



CCHRAG Status on Halon Replacement

Cargo Compartment Halon Replacement
Advisory Group
Dr. André Freiling, CCHRAG Chair

The Tenth Triennial International Fire & Cabin
Safety Research Conference
October 17-20, 2022



International Coordinating Council of
Aerospace Industries Associations

CCHRAG - organisational context



Representation

ICCAIA

International Coordinating Council of Aerospace Industry Associations

Members



Member

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AIRBUS

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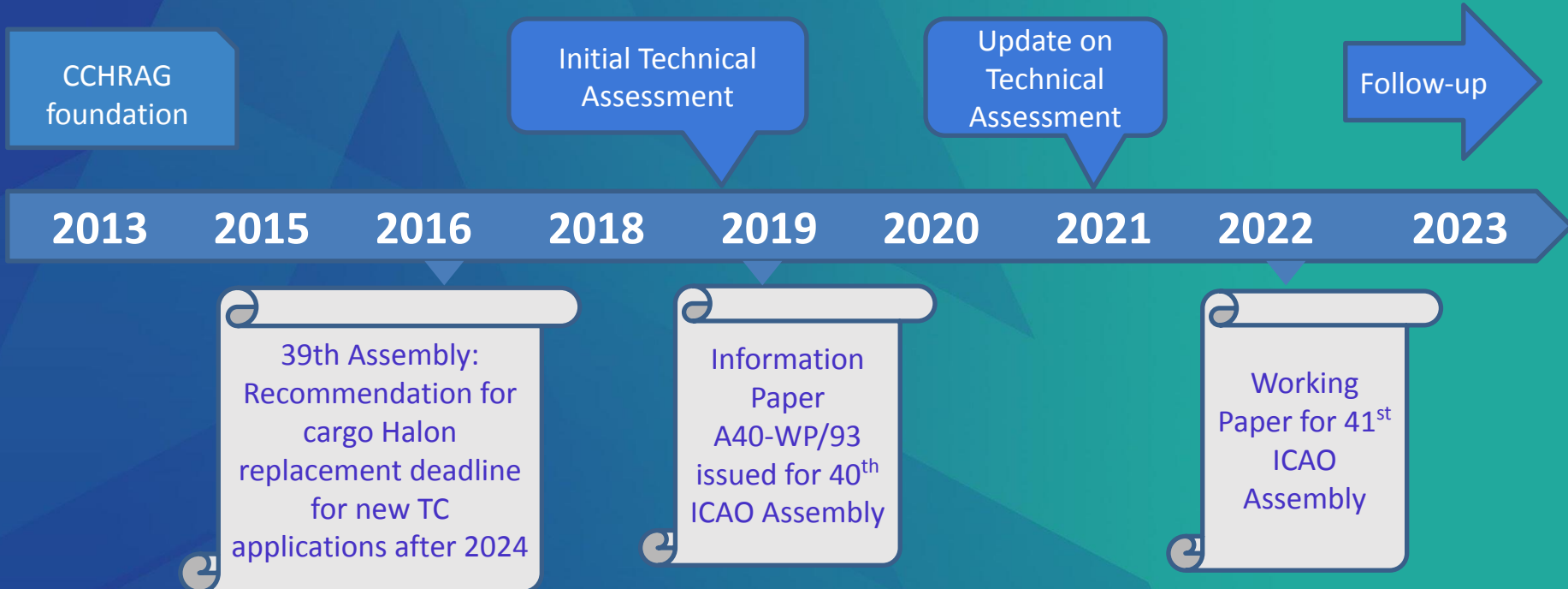
CCHRAG

Cargo Compartment
Halon Replacement
Advisory Group

ICCAIA

CCHRAG Charter, History and Achievements

Charter: to report status of cargo halon replacement solutions to ICAO



Technical Assessments Cargo Compartment Halon Replacements

- Questionnaire submitted to: Chemical manufacturers, fire protection suppliers, and aircraft system suppliers
- Responses received in June 2018
 - 8 Participants with 9 potential halon replacement solutions
- Responses received in March 2021
 - 7 Participants with 9 potential halon replacement solutions



Questionnaire Categories

- Fire Fighting Performance
- Physical Properties
- Production
- Health and Safety
- Schedule

2021 Technical Assessment Key Criteria

Category	Criteria
Fire Fighting Performance	Cup burner fire extinction/suppression concentration established (ISO, NFPA)
	FAA MPS testing successfully passed
Physical	Weight / Design concentration is less than or equal to Halon system
	The agent is gaseous / no clean-up required
Production	Currently used in other industries and/or applications
	Risks for aircraft system adaptation/integration are mitigated or low
Environmental, Health & Safety	Not Present on regulatory lists (e.g. Montreal protocol listed ODS, Kyoto Protocol listed GHG, GHS listed Hazardous material, ECHA/EPA regulatory lists, SNAP/REACH regulated, etc.)
	Cardiac sensitization: LOAEL, NOAEL is less than or equal to Halon 1301
Schedule	Current TRL is equal or greater than 4
	TRL6 Roadmap in place (expected TRL6 completion date with +/- 0.5 years accuracy would be appreciated)

