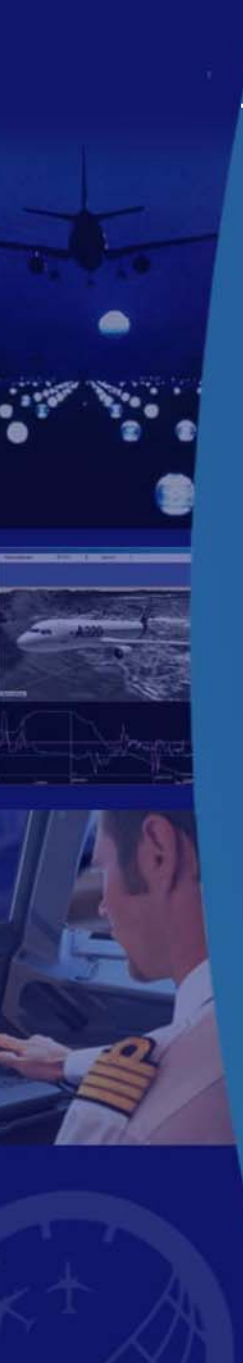
Protections against fuel vapor ignition

Protections Against Fuel Vapor Ignition

Contents

- Introduction
- Design Review
- In Service Aircraft Intensive Inspection
- General Conclusion

Protections Against Fuel Vapor Ignition



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Introduction

- Flight TWA 800
- 17th july 1996
- Boeing 747-100
- Exploded in flight shortly after takeoff
- Reason:
  - Center tank explosion
  - Source of ignition not identified

Introduction

- Combination of several factors:
  - Low fuel level in center tank
    - Existence of flammable fuel vapor
  - Center tank elevated temperature
  - Most likely ignition source: excessive voltage, following a short circuit, entering the center tank
- Higher probability of occurrence on ground due to higher temperature

Introduction

Industry reaction

- Industry formulated the Aircraft Fuel System Safety Program (AFSSP)
  - Manufacturers
    - Airbus
    - Boeing
    - British Aerospace
    - Bombardier
    - Fokker
    - Lockheed
  - Airlines Associations
    - ATA
    - AEA
    - AAPA
  - Airworthiness Authorities

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Design Review

- Review of the possible reasons of the explosion
  - Flammable fuel vapor
  - Elevated temperature in center tank
  - Spark generation

Design Review

- Flammable fuel vapor
  - Explosion can only occur if flammable fuel vapor is present
  - A spark generation has no effect on liquid fuel (no oxygen)
  - Reduced risk of explosion in tanks as long as tanks are full:
    - Less quantity of oxygen
    - Lower temperature
  - Heat is a contributing factor to increase flammability of fuel vapor

