

Engine Relight After an All-Engine Flameout



An all-engine flameout is one of the most stressful situations where flight crews need to urgently relight the aircraft engines. Incorrect application of the engine relight sequence can lead to delayed or unsuccessful engine restarts.

This article describes an in-service event in which such a situation was encountered. It recalls the various steps of the engine relight sequence in the ALL ENG FAIL procedure of the QRH and highlights the improvements that have been made on the operational procedure of A300, A310, A320 family, A330, A340, A350 and A380 aircraft.

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CASE STUDY

Event Description

Diversion to alternate airport

An A320 aircraft equipped with CFM56-5B engines was approaching its destination airport. Due to adverse weather conditions, the flight crew decided to divert to an alternate airport, where they performed a safe landing at 18:40 local time. After a three-hour stopover, the aircraft departed the diversion airport at 21:51 local time, heading towards its initial destination.

Weather avoidance and storm encounter

During the night flight, persistent adverse weather remained along their route. ① The flight crew requested a northward deviation to avoid storm cells that they detected on their weather radar. ② The aircraft was cruising at FL 240 with autopilot and autothrust ON when the flight crew executed a 90° left turn toward their final destination.

Severe storm and dual engine flameout

③ Shortly after the turn, the aircraft encountered severe turbulence and hail. Loud impact noises were heard, and both the left and right windscreen sustained damage. Several ECAM alerts were triggered, including **ANTI ICE R WINDSHIELD**, **ANTI ICE L WINDSHIELD**, **ENG 1 STALL**, **NAV RA 2 FAULT**.

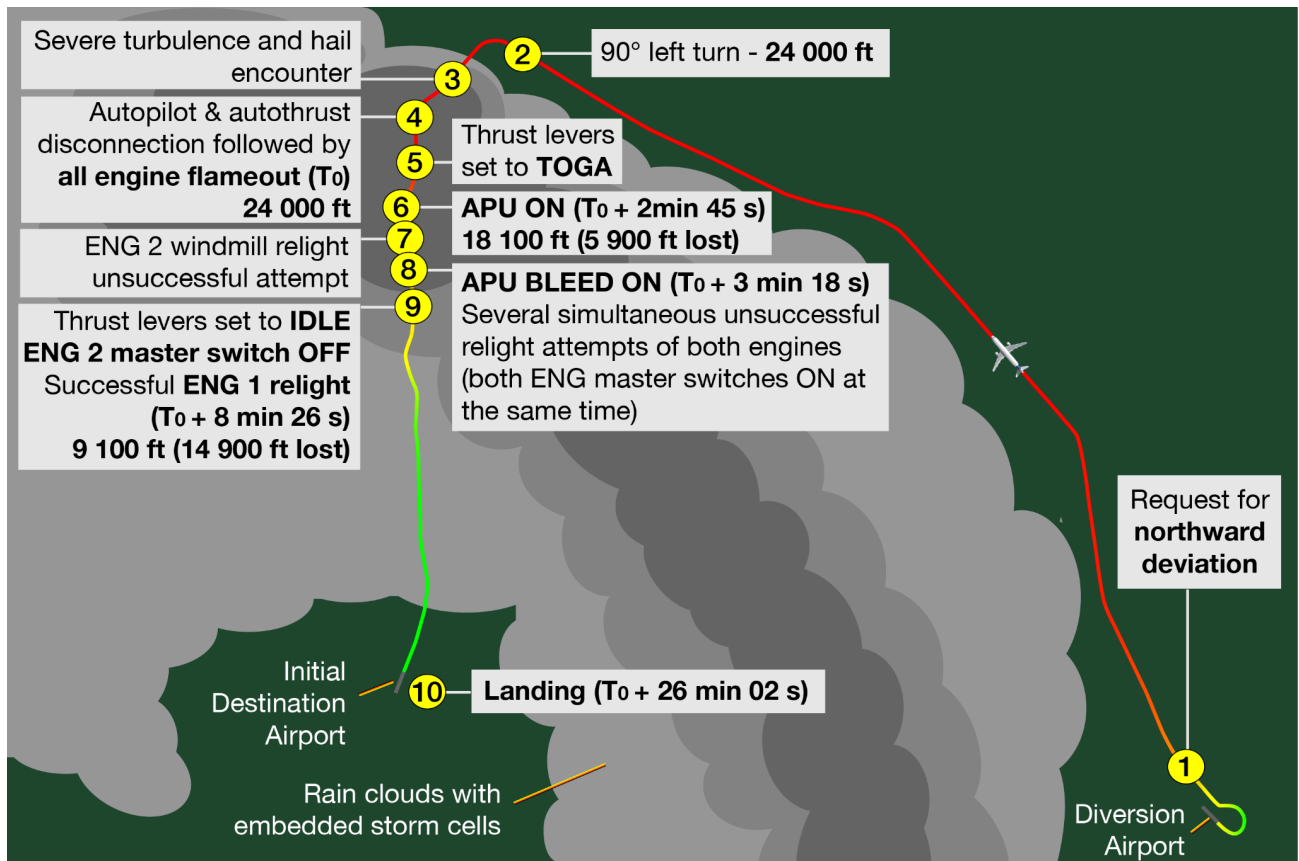
④ The autopilot and autothrust disconnected, and within one second, the cockpit went dark. Flight recorder data is not available for the following 2 min and 46 s due to an EMER ELEC configuration. ⑤ During this time, the thrust levers were moved to TOGA position.

