Update to The IAEG Review of Aerospace and Defence Dependencies and Regulatory Action Relating to Per- and polyfluorinated alkyl substances (PFAS)

10 April 2026

Version 1.0

This document is an update to the work carried out in 2023 and published in 2024 [2024 PFAS White Paper] and provides an overview of the continued work on PFAS by IAEG WG5.

This document is released for purpose of informing the Aerospace and Defence industry of the work carried out in IAEG WG5 in partnership with WSP to identify uses of PFAS in the sector.

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Glossary

Abbreviation	Definition
A&D	Aerospace and Defense
AIA	Aerospace Industries Association
AMS	Aerospace Material Specifications
AS	Aerospace Standard
ASD	Aerospace, Security, and Defense Industries Association
ASTM	American Society for Testing and Materials
CAS	Chemical Abstracts Service
CHF	Carbon-Hydrogen-Fluorine
CLP	EU Classification, Labelling, and Packaging regulation[1]
DoD	Department of Defence
ECHA	European Chemicals Agency
EiF	Entry into Force
EMI	Electromagnetic Interference
EPA	Environmental Protection Agency (US)
EPDM	Ethylene Propylene Diene Monomer
ETFE	Ethylene Tetrafluoroethylene
EU	European Union
FCM	Food Contact Materials
FEP	Fluorinated Ethylene Propylene
FFKM	Perfluoroelastomers
FKM	Fluorocarbon Based Fluoroelastomer
FP	Fluoropolymer
FPG	Fluoropolymer Product Group

[1]ECHA, Classification and labelling of packaging regulation. https://echa.europa.eu/regulations/clp/legislation

Abbreviation	Definition
HCFCs	Hydrochlorofluorocarbons
HFCs	Hydrofluorocarbons
HNBR	Hydrogenated Nitrile Butadiene Rubber
HVACR	Heating, Ventilation, and Air Conditioning
IAEG	International Aerospace Environmental Group
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MIL-DTL	Military Detail Specification
MIL-PRF	Military Performance Specification
MIL-SPEC	Military Specification
MLI	Multi-Layer Insulation
MoD	Minitry of Defence
NA	Not Applicable
NVH	Noise Vibration Harshness
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
OLED	Organic Light Emitting Diode
PCB	Printed Circuit Board
PE	Polyethylene
PEEK	Polyether Ether Ketone
PFAS	Per- and polyfluorinated Alkyl Substances
PFPEs	Perfluoropolyethers
PPE	Personal Protective Equipment
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl Chloride

Abbreviation	Definition
PVDF	Polyvinylidene Fluoride
PVF	Polyvinyl Fluoride
R&D	Research and Development
REACH	Registration, Evaluation, Authorisation, and restriction of CHemicals legislation (EU)[2]
RF	Radio Frequency
RFI	Radio Frequency Interference
SAE	(Formerly the) Society of Automotive Engineers
SEAC	Committee for Socioeconomic Analysis
TBC	To Be Confirmed
TSCA	Toxic Substances Control Act
US	United States
VMQ	Vinyl Methyl Silicone
WG	Working group

[2] ECHA, Registration, Evaluation and Authorisation of Chemicals. https://echa.europa.eu/regulations/reach/legislation

1. Overview of this PFAS report

1.1 Introduction

Recent years have seen a rapid increase in awareness of risks and harm potentially caused by fluorinated substances among the public and the regulators. Regulators in many jurisdictions are acting to limit usage and exposure. In particular, the EU proposed universal PFAS restriction is wide in scope. Such restrictions could potentially have significant implications for the aerospace and defense (A&D) industry. Depending on how regulators scope a PFAS grouping, many different substances including polymers and small molecules can be in scope (>10,000 substances). PFAS are found in many different applications and fully understanding the nature and extent of uses in the Aerospace & Defense (A&D) industry is very challenging. In 2023 IAEG undertook a preliminary mapping activity and assessment of the risks posed by potential PFAS regulatory activity to A&D. This culminated in a white paper published in February 2024[3]. This report is a continuation of that work and seeks to add to the identification and understanding of PFAS uses in the sector.

1.1.1 Purpose of this report

The International Aerospace Environmental Group (IAEG) has built on the work done in 2023 and commissioned this report to continue the mapping activity to identify products and formulations which are known or suspected to contain PFAS. It will also illustrate the complexities facing this industry with regard to the identification and understanding of PFAS uses across the A&D supply chain. This is an ongoing activity, building on the 2023 work, and the data represents an increase in the maturity of understanding and information on PFAS uses in the sector. This update presents a deeper, though by no means complete, understanding of the uses of PFAS in A&D. In particular, this report aims to:

- Highlight and map the key uses of PFAS within parts and formulations in A&D currently overlayed against the proposed EU restriction proposal (both in relation to 'transport' and other related markets), as well as uses not explicitly discussed in the restriction proposal.
- Provide an overview of PFAS uses in A&D where alternatives that meet required performance or safety standards are not currently available.
- Illustrate the challenges of identifying PFAS in specific products or components due to the complexity of the A&D supply chain.

1.1.2 IAEG

IAEG is a non-profit organization that collaborates and shares information regarding environmental solutions for the aerospace and defense (A&D) industry[4]. IAEG has more than 50 member companies that send delegates to multiple work groups (WGs) supporting topics that include substance declarations, replacement technologies, greenhouse gas reporting and REACH authorisation and restriction, among others.

WG5 is the REACH Authorisation and Restriction work group. WG5 carries out supply chain mapping activities to better understand the risk associated with specific substances. To this end, WG5 regularly

[3] IAEG, 2023. IAEG Review of Aerospace and Defense Dependencies and Regulatory Action relating to Per- and polyfluorinated alkyl substances (PFAS). https://www.iaeg.com/binaries/content/assets/iaeg/2024/iaeg-pfas-white-paper-feb-2024-v1.0-counsel.pdf

[4] IAEG. https://www.iaeg.com/about

conducts assessments of substances that are actually or potentially subject to EU REACH Authorisation, including Candidate List substances, and identifying substances in use in the A&D industry that may require Authorisation. This includes conducting supply chain analysis to investigate the wider potential implications associated with forthcoming regulations impacting specific chemicals.

1.1.3 PFAS in the A&D Industry

Non-polymeric and polymeric PFAS are widely used in the manufacture, operation and maintenance of aerospace and defense (A&D) products and/or in the manufacture of component parts (articles), sub-assemblies and formulations (mixtures), as well as in manufacturing and process equipment in A&D defense supply chains.

The specific type of applications for which PFAS are used in the A&D industry are sometimes complex and wide-ranging. Some of these are specific to A&D but, in many cases, these uses interlink with many other wider industries (e.g., electronics, coatings, lubricants and hydraulic fluids, metal plating, fluorinated gases, cables and wiring, etc). A further complication for an industry with a global footprint like A&D, is that 'PFAS' may be defined differently under different regulatory regimes in different regions. Moreover, the uses of PFAS that relate to A&D are not always consistently or uniformly described or defined in different sources, or in different regulatory procedures.

PFAS have been identified in many uses relevant to A&D that are common with other sectors. In the case of the January 2023 EU REACH restriction proposal[5], which aims to manage PFAS derogations by category, A&D uses cut across many of these. Examples of relevant use categories for the A&D sector, highlighting specific applications within those categories, include the following (noting that this does not constitute an exhaustive list of all A&D uses):

- **Lubricants** – e.g. high temperature and high-performance greases and dry film lubricants used on bearings and moving parts; and thermoset / thermoplastic moulds / unmoulding agents
- **Hydraulic fluids** – e.g. used in aircraft flight control systems, actuators for flying surfaces, landing gear and actuators in defense systems.
- **Electronics and semi-conductors** – e.g. printed circuit boards and assemblies, gaskets and moulded products, semiconductors, optical fibres, high temperature film capacitors, electronic displays and touch screens, lithium (Li) ion Batteries.
- **Wires and cables** – e.g. use of PFAS in wire and cable insulation, sheaths, tapes, jackets, sleeves and binders, cable glands, breather drains and electrical connectors.
- **Metal plating and manufacturing of metal products** – e.g. PFAS used as mist suppressants in the A&D industry in the chrome plating process.
- **Textiles, upholstery, leather, apparel and carpets** – e.g. water-repelling and stain-resistant compounds.
- **Fluorinated gases** – e.g. in cooling, refrigeration, fire suppression, leak testing, cleaning etc.
- **Fire supressing agents** – e.g. fire extinguishers.
- **Transportation –** e.g. aerospace hoses (liners of aerospace hose assemblies and PTFE-lined flexible high-pressure hoses); body, hull and fuselage construction.
- **Sealing applications*** - e.g. fluoropolymer O-rings, seals, gaskets, piping, linings, valve parts, and packing.

[5] ECHA (2023). https://echa.europa.eu/-/echa-publishes-pfas-restriction-proposal

- **Machinery applications*** - e.g. manufacture of FP/PFPE-containing machinery parts, and during their service life as components in complex objects (e.g. engine parts)
- **Military applications*** - e.g. radar applications and military fluid resistance
- **Broader industrial uses*** - e.g. adhesives, cleaning solutions, heat transfer fluids

(Uses marked with an asterisk (*) above were added between the original 2023 proposal and the revised 2025 proposal[6].)

1.2 IAEG Phase 1 Mapping Activity

Mapping PFAS dependencies throughout A&D is complicated and challenging. This is because of the very large number of chemical substances potentially covered by the proposed restriction, lack of current requirements for disclosure of all PFAS substances (e.g. where they are not hazard classified, currently required to be declared in articles or used several layers down the supply chain) and the wide range of uses for PFAS that are likely to be associated with uses for A&D companies (as discussed above).

A preliminary mapping exercise was conducted in 2023 to gain a basic understanding of the key products and uses involving PFAS in the A&D sector. This is referred to as 'phase 1' of the IAEG PFAS mapping. This preliminary study was used to produce an IAEG White Paper[7] presenting a review of A&D dependencies and regulatory action relating to PFAS. Within this, the uses of PFAS within a number of 'sub-uses' under a number of key broad use categories were investigated, including several that are considered by IAEG WG5 members as 'critical'[8] uses to the A&D sector. While many of these are explicitly mentioned in the January 2023 EU restriction proposal, a number of 'additional' or 'missing' uses were identified.

The phase 1 mapping was constrained to a large extent by the limited timescales available for consultation with both WG5 member companies and wider industry. For example, relatively little information could be gathered from individual supplier companies or industry associations representing different key upstream sectors as part of the preliminary mapping (in part because they were focused on inputting to ECHA's public consultation at the time).

Several data gaps were identified from the phase 1 mapping study, that will need to be addressed to provide the IAEG and the wider A&D sector with a more detailed understanding of PFAS uses. These include:

- Uncertainty over where (and which) PFAS are used in the A&D sector, and for which application(s), especially for uses of non-polymeric PFAS where these may not be present in the final products or articles.
- Limitations in identifying uses of relevant substances. While approximately 40 PFAS with specified CAS numbers were identified for products used by WG5 members, it is expected there are likely to be substantially more than this that are highly relevant in the A&D sector, particularly considering the significance of upstream uses. Many uses of PFAS are also not identifiable in practice based on the lack of substance CAS numbers for those PFAS.

As discussed above, significant challenges persist in being able to obtain information and track PFAS uses through supply chains. There is, thus far, limited visibility on PFAS uses further up the A&D supply chain e.g. the upstream uses and users of PFAS and PFAS-containing products.

[6] Background Document to the Opinion on the Annex XV dossier proposing restrictions on Per- and polyfluoroalkyl substances (PFASs), version no. 14, 24 June 2025

[7] https://www.iaeg.com/binaries/content/assets/iaeg/2024/iaeg-pfas-white-paper-feb-2024-v1.0-counsel.pdf

[8] Defined by WG5 for this work as: uses required for product development, operations, support or safety where alternatives are not generally available to meet requirements or demand.

The phase 1 mapping did not investigate PFAS alternatives for uses in the A&D sector in great detail, so there were limited insights at that stage regarding the technical readiness (i.e. availability and technical and economic feasibility) of alternatives for different products or uses.

There is currently limited disaggregation of information on uses, products and presence of PFAS between different categories within the A&D sector (e.g. civil/military/defense/space applications).

While initial insight has been derived regarding which performance standards require (or stipulate) the use of PFAS, further investigation is needed to understand how each specific use is impacted, for example where standards need to be re-drafted or replaced if alternatives to PFAS materials are developed and qualified for the specific application.

1.3 Aims of this Phase 2 study

It is important for the IAEG to fully understand the uses of PFAS for A&D, in products and manufacturing processes, to better understand the potential implications of the proposed restriction. Without this, the industry risks losing access to products and processes that may be critical to its products and operations. The overall aim of this supply chain mapping study is therefore to conduct additional research and supply chain mapping to support the IAEG in further understanding the use of PFAS across the A&D supply chain and the potential implications of the 2025 EU PFAS restriction proposal across their products and applications.

The main priority areas to investigate in this phase 2 of the supply chain mapping work were concluded in the IAEG White Paper 2023 and are as follows:

- Further investigation of PFAS use across the A&D sector – including:
    - A more targeted and simplified assessment of key uses across the A&D sector that involve PFAS.
    - More detailed assessment of different types of PFAS used (e.g. polymeric vs non-polymeric) and their presence in articles vs formulations/mixtures.
    - Identification of specific CAS numbers of interest in the A&D supply chain.
    - Further investigation at a product/formulation level, e.g. to identify ‘missing’ uses not covered in the EU PFAS restriction proposal.
    - Better understanding of the specific products and the uses of PFAS within different A&D categories (e.g. civil/military/defense).
- Understanding suppliers’ likely response to proposed restrictions:
    - Identifying, testing, implementing alternatives; planned actions if REACH restriction is implemented as currently drafted, (e.g. reformulation or obsolescence of current products).
    - Better understanding of likely actions of other actors in the supply chain, including the impact on specific uses and product lines (e.g. whether these will become obsolete or be reformulated).
    - Understanding the upstream supply chain, e.g. to identify if there are uses of PFAS that the A&D industry is not aware of because they are no longer present when used by the A&D industry. This also includes the likelihood of obsolescence/reformulation of the products based on PFAS.
- Any relevant ongoing research into PFAS alternatives, including:

- Better understanding of uses at risk of restriction or obsolescence to target for alternatives assessment and identification of possible supply chain issues (technical/economic/regulatory) associated with using alternatives for those uses.

2. Identified critical uses of PFAS for Aerospace and Defense

2.1 Introduction

2.1.1 The WG5 member survey

A survey to collect information from WG5 members was developed for this, the phase 2 of the IAEG PFAS supply chain mapping assessment. The information gathered from the 'phase 1' mapping was used to conduct a more in-depth study on the use of PFAS uses across the whole supply chain, representing phase 2 of this work.

The approach followed was developed in discussion with the WG5 members, adapted from the 'standard preliminary assessment' supply chain mapping methodology used previously by WG5[9]. This section of the report presents the results from the mapping. It was considered that, due to the large number of PFAS CAS numbers covered by the proposed ECHA restriction, and the wide range of different uses these are likely to cover across the A&D sector, the questions in typical WG5 survey needed to be modified and expanded to collect the most relevant information to address the key research questions outlined in the previous section.

The questions in the survey were divided into three main sections:

1. Information on products[10]:
    - CAS number / substance name
    - Product name
    - Name/supplier of the product
    - Category of use (according to ECHA restriction)
    - Properties/functions that the product provides
2. Information on use of PFAS:
    - Specific (sub)sectors within A&D that these uses/products or formulations are used for
    - Following WG5 members' use of the product, is PFAS still present in the article delivered to the customer?
    - Was PFAS used to manufacture the product, but is no longer present in the product as received by the WG5 member?
3. Information on the supply chain:
    - Identity of the OEM (if known)
    - Where is the PFAS-based product sourced by the WG5 member?
    - Where is the PFAS-based product used by the WG5 member?

[9] IAEG, WG5. https://www.iaeg.com/workgroups/wg5/process

[10] For purposes of the survey, the term 'product' encompasses both 'formulations/mixtures' and 'articles'

- Are the products identified supplied for general industrial use or is their use always specific to A&D?

2.2 Summary of survey results

2.2.1 Overview of this assessment

This section of the report presents a summary of findings from the WG5 survey, with a particular focus on:

- High-level details about the survey responses from across the WG5 membership, for all products included in the responses (Section 2.2);
- Key insights into the key use categories of PFAS highlighted in the survey results (Section 2.3); and
- Identification of PFAS CAS numbers reported in the survey results (Section 2.4).

The analysis covers the inputs of all WG5 members that have provided responses to the survey. Since the inputs of the different individual WG5 members is strictly confidential, the results and insights presented in this summary report are provided without any identifying information on the responses of individual members.

2.2.2 Number of survey responses

In total, there were 11 responses to the phase 2 PFAS mapping survey from WG5 members, a similar number to the phase 1 survey (12).

2.2.3 Number of products/formulations

When all 11 WG5 member responses were compiled, the total number of products listed in the phase 2 survey (i.e. the total number of individual rows in the aggregated list) was **9,949**. The distribution of the number of responses among different WG5 members (i.e. the range of total products listed per WG5 member) was quite substantial:

- Lowest: 50 (approximately)
- Highest: 7000 (approximately)

In nearly all cases (>99%), WG5 members indicated that they believe there was a ‘known’ presence of PFAS in the reported products (see Table 2.1). These are indications based on the input of the WG5 companies and do not necessarily reflect the definite presence of PFAS in that product. In a small number of instances (3 products), the product was reported by a WG5 member to have ‘known’ presence of PFAS, but on further verification it did not in fact contain PFAS.

For 542 of the products in the survey indicated to have a ‘known’ presence of PFAS (approximately 5% of total products) no CAS number was indicated. This is not unexpected, because CAS numbers will typically not be reported when polymers (including PFAS fluoropolymers) are present in articles, for example.

For the products where WG5 members indicated ‘possible’ presence of PFAS, all (22) products did not have an indicated CAS number. Therefore it was not possible to confirm if PFAS was present or not in those products. Despite these uncertainties, the survey entries suggest that the vast majority (>95%) of products indicated by WG5 members in the survey responses contain PFAS (either polymeric or non-polymeric).

Table 2.1 Indicated presence of PFAS from WG5 survey responses

	Number of products	%
Known	9,868	99.2%
Likely	12	0.1%
Possible	20	0.2%
Not present/ unknown/blank	49	0.5%

2.2.4 Product standards / specifications

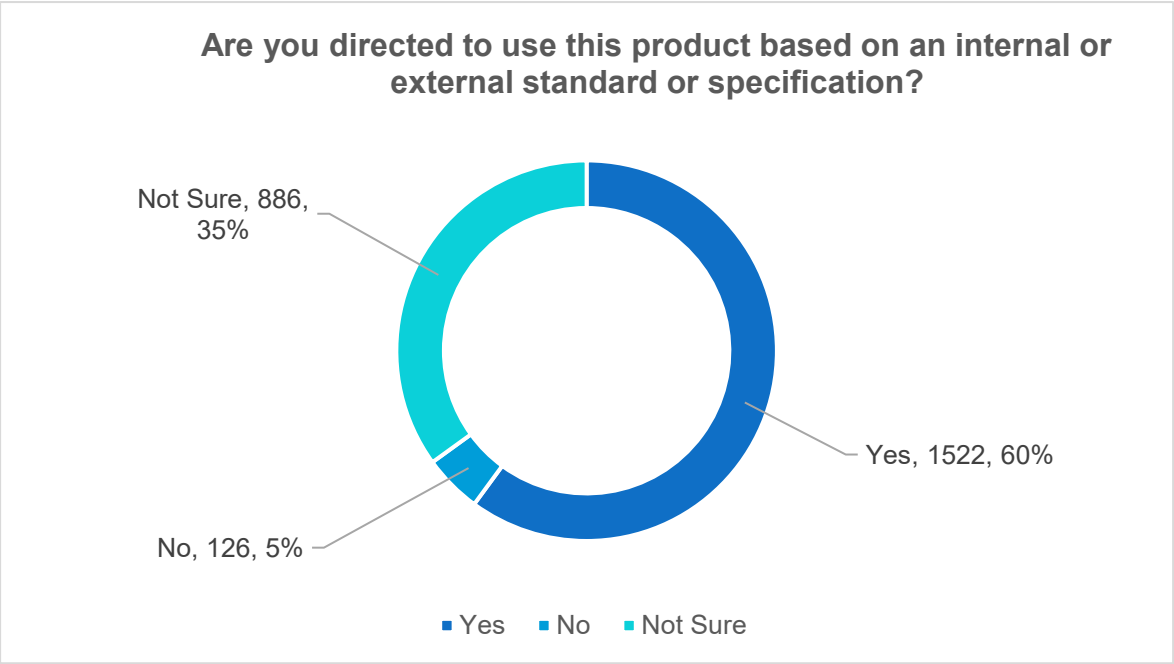
WG5 members were invited to indicate if they are directed to use each PFAS-based product based on an internal or external standard or specification. The overall results from these responses are outlined in Table 2.2 and Figure 2.1.