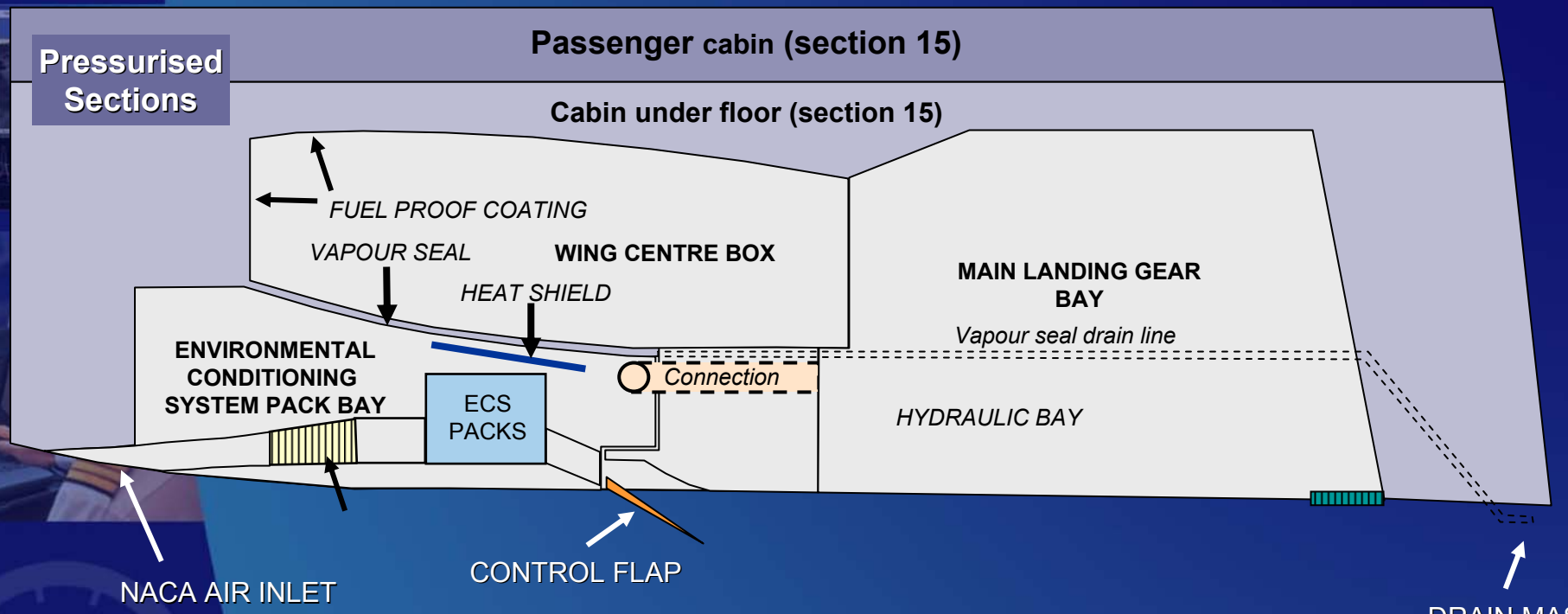
Design Review

- Elevated temperature in fuel tank
  - Fuel tank heated via:
    - Outside ambient temperature
    - Adjacent systems:
      - Air conditioning
      - Bleed air
      - Hydraulics

Design Review

Environment of the center tank

Example of the A320



Design Review

- Fuel and adjacent systems protected against overheat:
  - Fuel pumps protected against overheat (thermal fuses) and explosion (fuel pumps are located inside explosion proof canisters)
  - Air conditioning:
    - Thermal protection between center tank and air conditioning bay
    - Hot air ducts are fully insulated
    - Cockpit warnings in case of Pack or Duct overheat

