Responses to questions – meeting with PPE companies (protective clothing)

Date : 17/10/2021

Introduction
PPE can include items such as safety helmets, gloves, eye protection, hazmat suits, high-visibility clothing, safety footwear, safety harnesses, ear plugs, ear defenders and respiratory protective equipment (RPE). This document focuses on protective clothing.

The responses included in this document are a compilation of responses received from different companies. The replies from a company are under one bullet point. A different bullet point indicates reply from a different company.

Please see also document 'contribution 2nd consultation on a restriction for PFAS' dated 17/10/2021. This document includes also other types of PPE that are not protective clothing. As in the consultation the mentioned sectors do not include all types of PPE, it is essential that this is taken into account.

The Euratex contribution to the SEAC public consultation of the 7th of September 2021, contains several pieces of evidence valid for PPE (several of our common members have contributed to this paper).

- To the best of our knowledge none of the TCs in CEN/CENELEC have been directly contacted nor has the CEN-CENELEC PPE sector forum.
  The agenda below focuses too much on clothing rather than PPE in general. Many of these PPE are not covered by CEN TC162, but by other TCs under CEN or CENELEC:
  - CEN TC 158 Head protection
  - CEN TC 159 on hearing protection
  - CEN TC 160 on fall protection
  - CEN TC 161 on foot and leg protection
  - CEN TC 79 on respiratory protection
  - CENELEC TC 78 on live working

  All these TC are responsible for standard not unlike CEN TC 162 for which PFAS may be directly required to meet requirement or are indirectly so that the PPE meet the longevity needed for the uses and applications. Also many ensembles containing combination of different PPE may be covered by more than one standard and contain multiple component that are not necessarily tested individually but rather must meet a number of requirements whether from a chemical, heat and flame, or mechanical perspective that would require different PFAS products in the PPE from ranging from repellency, visors, o-rings in RPD and other connections in an ensemble, etc.

- As a general comment we believe fluoropolymers (plastics and rubbers) should receive less strict legislation and/or longer phase-out period or be subject to exceptions compared to the other more environmentally problematic PFAS substances, in general or at least for special and demanding PPE applications as discussed here i.e. high level chemical protection including applications where heat and flame retardancy may also be required. In this area they are very difficult to replace. Also, their use in these applications allows for positive environmental aspects such as re-usability and longer product life. Moreover, these polymers

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do not create the same issues related to leaching that short molecule PFAS do. Also, this may be speculation but another aspect may be that these advanced PPE products for demanding applications typically receive a high degree of attention in terms of care and maintenance from their users and knowing this, it is probably easier to point the user towards proper disposal at the end of the product lifetime i.e. avoiding landfill.

We would also like to refer to the replies from Euratex and ETSA.

Agenda point 1 - Critical properties (performance) for protective clothing

Questions

1. *Please describe quantitatively critical properties (performance) for protective clothing, see table 1, in the form of comparable measurements / studies between performance for fluorochemistry and alternative non fluorochemistry?*

   - The standards in Table 1 are incomplete from a garment PPE perspective (see comments in Table 1 and the table below), there are many other textiles used in PPE. From the garment perspective, the fluorochemistry (for repellence or fluoropolymers) is used on the one hand for repellency, but also has an effect to increase longevity of the PPE and other textiles used (e.g. boots, fall protection harnesses or ropes).

     The repellency chemistry may have an effect on other properties (e.g. antistatic) or may make the protection more durable where contamination through chemicals effects the protection (e.g. chainsaw protection).

     Based on the alternative and completed table 1 (see directly under the original table 1), PPE in garments, very frequently use fluorochemistry (for repellence or fluoropolymers) but also to review the whole supply chain for the PPE is impossible to ascertain where fluorochemistry may be used or not.

     Military (including civil defence) and police (law enforcement), public rescue teams are frequently exempt from the PPE regulation but use similar standard from a repellency or other protection frequently require to use fluorochemistry (for repellence or fluoropolymers) to ascertain their protection from a bullet-proof, cut and stab, in additiona to heat and flame, chemical, biological or particulate perspective.

   - We have only recently started to look at alternative fabric finishes. We do not have any test data to date that we can compare.

