Certification Challenges of Hydrogen Propulsion

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H2FLY

EASA
European Union Aviation Safety Agency

Certification Conference

October 24, 2023
Cologne

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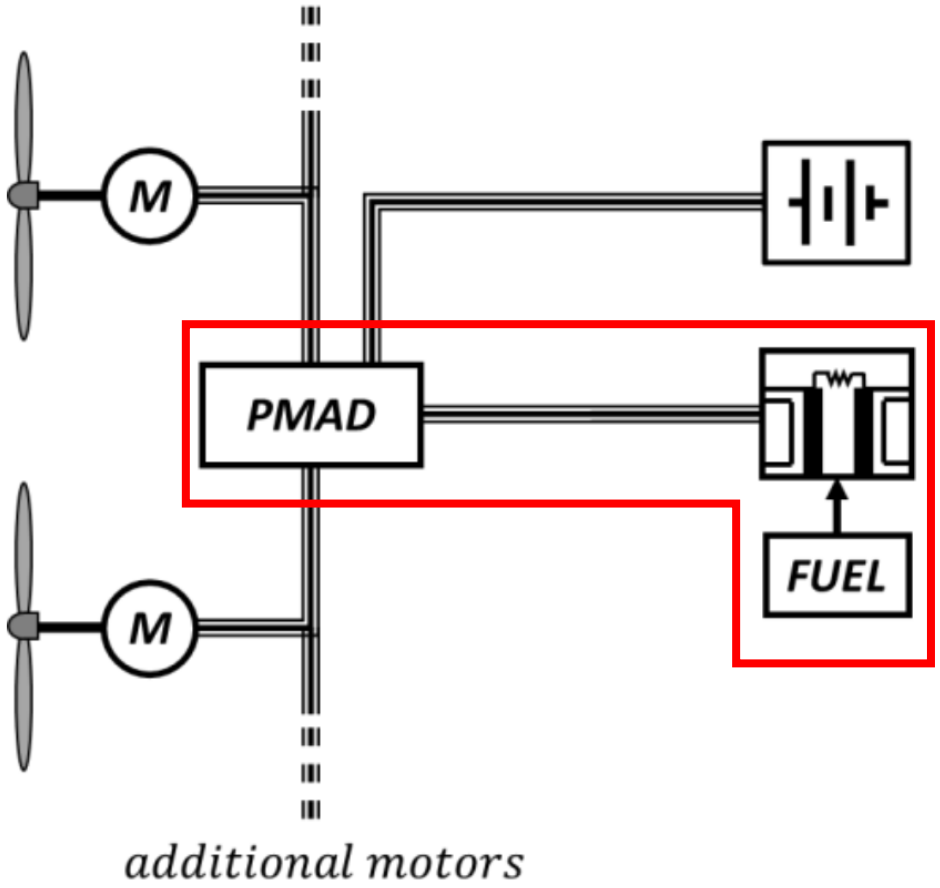
Overview

European Union Aviation Safety Agency

Overview

Regulatory Coverage

- Fuel cell system – not covered
- LH2 fuel system – partly covered by exsisting regulations for conventional fuel
- HV power management / control / transmission / distribution – not covered
- Emission requirements – not covered



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Major Safety Concern of H2 – Explosive Atmosphere

Concept of Preventing and Controlling H2 Leakages?