For the majority of products (84%), this question was left blank or marked as 'not sure'. Of the products where a definitive response was provided, 60% (approximately 1500 products) were indicated as being used because of an internal or external standard or specification.

Table 2.2 Indicated application of standards/specifications

Are you directed to use this product based on an internal or external standard or specification?	Number of products	% (incl. blanks)	% (excl. blanks)
Yes	1,522	15%	60%
No	125	1%	5%
Not Sure	886	9%	35%
Blank	7,415	75%	60%

Figure 2.1 Indicated application of standards/specifications [based on 2,533 products] – excluding blanks



As shown in Table 2.3 and Figure 2.2 below, of the approximately 1,500 products that were indicated to have an applicable standard/specification, nearly half did not specify the type (48%), and a substantial proportion were listed as 'internal' to the company (WG5 member) (39%). Around 11% (162 total products) were indicated to have applicable 'external' standards.

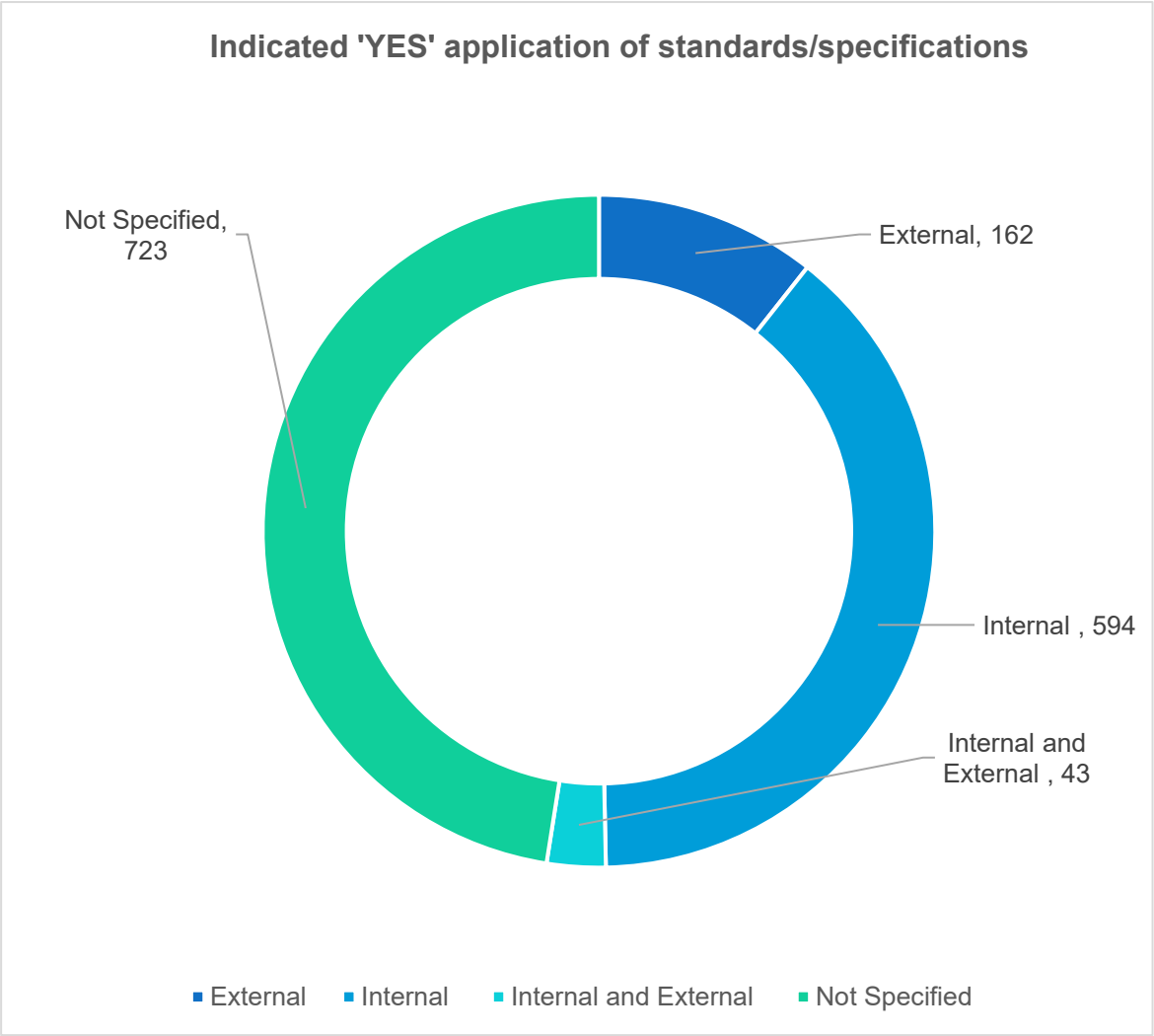
A wide range of different types of standards/specifications were mentioned across the product range identified in the WG5 survey responses. The most common occurrences included the following:

- SAE - Aerospace Material Specifications (AMS) standards
- SAE – Government and Defense (AS) standards
- MIL-DTL (Details)
- MIL-PRF (Performance Specification)
- ASTM standards

Table 2.3 Type of standards indicated by WG5 members

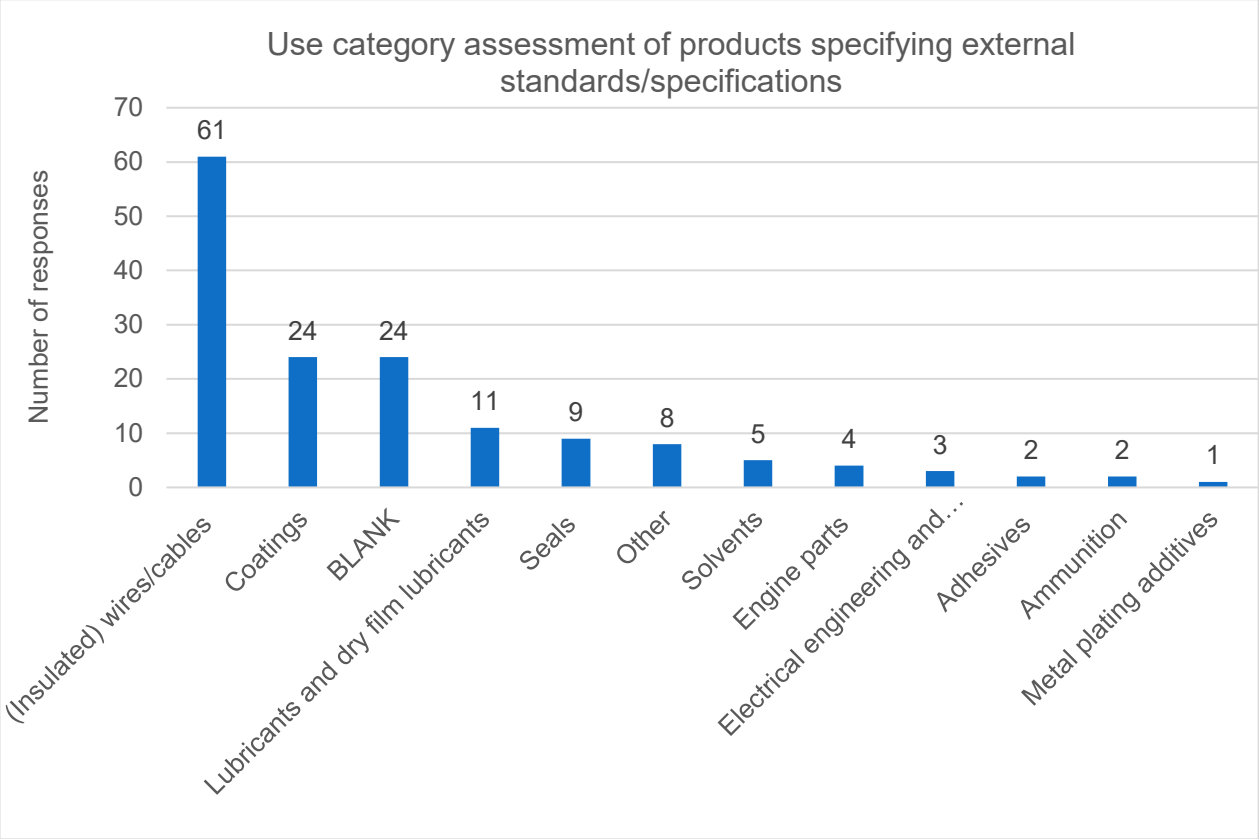
Type of standard	Number of products
External	162
Internal	594
Internal and External	43
Not Specified	723

Figure 2.2 Type of standards indicated by WG5 members



The products listed as being used based on an applicable external standard were also assessed for their product use category. An overview of the results of this assessment is provided in Figure 2.3. It can be seen from this that the use category with the most applicable external standards is insulated wires/cables. This is somewhat expected as this use category represents the majority of products listed in the WG5 survey (see Section 2.3 below), so the significance of this observation (in relation to the entire A&D sector) should be viewed with caution. It is also noted that coatings constitute a relatively large number of products for which an external standard applies. In some cases the product category was left 'BLANK' by a WG5 member; this does not necessarily mean that the information is unknown, just that it was not reported as part of this activity.

Figure 2.3 Use categories of products for which external standards/specifications apply



A further component of this assessment was to investigate the specific standards and specifications that have been mentioned in submissions to the ECHA consultation[11] This assessment contains detailed information proprietary to IAEG WG5 and as such is contained within a separate report available to IAEG WG5 member companies. A summary of the findings is presented in this white paper.

It must be noted that this was not a comprehensive analysis of all consultation responses, so the list obtained should not be seen as exhaustive. However, none of the specific standards/specifications were observed in the list extracted from ECHA consultation responses.

Of the 162 responses for products that indicate 'yes' to being directed to use an external standard, a total of 124 individual standards are identified, with some standards covering multiple products. 29 additional

[11] ECHA (2023). PFAS consultation responses for 2023 consultation. https://echa.europa.eu/restrictions-under-consideration/-/substance-rev/72301/term

external standards (covering 37 products) were identified from the 'not sure' responses or those that were left blank, when indicating the use of external standards.

Some standards/specifications identified in the ECHA consultation responses could be relevant to A&D uses of PFAS. For example, some specific standards (from within the range of ASTM, SAE, or MIL-SPEC standards that are known to apply to A&D) highlighted in the ECHA consultation responses include:

- ASTM D26 - Halogenated organic solvents and fire extinguishing agents
- SAE AS4372C - Performance requirements for wire, electric, insulated copper or copper alloy
- SAE AE-8A - Electrical wiring and fiber optic interconnect systems installation associated with aerospace electronics and electrical systems
- SAE AS6271 - Halocarbon clean agent hand-held fire extinguisher (establishes minimum requirements for extinguishers on board civil aircraft)
- MIL-DTL-83528 REV E - Gasketing material, conductive, shielding gasket, electronics, elastomer, EMI/RFI general specifications. US Military detail specification for design requirements of conductive elastomers.

2.3 Assessment of PFAS uses

2.3.1 Breakdown of PFAS-containing products according to key categories

Polymeric vs non-polymeric PFAS

The WG5 member survey included a question inviting members to indicate whether the PFAS in the product or formulation are polymeric or non-polymeric.

It was agreed with the WG5 members that it would be preferable to base this distinction on an objective assessment of the classification of the corresponding CAS number for that PFAS (i.e. using the indication of polymeric vs non-polymeric, used in OECD database of CAS numbers). The split of polymeric vs non-polymeric PFAS across the products indicated in the WG5 member survey responses is shown in Table 2.4 and Figure 2.4.

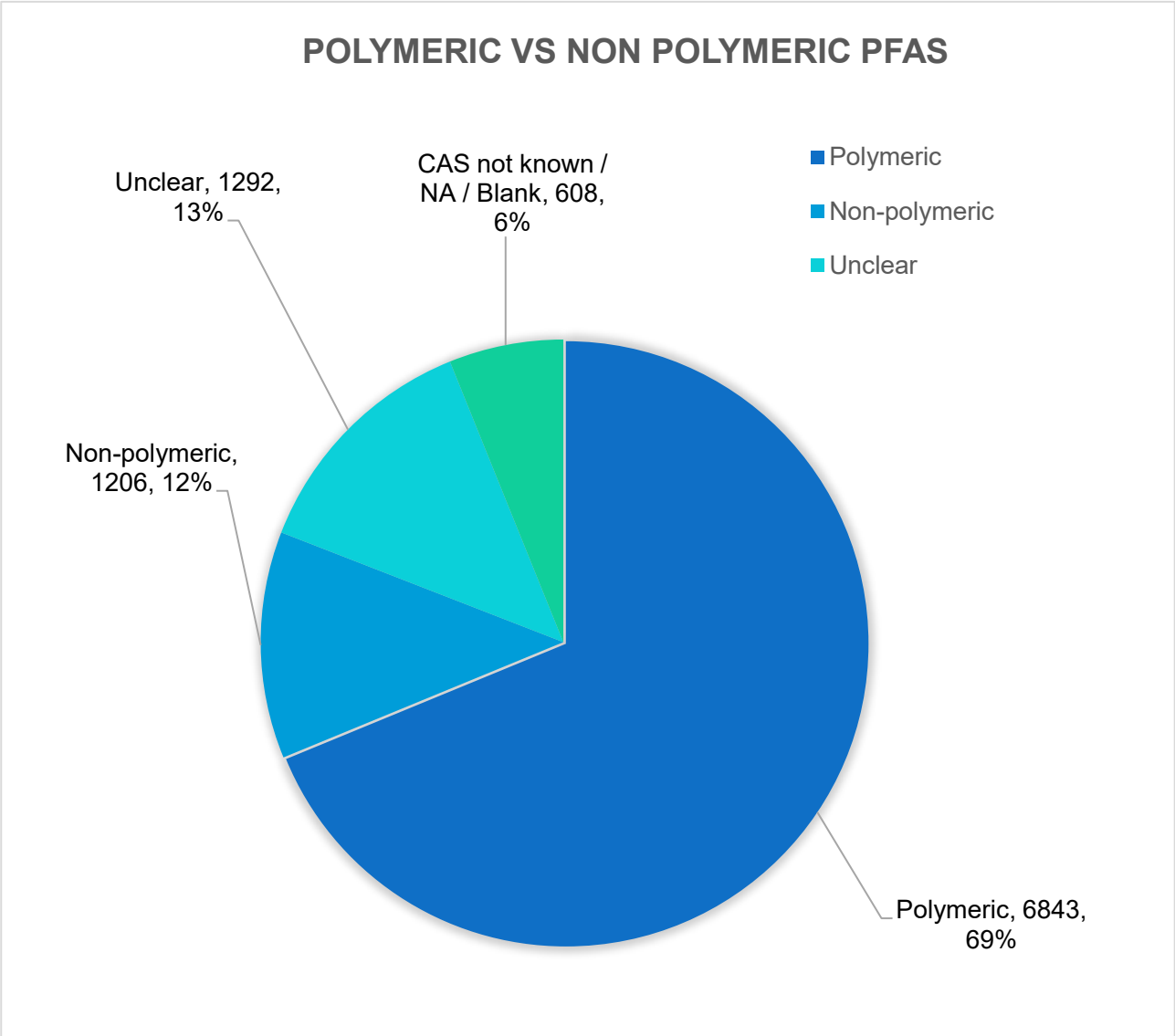
In many cases the distinction of polymeric vs. non-polymeric was listed in the WSP analysis to be 'unclear' as the CAS number is not on either the WG1 list[12] or the OECD list. In the vast majority of these 'unsure' designations, this is because the WG5 member survey response listed multiple CAS numbers for the product. In the majority (>90%) of these cases, these can be attributed to FKM and ETFE (see Section 3.4 for further discussion) used in articles. Therefore, these are considered, for the purposes of these results and further analysis to be polymeric PFAS. It can therefore be concluded that over 80% of the reported products from the WG5 survey contained polymeric PFAS.

Table 2.4 Indicated split of polymeric vs non-polymeric PFAS in products (based on the WG5 survey responses)

[12] WG1 PFAS CAS list. https://www.iaeg.com/workgroups/wg1/chemicalrpt/pfas

	Number of products	%
Polymeric	6,843	69%
Non-polymeric	1,206	12%
Unclear	1,292	13%
CAS not known / NA / Blank	608	6%
TOTAL	**9,949**	**100%**

Figure 2.4 Indicated split of polymeric vs non-polymeric PFAS in products



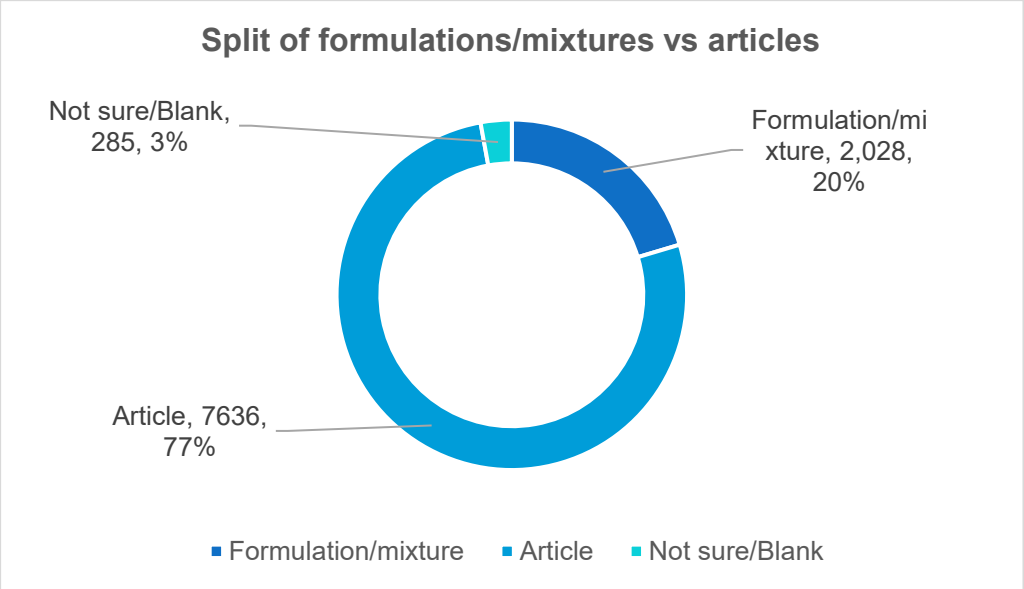
Formulations/mixtures vs articles

For the majority of the products listed in the survey responses (77%) it was indicated that the products were articles, with a smaller proportion (20%) of products being formulations/mixtures. It must be emphasised that these results are based on each WG5 member's own assessment, based on two broad 'categories' of product, as specified in the survey question. Results should be interpreted with some degree of caution. In some cases, it is possible the products themselves will not actually be mixtures, but could be (unmixed) substances. It has not been feasible to investigate this further in this assessment.

Table 2.5 Indicated split of formulations/mixtures vs articles (including blank/not sure responses)

	Number of products	% (including blanks)	% (excluding blanks)
Formulation/mixture	2,028	20%	21%
Article	7,636	77%	79%
Not sure/blank	285	3%	-

Figure 2.5 Indicated split of formulations/mixtures vs articles (excluding blank/not sure)



2.3.2 Specific (sub)sectors of use within A&D

Overview of A&D subsectors

WG5 members indicated if the listed products were used in different sub-sectors within the A&D industry (civil, military[13], defense[14], and space applications). The number of products indicated for each of these sub-sectors is shown below in Table 2.6 and Figure 2.6. In many instances, there were indicated to be multiple applicable sub-sectors for the same product, hence the total number of responses listed is greater than the overall total number of all products under each sub-sector.

In terms of the number of WG5 members, the number of member companies reporting use of products in the different subsectors were as follows:

- Civil (8)
- Military (6)

[13] Military uses were defined as: used by a Ministry of Defense (MOD) customer (i.e., DoD, MoD, army, etc).

[14] Defense products were defined as: Commercial products used for defense but not necessarily a military customer. Examples could include border forces, police or security forces and communications infrastructure.

- Defense (8)
- Space (2)

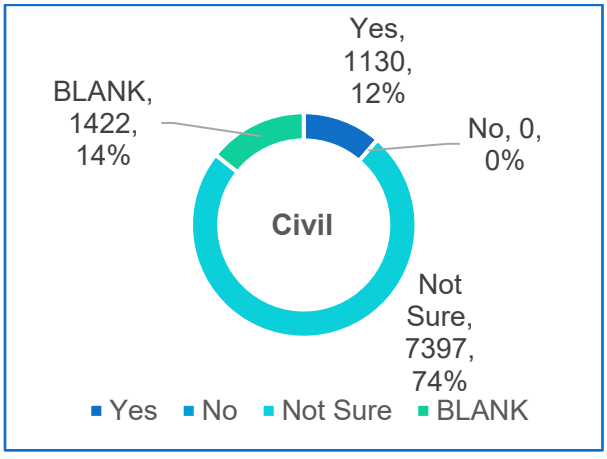
Most of the products identified by WG5 members in the survey were indicated to be used in military (75%) or defense (85%) applications. Fewer products (just over 11%) were identified to be used civil uses but, for the majority of products, the responses indicated 'not sure' or were left blank. Relatively few of the products identified (2%) were indicated to be used for space applications. It is emphasised that this distribution is based on the specific WG5 member companies that responded to the survey (which varied in terms of level of detail) and should not be seen as being representative of the whole A&D sector.

