EASA
European Union Aviation Safety Agency

H2 workshop
APUS i-2 approach for Flight Conditions

Small Aircraft, Balloons and Airships section

17 December 2024

APUS i-2 approach for Flight conditions. Substantiation approach

- Proof of concept:
  - Limited number of tests, with a limited envelope
  - Experienced flight test pilot

- Flight test documents
  - FTOM (DOA)
  - Flight Test Program:
  - Flight Test Plan
    - Containing 25 Flight Test Hazard Assessments,
    - Visibility of high level risks, initial and final classification after mitigations. Reference to supporting documents
  - Interactive AFM.
    - Power management and control is a focus of interest for the Flight Panel

APUS i-2 approach for Flight conditions.

Safety Assessment and Development Assurance

- Substantiation Program First Flight
  - Substantiation approach (~1 page per discipline)
  - List of tests
  - CS 23 high level requirements and substantiation documentation

- Master Certification Program : framework for TC and FC, including schedules. Extension validity of application 5Y.

- Safety Assessment and Development Assurance
  - At minimum, it is required that all Failure Conditions have been properly identified
    - Special attention to undetected events
    - Failure Condition classification may be different from TC, based on FT operations and mitigations
  - Mitigations
    - Mitigation means have to be identified and analysed
    - Risk mitigation by pilot action has to be substantiated.

APUS i-2 approach for Flight conditions. Fire and explosion protection

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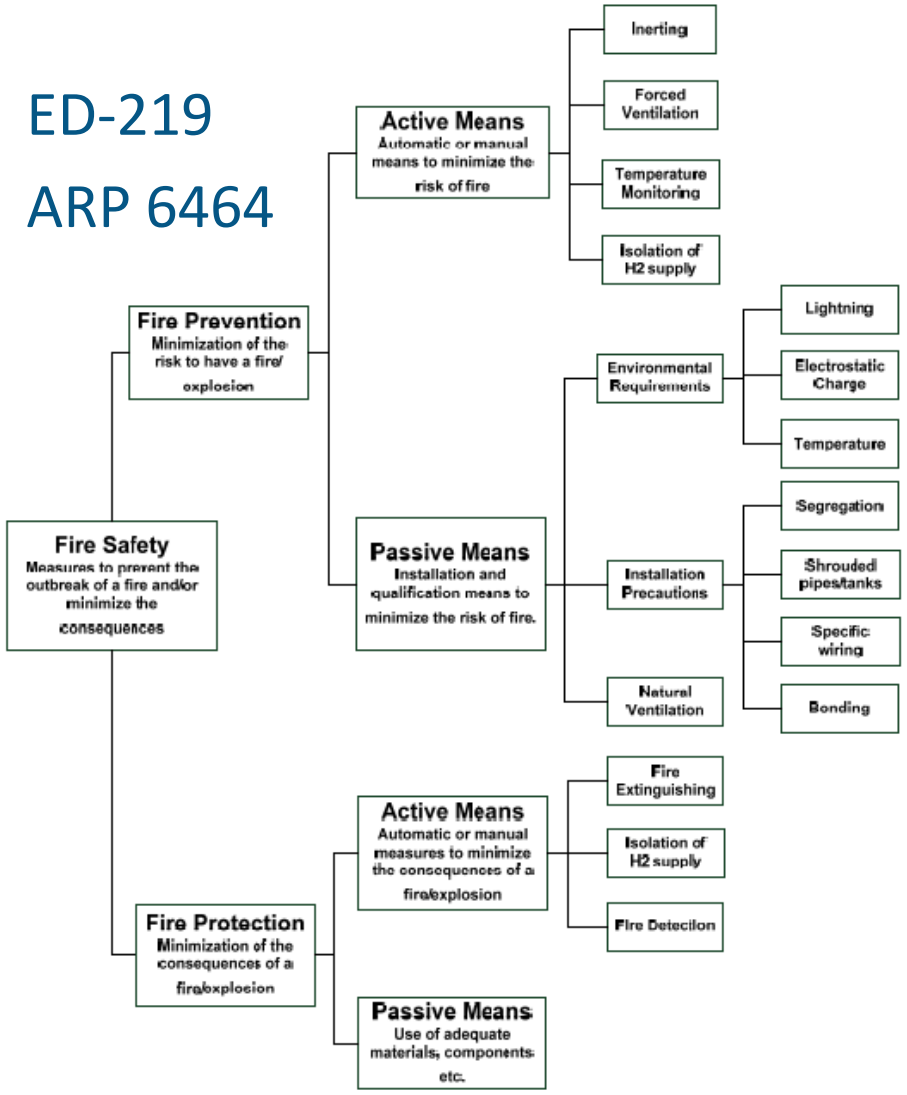