     Our fabrics use fluorocarbons for a number of reasons:

     1. To enable us to pass certain standards eg: EN343 Rain Protection, Chemical Protection mainly EN 13034.
     2. We cannot pass EN13034 using C6 chemistry for all 4 chemicals. C6 does not have enough carbon chain and does not have a stable molecular structure.
        The stronger molecular structure also offers better adaptability to dyeing and flame resistance finishing.
     3. Under EN343 standard 5.5, fabrics are subjected to pre-treatments including cleaning, abrasion and with fuel and oil in accordance in ISO 1817 for Class 2 and Class 3.

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Without C6 chemical, fabrics will not pass so manufacturers will not be in a position to claim EN343 Class 2 or 3.

4. To ensure colour fastness stability, in particular on Hi-Vis garments where this is a very important property. Most of our Hi-Vis garments we claim 50x washes - using these finishes allows us to achieve this.
5. To prevent soiling – stain prevention Not having this finish will increase the maintenance required on the product. It will limit the lifetime of the garment.
6. It will reduce the sustainability element – garments will have to be replaced more often.
7. Adhesion of Coatings: PFAS are also essential for coating of textiles- to prevent the coating paste from penetrating the fabric.
   C6/C8 fluorinated polymers are used as auxiliaries in the coating process to prevent the coating paste from penetrating the fabric". PFAS is not used to claim a certain functionality but rather as a "process" chemical. In fact this use should also be claimed as an "essential use" for textiles (coating).

- In case we cannot use C6 based finishes, the ISO13034 and EN469 will be influenced. The ban on C6 will imply that resistance to oily based chemicals will decrease in case the industry moves to silicone or parafinn based finishes. For water based repellency and penetration, less problems are expected.

  For the ISO13034, this means:
  - Repellency to water based chemicals (probably PASS on Sulphuric Acid and Sodium Hydroxide)
  - Repellency to O-Xylene and 1-Butanol will probably be a FAIL.

  EN469: all chemicals listed require PASS to fulfill the norm
  EN13034: only 2 out of 4 chemicals require PASS to fulfill the norm.

Oppervlakte energie niveau (mN/m)	Finish (mN/m)		Vervuiling (mN/m)	
>70			Water	**73**
40-70			Koffie	**42**
30-40	Parafine (-CH_2-)	**31**	Wijn	**40**
20-30	Siliconen (-Si-CH_3) Dendrimeren (-CH_3)	**24** **24**	Diesel Ethanol Bezine	**24** **22** **20**
10-20	Fluorcarbon (niet optimaal geactiveerd) (-CF_2-)	**18**	N-hexaan	**18**
<10	Fluorcarbon (optimaal geactiveerd) (-CF_3)	**9**		

- Type 1, high chemical protective clothing: Critical chemical barrier properties, not achievable with as broad spectrum protection with alternative materials. May possibly be achieved with other combinations of materials, i.e. layered but certainly at the expense of comfort and ease of movement, as the resulting composite would likely be much heavier per unit area of material.
  It would also have to be factored in to achieve appropriate flame retardant protection, which is contributed to with fluoropolymers, making finding alternative materials time consuming, painstaking, with sub-optimal results most likely which in the case of e.g. first responders to incidents could be detrimental as the product may not perform as well, be heavier, more difficult to move in, etc. It is important to note the environmental advantages

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i.e. long-term reusability and maintenance of such products and also that these fluoropolymers are not expected to leech chemicals to the environment (anyway in polymeric form) as opposed to other technologies.

Reusable protective clothing (chemical and fire protective) which may contain PTFE membranes as well: less critical overall. The membrane does offer excellent chemical resistance as you would expect, but mainly to splash and penetration under pressure risks (the permeation situation being totally different to above Type 1 suits, because whereas fluoro rubbers (and monolithic fluoropolymer films for example) offer protection to permeation against a wide range of chemicals, the porous nature of the PTFE membrane in products like these mean that permeation protection is not typically afforded – certainly not against volatile solvents and the like. Easier to consider alternative material types here but not easy to capture the breathability with broad spectrum protection in one material if not using PTFE. Similarly, to above, reusable products with long term use expected and fluoropolymer "trapping" the chemicals in the product, essentially.