A discussion of specific use categories relating to the different sub-sectors within the A&D sector is provided in Section 2.3.4 below.

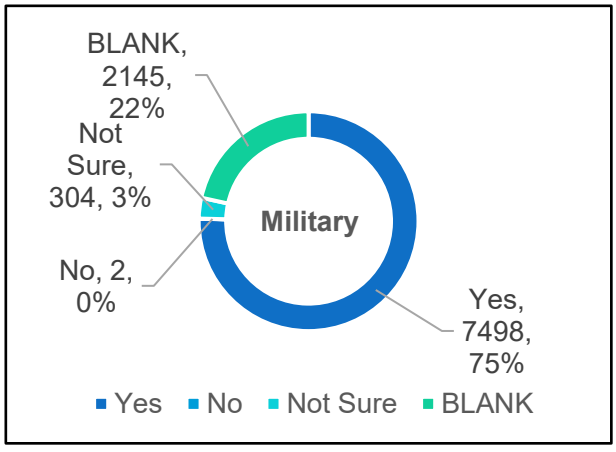
Table 2.6 Indication of the number products used in different A&D sub-sectors

	Civil	Military	Defense	Space
Yes	1,130	7,498	8,434	204
No	0	2	51	7,239
Not Sure	7,397	304	298	481
Blank	1,422	2,145	1,166	2,025

Figure 2.6 Indication of the number of products used in different A&D sub-sectors, (a) civil, (b) military, (c) defense, (d) space.

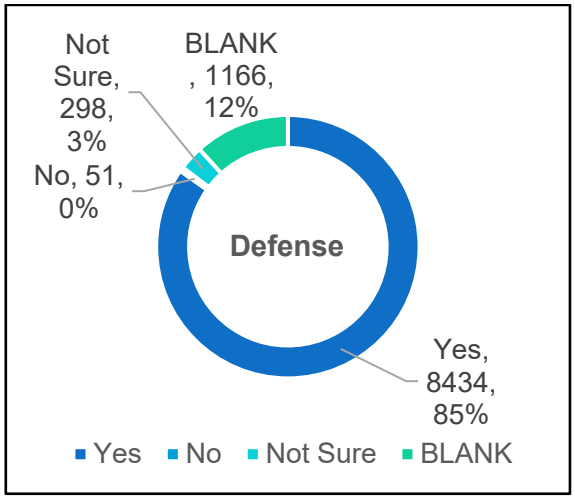


a

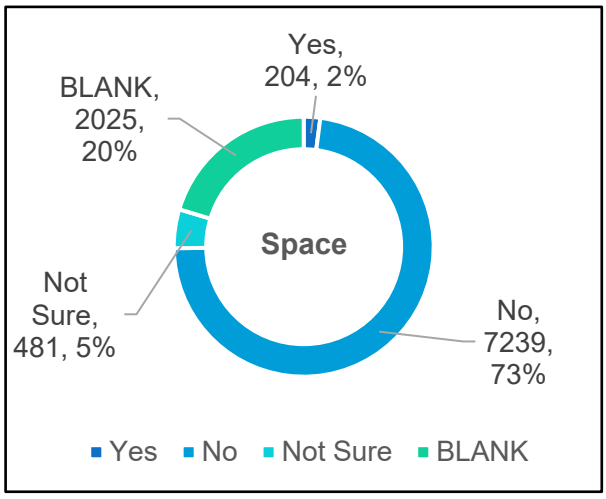


b

c



d



Products with multiple sub-sectors

As mentioned above, for many of the products listed in the WG5 survey, multiple sub-sectors are applicable, so additional analysis was undertaken to investigate those products and where products apply to multiple A&D subsectors. An overview of the number of products applicable to two different sub-categories is provided in Table 2.7 below.

Table 2.7 Indication of the number products used in multiple A&D sub-sectors

AND	Civil	Military	Defense	Space
Civil	-	78	435	110
Military		-	7430	1
Defense			-	204
Space				-

Civil uses

Table 2.7 indicates that, of the 1,130 products reported by WG5 members to be used in civil applications, 78 (7%) are also used for military applications, 435 (38%) are also used for defense applications, and 110 (18%) also for space applications. There is therefore not indicated to be a substantial overlap between the use of PFAS-containing products in civil aviation and use in other A&D sub-sectors.

Military uses

Of the 7,498 products reported by WG5 members to be used in military applications, 78 (<1%) are also used for civil applications, 7,430 (99%) for defense applications, and 1 (<0.01%) for space applications. There is clearly an overlap between the use of PFAS-containing products in military uses and in and defense uses but not with civil or space uses.

Defense uses

Of the 8,434 products reported by WG5 members to be used in defense applications, 435 (5%) are also used for civil applications, 7,430 (88%) for military applications, and 204 (2%) for space applications. There

is clearly an overlap between the use of PFAS-contain products in defense uses with military and space uses but less so with civil uses.

Space uses

Of the 204 products reported by WG5 members to be used in space applications, 110 (54%) are also used for civil applications, 1 (0.5%) for military applications, and 204 (100%) for defense applications. This indicates there is a clear overlap between space and defense uses, some overlap with civil uses and no substantial overlap with military uses.

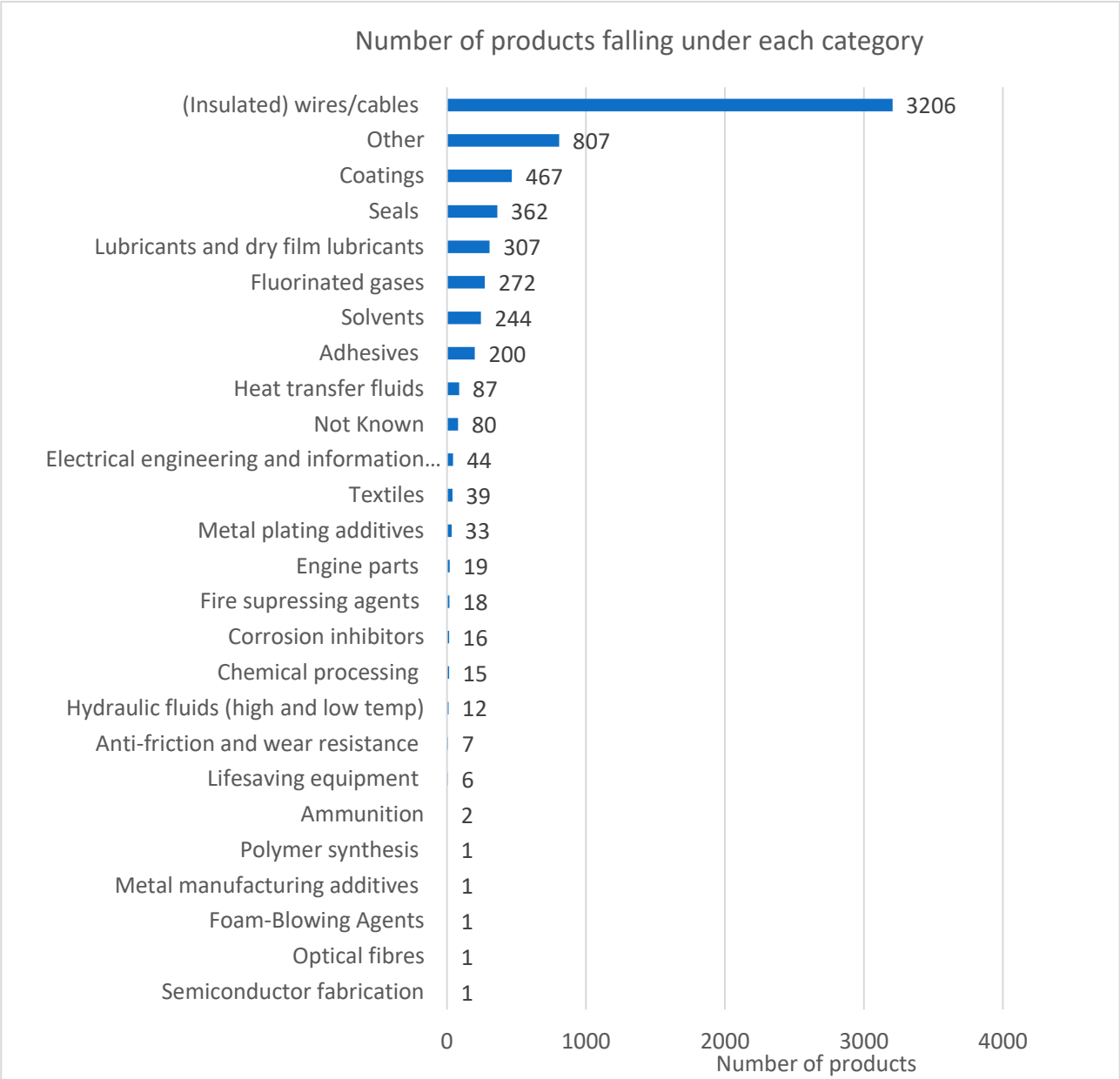
2.3.3 Assessment of use categories for PFAS in A&D

Use categories by product numbers

The use categories of PFAS (based on the use categories referred to in the ECHA restriction proposal) for the PFAS-containing products have been investigated in the WG5 survey responses.

An overview of key use categories, according to the number of products indicated, is provided in Figure 2.7. In terms of the number of products assigned to different use categories, the results are impacted largely by the relatively large number of responses from one member company. In order to investigate uses from a more representative view across the A&D sector uses were investigated in terms of the number of WG5 members reporting use of products in those use categories (see below).

Figure 2.7 Number of products according the PFAS use categories



Use categories by WG5 members

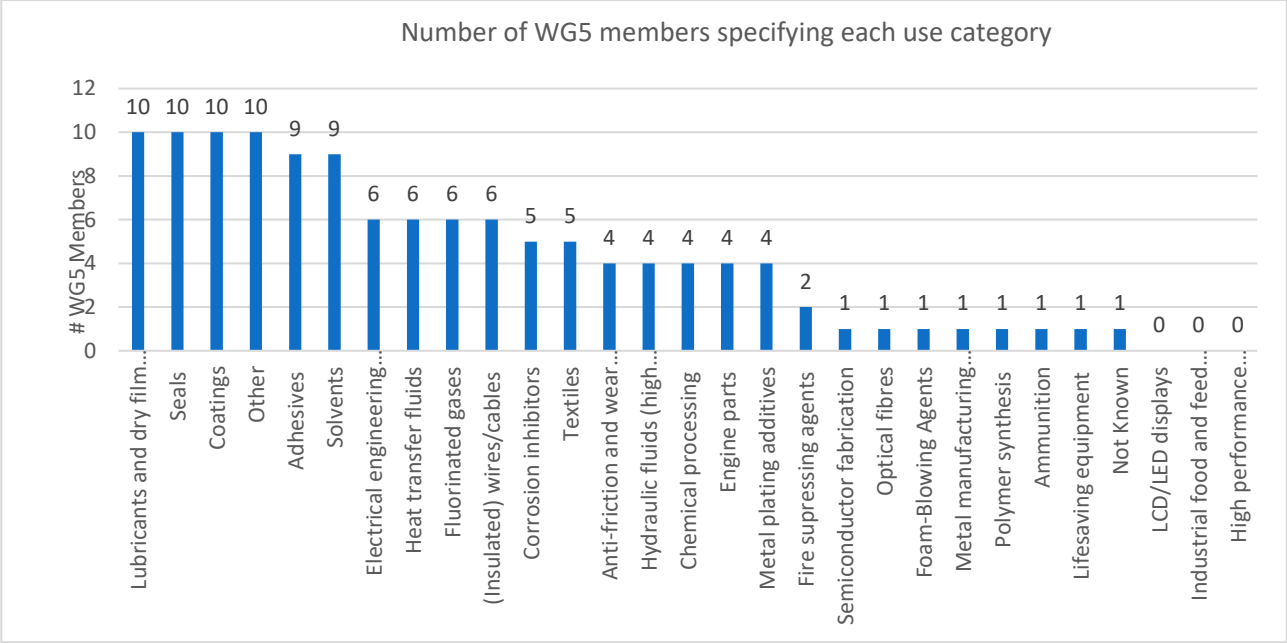
The key use categories of PFAS, according to the number of WG5 members that reported at least one product falling into each use category, have been investigated from the survey results. An overview of key use categories, according to the number of WG5 members, is shown in Figure 2.8. A comparison between the results of the phase 1 and phase 2 survey is provided. From these results, there is generally very good agreement between this phase 2 mapping and the previous phase 1 mapping on the main use categories highlighted by most WG5 members.

The key use categories identified include (indicating the number of WG5 members from the phase 2 survey):

- Lubricants and dry film lubricants (10 WG5 members)

- Seals (10)
- Coatings (10)
- Electrical engineering and information technology products (6)
- (Insulated) wires/cables (6)

Figure 2.8 Number of WG5 members indicating use of products under specific PFAS use categories



A number of use categories are reported by a greater number of WG5 members in this phase 2 assessment, compared to the phase 1 mapping. These include:

- Solvents (9 WG5 members compared to 5 in the phase 1 mapping)
- F-gases (6, previously 3)
- Heat transfer fluids (6, previously 3)

A number of uses were not explicitly covered in the Phase 1 mapping, hence there is no comparison available for the Phase 2 mapping results. These include, for example, adhesives, ammunition and engine parts.

2.3.4 'Other' uses identified

10 WG5 members (out of 11 responses) have reported products with 'other' listed as the use category. These 'other' uses represent a total of 807 products (8% total products[15]).

An overview of the 'other' uses, according to the number of products indicated, is shown in Figure 2.9. Figure 2.10 shows 'other' use categories with more than one WG5 member with at least one product under that category.

[15] This represents 13% of products if 'blank' responses are excluded.

These figures indicate that:

- By number of products, the ‘other’ uses are dominated by mould release (for composites or other plastics) and composite release films.
- There are relatively few ‘other’ sub-categories reported by multiple WG5 members. In most cases these are defined by one WG5 member only. It must be noted that there was no applied (consistent) ‘definition’ for the ‘other’ uses specified so it is possible that ‘other’ use categories highlighted by different WG5 members could apply to the same type of use, albeit with different descriptions.

Figure 2.9 Number of products listed with 'other' uses

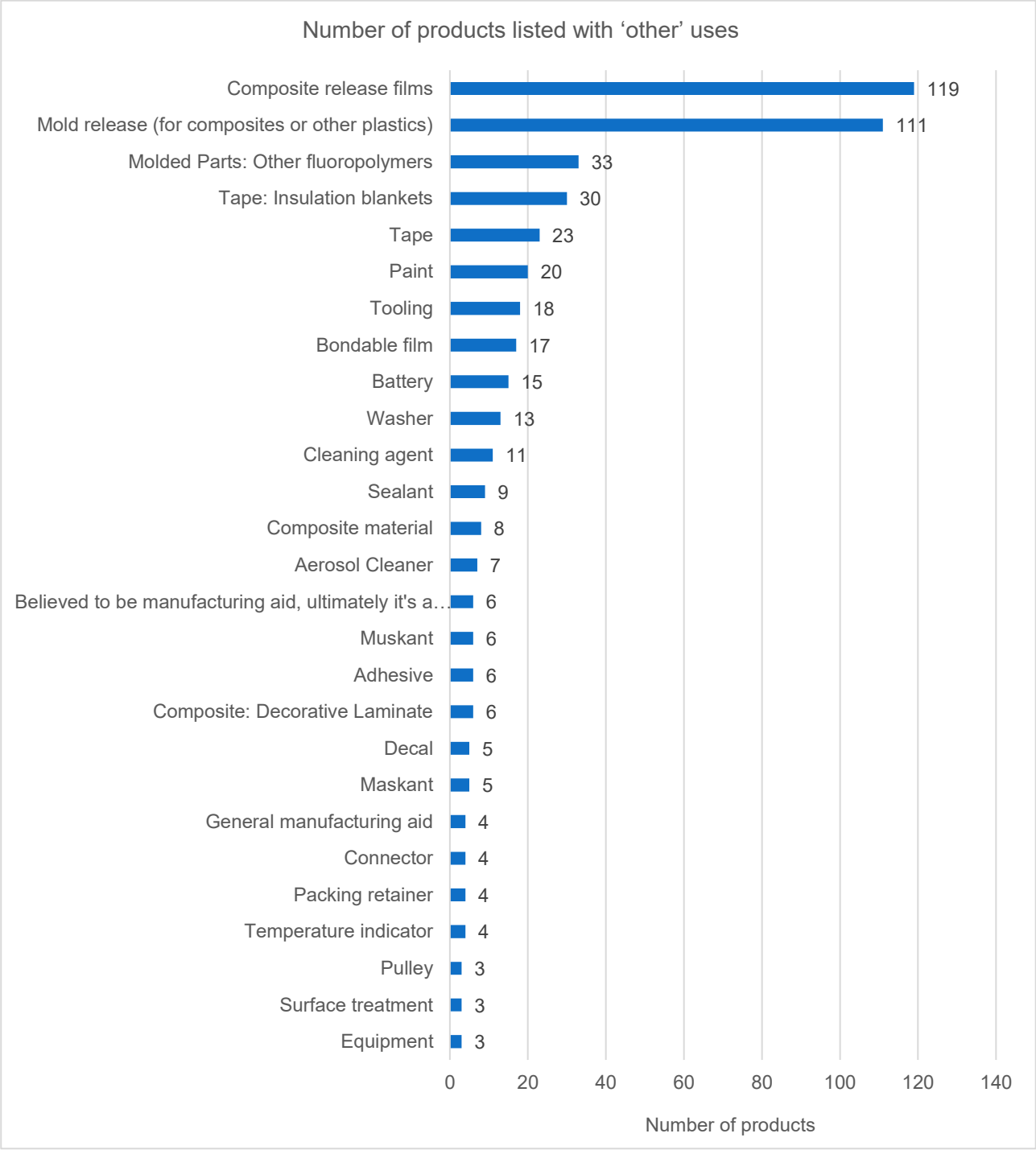
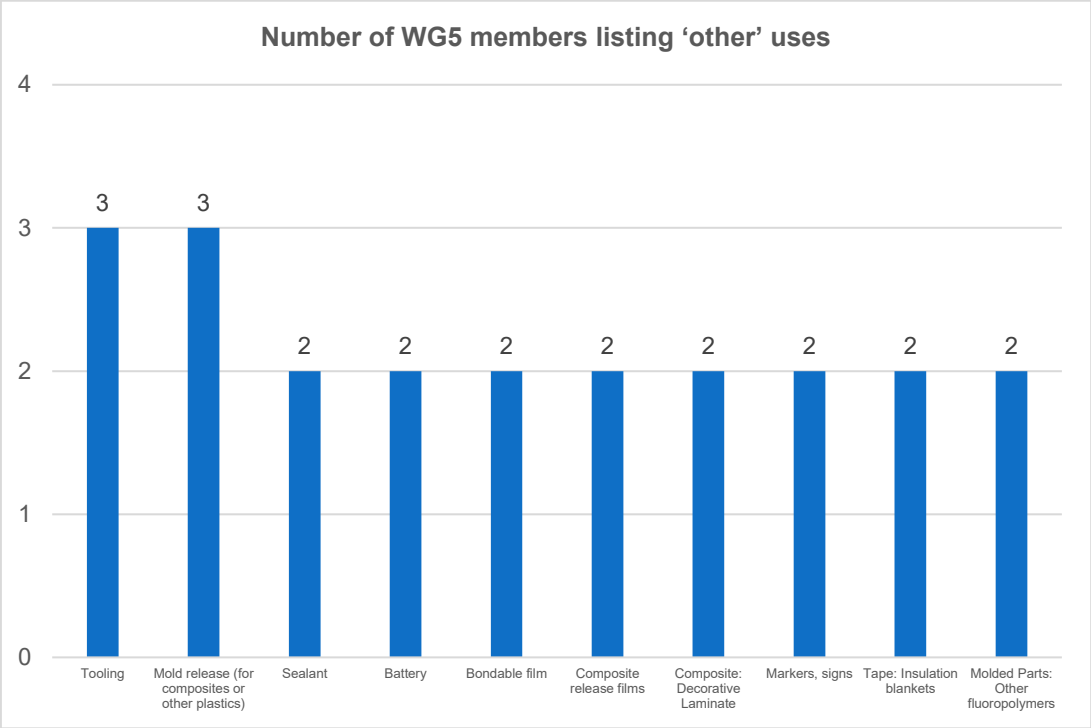


Figure 2.10 Number of WG5 members listing 'other' uses



2.3.5 Uses according to different A&D subsectors

As discussed in Section 2.3.2, an assessment has been made of the different products used in the four key sub-sectors of use within the A&D industry (civil, military, defense and space). In this section, the key use categories that are associated with each of these four sub-sectors are investigated.

