

Take Care of Your Brakes



All Brakes are subject to wear. Some brakes may also experience oxidation which can lead to brake rupture. In the case of a brake rupture or if brakes are too worn, the aircraft braking performance is reduced. This can result in a runway overrun if the full braking capacity is required such as during a rejected takeoff with an aircraft weight at or close to the maximum takeoff weight. Brake rupture can also lead to damage that can cause a brake fire due to hydraulic fluid coming into contact with hot parts.

This article describes carbon wear and oxidation phenomena. It recalls the maintenance procedures used to identify worn or oxidized brakes, flight crew procedures, and good practices to prevent brake wear and oxidation.

This article is also available on safetyfirst.airbus.com and on the Safety first app for iOS and Android devices.



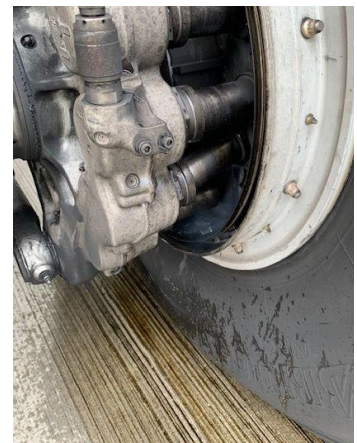
CASE STUDY

Event Description

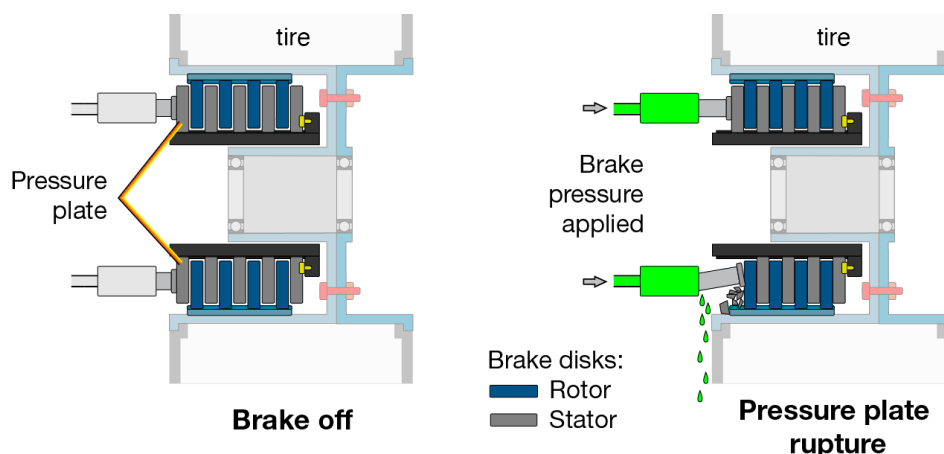
Shortly after landing, the flight crew of an A330 aircraft heard a strong and unusual noise during taxi-in. When the aircraft reached the parking stand, ground crew observed smoke coming from the area of the left Main Landing Gear (MLG) and informed the flight crew. The fire brigade arrived but did not see any fire. The flight crew noticed a 400 °C temperature on wheel no. 6. Maintenance personnel performed a quick inspection of the landing gear, which revealed that one of the brake pistons of wheel no. 6 had twisted and dislodged from its housing with evidence of a hydraulic fluid leak (**fig.1**). There was no sign of fire on the landing gear structure and components.

Event Analysis

The investigation showed the most probable cause was a rupture of the brake pressure plate during brake application. The brake piston pushed through the pressure plate and came into contact with the first rotor (**fig.2**). This applied a lateral force to the piston causing it to be dislodged from its housing and causing the hydraulic fluid leak. The hydraulic fluid that leaked onto the hot parts of the brake created the smoke. The pressure plate was found to be significantly oxidized, which was the reason it ruptured when the brake piston pressed against it. ■



(fig.1) Picture of the damaged piston



(fig.2) Rupture of the pressure plate during brake pressure application with damage to one of the brake pistons.

