Havarikommissionen
Accident Investigation Board Denmark

Statement 2023-638

Serious incident to SE-DMS (Airbus A321-253NX) northwest of the city of Elsinore on 20-12-2023

ISSUED DECEMBER 2024

INTRODUCTION

This statement reflects the opinion of the Danish Accident Investigation Board regarding the circumstances of the occurrence and its causes and consequences.

In accordance with the provisions of EU Regulation 996/2010, the Danish Air Navigation Act and pursuant to Annex 13 of the International Civil Aviation Convention, the safety investigation is of an exclusively technical and operational nature, and its objective is not the assignment of blame or liability.

The safety investigation was carried out without having necessarily used legal evidence procedures and with no other basic aim than preventing future accidents and serious incidents.

Consequently, any use of this statement for purposes other than preventing future accidents and serious incidents may lead to erroneous or misleading interpretations.

GENERAL

State file number:	2023-638
UTC date:	20-12-2023
UTC time:	07:15
Occurrence class:	Serious incident
Location:	Northwest of the city of Elsinore
Injury level:	None
Aircraft registration:	SE-DMS
Aircraft make/model:	A321-253NX
Current flight rules:	Instrument Flight Rules (IFR)
Operation type:	Ferry
Flight phase:	Climbing
Aircraft category:	Fixed wing
Last departure point:	Copenhagen (EKCH)
Planned destination:	Oslo (ENGM)
Aircraft damage:	Minor
Engine make/model:	2 x CFM LEAP-1A33

Notification

All time references in this bulletin are Coordinated Universal Time (UTC).

The Aviation Unit of the Danish Accident Investigation Board (AIB) was notified of the serious incident by the operator on 20-12-2023 at 08:06 hours (hrs).

The AIB notified the Danish Civil Aviation and Railway Authority (DCARA), the French Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA), the European Aviation Safety Agency (EASA), the International Civil Aviation Organization (ICAO), the Directorate-General for Mobility and Transport (DG MOVE) and the Swedish Accident Investigation Authority (SHK) on 21-12-2023 at 09:56 hrs.

FACTUAL INFORMATION

History of flight

The flight was an IFR ferry flight from Copenhagen (EKCH) to Oslo (ENGM). The commander was Pilot Monitoring (PM), and the first officer was Pilot Flying (PF).

Prior to the flight additional fuel was uplifted as ballast.

Upon arriving in the cockpit, the flight crew noticed on the Electronic Centralized Aircraft Monitor (ECAM) display, that the fuel distribution in the fuel tanks was not as expected. There was still fuel in the Additional Center Tanks (ACT), which the flight crew expected to be empty.

In addition, ECAM presented a fuel message "ACT XFR FAULT". The flight crew performed the associated ECAM fuel message procedure to clear the fault by selecting on manual transfer of fuel from the ACT to the center tank.

After approximately five minutes, the ECAM fuel message "ACT XFR FAULT" disappeared. The flight crew switched off the "manual fuel transfer".

During climb from EKCH and at approximately 5,000 feet (ft), the ECAM fuel message "ACT XRF FAULT" came on again, and the flight crew performed the associated ECAM fuel message procedure to clear the fault.

During climb when passing Flight Level (FL) 250, the first officer said "I smell electrical fire".

The commander inhaled a few times and said, "You are right, oxygen mask on, divert back to Copenhagen".

The commander transmitted to Sweden Control," MAYDAY, immediate return and descend to Copenhagen".

Sweden Control responded, "Turn right inbound LAMOX (approach waypoint for runway 22L), descend to FL 180".

The first officer started the approach to EKCH, and the commander consulted the Quick Reference Handbook (QRH) "Abnormal and emergency procedures/Smoke/ Fumes/AVNCS smoke" checklist.

During the approach, the first officer set the transponder to code 7700.

The flight crew landed on runway 22L and vacated the runway via taxiway B5.

The flight crew stopped on the taxiway.

The onsite fire brigade did externally neither observe nor detect any fire or smoke.