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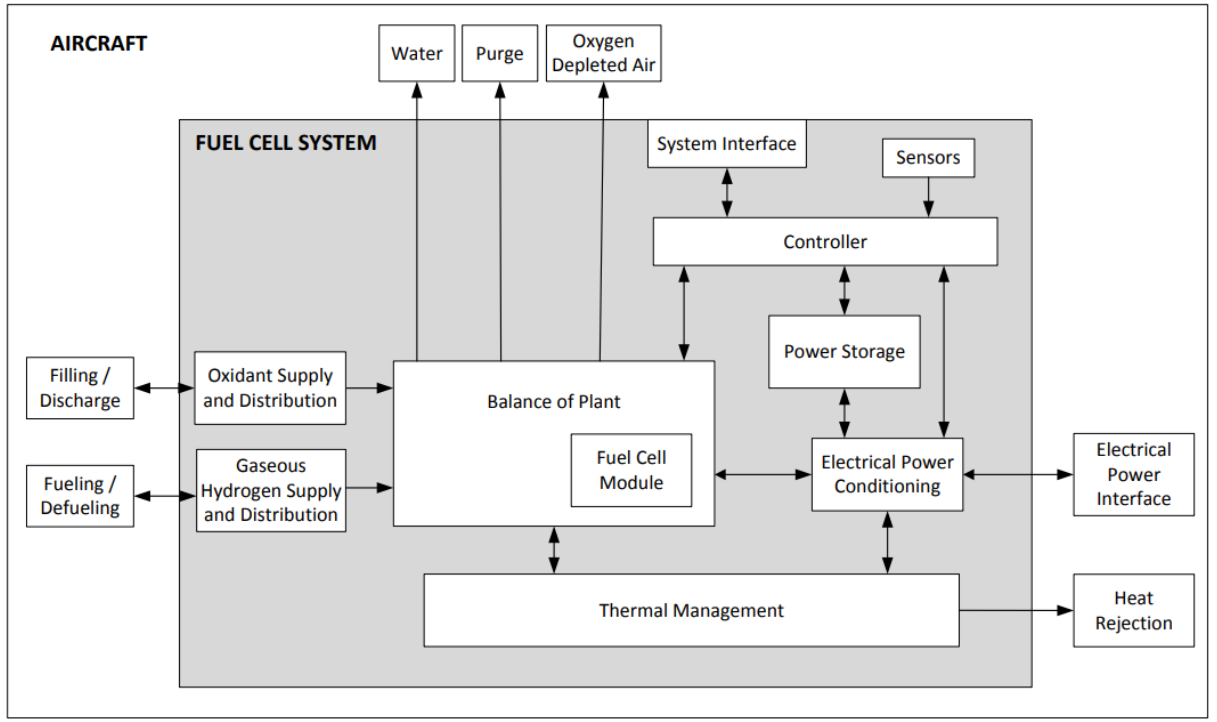
Explosive Atmosphere

Leakage Prevention

1. Natural component permeation
2. Cell stack or process fault
3. Internal transfer between anode to cathode fault
4. Internal transfer between gas and cooling fault
5. External gas leakage fault
6. External coolant leakage fault / loss of cooling
7. High coolant conductivity fault
8. Over current fault
9. Short circuit fault
10. Supply line and component fault
11. Tank leakage fault



Appropriate system reaction has to be defined if a failure mode is detected by the monitoring to bring the system into a safe status.

