Reference:

L. Fournier, *Summary of PFAS use mapping across ESA projects and obsolescence,* 6th ESA REACH Workshop, ESA ESTEC, Noordwijk, the Netherlands, 17th June 2025

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Leo Fournier, Sustainable Engineering Section, European Space Agency

# Summary of PFAS use mapping across ESA projects and obsolescence

Léo Fournier

TEC-SFS

Sustainable Engineering Section

ESA 6th REACH WORKSHOP
17-06-2025
ESA-TECSFS-HO-2025-001864

# Outlines


Introduction

1. Scope and objectives of the PFAS mapping
2. Information research methodology
3. Mapping of PFAS used for space missions
    1. Space relevant projects
    2. Standardization – Application to space
        1. PFAS impact on space sector – ESCC
        2. PFAS impact on space sector - Fluorocarbons
    3. Impact of PFAS restriction on space textiles
        1. Textile and space sector
        2. Space fabrics
        3. Beta® Cloth
        4. Intravehicular activities

Conclusions

# Introduction

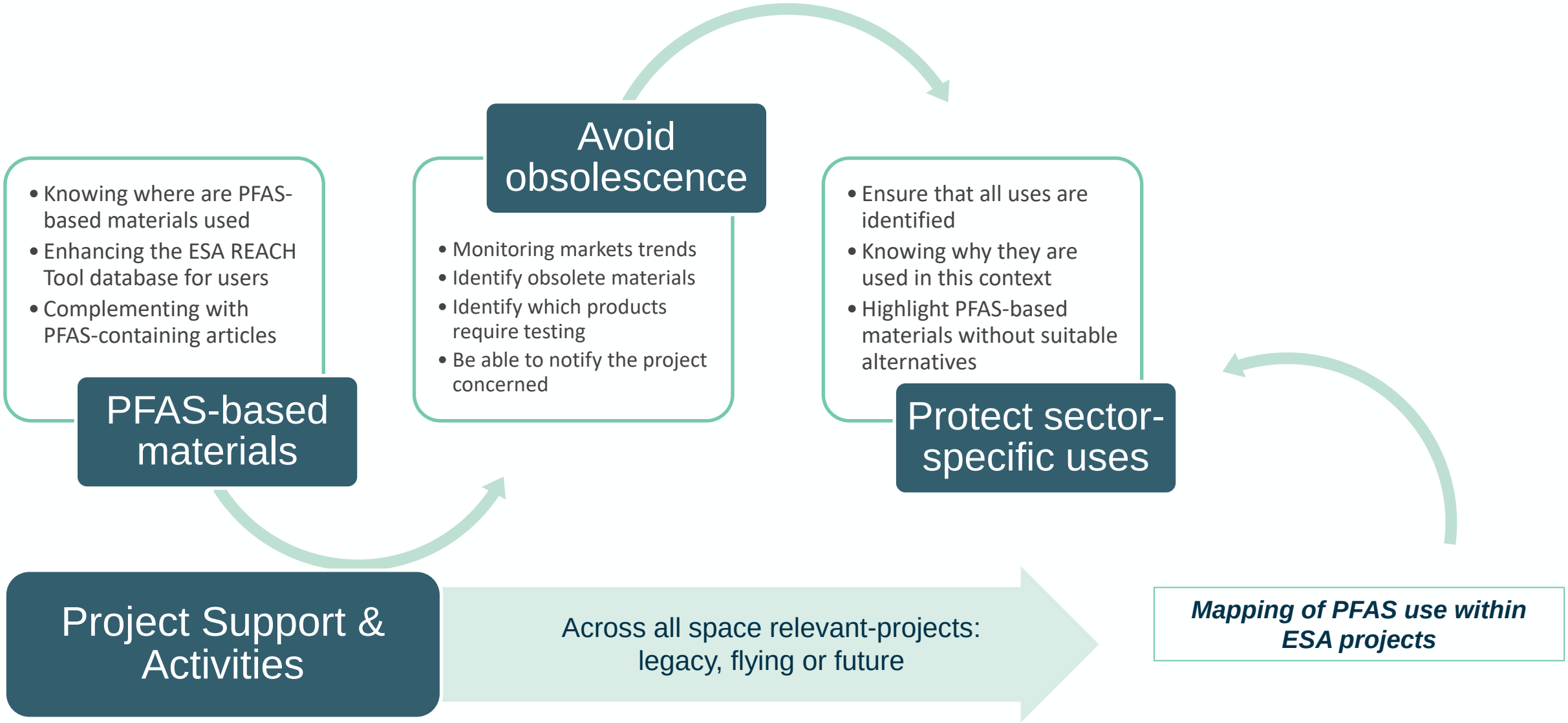
## Specificities of the European space sector

- Low production volumes
- Use of specific materials and components
- Very specific objectives
- Europe’s independence and competitiveness
- Long time needed for research and development of space missions

**All the materials used in space are carefully selected and essential to the smooth development of ESA missions**

# Outlines

# 1. Scope and Objectives of the PFAS Mapping



# Outlines


2. Information research methodology

# 2. Information research methodology

What impact will this have on my project ?

Are there alternatives to this PFAS-based material ?

## Declaration materials lists (DML, DPL)

Find the chemical substances in the list of materials for a project

## Standards

In the documentation section, information are accessible to all

## Knowledge, news, workshop, webinars

By taking part in meetings, workshops, with the help of people in the space-sector, through knowledge

# 2. Information research methodology

What impact will this have on my project ?

Are there alternatives to this PFAS-based material ?

## Declaration materials lists (DML, DPL)

CONFIDENTIAL

## Standards

In the documentation section, information are accessible to all

## Knowledge, news, workshop, webinars

By taking part in meetings, workshops, with the help of people in the space-sector, through knowledge

# Outlines


3. Mapping of PFAS used for space missions

# 3.1. Space relevant projects

## DML - DPL

- Search the list of materials, processes and product uses
- Use of keywords, knowledge of PFAS names
- Typical brands names
- Typical functions

## TDS - SDS

- Search for Technical Data Sheet or Safety Data Sheet
- Look at manufacturer website, SDSs database
- Input for ESA REACH Tool

## Chemical composition

- Check at the chemical composition of the material/ product
- Chemical substance corresponding to ECHA definition of PFAS

# 3.1. Space relevant projects

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- Search the list of materials, processes and product uses
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**Chemical composition**
- Check at the chemical composition of the material/ product
- Chemical substance corresponding to ECHA definition of PFAS

