EASA
European Union Aviation Safety Agency

EASA update on rulemaking and research on lithium batteries

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EASA Certification Directorate

INTERNATIONAL AIRCRAFT
MATERIALS & SYSTEMS FORUM MEETING
24 September 2024

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Agenda

→ EASA Rulemaking

→ PED battery fire on the flight deck

→ EASA Research

→ LOKI-PED

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PED battery fire on the flight deck

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PED battery fire on the flight deck

- **Continuing Airworthiness (CAW) activities:**
  - In May 2018 EASA issued a Continuing Airworthiness Review Item (ref. CARI 25-09) to request TCHs to assess the hazard associated to a lithium battery fire on the flight deck
  - The CARI identifies a minimum set of measures necessary to address the hazard
- **Initial Airworthiness (IAW) activities:**
  - In December 2021 EASA published proposed special conditions to address the safety concern highlighted in the CARI for new design certification project
  - On 26 April 2022 EASA published the final Special Condition M-TS-0000419 (Past Ref. SC-G25.1585-01) and the related CRD
- **SIB addressed to operators:**
  - On 12 October 2022 EASA published SIB 2022-08 including recommendations based on the special conditions
  - The SIB was shared with other Aviation Authorities before pubblication

PED battery fire on the flight deck

- EASA will release a Certification Memorandum to communicate all the IAW and CAW activities performed since the release of CARI 25-09

- The CM should have the following minimum content:
  - Background for CARI 25-09
  - Definition of the intent of Special Condition M-TS-0000419 (Past Ref. SC-G25.1585-01) and of the criteria for the applicability of the special condition to certification projects
  - Classification of design changes affecting the level of mitigation of flight deck fires originating from lithium batteries that are not part of the aircraft design
  - Specific guidance applicable to EFB mounts, addressing also already certified EFB mounts installations (ref. SIB 2022-08)

- Target for publication of the Proposed CM: **Q1 2025**

CARI 25-09 : main findings

- Unambiguous information on safe stowage locations available on the flight deck should be provided to operators (through placards and training material).
- Donning fire gloves is essential to safely handle PEDs:
  - Not always available on the flight deck or in its proximity
  - Minimum performance standard for fire gloves should be specified
- Use of fire containment bags not acceptable for fire fighting
- Fire Containment Bags may be used as PED stowage facilities, if adequate fire containment performance is demonstrated.

Fire containment bags

- FCBs may be used by TC holders as stowage means on the flight deck, if adequate performance is demonstrated.
- Fire containment should be demonstrated against a standard test method (e.g. UL5800).
- UL5800 needs improvement.
- Relocation of the bag to another compartment (e.g. a lavatory) is essential to address smoke released by the PED during the thermal runaway event
- Fire containment performance significantly depends on the strict application of the instructions for closure of the bag.

Considerations on UL5800

- Lack of definition of the configuration of the artificial battery fire source:
  - Orientation of the 18650 cells with respect to critical features in the construction of the box (holes, joints, etc.).
  - Orientation of the artificial battery fire source with respect to critical features of the fire containment bag.
- How to achieve airtightness of the box

Next steps

- Release of the CM on PED battery fire on the flight deck
- Make progress in the definition of a standard for FCBs addressing PEDs handling and battery fire containment: on-going EASA research project LOKI-PED
- Revision of UL5800
- Definition of a minimum performance standards for fire gloves

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EASA research

LOKI-PED

Research Project details

Contracting Authority: EASA

Project Leader: Fraunhofer Gesellschaft

€ 800,000

08/2022 › 07/2025

This project will be funded from the European Union's Horizon Europe research and innovation programme.

At Frauenhofer Gesellschaft

Project manager: Simon Holz, simon.holz@emi.fraunhofer.de

Technical lead: Victor Norrefeld, victor.norrefeldt@ibp.fraunhofer.de

Consortium members

Airbus

At EASA

Project manager: Simone Schwerdorf, simone.schwerdorf@easa.europa.eu

Technical lead: Lia Calleja Barcena, lia.calleja-barcena@easa.europa.eu

Technical expert: Enzo Canari, enzo.canari@easa.europa.eu

LOKI-PED Project

LOKI-PED: Lithium Batteries Fire/Smoke Risks in Cabin

Overview

Sponsor: European Union Aviation Safety Agency EASA

Partners

- Fraunhofer Institute for Highspeed Dynamics, Ernst-Mach-Institute, EMI
- Fraunhofer Institute for Building Physics
- Airbus Operations GmbH & Airbus SAS

including 20 experts, researcher and technicians.

Focus

- Cabin and cockpit
- Not cargo nor checked luggage

Tasks

- Characterization of the main hazards posed by PEDs
- Consequences of fire and smoke in cockpit and cabin
- Risk assessment regarding number and energy content of PEDs
- Assessment of emergency procedures
- Assessment of additional mitigation measures
- Identification of gaps in the regulatory provisions

Duration: 01/2023 – 06/2025

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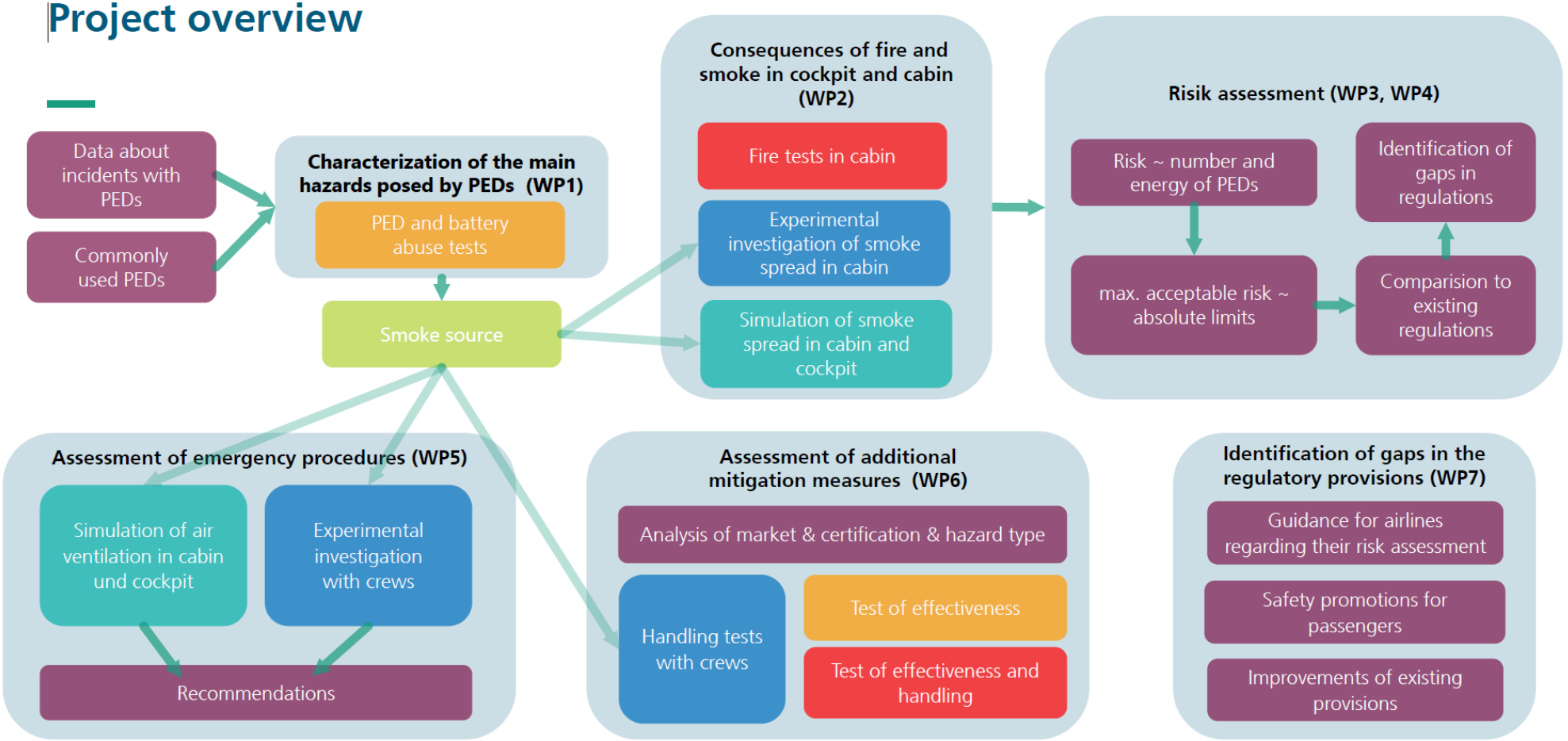
LOKI-PED

(https://loki-ped.de)

Project overview



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Experimental Approach – PED and battery abuse characterization

Battery Test Center – Fraunhofer EMI

Battery Test Center

08/2023 & 06/2024

WP 1

TR and source characterization

Realization: Laptops, Tablets, Smartphones, Power tool batteries are triggered by heating foils

WP 6

Containment capability of bags

Cooling capability of extinguishers

Realization: Laptop (100Wh, 9 cylindrical cells)

Selection of bags and extinguishers by working principle

Diagnostics:

