Safety first
The Airbus Safety magazine

Fuel Leak Management in Flight

A fuel leak can have serious consequences, especially because of the risk of fire and fuel starvation. When a fuel leak is detected, it is essential to follow the operational procedures to maintain the safety of the flight. This article highlights how to detect and confirm a fuel leak on A300-600, A310, A320 family, A330, A340, A350, and A380 aircraft. It also recalls which actions to perform, especially shutting down the engine in the case of an engine fuel leak to prevent any risk of engine fire. Fuel leak management for A220 aircraft will be addressed in a future article.

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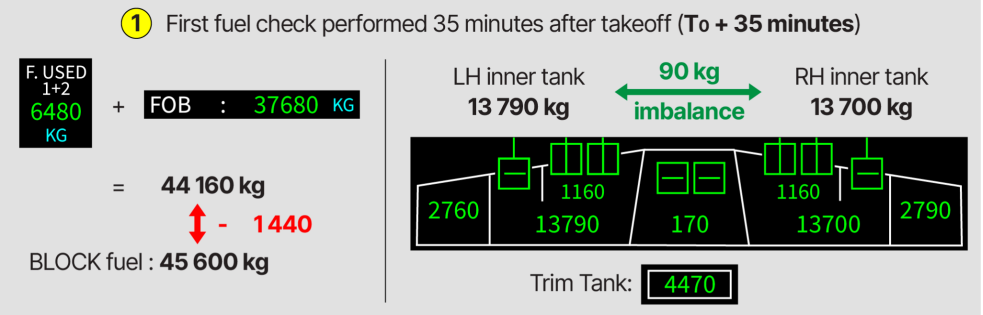
CASE STUDY

Event Description

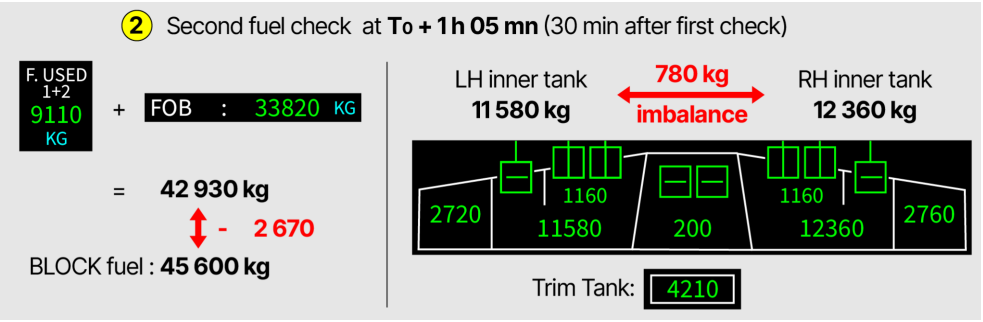
An A330 aircraft was reaching its cruise flight level during a night flight. It was 35 minutes after takeoff **(T0 + 35 mn)** and the flight crew performed the first fuel check. **The initial fuel quantity after refueling (BLOCK fuel) was 45 600 kg.**

① The first fuel check showed a Fuel On Board (FOB) value of 37680 KG with an indicated fuel used quantity of 6480 KG. Their sum represented a **discrepancy of 1 440 kg** with the BLOCK fuel value. A non-significant lateral fuel imbalance between the two inner tanks (90 kg) was displayed. The captain attributed the 1.4 T fuel quantity discrepancy to the ongoing fuel transfers from the inner wing tanks to the trim tank and suggested monitoring the evolution of the fuel quantity.



(fig.1) First fuel check performed during the event

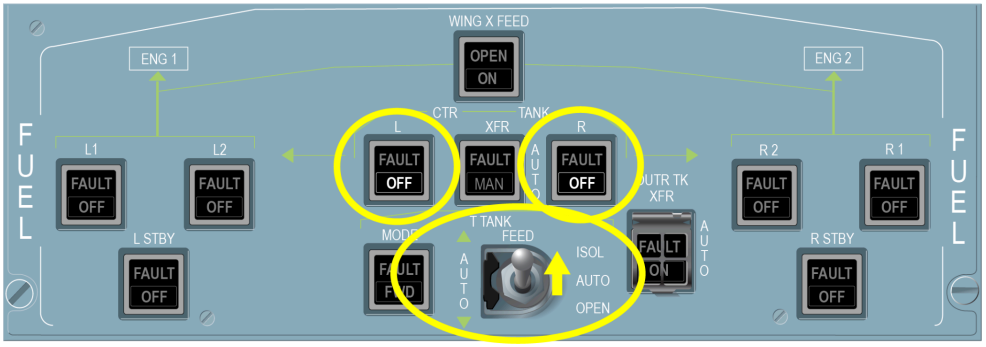
② 30 minutes later **(To + 1 h 05 mn)**, the flight crew noticed that 2 670 kg of fuel was missing with an imbalance of 780 kg indicating a possible fuel leak on the left side.