Both engines had flamed out combined with an unreliable airspeed indication. The flight crew switched the APU to ON. ⑥ When the APU came online, electrical power was restored. The aircraft pitch was -3.5°, corresponding to the pitch provided in the QRH to reach the optimum windmill relight speed. The speed, which was unreliable, was 232 kt indicated on the captain PFD and the aircraft altitude was 18 100 ft (5 900 ft lost from cruise altitude). The aircraft was in ALTERNATE flight control law and thrust levers remained in the TOGA position.

⑦ One windmilling relight attempt of ENG 2 was recorded, then ⑧ the flight crew switched APU BLEED ON and performed several simultaneous attempts (both ENG Master switches ON at the same time) of starter-assisted engine relight with the thrust levers still in the TOGA position. ⑨ The flight crew eventually set the thrust levers to IDLE and both master levers OFF before performing a successful ENG1 starter-assisted relight with ENG 2 master switch left to the OFF position. The altitude was 9 100 ft, representing a loss of 14 900 ft from the cruise altitude. The flight crew then tried to relight engine #2 twice, but both attempts were unsuccessful.

Safe landing with single engine, unreliable airspeed and ALTERNATE law

The aircraft emerged from the storm and continued to the destination airport. ⑩ The flight crew performed a safe landing with a single engine operative, ALTERNATE flight control law, unreliable airspeed indication, and significantly damaged windshields impairing visibility.



(fig.1) Lateral trajectory of the aircraft during the event

Severely damaged aircraft

When the aircraft came to a stop, the crew assessed the aircraft's damage, including a destroyed radome.



(fig.2) View of the damaged windshield and radome after the event (photos: Investigation Board)

Event Analysis

Unsuccessful weather avoidance

Night conditions and numerous storms in the area made effective weather avoidance challenging. Despite having an automatic radar and performing both automatic and manual scanning, the flight crew entered a severe hailstorm.



INFORMATION

For more information on the use of weather radar for weather avoidance, refer to:

- the FCTM "Aircraft Systems - Weather Radar" chapter,
- the "[Optimum use of weather radar](#)" article published in July 2016,
- the "[Operational use of the weather radar](#)" WIN video.
- the Pilot's guide of the weather radar manufacturer.

Extreme weather conditions

The hailstorm significantly exceeded the engine design and certification criteria. The water/ice content was approximately **twice the level for which engines are designed and certified**. This explains the observed engine damage and flameout.

Radome damage impact

Radome damage disrupted airflow around the air data probes, causing unreliable airspeed indications and reversion to the ALTERNATE flight control law.

Thrust lever positioning

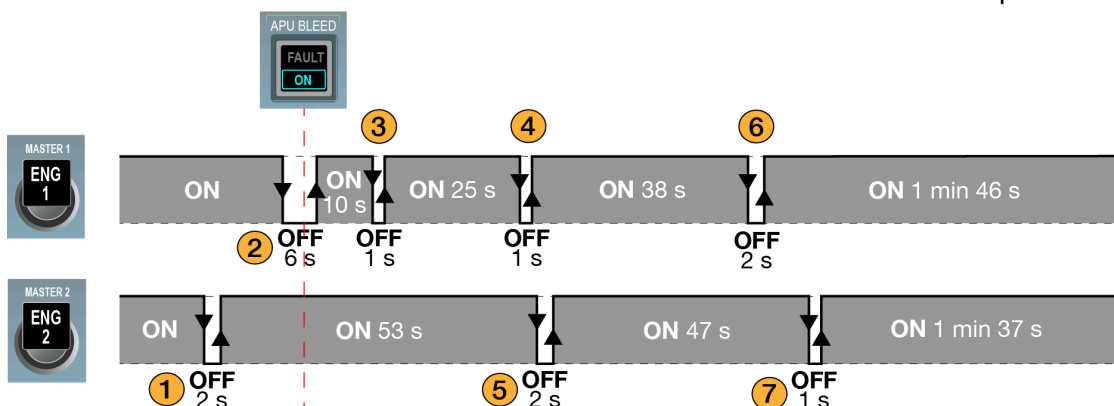
The thrust levers remained in the TOGA position during seven relight attempts. The **ALL ENG FAIL** QRH procedure requires setting the thrust levers to IDLE before attempting to relight the engines.