Abbreviations in order of appearance

ISO: International Standards Organization
 NFPA: National Fire Protection Association
 FAA: Federal Aviation Administration
 MPS: Minimum Performance Standard
 ODS: Ozone Depleting Substance
 GHG: GreenHouse Gas
 GHS: Globally Harmonised System
 ECHA: European Chemical Agency
 EPA: Environmental Protection Agency
 SNAP: Significant New Alternatives Policy
 REACH: Registration, Evaluation, Authorisation and Restriction of Chemicals
 LOAEL: Lowest Observed Adverse Effect Level
 NOAEL: No Observed Adverse Effect Level
 TRL: Technology Readiness Level
 TRL4: Laboratory Testing of prototype
 TRL6: Prototype System verified

Fire Fighting Performance

“FAA MPS testing successfully passed”



Bulk Load Fire



Exploding Aerosol Can



Pool Fire

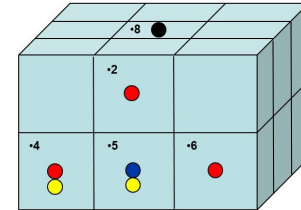


Containerized

Multiple Fuel Fire: TBC!

Pallet Configuration

- 50 - 18650 Li-ion Cells @ 50% SOC
- 500 ml denatured ethanol
- 1 gallon ethanol
- Ignition source
- 17 – Boxes filled with 2.5 lbs of shredded paper



- The FAA MPS test standard is currently under revision
- A Multiple Fuel fire is introduced

Fire Fighting Performance

- **Key Criteria**

- **Cup burner fire extinction/suppression concentration established**

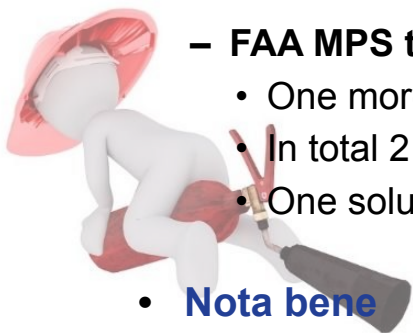
- For the majority of agents (7 out of 9 solutions) the concentration has been established.

- **FAA MPS testing successfully passed**

- One more agent compared to 2019 assessment has successfully passed FAA MPS testing
 - In total 2 out of 9 technical solutions have passed MPS testing, including multiple fuel fire
 - One solution is foreseen to be MPS tested in Q3 2022

- **Nota bene**

- Successful MPS testing is the entry point for further aircraft integration studies
 - Ensuring performance under the applicable environmental conditions may pose significant challenges to the system design, integration and certification.

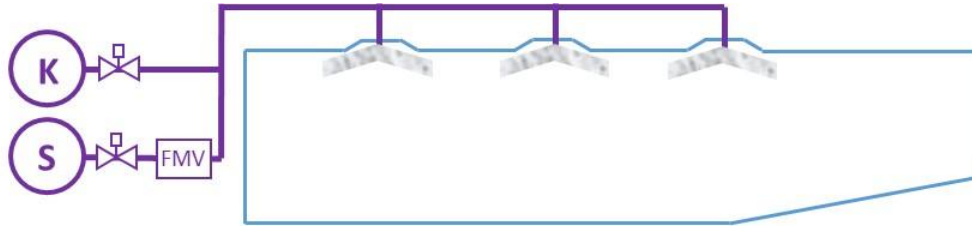


**CCHRAG concludes that two solutions successfully passed MPS testing.
Integration and Certification risks to be mitigated**

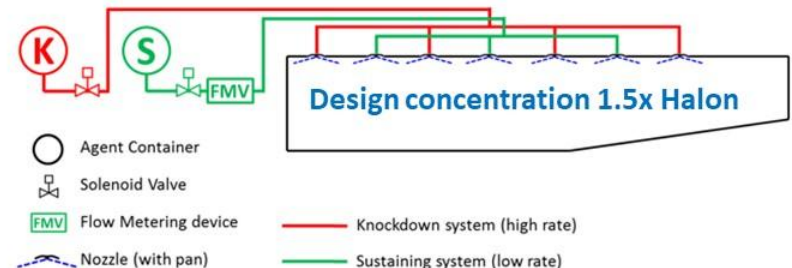
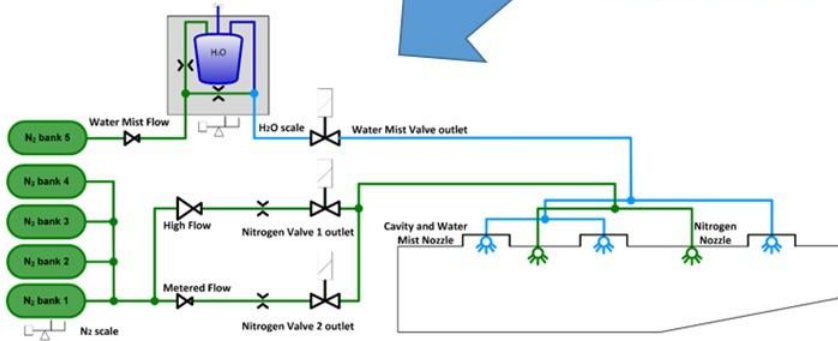
Physical Properties