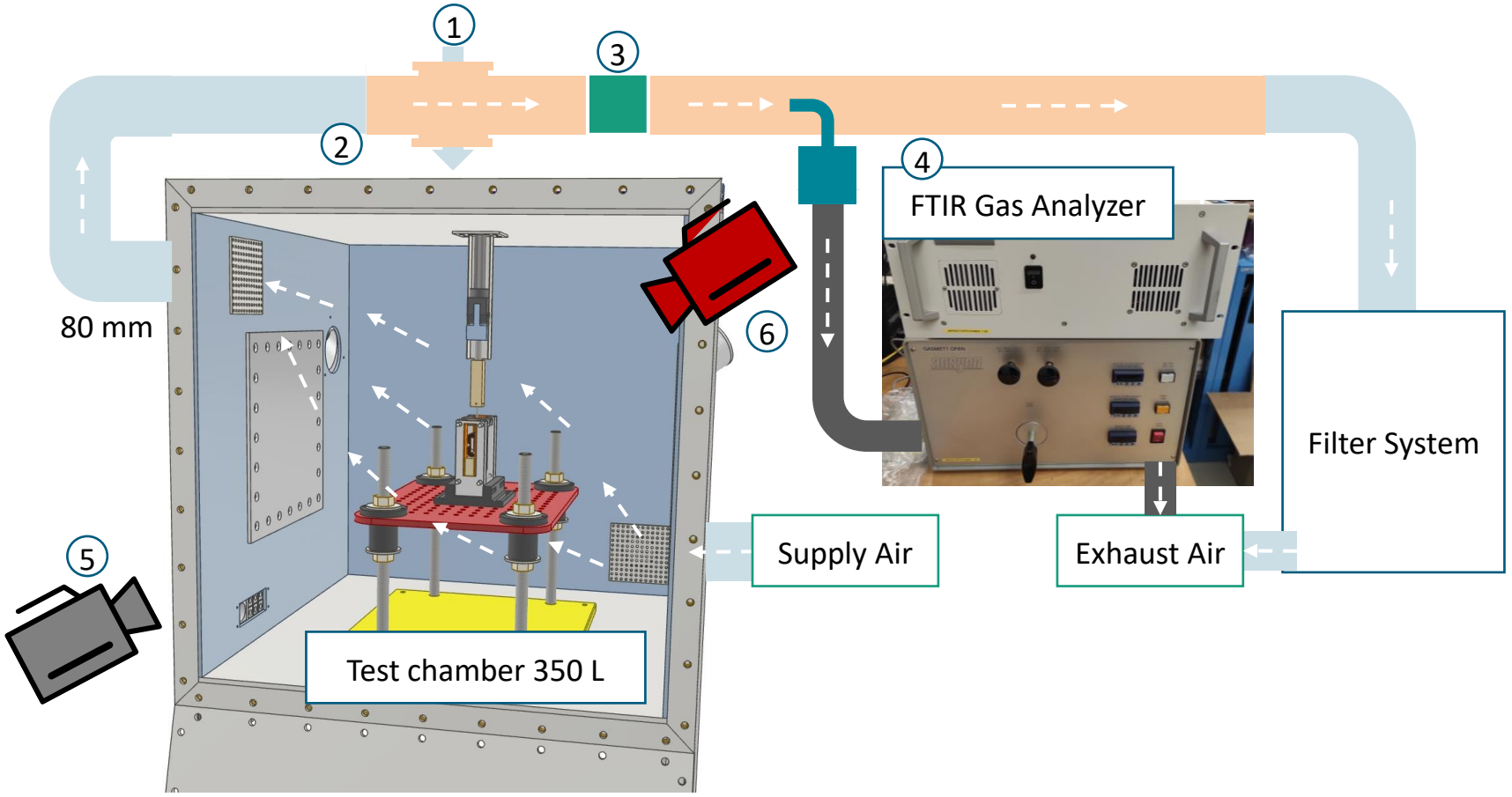
- gas volume (source)
- gas composition (toxicity)
- temperature on bag (handling)

Experimental Approach – PED and battery abuse characterization

Battery Test Center – Fraunhofer EMI

PED abuse

Battery Test Center



Diagnostics:

1. Light source / photo detector
   → *Smoke release rate*
2. Type K thermocouple
   → *Temperature / heat rate*
3. Flowmeter / Hot-Wire Anemometer
   → *Volume flow*
4. Gasmet FTIR Gas Analyzer
   → *Gas composition*
5. Optical video recording
6. InfraTec VarioCAM
   → *Thermographic images*

Exemplary test results

Battery Test Center – Fraunhofer EMI

PED abuse

Battery Test Center

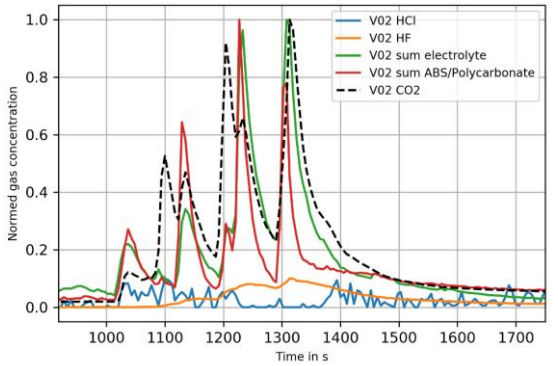
Smoke hazard

Lithium-Ion battery emissions under thermal runaway

Polymer fire resulting from casing of both PED and battery

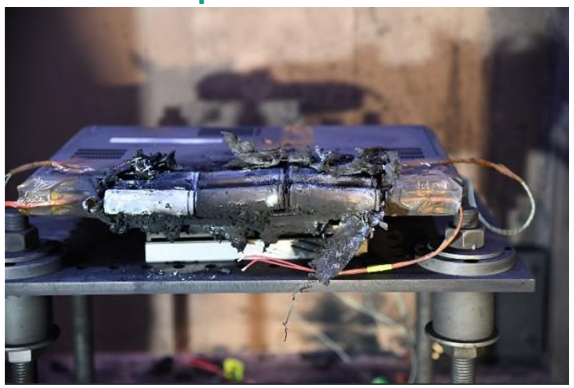
Flammable and toxic gases

Fresh air ventilation

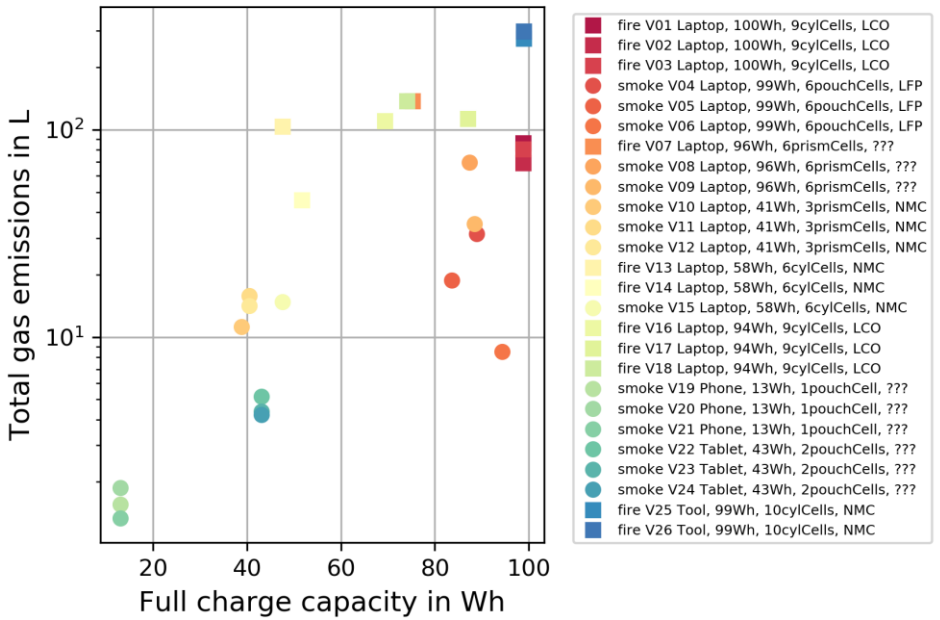


Fire hazard

Post test inspection



Battery emissions under thermal runaway



Experimental Approach – PED fire in single aisle cabin

A320 mockup

06/2024 & 09/2024

WP 2

TR and source characterization in cabin

Scenarios: on floor, on/in/under seat/pocket, overhead bin

Realization: PEDs triggered by heating. Realistic air flow pattern and geometry including aircraft seats.

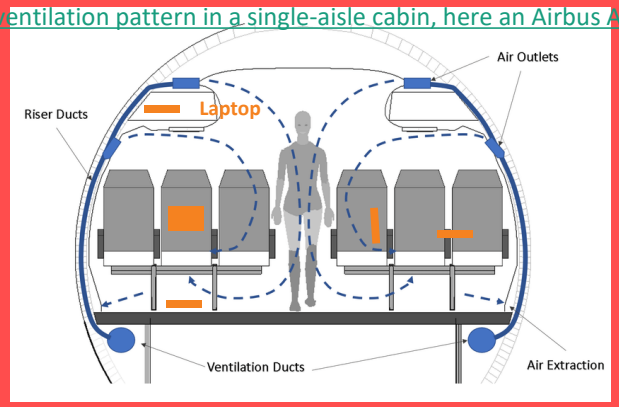
WP 6

Handling of fire and heat from PEDs

Worst case scenario: laptop (100Wh) in TR on seat, in seat-back pocket, in overhead bin

Realization: PEDs triggered by heating. Person in PSE will handle the PEDs with containment bags and extinguishers.

Air ventilation pattern in a single-aisle cabin, here an Airbus A320



A320 Mockup, Fraunhofer EMI & IBP

DSAC: Treatment of a thermal runaway in cabin with 1 flight attendant on youtube.com

Experimental Approach – Smoke spread and handling in wide-body cabin

Flight Test Facility

06/2024 & 03/2025

Flight Test Facility, Fraunhofer IBP

WP 2	**Smoke spread in cabin** as reference for simulations
WP 5	**Influence of air ventilation** on smoke spread **Where to place the PED** during/after TR w/o bag, gloves
WP 6	**Handling of smoke** emitted from PEDs by crew in real cabin with bags, extinguishers and personal protective equipment like gloves and smoke hoods