Unsuccessful engine relight attempts

Recorder's data enabled analysis of the sequence of the various engine relight attempts.

① The flight crew cycled the ENG 2 master switch OFF then ON 2 s later. ② They switched the ENG 1 master switch to OFF. APU BLEED was set to ON shortly after. The ENG 1 master switch was then set back to ON 6s after being switched OFF. 10 s later, ③ the ENG 1 master switch was cycled OFF then ON. 25 s later, both ④ ENG 1 and ⑤ ENG 2 master switches were cycled OFF then ON. The flight crew then ⑥ cycled ENG 1 master switch again shortly followed by ⑦ ENG 2 master switch. All relight attempts were unsuccessful. The thrust levers remained in the TOGA position.

(fig.3) Sequence of unsuccessful relight attempts during the event



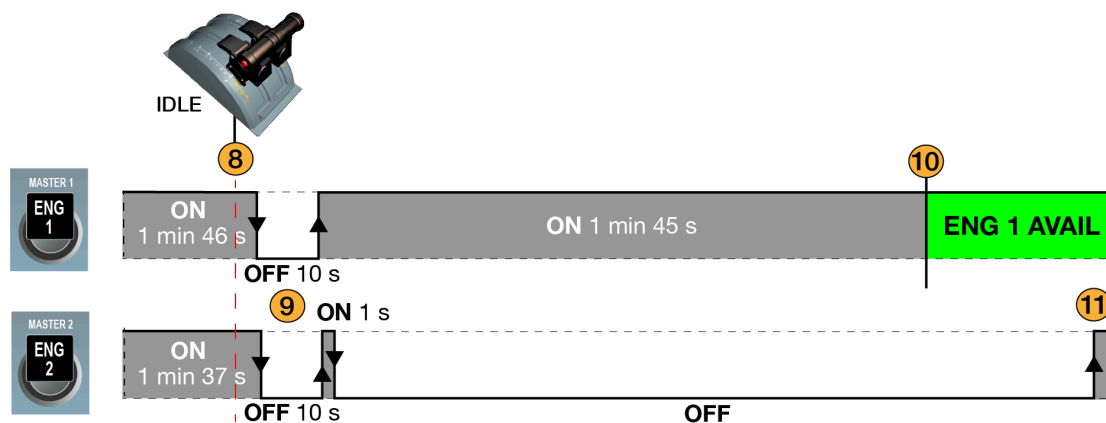
These Simultaneous starter-assisted relight attempts failed due to the fact that APU bleed provides sufficient air pressure to restart only one engine at a time. It was observed that no ventilation of 30s was performed between each relight attempt.

Successful ENG 1 relight

⑧ The crew then set the thrust levers to IDLE and ⑨ set both engine master switches to OFF. The ENG 1 master switch was set back to ON, while the ENG 2 master switch was briefly set to ON then back to OFF. Within 1 minute and 45 seconds, ENG1 N2 and EGT increased and ⑩ ENG1 successfully restarted.

The ENG 2 master switch being OFF enabled sufficient bleed pressure to be delivered to ENG 1 starter for a successful relight.

(fig.4) Successful ENG 1 relight



Damaged ENG2

⑪ The flight crew then tried two ENG 2 relights, but both attempts remained unsuccessful. Detailed inspection revealed sufficient damage to ENG 2 preventing successful inflight restart.

Significant relight time and altitude loss

ENG 1 became available 8 min 26 s after the all-engine flameout. The aircraft altitude was 9 100 ft, representing a loss of 14 900 ft from the 24 000 ft initial cruise altitude. ■

OPERATIONAL CONSIDERATIONS

Careful application of the windmill and starter-assisted relight procedures in the **ALL ENG FAIL** QRH procedure (A300, A310, A320 family, A330 and A340 aircraft) and in the **ENG ALL ENGINES FAILURE** ECAM alert (A350 and A380 aircraft) is critical for successful in-flight engine restart.