“Agent & System Weight / Design concentration is less than or equal to Halon system”

Current System



Weight and complexity increases



Physical Properties

- **Key Criteria**

- **Agent & System Weight is less than or equal to Halon system**

- Weight increase cannot be avoided for any halon replacement solution assessed

- **Clean agent (gaseous) - no clean up required – corrosion free – minimization of maintenance**

- The majority of the proposed agents are gaseous (7 out of 9 technical solutions) including the solutions that passed MPS
 - It cannot be assumed that a gaseous agent is by definition unarmful to materials used in the cargo compartment

**CCHRAG concludes that weight increase is imminent.
Material compatibility risks to be mitigated**

Key Criteria



- **Currently used in other applications / industries**
 - Verdagent is developed especially for aircraft application
 - Nitrogen inerting is currently used in other industry
 - Solutions are at different stages of risks for serial production readiness
- **Risks for adaptation/integration are mitigated/low**
 - Risks for system adaptation/integration are under industry assessment

**CCHRAG concludes that solutions are at different stages of production.
Integration risks to be mitigated**

Regulatory issues: Introduction to PFAS

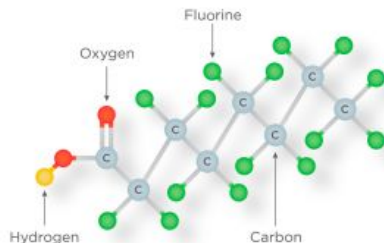
Poly- and perFluoroAlkyl Substances → PFAS
family of substances



<https://www.mn-net.com/de/pfas>
22 Aug 2022

Main effects:

- **Persistent substances** leading to irreversible environmental exposure and accumulation → **"forever chemicals"**
- **Mobile**, leading to long range pollution
- **Toxic and/or bioaccumulative** (human health and environment) → dispersed through air and water, with a wide variety of adverse effects: diminished immune response, obesity, developmental neurotoxicity, fertility decrease, increased cholesterol or increased chance of diabetes, etc.



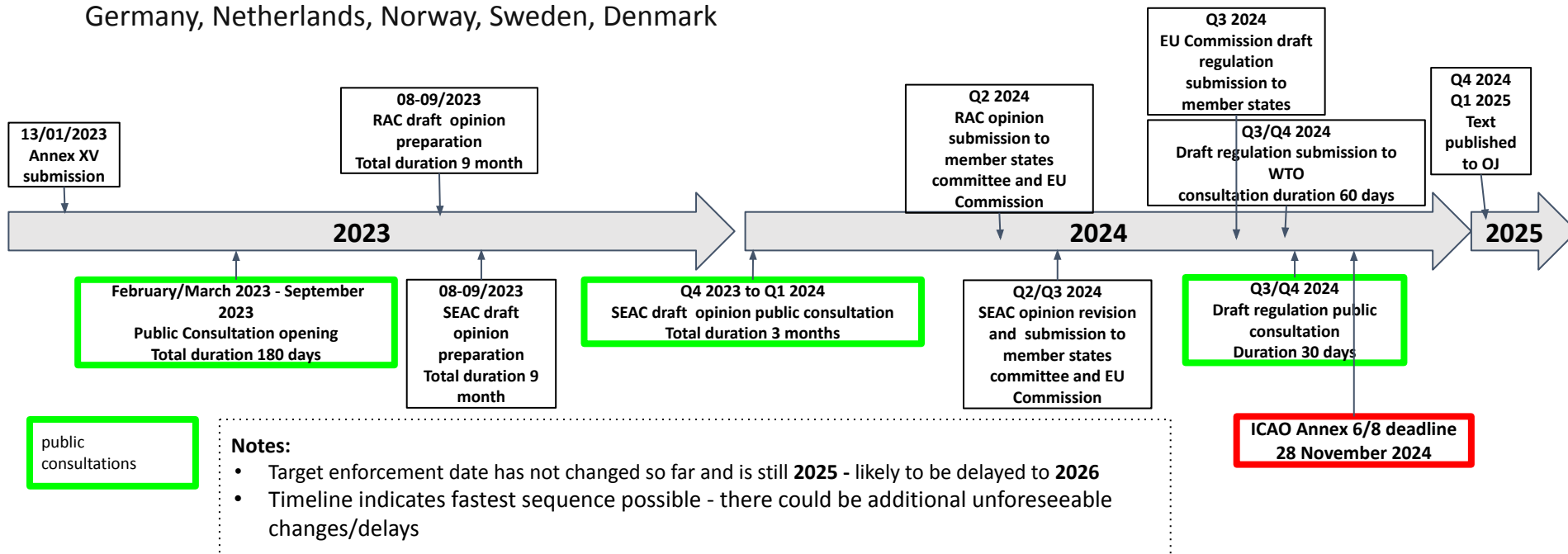
<https://news.northwestern.edu/stories/2022/08/forever-chemicals-destroyed-by-simple-new-method/>
22 Aug 2022