BRAKE WEAR VS. BRAKE OXIDATION

Brakes are subject to two different phenomena: Wear and oxidation.

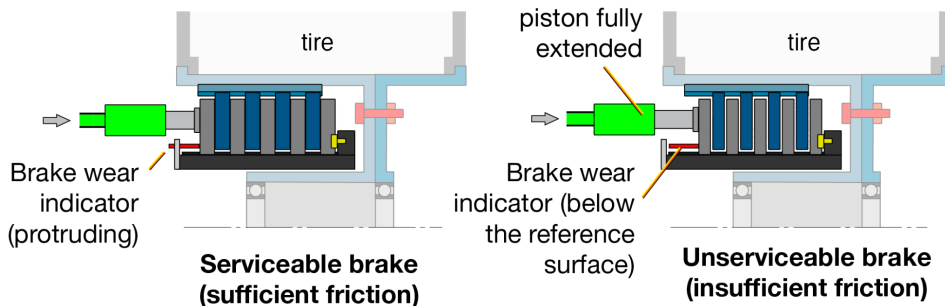
Brake wear

Brake wear is the progressive loss of width on the brake disks due to friction. Brake wear on carbon brakes depends on the number of brake applications and on the brake temperature. Each carbon brake type has its own temperature range for optimum operation and its temperature range for maximum wear. The temperature range varies from one brake manufacturer to another.

Guaranteed braking efficiency until the wear limit

Brakes are guaranteed to provide sufficient braking until the brake wear indicator is flushed with the reference surface. If the indicator is below the reference surface, the brake disks are too worn, and the braking performance can be significantly reduced. If the brake disks are too worn, their width is reduced. As a result, the pistons do not

have enough extension to push the disks and create sufficient braking friction to slow down the aircraft (**fig.3**). In addition, if the brake is too worn, the amount of heat sink mass that is available to absorb braking energy is reduced. In the event of a high speed RTO this can lead to increased risk of runway overrun or brake fire.



(fig.3) Loss of braking performance due to brake wear

Brake oxidation

Carbon from the brakes naturally combines with oxygen from the ambient air to become carbon dioxide (CO₂). Under normal circumstances the oxidation occurs at a very slow rate. However the rate of oxidation can be accelerated by external factors such as high temperature and catalytic (chemical) pollution (**table 1**). This results in a loss of carbon mass from the brake disks, carbon softening, and delamination. It can ultimately lead to brake rupture if an affected brake is not changed in due time (**fig.4**). Carbon oxidation due to exposure to high temperatures is referred to as thermal oxidation. When carbon oxidation is due to the presence of catalysts, it is usually referred to as catalytic oxidation.

Thermal oxidation

Thermal oxidation is the main cause of accelerated degradation of carbon brakes. It can occur if high brake temperatures are reached after landing and during taxi. Thermal oxidation affects all brake disks, but the middle disks are most affected because they reach a higher temperature and take longer to cool down. Worn brakes tend to reach higher temperatures making them more prone to the effects of thermal oxidation.

Catalytic oxidation

Catalytic oxidation of the brakes is generally caused by contact with deicing or cleaning fluids. The potassium or sodium coming from some aircraft and runway deicing fluids acts as a catalyst and further accelerates the oxidation (**table 1**). The presence of the catalyst also reduces the temperature at which significant oxidation occurs. When the potassium or sodium is absorbed by the carbon it remains within the material causing catalytic oxidation to continue well after the end of the winter season. The outer disks, including the pressure plate, are most exposed to external pollution and are usually more susceptible to catalytic oxidation.



(fig.4) Heavily oxidized brake disks

Temperature	Time to lose 5 % mass = Time to lose 25 % strength	
	Thermal oxidation only	Thermal + catalytic oxidation
25 °C	7.5 x 10 ⁸ years	3.6 x 10 ⁸ years
400 °C	3 years	33 days
500 °C	14 days	15 hours
600 °C	12 hours	45 minutes
700 °C	49 minutes	4 minutes

(table 1) High temperatures and catalytic pollution significantly increase the oxidation rate of the brake carbon disks

Risks of brake rupture: loss of performance and potential brake fire

In addition to high maintenance costs, brake oxidation can lead to brake rupture and a loss of braking for the affected wheel. If maximum braking is necessary, such as in the case of a rejected takeoff at or close to the maximum takeoff weight, it may result in a runway overrun.