Design Review

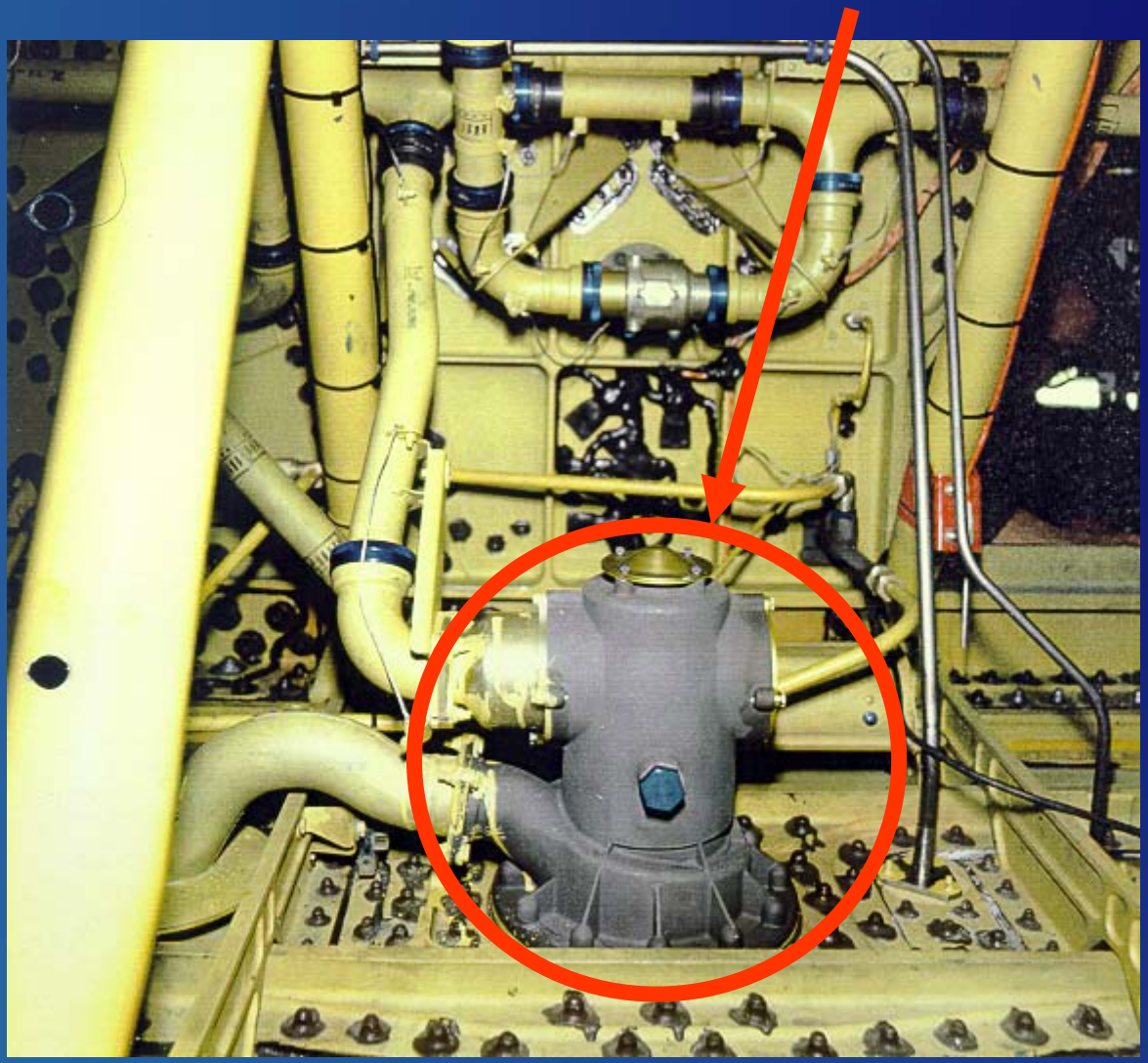
- Bleed air:
  - bleed ducts fully insulated
  - the system is continuously monitored to detect any ambient overheat in the vicinity of the hot air ducts
  - this particularly applies to wing and center section of fuselage
  - this triggers cockpit warnings and automatic bleed valve closure
- Hydraulic systems:
  - not considered as a heat contributor
    - » it is located in the landing gear bay (open area) and
    - » operating temperatures are lower than 100°c

Design Review

- Spark protection
  - fuel system:
    - Pumps located inside explosion proof canisters
    - No power cables inside the fuel tanks
    - Fuel valve actuators are mounted externally to the fuel tanks
    - Valve actuator casings are fully sealed and explosion proof
    - Electrical (solenoid) valves protected against electrical arcing

Design Review

Fuel pump - explosion proof canister



Design Review

- Electrical system

  - All structures are protected against lightning strikes and static electricity through electrical bonding (wires directly connected to the fuselage) to avoid accumulation of electricity
  - Protection of all wires against short circuit and induced electrical fields
  - Automatic tripping of circuit breaker to electrically isolate a failed system
  - A320 FCOM recommendation (FCOM 3.04.24):
    - On the ground,do not re-engage any fuel tank pump circuit breaker

Design Review

Bonding Lead (damaged)

Design Review

Conclusion

- Review confirmed the safe aircraft design in terms of ignition sources and overheat protection, even considering system failure.

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In Service Aircraft Intensive Inspection

- Inspection performed on all airbus aircraft types following requests of AFSSP
- More than 130 airbus in service aircraft inspected
- Fuel tank and electrical bonding intensive inspection:
  - Robust design confirmed, good condition, no unacceptable degradation with age

In Service Aircraft Intensive Inspection

- Electrical wires and connectors:
  - Good condition and performing intended function
- In some cases,improvements of maintenance training and procedures

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General Conclusion

- Intensive design review and in service aircraft inspection confirmed
  - The safe original design and
  - No impact on safety of forecasted minor material degradation with age
- Airbus will continue to actively participate to safety programs to further improve quality and safety of its aircraft

Thank you for your attention