

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.

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



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

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

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

At T0 + 2 min 43 s, 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 + 3 min 38 s, the flight crew engaged the autopilot and leveled off the aircraft at 7 000 ft.

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

At T0 + 9 min 39 s, 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 + 10 min 03 s, the **ENG 2 FIRE** alert stopped and the **ENG 2 FIRE DET FAULT** amber ECAM alert triggered.

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

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

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

At T0 + 25 min 02 s, 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)

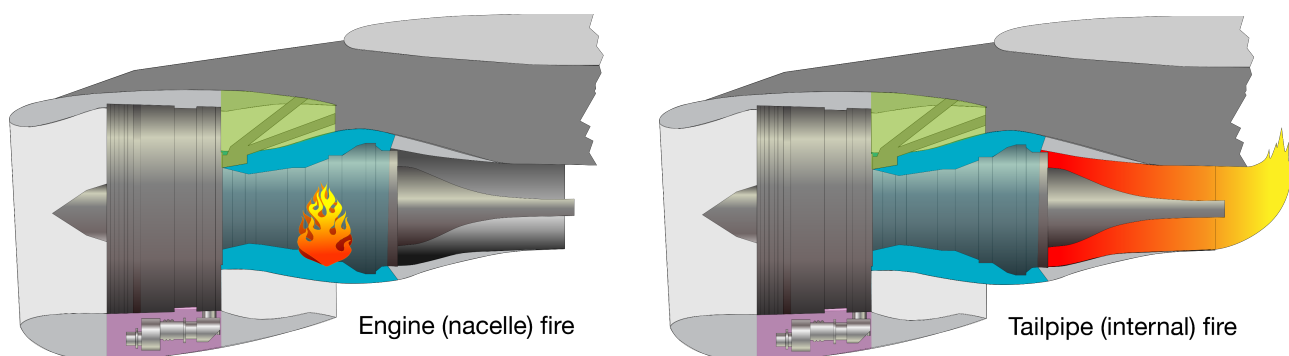
A tailpipe fire occurs inside the engine core. This type of fire will only occur during the engine start or shutdown sequence. A tailpipe fire occurs when the engine rotates at a very low speed and residual fuel is present in the combustion chamber or turbine area, or if there is an oil leak in the tailpipe 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

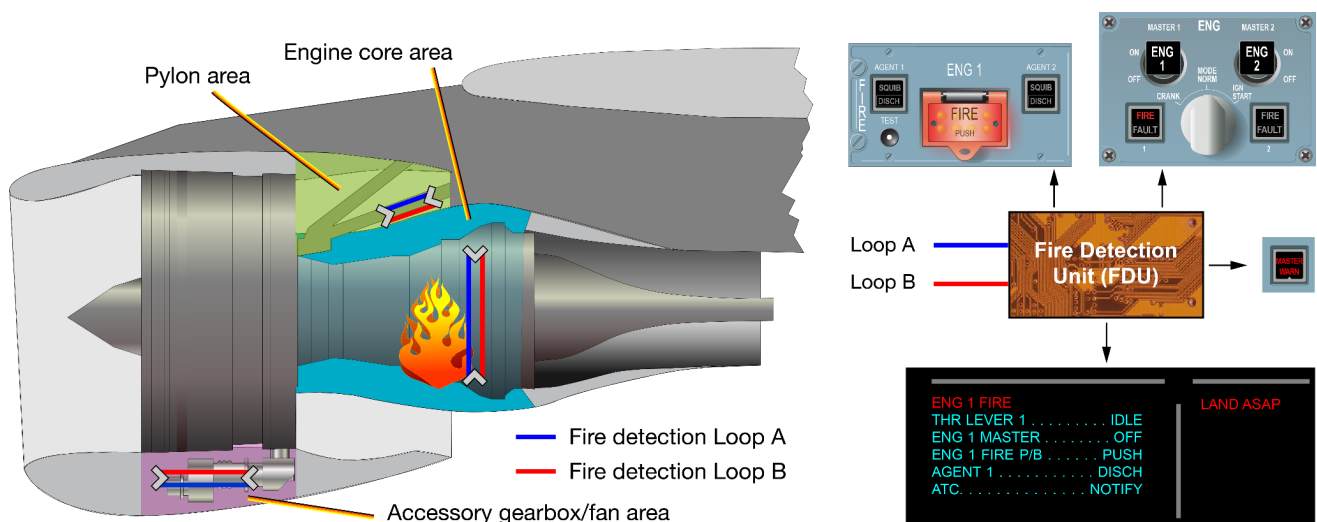
The detection system for engine fire is composed of dual sensing element loops. They are located in the areas around the engine with the highest risk of fire and near compartment air exhausts for overheat detection. These are zones where flammable liquids are present with a potential ignition source, 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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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.

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