Brake rupture can also damage brake pistons and lead to leakage of hydraulic fluid. The fluid may vaporize and create smoke if it comes into contact with hot components. This could result in fire. The hydraulic fuses will limit the amount of hydraulic fluid lost and the fire should remain contained to the brake, but damage may be caused to nearby components. Maintenance personnel and flight crews both have a role to play to prevent brake rupture. ■

BRAKE MAINTENANCE

There are a number of ways to identify worn brakes and prevent brake rupture including visual checks, inspection, and taking precautions when using deicing or cleaning fluids.

Regularly check the brake wear indicator

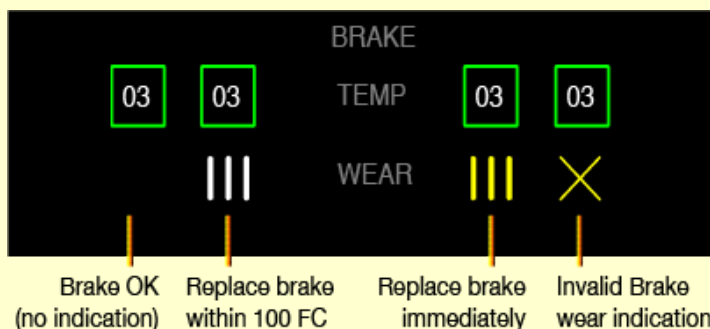
The Maintenance Planning Document (MPD) requires a regular visual inspection of the brake wear indicator to assess the level of thickness loss of the brake disks (**table 2**). The check must be done with the braking applied (parking brake ON or pedal pressed or BITE activated). If the brake wear indicator is flushed with the reference surface, the brake unit must be changed.

A300/A310	A320 family	A330/A340	A350	A380
8 days	6 months or 100 flight cycles	42 flight cycles	10 days	7 days

(table 2) MPD interval for checking the brake wear indicator

A220 brake wear monitoring

Brake wear monitoring is done via the EICAS STATUS synoptic page (**fig.5**). This page provides an indication of the status of the brake wear. When brakes are 100 % worn, three amber bars appear on the EICAS STATUS and a **L BRAKE FAIL** or **R BRAKE FAIL** caution message appears if the parking brake is applied. If this indication becomes inoperative, the MMEL requests a daily check of the mechanical brake wear indicator located on the brake assembly.



(fig.5) Brake information on the A220 EICAS STATUS synoptic page



BEST PRACTICE

To estimate the remaining service time of a brake unit, an average wear rate of 1 mm (0.04 in.) for every 20 flight cycles can be used. This number of flight cycles is an average value and can be customized depending on the aircraft operations and aircraft type.

Inspect the brake

Visually inspect the brake assembly at every wheel removal, in accordance with the corresponding AMM/MP procedure, to check that there is no damage or crack on the disks and to check the condition of the brake components. Pay particular attention to any signs of oxidation marks, and if the oxidation is beyond acceptable limits, replace the brake **(fig.6)**.



INFORMATION

Brake manufacturers provide training for maintenance personnel to better detect brake disk oxidation. Operators can contact their brake manufacturer for more information.