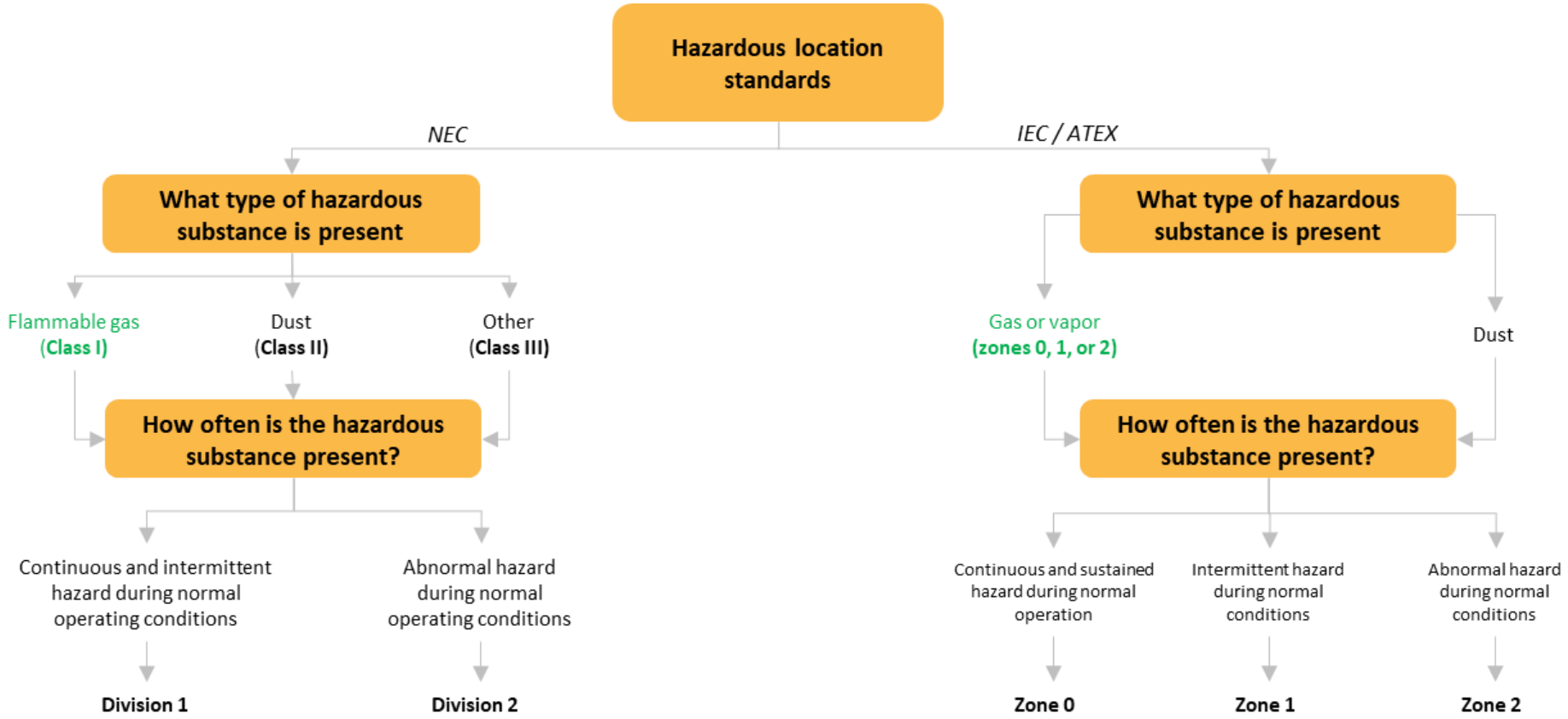
Explosive Atmosphere

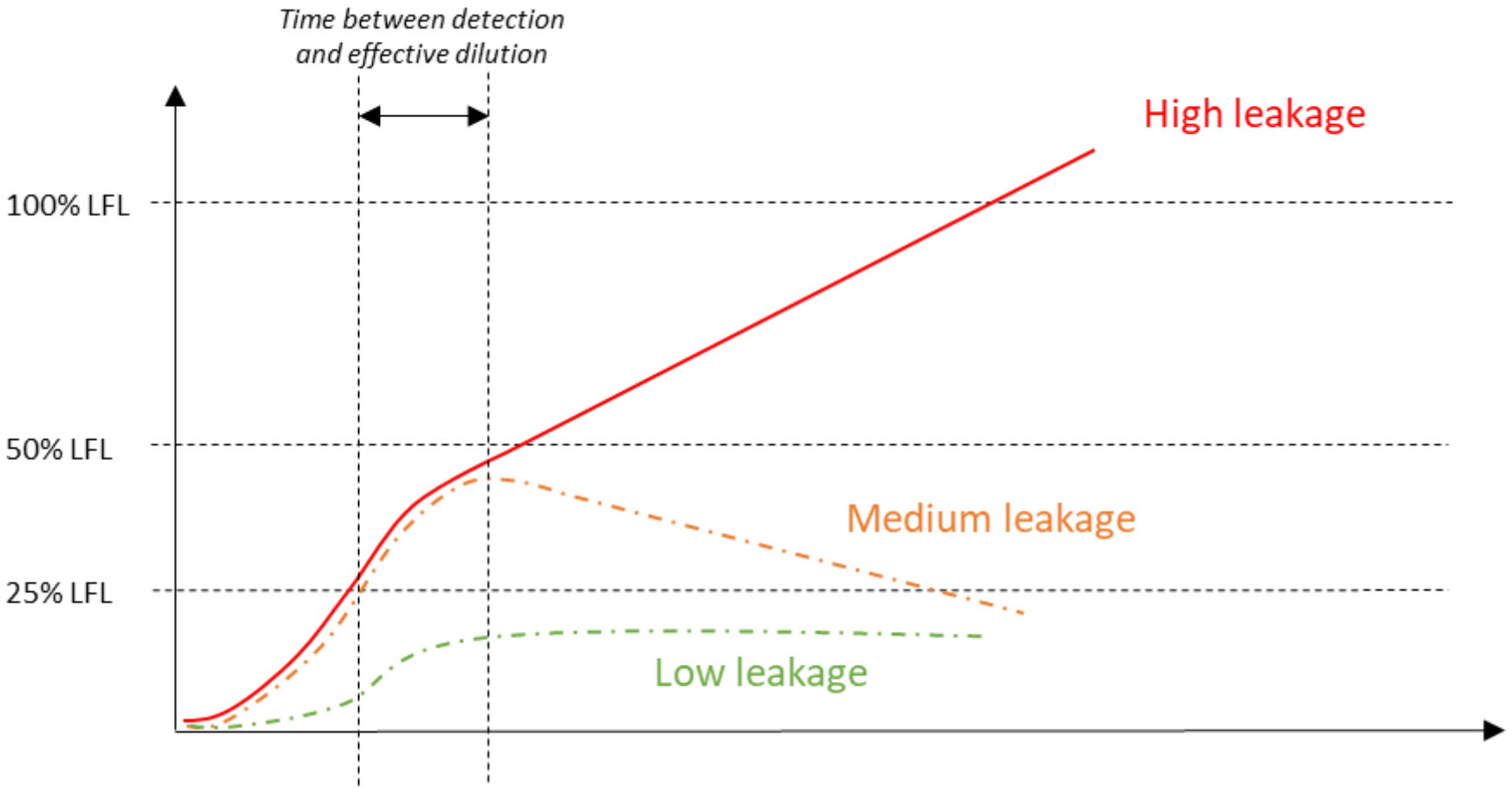
Prevention of Ex. Atmosphere (H2/air)