Limited Use protective clothing: The FPAS surface treatments again offer a significant enhancement to the splash protection afforded by low end, lightweight materials (nonwovens for example) typically used in these sorts of products. The treatment allows a much broader spectrum of protection, for example against oils and certain solvents due to the ability to repel such that the liquids either run off the material or do not soak in (or soak in as quickly). It is not easy to consider an alternative treatment allowing the high degree of air transfer afforded by these types of material, although it is feasible to enhance the barrier in other ways at the expense of this, while still retaining some degree of comfort. More of a concern environmentally speaking but limited use – i.e. not to be washed. May need to consider end of life treatment.

- As regard to table 1, it is very important to understand that even if water- or oil repellence specifications are NOT explicitly foreseen in an EN or ISO PPE standard, that this doesn't mean there are no 'de facto' oil-repellence criteria for the product 'under the foreseeable conditions of use' and we should also never forget that we are talking of protecting HUMAN WORKERS against life-threatening risks while doing their daily job !

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The already foreseen derogations are completely justified for:
-EU 2016/425 regulated Cat. III PPE (a), (c), (d), €, (f), (g), (h), (l) BUT (j) = cuts by hand-held chainsaws was missing. The chain is constantly lubricated and the machine oil is projected at the PPE at speeds of 20m/s, 24 m/s or 28/m/s and several (German) scientific papers (in footnote 3 of the Euratex 940 document) proof that the protection drops rapidly in the presence of oil (even if oil repellence is not mentioned in the EN ISO 11393 series.

-o-xyleen is reference chemical used in several standards (chemical protection, firefighting PPE, …) and a CEN TC162 WG2 PG has proven (see footnote 4 of the 940 Euratex doc) that with C4 FLC it is impossible to meet the criteria even before washing; it is even challenging with C6-FLC chemistry (after washing). Whereas in the past most criteria needed to be met in 'as received' or after 5 washes, let us not forget that the CEN HAS consultant has now introduced tests as per the recommendations of the manufacturer(s). The number of claimed washes have become a commercial argument (25x, 50x, 75x, 100x) but there is a difference between washing of new, clean, unused, … garments in a laboratory and real life use on the job. This creates safety risks.

Inherently flame retardant fabrics with an LOI (Limited Oxigen Index) of >28 like meta-aramids (e.g. Nomex ®) will burn like cotton or paper when contaminated with flammable chemicals, oils, …

-Also there will be safety & environmental issues with some other PPE cat. II, eg; hi vis clothing to EN ISO 20471, … (not only class 1 but all classes). Workers using this clothing work with oils, greases, suit, … and dirty clothing makes them less visible. The need for more frequent washes, at higher temperatures, with more chemicals, … will increase the emissions and footprint; and shorten the life-expectancy of the garments needing to be replaced increasing the footprint again (= against the EU Green Deal).

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2. *Are these data available to us?*

   - Yes, the above table is publicly available.

   - The key performance for PPE clothing or textiles which is made IMPOSSIBLE with today's state of the art when PFAS is banned is OIL REPELLENCE and these data are already know to KEMI and other stakeholders – see Euratex contribution to the SEAC public consulation of the 7th of September 2021. This contribution contains several pieces of evidence valid for PPE.

   - Benchmarking testing would need to be conducted.

Agenda point 2 – Standards for protective clothing need for PFAS

Questions and remarks

3. *Are there comparable quantitative test results between fluorochemistry and non-fluorochemistry available to us performed with the test standards listed in table 1 (or others, please specify)?*

   - See study conducted by CEN TC 162 WG 2 on repellency on the outer layer of fire fighter garments (EN469) that shows the C6 chemistry barely provides the protection for chemicals such xylene (surrogate for petroleum, or other solvents) when applied as new. It needs to be reimpregnated very frequently to maintain protection. Below C-6 chemistry or with non-fluorinated protection xylene and other chemistries did not pass the requirement. For woven textiles, oil, alcohol and solvents repellency is not possible currently without C-6 or C-8 type chemistries. This study can also be used as basis for other woven garments meeting for example EN 13034.
     This study has been shared in the Euratex contribution to the SEAC public consultation dated 7th of September 2021.

   - Cf. CEN TC162 WG2 PG who have proven (see footnote 4 of the earlier mentioned Euratex document) that with C4 FLC it is impossible to meet the criteria even before washing; it is even challenging with C6-FLC chemistry (after washing).