Fraunhofer EMI

Fraunhofer IBP

AIRBUS

www.loki-ped.de

INTERNATIONAL AIRCRAFT MATERIALS & SYSTEMS FORUM MEETING, 2024, Atlantic City

Simon Holz, Victor Norrefeldt

Lithium batteries in pOrtable electronic devices risK of fIre and smoke

WP 2.2 A320 mockup test

Test setup

Cabin fire

A320 mockup

9 Tests without human intervention at **4 positions** with realistic ventilation conditions and PED in thermal runaway

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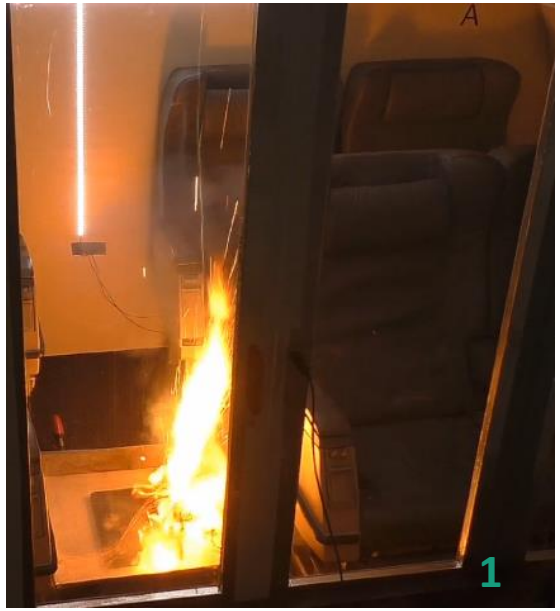
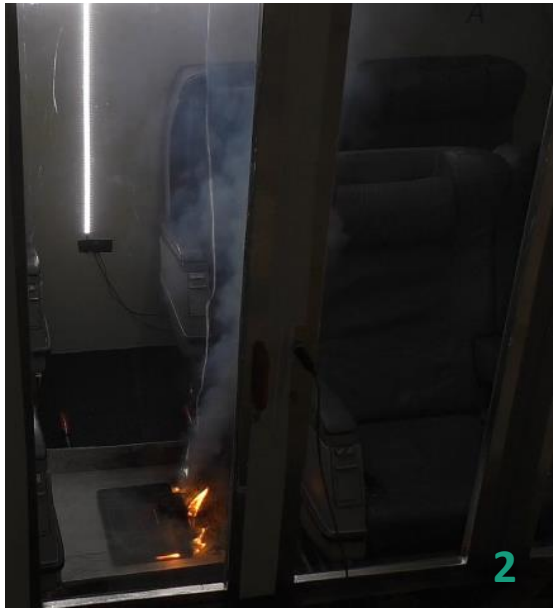
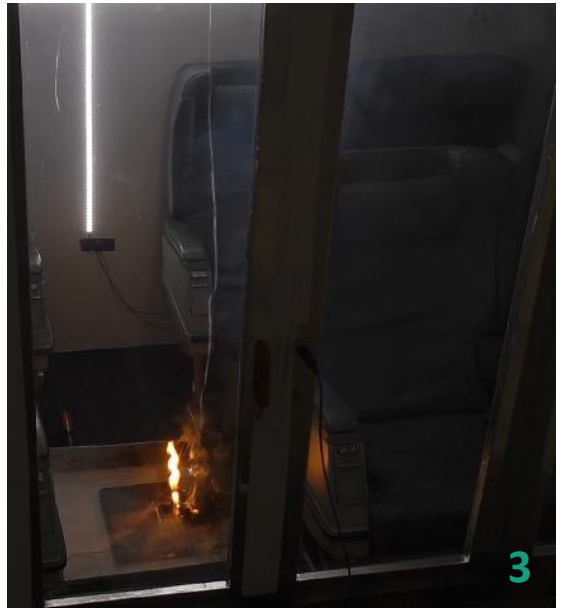
WP 2.2 A320 mockup test

V31







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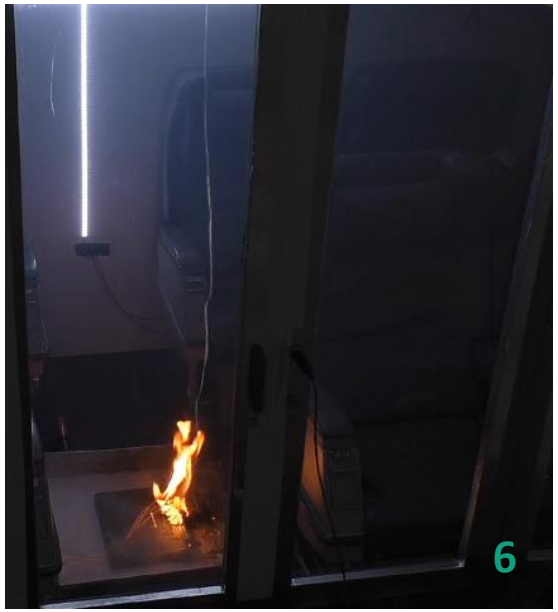
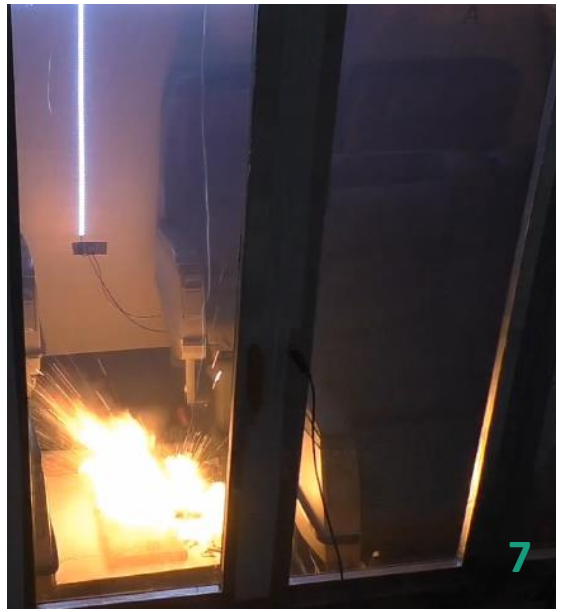
WP 2.2 A320 mockup test

V31





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WP 2.2 A320 mockup test

V31 – Video

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WP 2.2 A320 mockup test

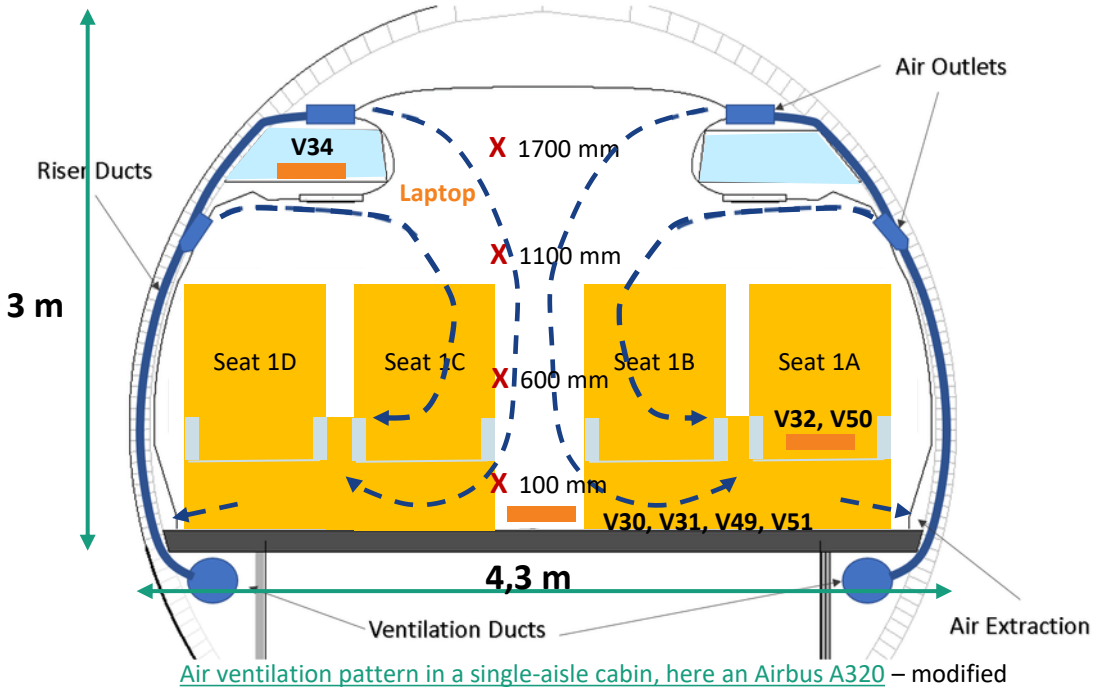
Smoke spread in single aisle cabin without human intervention