Upon removing the commander's oxygen mask, the smell of electrical fire/burning was now less noticeable.

The flight crew taxied the aircraft to a remote parking stand followed by the fire brigade.

The flight crew shut down both engines, and the fire brigade came on board.

The smell of electrical fire/burning was only present in the cockpit area and not in the passenger cabin.

Upon opening the door to the avionics compartment under the cockpit floor, a strong smell of electrical fire/burning was present.

There was no sign of neither smoke nor trace of fire.

Injuries to persons

Injuries	*Crew*	*Passengers*	*Others*
Fatal			
Serious			
None	2	0	

Damage to aircraft

A burnt electrical Ground Fault Interrupter (GFI) relay.

Other damage

None.

Aircraft information

General information

Manufacturer:	Airbus
Type:	A321-253NX (A321 Long Range (LR))
Serial number:	10,500
Airworthiness review certificate:	Valid until 22-2-2024
Engine manufacturer:	CFM International
Engine type:	LEAP-1A33
Maximum take-off mass (MTOM):	97,000 kilos (kg)
Fuel on board at take-off:	12,000 kg

Fuel system (An extract from the operator A321 FCOM (Flight Crew Operating Manual)):

The fuel tank system consisted of:

- two wing tanks
- one center tank
- three ACT (FORWARD, AFT 1 and AFT 2)
- two outboard vent surge tanks.

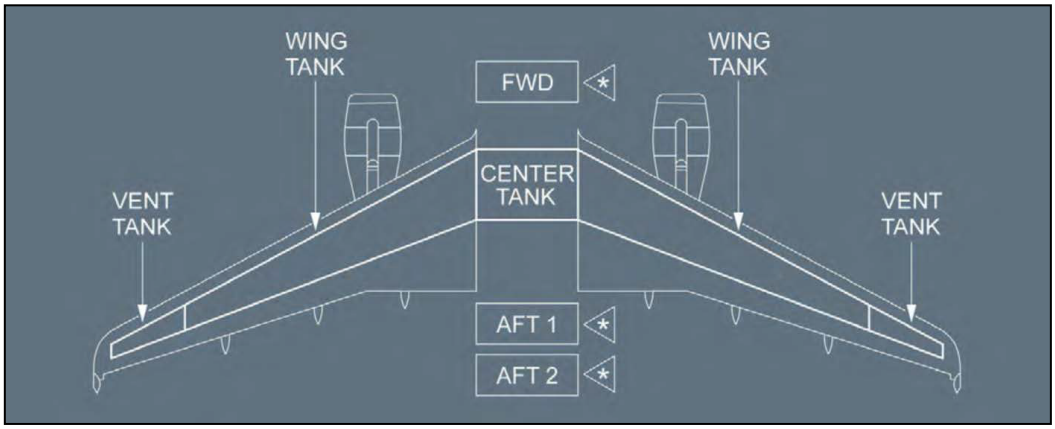

Figure 1. A321LR layout of fuel tanks.