Civil uses

- The key use categories for PFAS in civil aerospace uses (on the basis of the number of products) are shown in Figure 2.11.

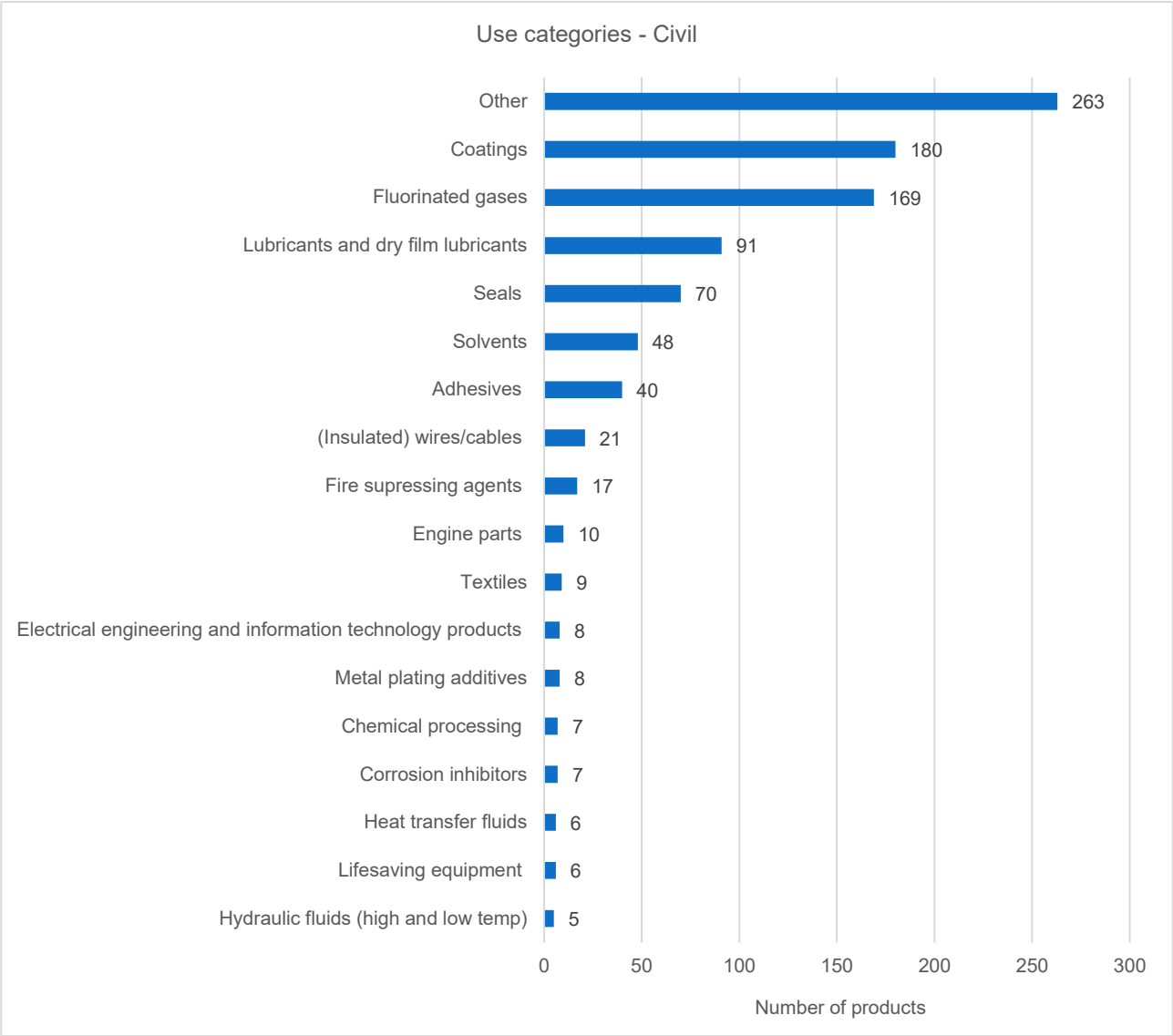
Figure 2.11 Within the 1130 products indicated for 'civil' uses, the key use categories (those with 50+ products) included:

- Coatings (180)
- F-gases (169)
- Lubricants (91)
- Seals (70)

263 products in the civil subsector were indicted to have an 'Other' use category. The specific uses under 'other' for civil uses were dominated by:

- Mould release (for composites or other plastics) (47)
- Composite release films (38)
- Paint (19)
- Tape (17)

Figure 2.11 Key use categories – civil



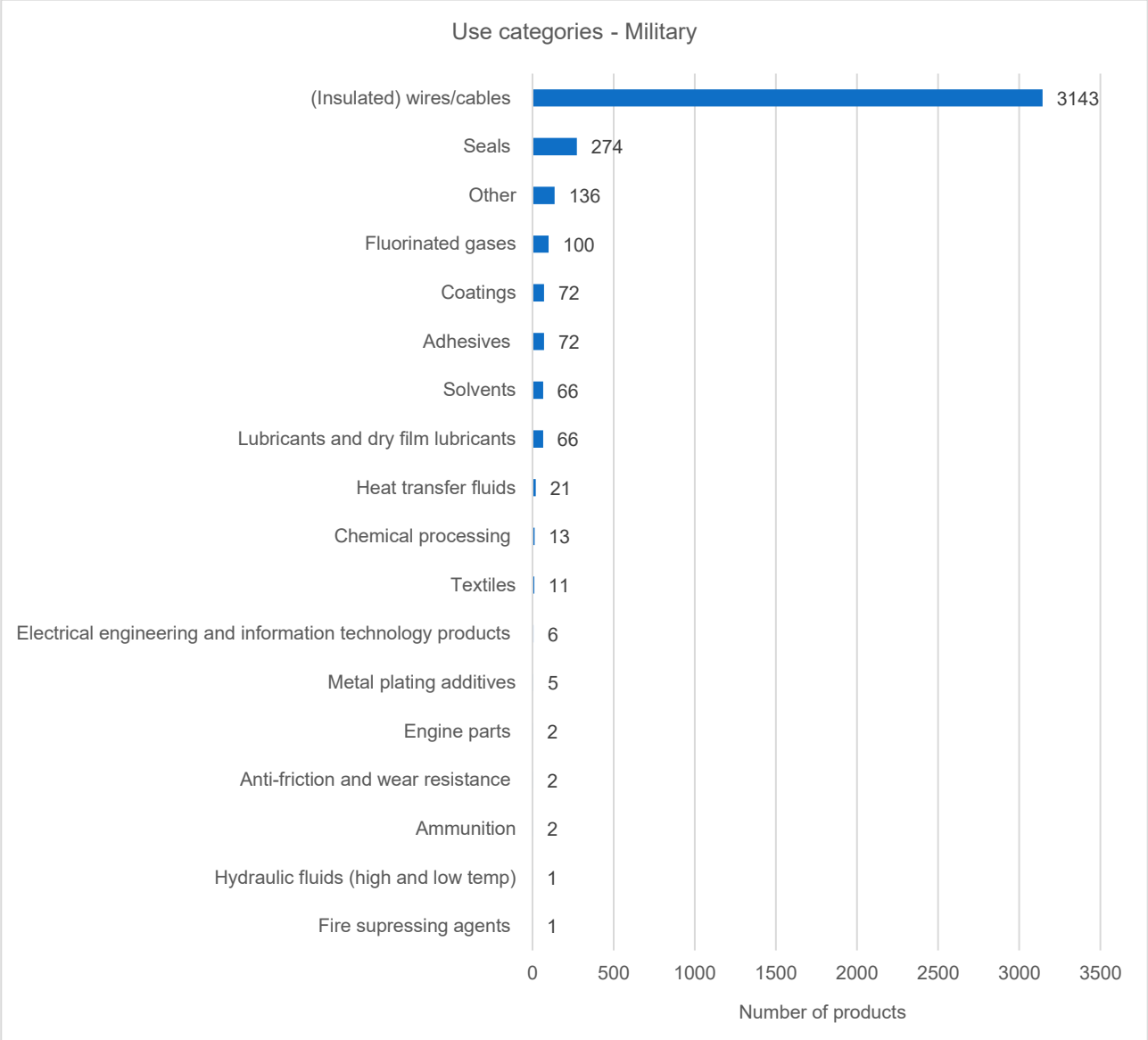
Military uses

The key use categories for PFAS in military A&D uses (on the basis of the number of products) are shown in Figure 2.12. It is clear the dominant use category for the military sub-sector is insulated wire/cables (3505 products). The next largest contributors (i.e. those with 50+ products) are:

- Seals (274)
- Other (136)
- Fluorinated gases (100)
- Coatings (72)
- Adhesives (72)
- Solvents (66)
- Lubricants and dry film lubricants (66)

Of the 'other' uses within the military sub-sector, that majority (70%) did not provide further details on the specific use.

Figure 2.12 Key use categories – military



Defense uses

The key use categories for PFAS in defense A&D uses (on the basis of the number of products) are shown in Figure 2.13. It is clear the dominant use category for the defense sub-sector is insulated wire/cables. The next largest contributors (i.e. those with 50+ products) are:

- Coatings (327)
- Seals (292)
- Solvents (128)
- F-Gases (108)
- Lubricants and dry film lubricants (105)

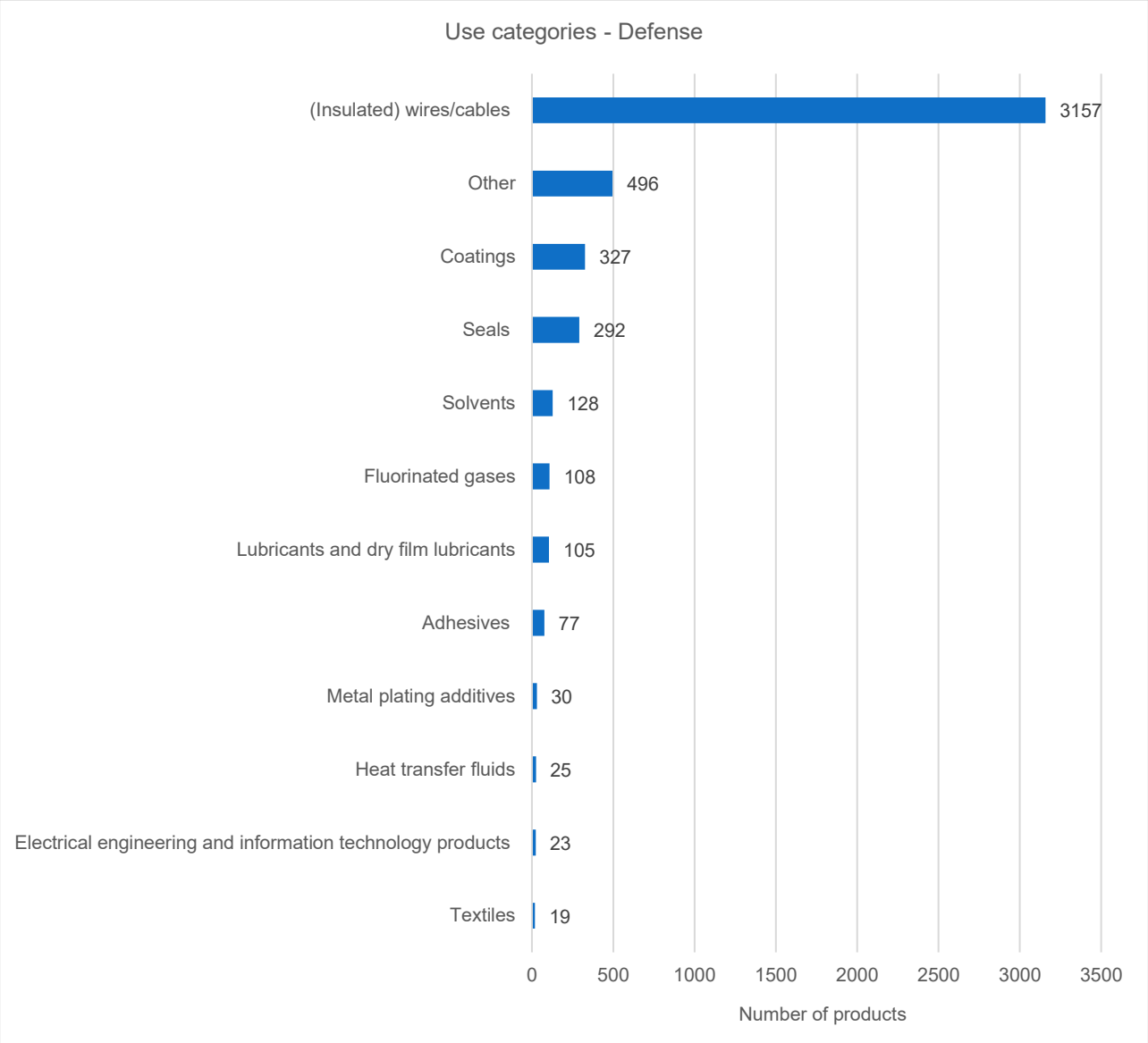
- Adhesives (77)

496 products in the defense subsector were indicted to have an ‘other’ use category. The specific uses under ‘other’ for defense were dominated by:

The category of ‘other’ uses within the defense sub-sector is dominated by:

- Composite release films (109)
- Mould release (for composites or other plastics) (108)
- Tape: Insulation blankets (30)
- Moulded Parts: Other fluoropolymers (28)

Figure 2.13 Key use categories – defense



Space uses

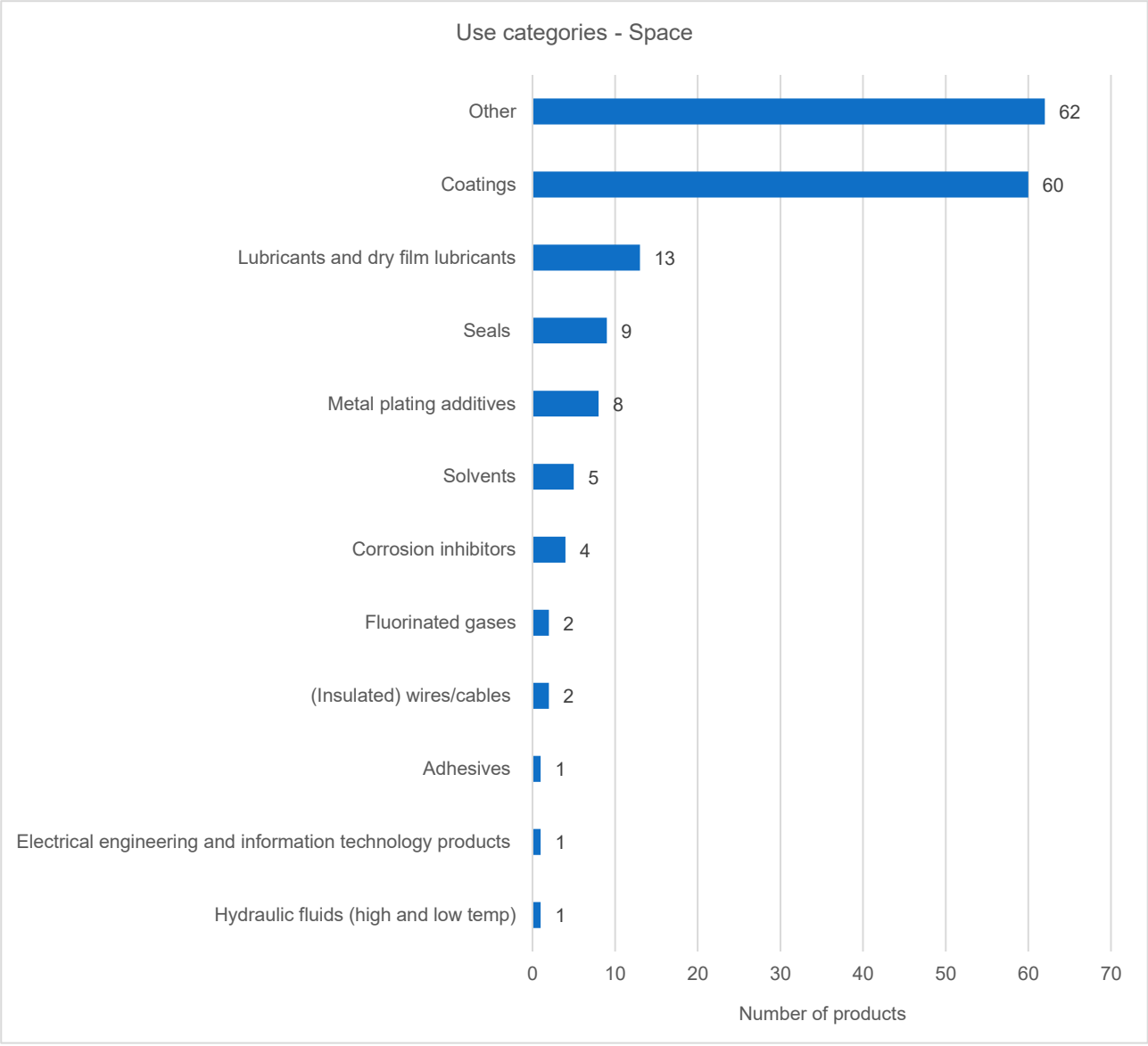
The key use categories for PFAS in space A&D uses (on the basis of the number of products) are shown in Figure 2.14. Within the 204 products indicated for 'civil' uses, the key use categories (i.e. those with 50+ products) included:

- Other (62)
- Coatings (60)

The category of 'other' uses within the space sub-sector is dominated by:

- Composite release films (20)
- Mould release (for composites or other plastics) (12)

Figure 2.14 Key use categories – space



2.4 Assessment based on CAS numbers

2.4.1 Overview

This study has included more detailed collection of information from WG5 members to identify specific PFAS with specified CAS numbers present in the products listed in the survey responses. This represents an important extension of the supply chain mapping assessment from the phase 1 study.

In this section, the results of the WG5 survey are investigated, with regards to the PFAS with specified CAS numbers that were identified. This includes:

- An indication of how many/what proportion of reported products had identified CAS numbers;
- A cross reference of CAS numbers against key lists/databases to indicate if these fall within the scope of regulatory coverage in different geographic regions (e.g. under TSCA and the EU REACH restriction proposal);
- Mapping CAS numbers with PFAS use categories relevant to A&D; and
- Identifying 'priority' CAS numbers i.e. identifying common PFAS CAS numbers that are indicated to be particularly prevalent, both in terms of number of products identified, and the number of WG5 members using them.

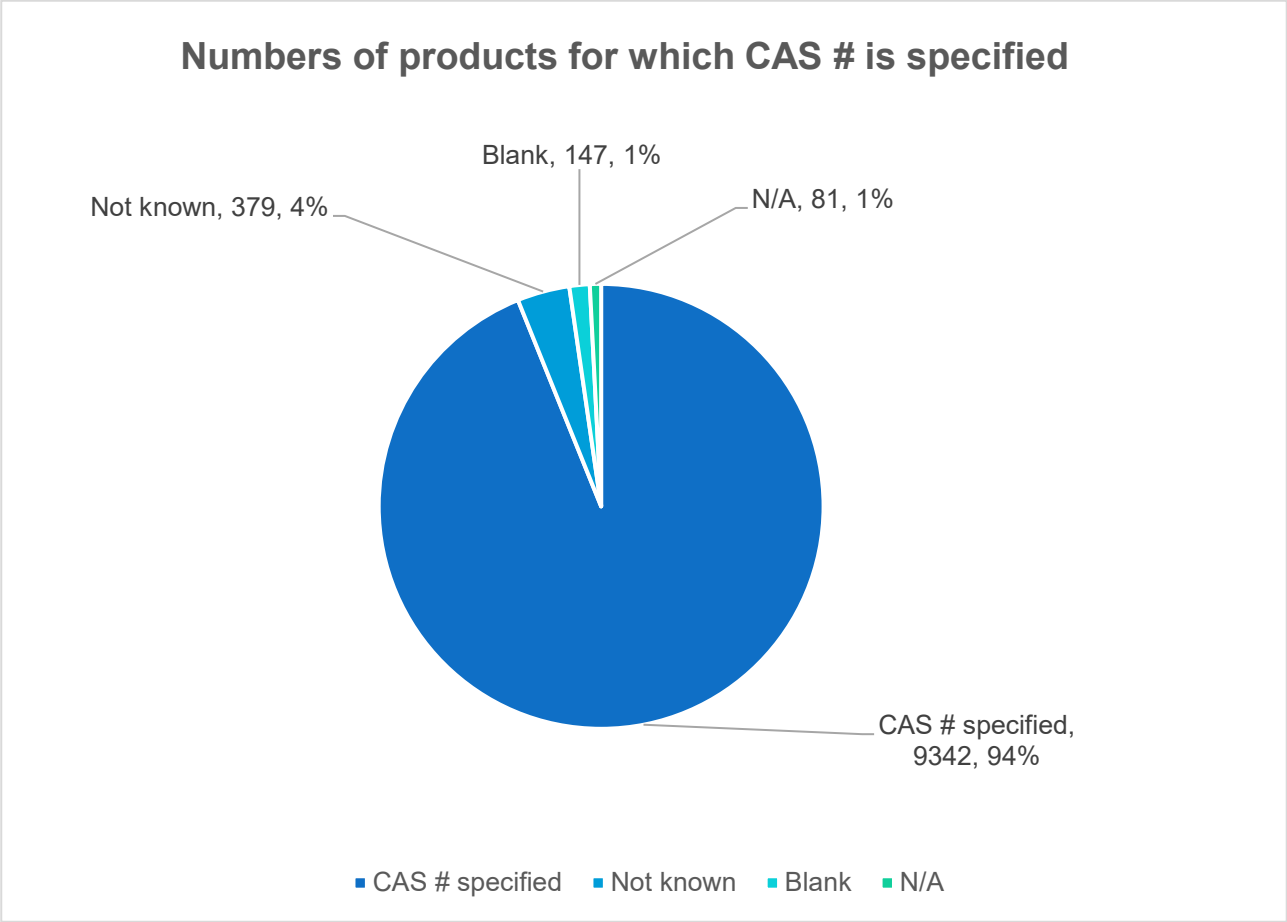
2.4.2 Overview of reporting on CAS numbers

The vast majority of products (94%) listed in the WG5 survey submissions specified a CAS number (see Table 2.8 and Figure 2.15). This indicates that the WG5 member companies providing data were able to conduct more targeted searches of their products to investigate where PFAS are being used in their supply chains.

