIR5567 test results have shown that formate runway deicers cause more structural damage (as evidenced by more carbon weight loss) to carbon brake disks than do acetate runway deicers.
- c. Sodium, calcium, or potassium containing cleaning agents typically found in airplane, landing gear, engine, and wheel well cleaners.
- d. Dry chemical fire extinguishers that contain alkali metal such as potassium used in Purple K fire extinguishers.
- e. Temperature indicating sticks have also been reported as a potential source for catalysis. In some cases it has been severe enough to induce pressure plate structural failures.
- f. Disinfectants/Anti-viral agents - In response to the outbreak of Foot and Mouth disease in Europe, operators have been directed to apply disinfectants or anti-viral agents to aircraft landing gear. Many of these products have catalytic effects on carbon-carbon friction material.

NOTE: It is known that contamination of carbon disks with phosphate-ester based hydraulic fluid can reduce oxidation rates of unprotected carbon brake disk materials. These results were interpreted as cases where sodium (Na) or other catalytic impurities already in or on the carbon were combined as phosphates during oxidation, and thus removed from carbon surfaces where they normally would have catalyzed carbon oxidation. However, hydraulic fluids can also affect brake performance and care should be taken to avoid inadvertent application to carbon friction surfaces. Brakes contaminated with hydraulic fluid can, and has resulted in smoke emanating from the brakes during airplane taxi after landing when the brakes are applied. When smoke is seen coming from the landing gear it is presumed by airport personnel that there is a fire on the airplane and the airport fire department may be dispatched. The flight crew may even order an emergency evacuation of the airplane via the escape slides which has been known to result in injuries to passengers and crew.