## NEXT STEPS

Calculation of a ***range*** of PFAS mass in particular spacecraft

# Outlines


3.2. Standardization – Application to space

# 3.2. Standardization – Application to Space

## Importance of Standards in the Space Sector

- Safety & Reliability
- International partners
- Cost & Time efficiency
- Quality assurance
- Traceability & Documentation
- Regulatory Compliance

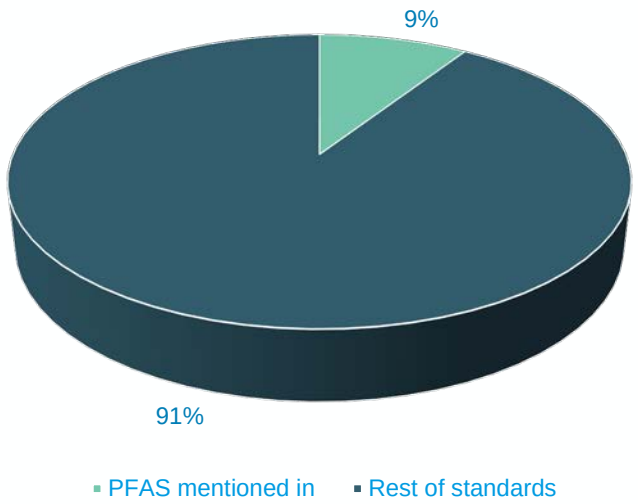
**The material mentioned is approved by multiple contractors and agencies, and defined for specific application conditions**

# 3.2.1. PFAS impact on Space sector – ESCC

The European Space Components Coordination (ESCC) mention PFAS, including :

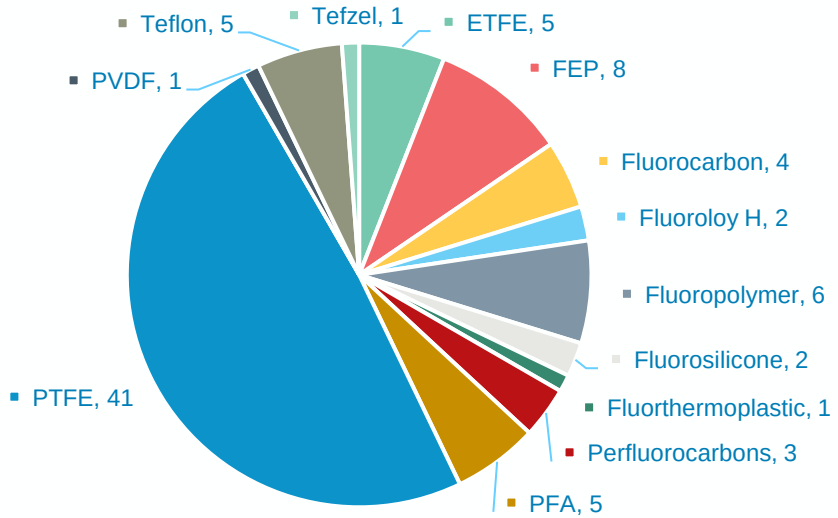
- 59 standards impacted out of 639 Specs

Pourcentage of Standards mentionning minumum one PFAS




- 13 different PFAS mentioned

Standards mentioning PFAS in ESCC 2024

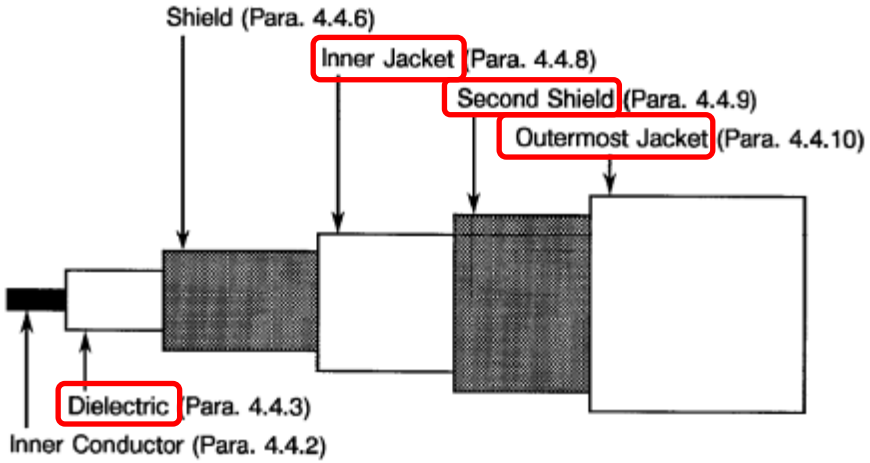



Notes :
- One hit correspond to one occurrence in the standard; the same fluoropolymer can be mentioned several times in the same ESCC document.
- Several PFAS can be mentioned in the same standard

# 3.2.1. PFAS impact on Space sector – ESCC

**EEE parts with ESCC specifications :**

This represents the use of fluoropolymers in space qualified passive electronics, such as wires, cables, resistors, connectors, etc... all being very critical for ESA missions.




- Dielectric made of PTFE
- Inner Jacket made of PTFE
- Second shield made of PTFE
- Outermost Jacket made of PTFE copolymer PFA