Windmill Relight

In the case of an all-engine flameout, the windmill relight is possible at higher altitudes while the starter assisted relight is only available below FL200. In addition, a windmill relight enables the flight crew to perform simultaneous engine restart attempts.

① Maintain optimum relight speed

Maintaining aircraft optimum relight speed provides sufficient airflow for the engines to reach a rotation speed that produces sufficient compression of the air in the compressor and combustion chamber necessary for a successful engine relight.

The optimum relight speed is provided:

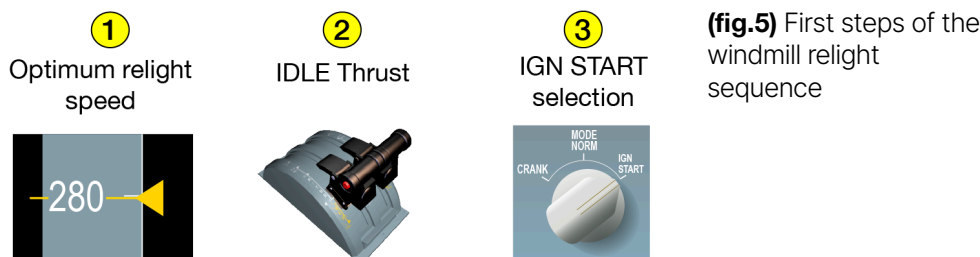
- in the **ENG ALL ENGINES FAILURE** ECAM alert and in the QRH **ALL ENG FAIL** procedure of A320 family, A330 and A340 aircraft
- in the **ENG ALL ENGINES FAILURE** ECAM alert of A350 and A380 aircraft
- in the **ALL ENG FAIL** FCOM/QRH memory item of A300 and A310 aircraft.

② Thrust levers set to IDLE

Positioning the thrust levers to idle will enable stable idle restart, and a reduced risk of stall that may be caused by immediate acceleration to high thrust if the thrust levers remained above the idle position.

③ ENG mode selector set to IGN

Set ENG mode selector to IGN to activate combustion chamber ignitors.



④ ALL ENG MASTER switches to OFF for 30 s

This step will ventilate the combustion chamber to remove any residual fuel before the first relight attempt, and between relight attempts. Failure to ventilate the engine may result in an engine stall, an EGT overlimit, a tailpipe fire, or an unsuccessful relight attempt.

⑤ ALL ENG Master switches to ON

All ENG MASTER switches can be simultaneously set to ON for windmill relight attempts.

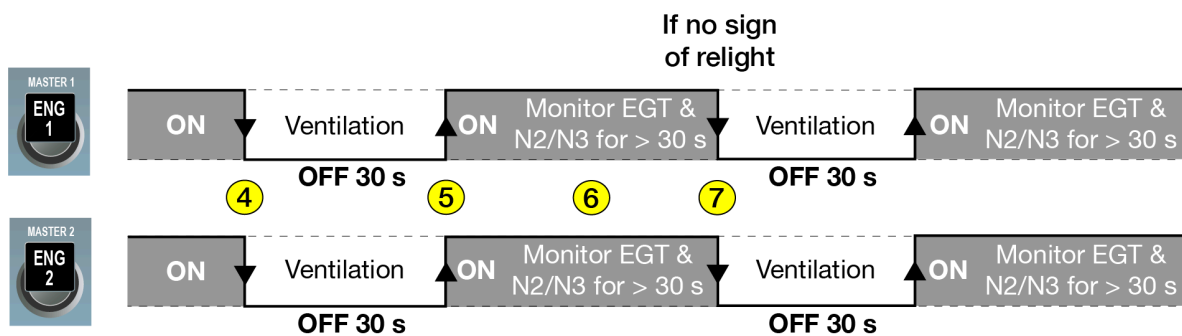
⑥ Monitor Engine parameters for at least 30 s

Monitor the EGT and N2 (N3 for Rolls Royce engines) for signs of relight for at least 30 s. If increase in N2/N3 and EGT is observed, continue with the relight attempt.

A successful in-flight windmill relight can take up to 2 minutes.

⑦ Repeat attempts if no restart occurs

If no sign of relight appears within 30 s, switch both engine master levers to OFF for 30 s to ventilate the engines and repeat the relight attempts until successful, or until reaching FL 200 where a starter-assisted relight can be attempted.