PFAS regulations are anticipated to be put in place
on a global scale

PFAS regulation EU timeline

REACH restriction Registry of Intentions - 5 EU Competent Authorities:

Germany, Netherlands, Norway, Sweden, Denmark



PFAS regulations might not be in place at time of ICAO deadline

Environmental, Health and Safety



Key Criteria

- Not present on regulatory lists
- Less toxic than Halon 1301
- **For the 2 solutions that passed MPS testing**
 - Verdagent is at risk of being subject to upcoming international PFAS (per- and polyfluoroalkyl substances) regulations
 - Toxicity might be greater than Halon 1301 - Assessment ongoing
- **For the remaining 7 solutions**
 - 5 solutions are stated with less or equal health impact compared to Halon 1301
 - 1 solution requires confirmation of impact
 - 1 solution stated that impact is greater than Halon 1301

CCHRAG concludes most of the solutions bear regulatory and health & safety risks to be mitigated

- **Key Criteria**

- Current TRL is equal or greater than 4
- TRL 6 Roadmap in place - to be achieved by 2023

- **Successful MPS testing is a key milestone for TRL6**

- One solution (Verdagent) was flight-tested on Boeing 2019 EcoDemonstrator
- One solution (Water Mist+N2) is put on hold by participant due to pandemics
- CCHRAG concludes that TRL4 has been achieved for both solutions.

For the remaining 7 solutions

- 4 solutions are stated TRL 4, some participants without TRL assessment experience
- 3 solutions are stated TRL 6 roadmap in place, **one of them being assessed as realistic**

CCHRAG concludes that at least one solution (Verdagent) has a robust TRL6 roadmap in place (slight delay due to pandemics)



Overall Assessment Summary

Criterion	2019 Conclusion	2021 Conclusion	2022 status	Remarks
Cup burner fire extinction/suppression concentration established (ISO, NFPA)	Achievable	Achievable	Achievable	
FAA MPS testing concentration determined	Achievable on condition	Achievable	Achievable	2 agents have passed MPS testing, 2 show potential. Continued technology development is needed to guarantee successful certification
Agent & System Weight is less than or equal to Halon system	Not Achievable	Not Achievable	Not Achievable	A weight increase cannot be avoided for any of the halon replacement solutions presented. A consequence is an increased CO2 emission caused by higher fuel burn.
Clean agent (gaseous) - no clean up	Achievable	Achievable	Achievable	All candidate agents that have passed MPS are gaseous
Currently used in other industries and/or applications	Achievable	Achievable	Achievable	One solution is dedicated to the aircraft industry.
Risks for aircraft system adaptation/integration are mitigated or low	Achievable on condition	Achievable on condition	Achievable on condition	Three participants additionally mitigated the risks from 2019.
Not Present on regulatory lists	Full compliance will take time and resources.	Achievable on condition	Risk to be mitigated	High risk that candidate replacements will be regulated as PFAS.
Toxicity is less than or equal to Halon 1301		Achievable on condition	Risk to be anticipated	Need to monitor: toxicity may be greater than Halon 1301
Current TRL is equal or greater than 4	Achievable	Achievable	Achieved	
TRL6 Roadmap in place	-	Achievable on condition	Achieved	Pandemics has slowed down efforts of some participants. Roadmap in place for at least 2 candidate agents with TRL6 before 2024

Take away

In order to meet the deadline with suitable replacements for Halon, we will need international awareness:

- Acknowledge the significant impact of international PFAS (Per- and PolyFluoroAlkyl Substances) regulations on the schedule of Aircraft Halon replacement efforts
- Classify the application of aircraft fire protection as (permanent) essential use to ensure the safe continuation of air transportation using the best available solutions

...in a nutshell



**ICAO 41st Assembly working paper
presented in Sep 2022 .**



Summary

CCHRAG remains optimistic that a solution will be available to meet the ICAO deadline assuming timely mitigation of the identified risks

Thank you!



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