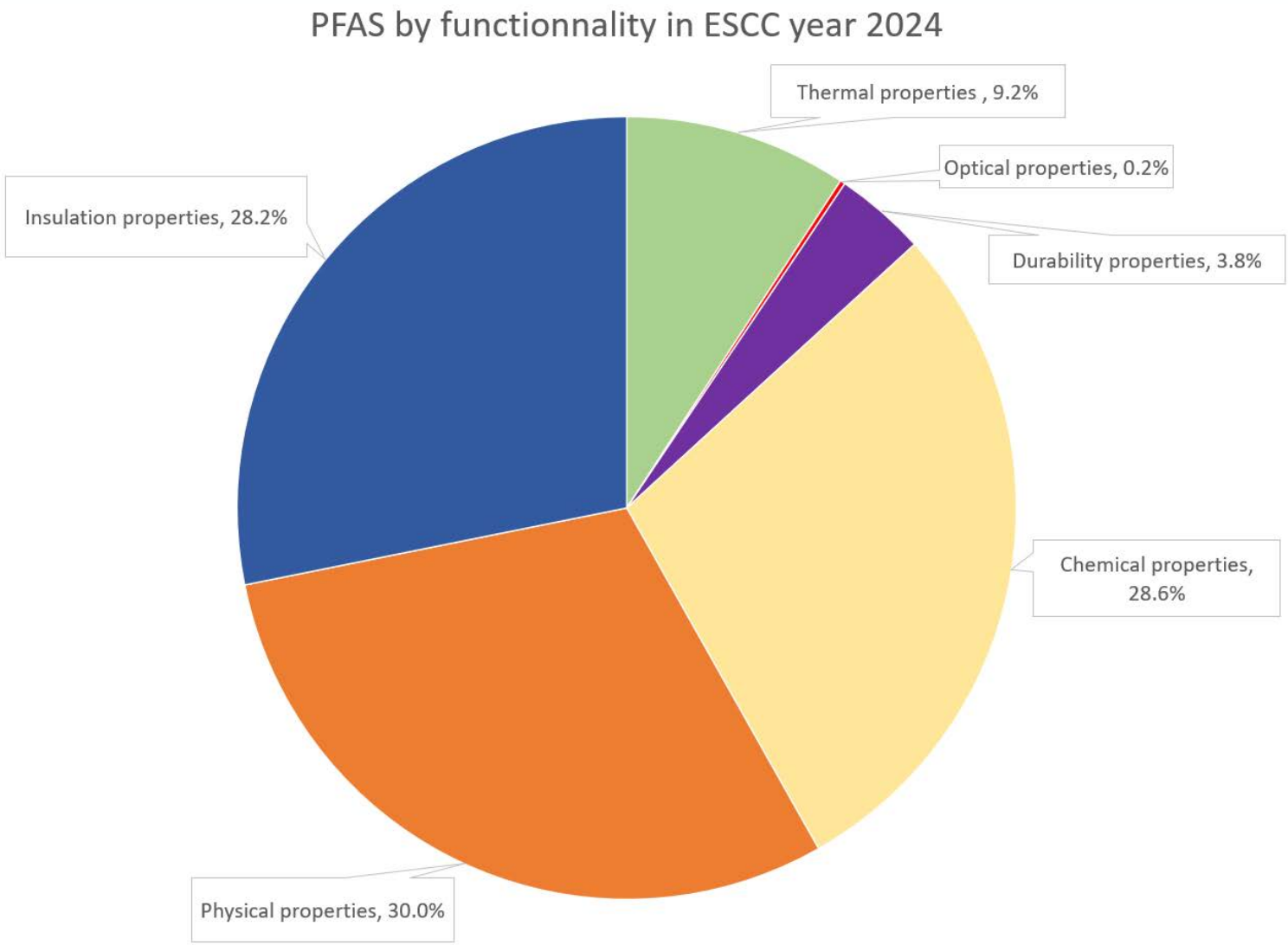
*Triaxial Cable – ESCC 3902/002 (Wires and Cables) Figure 2(a)*

# 3.2.1. PFAS impact on Space sector – ESCC

## EEE parts with ESCC specifications :

This represents the use of fluoropolymers in space qualified passive electronics, such as wires, cables, resistors, connectors, etc... all being very critical for ESA missions.

| Function Type | Key properties |
|---|---|
| Thermal properties | Thermal conductivity |
| | Thermal resistance |
| | Thermal stability |
| | Flame retardant |
| Optical properties | Transparency |
| Durability properties | Consistency and reliability |
| | Resistance to weathering |
| | Fire resistant |
| Chemical properties | Chemical inertness |
| | Anti-adhesives |
| | No solvents, low non-volatile residue |
| Physical & Mechanical properties | High elongation |
| | Lightweight |
| | Low compression set |
| | Low surface tension |
| | Low friction |
| | Heat shrinkability |
| | Mechanical strength |
| Insulation & Dielectric properties | Electrical insulation |
| | Sealing properties |



# 3.2.2. PFAS impact on Space sector – Fluorocarbons

## Impact of UPFAS regulation on space sector

**Regulations**

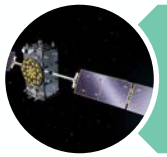
UPFAS impacted space sector

**Phase 1 PFAS mapping for Sectorial response paper completed**

**Phase 2 mapping to complement it**

To ensure suitable derogations


Cooling fluids


Lubricants


Coatings and finishings


Electronics and semiconductors


Cable & harness

Non-exhaustive list

**Obsolescence**

3M discontinuation PFPE fluids in 2025

**New list updated from January 2025**
3M released >22.000 items PFAS-based

To mitigate risk of emerging obsolescence

# 3.2.2. PFAS impact on Space sector – Fluorocarbons

Impact of UPFAS regulation on space sector

**Regulations**

UPFAS impacted space sector

**Phase 1 PFAS mapping for Sectorial response paper completed**

**Phase 2 mapping to complement it**

EEE hermeticity tests liquids

**Obsolescence**

3M discontinuation PFPE fluids in 2025

**New list updated from January 2025**
3M released >22.000 items PFAS-based

# 3.2.2. PFAS impact on Space sector – Fluorocarbons

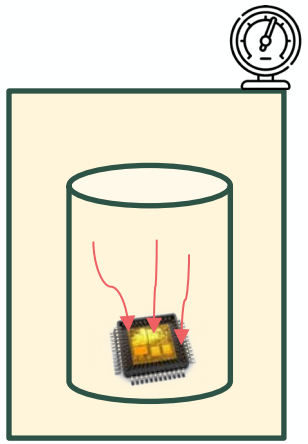
**Specific test standards :**

Standards utilising Fluorocarbons fluids as liquid test

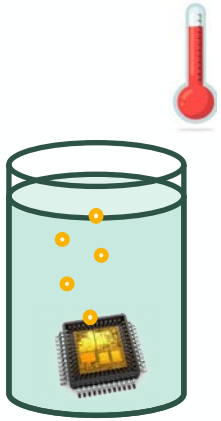
(b) Gross leak: Test Qc, container sealing, gas leakage:
- Test method 2
- Test liquid temperature: +125 ±5°C. Recommended liquid: fluorocarbon liquid FC40 or FC43.

*Gross leak, Test Qc – ESCC 3702*

The gross leak test is an inspection test based on boiling points differential of two fluorocarbons.