FIGURE 5: TENTATIVE FUNCTIONAL BREAKDOWN OF H2 FIRE PROTECTION LEAKAGE MANAGEMENT

→ Novel Fire and Explosion risk

→ EASA materials

- → CAI 12-01 Hydrogen fire and explosion protection, with some references
- → Presentation fire protection for H2 systems

→ Fault Tree Analysis

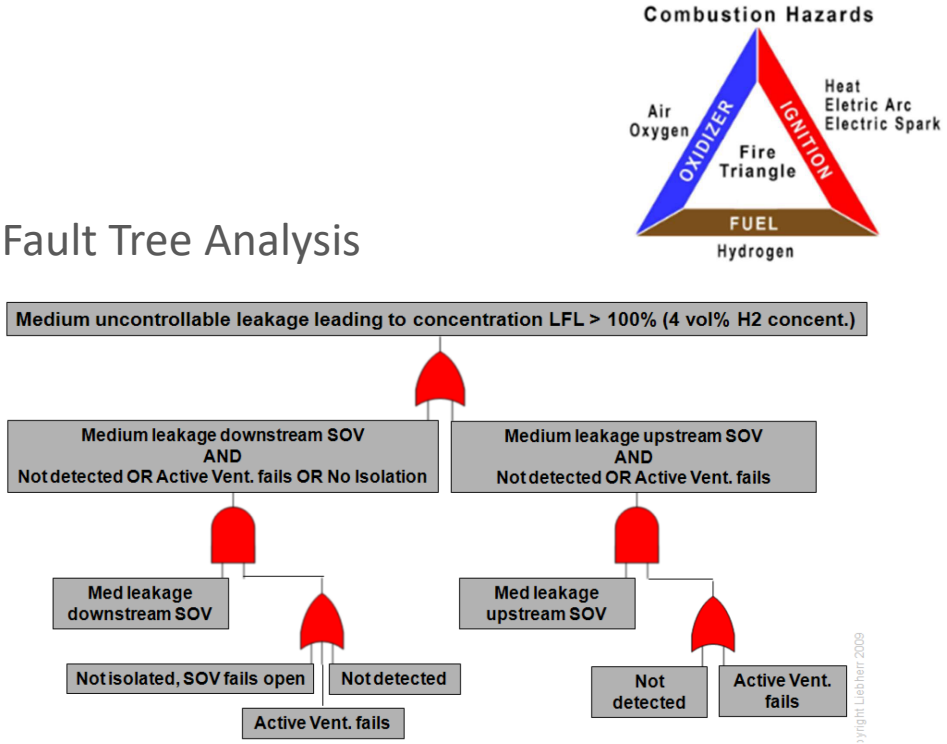


FIGURE 8: FAULT TREE FOR MEDIUM LEAKAGE LEADING TO CONCENTRATION ABOVE LFL

APUS i-2 approach for Flight conditions. Fire and explosion protection

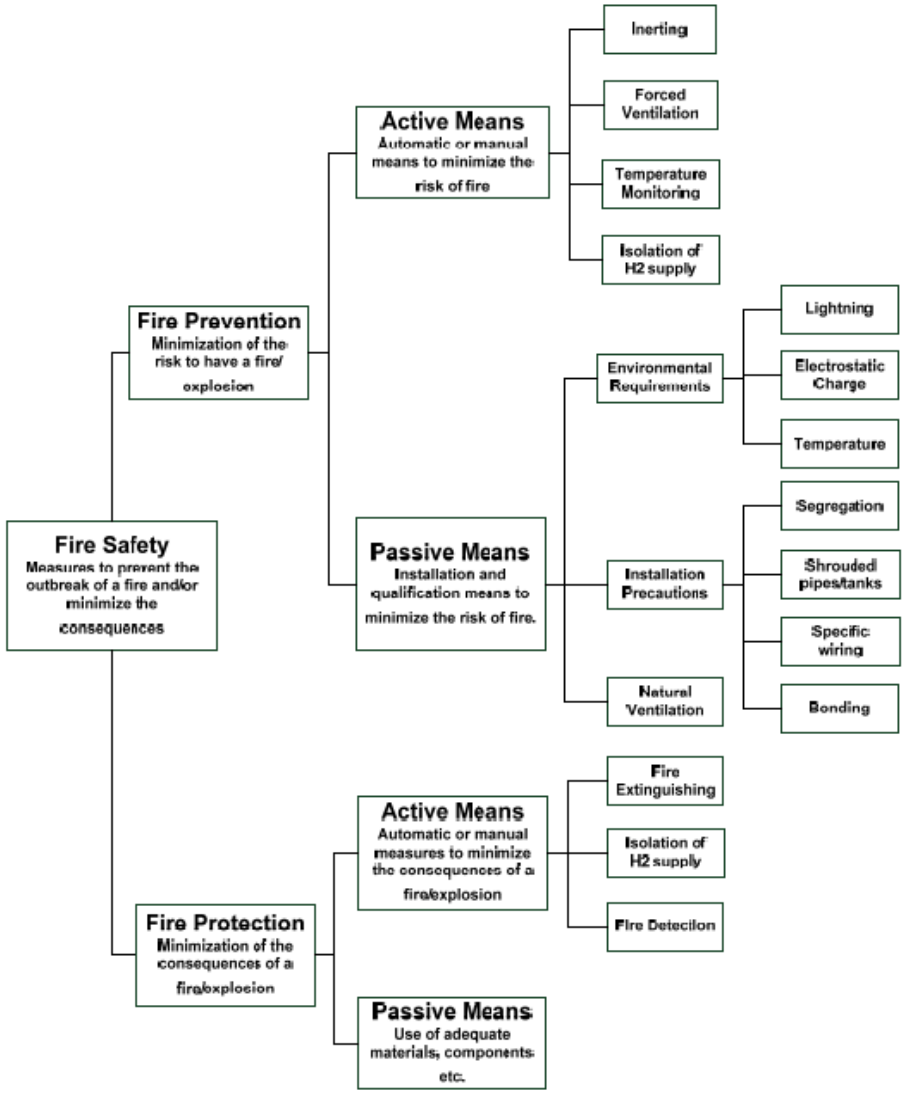
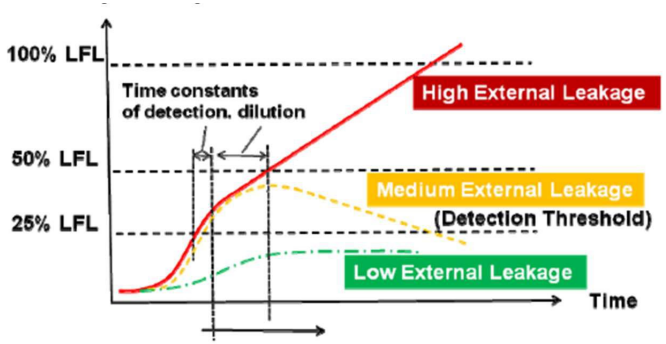


