The Airbus safety magazine

#34

Safety first

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Safety first

The Airbus magazine contributing to the enhancement of the safety of aircraft operations by increasing knowledge and communication on safety related topics.

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editorial

YANNICK MALINGE

SVP & Chief
Product Safety Officer

Dear Aviation Colleagues,

The aviation industry has continuously adapted to the changeable conditions of the Covid-19 crisis, and the wake vortex effect of this pandemic will still be with us for some time. However, the global safety record over this period has shown a high level of resilience thanks to robust safety governance and safety culture. This has demonstrated the added value of the safety management systems that were implemented and continuously reinforced across the industry.

The same challenges remain for the return to service and ramp-up of operations in the recovery phase. In addition to this, there is a significant number of people who have left the industry, meaning we must now attract and engage a new generation of aviation professionals. It is also an opportunity to reinject the right safety culture for everyone working across the air transport system.

A shared safety culture also supports safety at the interfaces across organizations and in aircraft operations. This is a big part of why we share safety information in Safety first articles to flight crews, technicians, and cabin crews with the aim to reinforce safety at the interface of flight operations and maintenance. It is why I want to encourage everyone to widely share this information and the lessons learned, especially for the benefit of all newcomers who will shape our shared safety culture for tomorrow.

I pass on my best wishes to everyone, together with the Airbus Safety team, for safe and fair-weather flying ahead.

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Safety first

The Airbus safety magazine

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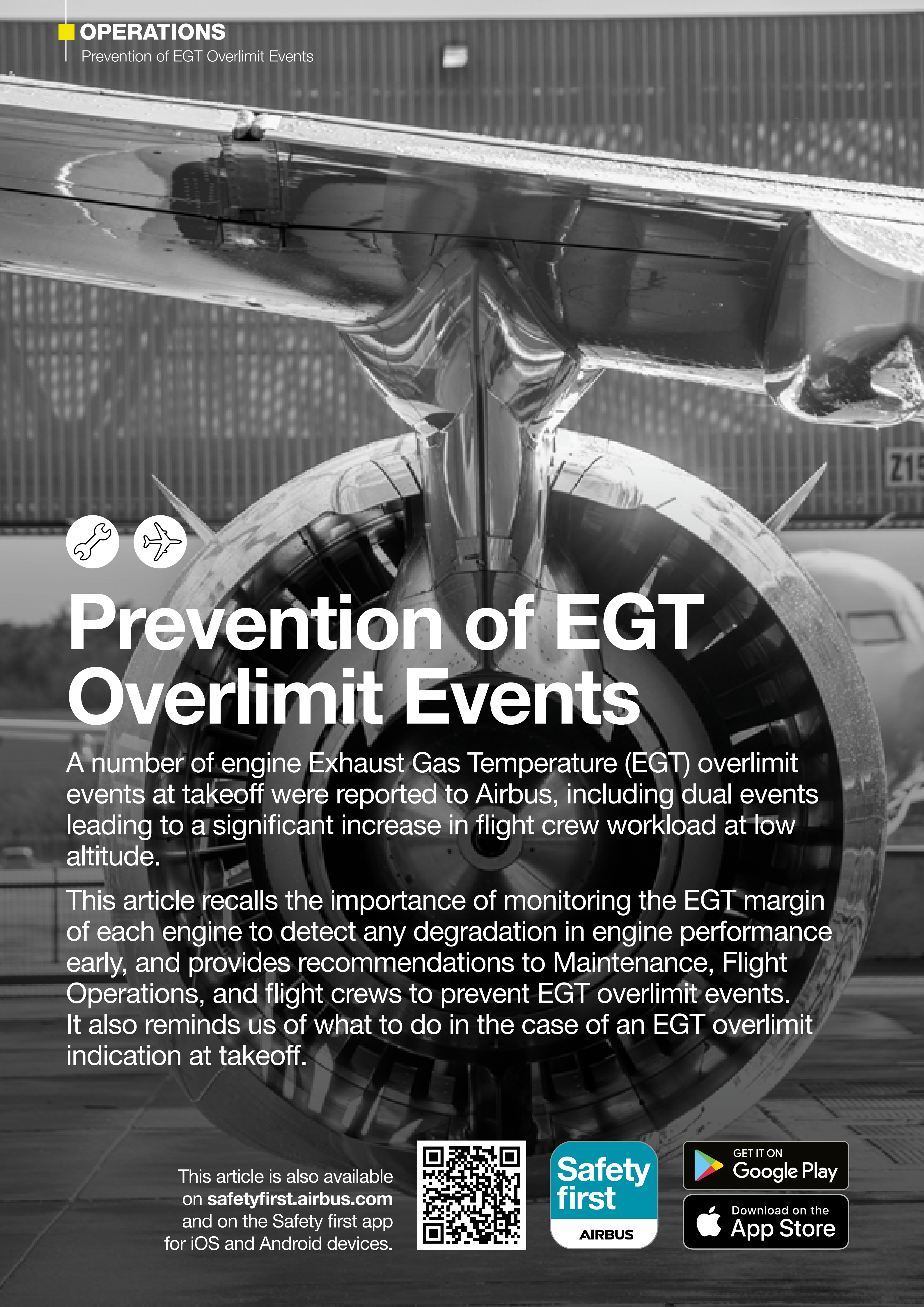
Save the date in your calendars for the next Airbus Flight Safety Conference to be held 20-23 March, 2023 in Berlin, Germany.

Invitations for the event will be sent to all of our customers in January 2023.

Safety first #34

OPERATIONS & MAINTENANCE



Prevention of EGT Overlimit Events

A number of engine Exhaust Gas Temperature (EGT) overlimit events at takeoff were reported to Airbus, including dual events leading to a significant increase in flight crew workload at low altitude.

This article recalls the importance of monitoring the EGT margin of each engine to detect any degradation in engine performance early, and provides recommendations to Maintenance, Flight Operations, and flight crews to prevent EGT overlimit events. It also reminds us of what to do in the case of an EGT overlimit indication at takeoff.

Among the reported events of EGT overlimit, 10 occurred on both engines between May and September 2021. Even if EGT overlimit events are common, they can increase the flight crew workload in a critical phase of flight, especially when they happen on both engines simultaneously. They can create operational disruptions (e.g. rejected takeoff or in-flight turnback) and require maintenance actions.

CASE STUDY

Event Description

An A321 aircraft, with a takeoff weight of 73 T (MTOW 98.7 T), was in CONF2 with packs ON and ready for takeoff on a relatively warm weather day (30°C OAT/ISA+15). The flight crew applied standard thrust stabilization and then TOGA thrust. The takeoff was uneventful until liftoff. At 90 ft RA, the ENG1 EGT OVER LIMIT and ENG2 EGT OVER LIMIT ECAM alerts triggered. The PF initially moved both thrust levers to MCT, then engaged the autopilot at 450 ft and moved the thrust levers to the CLB notch. At 890 ft, the PF set the ENG1 thrust lever to idle. The vertical speed began to decrease and the PF set the ENG2 thrust lever to MCT. The flight crew then set the ENG1 master switch to OFF when crossing 1 300 ft, leveled off at 1 500 ft, and decided to perform an in-flight turnback. The PF climbed to 4 000 ft. The flight crew started the APU and began descent to initiate the approach. The ENG1 master switch was set back to ON during the descent and Engine 1 successfully restarted at approximately 2 700 ft. The approach and landing were performed without any further events.

Event Analysis

The investigation confirmed that both engines had an EGT overlimit and compressor stall during the event. This was the combination of degraded performance on both engines, combined with a relatively high OAT (30°C), and the use of TOGA thrust with packs ON.

The inspection of both engines by the engine manufacturer stated, “General dirty/eroded/corroded/worn condition of engine’s flow path. Deteriorated airfoil profile and tip & seals clearance identified as major contributors to both engines EGT overtemperature.” It was also noted that an interruption of in-flight engine data transmission between the Operator and the engine manufacturer did not facilitate a timely assessment of the engine degradation.

THE EGT PARAMETER

The EGT sensors are located either on the inlet or the outlet of the Low Pressure Turbine (LPT), depending on the engine type.

Parameters that Influence EGT

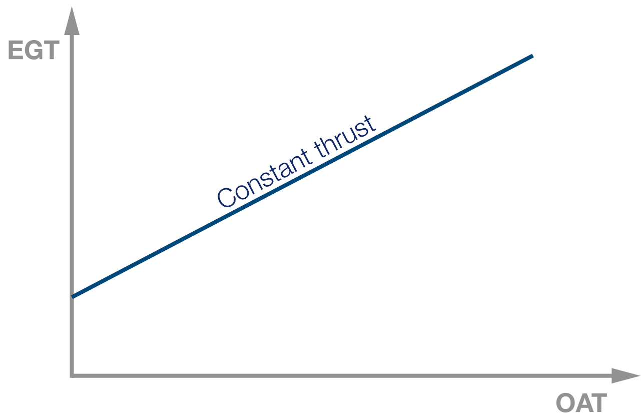
An engine with degraded performance is less efficient and requires more fuel to produce the same thrust leading to an increase in EGT. A number of parameters can cause temporary performance degradation that will have an influence on EGT or there can be a progressive degradation of engine performance.

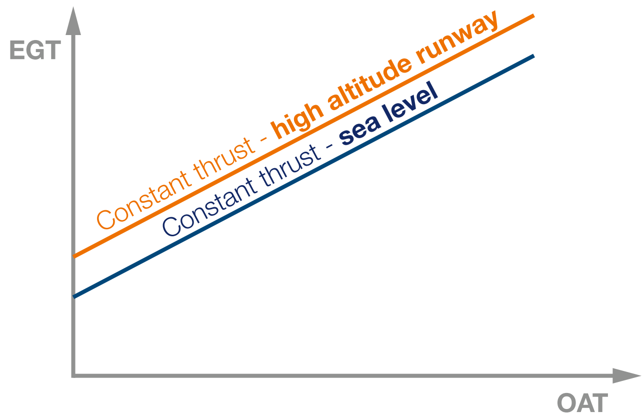
Temporary performance degradation

Several parameters can cause temporary engine performance degradation and result in increased EGT values:

- **Environmental parameters** such as Outside Air Temperature (OAT) **(fig.1)** and altitude **(fig.2)**. For example, every increase of 1°C in OAT can lead to an EGT increase of approximately 3°C to produce the same thrust at takeoff, depending on the engine type.