Step 1



Step 2

| Property | Type I | Type II | Type III | ASTM test method |
|---|---|---|---|---|
| Boiling point (°C) | 50-95 | 140-200 | 50-110 | D-1120 |
| Surface tension (dynes/ cm) at +25°C | | < 20 | | D-971 D-1331 |
| Density at +25°C (gm/ml) | > 1.6 | > 1.6 | > 1.6 | D-941 |
| Density at +125°C (gm/ml) | | > 1.5 | | D-941 |
| Dielectric strength (volts/mil) | > 300 | > 300 | > 300 | 877 |
| Residue (µgm/gm) | < 50 | < 50 | < 50 | D-2109 |
| Appearance | Clear colorless | | | NA |

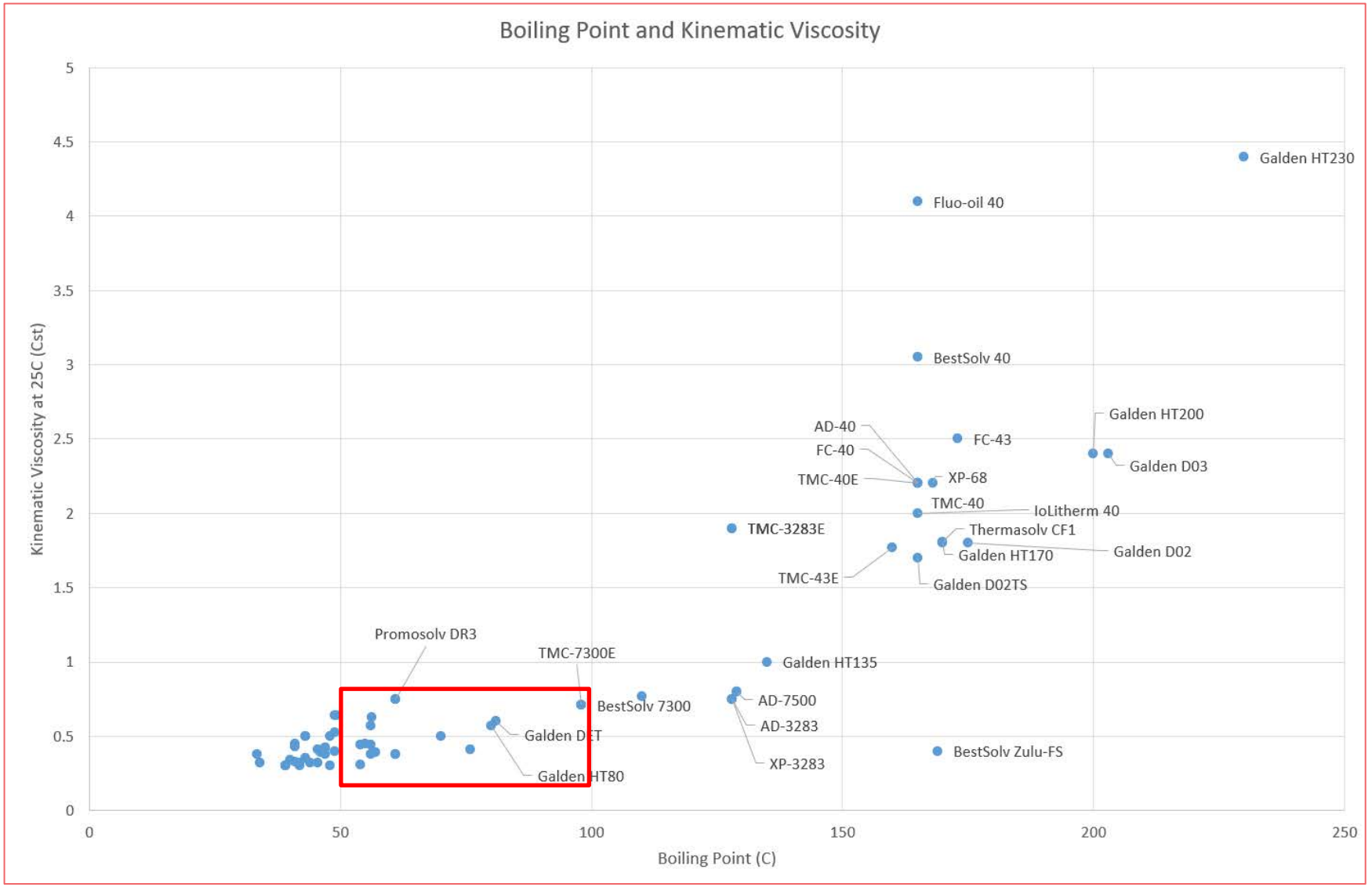
1/ Perfluorocarbons contain no chlorine or hydrogen.

Table 1071-II- Physical property requirements of Perfluorocarbons fluids from MIL-STD-750 TM 1071