FIGURE 5: TENTATIVE FUNCTIONAL BREAKDOWN OF H2 FIRE PROTECTION LEAKAGE MANAGEMENT

→ Leaks and flammability

- → If the design is good, large leaks are less probable, and more easily detectable
- → Smaller leaks reach flammability levels only very locally
- → Intermediate leaks can be more difficult to detect, number of detectors.
- → Structural H_2 tightness
  - → Crashworthiness by analysis, pressurization and static tests
- → Leak and ventilation tests



→ H2 and fire Detection and shut-off

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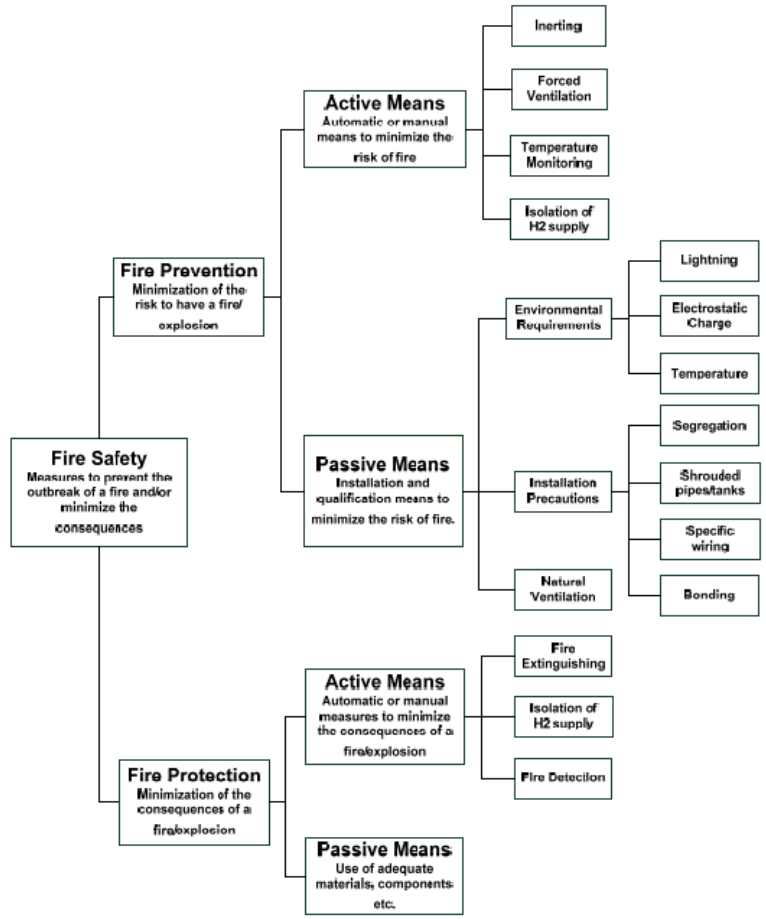
APUS i-2 approach for Flight conditions. Exchanging experiences with NAAs

- Exchanges with NAA and other manufacturers to learn about their safety approach. NAA workshop
- Some experiences
  - Stepwise testing and readiness gates
  - Designers, pilot, production, maintenance and operation staff same throughout, very aware of design
  - Tight configuration control and approval by authority
  - Different approaches for SA/DA activities
  - Very low ignition energy. Preventing single point of failure=CAT can be challenging
  - Difficult to predict leak for seal degradation
  - H_2 Flushing process is sensitive (prevent mix H_2 /air)

  - Different safety strategies
    - Systematic sniffer before and after the flight
    - Inerting
    - Double shroud pipes/double seal
    - Thermal cameras
    - Draining while parked
    - Possibility to ventilate on ground with fans



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Thank you!

Your safety is our mission.

An agency of the European Union