- H2 detection (reliability / diagnostic coverage?)
- Definition of min. ventilation rate for enclosed compartments
- Separation in zones (likelihood of H2 presence) required, similar to ATEX or NEC Division System
- Explosionproof equipment needed
- Probability of an ignition of an atmosphere > 4 vol-% H2 is considered to be 1

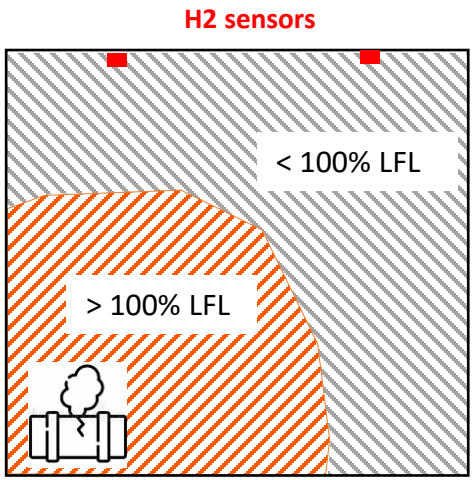
	Hydrogen
Flammability Limits (in air)	4-74%
Explosion Limits (in air)	18.3-59.0%
Ignition Energy (mJ)	0.02
Flame Temp. in air (°C)	2045
Stoichiometric Mixture (most easily ignited in air)	29%