Table 2.8 Numbers of products for which CAS number is specified

Products for which CAS number is specified	Number	Percent
CAS number specified	9342	94%
Not known	379	4%
Blank	147	1.5%
N/A	81	0.8%

Figure 2.15 Numbers of products for which CAS # is specified



2.4.3 CAS numbers identified

Across the 9,949 total products listed in the survey responses in the phase 2 mapping survey, a total of 149 different CAS number entries were listed (compared with 41 identified in the phase 1 mapping assessment).

In a number of cases (1288 products, 13% of all reported products), multiple CAS numbers were reported for the same product. Cross-reference with the WG1 trade name list shows that nearly all of these are attributed to:

- Ethylene tetrafluoroethylene, ETFE (1004 products, 10% of all products), and
- FKM (196 products, 2% of all products)

A total of 128 unique CAS numbers are identified in the survey entries. The number of CAS numbers identified in different PFAS types (polymeric vs non-polymeric) is shown in Table 2.9. The vast majority of CAS numbers identified in the A&D products/formulations listed in the survey are non-polymeric: approximately three times as many as polymeric PFAS. It should be noted that many polymeric PFAS will not be identifiable by CAS number, especially where they are present in final products.

The number of CAS numbers identified in different product categories (formulation/mixture vs articles) is shown in Table 2.9. The vast majority of CAS numbers identified in the A&D products/formulations listed in the survey are used in formulations/mixtures (approximately three times as many as in articles). In the case of product type, in some cases, products including the same CAS number have been listed under both the

article and the formulation/mixture categories (see below), hence the total number of CAS numbers presented in Table 2.10 & Table 2.9 is higher than the overall total CAS numbers identified in the survey.

Table 2.9 Number of specified CAS numbers by PFAS type

PFAS type	Number of CAS numbers
Polymeric	29
Non-polymeric	87
Not sure	12

Table 2.10 Number of specified CAS #numbers by product type

Product type	Number of CAS numbers
Formulation/mixture	113
Article	35
Not sure	5
Blank	30

2.4.4 Inclusion of CAS numbers on existing lists

Introduction to the approach

All (individual) CAS numbers reported by WG5 members in the survey results have been cross referenced against the various lists or databases of PFAS that are available. This includes a cross reference with the following sources:

- **OECD list**[16]. The OECD's global database of per- and polyfluoroalkyl substances (PFAS), which lists 4730 PFAS that fulfil the common definition of PFAS. This provides chemical substance information relating to each of the PFAS in this database.
- **TSCA List**[17]**.** The names and CAS numbers of the 613 PFAS identified by the US EPA as being relevant to the reporting requirements under TSCA (Section 8(a)(7) reporting and recordkeeping requirements).

[16] See https://www.oecd.org/en/topics/sub-issues/risk-management-risk-reduction-and-sustainable-chemistry.html

[17] US EPA, TSCA guidelines. https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/tsca-section-8a7-reporting-and-recordkeeping

- **WG1 CAS LIST[18].** A list of CAS numbers has been developed by WG1. The list identifies CAS numbers determined to be relevant to the A&D sector.
- **WG1 TRADE NAME LIST[12].** A list of trade names has been developed by WG1. The list identifies trade names of PFAS determined to be relevant to the A&D sector.
- **IAEG White Paper (PHASE 1).** The names and CAS numbers of the 41 PFAS identified in the phase 1 mapping assessment.
- **ECHA REACH restriction.** An indication (based on the OECD PFAS definition) as to whether the CAS number indicated will be subject to the proposed EU PFAS restriction.

Key insights from assessment of CAS numbers

The CAS numbers identified in the analysis of WG5 survey responses (as discussed in earlier sections), have been cross-referenced with the lists and databases mentioned above.

Key insights from the survey results include:

- All 41 CAS numbers identified in the phase 1 mapping were reported in the phase 2 mapping.
- Nearly all (125 of 128 reported CAS numbers) are confirmed to be PFAS according to the ECHA/OECD definition. Three of the CAS numbers reported are not identified as PFAS on that list. These cover only 3 products (<0.1% of all products listed).
- Most (121 of 128 reported CAS numbers) are confirmed to be on the WG1 list of CAS numbers and/or trade names. Several CAS numbers identified in the WG5 survey results were not in the list of CAS numbers provided by WG1. In some cases, this is because the CAS numbers are listed in combination, and do not appear in the WG1 list when considered individually.
- Not all CAS numbers are included in the OECD database (72 of 125). A total of 5,738 products (58%) of the products listed have CAS numbers that are on the OECD list.
- Most (80 of 128 reported CAS numbers) are confirmed to be on the TSCA reporting list. A total of 6481 products (65%) of the list products have CAS numbers on the TSCA list.

2.4.5 'Priority' CAS numbers

As outlined above, this assessment has aimed to highlight PFAS CAS numbers that are most common to the A&D sector, on the basis of the WG5 survey results. These are referred to in the report as 'priority' CAS numbers. Key 'priority' CAS numbers were identified in the analysis of WG5 survey results by considering the following criteria:

- *Any CAS number being used in at least one reported product/formulation by 6 or more WG5 members (i.e. the majority of respondents)*

  and/or

- *Any CAS number representing a large proportion (>2% of total reported) of products/formulations listed in the survey responses.*

[18] WG1. A&D CAS list. https://www.iaeg.com/workgroups/wg1/chemicalrpt/addsl

On this basis, 16 individual CAS numbers have been identified as 'priority' from within the WG5 survey results based on commonality of use[19]. These are shown below in Table 2.11, with an indication of the number (and percentage) of total products they are present in and the number of WG5 members using them. Nine of the identified most commonly reported CAS numbers are polymers, while seven are non-polymeric[20].

For each of these priority CAS numbers a 'fact file' has been produced which is available to WG5 members, highlighting the key information from the survey relating to that CAS number. With regard to the 'full' list of 9,949 products in the WG5 survey results, the 16 highlighted 'priority' CAS numbers represent[21] :

- **92%** of all formulations/products listed by WG5 members in the survey responses
- **97%** of the products containing polymeric PFAS
- **64%** of the of the products containing non-polymeric PFAS
- **98%** of reported articles
- **67%** of reported formulations/mixtures

Table 2.11 Priority CAS numbers identified

CAS Number	Chemical Name	Total number of products	Percentage of all products (%) [1]	Number of WG5 members	Polymeric PFAS?
9002-84-0	Polytetrafluoroethylene (PTFE)	4179	44.7%	11	Y
24981-14-4	Polyvinylfluoride (PVF)	1004	10.7%	8	Y
25067-11-2	Fluorinated ethylene propylene (FEP)	1004	10.7%	1	Y
24937-79-9	Polyvinylidene fluoride (PVDF)	641	6.9%	6	Y
25038-71-5, 68258-85-5	Ethylene tetrafluoroethylene (ETFE)	619	6.6%	8	Y

[19] One of the 'priority' CAS numbers highlighted here is polyvinylfluoride (PVF) (Tedlar). It is the understanding of WG5 that, because PVF has a CHF-CHF repeating structure, it does not meet the definition of PFAS in the context of the proposed EU REACH PFAS restriction. However, it has been included as part of the WG5 supply chain mapping as there may still be supply chain risks for these products, depending on specific actions of manufacturers and suppliers

[20] It should be noted that these 16 CAS numbers are identified as 'priority' only within the future scope of work for WG5 and not wider A&D industry activities.

[21] Excluding blank, NA and 'not sure' responses.

CAS Number	Chemical Name	Total number of products	Percentage of all products (%) [1]	Number of WG5 members	Polymeric PFAS?
98-56-6	1 chloro-4-trifluoromethyl benzene	295	3.2%	7	N
811-97-2	HFC-134a	212	2.3%	9	N
9011-17-0, 26425-79-6, 25190-89-0	Fluorine Kautschuk Material (FKM)	196	2.1%	1	Y
25190-89-0	Difluoroethene-hexafluoropropene-tetrafluoroethene terpoymer	124	1.3%	7	Y
138495-42-8	2H,3H-Perfluoropentane	89	1.0%	9	N
163702-07-6	Methyl-nonafluorobutyl ether	52	0.6%	9	N
163702-08-7	Methyl perfluoroisobutyl ether	46	0.5%	8	N
69991-67-9	Perfluoropolymethylisopropyl-ether	43	0.5%	6	Y
86508-42-1	Perfluoro compounds, C5-18	51	0.5%	8	N
60164-51-4	Perfluoralkylether	18	0.2%	7	Y
55120-75-7	Benzene, 1-chloro-4-(trifluoromethyl)	21	0.2%	6	N
All Others [130 CAS numbers)		748	8.0%	-	
BLANK / NA / NOT KNOWN		607	-	-	
TOTAL		**9949**			

[1] Excludes Blank/NA/Not Known

2.4.6 Articles vs formulations/mixtures

The distribution of the 'priority' CAS numbers between formulations/mixtures and articles (as indicated in the responses by WG5 responses) is shown in Table 2.12.

Table 2.12 Distribution of key CAS numbers between formulations/mixtures and articles

CAS	Chemical Name	Formulations /mixtures	Article	Not sure	Blank	Total
9002-84-0	Polytetrafluoroethylene (PTFE)	325	3774	8	72	4179
24981-14-4	Polyvinylfluoride (PVF)	53	945	0	6	1004
25067-11-2	Fluorinated ethylene propylene (FEP)	0	1004	0	0	1004
24937-79-9	Polyvinylidene fluoride (PVDF)	0	641	0	0	641
25038-71-5 68258-85-5	Ethylene tetrafluoroethylene (ETFE)	52	563	0	4	619
98-56-6	1 chloro-4-trifluoromethyl benzene	215	0	0	80	295
811-97-2	HFC-134a	205	1	0	6	212
9011-17-0, 26425-79-6, 25190-89-0	Fluorine Kautschuk Material (FKM)	0	196	0	0	196
25190-89-0	Difluoroethene-hexafluoropropene-tetrafluoroethene terpoymer	8	114	1	1	124
138495-42-8	2H,3H-Perfluoropentane	86	1	0	2	89
163702-07-6	Methyl-nonafluorobutyl ether	49	0	0	3	52
86508-42-1	Perfluoro compounds, C5-18	42	1	0	8	51
163702-08-7	Methyl perfluoroisobutyl ether	46	0	0	0	46

CAS	Chemical Name	Formulations /mixtures	Article	Not sure	Blank	Total
69991-67-9	Perfluoropolymethylisopropyl-ether	42	0	0	1	43
55120-75-7	Methanesulfonic acid, trifluoro-, calcium salt	20	0	0	1	21
60164-51-4	Perfluoralkylether	16	1	0	1	18
BLANK/NA/NOT KNOWN		294	251	8	54	607
						748
TOTAL		**1453**	**7492**	**17**	**239**	**9949**

From the results of the survey presented in this section, a clear correlation can be seen between articles and polymeric PFAS and between formulation/mixtures and non-polymeric PFAS. When the blanks/unsure responses are removed from the analysis of survey results, 92-100% of products with polymeric PFAS are associated with articles and 94-100% of products with non-polymeric PFAS are associated with formulations/articles.[22]

2.5 Summary and conclusions

Overview of results

Data for A&D PFAS uses has been collected and assessed in this report based on the inputs of 11 IAEG WG5 member companies. Collated together, these inputs provide information on approximately 10,000 individual products containing PFAS used in A&D applications. This number is highly influenced by the wide range in the number of products reported by different member companies. For example, to base the conclusions solely on how many products are applicable to specific uses / sub-sectors / CAS numbers, could risk skewing the results based on the input of one (or a small number of) companies. For this assessment, consideration has also been given to the number of WG5 members reporting, to gain an insight into the significance of the results (e.g. on PFAS uses, individual PFAS species, etc) across the broad WG5 membership.

PFAS Uses in A&D

Key use categories for PFAS within A&D have been identified and compared with the results from the phase 1 mapping study. Cross referencing the results on the basis of (a) number of products and (b) number of WG5 members – the most notable uses are: lubricants and dry film lubricants; seals; coatings; other; solvents; adhesives; electrical engineering and information technology products; (insulated) wires/cables;

[22] On the basis of the 16 'priority' CAS numbers. The ranges presented here indicate the range in percentage terms observed within those priority PFAS.

fluorinated gases. In general, 'other' uses appear to be dominated by mold release (for composites or other plastics) and composite release films. These uses have not been mentioned explicitly in the proposal for the PFAS restriction under EU REACH (see Section 4).

Further insight has been gained in the phase 2 mapping study (in comparison with the phase 1 mapping study) to investigate the use of PFAS in the different sub-sectors of A&D (civil/military/defense/space), including how these uses overlap. Based on the survey inputs, it has also been possible to investigate specific use categories that are significant to each sub-sector individually.

Assessment of products by CAS number

The phase 2 mapping survey has enabled a wider identification of specific PFAS CAS numbers used in A&D applications (more than three times as many as in the phase 1 assessment). In total 125 individual PFAS products with specified CAS numbers were identified from the WG5 survey results. A relatively small number of polymeric PFAS (29) are used in a relatively high proportion of the different products listed in the survey (>80%). Conversely, a relatively high number of non-polymeric PFAS (87) are used in a relatively low proportion of the different products listed in the survey (10%).

Key 'priority' PFAS were highlighted by considering (a): Any PFAS with an identified CAS number being used in at least one reported product/formulation by six or more WG5 members (i.e. the majority of respondents) AND/OR (b) Any such PFAS product (with an identified CAS number) representing a large proportion (>2% of total reported) of products/formulations listed in the survey responses. 16 individual CAS numbers have been identified as 'priority' from within the WG5 survey results, including both polymeric (9) and non-polymeric (7) PFAS. A strong correlation between polymeric PFAS and articles, and between non-polymeric PFAS and formulations/mixtures is noted.

Specifications and standards

For around 1,500 of the products used in A&D identified in the WG5 survey, members noted that they were directed to use the product because of associated 'external' standard or specification (e.g. SAE/AMS, MIL-DTL, MIL-PRF, ASTM). These were predominantly associated with cable/wiring and with coating applications. It is expected that the full list of standards/specifications extracted from the WG5 survey results is not an exhaustive or definitive list. It is notable that, when the ECHA consultation responses were assessed in terms of listed standards/specifications, the standards mentioned in the WG5 survey were not observed.

Remaining data gaps

While the results of this 'phase 2' of the PFAS mapping have enabled additional or further insights into the uses of PFAS in A&D, building from the 'phase 1' mapping work, several areas of uncertainty and data gaps remain. These include:

- Significant differences amongst WG5 members in terms of numbers of products identified. This may be attributed to differences in the methods and resources available to perform searches of PFAS-containing products, as well as differences in interpretation of questions.
- Differences amongst WG5 members in identification of product types (e.g. articles were dominant in some responses while formulations/mixtures dominated others). Overall, more data was provided relating to articles.
- There is continued lack of visibility of the use of PFAS further up the supply chain than tier 1 suppliers. Some use categories received very few responses (e.g. semi-conductors, metal

manufacturing additives, optical fibres) where it can be expected that PFAS may be used in their manufacture but not present in the final product.

- Relatively few responses to the survey (15%) provided an indication of whether products were used based on a standard or specification. The standards and specifications identified through the survey are expected to represent only a small proportion of all relevant standards that are relevant to the A&D sector.
- While the number of CAS numbers identified in this phase 2 study is substantially higher (approximately 3 times) than in phase 1, it is not expected this represents an exhaustive list and further investigation is needed to identify a wider range of PFAS that are relevant in A&D.

3. A&D supply chain

3.1 Introduction

As introduced in Section 2, the approach followed for this PFAS supply chain mapping study has been adapted from the 'standard' supply chain mapping methodology used by WG5[23]. This section of the report presents the results from the 'detailed assessment phase' of the mapping, involving data collection from individual formulators or suppliers.

The overall aim of the supply chain impact assessment is in line with the goals of WG5's standard supply chain mapping: To gather information on substances used in the sector and allow the WG5 members to better understand the risk associated with those substances, provide them with the insight needed to make informed decisions around the restriction of those substances (i.e. with reference to the proposed ECHA restriction, as well as other potential restrictions globally) and avoiding, or allowing earlier identification of, key supply chain risks associated with the restriction of those substances.

As previously stated in this report, the scope of this assessment is the proposed restriction of PFAS *as a group* under REACH, and the complexity of the assessment is significantly greater than for a relatively simpler list of specific chemical substances on a REACH Recommendation list for Authorisation. The information gathered from the WG5 survey (as presented in Section 2) has been used to inform this supply chain assessment.

The work carried out in IAEG WG5 is paid for by the members under the agreement that any sensitive formulation and supplier data that is shared is anonymised and remains within WG5 visible to the members that have contributed to the work. To maintain this, the supply chain data presented here is redacted to keep this level of confidentiality. Full data is available for those within IAEG WG5 and for those that join the group through IAEG.

3.2 Approach to supply chain impact assessment

3.2.1 Overview of approach to supplier engagement

The approach was to undertake targeted engagement with a sample of suppliers.

It was agreed that 10-12 key suppliers would be identified and they would be consulted directly.

3.2.2 Selection of suppliers

The selection was based on (a) how many different WG5 members each supplier provides products to (see Figure 3.1); (b) the number of PFAS use categories they cover (see Figure 3.2); and (c) how many of the 'priority' products (identified by CAS number) their products cover (see Figure 3.3).