No sign of oxidation



Oxidized stator 3



Highly oxidized brake

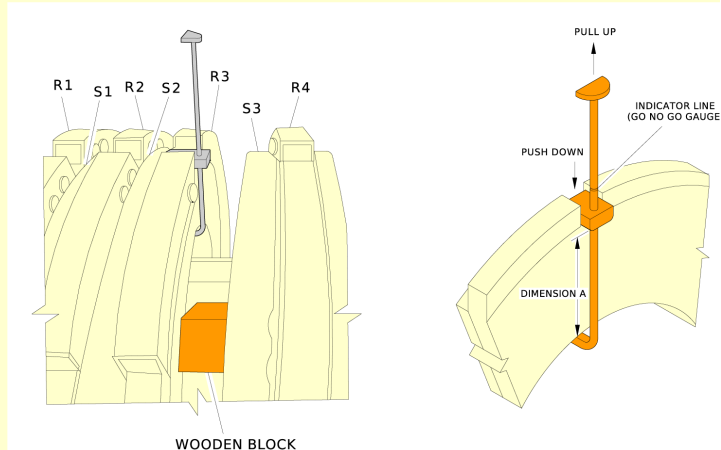
(fig.6) Examples of non-oxidized and oxidized brakes

Optional AMM inspection for A320 aircraft

Some operators are more exposed to the risk of brake rupture due to their specific operations. Airbus proposes an optional brake inspection with the wheel removed. This inspection was developed together with brake manufacturers and can be added to the AMM procedure by request of the operator. Steps were added to the brake inspection procedure that require measuring the outer perimeter of the central stator (Safran Landing Systems and Messier-Goodrich brakes) **(fig.7)** or the radius of the friction surface (Collins Aerospace brakes) **(fig.8)**. The reduction of this measured value provides an additional indicator of brake oxidation.



(fig.7) Optional inspection to measure the perimeter of the central stator on Safran Landing Systems and Messier-Goodrich brakes



(fig.8) Optional inspection to the radius of the friction surface on Collins brakes

Report any brake damage/rupture

Airbus encourages operators to report any brake damage or rupture through the Tech Request tool using the **Brake Disk Failure Reporting Sheet** available in the AMM/MP procedure for brake inspection.

Precautions during Cleaning and Deicing

When cleaning the aircraft or performing deicing, particular care should be taken to prevent fluids coming into contact with the wheels and brakes. Always follow the AMM/MP/AMP procedures for cleaning and deicing and protect wheels and brakes to prevent them from becoming contaminated with chemicals that will accelerate oxidation. ■

OPERATIONAL CONSIDERATIONS

The flight crew can detect worn brakes before the flight during the exterior walkaround. They can reduce wear and oxidation by using the brakes in an optimal manner during taxi and landing.

Brake wear indicator check on walkaround

A quick check of the brake wear indicator (**fig.9**) during the exterior walkaround will determine if the brakes are worn. If there are only a few millimeters remaining before the indicator is flush with the reference plate, inform maintenance personnel to anticipate and plan for a brake replacement before the wear limit is reached. On A220 aircraft, the flight crew can also check the brake wear status on the EICAS STATUS synoptic page.

Reducing brake use during taxi

Flight crews should reduce the number of brake applications during taxi to limit brake wear. The FCTM and A220 FCOM recommend that on long, straight taxiways, and with no ATC or other ground traffic constraints, the PF should allow the aircraft to accelerate to 30 kt of ground speed, and then use one smooth brake application to decelerate to 10 kt.

Keep thrust at idle

Maintaining idle thrust during taxi enables a reduced number of brake applications to keep the aircraft below the 30 kt maximum taxi speed.

Single engine taxi

Single engine taxi is a fuel saving initiative that also reduces brake wear, because it further reduces the idle thrust during taxi.

Reducing braking energy at landing

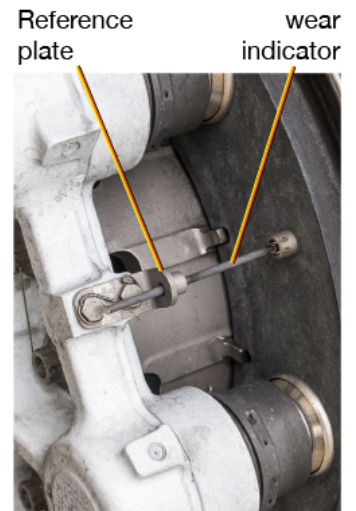
The number of thermal oxidation reports is increasing, especially on the A320 family fleet. This phenomenon may be linked with efforts by many operators to save fuel. It was observed that a majority of operators reporting high thermal oxidation were using CONF 3 and thrust reversers on IDLE at landing. There is a trade-off between fuel savings, engine maintenance costs, and increased brake replacement due to higher rates of oxidation. This will depend on the flight conditions, aircraft condition, and the operator's policy.