(fig.6) Windmill relight sequence (simultaneous relight attempts)

Starter-Assisted Relight (Below FL 200)

The **ALL ENG FAIL** QRH procedure requests to start the APU when below the upper limit of the APU battery restart envelope, enabling recovery of the electrical power and the use of APU bleed.

Below FL 200, if the windmill relight was unsuccessful and if the APU is available, the flight crew can attempt a starter-assisted relight. **Only one engine (two on A380 aircraft) can be restarted at a time when attempting a starter-assisted engine relight.**

Thrust levers set to IDLE

The thrust levers should already be set to IDLE in the first part of the procedure.

ENG mode selector set to IGN

The ENG mode selector should also already be in the IGN position to activate combustion chamber ignitors.

① ENG MASTER switches to OFF

Each engine must first be switched off for ventilation to remove residual fuel from the combustion chamber before any engine relight attempt. The time to perform the next two steps ensure a sufficient ventilation close to 30 s.

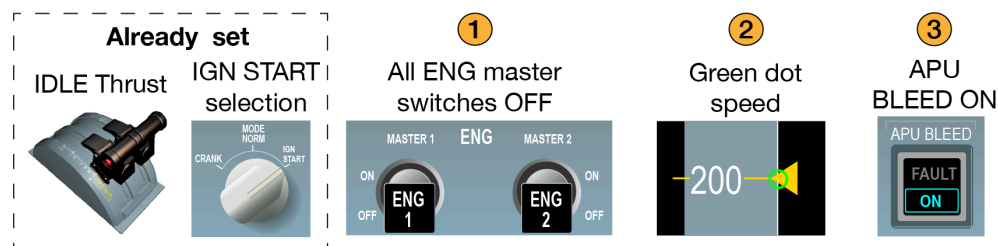
② Reduce speed to green dot speed

Reducing the speed down to green dot speed reduces the aircraft rate of descent.

③ APU BLEED ON

APU BLEED should be set to ON.

(fig.7) First steps of the starter-assisted relight sequence



④ Only one ENG MASTER switch to ON (two on A380 aircraft)

The flight crew must attempt to relight only one engine at a time during a starter-assisted relight on A300, A310, A320, A330, A340 and A350 aircraft.

The APU cannot provide sufficient bleed pressure to relight two (or four) engines at the same time. On A380 aircraft, the relight attempt can be done on two engines simultaneously.

⑤ Monitor Engine parameters

Monitor the EGT and N2 (N3 for Rolls Royce engines) for signs of relight for at least 30 s. If increase in N2/N3 and EGT is observed, continue with the relight attempt.

A successful in-flight starter-assisted relight can take up to 2 minutes.

⑥ If no sign of relight within 30 s, all ENG MASTER switches OFF

If there is no sign of relight within 30 s, the flight crew should switch the engine master switch back to OFF to ventilate the engine.

Two options are then possible:

- ⑦ Immediate relight attempt of the other engine**

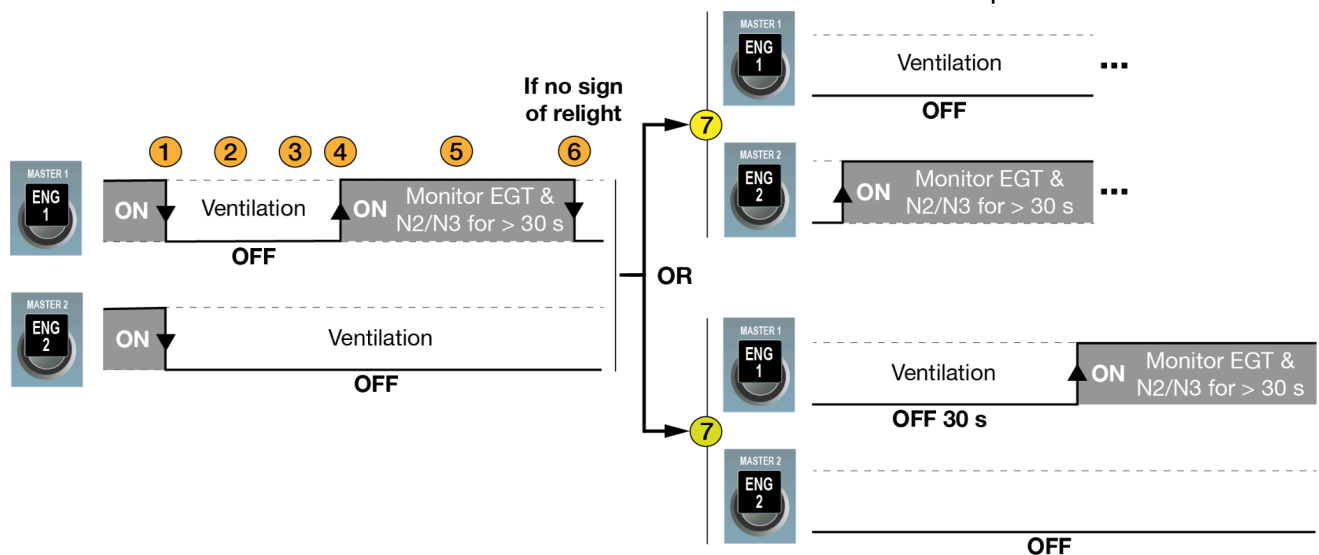
The flight crew can attempt to relight the other engine immediately since it was ventilated during the relight attempt of the first engine.