(fig.2) The flight crew noticed an increase in fuel loss and a significant imbalance

The flight crew initiated the FUEL LEAK QRH procedure: ③ They maintained the crossfeed valve closed, set the L CTR TANK and R CTR TANK pushbutton switches to OFF, and set the T TANK FEED selector to ISOL. The procedure then requests that the flight crew monitor the fuel depletion rate of each inner tank.

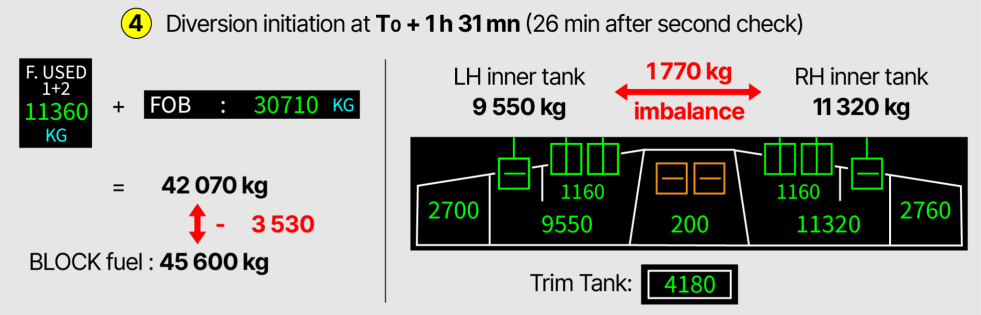
③ Initiation of the FUEL LEAK procedure at **T0 + 1 h 31 mn** (26 min after second check)



(fig.3) The flight crew applied the first step of the FUEL LEAK procedure to isolate the tanks

AIRBUS

④ 26 minutes later **(To + 1 h 31 mn)**, 3 530 kg of fuel was missing and there was an imbalance of 1 770 kg (+990 kg in 26 minutes) between the two inner tanks. Given the significant fuel imbalance, the FUEL LEAK QRH procedure requests that the affected engine be shut down. The flight crew initiated a diversion and decided to keep the left engine running.



(fig.4) The fuel imbalance increased by almost 1 ton within 26 minutes with the tanks isolated

4 minutes later **(To + 1 h 35 mn)** the FUEL F. USED/FOB DISAGREE ECAM alert triggered referring to the FUEL LEAK QRH procedure, which the flight crew had initiated 30 minutes previously and stopped when requested to shut down the affected engine. Both engines were kept running. One maintenance technician, who was present onboard the aircraft, visually confirmed the fuel leak from the left engine.

30 minutes later **(To + 2 h 05 mn)**, the fuel imbalance advisory triggered (fuel quantity values of both inner and outer tanks were flashing) due to the imbalance of more than 3 000 kg. The QRH associated with this advisory requires that the flight crew consider that the imbalance may be due to a fuel leak. In this case, it redirects to the FUEL LEAK QRH procedure. Again, both engines were kept running.

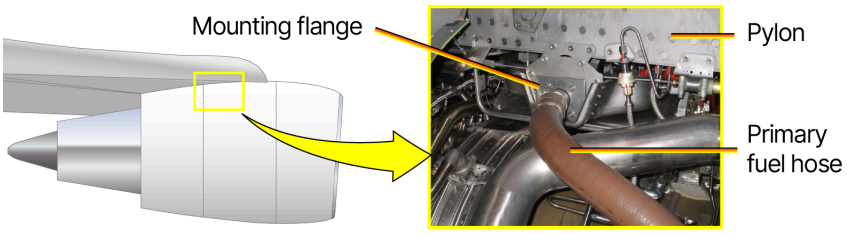
15 minutes later **(To + 2 h 20 mn)**, the aircraft landed with 5.2 T of fuel missing and 3.5 T of imbalance. The thrust reversers were not used, in accordance with the FUEL LEAK QRH procedure. The flight crew decided to keep the left engine ON to ease the 180° turnaround maneuver at the end of the runway. They shut down the left engine after the turnaround, and shut down the right engine when they reached the parking area.