Concept for Facilities

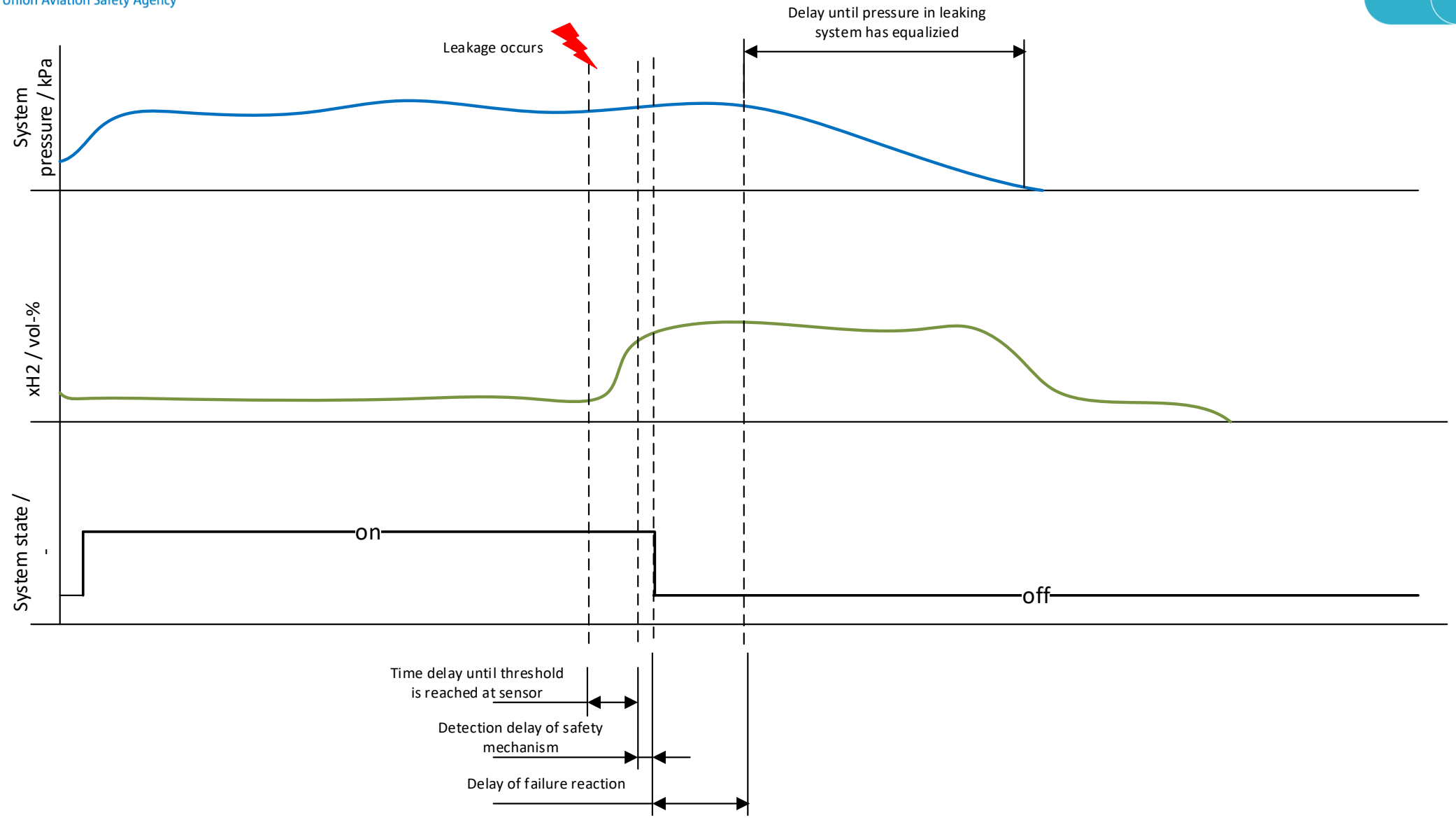




(Derived from „SAE ARP6464 – Aircraft Fuel Cell Safety Guidelines“, 2013-06)