Cabin fire

A320 mockup

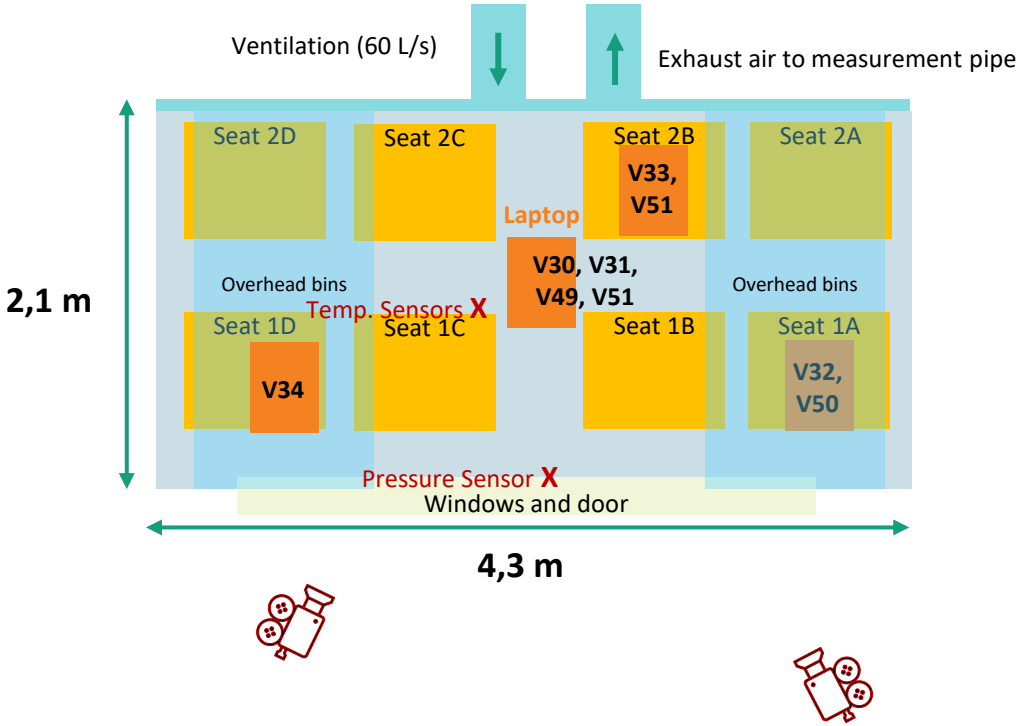
Front

Position PED | **Position Temp. Sensors**



Air ventilation pattern in a single-aisle cabin, here an Airbus A320 – modified

Top



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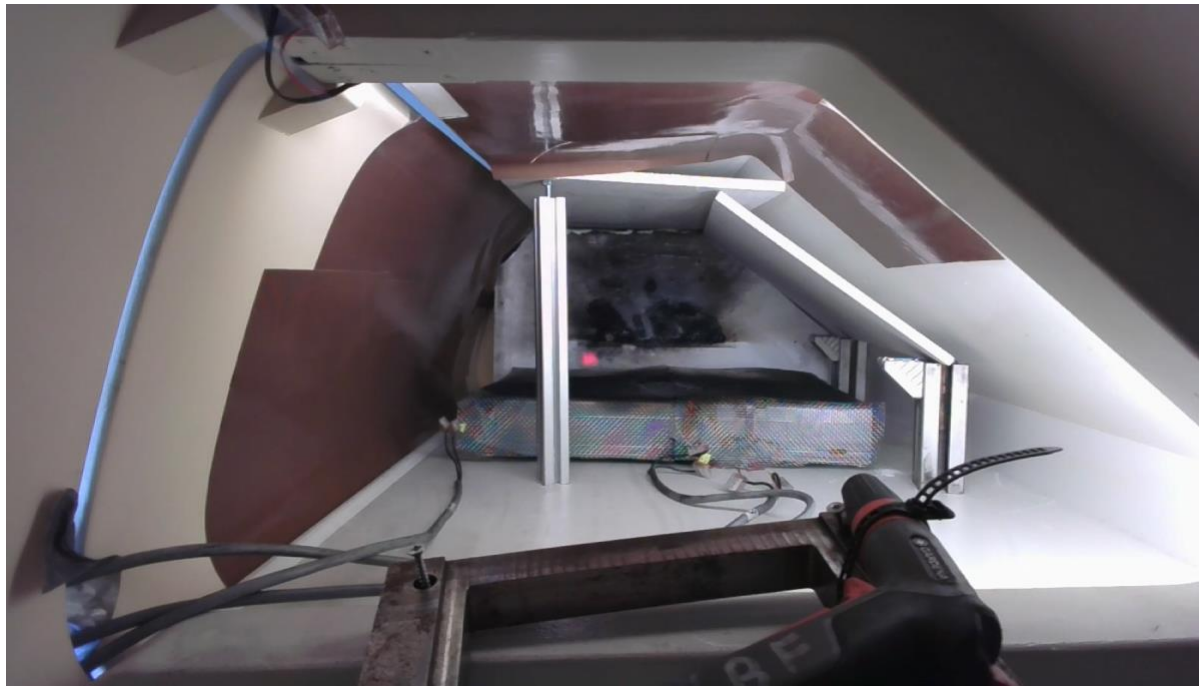
WP 2.2 A320 mockup test

V34



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Full-scale cabin test conduct

Test setup Cabin:

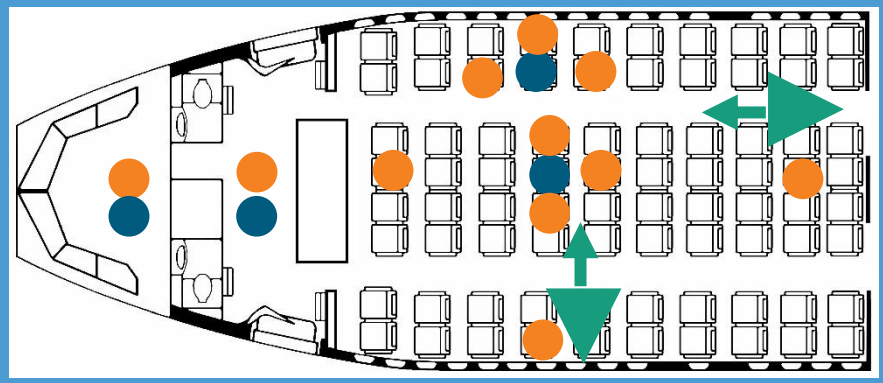
72 Dummies, 75W each
Use of theatre smoke and tracergas

- Visual spread of gas
- Measured spread of gas

Variations

- Ventilation scenarios
  - Normal flow per PAX: 0.55 lb./min. fresh
  - Flow, incl. Recirculation: +50% recirc
  - Normal flow with gaspers
- Emission locations
  - Below seat 4F & 4H
  - Overhead locker closed 4H, short intermediate small opening (simulate extinguisher discharge) and closing
  - Newspaper holder 4F & 4H
  - Galley
  - Cockpit

Flight Test Facility FTF, FhG IBP



Emission
CO2
Camera

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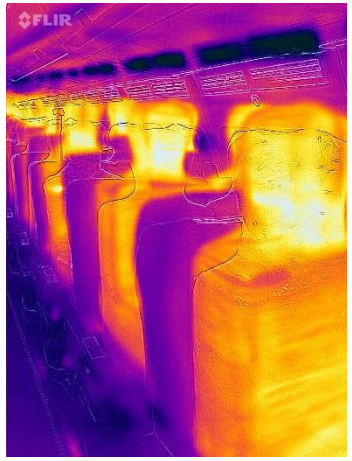
Full-scale cabin test conduct – ventilation flow pattern

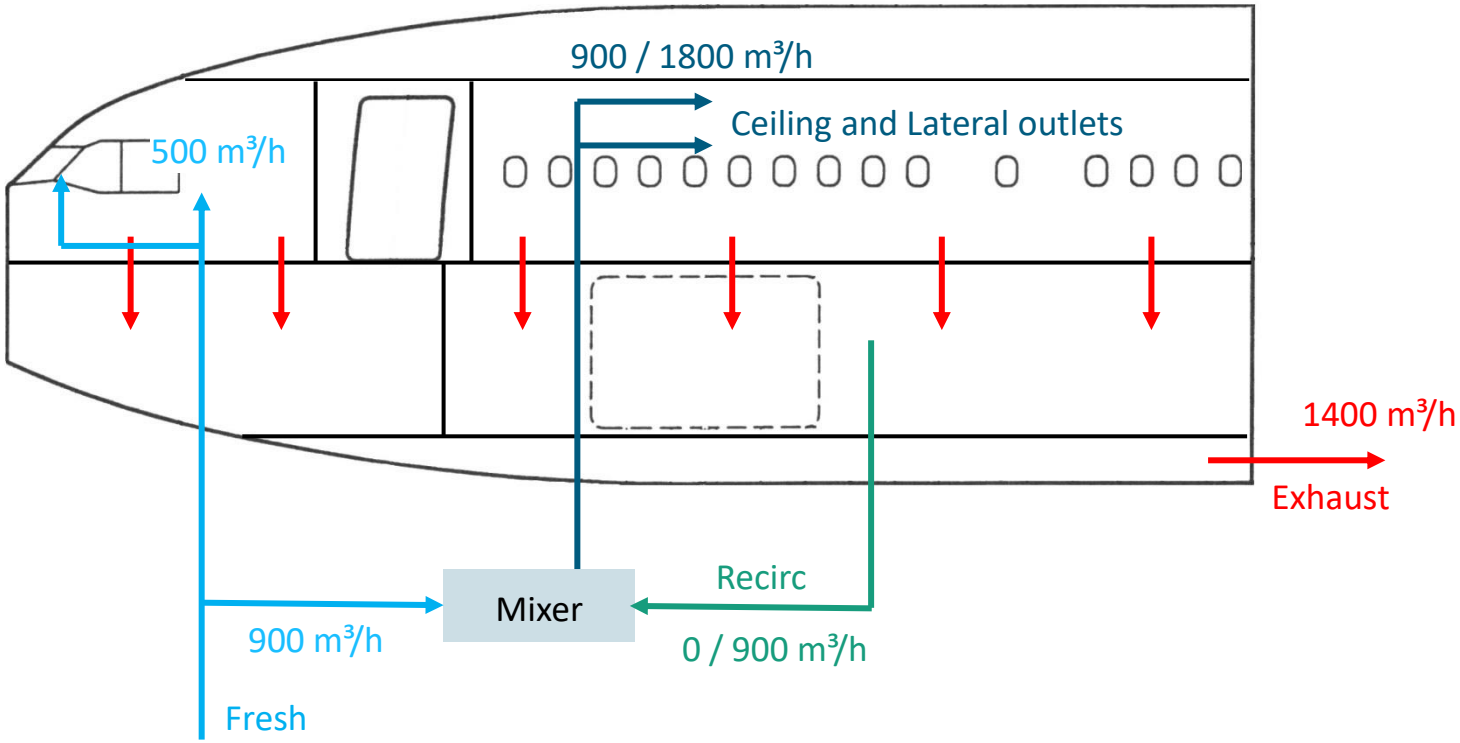
Ventilation flow rates:

- Cabin Fresh: ~900 m³/h → 3.5 l/s for 72 passengers
- Cabin Recirc: 0 or ~900 m³/h (50%)
- Cockpit Fresh: ~500 m³/h