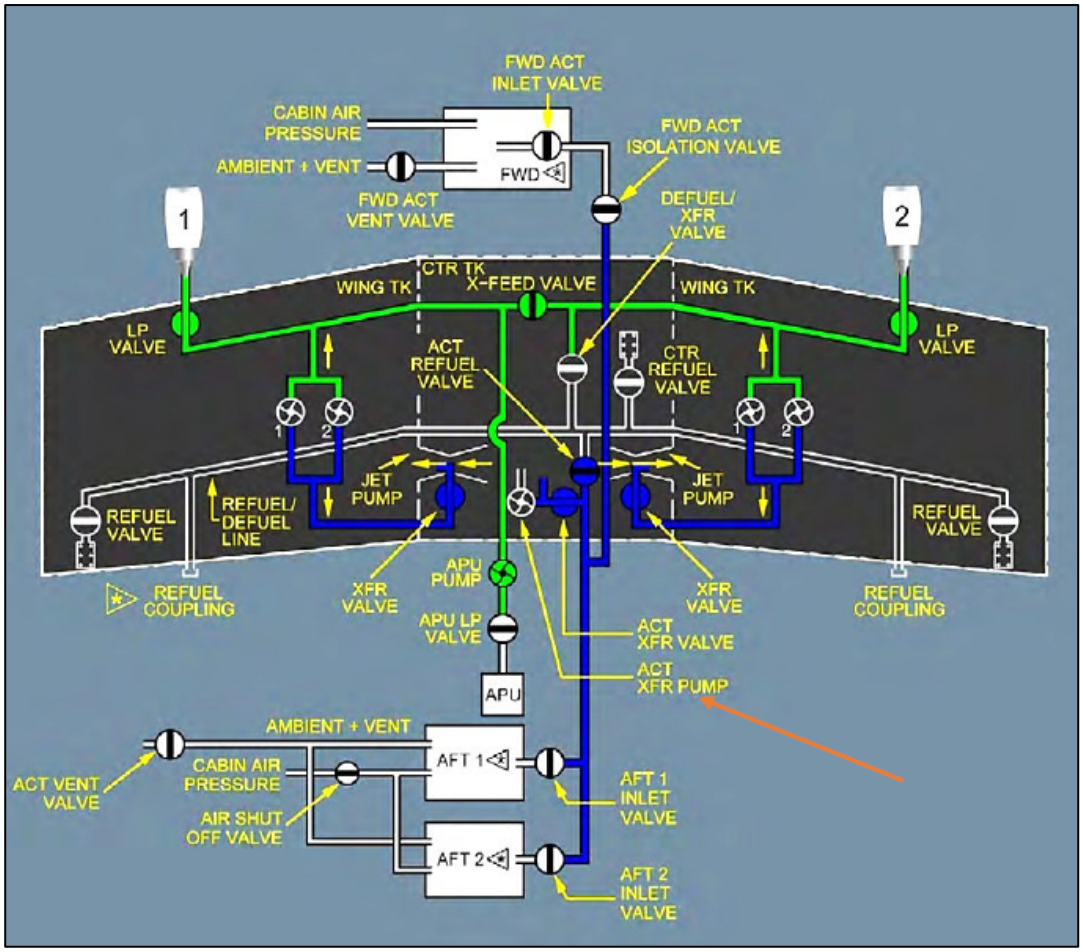

Figure 2. A321LR ACT Transfer (XFR) pump.

Fuel was transferred from the ACT to the center tank one at a time in the following order: First FWD, then AFT 2 and then AFT 1. The transfer was fully automatic and was achieved by pressurizing the fuel tanks with cabin air.

The automatic fuel transfer started in flight, when the landing gear was up for more than 30 minutes, and when the center tank quantity was below 5,000 kg.

In case of an automatic transfer failure, a manual transfer could be performed by the flight crew by selecting the manual transfer push button switch on the ACT FUEL panel.

This action closed the main contacts in the Ground Fault Interrupter (GFI) relays (122HQ and 124QH = Functional Item Number (FIN)) and supplied power to the electrical ACT transfer pump (ACT XFR PUMP).

The two GFI relays were in series on the power supply lines to the ACT transfer pump.

If a ground fault (short to ground) occurred in the wiring to the ACT transfer pump or in the ACT transfer pump, the GFI relay would open and isolate the fault from the electrical power supply to the ACT transfer pump.

An ACT XFR FAULT caution was triggered when:

a. Automatic transfer was on, and
b. any ACT empties before the previous ACT was empty.

Location of the GFI relay (124QH)

The GFI relay (124QH) was installed in the avionics compartment under the cockpit floor in the contactor box 107VU.