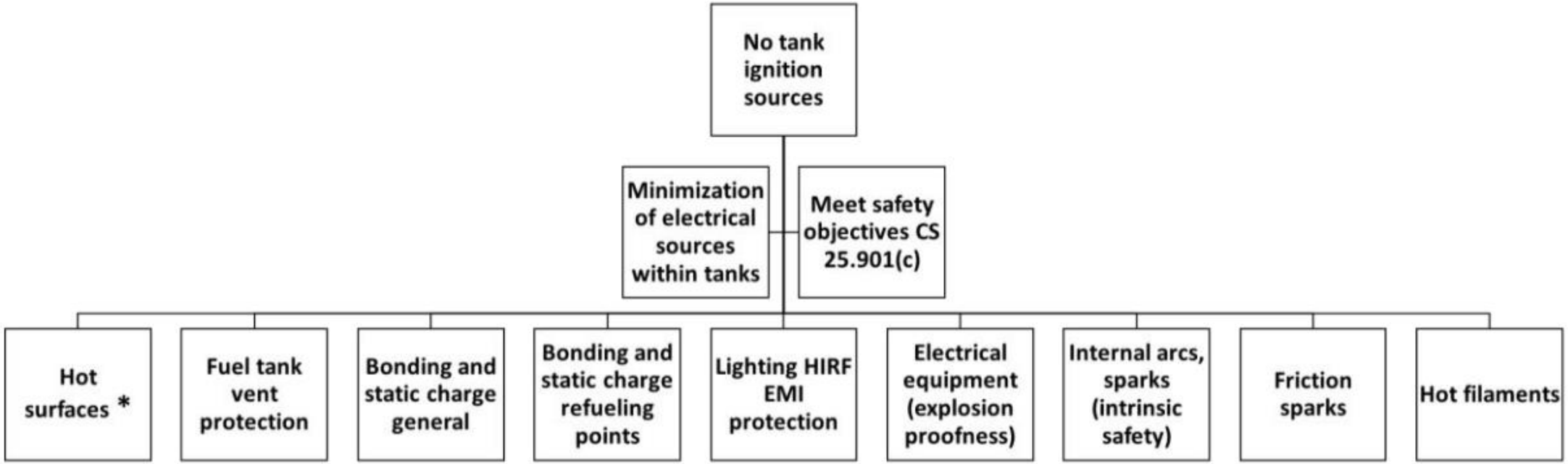


In a leakage event, there are zones that might exceed LFL while the sensors read lower values (< 100% LFL). By separating the potential leaking systems, those zones are held smaller, thus less energetic in case of an ignition.


Leakage occurs
Delay until pressure in leaking system has equalizied
System pressure / kPa
xH2 / vol-%
System state / -
on
off
Time delay until threshold is reached at sensor
Detection delay of safety mechanism
Delay of failure reaction

Explosive Atmosphere

Ignition Prevention



Easy Access Rules for Large Aeroplanes (CS-25)
(Amendment 21)

Explosive Atmosphere

Safety Targets

Primary safety target:

1. Prevent escaping hydrogen gas. The design must be inherently safe with sufficient safety margins. Hydrogen carrying components must be technically tight.
2. Reliable emergency shut off and isolation function if the system runs into abnormal operating conditions or malfunctions

Secondary safety target:

1. Elimination of all electrical and non-electrical ignition sources
2. Sensor and monitoring concept with a good diagnostic coverage
3. Establish a ventilation concept in case of an abnormal hazard condition that leads to an explosive atmosphere in the A/C

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LH2 Storage / Fuel Tank

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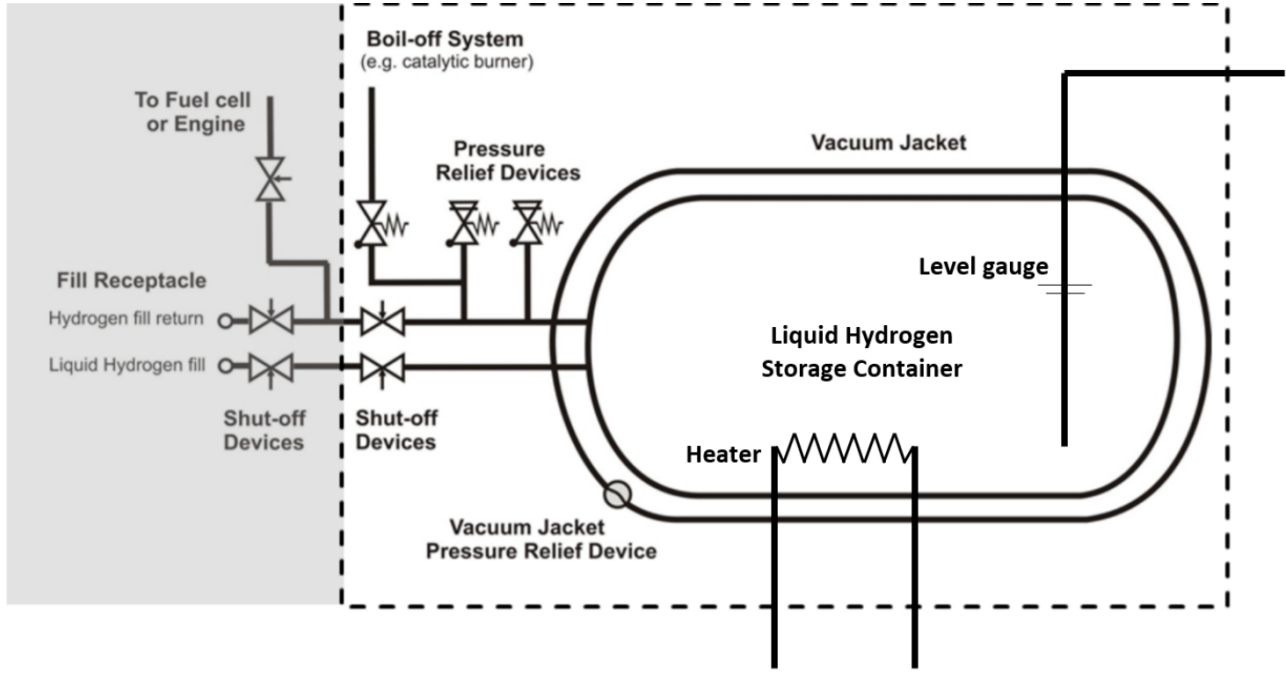
LH2 Storage / Fuel Tank