Use of Flaps FULL (or FLAP 5 on A220)

The use of flaps FULL (FLAP 5 on A220) at landing reduces the approach speed, and therefore, the aircraft energy to be absorbed by the brakes.

Use of autobrake or Brake-to-vacate (BTV) at landing

Use of autobrake or BTV (if installed) enables a single brake application with an optimized braking intensity. When autobrake is used and if conditions permit, the use of autobrake LOW reduces the heat of the brakes, and therefore, reduces the likelihood of oxidation.



(fig.9) Brake wear indicator of an A350-1000 aircraft

Updated AUTOBRAKE LOW mode for A320 family aircraft

An updated autobrake LOW mode with a slightly increased deceleration rate (2 m/s² instead of 1.7 m/s²) and a shorter delay for brake application (2 s instead of 4 s) was introduced on recent A320 aircraft. This updated LOW mode enables the use of the LOW mode on shorter runways and reduces the observed tendency of the flight crew to switch to manual braking due to a perception of late and low braking application. This updated autobrake mode is installed on A320 family aircraft delivered since Q2 2018 and can be retrofitted on earlier aircraft using a dedicated Service Bulletin (SB) **(table 3)**.

A319/A320	A319neo/A320neo	A321	A321neo
SB 32-1464	SB 32-1465	SB 32-1476	SB 32-1477

(table 3) Activation SBs for the updated autobrake LOW mode on A320 family aircraft

Timely thrust reduction during flare

A timely thrust reduction during the landing flare prevents extra thrust provided by the autothrust trying to maintain V_{app} after the flare. The flight crew should retard the thrust levers at 20 ft (A320/A330/A340/A350/A380) or 30 ft (A220/A300/A310) as per the SOP, and at the latest, at landing gear touchdown to enable spoiler extension.

Use of thrust reversers at landing

The use of thrust reversers reduces the energy to be absorbed by the brakes. It is therefore a good option to use thrust reversers to limit brake oxidation, especially on short runways.



Use most appropriate runway exit

Taking over the autobrake to use full or strong manual braking to quickly slow down the aircraft in order to reach a specific runway exit may save some taxi time. However, this will also significantly increase brake wear. Using the next exit may slightly increase taxi time, but will also reduce brake wear and temperature.

Use of brake fans

The use of brake cooling fans, when available, reduces the exposure time of the brake units to high temperature after landing. This reduces the effects of carbon thermal oxidation. ■

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Maximum available braking performance is necessary to prevent the risk of a runway overrun in an event such as a rejected takeoff with a fully loaded aircraft. Brakes need to be closely monitored to ensure that they do not have excessive wear or oxidation that will affect the braking performance of the aircraft or to ensure that they do not degrade to a condition that could cause a brake rupture.

The flight crew or maintenance personnel can quickly check brake wear during the exterior walkaround inspection by looking at the brake wear indicator pin on each brake unit. If the indicator is flush with the reference plate, or below it, the brake must be changed.

It is important to perform a careful visual inspection of the brake assembly at every wheel removal to check for signs of excessive oxidation. Operators should consider adding the optional inspection check developed with the brake manufacturers into their AMM/MP.

Flight crews can apply a number of recommended procedures and techniques to help reduce the rates of brake wear and oxidation. This includes reducing the number of brake applications during taxi, applying techniques that will reduce braking energy at landing, and using brake fans when available.

These operational and maintenance considerations will ensure that the brakes have a longer service life and are in a condition to create the necessary friction for optimal aircraft braking performance.

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