# 3.2.2. PFAS impact on Space sector – Fluorocarbons

Alternative chemicals :
Type I detector fluid : 3M FC-72

Boiling Point : 50 < X < 100 C
Low Viscosity




Non-exhaustive list

# 3.2.2. PFAS impact on Space sector – Fluorocarbons

Alternative chemicals :
Type I detector fluid : 3M FC-72

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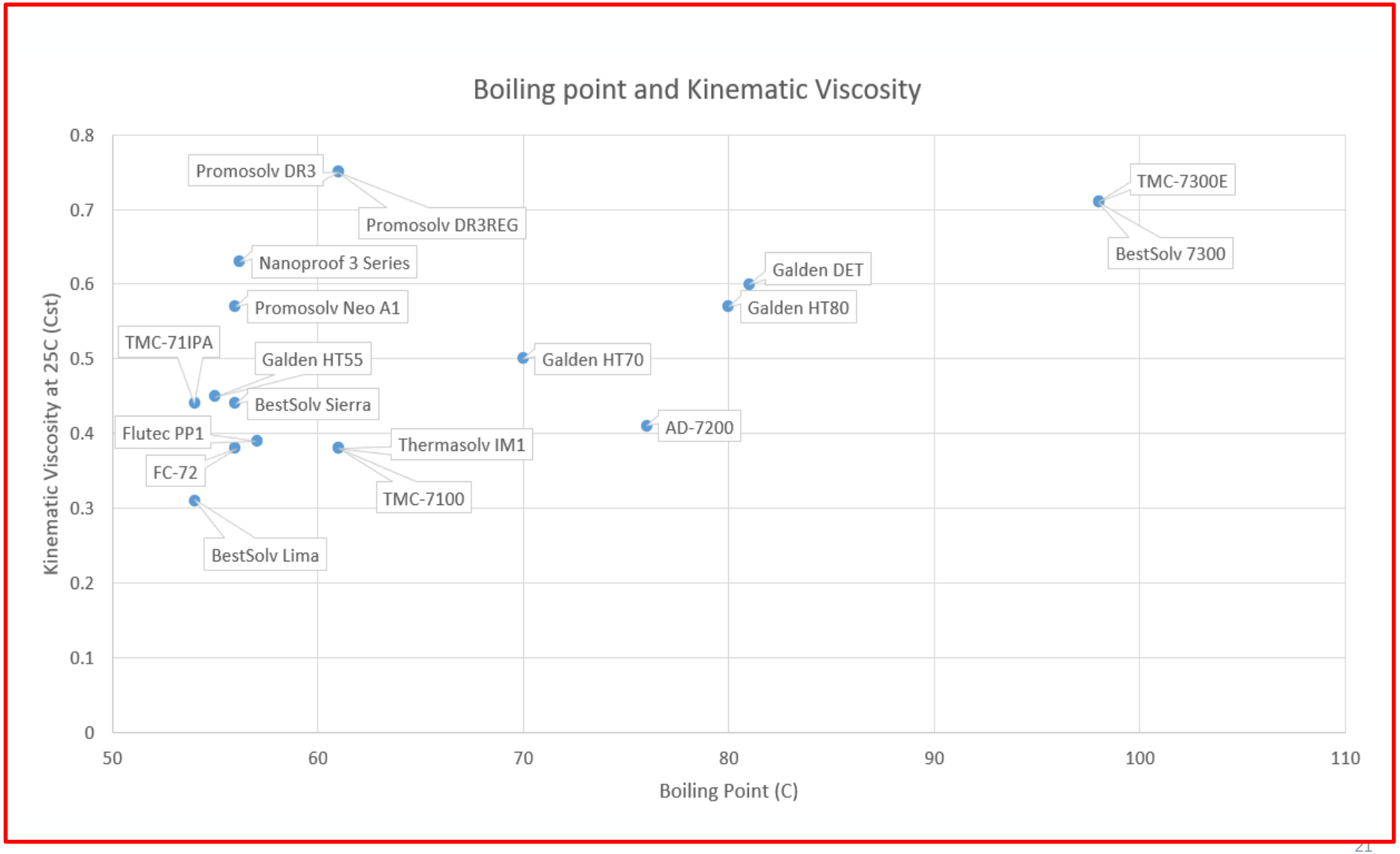
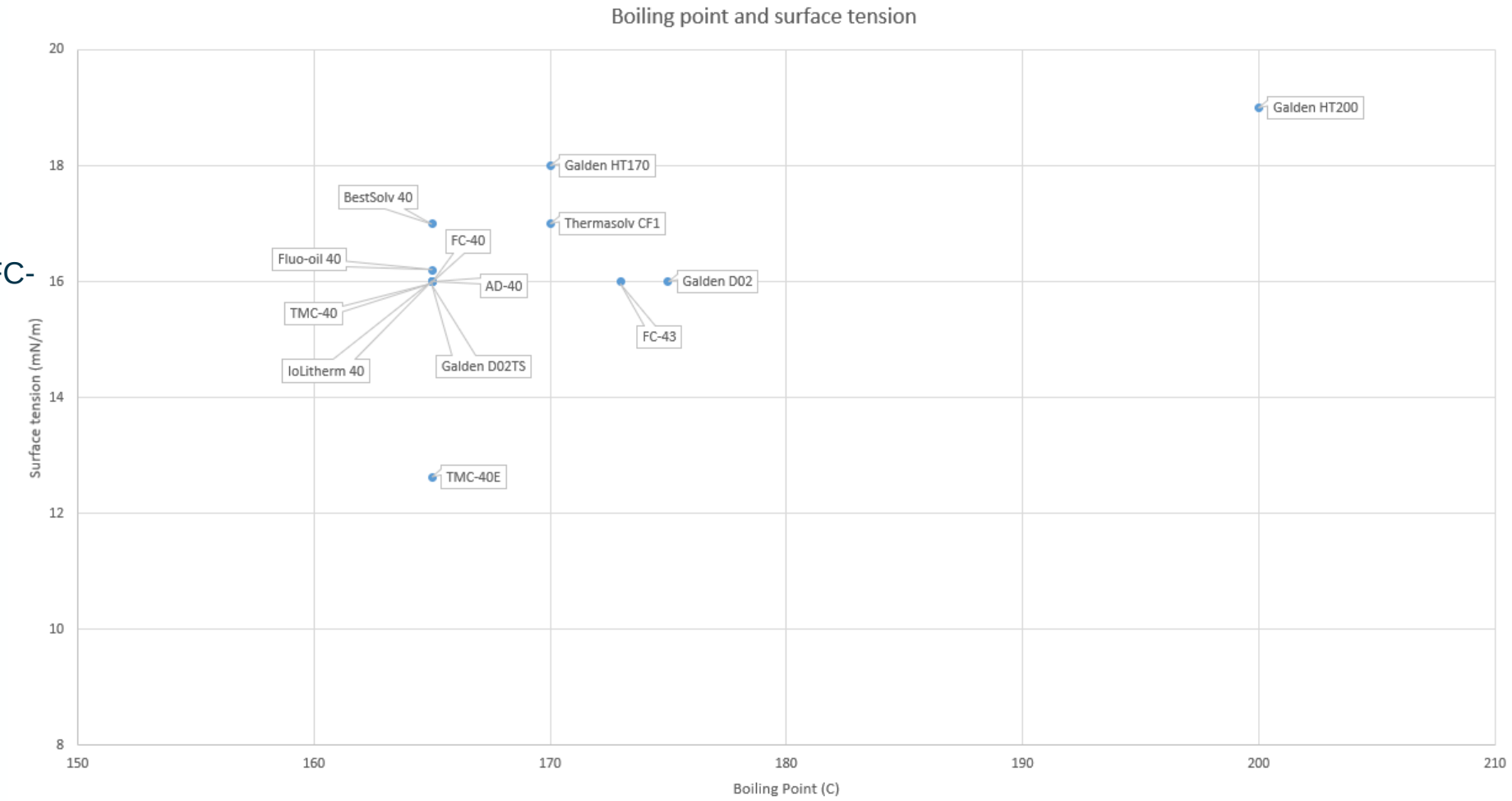



Non-exhaustive list

# 3.2.2. PFAS impact on Space sector – Fluorocarbons

Alternative chemicals :
Type II detector fluid : 3M FC-40 or 3M FC-43

Boiling Point : 140 < X < 200 C
Surface tension : <20 (dynes/cm)