OR

- ⑦ Relight attempt of the same engine after a 30 s ventilation**

If the flight crew wants to relight the same engine if the other engine is damaged, they have to wait for 30s with the master switch to OFF until the engine is ventilated.

(fig.8) Starter-assisted relight sequence (one engine at a time)



PRODUCT ENHANCEMENTS

Operational Documentation Improvement

The event described previously led Airbus to improve the operational documentation to prevent misinterpretation of the starter-assisted relight procedure included in the ALL ENG FAIL procedure of A300, A300-600, A310, A320 family, A330, A340, A350 and A380 aircraft. The update of the ALL ENG FAIL procedure in QRH/FCOM (for A300/A310/A320/A330/A340) and ECAM/FCOM (for A350/A380) is also associated to an update of the All Engines Failure procedure in the FCTM. This improvement is available in the following documentation revisions:

- A320 family, A330 and A340 aircraft: November 2024
- A300, A300-600 and A310 aircraft: March 2025
- A350 aircraft: mid 2025
- A380 aircraft: 2026

Previous Procedure

● If APU available and windmill relight unsuccessful: Starter Assisted Relight below FL 200
ALL ENG MASTERS.....OFF
OPTIMUM SPEED: GREEN DOT
(REFER TO [QRH/OPS Operating Speeds](#))
WING ANTI ICE.....OFF
APU BLEED.....ON
ENG MASTER (ONE AT A TIME).....ON
Between each attempt to relight the same engine, wait at least 30 s with the associated ENG MASTER lever set to OFF.

Improved Procedure

● If APU available and windmill relight not successful: Starter Assisted Relight below FL 200
ALL ENG MASTERS.....OFF
OPTIMUM SPEED: GREEN DOT
(REFER TO [QRH/OPS Operating Speeds](#))
WING ANTI ICE.....OFF
APU BLEED.....ON
ENG RELIGHT (One at a time)
ALL ENG MASTERS.....OFF
ENG MASTER 1 or 2.....ON
ENG PARAMETERS (N2/EGT).....MONITOR AT LEAST 30S
● If relight not successful
ALL ENG MASTERS.....OFF
FOR SAME ENGINE RELIGHT.....WAIT 30S
ENGINE RELIGHT (one at a time).....TRY REGULARLY

(fig.9) Example of the procedure update on A320 family aircraft

Flight Warning System Enhancements (A350 and A380 aircraft)

A Flight Warning System update is under study on A350 and A380 aircraft to improve the ECAM procedure.

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An all-engine flameout is a high-stress situation that requires immediate and precise crew action. Successful engine relight depends on meticulous execution of the procedure.

The 30 seconds engine ventilation removes any residual fuel from the engine's combustion chamber before the first relight attempt, and between relight attempts if unsuccessful. It prevents risks of engine stall, EGT overlimit, tailpipe fire or unsuccessful relight.

Windmill relights enable attempts to restart all engines at the same time at higher altitude.

Starter-assisted relights enable restart of only one engine at a time (two engines at a time on A380 aircraft only) due to APU bleed air limitations and can only be performed below FL200.

Flight crew should monitor the EGT and N2 (N3 for Rolls Royce engines) for signs of relight for at least 30 s. If there are signs of relight within 30 sec, continue with the current engine restart attempt. A successful in-flight relight may take up to 2 minutes. If there are no signs of relight within 30 s, set all ENG MASTER switches to OFF and initiate a new relight attempt.

The event described in this article also illustrates the importance of maintaining situational awareness during emergencies, and correctly applying QRH procedures during an extremely high stress situation.

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