Occupancy

- 72 heated dummies in cabin
- 2 heated dummies in cockpit





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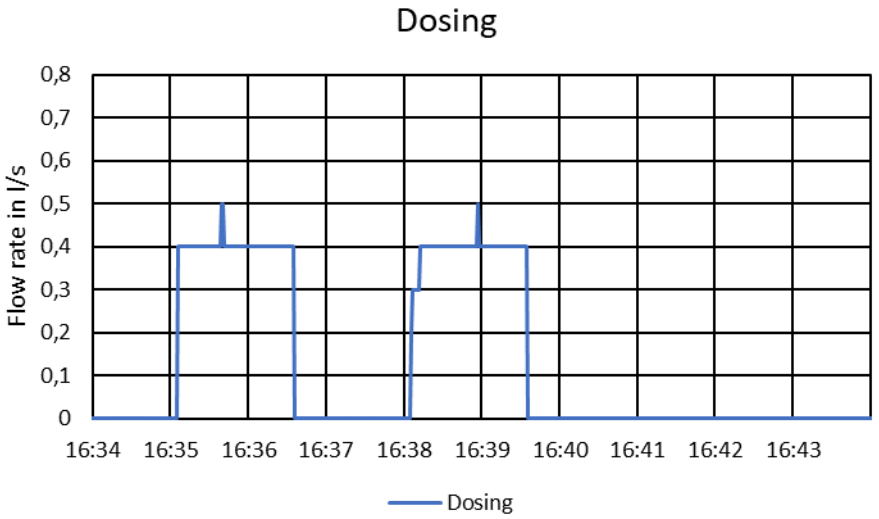
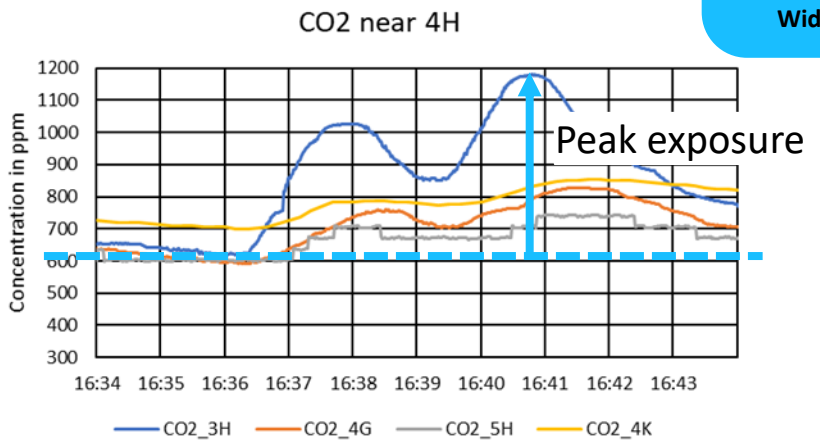
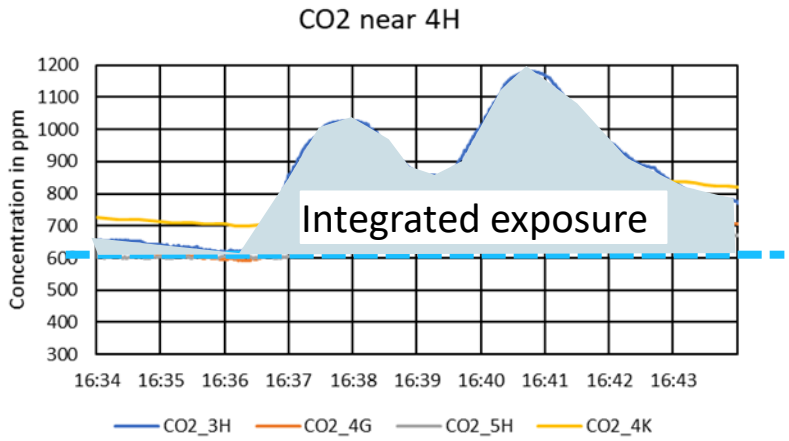
Test conduct and data evaluation







1. CO2-dosing through artificial laptop: 2x90s, Total 70l
2. Continuous measurement of local concentration profile
3. Determination of concentration peak and integrated exposure
4. Generation of 2D-plots with color scale, comparison plots

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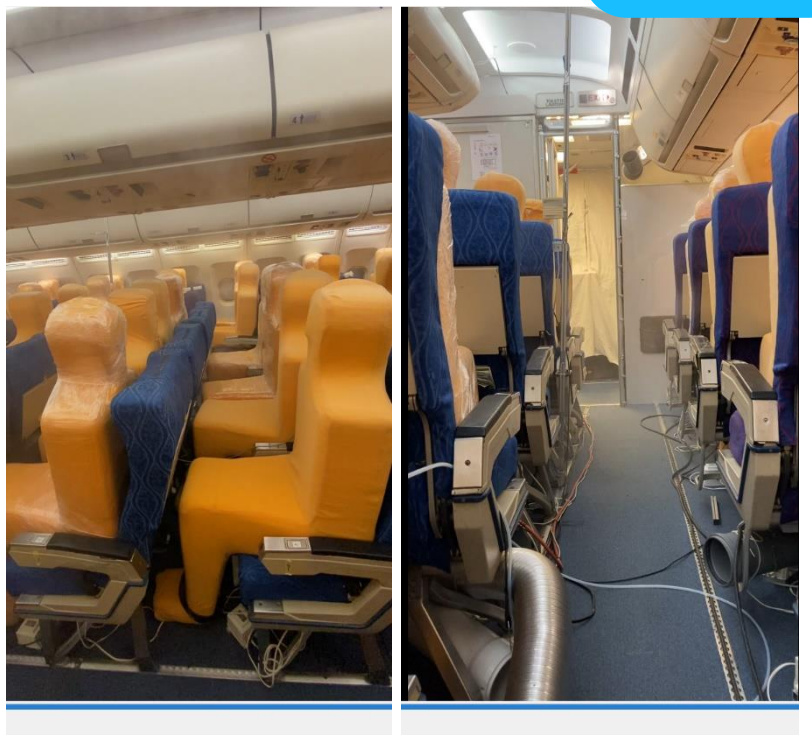
4G Emission

FTF

Wide-body

After 90s Smoke emission



120s

(30s after stop of smoke)

31.7.24 12:47, Emission 4F below seat

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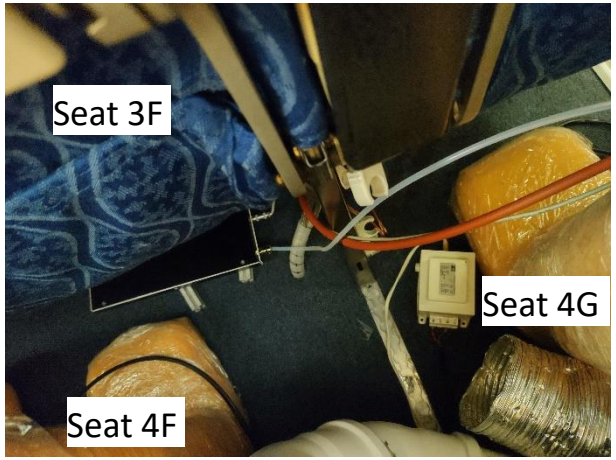
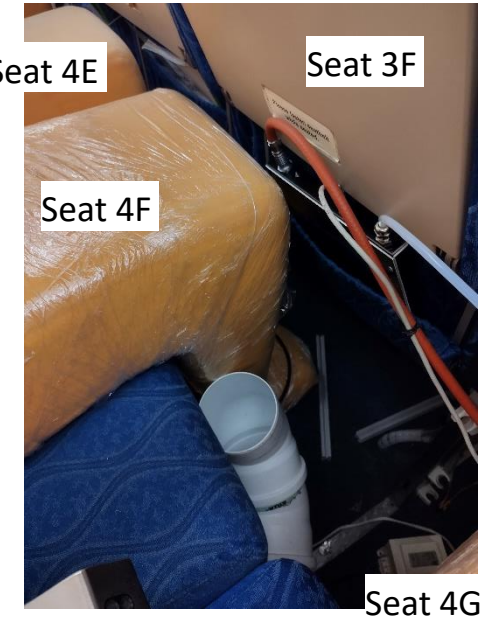
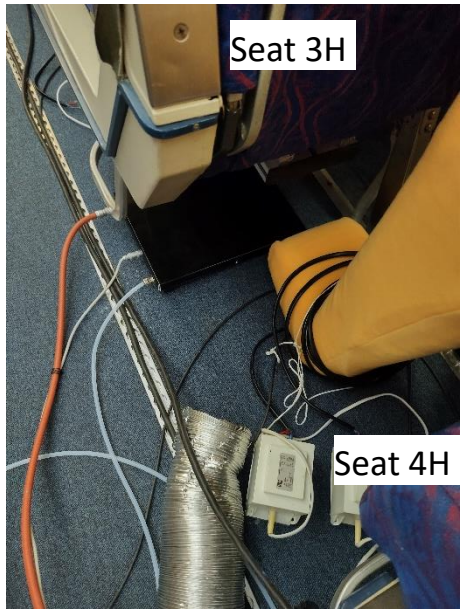
Emission locations in cabin



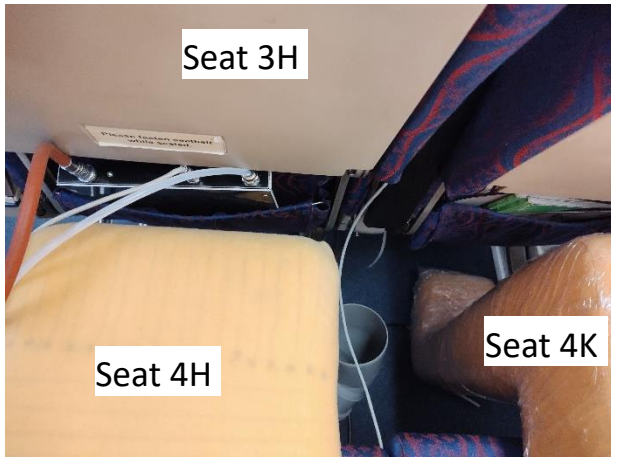
4F below seat



4F newspaper holder



4H below seat



4H newspaper holder

4H overhead locker

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Obs for cabin emission tests

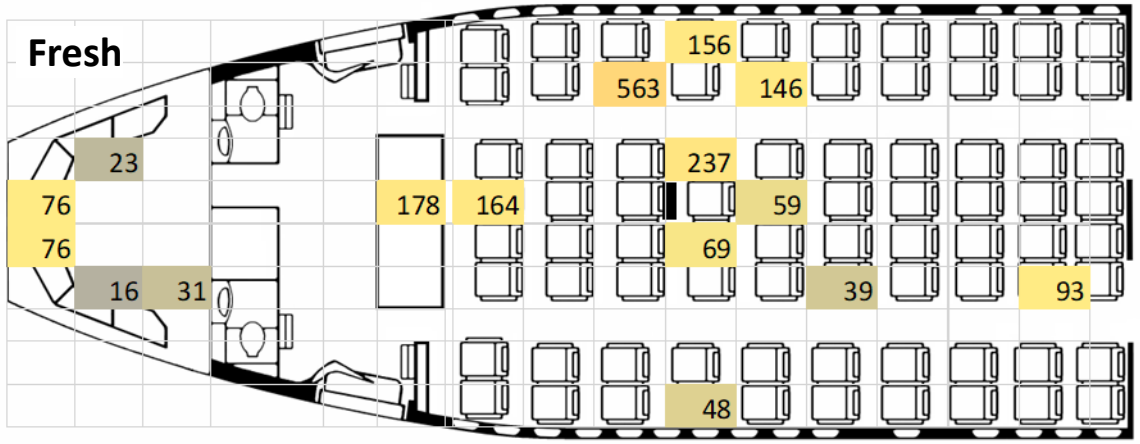
Elevated concentrations found 1-2 seats away from source