Non-exhaustive list

# 3.2.2. PFAS impact on Space sector – Fluorocarbons

According to TDS, Fluorinert fluids from 3M have all these properties and functionalities

| Function Type | Key properties |
|---|---|
| Functional requirements | No-Residue |
| | Non-conductive |
| | Operates in sealed and circulating systems |
| | Efficient heat transfer |
| | Compatible with electronic components |
| Chemical properties | Non-reactive/inertness |
| | Chemically stable |
| | Non-Flammable |
| Safety & environmental | Non-Flammable |
| | Low ODP |
| | Low Acute toxicity |
| | Regulatory considerations |
| Electrical properties | Dieletric strength |
| | Electrical resistivity |
| Physical properties | Surface tension |
| | Density |
| | Heat capacity |
| | Viscosity |
| | Freezing point |
| | Boiling point |
| | Evaporates without leaving any residues |


Requirements to replace 3M Fluorinert according to TDS

# 3.2.2. PFAS impact on Space sector – Fluorocarbons

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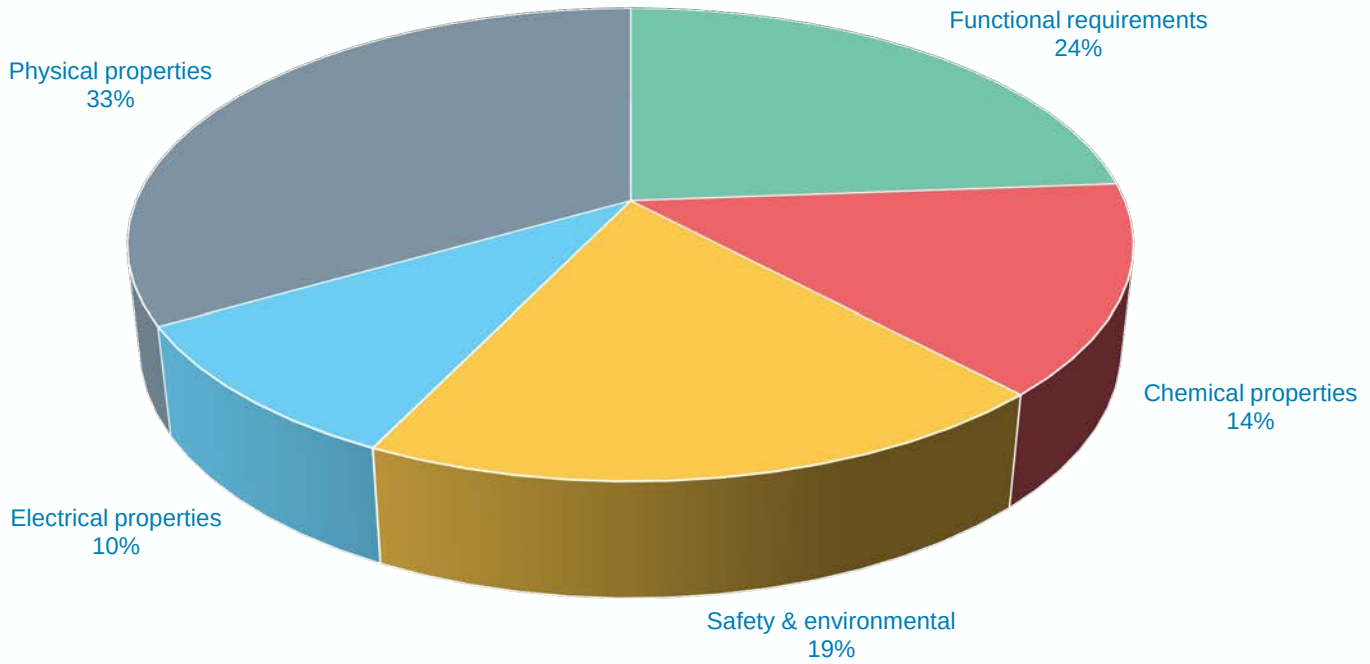
| | Electrical resistivity |
| Physical properties | Surface tension |
| | Density |
| | Heat capacity |
| | Viscosity |
| | Freezing point |
| | Boiling point |
| | Evaporates without leaving any residues |

Function type of 3M Fluorinert for replacement

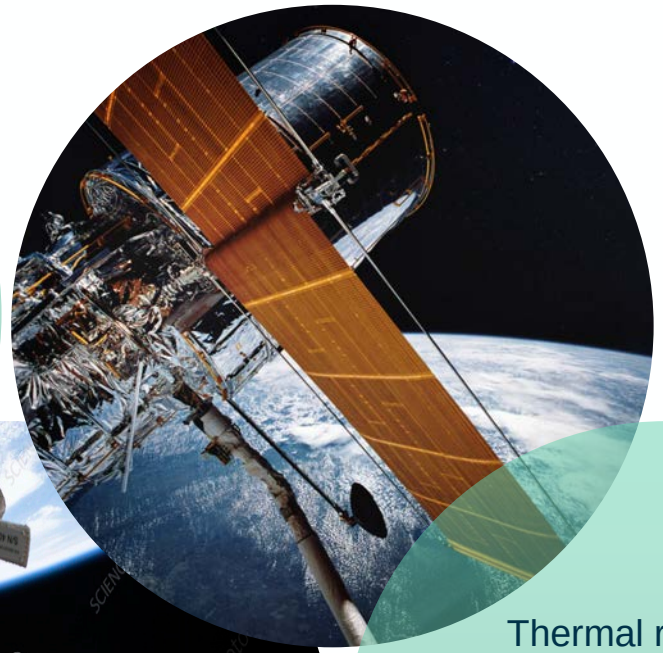



Requirements to replace 3M Fluorinert according to TDS

# Outlines

# 3.3.2 Space fabrics

Abrasion resistant
Thermal insulation
Strong yet lightweight
Low creep
High tensile strength
Chemical resistant
Flame resistant
…



Thermal resistance
Lightweight
Low moisture absorption
Impact resistant
Low thermal extension
Flexibility
…

## Essential materials for space missions

*Space suits*
*Multi-Layer Insulation for spacecrafts*
*Deployable structures*
*Shielding*
*Parachutes and landing systems*
*Dust and contamination control*
*Solar and Drag Sails*
*…*