Firefighters sprayed water under the left engine and, when the aircraft was safe, the passengers disembarked uneventfully. A total of 5.7 T of fuel was lost during the flight.

Event Analysis

Incorrect assembly of the primary fuel hose as a root cause

Examination of the engine showed that the fuel leak was located downstream of the LP valve, at the interface between the left pylon and the left engine **(fig.5)**. The primary fuel hose, which brings fuel from the pylon to the engine, was not correctly installed. Its mounting flange that connects it to the pylon was not correctly aligned. Vibrations caused the flange to move and created a leak.



(fig.5) Location of the engine leak during the event

Prevention of incorrect primary fuel hose installation on A330 aircraft with CF6 engine

The Aircraft Maintenance Manual (AMM) task 73-11-46-400-801-A "Installation of the Primary Fuel Hose" provides specific recommendations to prevent any incorrect installation with the associated risk of assembly distortion.

In addition, the engine manufacturer designed an improved mounting flange to limit the possibility of a mounting flange alignment error. This improved design can be installed by the Airbus Service Bulletin 73-3066.

Technical Follow Up **TFU 73.11.00002** is also available on Airbusworld with further information.

Constant fuel leak

Recorder data analysis showed that the fuel leak from engine 1 was present from the start of the flight at a constant rate of about 45 liters per minute, equivalent to 2 tons per hour.

Fuel imbalance temporarily compensated by fuel aft transfer during climb

The aft transfer starts above FL 255. If the fuel quantity between the two inner tanks differs by more than 500 kg, the aft transfer is done from the heavier inner tank to the trim tank until the balance is restored or the trim tank is full.

It explains why the imbalance was limited to 90 kg during the first fuel check performed at the beginning of the cruise phase.

Shutting down the engine is necessary to confirm the left engine leak

The flight crew started to apply the leak identification step of the FUEL LEAK QRH procedure by making sure that the crossfeed valve was closed, setting the L CTR TANK and R CTR TANK pushbutton switches to OFF, and setting the T TANK FEED selector to ISOL.

A little more than 20 minutes later, the imbalance increased by 990 kg (from 780 kg to 1770 kg), confirming the presence of a leak on the left side. The next step of the procedure requires that the flight crew shut down the left engine to determine if the leak comes from the engine or from the left wing. However, the flight crew stopped applying the procedure at this stage and maintained the left engine ON, which continued to feed the fuel leak until the end of the flight.

High risk of engine fire

Keeping the left engine running maintained a high risk of fire since fuel was leaking on hot parts of the engine.

Fuel loss and runway contamination

Keeping the engine running until the 180° turn on the runway created fuel diffusion in the atmosphere during the remainder of the flight and contamination of the runway.

Excessive AFT CG due to trim tank left isolated

The flight crew interrupted their application of the FUEL LEAK QRH procedure at the leak identification step. Therefore, the fuel tanks remained isolated. Especially, with no possible fuel transfer from the trim tank, the aircraft CG increased further aft throughout the flight and reached 39.8 % at landing, only just below the threshold of 40.5 % for a gross weight of 174 T to trigger the FUEL EXCESS AFT CG red ECAM alert.

FUEL LEAK DETECTION

A fuel leak can be detected visually with the presence of fuel spray from an engine, a pylon, or the wing. A smell of fuel in the cabin can also indicate a possible fuel leak. However, most of the time, it is the check of the fuel indications that enables timely detection of a fuel leak.

Regular Fuel Checks

Alerting indicators that could signal a fuel leak

Indicators of a possible fuel leak are an abnormal decrease in a fuel tank quantity or the total fuel, a sudden overflow in a tank, an excessive fuel flow, or a low N1 from an engine. The development of a fuel imbalance can also be caused by a fuel leak.

NOTE

A light fuel imbalance can exist at the start of the flight due to the APU that is fed only from one side and single engine taxi operations.

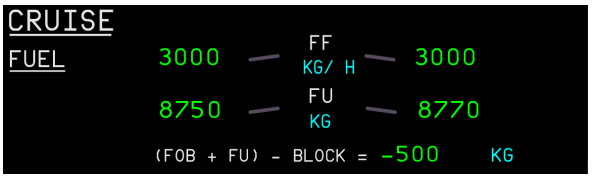
Regular fuel checks should be performed during cruise

The Standard Operating Procedures (SOPs) for A300-600, A310, A320 family, A330, A340, A350 and A380 aircraft recommend that the flight crew perform regular fuel checks during cruise. A check should be done when overflying a waypoint or at least every 30 minutes.