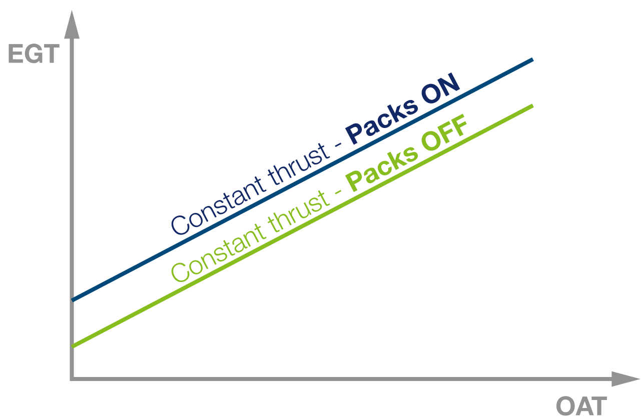
(fig.1) & (fig.2)
Effect of OAT and altitude on the EGT for a constant thrust

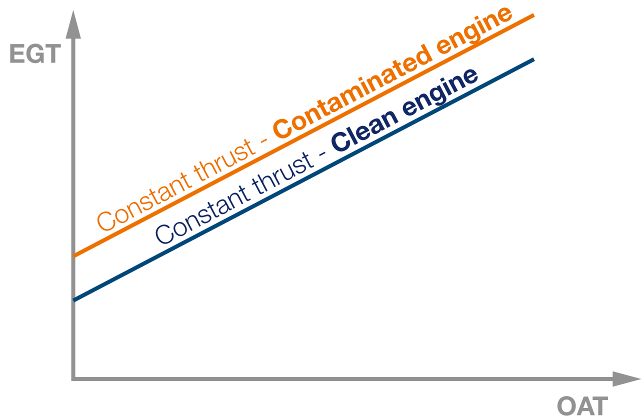




- **Bleed demand:** Use of air conditioning packs and anti-ice increases the bleed demand on the engine and will result in a higher EGT to produce the same thrust **(fig.3)**.
- **Engine contamination** (e.g. dust, pollution) can disturb the airflow through the engine, which affects the overall performance of the engine and results in higher EGT values **(fig.4)**.

(fig.3) & (fig.4)
Effect of bleed demand (packs) and engine contamination on the EGT for a constant thrust



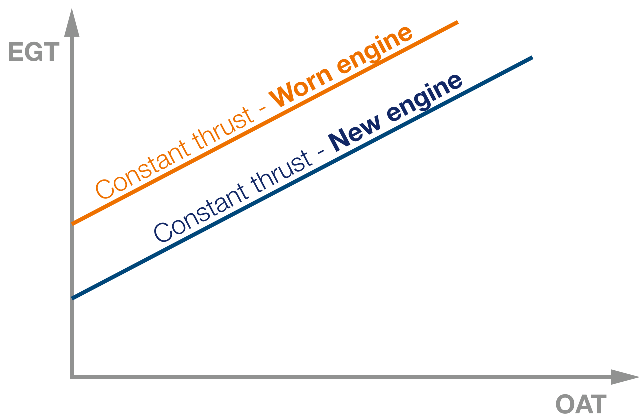


- **Engine temperature:** An engine is “cold” when the EGT is almost the same as the OAT at engine start. This can lead to an increased peak in the EGT during takeoff if the engine does not have sufficient time to warm up after starting.

Progressive Performance Degradation: Engine Wear

The performance of any engine progressively degrades with time due to inevitable wear of its components. This is generally due to eroded or damaged compressor foils, worn seals, and the increased clearance between rotor/stator blade tips and the stator/rotor in the compressor and turbine sections due to erosion.

(fig.5)
Effect of engine wear on the EGT

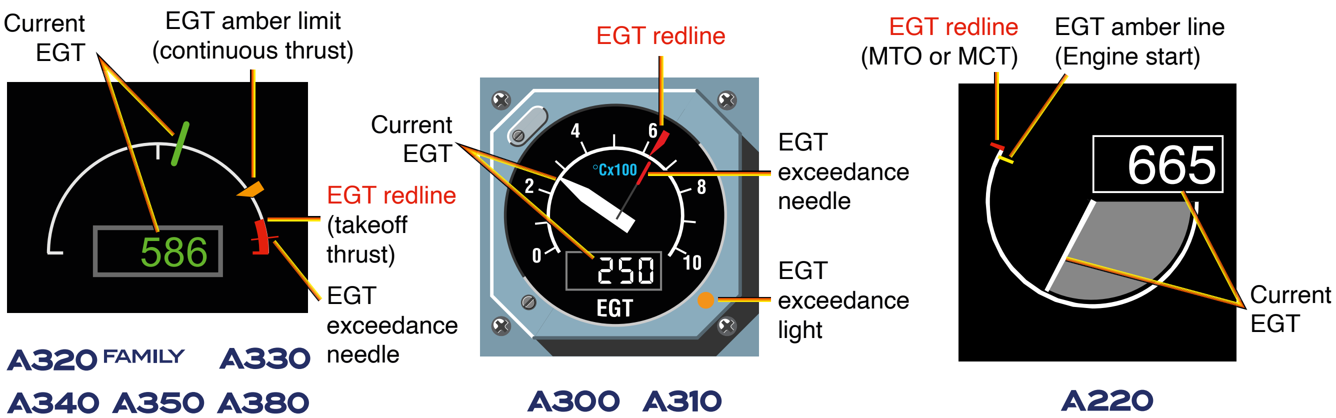


EGT Redline

The "EGT redline" is defined as the engine operational limit that prevents damage to the engine due to an excessively high temperature. EGT limits for each flight phase are provided in the "AFM - LIMITATIONS - POWER PLANT - Engine Parameters" and "FCOM - Limitation - Engines - Thrust Setting/EGT Limits". **The EGT redline corresponds to the EGT limit for takeoff and go-around.**

The EGT redline appears as a red line on the EGT indicator of A300/A310 aircraft and on the engine display of A220 aircraft. On A320 family, A330, A340, A350, and A380 aircraft, the EGT redline is the start of the red zone of the EGT arc on the engine display **(fig.6)**. An EGT amber limit indicates the EGT limit for maximum continuous thrust or engine start provided in the FCOM on A320 family, A330, A340, A350, and A380 aircraft. This amber limit indication is hidden when takeoff power is applied. On A220 aircraft, an amber line indicates the EGT limit during engine start.

(fig.6)
EGT indication



"In the absence of severe damage, an engine is capable of operating above the EGT redline without thrust loss, but at the cost of an accelerated engine wear."

The EGT redline is not a "hard" limit

In the absence of severe damage, an engine is capable of operating above the EGT redline without thrust loss, but at the cost of an accelerated engine wear. This was demonstrated during the engine certification tests. It is why an amber caution alert is used to inform the flight crew of an EGT overlimit rather than a red warning alert.

- The ENG1(2) EGT OVER LIMIT ECAM alert is combined with an amber or red EGT indication for A320 family, A330, A340, A350, and A380 aircraft or an amber light on the EGT indicator for A300-600 and A310 aircraft. The alert is inhibited from 80 kt (70kt for A300-600/A310) during takeoff roll until liftoff to prevent a high-energy rejected takeoff and from touchdown down to 80 kt at landing to prevent the flight crew from stopping the use of thrust reversers.
- The ENG EGT warning light on the Master Warning Panel is combined with an amber light on the EGT indicator for A300 aircraft.
- The L(R) ENG EXCEEDANCE EICAS caution is combined with an AMBER or red EGT indication for A220. The caution is inhibited during the takeoff roll.

An EGT overlimit requires maintenance

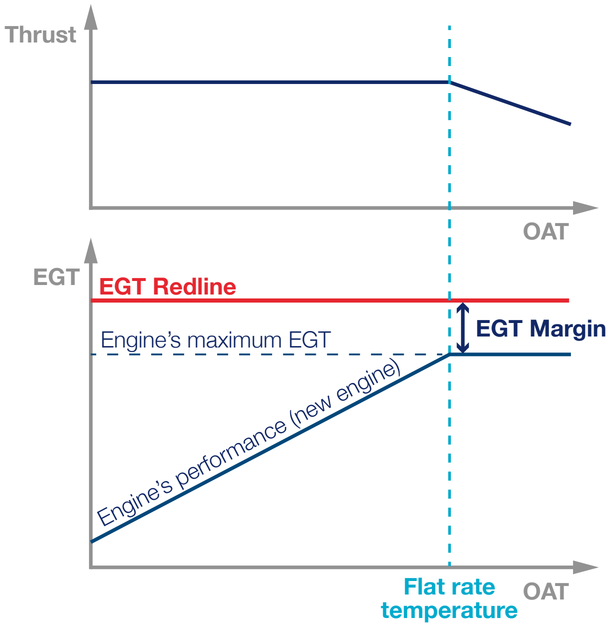
After an EGT overlimit, inspection and troubleshooting are necessary to identify the root cause of the overlimit and assess the engine's health.

EGT MARGIN INDICATES ENGINE HEALTH

Engine manufacturers define the guaranteed maximum thrust of an engine based on its maximum limits (e.g. EGT, N1, N2) and up to a defined OAT. This OAT is called the flat rate temperature.
It is also commonly called corner point temperature, breakpoint temperature, or kink point temperature. Above this OAT value, the engine control (FADEC) automatically manages the thrust to maintain a constant EGT. The maximum thrust and flat rate temperature are selected so that a new or overhauled engine has a sufficient EGT margin to the EGT redline **(fig.7)**. This will enable the engine to sustain a certain amount of engine wear and still be capable of producing its maximum thrust rating without reaching the EGT redline. An OAT of 30°C at sea level (ISA +15°C) is usually defined at max take-off by engine manufacturers as a compromise for flat rate temperature because it enables maximum thrust in a wide range of conditions.

EGT monitoring

The EGT margin gradually decreases with the progressive degradation in the performance of an engine. Use of the Engine Condition Monitoring (ECM) tool to measure the EGT margin of an engine provides a good indication of its health and can highlight if there is a need for maintenance. EGT margin trends can also provide a useful forecast of the average time on wing remaining for an engine.