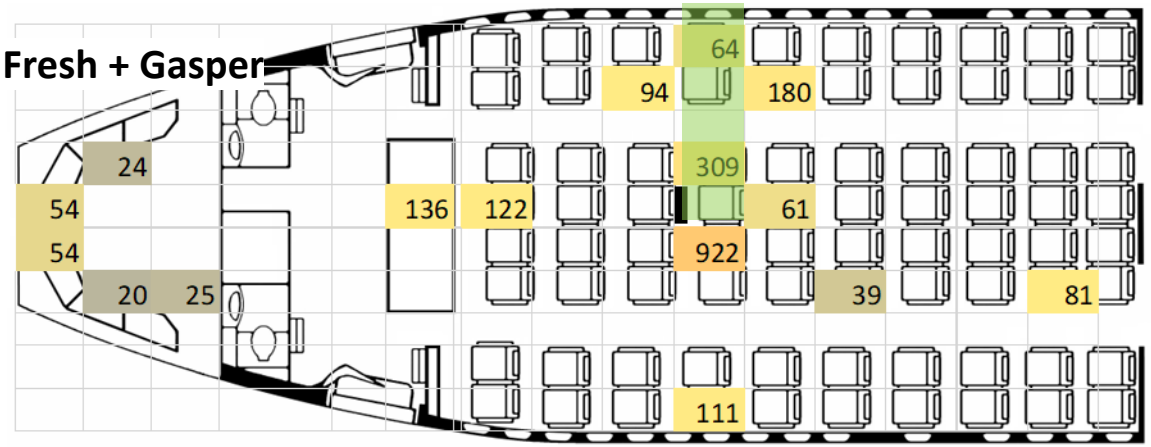
With / without recirc does not show major overall difference for cabin exposure

Without recirc double exposure in galley
→ unventilated in test

- Side flow paths may overflow to galley
- Recirc draws air downwards from cabin → effect weakened when disactivating recirc

Gaspers show to redirect the peak (4HK lowered, 4E increased)





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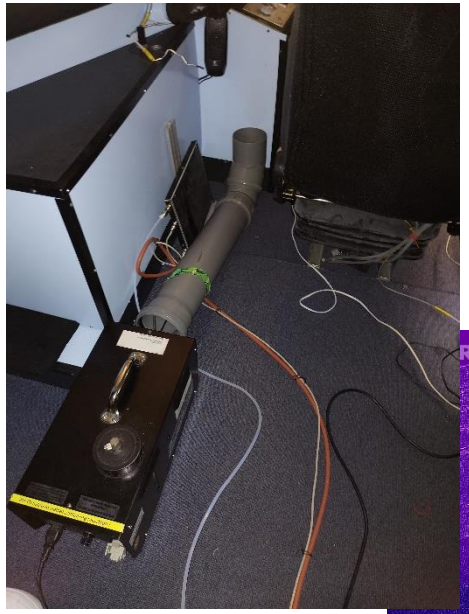
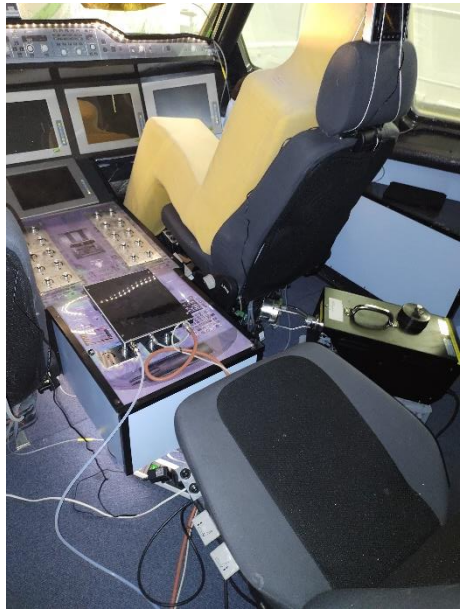
Cockpit and Galley Emissions



Cockpit left



Cockpit middle

Galley

FTF

Wide-body

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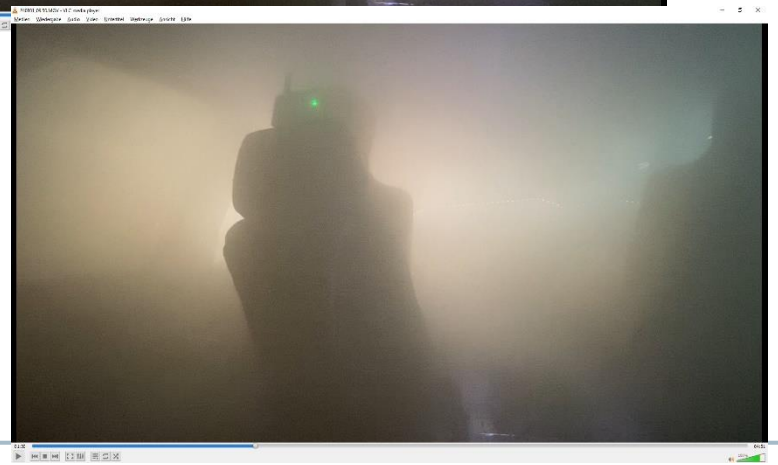
Cockpit

30s

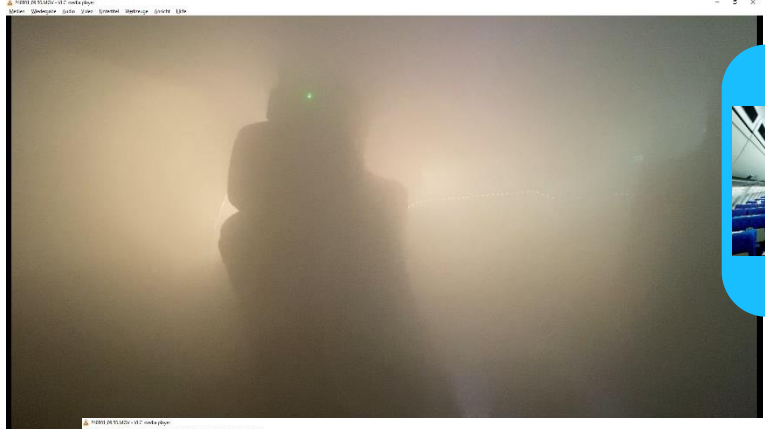
60s

Smoke emission active



90s

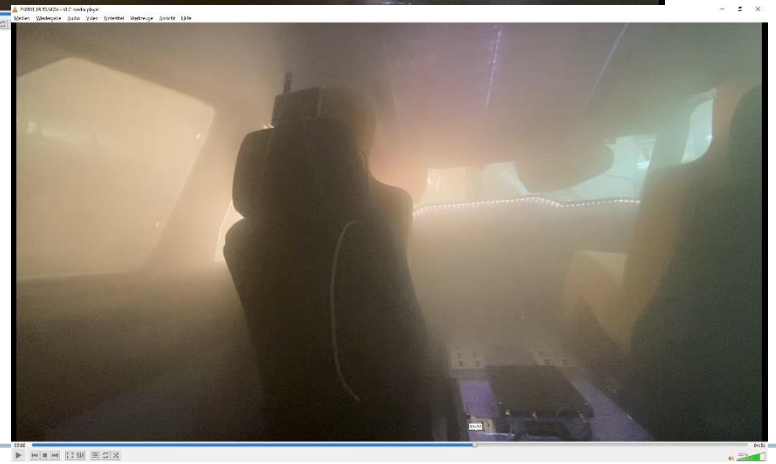
120s



Smoke emission off

150s

180s



FTF

Wide-body

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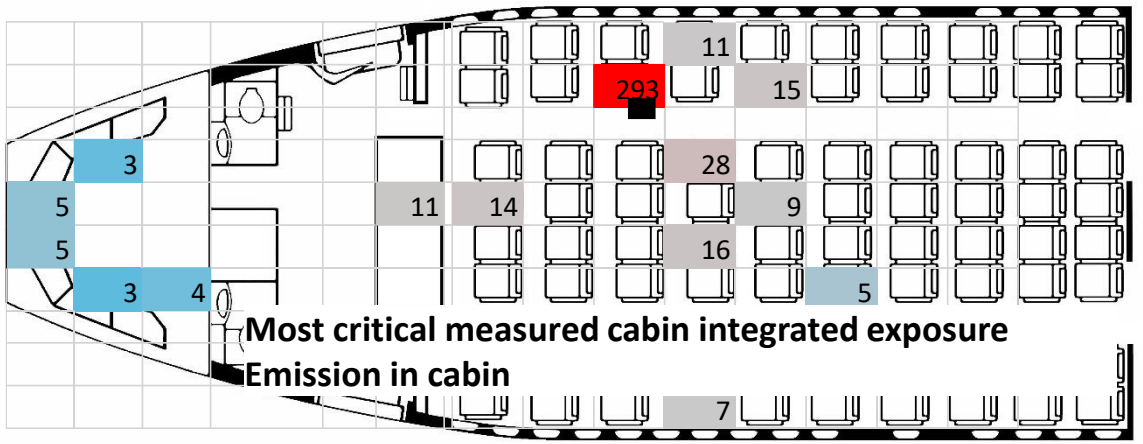
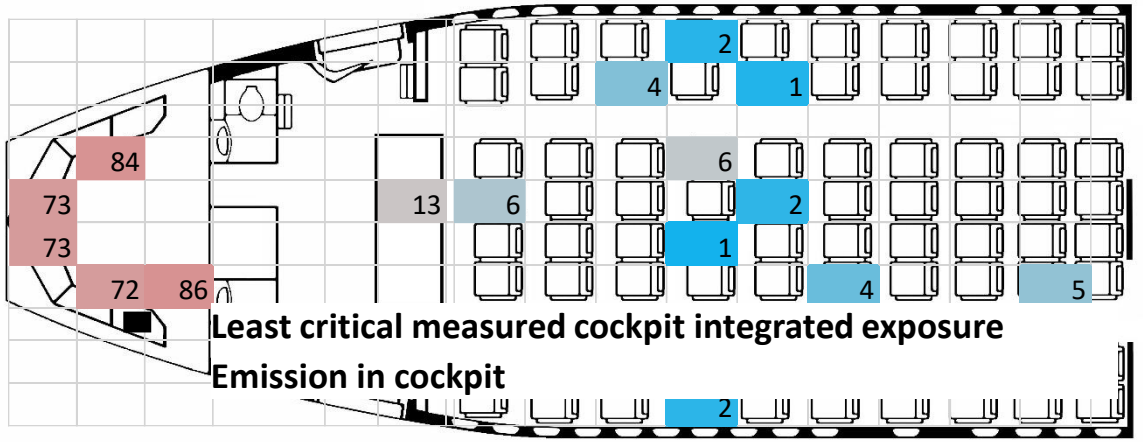
Conclusion Cockpit and Galley emission results