[23] IAEG, WG5. https://www.iaeg.com/workgroups/wg5/process

Figure 3.1 Number of WG5 members supplied by different suppliers (includes all companies supplying 4 or more WG5 members) – supplier names have been removed as information is confidential to WG5

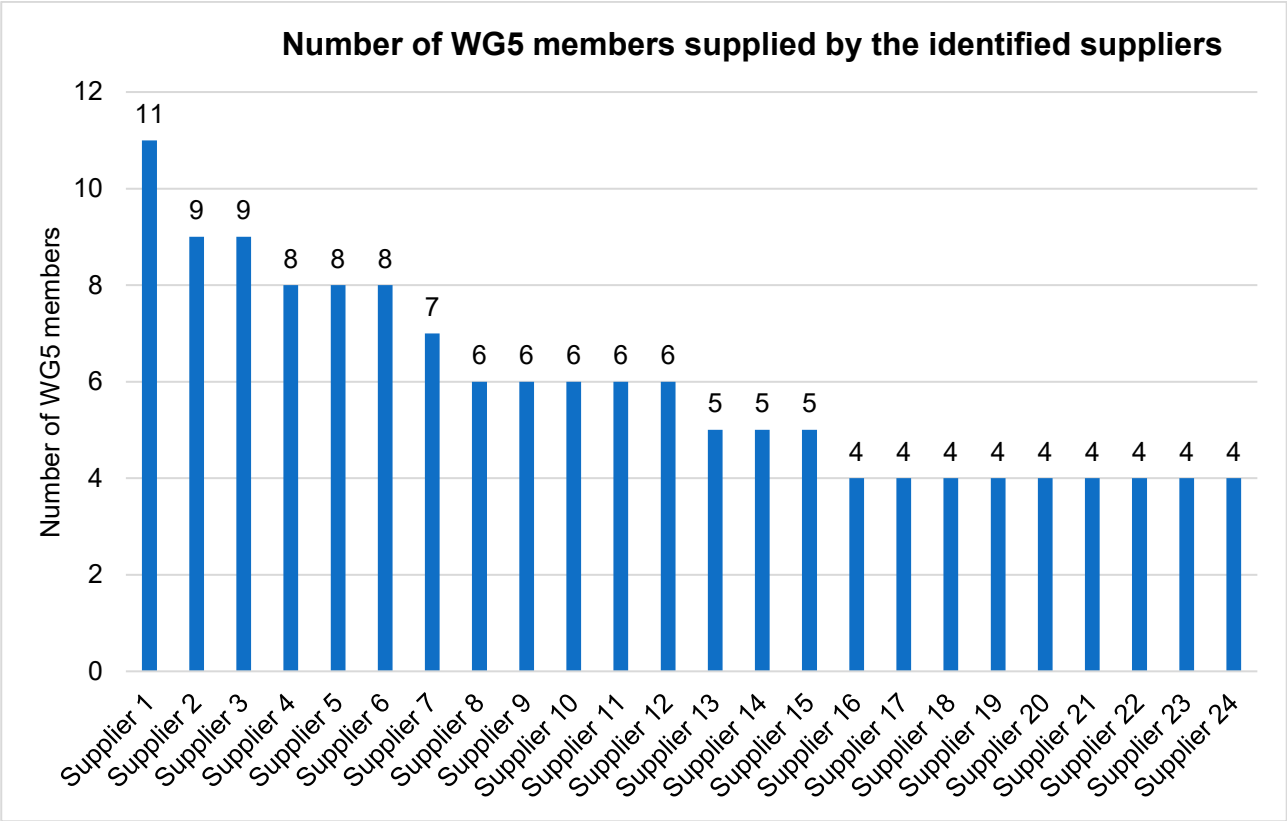


Figure 3.2 Number of PFAS use categories covered by a subset of the suppliers (includes all companies supplying products with 5 or more use categories) - supplier names have been removed as information is confidential to WG5

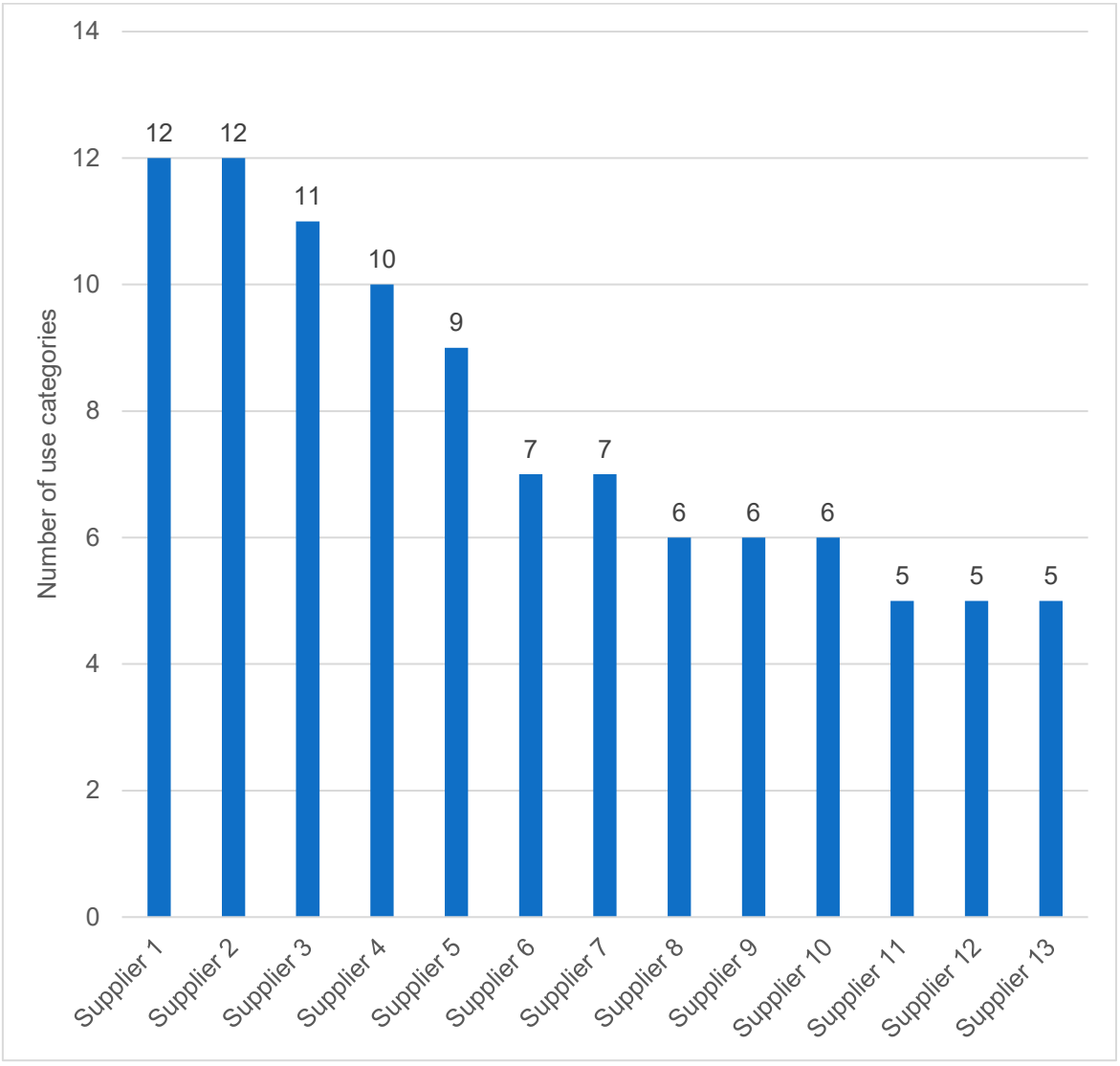
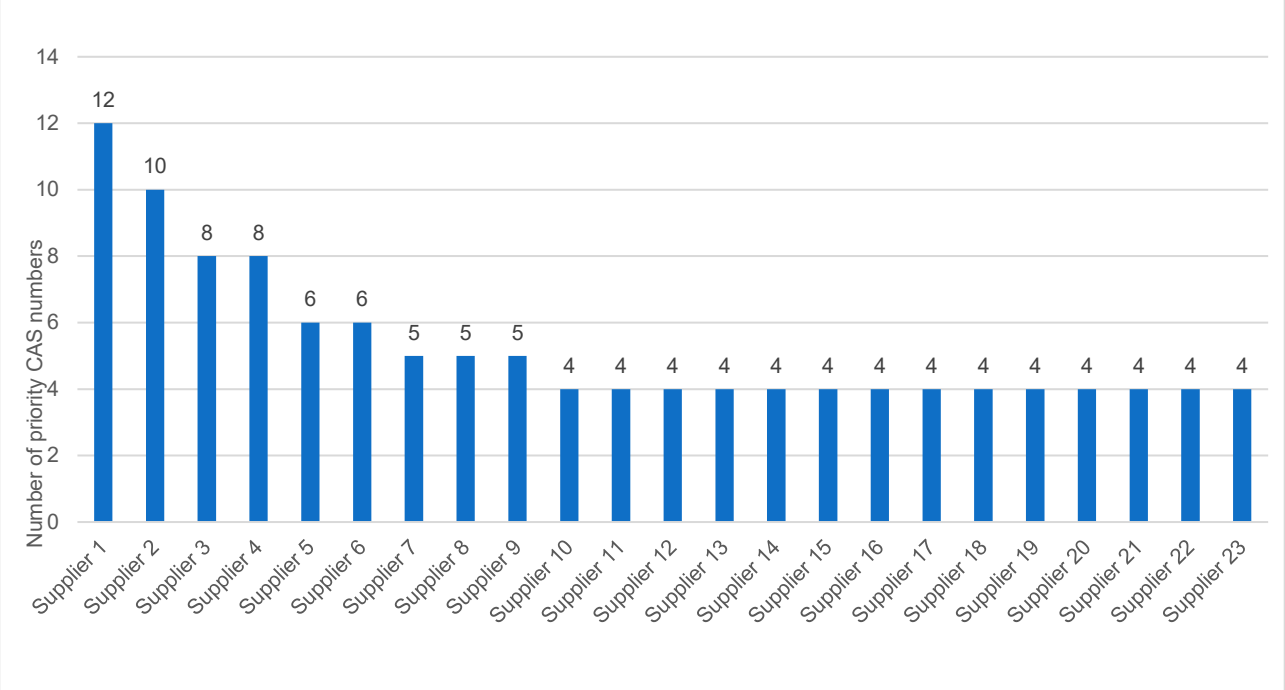


Figure 3.3 Number of the 'priority' CAS numbers covered by different suppliers (includes all companies supplying 4 or more priority CAS numbers)- supplier names have been removed as information is confidential to WG5



3.2.3 Research questions

The specific research questions for the supply chain assessment were agreed with the WG5 members (through a discussion at the October 2024 meeting in Madrid). A summary of these is outlined below:

1. Planned actions relating to planned legislation including its perceived effects on specific product availability.
2. Actions on identifying alternative PFAS free materials and their technological readiness for products.
3. Upstream supply chain visibility of where their PFAS containing products are used relating to A&D.
4. Willingness for further interaction with the WG5 members/wider A&D industry.

As part of the consultation with individual suppliers, the specific products associated with that supplier were extracted from the WG5 survey results, and provided to the supplier in the introductory email exchanges. This allowed the supply chain assessment to include a consideration of specific products (or product lines) or individual use categories, with interview questions included to invite supplier feedback on the lists provided.

Information from direct stakeholder interviews (or e-mails) has been supplemented with a review of inputs to the ECHA consultation (and associated position papers) as well as inputs from relevant trade associations. In some cases this has been included in place of direct inputs where no supplier contact was possible.

3.3 Supply chain assessment – key insights

3.3.1 Overview

This section provides an overview of the information gathered and synthesised across all supplier inputs. The names of specific suppliers are only included where their inputs are in the public domain. Specific positions, actions or opinions are not attributed to an individual supplier if these are directly from the supplier interviews.

The inputs from the suppliers have been synthesised to answer, to the extent possible, the key research questions outlined in Section 3.2. The discussion is divided into the following sections:

- Planned actions relating to the forthcoming EU REACH restriction
- Current actions on PFAS-free alternatives
- Upstream supply chain issues
- Further interaction with WG5/IAEG/A&D industry

It should be noted that it has not been possible to provide a detailed assessment on the basis of each individual product listed in the WG5 survey (i.e. in terms of potential obsolescence or reformulation), given the large number of products (approximately 10,000) distributed across many different suppliers.

3.3.2 Planned actions relating to the forthcoming EU REACH restriction

General observations

Input has been provided in this supply chain assessment from different types of organisation (e.g. some were fluoropolymer manufacturers, some were formulators of specific products or articles, and some were both). The type of actions or approaches relating to the issue of PFAS and the proposed restriction vary significantly amongst the different companies consulted. This section highlights some key consistent observations across different types of suppliers, but also some key differences in planned actions.

Most companies consulted indicated that they are ‘monitoring closely’ the developments in regulations relating to PFAS, in the EU and US primarily, but also elsewhere. It is not always clear precisely what these ‘monitoring’ activities consist of, but in general, the key suppliers consulted are active and well informed when considering actions on PFAS. This should not be considered surprising given that these larger companies will include regulatory compliance staff to ensure current regulations are followed and developing regulations are monitored.

The key point of focus across the interviewed suppliers is on the issue of fluoropolymers (FP), and their (potential) coverage under the proposed EU REACH restriction, including the use of FP in A&D uses (see Section 4).

The proposed EU REACH restriction of PFAS

At the time the supply chain assessment was conducted, the draft proposal for the EU REACH restriction of PFAS under REACH is still under consideration

Some suppliers consulted are largely of the position that the restriction is still not fully ‘confirmed’ and is likely to be subject to further changes (e.g. to the nature/scope/wording of derogations). Given this uncertainty, some suppliers consulted indicated that they are unable to confirm what specific actions they will take at this stage.

Several of the suppliers contacted have submitted input and evidence to the ECHA public consultation and have taken a strong position of advocacy for the use of PFAS in various industries, including A&D. These submissions, for example, emphasise:

- The importance of the function(s) that PFAS provide in key uses, including A&D (amongst others)
- The broad socio-economic value of PFAS in various uses
- The lack of available alternatives to replace PFAS in these applications

A particular area of focus is on the production and use of fluoropolymers. Various inputs have proposed, maintained, expanded or suggested additional derogations for PFAS. These proposals/requests have been in various forms:

- Derogation for fluoropolymers broadly, i.e. across all uses. This has been suggested, for example, by the European FP industry (the Fluoropolymers Product Group (FPG))[24].
- Derogation for use in the A&D sector specifically. For example, this has been requested by WL Gore[25].
- Derogation for other specific uses that (indirectly) impact the A&D sector, e.g. semiconductor manufacturing. For example, this has been requested by Dupont[26].

Strategies of specific companies to manage PFAS

The specific approach to managing or controlling hazardous chemicals (including PFAS) differs between companies and only a limited number of the suppliers contacted provided specific details.

In general, companies (i.e. the formulators of products) indicate that they aim to be fully compliant with existing chemicals regulations, and aim to be 'ahead of the curve' with potential developments in regulations. The general goal for many suppliers is to continue to offer their PFAS containing products in a way that is fully compliant with the regulations.

In some cases, suppliers provided inputs detailing specific programmes to strategically manage chemicals of concern, e.g PFAS. These aim to ensure transparency for their customers on the content and sustainability of their products.

Some suppliers (particularly those producing articles using FP materials) indicated that their main interest is on the regulatory coverage of FP and the residual levels of (non-polymeric) PFAS in FP. These companies are heavily reliant on their suppliers to ensure compliance with any regulations (in this case particularly with reference to residual non-polymeric PFAS levels in FP material) and consider that any major changes in the supply chain for FP materials could potentially cause issues with future compliance (e.g. if production is driven outside of Europe).

Obsolescence

In general, to date, there have been relatively few definitive announcements to confirm with certainty (or even indicate in general) what different companies are planning to do in terms of potential obsolescence of products. However, some companies have announced plans to partially or totally exit the PFAS manufacturing market. Two examples include:

[24] Plastics Europe, The restriction of fluoropolymers under REACH will hamper key EU strategic sustainability ambitions. https://fluoropolymers.eu/wp-content/uploads/2023/08/FPG-Statement-on-the-PFAS-REACH-restriction-report.pdf
[25] See ECHA consultation reference [6301-35]
[26] See ECHA consultation reference [6016-28]

- 3M announced an intention to exit PFAS manufacturing by the end of 2025[27]. Within the WG5 survey results, 3M was identified as a significant supplier, with over 200 different products identified as supplied to WG5 members. These products are spread across many use categories utilising 10 of the 'priority' CAS numbers. Clearly this will impact the WG5 members and uses across the A&D sector more widely.
- Solvay announced in June 2022 that it would discontinue its Hyflon® perfluoropolymer and Algoflon® PTFE product lines manufactured with fluorosurfactants by 30 June 2023[28]. Solvay announced a commitment to manufacture nearly 100% of its fluoropolymers without fluorosurfactants at its Spinetta Marengo site by 2026.[29]

Other companies consulted during the supply chain assessment indicated that, for the immediate future, there are no set plans to discontinue their products, until more is clarified or confirmed with regards to the proposed EU REACH restriction of PFAS.

As discussed above, it is not possible to provide a clear indication of the potential likelihood of obsolescence for all individual products

Specific impacts on A&D uses and products

As already well-understood by the IAEG and wider A&D sector, the mapping of PFAS in the A&D supply chain is complicated by the fact that the A&D industry procures both products that are specifically marketed as 'aerospace' products, but also more general products, which are not specifically marketed as for the A&D industry. This causes challenges for suppliers when identifying products that are ultimately used by the A&D industry.

Several suppliers indicated that it can be relatively easy to provide information on specific products marketed as 'A&D' products. For example, one company was able to indicate clearly that their entire aerospace product line is unaffected by PFAS (i.e. does not contain PFAS at >25ppb). However, they also noted that they have product lines that are for 'general industrial' or for other specific industry sectors (e.g. electronics); for these products the situation with PFAS is less clear. It should also be noted here that supplier intent does not always drive part selection and there is a possibility that 'general industrial' products can be utilised for A&D products if they are suitably qualified for form fit and function.

Emissions control

A key emphasis of current and further action from a number of companies (particularly FP producers) is around improvement to controlling emissions to the environment (i.e. during the manufacturing stage). For example, this has been highlighted by member companies of the FPG. FPG members have committed to reduce non-polymeric PFAS emissions from fluoropolymer manufacturing[30].

One specific example is Chemours, which has a corporate target[31] as follows: "We take very seriously our obligation to manage the PFAS compounds in our manufacturing processes in a responsible manner and our commitment to eliminate at least 99% of PFAS air and water emissions from our manufacturing processes by 2030 [compared to a 2017 baseline]".

[27] 3M, 2022. 3M to Exit PFAS Manufacturing by the End of 2025. https://news.3m.com/2022-12-20-3M-to-Exit-PFAS-Manufacturing-by-the-End-of-2025

[28] Algoflon products already manufactured without the use of fluorosurfactants in Spinetta Marengo will not be impacted by this decision.

[29] Solvay, 2022. Solvay to discontinue Algoflon® PTFE and Hyflon® perfluoropolymers made in Italy. https://www.solvay.com/en/news/solvay-discontinue-algoflon-ptfe-and-hyflon-perfluoropolymers-made-italy

[30] See ECHA consultation reference [8524-94]

[31] Chemours. Responsible Manufacturing. https://www.chemours.com/en/pfas-advocacy/responsible-manufacturing

While the actions on abatement of emissions are not expected to have a negative impact on quality or availability of products, it is expected that the investment costs could be substantial. This could potentially have a knock-on impact the cost of products procured by the A&D industry, although this is not clear how likely or significant this could be.

3.3.3 Current actions on PFAS-free alternatives

Current work to identify and/or test PFAS-free alternatives

PFAS-free materials

Most of the input gathered from the supply chain assessment is focused on FP materials and their use in the manufacturing of products. This reflected the main inputs and opinions gathered from the suppliers consulted, as well as the focus of many of the position papers and/or submissions to the ECHA consultation, which have come from the FP manufacturing industry.

Several FP manufacturers consulted have indicated that they are prioritising activities related to three core areas: i) continued advocacy, ii) further developments in (PFAS-free) processing aids/surfactants, and iii) the control of (PFAS) emissions during manufacture, with currently lower emphasis on R&D for PFAS alternatives, which have already been investigated extensively in many cases.

These companies noted that research into alternatives to FPs at the material science level has been ongoing for many years. In many cases, while potential PFAS-free options are known, they are not considered viable to cover all the functions/properties required. It is also considered by this industry that FPs are typically the most expensive option (based on unit costs), so in their opinion, the use is largely through necessity rather than choice or financial preference[32].

FP manufacturers emphasised that some of the current front runner PFAS-free alternatives will be capable of replacing some of the functionality, but not all aspects of performance. The suppliers indicated that the use of an alternative will always come with some trade-offs and very much depends on the specific use. They also note that this is particularly complex for A&D as the sector covers a very wide range of use categories, use conditions and specific performance requirements.

Suppliers also stated that alternatives may be able to replace a singular property, but when two or more properties are required simultaneously, especially in harsh conditions and demanding applications, the only viable material is fluoropolymer based.

The common options considered as FP alternatives are typically:

- Polyethylene (PE)
- Polyvinyl chloride (PVC)
- Silicone / silica materials
- Ethylene propylene diene monomer (EPDM)
- Polyetheretherketone (PEEK)

PFAS-free products

Connected to, but considered separately from, the manufacture of FP materials, input has also been received relating to the downstream formulation of products manufactured from FP materials (e.g. O-rings, lubricants). Several manufacturers/formulators of products indicated they are actively conducting R&D

[32] See ECHA consultation reference [8521-94]

investigating PFAS-free solutions for various product lines, including for products with specific A&D applications. While for some suppliers, this is indicated to be part of an ongoing/continuous R&D process, it is also suggested this has been accelerated/driven by the ongoing ECHA restriction proposal.

At the product level, several companies have already begun to develop and market PFAS-free products or product lines that are targeted to certain A&D uses. The verification of the performance of these parts at product level is still to be fully investigated and confirmed at platform level. These include, for example:

- Saint Gobain's Omniseal range[33] which covers various seals and O-ring products
- Henkel's Loctite products, which includes a list of epoxy adhesives in the 'aero' range that have been confirmed by Henkel as being PFAS-free.

However, a full assessment of all PFAS use categories, as covered in the WG5 survey/ECHA restriction and their coverage by PFAS-free alternatives has not been feasible on the basis of the evidence gathered in this assessment, so while some A&D uses are known to have PFAS-free options, it is not clear how feasible PFAS-free alternatives are across all A&D uses..

One company provided the example of PFAS-free temperature seals developed for the space sector. These are considered viable in terms of their resilience to aerospace fluids (with a temperature range of -380°C to +320°C). However, this is constrained by the practical issue that the material is rigid and therefore cannot be used in all space applications.

The timescale for identifying, developing and testing alternatives is suggested by suppliers to be highly variable, depending on the specific product/use in question. However, the more complex process of validation and qualification could be much longer, and this would be needed before a new product is accepted by the final manufacturer[34]. According to the FPG, it is expected that aviation and space applications will have longer qualification times, as they have more demanding specifications and a longer list of required validation tests. They also state that, where viable alternatives exist, a typical timescale for the whole R&D and substitution process is expected to be as long as 10-15 years in some cases[35].