(fig.7)
EGT margin

Calculating the Current EGT Margin of an Engine

Each time a takeoff is performed with TOGA thrust, the ECM tool takes a snapshot of the engine parameters and of the external conditions (e.g. OAT, pressure). The tool then uses this measurement to calculate a delta vs the engine performance model and project it to the worst condition to determine the projected EGT of the engine **(fig.8)**. The difference between this projected EGT and the EGT redline value is the current EGT margin of the engine.

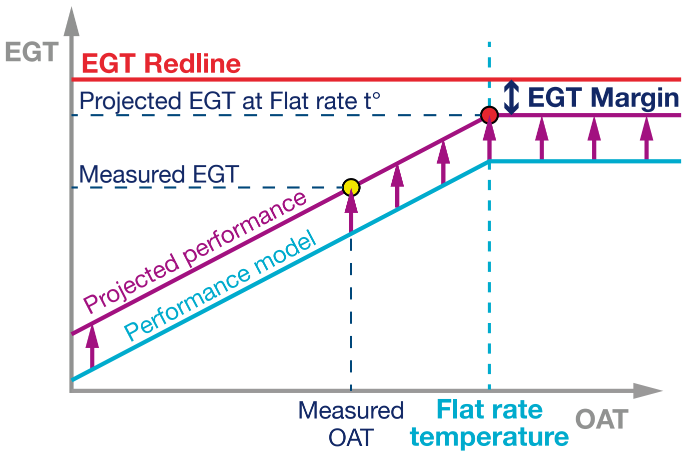
The ECM also estimates the EGT margin when a FLEX or derated takeoff is performed, however, the computation is less accurate than when TOGA thrust is used. The need to perform a regular takeoff with TOGA thrust is therefore necessary to ensure efficient EGT monitoring. This is particularly important when the engine is near the EGT redline.

> "The need to perform a regular takeoff with TOGA thrust is necessary to ensure efficient EGT monitoring."

All parameters should be considered to prevent EGT overlimit

Several parameters such as altitude, OAT, takeoff thrust used, and bleed demand can affect the peak EGT value at takeoff. Therefore, an engine with a slightly positive EGT margin may experience an EGT overlimit at takeoff but an engine with a slightly negative EGT margin may not necessarily experience EGT overlimit at takeoff.

(fig.8)
Computation principle of the current EGT margin of an engine (altitude and mach corrections are not represented)



PREVENTION OF EGT OVERLIMIT EVENTS

Maintenance, Flight Operations and flight crews can all play a role to prevent EGT overlimit events.

Role of Maintenance

Monitoring engine performance degradation

The engine manufacturer Instructions for Continued Airworthiness (ICA) manual requests Operators to monitor the EGT Margin of their aircraft engines. This monitoring may be performed by the Operators or through a service provided by the engine manufacturer. The Operator should check the maximum thrust (TOGA) by performing full-rated takeoffs at regular intervals, in order to detect a reduced EGT margin, or maintaining an adequate engine monitoring program, in order to follow up on the engine parameters.

Maintenance should inform Flight Operations and request that flight crews perform a takeoff with TOGA thrust when it is necessary to ensure an accurate computation of the EGT margin.

Avoid fitting two performance limited engines to the same aircraft

Operators should manage their fleet to ensure as much as possible that aircraft have no more than one engine with low EGT margin. An aircraft that has two performance-limited engines increases the probability of a dual EGT overlimit event.

Regular engine washes

Performing regular engine washes will remove particles from the compressor such as dirt, oil, sand, and salt that reduce the engine efficiency. The engine wash procedure is available in the AMM/MP. Operators can request additional or specific recommendations directly from the engine manufacturer.

Sharing engine performance information

It is important to ensure there is good communication between Maintenance and Flight Operations about the conditions and performance of engines fitted to an aircraft. Maintenance must inform the Flight Operations department when an aircraft is fitted with performance-limited engine(s). This will enable operations to be adapted according to the limitations of each aircraft.

Role of Flight Operations

Adapting operations for aircraft with performance-limited engines

Flight Operations should adapt operations to avoid using aircraft with performance-limited engines on performance-demanding routes such as into airports with hot weather or high-altitude runways. Operators should take particular care during the summer season when EGT events are more likely to occur.

Informing flight crews

Flight Operations should provide information to the flight crew before they fly an aircraft with performance-limited engines, so that they can adapt their procedures accordingly. Flight Operations also need to plan and pass on the request from Maintenance to perform a TOGA takeoff for an accurate computation of the EGT margin.

Role of Flight Crew

Engine warm-up time

High EGT is often experienced when the engine is cold on the first takeoff of the day or after a long stay on the ground. When the EGT is almost the same as the OAT before engine start, the flight crew can extend the warm-up time to reduce the EGT peak during takeoff, especially at airports with hot weather and high-altitude runways, or if the aircraft engines have limited EGT margins. The usual warm-up time is between 2 and 5 minutes, however, a warm-up time of 10 minutes can reduce the takeoff EGT by approximately 10°C depending on the engine type. Some Operators have made it a policy to extend this warm-up time for each first flight of the day.

Use reduced takeoff thrust

If the flight crew uses reduced takeoff thrust, it can enable the engine to have an increased margin to the EGT redline. The use of “Flex” or “Derated” takeoff configuration can help to extend engine life and to save on maintenance costs.

Take off with packs OFF

If it is not possible for the flight crew to reduce the thrust takeoff, they can choose to take off with packs set to OFF, in order to reduce the bleed air demand on the engine.

Take off with APU BLEED ON

If the OAT is high and it does not enable the flight crew to take off with packs set to OFF, then they can perform the takeoff with APU BLEED ON to remove the bleed air demand from the engines and maintain passenger comfort.

WHAT TO DO IN THE CASE OF AN EGT OVERLIMIT DURING TAKEOFF

Despite applying all of the prevention measures, EGT overlimits can still happen and especially during hot weather. The EGT usually reaches a peak at the end of the takeoff roll, near rotation, or just after liftoff. If an EGT overlimit is combined with vibrations and happens shortly after the application of takeoff power, this can be an indication of more severe engine damage.

EGT overlimit between takeoff power application and 100 kt

If the EGT overlimit alert is triggered or if the flight crew notices that the EGT value becomes red on the engine display (on A220/A320/A330/A340/A350/A380 when the alert is inhibited) between takeoff power application and 100 kt, they should consider rejecting the takeoff.

EGT overlimit between 100 kt and V1

If the flight crew notices that the EGT value becomes red on the engine display (on A220/A320/A330/A340/A350/A380) or if the EGT overlimit warning light comes on (on A300/A310) between 100 kt and V1, they should continue the takeoff to establish the aircraft on the initial climb path. The flight crew should then wait to be above 400 ft before they apply the ECAM/FCOM procedure. However, the decision to perform a rejected takeoff is at the captain's discretion and it depends on the situation, especially in the case of a dual EGT overlimit event or if the aircraft is in a mountainous area, for example.

EGT overlimit after V1 or after liftoff

If the EGT overlimit happens after V1 or after liftoff, the flight crew must continue the takeoff. They should wait until the aircraft is safely established on its climb path above 400 ft before they apply the ECAM/FCOM procedure and gently reduce the thrust of the affected engine. If the temperature goes above a given threshold or if the overlimit situation persists after reduction of the thrust, the flight crew may shut down the affected engine as requested in the ECAM/FCOM procedure.

Reporting EGT overlimit events

Each time the flight crew experiences an EGT overlimit event, they must report it to maintenance, so that the necessary inspections and troubleshooting can be performed.

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Engine performance progressively degrades over time, which leads to an increase in EGT to produce the same thrust. Operators must monitor the performance of their aircraft engines and the evolution of the EGT margin. This will allow for maintenance or removal of an engine, if necessary, before engine performance degrades too much.

Maintenance, Flight Operations and flight crews all have a role to play to prevent EGT overlimit events on their aircraft in operations. In addition to monitoring the EGT margin, regular engine washes should be performed. Maintenance should avoid installing more than one engine with an EGT margin close to the EGT redline or a negative margin. Flight operations and flight crews should be informed when an aircraft is fitted with performance-limited engines. Maintenance should also request that Flight Operations plan for, and ask flight crews to perform, regular TOGA thrust takeoffs to ensure efficient monitoring of the EGT margin of the engines.

Flight Operations should avoid scheduling performance-limited aircraft on demanding routes and inform flight crews before they fly on a performance-limited aircraft, so that they can adapt their procedures accordingly. This can be done, for example, by extending the engine warm-up time before takeoff, using reduced-thrust takeoff, or performing the takeoff with packs set to OFF or APU bleed ON to gain extra EGT margin.

Flight crews should keep in mind that the EGT red line is not a hard limit. An engine can still produce thrust above the redline but with more wear on the engine components. As a result, if an EGT overlimit occurs during takeoff:

- Before 100 kt, the takeoff should be aborted, because an EGT overlimit in the early stage of the takeoff roll can be a sign of engine damage, especially if associated with vibrations.
- Between 100 kt and V1, the flight crew should continue the takeoff, establish the aircraft on the initial climb path, and wait until the aircraft is above 400 ft before they apply the ECAM/FCOM procedure. However, the captain may decide to reject the takeoff depending on the situation.
- After V1 or after liftoff, the flight crew must continue the takeoff and wait until the aircraft is above 400 ft before they apply the ECAM/FCOM procedure.

The flight crew must report any EGT overlimit to the Maintenance personnel and make a logbook entry so that appropriate troubleshooting and inspection are performed before the aircraft returns to service.

Good Quality Hydraulic Fluid for Safe Operations

Several cases of uncommanded spoiler extension were reported to Airbus in recent years. Investigations showed that a high acidity level of the hydraulic fluid was a contributor to these events.

This article recalls the importance of checking the quality of the hydraulic fluid and describes the improvements made to the AMM/MP procedure to perform hydraulic fluid analysis and reduce buildup of acid in the fluid. It also recalls some good practices to prevent hydraulic fluid contamination during maintenance or servicing operations.