     We have a case where we fail to meet the NATO AEP-38 criteria on oil-repellency (tested to ISO 14419 or AATCC118), needed to protect against liquid droplets of HD (Mustard Gas) in Military CBRN clothing, with C6 FLC, which passes with C8-FLC chemistry. 'Dismounted' soldiers can be needing to wear CBRN clothing for 12 or 24 hours…; hence the requirement of open fabrics with air-permeability for thermo-physiological comfort.

4. *Please indicate which quantitative measurement results/limits are acceptable for your markets for the test methods listed in table 1 below (or others, please specify).*

   - See study conducted by CEN TC 162 WG 2 on repellency of fire fighter garments (EN469).

   - Gloves:
     Gloves that are being made from PFAS chemicals are Viton gloves, which are typically used for high chemical protection against highly corrosive chemicals/acids, aliphatic & aromatic hydrocarbons as well as chlorinated solvents. Such gloves are to be made compliant to the EN ISO 374-1 standards.
     Viton gloves will typically protect for > 8 hours of uninterrupted contact against above mentioned chemicals, whilst current alternative rubber materials will mainly last few minutes user safety issue. Also, the product lifetime and degree of re-usability with fluoropolymers like Viton can be expected to be significantly higher than for other technologies.

Clothing:
See Q1, type 1 clothing. For this type of clothing and in particular the reusable types, fluoropolymers provide good barriers and broad spectrum protection e.g. as required in EN 943-2 where Viton and fluoropolymers enables good chemical performance coupled with durability, chemical degradation resistance which makes for reusability and long product life, something that is not measured in referenced standards but certainly an important aspect in this discussion.

Table 1: *Critical properties (performance) vs Standards for protective clothing (CEN/TC 162)*

Critical properties (performance)	**Standards for protective clothing (CEN/TC 162)**
Electrostatics	EN 1149-5:2018[1]
Liquid chemicals	EN 13034:2005+A1:2009[2] EN 14605:2005+A1:2009[3] ~~EN 16523-1:2015+A1:2018~~[4] (this is a test method, not a product standard)
Protection against chemicals	~~EN ISO 17491-3, -4:2008~~[5] ~~EN ISO 17491-4:2008~~[6] ~~EN ISO 19918:2017/A1:2021~~[7] ~~EN ISO 6530:2005~~[8] (these are test methods, not a product standard) NATO AEP-38
Liquid and gaseous chemicals, including aerosols and solid particles	~~EN 464:1994~~[9] product standard has been superseded by : EN 943-1:2015+A1:2019 EN 943-2:2019

[1] EN 1149 series, https://standards.cen.eu/dyn/www/f?p=204:105:0:::::
[2] EN 13034:2005+A1:2009, https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT,FSP_ORG_ID:32982,6143&cs=1A0EC674842C38E0EA1FF3289F91BC76C
[3] EN 14605:2005+A1:2009, https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT,FSP_ORG_ID:32983,6143&cs=1868F123B185CBECCA30C484231EB9233
[4] EN 16523-1:2015+A1:2018 https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT,FSP_ORG_ID:67114,6143&cs=1753CA3DD9D58A4835043F014216B2C1A

[5] EN ISO 17491-3, -2008 https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT,FSP_ORG_ID:23098,6143&cs=12D3A8D6D32D899469296826BC259C835
[6] EN ISO 17491-4:2008 https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT,FSP_ORG_ID:23099,6143&cs=10D51599070E9BD60C8715CAEBF4C7841
[7] EN ISO 19918:2017/A1:2021 https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT,FSP_ORG_ID:70836,6143&cs=1F09ABC9AAD96F9554D60B9F78952CF49
[8] EN ISO 6530:2005 https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT,FSP_ORG_ID:6778,6143&cs=10DC0A31382F43CA906841B78380B3F27
[9] EN 464:1994, https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT,FSP_ORG_ID:6659,6143&cs=165B04976C33240ACD0DD3E668DD67408