Processing aids and surfactants

Some suppliers have indicated that they have a long-term action plan to move away from use of fluorinated surfactants and processing aids in their manufacturing processes and suggest that this is a realistic and achievable target. Some companies have already developed and market PFAS-free processing aids for production of fluoropolymers (see Section 3.3.4). However, it must also be noted that the industry has also raised a number of caveats and uncertainties over the use of PFAS-free processing aids. For example, the FPG stated that[36]:

"FPG member companies continue investigating and developing R&D programs for the advancement of technologies allowing for a transition away from using PFAS-based polymerization aids during fluoropolymer production. However, during this transition, it may be necessary to continue using fluorinated polymerization aids until non-PFAS polymerization aids are developed that can produce polymers that meets all performance requirements".

[33] Omniseal PFAS-Free* Seals | Digital Assessment Tool
[34] See ECHA consultation reference [6150-31]
[35] See ECHA consultation reference [6148-31]
[36] See ECHA consultation reference [6148-31]

Uses or products where viable alternatives are not currently available

General points on alternatives in A&D

As discussed above, much of the focus of suppliers contacted has been on the production and uses of FP. In general, the FP manufacturing industry have been vocal in highlighting that finding viable alternatives at the material level is very challenging from a technical feasibility perspective (i.e. in finding a drop-in replacement that can cover all functions/properties simultaneously).

The A&D sector in general is widely considered by many suppliers (as well as the inputs of the FPG and other sector-specific trade associations) as a 'critical' or 'challenging' use category when it comes to potential alternatives.

For example, the FPG[24] has stated that they consider there are no technically and economically feasible alternatives for the various fluoropolymer applications used in the 'harsh conditions' and high-performance requirements typically experienced in A&D uses. While alternative materials do exist (see above), e.g., for some cable jacketing or sealing uses, it is considered by the FP manufacturing industry that these cannot typically meet the required customer and regulatory specifications.

The (Chemours, 2023) position paper specifically refers to use conditions relevant for (and explicitly referring to) A&D applications, for example: "*the production and design process to produce any viable alternatives will require significant time, effort, and resources, with the potential for major product qualification issues, a narrower band of operating condition requirements, higher risk of exposure to hazardous substances, or higher safety risk and increased emissions from technical regression extremes in temperature (like air travel, space applications, or high-hazard manufacturing). From aerospace and defense to advanced electronics and clean energy, there is often no domestically manufactured alternative replacement*."

WL Gore have also commented[37] that: *"it is unlikely that feasible alternatives will be found in the foreseeable future and using alternatives that do not meet the performance requirements to the same degree as PFAS is not an option in the A&D sector due to system performance, reliability, and safety concerns*".

A number of specific examples of use categories directly applicable to A&D have been raised by suppliers that were consulted, for example: coatings, adhesives and seals, gaskets, capacitors and as well as wiring and cable insulation and in lubricants. This is clearly significant as these were use categories highlighted from the WG5 survey (see section 2) as being high priority (either in terms of the number of WG5 members reporting products in that category and/or the number of total products being reported).

An illustrative example has been provided by WL Gore[38] on the use in wires and cables (electronics, communications, critical infrastructures). This specifically related to the use of fluoropolymers in high-performance microwave/RF coaxial cables. It is noted 95% of the market for this type of cables is used within A&D and space applications, utilising PTFE as a dielectric material. Currently it is considered that no alternative is available that would provide a sufficient level of performance (e.g. low dielectric constant combined with physical properties to withstand harsh operating conditions) that would not require fluoropolymers.

Some suppliers have provided inputs (to the ECHA consultation[39]) related to specific products. For example, Dupont has conducted a socio-economic assessment of two key product lines – Vespel® (based on PTFE) and Kalrez® (based on FFKM) – which concluded that:

[37] See ECHA consultation reference [6301-35]
[38] See ECHA consultation reference [4489-20]
[39] Contained within WG5 confidential report

- While isostatic Vespel® (i.e. Vespel® without PTFE) would be able to meet some technical criteria in some applications, it would not meet the criteria in harsh conditions such as high temperature.
- For Kalrez®, the alternatives identified were fluoroelastomer (FKM), Hydrogenated Nitrile Butadiene Rubber (HNBR) and Silicone (VMQ). All three alternatives were found to not be technically feasible based on inadequate performance over the needed range of temperature and/or chemical conditions.

As discussed in Section 2 and above in this section, a key factor in developing and implementing alternatives is the qualification needed for new products and compliance with stringent standards and specifications. This has been discussed in Section 2.2.4 with a list of the standards and specifications reported by WG5 members. One key additional issue is that, for some uses, the specification will stipulate the use of a PFAS compound.

As discussed in Section 2, an important complicating barrier to alternative development and implementation in A&D in particular, is the number and stringency of specifications or standards that apply. Several suppliers have stressed that the development of alternatives will include the lengthy and costly requalification of products.

An illustrative example of this was reported in Dupont's submission to the ECHA consultation, which related to the use of fluorosilicones [40]:

- The example presented relates to fluorosilicones used in military applications that use electrically conductive shielding gaskets as seals e.g. in gas tanks, engines, and other surfaces that are exposed to hydraulic fluids and fuels. These components are reported to require key performance characteristics, including the ability to: resist swell when exposed to hydrocarbons (fuel/gas), resist breakdown when subjected to extreme temperatures, remain flexible at extreme low temperatures, and remain soft and pliable to reduce stress.
- The specification MIL-DTL-83528 Rev E is used to design electrically conductive elastomer shielding gaskets for military applications and this specifies the properties required for silicones used in military applications. It was considered [by Dupont] that at this time, no alternatives can be used as immediate replacements for fluorosilicone in the discussed military applications due to the MIL-DTL-83528 Rev E specification which specifies the use of "fluorosilicone" in the materials list.
- It is considered that fluorosilicones "cannot be replaced with alternative materials because the differential in performance of these materials is so great that the viability of certain current and future technologies that enable military applications, specifically aerospace applications of use, will be compromised or even extinguished entirely"
- It was further noted that, while this response is focused on military applications, these materials are used in non-military aerospace applications as well. Many of the same requirements noted in military specifications (MIL Specs) are the same reasons these materials are selected for civilian aircraft.

Alternatives to uses with an indirect impact on A&D

A key point of focus for WG5 will be uses of PFAS that are not always 'visible' to end users of products in the A&D sector, i.e. where PFAS are used but are not necessarily present in the final product itself. In

[40] See ECHA consultation reference [6212-33]

general, limited information on the current status of alternative development in such 'indirect' uses has been gained from supplier consultation.

Some indication of some specific product lines has been given by certain suppliers. For example, the manufacturer of Galden® products[41] (used on applications such as solvents, heat transfer fluids, and various processes in the manufacture of semiconductors) has highlighted these uses are challenging for finding a suitable PFAS-free replacement.

The key specific example of an 'indirect' PFAS use where more detailed insight from suppliers has been obtained relates to the manufacture of semiconductors.

Various suppliers and industry associations have provided input (to the ECHA consultation) to emphasise the importance of PFAS in the semiconductor manufacturing process and the current lack of feasible alternatives.

For example, Dupont commented that[42]

"*In addition to general research over the past few decades, we have dedicated several scientists to researching PFAS alternatives for the remaining short chain and polymeric PFAS in specific subcategories of process chemistries for the past ~3 years, and continue to dedicate these resources. These highly skilled scientists have yet to discover any non-PFAS solutions which can approach the performance required in current semiconductor manufacturing processes. Eliminating PFAS-containing materials from this industry will require years of research and development (R&D) to identify, demonstrate, integrate and implement alternatives*".

Furthermore, W L Gore in their ECHA consultation responses commented that:

"Fluoropolymer based solutions (whether it is cable assemblies, sealants, filters, or vents) are considered the only option currently on the market that can be used to achieve extreme cleanliness required during semiconductor manufacturing processes".

In addition, the (Chemours, 2023) position paper further states that:

"Semiconductor chips cannot be manufactured without fluoropolymers; in other words, every industry, sector, and consumer in the EU that relies on semiconductor technology will be put at a significant disadvantage".

One key specific use of PFAS within the semiconductor manufacturing industry is the use in/as lubricants and lubricant additives. It has been reported by the Semiconductor Industry Association that research has shown that, in a majority of cases, PFAS-containing materials provide properties integral to the semiconductor industry that are not found in known non-PFAS alternatives.

The 'indirect' use of PFAS in semi-conductor production is clearly significant for A&D and can be highlighted here as a key 'blind spot' for the WG5 members. For example, it can be seen from the WG5 survey results (see Section 2) that very few WG5 members highlight this as a use where they procure products i.e. PFAS are not present in specific products; while conversely the use of PFAS in 'electrical engineering and information technology' products is noted by a greater number of WG5 members (6) and a large number of specific products (44).

[41] Syensqo. Applications. https://www.syensqo.com/en/brands/galden-pfpe/applications

[42] See ECHA consultation reference [6016-28]

3.3.4 Upstream supply chain issues

Uses of PFAS that are not visible to A&D industry users

Hidden uses

It may be expected that certain uses of PFAS will be relevant to A&D, in the sense these are uses in the manufacture of specific products or formulations, but those PFAS will not remain present in the final product supplied to A&D users (except a low residual presence, in some cases only). This would potentially include use in solvents, cleaning products and F-gases e.g. for refrigeration.

This supply chain mapping assessment has found little direct information on the uses of upstream PFAS in manufacturing processes and impacts for A&D. A key exception, is the clear importance of PFAS in production of semi-conductors.

The importance of PFAS (and in particular FP) in the manufacture of semiconductors has been emphasised widely from many inputs across the industry. This was a use category that was not cited by many WG5 members directly in the survey (see Section 2), which may reflect that this use is occurring further up the supply chain and is not fully 'visible' to the A&D users of the electronic components produced (which do not themselves contain PFAS).

Fluorinated processing aids

The key issue highlighted here relates to the use of fluorinated processing aids and/or surfactants in the manufacture of FP materials and products. Again, this may be an aspect that is not fully 'visible' to the A&D users (of products made from FP materials).

This supply chain assessment has emphasised that the challenges of 'visibility' of PFAS across the supply chain are experienced from both sides (i.e. both 'supplier-down' and 'user-up').

4. Coverage of A&D uses by the proposed EU restriction

Based on the most recent version of the proposed EU PFAS restriction (August 2025), a review of the coverage of aerospace and defense uses in the scope of the restriction and associated derogations has been undertaken. This involved:

- Review of the definition of PFAS, including changes compared to the original (2023) proposal, and comparison against uses in the A&D industry (WG5 use mapping and other sources).
- Detailed review of the scope of the derogations in the original (2023) restriction proposal as well as the revised (2025) proposal, focused on those that may to be applicable to uses of PFAS that have been identified by IAEG WG5. This included a mapping against the uses listed in the restriction proposal and cross-sectoral uses and derogations (e.g. related to 'military' uses).
- Review of any other uses identified by aerospace and defense industry associations ASD and AIA that were highlighted in the public consultation on the 2023 restriction proposal (and which were not previously identified in IAEG WG5's mapping exercise).
- Drawing conclusions on the coverage of A&D uses by derogations in the most recent restriction proposal, and highlighting any uses that are not currently covered.

Key findings that apply to the entire table below include:

- Depending on the interpretation of 'machinery applications', derogations could potentially cover many of the uses of PFAS in coatings in the A&D sector.
- Wider / general derogations in the background document (e.g. military applications (5ll) , machinery applications in industrial uses(6q)) cover various uses, as well as derogations for upstream production of PFAS and PFAS containing mixtures or articles (4h).

The table below provides a summary of the main conclusions drawn.

Table 4.1 Summary of derogations covering A&D use categories

Use category (as identified by WG5)	Corresponding ECHA use categories[1]	Summary comments
Lubricants and dry film lubricants	Lubricants Broader industrial uses	There is an explicit derogation in the August 2025 restriction proposal for use of (all) PFAS in lubricants. It is understood that the derogation (5aa) in the updated background document will cover all A&D uses of lubricants. The text for the derogation has changed between the original and updated restriction proposal. In practical terms the coverage and scope of the derogation is no different in the updated version of the proposal compared to the original proposal. However, the ambiguity over use of lubricants in 'harsh conditions' is removed in the updated version, as the coverage of the derogation is now broader, covering all industrial and professional uses. The updated text also clarifies the inclusion of 'lubricant additives' as part of the derogation. The derogation for lubricants (para 5aa) overlaps with the

Use category (as identified by WG5)	Corresponding ECHA use categories[1]	Summary comments
		derogation for military applications (para 5ll). However, since the derogation for lubricants covers all industrial and professional use, and the time limit for both derogations is the same, it is interpreted that there is no conflict between the applicable derogations.
Seals	Sealing applications Transport	There is an explicit derogation (6p) in the August 2025 restriction proposal for use of (fluoropolymers and perfluoropolyethers) for sealing applications in industrial uses. It is understood that the derogation will cover all A&D uses of seals. It is noted that the vast majority of products/formulations in the WG5 mapping were polymeric PFAS. There are no conflicts highlighted with other derogations. There was no derogation for sealing applications in the original restriction proposal.
Coatings	Transport Electronics and semiconductors (Electronics)	The original restriction proposal did not include any derogations for coatings relevant to the A&D industry. The only derogations related to medical devices and bakeware. The August 2025 restriction proposal includes a number of derogations that cover uses in coatings and films of electronic components for all PFAS (5x) (13.5 years, except for displays and lenses where the derogation (5s) is 6.5 years) and for separator coatings for batteries for 6.5 years, for FP and PFPE (6l). The new restriction also includes a derogation (6q) of 13.5 years for use of FP and PFPE in machinery applications not covered elsewhere, which includes (among others) self-lubricating/low-friction components (either entirely made from FP/PFPEs or coated with them) and coatings for protection/durability. Derogations are also proposed for spare parts, i.e. articles and complex objects intended for the maintenance and repair of another article or complex object (para 4e and 4f). It is expected this would cover the use of coatings in such spare parts. A large number of uses of coatings in the A&D sector were identified by ASD and AIA, many of which are not specifically covered by these derogations. There is also a derogation for military applications (5(ll)) that would covers uses of coatings for military applications.
Solvents	Broader industrial uses	The original restriction proposal included a potential derogation (subject to reconsideration) for the use of all PFAS in industrial and professional solvent based debinding systems in 3D printing.

Use category (as identified by WG5)	Corresponding ECHA use categories[1]	Summary comments
		The new restriction proposal covers all industrial uses and is hence broader. It does not cover professional use, but most or all of the use in the A&D industry is understood to be industrial (5 w and 5vv). The comments submitted by ASD and AIA to the public consultation highlight a range of different uses of PFAS in the A&D sector, such as in cleaning agents for tanks; cleaning of electrical components and electrical contacts; industrial precision cleaning fluids; hermeticity test fluids; oxygen system cleaning; vapor degreasing; and as a general solvent in coatings, lubricants, cleaners, adhesives and water proofing agents.
Adhesives	Not clear	Neither the original restriction proposal nor the revised restriction proposal included a specific derogation for use of adhesives. The restriction proposal only identified the use in construction products and in wetting/levelling agents. However, the revised proposal includes a derogation for use in transport vehicles for FPs. Adhesives, unlike e.g. sealing applications or lubricants, are not specifically excluded from that derogation. The derogation 6(f) covers use of FP/PFPE for 13.5 years in transport vehicles subject to EU type approval or where use is necessary for safety or environmental reasons. Unlike other uses (e.g. sealants, lubricants) adhesives are not explicitly excluded from this derogation. The comments from ASD and AIA include a number of additional uses not specifically mentioned in the restriction proposal, such as processing aids to manufacture ammunition, adhesive sheets/fabrics/tapes preventing fluid leakage and providing protective surfaces. ASD Eurospace identify the need for bulky adhesives to be cast on a PFTE sheet and specifically mention use of adhesive repair tapes in multi-layer insulation (MLI). AIA mention use as an adhesion promoter in polysulfide and polythioether sealants, as well as use of PFAS as solvents for many different uses, including as a general solvent in […]adhesives”
Electrical engineering and information technology products	Electronics and semiconductors (Electronics)	There is no explicit derogation covering all electrical engineering and information technology products for A&D (or transport) uses. A number of different specific derogations cover these uses, at least in part, including: • PFAS used for printed circuit boards (PCB) and antennas (such as the use in aerospace, defense or communication) • Photonics (including LCD, OLED, optical fibres (polymer optical fibres) and other optical uses). • Coatings and films of electronic components (excluding displays

Use category (as identified by WG5)	Corresponding ECHA use categories[1]	Summary comments
		and lenses); • Insulation material of electronic components (excluding wires, cables and connectors) • Fuel cells and electrolysers A number of other derogations cover PFAS use in batteries, including: binders and electrolytes in batteries); (Oxygen-permeable membranes in zinc-air batteries and other types of alkaline metal-air batteries); Separator coatings for batteries Note that some of these derogations are described elsewhere in this table, under other uses.
Heat transfer fluids	Electronics and semiconductors (Electronics)	The updated background document includes derogations for use in heat transfer fluids (para 5(v) and para 6(g). Such a derogations were not included in the original proposal. It is specified that one derogation "covers the use of PFAS as a heat transfer fluid in 2-phase immersion cooling and does therefore not apply to other heat transfer fluid applications such as 1-phase immersion cooling or cold plate cooling", and "these fluids can be used in thermal management systems in vehicles." It is therefore suggested that the derogation would cover the relevant use of heat transfer fluids in A&D applications, but since there is no explicit mention of the specific applications or examples provided, it is not certain this derogation covers all A&D applications of heat transfer fluids. It is specified that a separate derogation covers "industrial and professional use of vapor phase soldering for electronics", e.g. for soldering of capacitors, resistors, integrated circuit chips and more on a printed circuit board, which has been raised as a key A&D use for PFAS by ASD. Wider / general derogations in the background document (e.g. military applications, machinery applications in industrial uses) will also cover this use, as well as derogations for upstream production of PFAS and PFAS containing mixtures or articles,
(Insulated) wires/cables	Electronics and semiconductors (Electronics)	The updated (August 2025) background document includes a derogation for (fluoropolymers and perfluoropolyethers) in wires and cables (incl. connectors) for 13.5 years after EiF (para 6h), which was not included in the original restriction proposal. It is expected that this derogation will therefore cover all A&D applications under this use category. Wider / general derogations in the background document (e.g. military applications (5ll) , machinery applications in industrial uses(6q)) will also cover this use, as well as derogations for upstream production of PFAS and PFAS containing mixtures or articles (4h).

Use category (as identified by WG5)	Corresponding ECHA use categories[1]	Summary comments
Fluorinated gases	Applications of fluorinated gases Transport	The updated background document (August 2025) includes several specific derogations relevant to uses of fluorinated gases in A&D applications. This includes derogations for use of refrigerants in mobile air conditioning-systems and heat pump systems in 'all other vehicles' until 13.5 years after EiF (para 5q), refrigerants in transport refrigeration other than in marine applications until 6.5 years after EiF (para 5r); and refrigerants, clean fire-suppressing agents and insulation gases for maintenance and refilling of existing HVACR, fire-suppressing and switchgear equipment put on the market before 18 months (or placed on the market after 18 months after EiF based on an applicable derogation) (para 5n). The derogation for the refilling and maintenance of equipment with fluorinated gases (para 5n) is more expansive than in the original (provisional) proposal, which only covered the refilling and maintenance of equipment with fluorinated gases. The derogation for refrigerants in mobile air conditioning-systems and heat pump systems (para 5q) did not cover 'other vehicles' in the original proposal, this has now been expanded to cover 'other vehicles', which is specified to include airplanes and spacecrafts. The derogation for refrigerants in transport refrigeration is the same as in the original proposal. Wider / general derogations in the background document (e.g. military applications, machinery applications in industrial uses) will also cover this use, as well as derogations for upstream production of PFAS and PFAS containing mixtures or articles.
Corrosion inhibitors	[captured under 'coatings' and 'hydraulic fluids']	[captured under 'coatings' and 'hydraulic fluids']
Textiles	Textiles, upholstery, leather, apparel and carpets (TULAC) Technical Textiles	The updated background document includes derogations that cover a number of different uses in textiles that are relevant to the A&D sector– including in PPE and technical textiles (see also 'high performance membranes'). It is noted that the derogations included for textiles, both in PPE and technical textiles have been expanded compared to the original proposal. For example, the updated background paper includes a specific derogation for PPE specifically designed for armed forces, the maintenance of law and order and other emergency response workers, and a derogation for technical textiles in transport vehicles for noise, vibration and harshness (NVH) insulation both inside and outside the engine bay. However it is noted that, the use in PPE has not been explicitly mentioned in the inputs of the ASD, AIA or in the WG5 mapping. It is not clear if all uses in A&D for textiles will be covered by derogations – e.g. seats, carpets, roof linings etc.