CASE STUDY

Event Description

An A320 family aircraft was on descent passing through 14 000 ft. After a brief extension and retraction of the speed brakes by the flight crew, the aircraft suddenly banked to the right and the F/CTL SPOILER FAULT ECAM alert triggered. The pilot flying disconnected the autopilot and manually flew the aircraft. The flight crew observed that spoiler 3 of the wing on the right side was still fully extended. They performed the ECAM actions and the pilot flying continued to manually fly the aircraft and safely landed without further incident. Spoiler 3 remained fully extended with the aircraft on the ground. Maintenance crews found that the servo valve of spoiler 3 was stuck in the extended position. It was replaced and sent to the equipment supplier for analysis and repair.

Event Analysis

Analysis of the faulty servo valve removed from spoiler 3 revealed that the high acidity of the hydraulic fluid led to corrosion of the internal parts and a crack was found. This caused the servo valve to malfunction, which resulted in the spoiler 3 to remain deployed after the speed brakes retraction command.

REGULARLY CHECK HYDRAULIC FLUID QUALITY

Poor quality hydraulic fluid can cause damage to the hydraulic circuit and the hydraulic components in systems such as flight controls, braking, and steering. A regular check of the hydraulic fluid quality can help to prevent damage.

Checks on A300, A310, A320 family, A330, A340, A350, and A380 aircraft

The **Maintenance Planning Document (MPD) task** for A300/A310/A320 family/A330/A340/A350/A380 aircraft requests sampling and analysis of the hydraulic fluid from each hydraulic circuit. This is to check the quality of the fluid, and these checks should be performed at regular intervals shown in the table below.

Aircraft	A300/A310	A320 family	A330/A340/A350/A380
Fluid sampling interval	24 MO	24 MO or 7500 FH	36 MO

KEYPOINT

To take a sample of the hydraulic fluid, it is important to apply the steps in the AMM/MP procedure. Avoid contaminating the sample to prevent an erroneous contamination measurement. **Flush the sampling valve** by discarding the first 200 ml of hydraulic fluid to remove any particles. Then collect the fluid sample in a **clean and dry chlorine-free bottle**.

The hydraulic fluid sample must be sent to an approved laboratory for analysis in accordance with **NSA307110 standard** recommendations. This documentation can be found in the **Airbus Process and Material Specification (PMS)** available in **Airnav^{X}**.

Checks on A220 Aircraft

An A220 MPD AMP task requests a check of the Differential Pressure Indicator (DPI) of the pressure filter, case drain filter, and return filter every 1 200 FH. Hydraulic fluid sampling should be done if contamination is identified during this check. The sample should then be sent to an approved laboratory for analysis.

Laboratory checks and results

The laboratory analysis checks the physical and chemical characteristics of the hydraulic fluid:

Particle contamination

Contamination of the hydraulic fluid by particles may cause erosion and damage to components such as pumps, valves, and ultimately cause components to jam or fail.

If the particle contamination is above the tolerance value provided in the AMM/MP, then the hydraulic fluid must be flushed and replaced or cleaned. For A220 aircraft, the hydraulic fluid must be replaced.

Viscosity & density

The hydraulic fluid must also have the correct viscosity and density characteristics to ensure the appropriate level of performance and responsiveness for the hydraulic system.

If the viscosity or density is not in the range provided in the AMM/MP/AMP, the hydraulic fluid must be replaced within the permitted time frame.

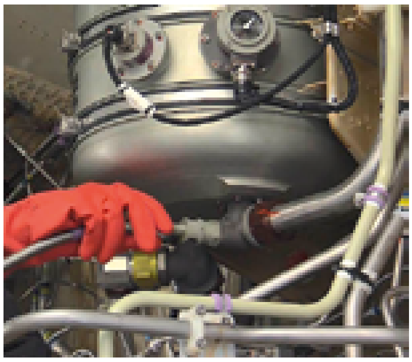
Electrical conductivity

If the electrical conductivity of the fluid is too low, it may lead to electrical discharging effects and arcing within the hydraulic system. This may further degrade the hydraulic fluid quality and cause damage to hydraulic components.

If the electrical conductivity is below the value provided in the AMM/MP/AMP, the hydraulic fluid must be replaced within the permitted time frame.

Acidity

High acidity of the hydraulic fluid leads to corrosion and erosion of the components it is in contact with. **The Total Acid Number (TAN)** is used to measure the hydraulic fluid acidity. The TAN is the number of milligrams of potassium hydroxide (KOH) needed to neutralize the acid in one gram of hydraulic fluid. The AMM/MP will define the amount of hydraulic fluid that must be replaced depending on the measured TAN value in the laboratory analysis report for the sample taken. This can range from replacing the quantity of hydraulic fluid in the reservoir (between 10 and 15% of the total fluid quantity) **(fig.1)** to full replacement (flush) of the fluid. For A220 aircraft, the hydraulic fluid must be replaced.



(fig.1)
Replacement of the hydraulic fluid contained in an hydraulic reservoir

Chlorine content

The use of chlorinated solvents to clean components of the hydraulic system introduces chrorine in the hydraulic fluid. Chlorine creates acid when combined with any water present in the fluid and this will increase the level of acid in the fluid.

If the quantity of chlorine is greater than the tolerance value provided in the AMM/MP, the hydraulic fluid must be either cleaned or flushed and replaced within the permitted time frame.

Water content

Water content can lead to an increase of acid in the fluid and can modify the physical characteristics of the hydraulic fluid, which may reduce the performance of the system. It also can contribute to corrosion of hydraulic circuit components.

If the quantity of water is greater than the tolerance value provided in the AMM/MP/AMP, the hydraulic fluid must either be cleaned or changed within the permitted time frame. Additional inspections and tests may be required depending on the level of water contamination.

BEST PRACTICE

The maximum water content permitted in hydraulic fluids is 0.8 %. However, Airbus recommends a limit of 0.5 %, which will increase the life of the hydraulic fluid.

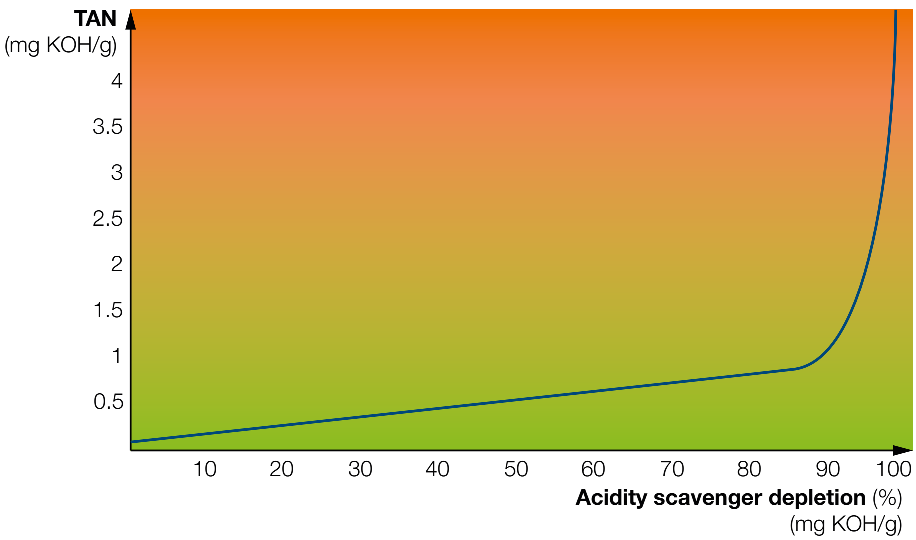
IMPROVED PROCEDURE FOR FLUID ACIDITY CORRECTION

In 2021, Airbus launched an improvement of the AMM/MP procedure for analysis of the hydraulic fluid of A300/A310/A320 family/A330/A340/A350/A380 aircraft. The AMM/MP of A320 family, A350, and A380 aircraft was updated accordingly in 2021. The AMM of A330/A340 aircraft will be updated by mid 2022.

The AMM/MP improvement modifies the acidity thresholds and their associated fluid replacement procedure. This is to increase the hydraulic fluid lifetime and reduce the risk of reaching high TAN values, which may result in system malfunctions.

Typical Evolution of the TAN

An acid scavenger is an additive in hydraulic fluid to reduce the likelihood of acid level increases in the fluid. This additive is progressively consumed over time and the level of acid in the fluid will begin to rise. When most of the additive is consumed, the acid level can rapidly increase **(fig.2)**.



(fig.2)
Typical evolution of the TAN

Improved procedure for acidity correction

The improved procedure now requests corrective actions to reduce the acidity of the fluid from a TAN threshold of **1.0 mg KOH/g** instead of the previous threshold of 1.5 mg KOH/g.

This lower limit for acid levels of 1.0 mg KOH/g was determined using in-service data analysis. This showed that when the results from the analysis of hydraulic fluid samples had a TAN value between 1.0 and 1.5 mg KOH/g, the very next sample taken was likely to show a significant increase of acid levels.

Performing corrective actions from 1.0 mg KOH/g will further prevent reaching high acidity values and this will improve the reliability of hydraulic components.