Compared to cabin, the emission test in cockpit and galley shows higher CO2-concentrations

With / without recirc shows to alter flow balance of galley flowing towards cabin / cockpit → to be considered for full-size aircraft to avoid overflow to cockpit

Emission in cockpit shows only low impact on cabin (with and without recirc)





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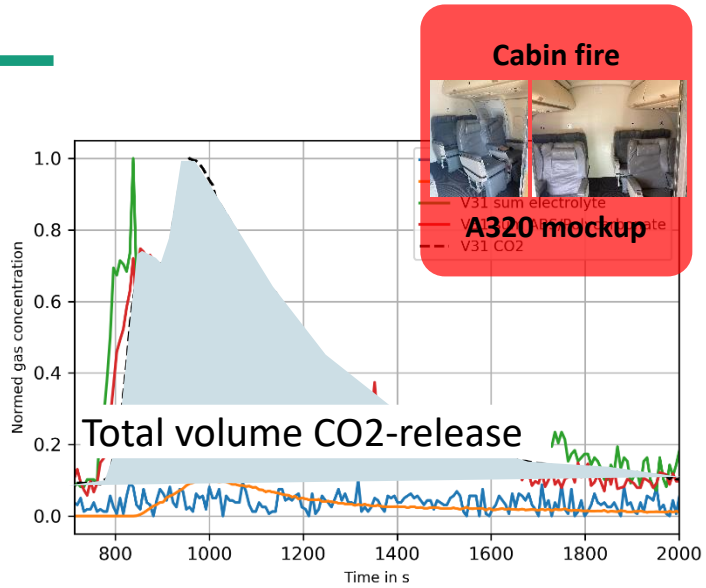
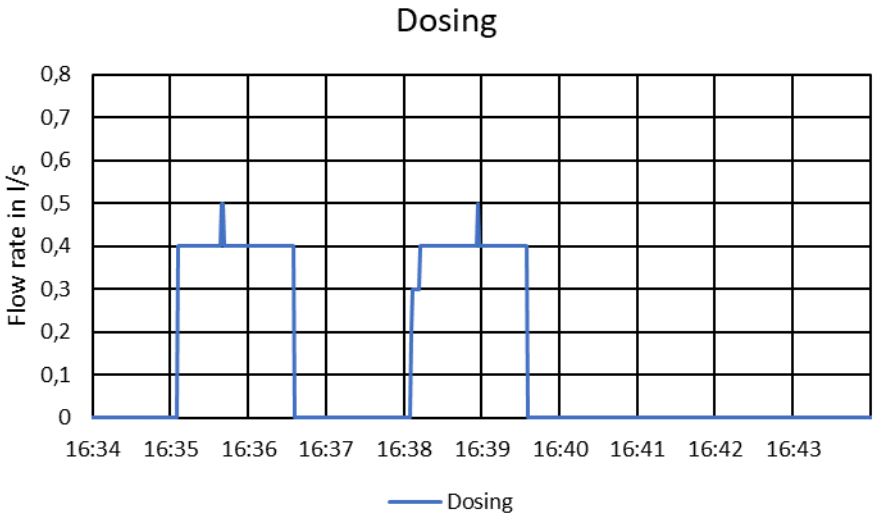
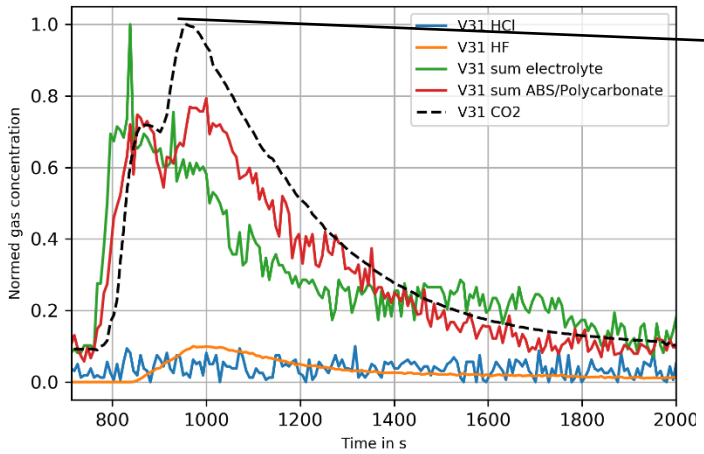
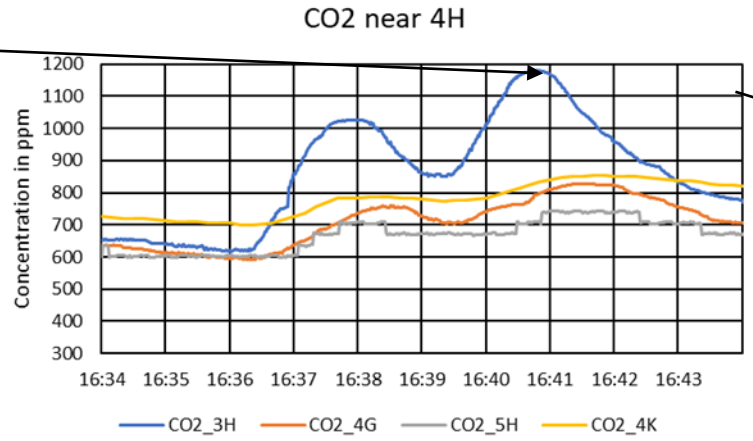
Test data usage way forward



Comparison and scaling







Estimation of corresponding HCl, HF, electrolyte and ABS/Polycarbonate concentration and integrated exposure

Comparison to exposure limits

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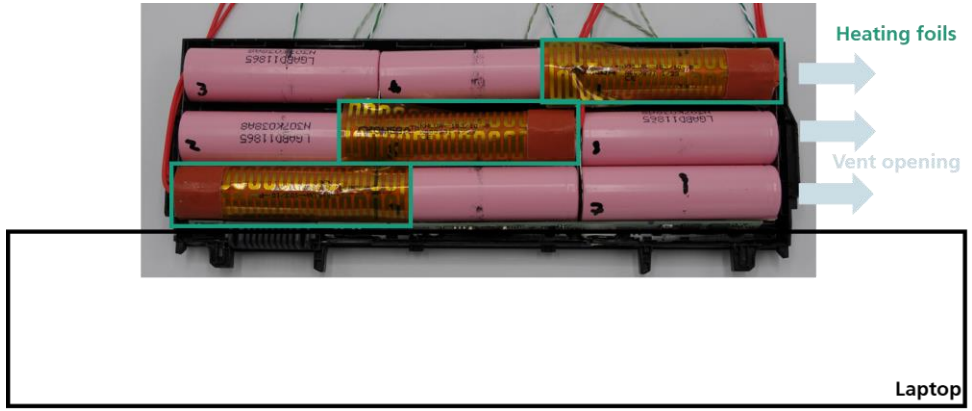
PEDs to be tested

Status

- 24 refurbished laptops
- New batteries: 11 on site, 13 delivered end of August
  - One order
  - Two shipments with different battery chemistry (new, new 2)



#	Test	Battery cells	Status
1	Characterization 1	9 cells 97 Wh	new
2	Characterization 2	9 cells 97 Wh	new
3	Bag 1	9 cells 97 Wh	new
4	Bag 2	9 cells 97 Wh	new
5	Bag 3	9 cells 97 Wh	new
6	Bag 4	9 cells 97 Wh	new
7	Bag 5	9 cells 97 Wh	new
8	Bag 6	9 cells 97 Wh	new
9	Bag 7	9 cells 97 Wh	new
10	Bag 8	9 cells 97 Wh	new
11	Characterization 3	9 cells 99 Wh	used
12	Extinguisher 1	9 cells 99 Wh	used
13	Extinguisher 2	9 cells 99 Wh	used
14	Extinguisher 3	9 cells 99 Wh	used
15	A320 w/o intervention 1	9 cells 99 Wh	used
16	A320 w/o intervention 2	9 cells 99 Wh	used
17	A320 w/o intervention 3	9 cells 99 Wh	used
18	A320 w/o intervention 4	9 cells 99 Wh	used
19	A320 w/o intervention 5	9 cells 99 Wh	used
20	Characterization 4	6 cells 66 Wh	used
21	A320 w/o intervention 6	9 cells 97 Wh	new 2
22	A320 w/o intervention 7	9 cells 97 Wh	new 2
23	A320 w/o intervention 8	9 cells 97 Wh	new 2
24	A320 w/o intervention 9	9 cells 97 Wh	new 2