System Overview

- Burst / Rupture discs vs. safety relief valves
- Availability in case of loss of vacuum insulation (fast pressure increase)?
- p_fail > 1.3 (MAWP + 0.2 MPa) -> high weight
  acc. to ISO 13985:2006-10



LH2 Storage / Fuel Tank

Additional Uncertenties

- Test criteria for LH2 fuel tanks in fuselage
- Fire zone in fuselage
- Consider external release of hydrogen from the A/C (offgas, operational boil-off, emergency venting)
  → A/C vent stack locations
- Areas around venting (ATEX zone)
- Etc.

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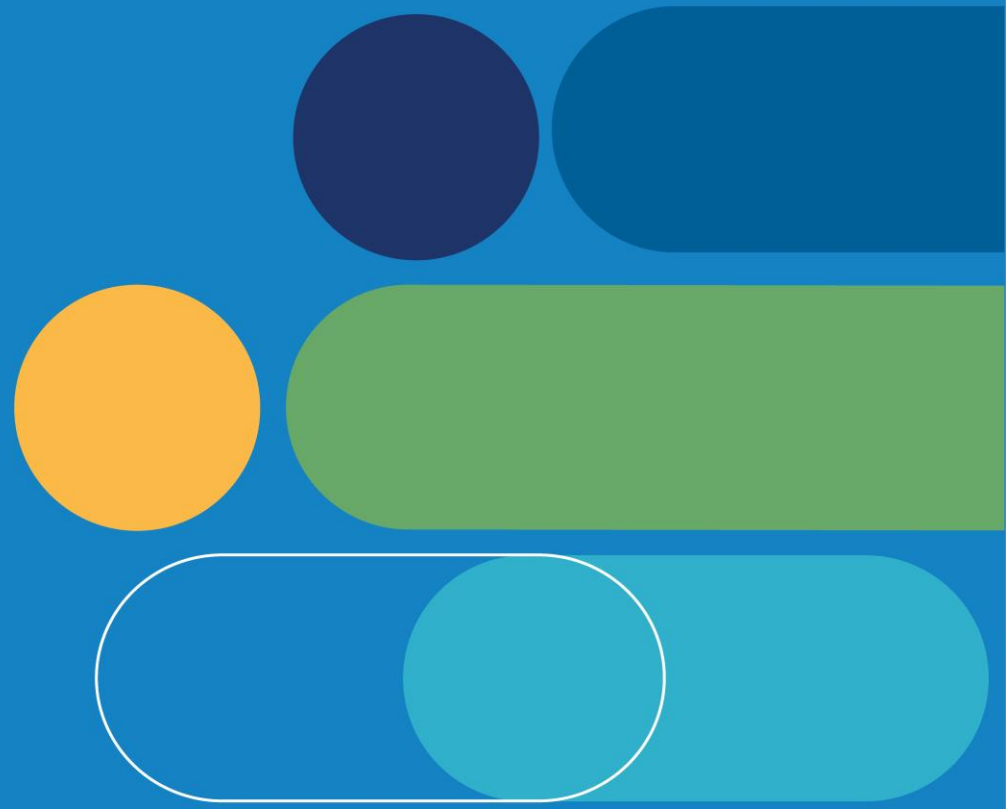
Thank you!



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