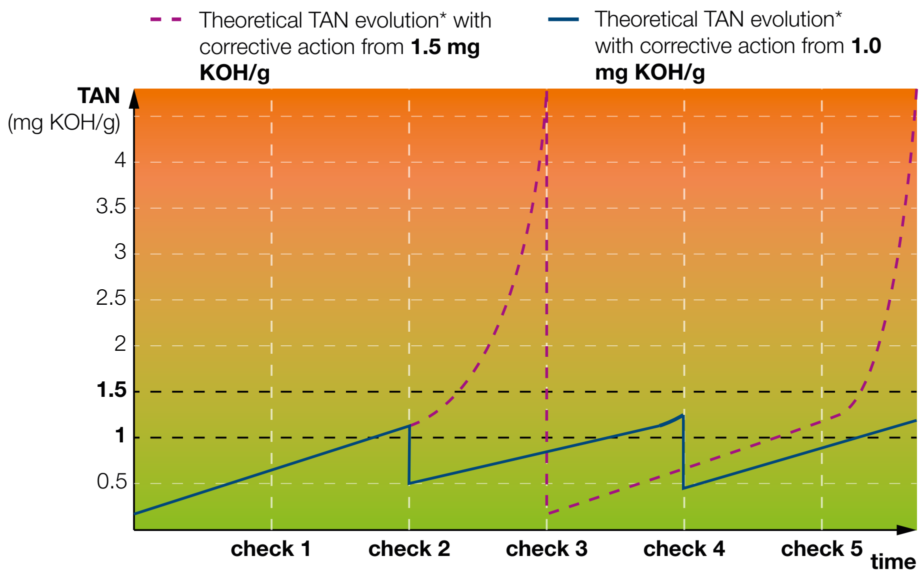
<table>
<tr><th>TAN
(mg KOH/g)</th><th>Permitted time frame for correction action</th><th>Fluid replacement</th><th>Procedure</th></tr>
<tr><td>TAN < 1.0</td><td>N/A</td><td>N/A</td><td>Next MPD check</td></tr>
<tr><td>1.0 < TAN < 1.2</td><td rowspan="2">30 Days</td><td>2x reservoir fluid replacement [(1)]</td><td rowspan="5">1. Replace fluid within the permitted time frame. Operate flight controls between each reservoir refilling or perform at least 1 flight cycle.
2. Take a new sample at least after 1 flight cycle and within 1 week[(2)], result within 30 days must be available
3. If TAN < 1 check at next MPD or within 24 months</td></tr>
<tr><td>1.2 < TAN < 1.5</td><td>3x reservoir fluid replacement [(1)]</td></tr>
<tr><td>1.5 < TAN < 1.8</td><td rowspan="3">14 Days</td><td>4x reservoir fluid replacement [(1)]</td></tr>
<tr><td>1.8 < TAN < 2.2</td><td>5x reservoir fluid replacement [(1)]</td></tr>
<tr><td>2.2 < TAN < 2.5</td><td>6x reservoir fluid replacement [(1)]</td></tr>
<tr><td>2.5 < TAN < 3.5</td><td>3 FC if only 1 system affected and other systems without any contamination; otherwise no grace period</td><td rowspan="2">Complete exchange of fluid</td><td rowspan="2">1. Replace fluid within the permitted time frame
2. Take a new sample at least after 1 flight cycle and within 1 week[(2)], result within 30 days must be available
3. If TAN < 1 check at next MPD or within 24 months</td></tr>
<tr><td>TAN > 3.5</td><td>No permitted time frame Immediate corrective action</td></tr>
</table>

[(1)] Complete fluid change can be selected optionally
[(2)] For Parking and Storage the flight cycle can be replaced by an operation of the flight controls for 5 minutes

As an example, **(fig.3)** shows that the 1.5 mg KOH/g TAN threshold would require a full hydraulic fluid replacement at the third check. This would allow the TAN value to exceed 2.0 mg KOH/g for one year and would be likely to reach high TAN values above 4.5 mg KOH/g before the fluid replacement is due.

(fig.3)
Theoretical evolution of the TAN with time

The 1.0 mg KOH/g threshold requires that only a volume of fluid 2x the hydraulic reservoir contents is replaced at the second and fourth checks. This will maintain the TAN value below 1.3 mg KOH/g during the entire period.



* No maintenance action on the hydraulic system is considered. The acidity evolution rate may vary depending the conditions of operation.

PREVENTION OF HYDRAULIC FLUID CONTAMINATION

Precautions taken during servicing and maintenance operations can reduce the risk of contamination of the hydraulic fluid and reduce the likelihood of increased levels of acid in the fluid.

Hydraulic fluid handling and storage

New fluid containers must be correctly blanked to prevent water ingress from humidity in the ambient air. They should be stored in dedicated areas and away from used fluids. Operators should refer to the recommendations provided by the fluid supplier for fluid handling and storage.

Hydraulic Ground Cart

Airbus recommends periodic monitoring of fluids that are contained in hydraulic ground cart reservoirs. This is to prevent contamination during refilling of the hydraulic system when using a cart.

Maintenance operations

Any maintenance operation (especially hydraulic component replacement) can have a risk of hydraulic fluid contamination. Hydraulic lines and equipment must be blanked and stored in clean areas. Aircraft hydraulic servicing ports must be blanked and hydraulic equipment must be suitably protected against contamination.

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Degraded hydraulic fluid can cause damage to hydraulic components. In some reported cases, high acid levels in hydraulic fluid was a contributing factor that led to component damage in the flight control spoiler system causing unintended flight control surface behavior.

It is essential to regularly check that the hydraulic fluid quality is within the limits defined in the AMM/MP/AMP.

Airbus improved the AMM/MP procedure for hydraulic fluid analysis of A300/A310/A320family/A330/A340/A350/A380 aircraft by reducing the threshold for corrective actions of the fluid acidity. This will further prevent the likelihood of reaching a high level of acid in the hydraulic fluid.

Operators should carefully follow the instructions and precautions provided in the maintenance documentation to prevent contamination of the hydraulic circuits during maintenance and servicing. All of these actions combined will ensure that the hydraulic fluid is of good quality, and that it retains its physical and chemical characteristics for safe and efficient operations.

Do not Wait to Apply the Engine Fire Procedure

Several recent engine fire events highlight the importance of timely application of the engine fire procedure.

This article explains why flight crew must apply this procedure without delay. Decisive action when there is an engine fire alert may prevent further damage to the engine. This can help to ensure that a manageable fire situation does not become an uncontrolled fire with more serious consequences.

CASE STUDY

Event Description

An A330 aircraft departed for a long-range flight. The aircraft was in CONF 2 for the takeoff. The takeoff roll was normal, but the ENG 2 FIRE red ECAM alert triggered **(T0)** 17 s after liftoff. The flight crew continued the climb. The engine display showed stable engine parameters for both engines.

At T0 + 51s, the aircraft reached 2 400ft RA. The PF set the engine 2 thrust lever to IDLE and pushed the engine 1 thrust lever to TOGA.

At T0 + 52s, the PF set the engine 1 thrust lever to MCT and this caused the autothrust to engage in thrust mode.

At T0 + 2min 27s, the flight crew set the engine 2 master lever to OFF.

At T0 + 2min 43s, the flight crew pressed the ENG FIRE pushbutton and discharged AGENT 1 followed by AGENT 2. The ENG 2 FIRE alert remained after both agents were discharged.

At T0 + 3min 38s, the flight crew engaged the autopilot and leveled off the aircraft at 7 000ft.

At T0 + 6min 31s, the flight crew started the APU, which provided the electrical power supply to the right side.

At T0 + 9min 39s, the EGT indication for engine 2 started to increase, even though it had shown decreasing EGT from the time when the engine 2 master lever was set to OFF.

At T0 + 10min 03s, the ENG 2 FIRE alert stopped and the ENG 2 FIRE DET FAULT amber ECAM alert triggered.

At T0 + 11min 23s, the ENG 2 EGT OVERLIMIT amber ECAM alert triggered when engine 2 EGT reached 600°C.

At T0 + 15min 09s, the engine 2 N1 value became invalid.

At T0 + 17min 35s, the engine 2 EGT reached a peak value of 801°C.

At T0 + 25min 02s, the aircraft touched down on the runway and safely came to a stop. Smoke and flames coming from engine 2 were seen. The fire brigade arrived and extinguished the fire.

Event Analysis

Probable cause identified

Investigation enabled Airbus to conclude that the most probable cause of the engine fire was a leak from the green hydraulic circuit, which may have been due to damage on a green hydraulic line during maintenance.

Delayed application of the fire procedure

Any red ECAM alert requires immediate action by the flight crew to ensure the continued safety of the flight. When the ENG X FIRE alert is triggered, a red LAND ASAP memo appears on the ECAM. This requires that the flight crew land as soon as possible at the nearest airport at which a safe landing can be made.

During this event, the engine 2 thrust lever was not set to IDLE until 51s after the ENG 2 FIRE alert was triggered. A further 1m 36s passed (T0 + 2m 27s) before the ENG FIRE procedure was completed to isolate the fire and use the fire extinguishing system.

Nominal engine parameter despite the fire

The engine indications in the cockpit appeared to show that engine 2 operation was normal. This may have been a factor in the flight crew's decision to delay application of the engine fire procedure.

Remaining fire and further propagation

Analysis showed that the engine fire extinguishing system operated as intended and both extinguisher bottles correctly discharged during the event. It is likely that the fire reignited shortly after extinction due to remaining conditions for fire reignition in the nacelle.

The EGT increased up to 801°C, which is a sign that the fire spread toward the EGT thermocouples. The fire continued to cause destruction of the fire detection loops and damage to wiring. This was the reason the ENG 2 FIRE ECAM alert stopped and was replaced by the ENG 2 FIRE DET FAULT amber alert. Note that this alert was in the overflow part of the warning display, indicated by a green arrow.

Similarly, the loss of the N1 information was due to damage to wiring.

TWO TYPES OF ENGINE FIRE

There are two types of engine fire **(fig.1)**: an engine fire (nacelle fire) and tailpipe fire (internal fire) . Both types of fire affect the engine, but must be treated differently.

Engine fire (nacelle fire)

An engine fire affects the external part of the engine core, but is contained within the engine nacelle. This type of fire can occur on ground or in flight and is usually caused by a malfunction or rupture of a component or pipe, which contains flammable liquids (e.g. fuel, oil, hydraulic fluid). When these liquids come into contact with hot surfaces on the engine case, such as the high pressure compressor, combustor, or turbine, they can self-ignite and cause a fire. This type of engine fire can also be caused by rupture of a part of the engine core causing damage to components and pipes, which can lead to a fire.

The engine fire protection system will detect the fire and trigger the red ENG X FIRE ECAM alert (L ENG FIRE or R ENG FIRE on A220 aircraft). The flight crew must apply the associated engine fire procedure without delay.