*Credit : ESA*

# 3.3.2 Space fabrics

## Essential materials for space missions

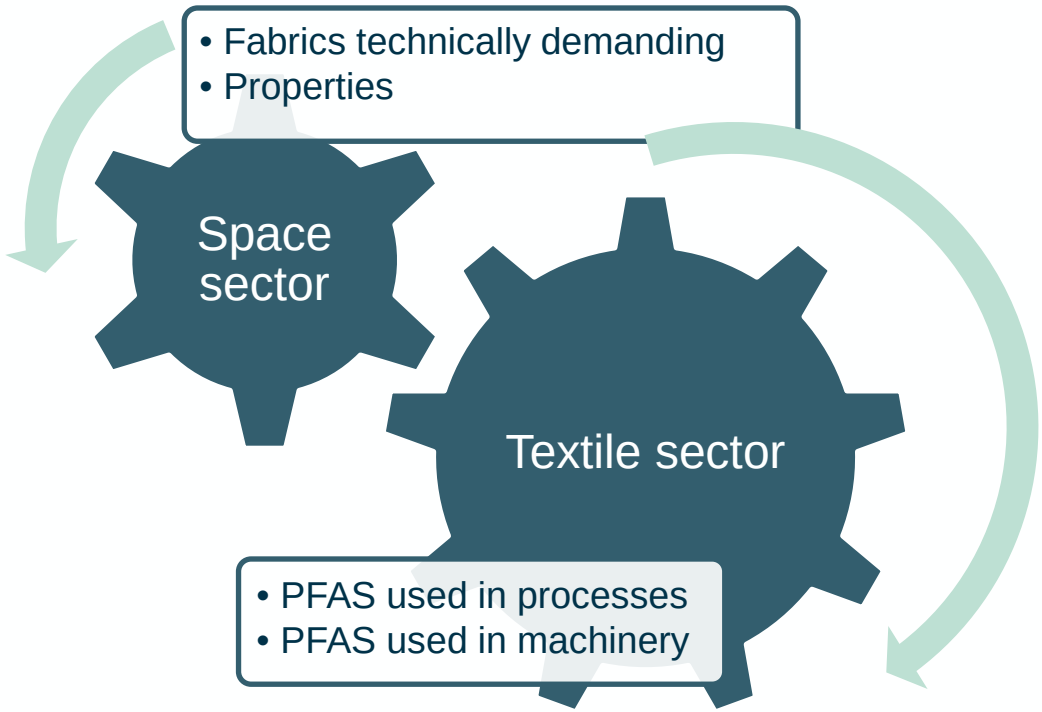
*Space suits*
*Multi-Layer Insulation for spacecrafts*
*Deployable structures*
*Shielding*
*Parachutes and landing systems*
*Dust and contamination control*
*Solar and Drag Sails*
*...*

**Regulations**

**Premature Obsolescence**

Credit : ESA

# 3.3.1 Textile and space sector




Textile Association from UK :

- Military products technically demanding
- PFAS to meet the required level of repellence
- PFAS-free alternatives developed so far not been able to match the performance (e.g. Lower resistance to laundering and abrasion)

Fabrics impregnated or coated with PFAS :

- Emerging obsolescence

Company specialized in textile machines :

- Analyse of PFAS used in machines
- Done with non-PFAS based → bad experience

# 3.3.3 Beta ® Cloth

Beta ® Cloth  is a high-performance fabric made from PTFE-coated fiberglass.

Used in spacecraft, ISS, spacesuits, …

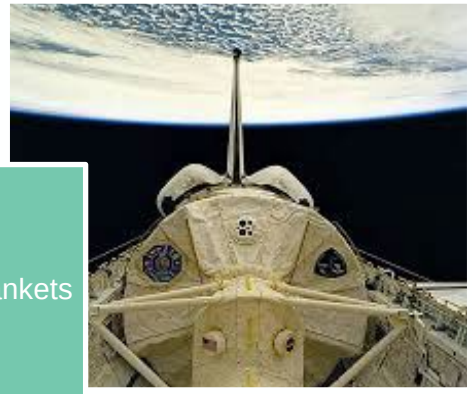
For decades, Saint-Gobain was a primary supplier, from factory in Merrimack, USA.

In the early 2020s, they announced immediate discontinuation of its Beta® cloth production.

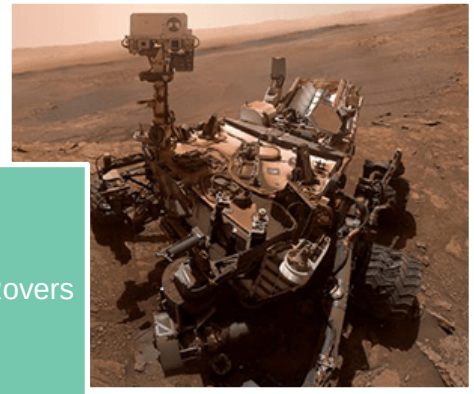
Spacecraft and spacesuit

Micrometeoroids protection

Thermal blankets



Planetary Rovers



*Credit : NASA, JPL and Bron Aerotech, LLC.*

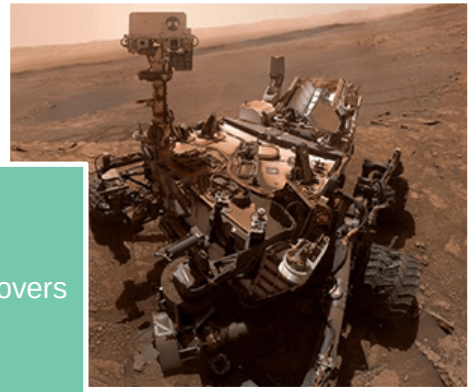
# 3.3.3 Beta ® Cloth

Spacecraft and spacesuit

Micrometeoroids protection

Thermal blankets

Planetary rovers

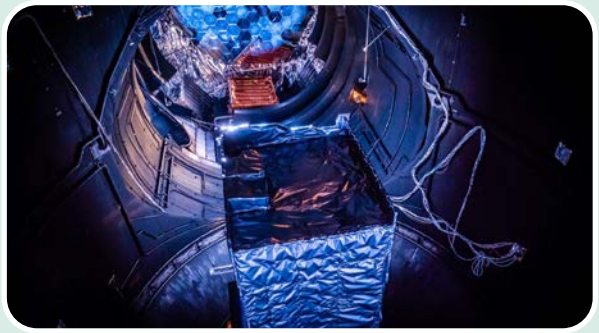


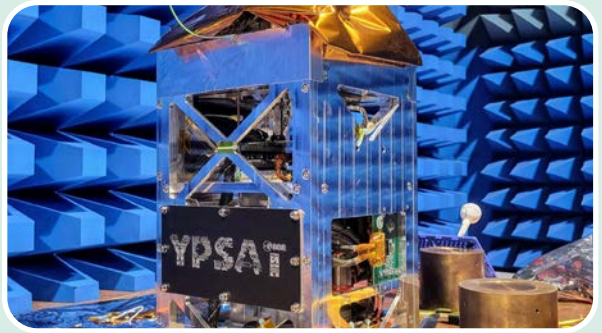
## NEXT STEPS

Perform several comparative tests on the “new” Beta® cloth to verify the performance of the material under exposure to typical space environment conditions