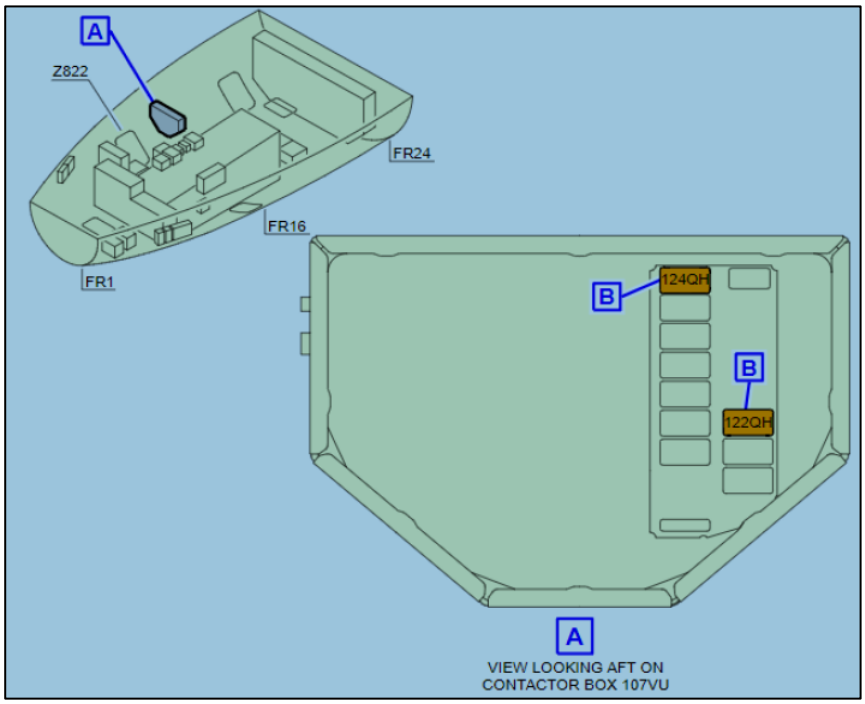

Figure 3. GFI relay (124QH) location.

AIB technical safety investigation

Onsite investigation

Shortly after engine shut down, maintenance crew inspected the avionics compartment. In the contactor box 107VU, the maintenance crew noticed a GFI relay (124QH) with black soot and a burnt hole in the plastic housing.

The adjacent relay (17QA) had on parts of its casing black soot deposits from the GFI relay (124QH). There were no other damages to this relay (17QA).

For quarantine, the maintenance crew removed the GFI relay (124QH) and the adjacent relay (17QA).

There were no other damages to the GFI relay mating installation or wiring in the aircraft

No circuit breakers were in open position.

Figure 4. Damaged GFI relay location.

Figure 5. Damaged GFI relay.

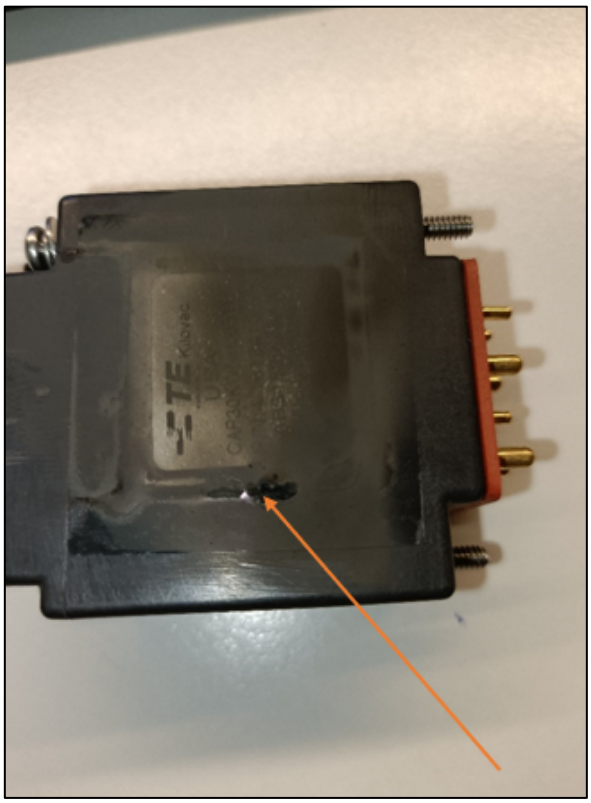

Figure 6. Burnt hole in the GFI relay plastic housing.