Tailpipe fire (internal fire)

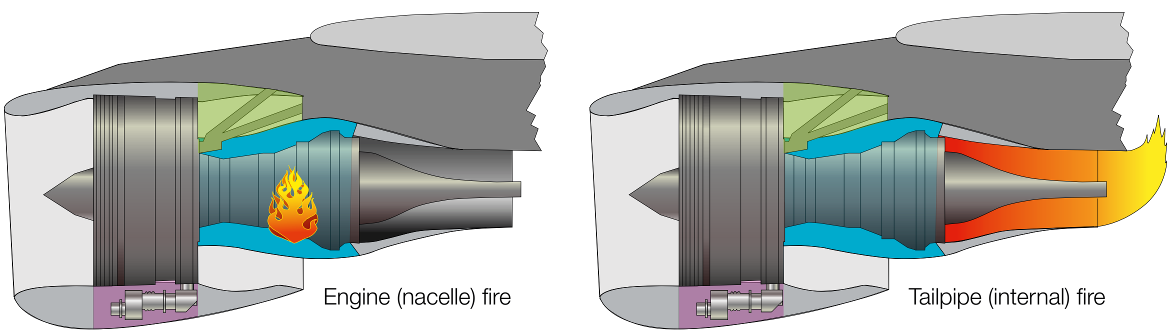
A tailpipe fire occurs inside the engine core. This type of fire will only occur during the engine start or shutdown sequence. A tailpipe fire occurs when the engine rotates at a very low speed and residual fuel is present in the combustion chamber or turbine area, or if there is an oil leak in the tailpipe of the engine. The risk of tailpipe fire is higher in the case of a second engine start attempt, because residual fuel may remain in the engine after the first attempted engine start.

The fire detection system does not detect tailpipe fires, because they occur inside the hot sections of the engine core, and therefore, are outside of the fire detection zone. Flight crews can detect tailpipe fires by observing any abnormal increase in EGT during the engine start sequence or if the EGT does not decrease after engine shutdown. Ground crew, cabin crew, or air traffic controllers may also observe a tailpipe fire and must inform the flight crew.

In the case of a tailpipe fire, the flight crew must apply the ENGINE TAILPIPE FIRE abnormal procedure from the QRH. This will ventilate the engine, and the airflow will extinguish the fire and remove any residual fuel or vapor from the engine. On the A220, a tailpipe fire procedure is under study to be introduced in the QRH/FCOM.

After any tailpipe fire, inspection by maintenance is required to check that there is no flame damage to the flaps, wing, or pylon areas.

(fig.1)
Engine fire vs Tailpipe fire



RELY ON THE ENGINE FIRE ALERT

The detection system for engine fire is composed of dual sensing element loops. They are located in the areas around the engine with the highest risk of fire and near compartment air exhausts for overheat detection. These are zones where flammable liquids are present with a potential ignition source, such as the accessory gearbox area, the pylon area above the combustion chamber, the combustion chamber area, and the fan area on certain engines. Each loop is doubled (loop A and loop B) for redundancy purposes. The loops can detect fire or hot air leaks.

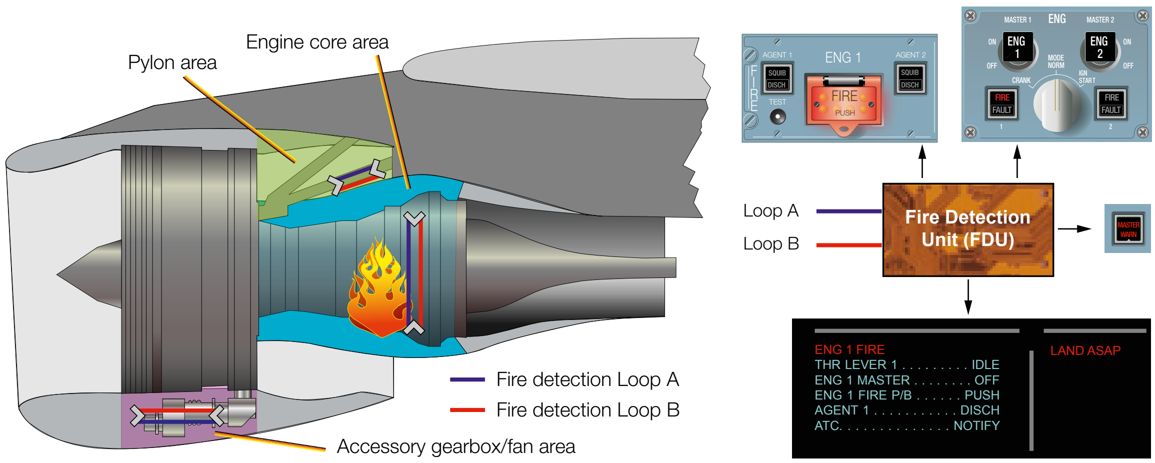
The dual sensing element loops are monitored by a Fire Detection Unit (FDU) (A300/A310/A320 family/A330/A340 and A380 aircraft), the Fire Protection Function hosted in CPIOMs J (A350 aircraft), or the Fire Detection and EXtinguishing (FIDEX) Control Unit (A220 aircraft).

Reliability of the engine fire detection system

The design and redundancy of the detection loops ensure a high level of reliability for the engine fire detection system. In the event of an engine fire alert, the flight crew must rely on it.

(fig.2)

Example of engine fire detection system on an A320 aircraft with CFM engines



Engine parameters may remain normal during an engine fire

Flight crews must be aware that engine thrust and engine parameters can remain normal in the early stage of an engine fire. The event described in this article is illustrative of this fact.

KEYPOINT

In the event of an engine fire alert, the flight crew must apply the procedure even if the engine thrust is stable and the engine parameters are normal on the engine display and on the engine SD page.

Apply the engine fire procedure without delay

The architecture of the nacelle is designed to contain the fire threat for a minimum, but also limited time. Therefore, the flight crew must apply the engine fire procedure without delay when there is an engine fire alert.

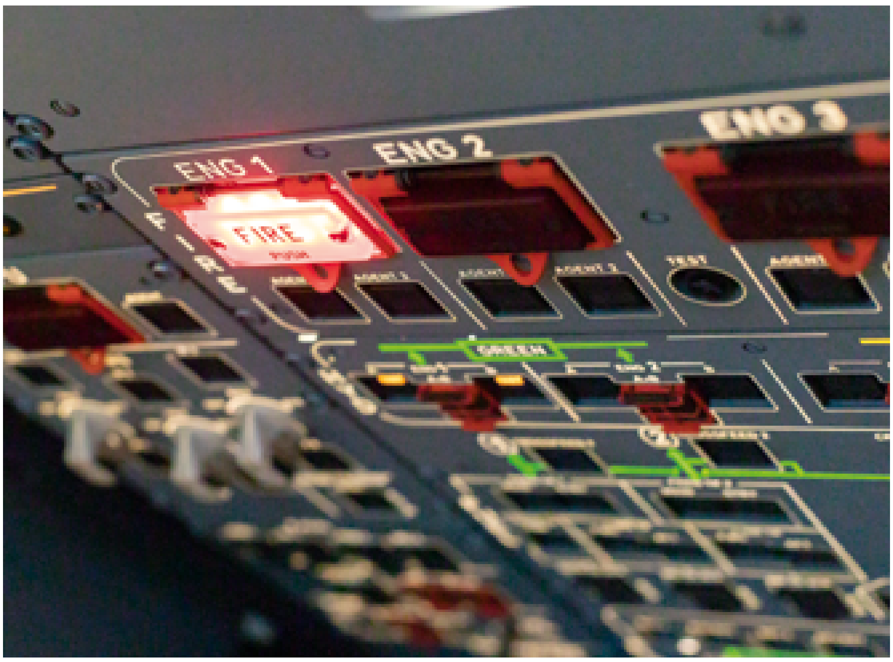
Timely application of the engine fire procedure will limit fire propagation and prevent further damage to components or pipes around the engine core. Such damage could cause additional leaks of flammable fluids, which could increase the intensity or duration of the fire.

BEST PRACTICE

The use of autopilot in the case of an engine fire alert reduces crew workload and enables a safe handling of the thrust asymmetry that is induced when thrust is reduced on the affected engine. Therefore, the flight crew can apply the ECAM procedure earlier and under less stress. This is particularly useful in phases of flight with a high workload, such as initial climb and the approach phase.

Detection fault and fire propagation

The event described in this article shows how a fire can propagate and damage the fire protection loops, which caused the engine fire warning to stop and be replaced by a fire detection amber fault. As a precaution, the flight crew should interpret a replacement of the ENG X FIRE red alert by an ENG X FIRE DET FAULT amber alert as the sign of a potential propagating fire. ENG X FIRE can similarly be replaced by both LOOP ENG X LOOP A FAULT and LOOP ENG X LOOP B FAULT on A300-600/A310 aircraft. On A220 aircraft, L ENG FIRE DET FAIL or R ENG FIRE DET FAIL can replace the L ENG FIRE or R ENG FIRE alert.



Steps of the Engine Fire Procedure

Step 1: Engine shutdown

The first step of the engine fire procedure is to set the thrust lever of the affected engine to idle and set its master switch to OFF. This will cut the fuel supply to the affected engine by closing the HP and LP fuel valves.

Step 2: Engine isolation

The second step is to press the FIRE pushbutton for the affected engine, in order to completely isolate the engine from the fuel, electrical, hydraulic, and pneumatic systems. This is to prevent further damage or fire propagation and prevent smoke from entering the air conditioning system.

Step 3: Fire extinguishing

The third step is to extinguish the fire by discharging the fire agents into the nacelle one after the other when in flight or simultaneously when on the ground (On A220, on the ground, the procedure also requests to discharge the agent one after the other). The 10 s delay requested by the ECAM procedure to discharge agent 1 in flight enables N1 to decrease. This will reduce ventilation of the nacelle, so that the fire extinguishing agent is more effective.

KEYPOINT

The flight crew must complete the procedure and discharge the agents as long as the engine fire alert is displayed and the FIRE lights are still ON on the overhead panel and pedestal.

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With thanks to Christophe MATHE and Thomas GOBEAUT from Flight Operations Support

Aircraft engines are equipped with a reliable fire detection system. Flight crews must be aware that in the event of an engine fire alert, the engine parameters can remain normal in the early stage of the fire. Therefore, the flight crew must apply the ECAM/EICAS procedure without delay, even if the engine display and engine SD page display nominal parameters.

Timely application of the engine fire procedure limits propagation of the fire and prevents further damage to components or pipes around the engine core that may create additional leaks of flammable fluids and increase the intensity or duration of the fire.