Check 1: (FOB + FU) - BLOCK fuel

Those regular checks consist of comparing the sum of the current FOB and FU with the FOB at the start of the flight (BLOCK fuel). If the sum is much less or is continually decreasing this can indicate a fuel leak.

On A350, the **(FOB+FU) - BLOCK** information is displayed on the Cruise SD page and on the Fuel SD page to help detect any anomaly more easily. An increasing negative value could indicate a fuel leak.



(fig.6) The (FOB + FU) - BLOCK information is displayed on the CRUISE and FUEL page

Check 2: FOB vs. FMS fuel prediction

Another check is to compare the FOB and the fuel predictions from the FMS with the estimated FOB information per waypoint from the Computerized Flight Plan (CFP) or any EFB performance application used. Any growing discrepancy can be an indication of a fuel leak.

INFORMATION

Further information on fuel monitoring is available in the Safety first article "Fuel Monitoring on A320 Family aircraft".

Automatic Fuel Leak Detection

Performing manual checks enables the flight crew to detect a fuel leak as soon as possible. However, following an event on an A330 aircraft, which resulted in total fuel exhaustion and landing with empty fuel tanks, ECAM alerts were introduced as an additional safety net to help the flight crew detect a fuel leak and make sure necessary actions are performed in a timely manner.

Fuel system leak detection: upstream of the fuel metering valve

On A320 family, A330, A340, A350 and A380 aircraft, the **consistency check between (FOB+FU) and BLOCK fuel** is automatically computed and triggers an ECAM alert when the difference reaches a specific threshold:

- FUEL F. USED/FOB DISAGREE on A320 family, A330 and A340 aircraft
- FUEL LEAK SUSPECTED on A350
- FUEL LEAK DETECTED on A380.

These alerts request the application of the FUEL LEAK procedure.

BEST PRACTICE

The ECAM alerts available on some aircraft and indicating a possible fuel leak are just additional safety nets. Performing regular manual fuel checks is the best practice to ensure early detection of a fuel leak before the triggering of such alerts.

Engine fuel leak detection: downstream of the fuel metering valve

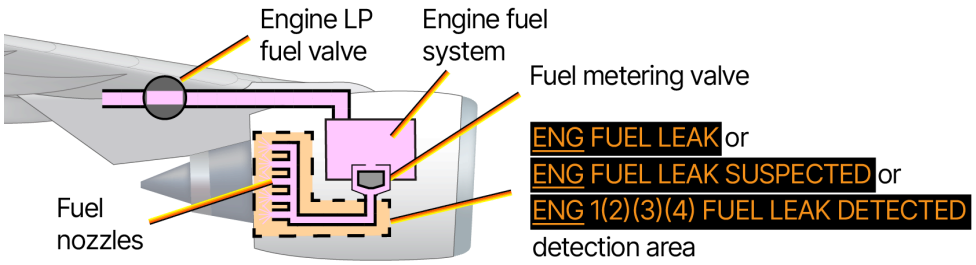
On A320neo family, A330, A340, A350 and A380, a **significant difference between fuel flow or fuel used of the different engines** triggers an ECAM alert:

- ENG FUEL LEAK on A320neo Family/A330/A340 aircraft
- ENG FUEL LEAK SUSPECTED on A350 aircraft
- ENG 1(2)(3)(4) FUEL LEAK DETECTED on A380 aircraft.

In the previous case study, the fuel leak was located downstream of the LP valve but upstream of the fuel metering valve, therefore, the ENG FUEL LEAK alert could not be triggered.

KEYPOINT

Following an engine fuel leak alert, the flight crew must confirm the fuel leak by checking the fuel parameters (FOB, FU, FF, fuel imbalance) and N1 parameter. If the leak is confirmed, the affected engine must be shut down.



(fig.7) The engine fuel leak automatic detectior detects potential leaks downstream of the fuel metering valve

FUEL LEAK HANDLING

Significant Risks

A fuel leak is a serious event that requires immediate attention due to:

- **The risk of fire**
  Fuel spillage on hot components such as the engines or the brakes can start a fire.

- **The risk of fuel starvation**
  Excessive loss of fuel may lead to a low fuel situation and ultimately may cause a flameout of the engines.