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Critical properties (performance)	Standards for protective clothing (CEN/TC 162)
	ISO 6529:2013 EN 1073 series and EN ISO 13982-1
Against rain	EN 343:2019[10]
Splashes of molten metal	~~EN 348:1992~~[11] (this is a test method, not a product standard)
For firefighting activities	EN 469:2020[12] ISO 21942 ISO 15384 EN16689, ...
For heat and flame protection	EN ISO 11612:2015 EN ISO 11611:2015 EN ISO 14116:2015 CAST (UK), VPAM(D), NIJ0101.06 (USA), ...
High or medium visibility	EN ISO 20471:2013[13] EN 17353:2020
Use, care and maintenance	CEN/TR 14560:2018[14] CEN/TR 15419:2017[15] CEN/TR 17330:2019[16]
Others? Cuts against hand held chain saws	 EN ISO 11393 series
(National) Ballistics standards / riot suits	national standards such as BS7971-10 & protection against Molotov cocktails specified tender specifications

table 1 : Alternative arrangement and completed – only for garments ! Gloves and other types of PPE are not included !

Type of fluorochemistry (repellency/polymer)	**Critical properties (performance)**	**Standards for protective clothing (CEN/TC 162 and CENELEC/TC78)**

[10] EN 343:2019, https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT,FSP_ORG_ID:63371,6143&cs=1B18C11D02C518D1B6A214EAC88838727

[11] EN 348:1992 https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT,FSP_ORG_ID:6616,6143&cs=147CE63961DE2AC855BCE710EC70E8A6D

[12] EN 469:2020, https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT,FSP_ORG_ID:63013,6143&cs=1468ACE394F638F27BB45A2E03DFBDEC2

[13] EN ISO 20471:2013 https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT,FSP_ORG_ID:30182,6143&cs=1ECA362937B4D0E8B641C9F80D8E88876

[14] CEN/TR 14560:2018 https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT,FSP_ORG_ID:66982,6143&cs=17067BF89BD9A0B10910D342106B34226

[15] CEN/TR 15419:2017 https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT,FSP_ORG_ID:65002,6143&cs=18D38E936501A138A7C0EB6CFFDB7E8FB

[16] CEN/TR 17330:2019 https://standards.cen.eu/dyn/www/f?p=204:110:0::::FSP_PROJECT,FSP_ORG_ID:39246,6143&cs=1557EDC845AD3EF1A19867E8E23C7F2EA

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Repellency	Protection against chemicals	EN 13034 (Type 6) ISO 16602 EN 1073 series (particulate protection) EN ISO 13982-1 (particulate protection) ISO 27065 (Agricultural chemicals) EN ISO 374 series (glove chemical and biological protection) CBRN standard from national countries or authorities
	Biological protection (including medical devices)	EN 14126 (biological) EN 13795-1: (medical gowns - medical device) – not PPE but medical devices
	Against rain	EN 343 (includes oil test)
	Heat and Flame	ISO 14116 (flame protection – chemical and soling protection) EN ISO 11611 (welding protection - protection of fabrics and soiling) EN ISO 11612- reduces metal adherence to textile) IEC 61482-2 (arc protection - protection of fabrics, water and soiling) EN/IEC 62819 (Eye & face protection – head protection fabric, water and soiling)
	Live working	EN 50286 (Electrical insulating protective clothing– water/stain protection) IEC 60903 (insulating gloves – water/stain protection) IEC 60984 (insulating sleeves – water/stain protection) IEC 60895 (Conductive clothing– water/stain protection)
	For firefighting activities	EN 469 (garment - chemical and biological protection) EN 1486 (garment with relective outer surface – stain/oil protection) EN 659 (gloves – chemical and water protection) EN ISO 15384 (wildland garments - water protection) EN 16689 (rescue – water and biological protection) ISO 21942 (station uniform – chemical, water and biological protection) *Other equivalent/similar ISO standards may be applied*
	High visibility	EN ISO 20471 (maintenance of high visibility criteria)
	Chain saw protection	EN 381 series (ISO 11393 series) protection of chain protection
	Motorcycle clothing	EN 17092 series (garments - protection against rain) EN 13595 series (garments professional - protection against rain)