The flight crew must complete the engine fire procedure and discharge the agents as long as the engine fire alert is displayed and the FIRE lights are still ON on the overhead panel and pedestal.

By taking decisive action when there is an engine fire alert, the flight crew can prevent a manageable fire situation from becoming an uncontrolled fire with more serious consequences.

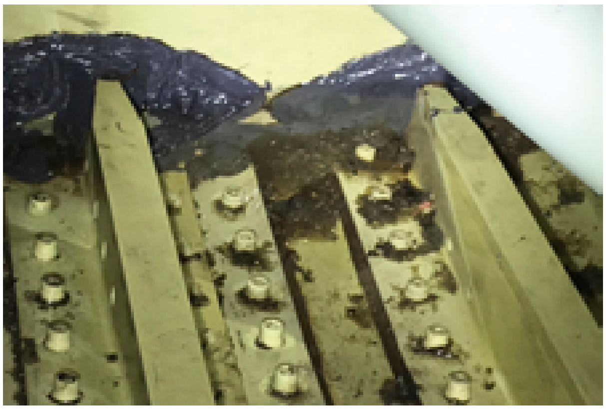
Fuel Microbiological Contamination Treatment

An aircraft fuel tank provides the perfect conditions for microbiological contamination to develop, especially when operating in hot and humid environments. Problems caused by microbiological contamination of fuel can range from inaccurate or erroneous fuel quantity readings to structural corrosion and engine fuel supply difficulties caused by clogged fuel filters.

As a result, if treatment is not correctly applied, microbiological contamination can also cause significant safety issues. This article describes why prevention is important and focuses on why it is essential to follow the maintenance procedures when treatment is required.

WHAT IS MICROBIOLOGICAL CONTAMINATION?

Microbiological contamination refers to the presence of microorganisms such as bacteria, yeast, or fungi. It can be seen as deposits, which vary in color from translucent to dark, with a viscosity that ranges from oily gel to solid.



(fig.1)
Examples of fuel tank contamination

Microorganisms need a food source, water, and warm temperatures to grow. A fuel tank provides the perfect conditions for microorganisms to develop, because they feed on the fuel hydrocarbons, and water is always present in a fuel tank. This water comes from two main sources: dissolved water in uplifted fuel and condensation due to vent air, which enters the fuel tank during normal operations, especially during descent from dry, cold air in cruise to warmer wetter air at lower altitudes. This is the reason why the risk of contamination from microorganisms increases in locations with hot and humid weather conditions.

"Microorganisms need a food source, water, and warm temperatures to grow."

Effects of fuel microbiological contamination

Erroneous fuel quantity measurement

Fuel microbiological contamination can affect the measurement of fuel quantity on board the aircraft. This can result in the flight crew observing false fuel quantity indications, which are often overreads. In extreme cases, these can lead to the total loss of fuel quantity indication for one or several fuel tanks.

Fuel filter clogging, pump failure, and engine malfunction

Deposits from contamination can clog fuel pumps and engine fuel filters, leading to fuel pump failures and degradation in the engine fuel supply.

Corrosion

Microorganisms can sometimes emit acid that causes corrosion, affects coatings, and deteriorates sealants in the fuel tank, which can eventually lead to fuel leaks.

"Microbiological contamination can cause significant operational disruptions, which can affect the safety and efficiency of operations"

Prevention is essential

As stated above, microbiological contamination can cause significant operational disruptions, which can affect the safety and efficiency of operations. An effective maintenance strategy needs to be developed to prevent contamination. Regular drainage of water from fuel tanks is necessary, even if the fuel system on Airbus aircraft is designed to manage and reduce the quantity of water in the fuel tanks. Regular tests to check for the presence of microorganisms are also crucial. If contamination is detected, curative treatment must be used.

KEYPOINT

Operators are responsible for ensuring that the correct quality of fuel is uplifted into the aircraft and managing this with their fuel suppliers. Poor quality fuel is one of the main causes of severe contamination inside a fuel tank. This can be due to fuel supply difficulties, or poor condition of the refueling infrastructure of an airport. Sharing knowledge at industry level, for example through the IATA Global Fuel Portal (IGPF), can provide Operators with early warning of any potential fuel supply and contamination issues. Operators can take additional steps, if necessary, to ensure that their contamination and prevention measures are adhered to.

Booklet
Airbus FAST magazine issue 38

Booklet
Airbus FAST magazine issue 42

INFORMATION

Further information can be found in the "Fuel Contamination - Prevention and Maintenance Actions" article of the **Airbus FAST magazine issue 38** and in the "Fuel Systems - Water Management" article of the **Airbus FAST magazine issue 42**. The "Microbiological Contamination in Fuel Tanks" In-Service Information (ISI) article 28.11.00002 is also available on the *AirbusWorld* portal.

CASE STUDY

Event Description

Before the event flight

A moderate level of fuel microbiological contamination was detected during scheduled maintenance checks of an Airbus A321 aircraft. As recommended in the Aircraft Maintenance Manual (AMM), a biocide curative treatment was performed using Kathon® FP 1.5 biocide.

Following the biocide treatment, there were four flights before the event occurred on the fifth flight (fig.1). The first flight was uneventful. 1 On the second flight, the ENG 1 HP FUEL VALVE ECAM alert triggered, but ENG 1 start was successful on the second attempt. The third flight was uneventful. 2 On the fourth flight, it took four attempts to successfully start ENG 1 with the reappearance of the ENG 1 HP FUEL VALVE ECAM alert and the ENG 1 START FAULT alert. This led to an automatic restart. 3 The ENG 2 STALL ECAM alert triggered twice during the descent and the flight crew felt airframe vibrations. They reduced N1 below 50 % and safely landed the aircraft.

4 Line maintenance performed the troubleshooting actions related to the ENG 2 STALL ECAM alert, but they could not confirm the fault. They released the aircraft back into service.

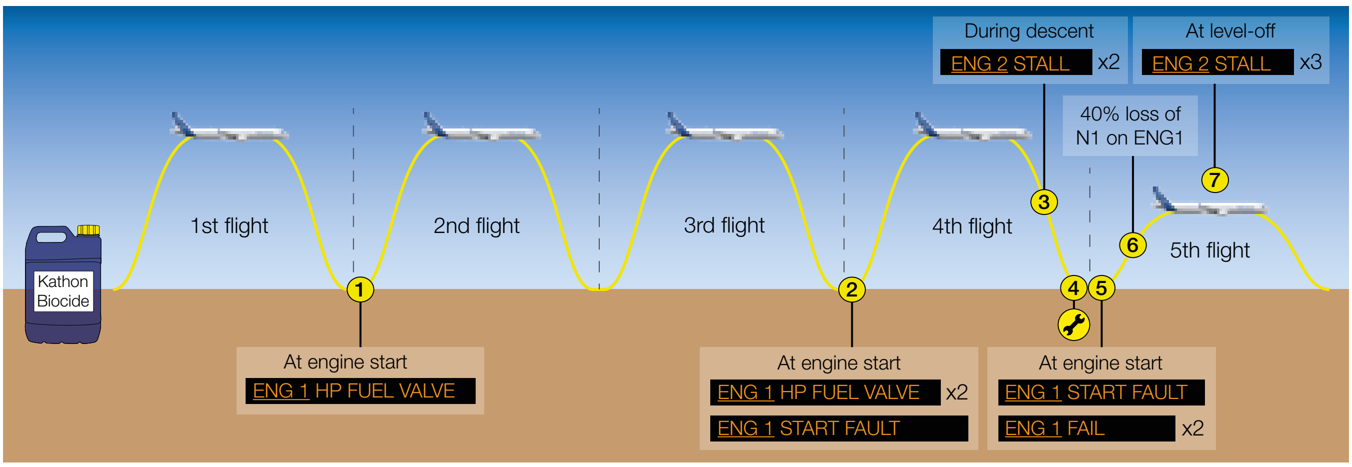
The event on the fifth flight

5 During ENG 1 start, the ENG 1 START FAULT ECAM alert triggered. The second start attempt generated the ENG 1 FAIL ECAM alert. This ENG 1 FAIL alert briefly appeared on the third attempt, but quickly disappeared and the ENG 1 start was finally successful. All engine parameters were normal during the taxi. At the runway holding point, the flight crew accelerated the engines twice for more than 10 seconds. All engine parameters were normal and the flight crew decided to take off.

6 ENG 1 began to surge at 500 ft RA and the engine parameters were fluctuating. N1 decreased below 40 % for 25 seconds. The Captain made a MAYDAY call and asked for an immediate return to the runway. He switched off the AP and noticed that the engine parameters of ENG 2 were also beginning to fluctuate. 7 During the level-off at 3 600 ft, the ENG 2 STALL ECAM alert triggered three times. The Captain reduced the thrust on both engines and was prepared to glide the aircraft, if necessary. The aircraft eventually landed safely. It was observed that the engine parameters had returned to normal when the aircraft came to a complete stop. The flight crew reported that they shut down both engines on the taxiway when they heard unusual noises from the engines.

(fig.2)

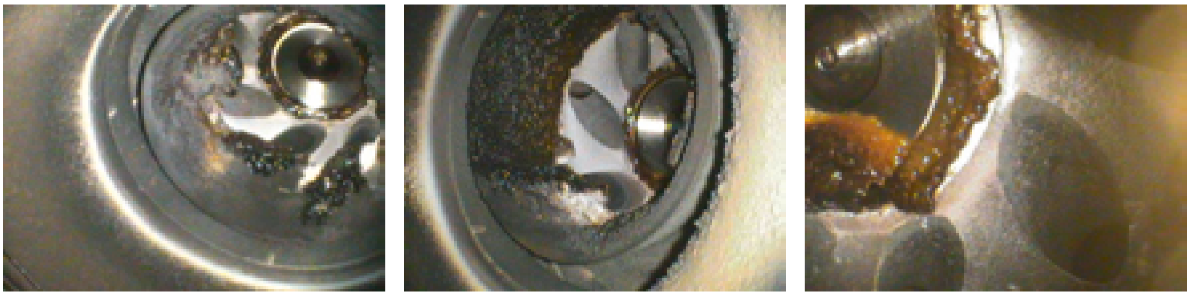
Flight chronology: from the biocide treatment until the event flight



Event Analysis

(fig.3)
Brown deposits found in Engine 2 during borescope inspection

The fuel from the aircraft showed contamination and an amount of undissolved Kathon® FP 1.5 biocide. An inspection of the engine found the presence of viscous, gelatinous deposits on the engine parts.