Figure 7. GFI relay disassembled with burnt and damaged components.

Further investigation

The BEA performed a non-destructive Computed Tomography (CT) scan of the damaged GFI relay.

The CT scan confirmed that overheating had occurred inside the GFI relay.

In cooperation with the BEA and under supervision of the NTSB, the GFI relay manufacturer performed further inspections of the damaged GFI relay.

The inspections concluded that the capacitor, current limiting resistor, Pulse Width Modulator (PWM) chip, PWM trace wires, Transient Voltage Suppressor (TVS), internal wiring, blocking diode and freewheeling diode had damages often seen after exposure to voltage levels exceeding the design limits.

Additional information:

Maintenance crew replaced the damaged GFI relay (124QH) and the adjacent relay (17QA) with new relays.

After replacement of the relays, the required tests in accordance with the maintenance manual gave no rise to remarks.

Failure classification

From a Continued Airworthiness perspective, a GFI relay failure is classified “Minor”.

The aircraft manufacturer and EASA provided the following justification for the failure classification:

1. The fuel system electrical ground fault protection was still effective, because:

   The ACT transfer pump, installed in the wing center tank, design and wiring installation provided primary protection against ground faults.

   The aircraft manufacturer considered that the above features provided compliance with the certification standard for large aeroplanes fuel tank ignition prevention.

   Even if the GFI relay failed to provide enhanced protection against ground faults, there would be no unsafe condition.

   When the GFI relay failed, the fuel pump became electrically isolated. Selecting the pump back on would have no effect.

   For that reason, there was no unsafe condition associated with a failure of a single or the dual GFI relay to provide enhanced protection against ground faults to the ACT transfer pump circuit.

2. Fire protection was still effective, because:

   The electrical components, like the GFI relay, in the pressurized areas of the aircraft, including the avionics compartment, complied with the certification standard for large aeroplanes concerning flammability, fire resistance, fire spreading and toxicity.

   For that reason, there was no risk of a fire spreading or toxicity, when a GFI relay failed (heat generation).

   This failure was considered as minor from a fire safety standpoint due to:

   - no smoke/slight fumes/slight odors in the cockpit.

- no smoke/fumes/odors in the avionics compartment.
- slight increase in flight crew workload and slight reduction in safety margins.

Severity of the Effects						
	Effect on Aeroplane	No effect on operational capabilities or safety	Slight reduction in functional capabilities or safety margins	Significant reduction in functional capabilities or safety margins	Large reduction in functional capabilities or safety margins	Normally with hull loss
	Effect on Occupants excluding Flight Crew	Inconvenience	Physical discomfort	Physical distress, possibly including injuries	Serious or fatal injury to a small number of passengers or cabin crew	Multiple fatalities
	Effect on Flight Crew	No effect on flight crew	Slight increase in workload	Physical discomfort or a significant increase in workload	Physical distress or excessive workload impairs ability to perform tasks	Fatalities or incapacitation
Classification of Failure Conditions		No Safety Effect	Minor	Major	Hazardous	Catastrophic

Figure 8. Failure classification table from the certification standard (CS-25 Amendment 21).

Mitigating actions by the aircraft manufacturer

Cooperation between the design office of the aircraft manufacturer, continuous airworthiness teams and the component equipment manufacturer defines test scenarios to fully understand the root cause of the GFI relay failure.

Upon revealing and understanding the root cause, the aircraft manufacturer implements mitigating actions.

AIB safety investigation process

Upon ending the preliminary safety investigation, the AIB decided - in accordance with article 5 of EC Regulation No. 996/2010 and § 138 of the Danish Air Navigation Act - not to conduct any further safety investigations.

With reference to article 16 of EC Regulation No. 996/2010 and § 143 of the Danish Air Navigation Act, this statement closes the AIB safety investigation.