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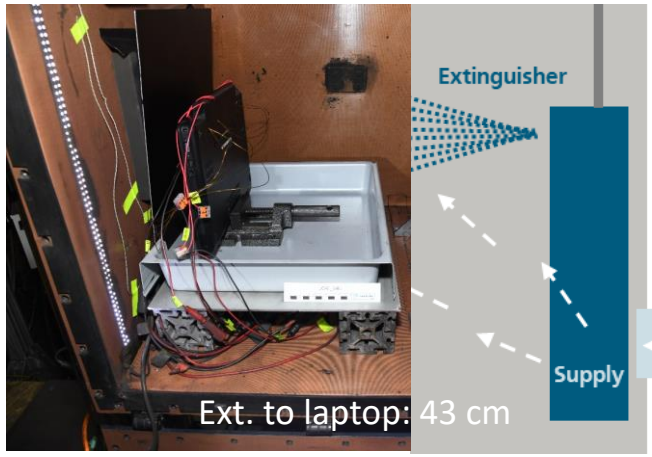
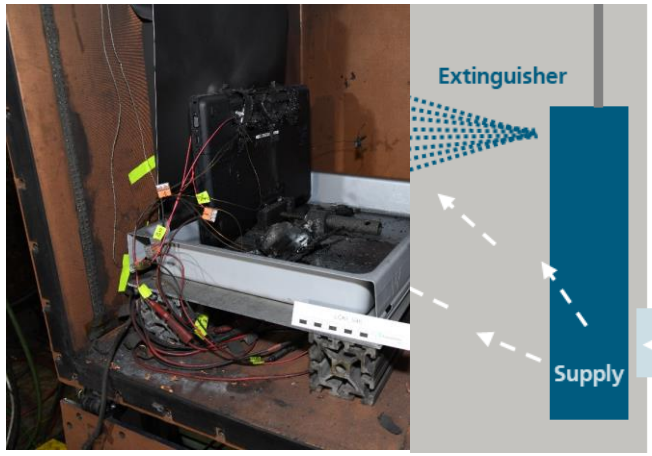
Cool down capability of extinguishers

Cooling

Battery Test Center





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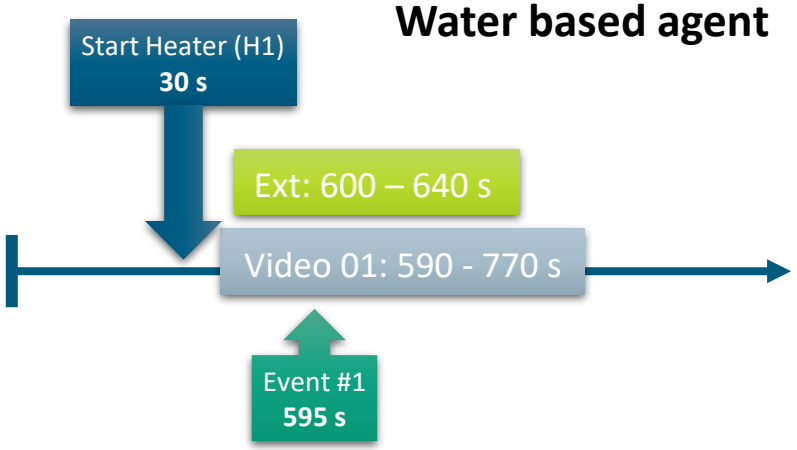
Cool down capability of extinguishers

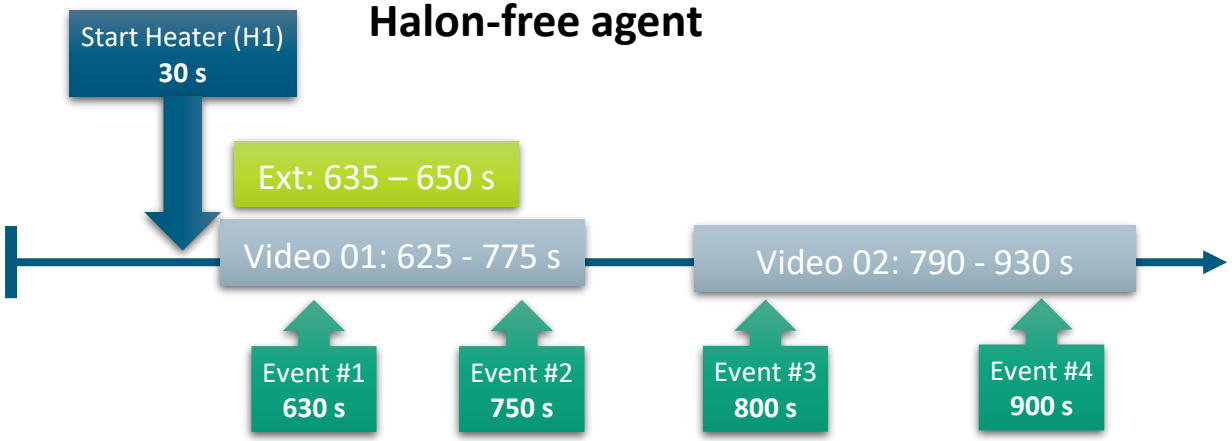
Cooling

Battery Test Center

Water based agent



Halon-free agent



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Cool down capability of extinguishers

Summary

Tested extinguishers

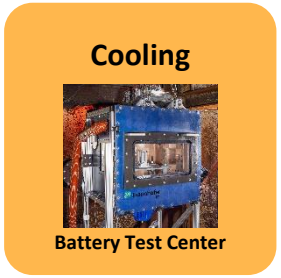
- Manufactures from Europe and US
- 3 of 3 especially for lithium battery fires
- 3 of 3 do not contain halon
- 3 of 3 commercially available
- 2 of 3 in service on aircraft

Test conditions

- Laptop with 9 cylindrical cells (100 Wh)
- One cell heated to enforce thermal runaway
- Ext. In operation when flames are observed until it is empty
- Ext are empty after 15s to 45s

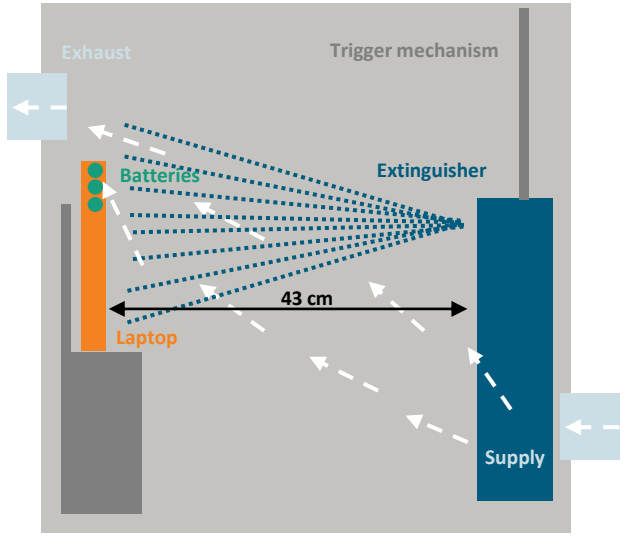
Findings

- 1 of 3 supressed thermal propagation
- 3 of 3 suppressed flames during operation



Temporal characteristics

- Duration of operation varies
- Multiple events possible
- 2 to 5min from first to next observed



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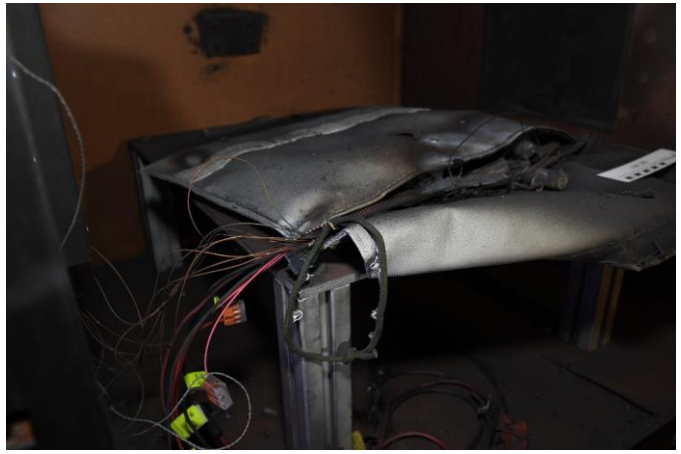
Containment bag example – post test

Containment

Battery Test Center



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Containment capability of bags

Summary

Tested bags

- Manufactures from Europe and US
- 2 of 8 bags in early design stage
- 6 of 8 commercially available
- 3 of 8 in service on aircraft

Test conditions

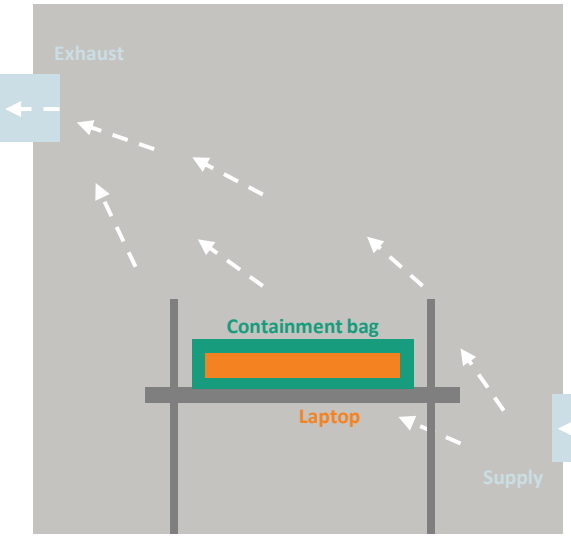
- Laptop with 9 cylindrical cells (100 Wh) packed in bag
- One cell heated to enforce thermal runaway
- Adopted from UL 5800 standard

Hazards observed

- Thermal propagation from cell to cell: 8 of 8
- Venting of smoke: 8 of 8
- Venting of hot particles: 8 of 8
- Venting of flames: 5 of 8
- Opening of bag closure: 2 of 8
- Destruction of bag: 2 of 8

Temporal characteristics

- Duration highly variable
- Multiple events possible
- 1h from first to last event observed



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Upcoming tests in Flight Test Facility

Fraunhofer IBP, Holzkirchen, Germany

FTF

Wide-body

Realistic ventilation and scenarios

Topics

- Influence of air ventilation on smoke spread
- Emergency procedures
- Handling of containment bags using artificial PEDs

DSAC: Treatment of a thermal runaway in cabin with 1 flight attendant on youtube.com

Artificial PED in action

Cockpit of Flight Test Facility

Cabin of Flight Test Facility

Cabin with heating dummies in FTF

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LOKI-PED

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Upcoming dissemination events

- 01. - 03.10.2024 IATA World Safety and Operations Conference 2024, Marrakech, Marocco
- 21. - 25.10.2024 ICAO Dangerous Goods Panel, Montreal, Canada
- 22. - 24.10.2024 SAE-S9 Cabin Safety Working Group, Oklahoma City, US
- 10.01.2025 AIAA SciTech Forum, Orlando, US
- 15.01.2025 Dangerous Goods Expert Group Meeting, Cologne, Germany

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AIRBUS

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European Union Aviation Safety Agency

Any Questions ?

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