Biocide overdose

The maintenance crew who performed the biocide curative treatment, was not familiar with the use of the "parts per million" (ppm) unit, which was used in the associated AMM task. They incorrectly used an online conversion tool and this led to a concentration of Kathon® FP 1.5 biocide that was **more than 37 times the correct dosage**.

Biocide not correctly mixed with the fuel

The maintenance engineer used the overwing refuel aperture to deliver the biocide into the aircraft fuel tanks, which prevented the biocide from correctly mixing with the fuel. It remained at the bottom of the tank and migrated along the wing towards the fuel pump.

The AMM task provided two options to introduce the biocide into the aircraft fuel tank. One method was to premix the fuel and biocide and then uplift the mixture into the fuel tank using the normal refueling procedure, but not using the overwing refuel aperture. The other method was to use an adjustable metered injection rig to inject the biocide and correctly mix the fuel during a normal refueling procedure.

Wrong troubleshooting procedure

Before the event flight, the maintenance crew used the TroubleShooting Manual (TSM) to perform the troubleshooting actions associated with the ENG 2 STALL ECAM alert. However, they referred to tasks that were applicable to CFM LEAP-1A32 engines, but the A321 aircraft from the event was equipped with CFM56 engines. Therefore, the troubleshooting actions did not correctly guide the maintenance crew to identify the cause of the ECAM alert and the aircraft was released for flight. If the crew had applied the CFM56 troubleshooting actions, it is likely that they would have identified the fuel contamination issue.

TREATMENT OF FUEL MICROBIOLOGICAL CONTAMINATION

When fuel microbiological contamination is confirmed, curative treatment based on fuel additives with antimicrobial properties, or biocides, is used to arrest and remove the contamination. If biocide treatment is not available, the fuel tanks must be thoroughly cleaned, which is a long process and not always 100 % effective. That is why the use of biocide is the preferred method to treat microbiological contamination.

The right biocide

There were two widely-used biocides approved for use in the aviation industry: Kathon® FP 1.5 and Biobor® JF. Further to in-service experience with Kathon® FP 1.5, including the above event and another case of dual loss of thrust control, GE took the proactive decision to remove the approval for Kathon® FP 1.5 as an approved additive for use in their engines, including CFM and Engine Alliance (EA). At the same time, the manufacturer of Kathon® FP 1.5 stopped producing its biocide for aviation applications to avoid any further risk of misuse.

In addition, currently the use of Biobor® JF is not approved in the European Union (EU) except under specific derogations that airlines and their local authorities discuss on a case-by-case basis.

KEYPOINT

Biocide overdose can cause unstable engine operations regardless of what type of biocide is used (Kathon® FP 1.5 or Biobor® JF).

Only Biobor® JF biocide can be used on Airbus aircraft equipped with GE, CFM, or EA engines. For other engines, such as Rolls-Royce (RR) and Pratt & Whitney (PW), Biobor® JF and any existing stock of Kathon® FP 1.5 can be used. When maintenance is performed in EU countries, Biobor® JF can be used if derogations are obtained.

	A220	A300/A310		A320			A330			A340		A350	A380	
	PW	GE	PW	CFM	IAE	PW	GE	RR	PW	CFM	RR	RR	EA	RR
Biobor® JF*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Kathon® FP 1.5**	✓	✗	✓	✗	✓	✓	✗	✓	✓	✗	✓	✓	✗	✓

* Maintenance can be performed in EU countries if derogations are negotiated.
** Production of Kathon® FP 1.5 for use in aviation ceased in 2020.
Only existing stocks of Kathon® FP 1.5 can be used.

KEYPOINT

Engine manufacturer recommendations should always be checked before the use of a biocide.

"There is now industry-wide agreement to use mL/L unit for both Biobor® JF and Kathon® FP 1.5 biocides."

Production of Kathon® FP 1.5 for aviation applications was stopped in 2020. Kathon® FP 1.5 has a shelf life of only 2 years and this means that any existing stock should be used this year (2022). Only Biobor® JF biocide will remain available for fuel contamination treatment. New biocides are under study, but are not expected to be available for several years due to the high cost and complexity of the approval process.

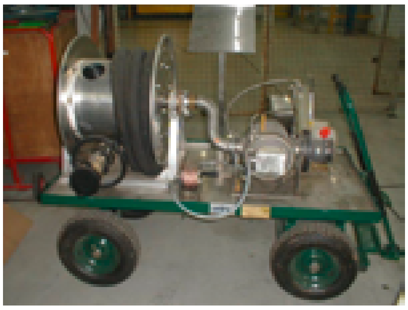
The right dosage

Unit standardization

The dosage of biocide required was previously provided in ppm by weight for Biobor® JF and by ppm by volume for Kathon® FP 1.5. There is now industry-wide agreement to use mL/L unit for both Biobor® JF and Kathon® FP 1.5 biocides. Airbus maintenance procedures for all Airbus aircraft, the AMM for A300/A310/A320/A330/A340/A380, MP for A350 aircraft and AMP for A220 aircraft, were updated accordingly by removing the use of the ppm unit.

Table of maximum biocide quantities

To prevent any future case of biocide overdose, Airbus maintenance procedures for biocide treatment now include a table, which provides the maximum quantity of biocide that can be uplifted in the aircraft for different fuel quantities. Maintenance crews should use this table as a guide to check if their computed quantity of biocide is correct before uplifting it into the aircraft.



(fig.4)
Metered injection rig

The right mix

As another lesson learned from the previous case study, a metered injection rig must be used to correctly mix the biocide with the fuel and uplift it into the aircraft fuel tanks. All Airbus AMM/MP/AMP procedures were updated to reflect this change and there is no alternative method if a metered injection rig is not available.

KEYPOINT

The biocide must never be directly added to fuel using the overwing refuel port and relying on the fuel pumps and transfers to mix the biocide with fuel. Only a metered injection rig must be used to uplift biocide.

The right procedure

Lessons learned from previous events involving incorrect use or overdose of biocide helped to define new curative treatment procedures that reduce the risk of incorrect mixing or overdose errors. The main steps of the procedure for efficient curative biocide treatment are:

Drain water from the fuel tank

If water remains in the tank it may cause crystallization inside the fuel tank following biocide treatment.

Defuel the aircraft

Contaminated fuel must be removed from the aircraft.

Clean the inside of the fuel tank

Only in the case of heavy contamination, thorough cleaning of the fuel tank must be performed to remove all deposits.

Compute the quantity of biocide needed

There is a table in the AMM/MP/AMP procedure that provides maximum biocide quantities depending on fuel quantities that should be used to avoid any risk of overdose.

Uplift the mix fuel/biocide inside the fuel tank using a metered injection rig

The only allowable method to uplift the biocide inside the fuel tank is by using a metered injection rig. The fuel tank should be full, because this will ensure that the contamination is treated in all areas, including on the upper surface of the tank.

Final crosscheck computation

Perform a new computation to crosscheck and confirm that the uplifted biocide quantity is correct and minimize any risk of biocide overdose.

BEST PRACTICE

It is recommended to keep as internal records the fuel quantity and biocide quantity uplifted in the aircraft during each biocide treatment.

Wait for 72 hours (Biobor® JF) or 24 hours (Kathon® FP 1.5)

Soak time is necessary before any engine operations.

Replace fuel filters

Fuel filters and engine filters that were in contact with the contaminated fuel must be replaced.

Burn fuel or defuel within 48 hours

The biocide is a corrosive product for the tank and must be removed after treatment, either by being burnt during normal engine operations or by defueling.

NOTE

For large aircraft, such as the A380, completely filling the fuel tanks may cause the authorized Maximum TakeOff Weight (MTOW) to be exceeded, depending on the payload. Partial defuel in this case is necessary.

Preventive Fuel Contamination Treatment: Specific Case of Parking and Storage

In the case of aircraft parking and storage, fuel tanks must be checked for microbiological contamination every 30 days and before the return to operation. Depending on the level of contamination detected, either preventive treatment or curative treatment must be performed. The quantity of biocide to be used differs for the two types of treatment and the filling of the fuel tank. (Note: completely filling the fuel tank is not required for preventive treatment). **The AMM/MP/AMP procedures for preventive and curative treatments must be carefully applied.**

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Microbiological contamination can cause significant operational disruptions with safety and economic effects. Therefore, prevention is essential with the development of an effective maintenance strategy that includes regular drainage of water from the aircraft fuel tanks and periodical tests to check for the presence of microorganisms. If contamination is detected, curative biocidal treatment or deep cleaning of the tank surface must be performed.

When biocide treatment is necessary, it is important to have the right biocide with the right dosage, and the right method to mix and uplift the curative treatment to the aircraft fuel tanks by use of a metered injection rig. Lessons learned from a previous event helped to improve the AMM/MP/AMP content by making the procedures clearer, and as a result, reducing the risk of incorrect mixing or overdose errors. This includes the replacement of the ppm (part per million) unit with mL/L unit and the inclusion of a table that provides the maximum biocide quantities depending on fuel quantities. To minimize any risk of biocide overdose, maintenance crews should use this table to crosscheck and confirm that the uplifted biocide quantity is correct. These updates are implemented for both the curative treatment procedure and preventive treatment procedure, which is dedicated to parking, storage, and return-to-service situations.

Only Biobor® JF biocide can be used on Airbus aircraft equipped with GE, CFM, EA engines. For other engines, such as Rolls-Royce (RR), Pratt & Whitney (PW), and IAE, Biobor® JF and existing stocks of Kathon® FP 1.5 may be used. The use of Biobor® JF is not approved in the European Union (EU). When treatment of microbiological contamination is performed in EU countries, derogations must be negotiated with national aviation authorities before using Biobor® JF.

Prevention of microbiological contamination in an aircraft fuel tank, and strictly applying the Airbus maintenance procedures and engine manufacturer recommendations, will ensure safe and efficient engine operations.