Use category (as identified by WG5)	Corresponding ECHA use categories[1]	Summary comments
Hydraulic fluids	Transport Broader industrial uses	In the updated background document, an explicit derogation (5p) is included for 'Additives to hydraulic fluids in transport vehicles'. It is noted that the wording has changed from the original restriction proposal: additives to hydraulic fluids in transport vehicles, whereas the original proposal only referred to aircraft and the aerospace industry. In practice, this is expected to cover all A&D uses.
Metal plating additives	Metal plating and manufacture of metal products	The updated background document includes a derogation for use in hard chrome plating until 6.5 years after EiF; (para 5(d)). An identical [potential] derogation had been included in the original proposal (para 5(v)) In the absence of further explanatory notes, it is assumed that the derogation will cover all hard chrome plating uses relevant to A&D applications. Wider / general derogations in the background document (e.g. military applications) will also cover this use, as well as derogations for upstream production of PFAS and PFAS containing mixtures or articles, It is noted that timescale of this derogation (6.5 y) is lower than for broader overlapping derogations, e.g. military uses (13.5 y).
Anti-friction and wear resistance	[captured under other uses - e.g. 'coatings', 'lubricants', 'textiles']	[captured under other uses - e.g. 'coatings', 'lubricants', 'textiles']
Engine parts	Machinery Applications Transport	The use of PFAS in 'engine parts' is expected to be covered under a number of derogations in the updated background documents, including: • for 'spare parts intended to replace PFAS-containing articles in articles or complex objects (which includes part of aircraft) • for machinery applications in industrial uses until 13.5 years after EiF [FP and PFPE] will apply here for any uses that are not covered under other derogations (e.g. seals, coatings, electrical components). • for 'vehicle systems, components or separate technical units where the type approval was obtained within 13.5 years after EiF (para 6f)' is also expected to apply here for any uses that are not covered under other derogations (e.g. seals, coatings, electrical components).
Chemical processing	Not clear	The key examples of the uses for PFAS/FP noted in the WG5 PFAS mapping assessment for chemical processing included 'seals' and 'tank liners'. While all seal applications will be covered under the derogation for 'sealing applications' (see above), it is not clear if the use in tank liners is covered.

Use category (as identified by WG5)	Corresponding ECHA use categories[1]	Summary comments
Fire supressing agents	Applications of fluorinated gases	An explicit derogation is provided here for 'fluorinated gases used as clean fire suppressing agents where current alternatives damage the assets to be protected or pose a risk to human health until 13.5 years after EiF (5k). In practical terms, the derogation is the same as included in the original proposal, the distinction 'fluorinated gases' is added to the definition of 'clean fire suppressing agents'. It is not expected this will limit or expand the scope of the coverage for this derogation. It is noted that the coverage of fire-fighting foams and portable fire extinguishers more broadly comes under a separate REACH restriction for PFAS in firefighting foam applications.
Semiconductor fabrication	Electronics and semiconductors (Semiconductors)	This use appears to be fully covered under the explicit derogation for 'Semiconductor manufacturing until 13.5 year after EiF' (5w).
Lifesaving equipment	Not clear	There is some uncertainty over the coverage of derogations for this use category, The derogation for vehicle systems, components or separate technical units requiring type approval (para 6f) is relevant here as Regulation (EU) 2018/1139 (on common rules in the field of civil aviation) states that "an aircraft must be equipped with all necessary safety, medical, evacuation and survival equipment". However, this derogation explicitly does not apply to 'technical textiles'. While it is stated in the ECHA mapping document that technical textiles applies to "technical textiles for transport vehicles", it is not made explicit if this covers life saving equipment. A general derogation also exists for 'military uses' (5ll), covering such uses in military applications.
Optical fibres	Electrical engineering and information technology products	The original restriction proposal did not include any derogation for use in optical fibres. Use of FP in optical fibres was mentioned in Annex A. The revised restriction proposal includes a derogation for all PFAS for 13.5 years as part of the group "photonics" (5u). The derogation covers other optical uses excluding uses covered by derogation 5t, which relates to printed circuit boards and antennas for 13.5 years after EiF (the same timescale as 5u), covering all uses of PCBs and antennas, such as the use in aerospace, defense or communication.
Foam-Blowing Agents	Applications of fluorinated gases	The original proposal included only a 'possible' derogation, related to use in expanded foam sprayed on site for building insulation. The revised proposal includes a wider use description, covering different kinds of foam use for insulation, including

Use category (as identified by WG5)	Corresponding ECHA use categories[1]	Summary comments
		spray foam, boards, flexible foam, etc. The revised proposal also includes a longer derogation period of 13.5 years, compared to 6.5 years after EIF. The derogation does not specifically mention the A&D industry. However, the use is now broader than the original proposal (which only covered buildings). WG5 previously identified the use in foam-blowing agents for insulation. The comments from ASD and ASD Eurospace provide specific information highlighting uses in many A&D products. Specific examples are provided, such as the use in cryogenic tanks for satellites, but wider aircraft and spacecraft uses are also mentioned. The new derogation (5i) appears to cover the identified uses in the A&D industry, whereas the previous derogation did not.
Metal manufacturing additives	Metal plating and manufacture of metal products	While it is expected that that some of the noted sub-uses within this category will overlap with other use categories (e.g. seals, coatings), it is not clear which (if any) derogations included will cover the use in metal manufacturing additives; or how this use category would be covered under broader derogations – e.g. for machinery; military uses.
Ammunition	Explosives	The updated background document includes an explicit derogation (6x) for 'explosives in military applications until 13.5 years after EiF, which was not in the original restriction proposal. While this is expected to cover the relevant uses under this category in A&D, it is not clear if or how this derogation would cover use in broader 'defense' uses since the derogation is specifically for 'military applications'.
Polymer synthesis	Broader industrial uses	In the original (2023) restriction proposal, the proposed derogation covered polymerisation aids in the production of polymeric PFASs until 6.5 years after EiF. The updated background document has expanded this to a (non-time limited) derogation (4h) for "production of PFAS with or without the use of fluorinated polymerisation aids in the production of polymeric PFAS under controlled conditions with average emission factors". In practice this should allow the continued manufacture of polymers required for the (derogated) uses in A&D.
LCD/LED displays	Electronics and semiconductors (Electronics)	There is a specific derogation (5u) applied to photonics for 13.5 years after EiF. This use covers, LCD, OLED, optical fibres (polymer optical fibres) and other optical uses, therefore it is expected that this will cover all relevant uses in A&D.

Use category (as identified by WG5)	**Corresponding ECHA use categories[1]**	**Summary comments**
Industrial food and feed production equipment	Food contact materials (FCM) and packaging	The original (2023) restriction proposal included a proposed derogation that would cover all food contact materials for the purpose of industrial and professional food and feed production, in practice covering the relevant uses relevant for A&D. However, this derogation is not included in the (August 2025) updated background paper. While some derogations (both specific and general) are expected to apply, it is not clear if all uses of PFAS for this category of use in A&D are covered.
High performance membranes	Technical Textiles	The derogations (5qq, 5rr, 6y) included in the August 2025 restriction proposal are expected to cover the key uses for 'high performance membranes' identified for the A&D sector from the initial mapping by WG5 members (specifically acoustic insulation e.g. inside the vehicle engine compartment, and gas and water filter membranes). It is noted that the derogation for technical textiles has been expanded in the updated background document to cover all transport vehicles instead of only automotive. It is not clear if the current derogations will cover all uses of ''high performance membranes'' in A&D, noting that there may be other uses not captured in the initial mapping.
Other uses including: Composite release films Mould release (for composites or other plastics) Moulded Parts: Other fluoropolymers Tooling	Transport Machinery applications	The 'other' uses highlighted in the WG5 mapping process cover several uses that do not fit under the original set of use categories identified. These are relatively less-well understood or defined so it is more challenging to map against the ECHA use categories and current derogations. It can be expected that such uses related to 'Body, hull and fuselage construction' in transport will be covered by the derogation for 'vehicle systems, components or separate technical units that are subject to EU vehicle type approval' (para 6q), however the situation is unclear for other A&D uses. The derogation for 'machinery applications in industrial uses until 13.5 years after EIF' (para 6(f)) is also potentially applicable to these uses.

[1] Based on the ECHA Annex to the Guidance for respondents to the consultation on the SEAC draft opinion on restricting per- and polyfluoroalkyl substances (PFAS)

In addition to the consideration of each individual A&D use category, and the coverage of proposed derogations, for each use, it is also noted that the proposed EU REACH restriction for PFAS also includes several 'broader' derogations. These derogations are expected to apply to A&D uses more generally (and/or upstream of direct use by A&D companies), and will cut across multiple different use categories. The table below provides a summary of broader derogations that will relevant to A&D.

Table 4.2 Summary of broad derogations covering the A&D use categories

Derogation type	Description in the restriction proposal text	Applicable A&D use categories
Transport	"Vehicle systems, components or separate technical units [(excluding 'sealing applications', batteries and fuel cells, lubricants, electronic and electrical systems, HVACR, technical textiles*)] that are subject to EU vehicle type approval, where the type approval was obtained within 13.5 years after EiF (e.g., motor vehicles within the scope of Regulation (EU) 2018/858, (EU) 2019/2144 or Directive 2007/46/EC, agricultural and forestry vehicles with the scope of Regulation (EU) 167/2013, aircraft within the scope of Regulation (EU) 2018/1139 or (EU) 748/2012, watercraft within the scope of Directive 2013/53/EU or 2009/45/EC, and rail vehicles within the scope of Regulation (EU) 2016/797 or Directive (EU) 2016/798)" (para 6f).	Coatings; Adhesives ; Engine parts
Spare Parts	"Spare parts intended to replace PFAS-containing articles in articles or complex objects until 20 years after the last date when the complex article was allowed to be placed on the market for the first time or until the end of service life for the specific object, when it is shorter than 20 years" (para 4e). Spare parts used in articles or complex objects for which legal obligations related to the use of specific spare parts exist until the end of service life of the complex object (para 4f).	Lubricants; Seals; Coatings; (Insulated) wires/cables; Electrical engineering and information technology products; Optical fibres Adhesives ; Engine parts; LCD/LED displays
Machinery applications	"Machinery applications in industrial uses until 13.5 years after EiF" (para 6q) The term "machinery applications", for the purpose of this restriction, encompasses all applications of fluoropolymers (FPs) and perfluoropolyethers (PFPEs) not covered elsewhere and where these are used as • Self-lubricating/low-friction components (either entirely made from FP/PFPEs or coated with them) • Structural elements • Coatings for protection/durability	Coatings ; Engine parts
Military uses	Military applications until 13.5 years after EiF.	Lubricants and dry film lubricants; Coatings; Solvents; Adhesives; Heat transfer fluids; Fluorinated gases; Corrosion inhibitors; Hydraulic fluids (high and low temp); Metal plating additives; Anti-friction and

Derogation type	Description in the restriction proposal text	Applicable A&D use categories
		wear resistance ; Engine parts ; Chemical processing ; Fire supressing agents; Lifesaving equipment ; Optical fibres; Foam-Blowing Agents; Metal manufacturing additives ; Ammunition (tbc); Polymer synthesis ; LCD/LED displays Industrial food and feed production equipment; Other uses

5. Conclusions

5.1 Summary of key insights from A&D supply chain mapping

From the further supply chain assessment carried out by WG5, several conclusions can be drawn, with regard to the key research questions the study has investigated. These key conclusions are outlined below.

- Supplier actions relating to potential restriction of PFAS are wide-ranging between different companies and associations. While most FP manufacturers indicate that they will continue to manufacture FP products for the foreseeable future, some companies have announced plans to exit the market, either fully or partially. Some manufacturers and suppliers of products are setting up action plans to halt or move away from the use of PFAS in their supply chains, at least to some extent (e.g. specific product lines). In these cases, they have indicated that they are taking steps to communicate their plans and the associated timelines to their customers.
- Very limited evidence of definitive plans for the obsolescence or reformulation of specific products has been identified in this study, aside from several companies that are ceasing production of PFAS-containing products completely or in part (e.g. 3M, Solvay, in the public domain). Most suppliers contacted are not planning to divulge their specific plans until the EU REACH restriction is finalised. The main actions currently being taken by EU-based FP manufacturers in the meantime are around emissions reduction or control and phasing out PFAS-based processing aids and surfactants from their manufacturing processes.
- FP manufacturers have indicated that there is a lack of available PFAS-free alternatives to meet the needs of many of the A&D applications highlighted in this study. For example, A&D applications are commonly associated with harsh temperature and/or chemical conditions, wide temperature fluctuations, exposure to highly aggressive fluids, radiation, and high mechanical stress, while meeting stringent safety and reliability requirements over very long service lives. Several ‘direct’ uses of PFAS in products/formulations used in A&D are highlighted as being particularly challenging to find technically and economically viable alternatives in this respect. These include coatings, seals, lubricants, wire and cables, and capacitors.
- A key aspect of ‘upstream’ in the supply chain for A&D is the lack of visibility of some PFAS uses. The use of PFAS in the manufacture of semiconductors is highlighted here as an important ‘indirect’ or ‘hidden’ use of PFAS in A&D, where PFAS will not necessarily be incorporated in the final electronic products used, and where industry has highlighted that finding non-fluorinated alternatives is considered particularly challenging. For other uses (e.g. solvents, cleaning products, F-gases), much less evidence is currently available.
- Another key ‘upstream’ aspect in the supply chain is the use of fluorinated processing aids or surfactants in the production of FP. While some companies are developing PFAS-free processing aids, it is also noted that these may not be suitable for the production of all FPs, so it is likely that PFAS will continue to be used in this application in the absence of a restriction.
- Suppliers have emphasised the importance of close communication with customers, e.g. with reference to key products that should be prioritised or targeted for developing alternatives or reformulating to remove PFAS, and several are prepared to work closely with the IAEG in the future.

5.2 Coverage of A&D uses by the proposed EU restriction

Since the WG5 supply chain mapping was undertaken, an updated restriction proposal has been published[43]. This introduces a number of additional use categories for PFAS, as well as modifying the conditions of the originally-proposed restriction, including the derogations. Key insights from this assessment are highlighted in section 4.

Additional areas where further information would help WG5 to understand the implications of the proposed restriction include:

- Further investigation would be beneficial in terms of the gaps that exist between the coverage of the restriction proposal (i.e. the derogations included) and the multiple PFAS uses in the A&D industry. The current work has drawn on extensive inputs to previous consultations by the A&D industry and has identified various additional uses, but some gaps will inevitably remain.
- In some cases, it is not fully clear whether certain uses/products in the A&D industry would be (fully) covered by the various derogations proposed under the updated (2025) restriction proposal. Different proposed derogations also have different associated timescales. An example is the proposed derogation for 'military' uses. The restriction proposal does not appear to state a precedence of the derogation for military (or other) applications versus those for specific applications in the A&D industry, except for example where specific uses are explicitly excluded from the description of military uses in the use mapping document. It could therefore be explored whether there is an order or precedence in terms of whether this derogation would apply.
- More specifically on the timescales associated with the derogations, further work is needed to understand whether the timescales (e.g. 6.5 years, 13.5 years) would be sufficient to replace the use of PFAS across different applications.
- Assessment of the proposed derogation coverage is limited to understanding if the A&D known uses would have a derogation. The assessment does not encompass whether the proposed timeframes for derogations would be sufficient for the A&D industry.
- A review of A&D uses and the coverage of derogations has been presented in Section 4. This assessment has highlighted that, while some key uses in A&D are expected to be fully covered by proposed derogations (e.g. seals, lubricants, wire and cable insulation, semiconductor fabrication), there are a number of cases where there are identified gaps, or uncertainty regarding the coverage of derogations. A key example relates to the coverage of 'military' uses and how this would overlap with other A&D use categories, especially where the timeframes of the derogations are different. The distinction between 'defense' and 'military' uses, while understood by WG5, is not currently fully clear in the restriction proposal.
- Several use categories in the A&D sector have been identified which are not fully covered by derogations, or where uncertainties exist over the level of coverage. Examples include uses of coatings, ammunition, explosives, adhesives and some electronics. In the case of coatings, for example, some derogations apply only to polymeric PFAS. One of the key CAS numbers highlighted in the WG5 PFAS mapping (see section 2.4.5) is 1 chloro-4-trifluoromethyl benzene (98-56-6), a non-polymeric PFAS used in coatings. There is therefore uncertainty over the status of such A&D coating applications under the proposed derogations. Similarly, the

[43] Background Document to the Opinion on the Annex XV dossier proposing restrictions on Per- and polyfluoroalkyl substances (PFASs), version no. 14, 24 June 202.

use of ‘adhesives’ is not explicitly mentioned in relation to derogations, so it is unclear how these products would be covered.

5.3 Remaining data gaps/uncertainties

This supply chain mapping assessment has provided a number of important insights into the potential implications for the A&D supply chain relating to the proposed restriction of PFAS under EU REACH. However, a number of key areas of uncertainty and data gaps still remain. These are outlined below.

- A key aspect of remaining uncertainty is the lack of clarity in the ongoing regulatory processes. The proposed EU REACH restriction of PFAS is not yet finalised and it is envisaged that the current coverage and scope (e.g. related to the derogations allowed) could change further. A key observation from the supply chain assessment is that several suppliers are not planning definitive actions until they have (more) regulatory clarity. Given the revised scope since the phase 1 and phase 2 mapping were undertaken, further consultation with suppliers would be needed to understand what actions are currently planned by suppliers as a result of the latest proposal.
- The wide and diverse range of uses (and associated products) in the A&D industry, highlighted by the WG5 mapping but also input from ASD, AIA and individual companies, combined with different definitions and terminology, make it challenging to gain a complete picture of all A&D uses that could be affected.
- Furthermore, as highlighted in Section 5.2, the updated restriction proposal has updated and expanded the coverage of the derogations included and many derogations will cover (fully or partially) the uses in A&D. The level of detail provided in the text describing different derogations, and the explanatory notes providing further detail, differ in their level of detail and specificity, so in many cases it is not apparent precisely which A&D uses would be covered by derogations. Additionally, the derogations assessment in Section 4 is limited by the availability and visibility of data on PFAS uses in A&D products to WG5 members. As WG5 are aware of data gaps in their use investigations, the applicability of the derogations to all A&D uses also carries a level of uncertainty which requires further investigation.
- This supply chain assessment has been based upon the inputs of a select few suppliers. The companies consulted are all larger-scale suppliers. A key missing aspect in relation to the full supply chain is the challenges faced, or actions that might be taken, by smaller business, which has not yet been fully captured. This could, for example, risk missing out important niche applications that are not covered by larger companies.
- The ‘hidden’ uses for PFAS in A&D remain very challenging to investigate. Since the assessment has been largely informed by the WG5 survey, it has collected information predominantly on uses where PFAS is present in the end product. Investigating other uses of PFAS deeper in the supply chain is challenging.
- Furthermore, a challenge that is already known to WG5 is the use of products both marked as being for ‘aerospace’ and those sold for other ‘general’ uses or for other sectors but which will indirectly impact A&D uses (e.g. electronics). The lack of transparency in the supply chain (both supplier-down and user-up) makes the identification and assessment of PFAS very challenging.
- The available information gathered in this assessment (from both WG5 members and suppliers) has been dominated by the production and use of FP and FP-containing products. This has meant that the focus has been largely directed at uses in articles. Relatively little

insight has been gathered about the use of non-polymeric PFAS and their specific supply chain risks. The use of FP represents by far the greatest use of PFAS in the A&D industry.

- This assessment has not been able to conduct a systematic assessment of each of the specific products used in the A&D industry in terms of potential obsolescence/reformulation. This is largely due to the issue (as detailed above) that suppliers will often not know the full extent to which their products are used by A&D end users, but also due to the very large number of products.
- This assessment has elected to assess uses of PFAS on the basis of the broad use categories defined in the ECHA consultation and the SEAC guidance[44] on the forthcoming (at the time of writing) consultation. However, as highlighted in the phase 1 mapping (and discussed in the AIA submission to the ECHA 2023 consultation[45]), each use can also be sub divided into many sub-uses. This could mean that, even for uses that seem to be well covered or understood in this assessment, there may be sub-uses that are 'at risk' or other sub-uses that are currently 'unknown'.
- Clearly identifying the applicability of specific derogations to many of the A&D uses identified remains difficult and, in several cases, uncertain. The mapping presented should therefore be understood for what it is—namely, an attempt to link the various uses with the relevant provisions in the EU PFAS restriction proposal. There is a lack of clarity as to if 'military' and 'defense' are being used interchangeably in the restriction proposal or if there are different definitions for the two terms.

[44] Consultation on the SEAC draft opinion on restricting per- and polyfluoroalkyl substances (PFAS) – Guidance for respondents and use mapping, European Chemicals Agency, December 2025.

[45] See ECHA consultation reference [9434-119].

Appendix 1: Detailed review of proposed EU restriction and derogations for A&D uses

A companion excel document has been generated as part of this work to review the derogations in both the original 2023 PFAS Restriction Proposal and the updated August 2025 document. This document is located on the IAEG WG5 webpage at the following link: https://www.iaeg.com/workgroups/wg5/activities.