- **The risk of environmental contamination**
  A fuel leak can lead to environmental contamination. On ground, contaminating the runway and taxiway with fuel may impair the operations of other aircraft.

To prevent these risks, when a fuel leak is confirmed, it is essential to apply the FUEL LEAK procedure to identify the source and contain the leak.

Fuel Leak Procedure

For A300-600, A310, A320 family, A330, A340, A350 and A380 aircraft, the FUEL LEAK procedure has the same philosophy and follows similar steps that are described below. We use an example of a fuel leak on an A320 family aircraft to illustrate those steps.

INFORMATION

The FUEL LEAK procedure is an approved procedure from the AFM and can also be found in:

- QRH FUEL LEAK procedure for A300-600, A310, A320 family, A330, and A340 aircraft
- FCOM ABN FUEL LEAK procedure for A350 aircraft
- FCOM ABN FUEL LEAK DETECTED procedure for A380 aircraft.

The Flight Crew Techniques Manual of each aircraft describes the philosophy of the fuel leak procedure in the Abnormal and Emergency Procedures section.

The management of a fuel leak is also described in the "Fuel Leak Management" video available on the Airbus Worldwide Instructor News (Airbus WIN) website.

Fuel leak = Consider Landing

As soon as a fuel leak is confirmed, the flight crew must consider landing at the nearest suitable airport.

Step 1: Is there an obvious leak from an engine or an engine pylon?

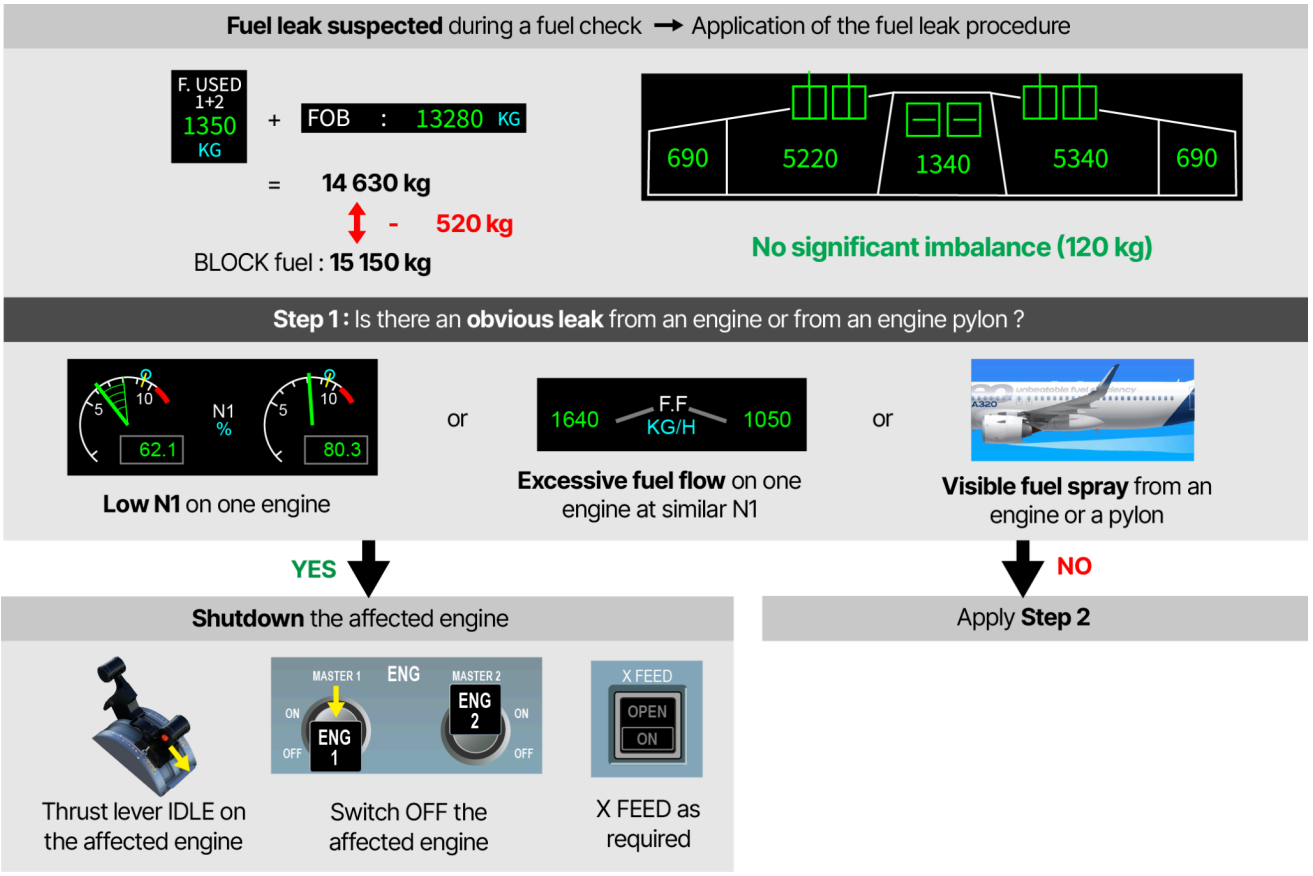
On A300-600, A310, A320 family, A330, A340 aircraft, the first step of the fuel leak procedure is to consider an engine fuel leak as it is the most common cause of fuel leak. The indicators to confirm an engine fuel leak are:

- Fuel spray directly visible from an engine/pylon
- N1 indication significant decrease on one side
- Excessive FF on one side.

If an engine fuel leak is confirmed, the affected engine must be shut down to avoid any fire risk and contain the leak.

KEYPOINT

When an engine fuel leak is confirmed, there is a **high risk of engine fire**. **The affected engine must be shut down and must not be restarted** for the remainder of the flight.

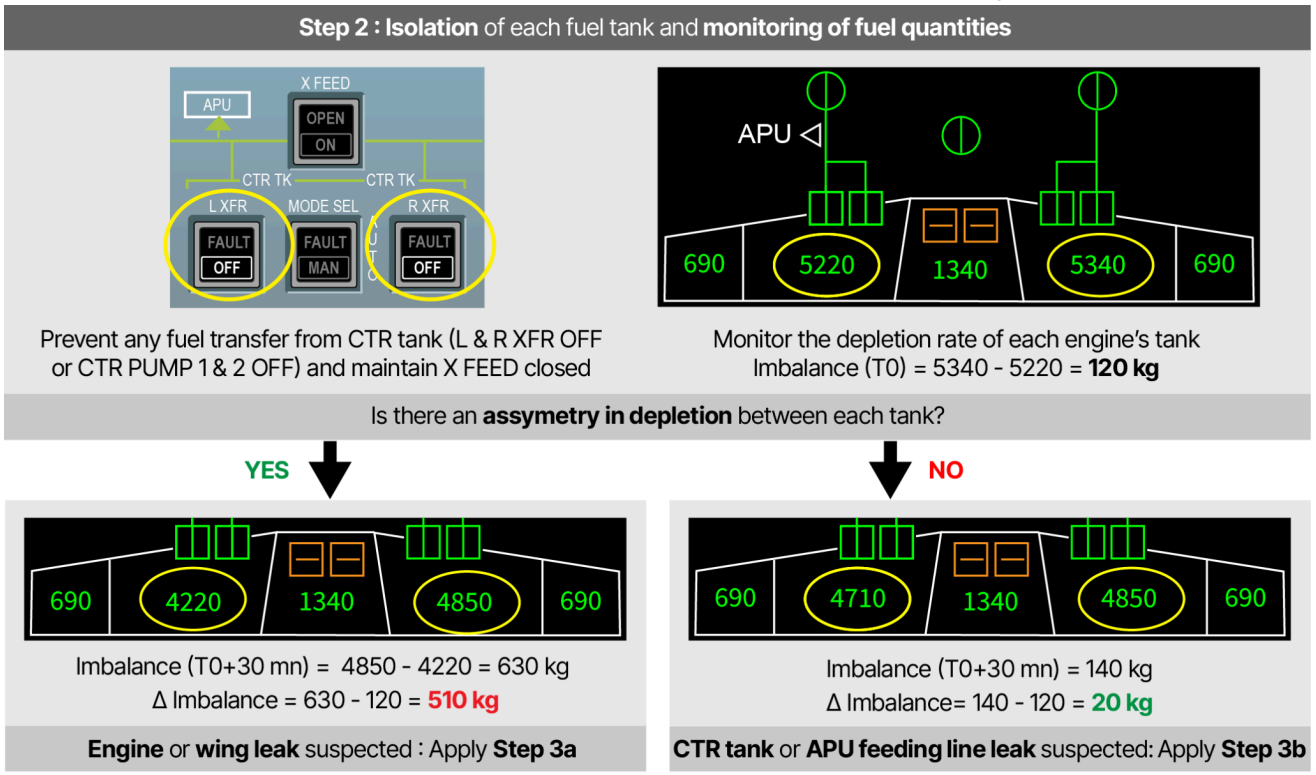


(fig.8) First step of the FUEL LEAK QRH procedure on an A320 family aircraft

Step 2: Isolation of fuel tanks and fuel quantity monitoring

If an engine fuel leak is not directly confirmed, the next step of the fuel leak procedure is to stop all fuel transfers and isolate each tank in order to locate the source of the leak. By doing so, each engine will be supplied by its own associated wing tank.