*Credit : NASA, JPL and Bron Aerotech, LLC.*

# 3.3.3 Beta ® Cloth






**Material characterisation**

Thermogravimetric Analysis

Differential Scanning Calorimetry

Outgassing

**Foldability**

**Full exposure scenario**

Thermo-Optical

TVAC

UV/VUV exposure

Atomic Oxygen

*Credit : ESA*

# 3.3.3 Beta ® Cloth

## Evaluating the role of PTFE in Beta ® Cloth

### PROTECTIVE COATING

- Protection on earth
- Removed on harsh conditions of space

### EROSION RESISTANCE

- Both protection in underlying layers between glass fibers and PTFE

### THERMAL INSULATION

- Keep thermal stability and performance of MLI

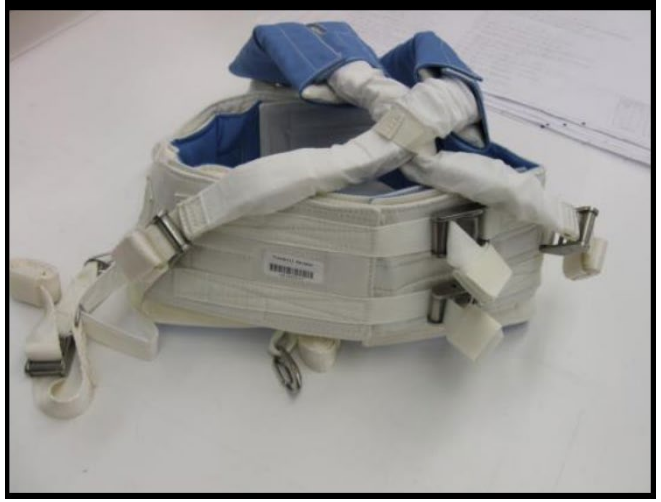
### MECHANICAL STRENGTH

- Reduce interfiber friction and prevent abrasion

### OPTICAL PROPERTIES

- Preserve material's reflectivity and emissivity
- Expect to darken

# 3.3.4 Intravehicular activity



*Credit : NASA*

## Treadmill with vibration Isolation and Stabilization Harness

- Nomex webbing
- Cotton comfort liner
- Nomex fabric outer layer
- Teflon fabric cover

## Sleep Station

- A custom sleeping bag with Teflon fabric lined interior for ease of cleaning and maintenance

*Credit : NASA*

# Outlines

# CONCLUSION

**Mapping ongoing**

- Covering all possible uses
- Be able to protect the sector best way possible

**Risks**

- UPFAS restriction
- Immediate obsolescence

**Next steps**

- Range of mass of PFAS used in space project
- Space environment conditions tests for alternatives

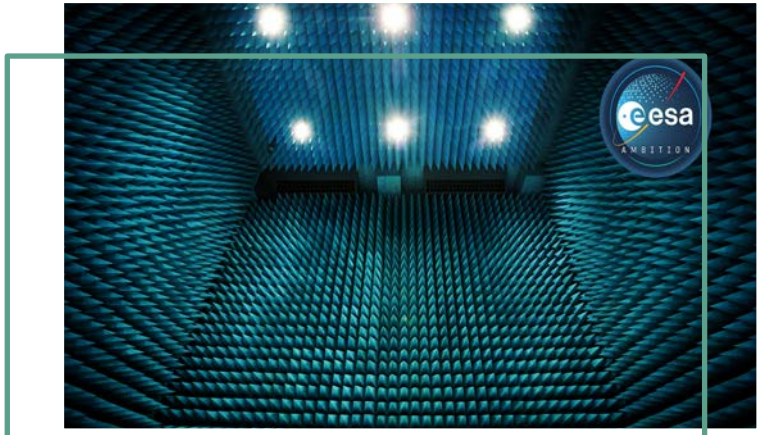
# Thank you

Thank you for your attention !

Questions?

*Credit : ESA*

# BACKUP SLIDES



*Credit : ESA*

# PFAS impact on Space Sector - ECSS

- ECSS-Q-ST-60-13C Rev 2 (5 Nov 2024) : Space product assurance – Commercial electrical, electronic and electromechanical (EEE) components

    - Seal Test – applicable to hermetic & cavity package
    - → Two standards are mentioned
        - MIL-STD-883 TM 1014 condition A or B (fine leak) and condition C (gross leak)
        - MIL-STD-750 TM 1071 condition H1 or H2 (fine leak) and condition C or K (gross leak with cavity) or condition E (gross leak without cavity)

- ESCC 21100 - Hermeticity test method
- ESCC 3702 Iss6 – Switches, thermostatic, bimetallic, hermetically sealed

→ Methods using perfluorocarbon, ESCC 3702 mentioned 3M Fluorinert products
→ 3M discontinuation notice for various materials and chemicals containing PFAS

# Alternative for 3M Fluorinert

## Which manufacturers offer alternatives for 3M Fluorinert

| Manufacturer | HQ country | Brand name |
|---|---|---|
| A.D Dawning | China | XP |
| A.D Dawning | China | AD |
| Aculon, Inc. | USA | Nanoproof |
| Best Technology, Inc. | USA | BestSolv • |
| Chemours | USA | Opteon |
| Emulseo | France | Fluo-oil |
| Enviro Tech Europe, Ltd | UK | Prosolv |
| Inventec Performnce Chemicals | France | Thermasolv |
| Inventec Performnce Chemicals | France | Promosolv |
| Inventec Performnce Chemicals | France | Quicksolv |
| io.li.tec Ionic Liquids Technologies GmbH | Germany | IoLiTherm |
| Syensqo | USA | Galden |
| TMC Industries, Inc. | USA | Flutec |
| TMC Industries, Inc. | USA | TMC |

Non-exhaustive list

• PFAS-free alternatives not compatible with standard

# References

Images : credit to ESA
Slides 30-31-32: images credit to Dunmore and Versiv Composites Ltd
Slide 34: images credit to NASA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