(fig.9) Second step of the FUEL LEAK QRH procedure on an A320 family aircraft



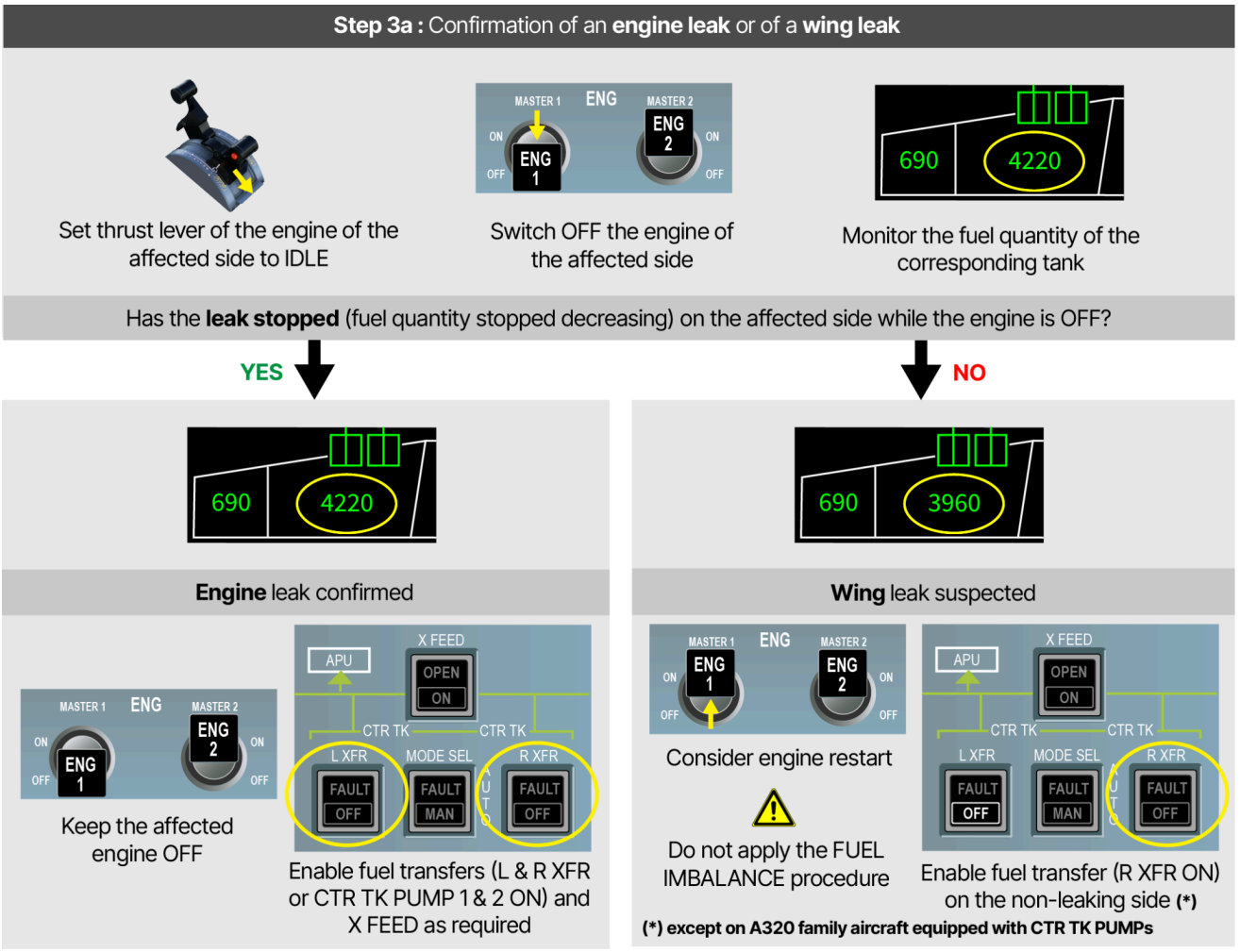
Step 3a: If there is an asymmetry in the fuel depletion rate between the two sides (left or right): Engine or wing leak suspected

A significant asymmetric depletion indicates a possible leak from the engine/pylon or from the wing of the side with the higher depletion rate. **The engine from the affected side must be shut down to confirm the leak location**:

- **If the leak stops after the engine shutdown** (fuel quantity in the corresponding tank remains constant), it indicates that **the leak comes from the engine**. The engine must remain shut down for the remainder of the flight.
- **If the leak did not stop** (fuel quantity in the corresponding tank is still decreasing), **a wing leak is suspected**, an engine restart can be considered. On A320 aircraft, fuel transfer can be enabled again on the non-leaking side.

KEYPOINT

If a wing leak is confirmed, it is important for the flight crew not to attempt to manually balance the wing tanks in order not to feed the leak even if requested by other procedures.

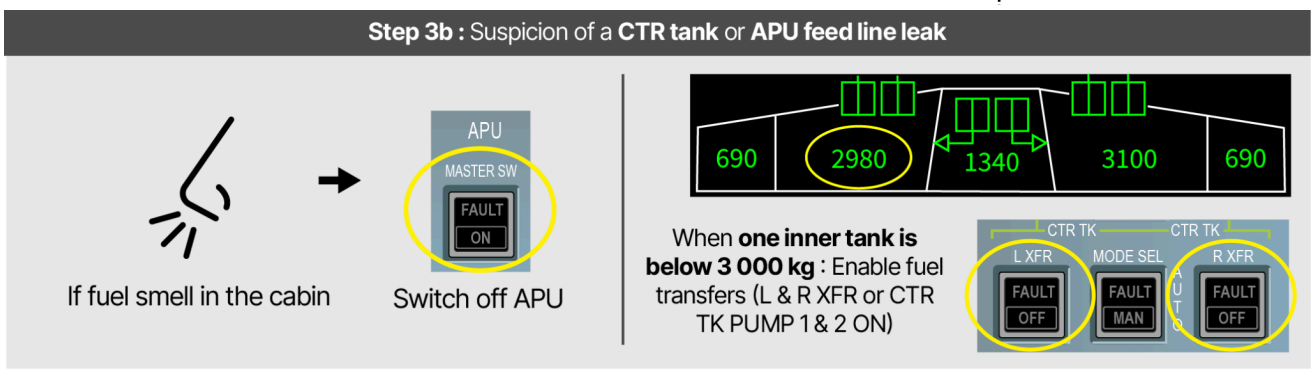


(fig.10) Confirmation step in the case of a suspected engine or wing leak on an A320 family aircraft

Step 3b: If there is no asymmetry in the fuel depletion rate between the two sides (left or right)

If there is no asymmetry in the fuel depletion rate between the two sides (left or right), the possible locations of the fuel leak are the center tanks, the trim tank feed line or the trim tank (if installed), or the APU fuel feed system.

If the APU is ON and if there is a smell of fuel in the cabin, the APU must be switched off to prevent fuel loss through the APU feed line.



(fig.11) Actions to perform when a CTR tank or APU feed line leak is suspected on an A320 family aircraft

Do not use thrust reversers at landing

Thrust reversers must not be used at landing to avoid blowing the leaking fuel toward the engine air inlet or the hot brakes. This could cause the overheat of the engine, reduced performance of the brakes, and most of all the start of a fire in the engine or on the hot brakes.

(fig.12) Thrust reversers must not be used at landing

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Adherence to operational procedures is crucial to ensure safe management of a fuel leak.

As per SOPs, the flight crew should regularly monitor the fuel consumption to detect a potential fuel leak as soon as possible. ECAM alerts indicating a possible fuel leak either in the aircraft fuel system or in the engine fuel system are also available as an additional safety net.

As soon as a fuel leak is confirmed, the flight crew must consider landing at the nearest suitable airport.

The flight crew must perform the various steps of the FUEL LEAK procedure to identify the location of the leak and contain it to prevent further fuel spillage.

If obvious cues enable the flight crew to confirm an engine fuel leak, the procedure requests that they shut down the affected engine immediately to prevent fire and contain the leak.

The thrust reversers must not be used at landing to avoid blowing fuel toward the engine air intake or toward the brakes.

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