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		EN 13594 (gloves - protection against rain)
Repellency	Various test methods used without garment certification to repellency	EN ISO 6530 (penetration gutter test) AATCC118 (oil, water) EN ISO 4920 (spray test) EN ISO 811 (water penetration) Garment test in EN ISO 17491-3, -4 series spray and jet test
Polymer (maybe found in parts of the garment or potentially fabric composition)	Protection against chemicals	EN 14605 (Type 4 and 3 clothing) ISO 16602 EN 943-1 and EN 943-2 EN 1073 series EN ISO 13982-1 (Could be part of the fabric material or in parts of these if garment that have a shield, connection to boots or gloves, connection to respiratory protection, etc.)
	For firefighting activities	EN 469 (vapour barrier , water column) EN 1486 (garment with relective outer surface – stain/oil protection) EN 659 (gloves – chemical and water protection) EN 16689 (rescue – water and biological protection) Other equivalent/similar ISO standards may be applied
	Heat and flame	EN/IEC 62819 (Eye & face protection – face protection polymers)
	Membranes	Frequently used to enhance water barrier protection (may need to be of fluoropolymer to avoid hampering heat and flame protection
NOTE 1 : next to standard reference protection and why/how fluorochemistry is applied although not necessarily a requirement in the standard but additional protection requested NOTE 2 : some of the standards may appear more than once depending on the situation, and to meet the requirement may be possible though other methods but for different uses, therefore not necessarily alternatives. NOTE 3 : this table does not include non-garment or glove applications outside of CEN/TC 162 or CENELEC/TC 78		

Agenda point 3 - Potential alternatives to PFAS

In the ongoing restriction work of PFAS in EU/EEA, a range of non-fluorinated alternatives to PFAS have been identified

- *Hyperbranched functionalized polymers (dendric polyurethanes)*
- *Paraffins (hydrocarbons)*
- *Waxes (fatty acid esters)*
- *Silicones (polydimethylsiloxanes abbr. PDMS)*
- *Polymeric compounds such as non-fluorinated (meth)acrylates*
- *Plasma treatment*
- *Graphene structures*
- *Other?*

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Questions

5. *For these above listed non fluorinated alternatives (and possibly other) to fluorochemistry, what are the biggest specific challenges to phase in those non fluorinated alternatives that may be feasible for your applications?*

   - See study conducted by CEN TC 162 WG 2 on repellency of fire fighter garments (EN469).
     Below C-6 chemistry or with non-fluorinated protection xylene and other chemistries did not pass the requirement. For woven textiles, oil, alcohol and solvents repellency is not possible currently without C-6 or C-8 type chemistries. This study can also be used as basis for other woven garments meeting for example EN 13034.

   - Generally also : limited oil repellency, lower wash durability and less possibility of re-application in wet-cleaning process (ISO15797 based), flammability, charge with static electricity.

   - Cost is the biggest challenge to phasing in any alternatives.

   - Biggest challenge will be ensuring we have materials and products that comply with existing certifications and performances. While this may be achievable, the route to do so may involve effectively over-engineering the product to end up with something very clunky in other respects, e.g. may be too heavy, too stiff, not great when it comes to practical performance which it also has to pass. It's all very well having something "just about ok" but if such products replace high performing ones on the market now, this would be a step backwards and potentially endanger users who are used to products behaving in a certain way that have done so without issue for many years, particularly for very mature products.
     - *Hyperbranched functionalized polymers (dendric polyurethanes)*
       It remains to be seen what the impact here would be on cost, barrier, physical strength (compared to material thickness etc.), flexibility, and so on. Dendritic polymer synthesis historically has not been the simplest always, so concerns are either with respect to uncontrolled or poorly controlled reaction to form the polymer, or the cost of the material if the synthesis is sufficiently complex to drive it up.
     - *Paraffins (hydrocarbons)*
       No good for chemical barrier compared to articles made from a combination with Viton suits and gloves to ensure broad spectrum chemical protection
     - *Waxes (fatty acid esters)*
       Will be a similar situation no doubt regarding barrier. It's like a scissors paper rock situation. You may find different materials which when combined allow to replace fluoro-types, but very difficult to find a single material to do the job. These fatty acid ester types may perform well in some areas but will perform poorly in others, and the same will be true of many "alternatives".
     - *Silicones (polydimethylsiloxanes abbr. PDMS)*
       Same story.
     - *Polymeric compounds such as non-fluorinated (meth)acrylates*
       And again. None of these materials are new or novel. If they could have the desired properties, we would have long since known about it.
     - *Plasma treatment*

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Surface effects only do so much, and are not permanent, so this is not really a viable solution. To be honest, it is already a consideration for materials in general, where needed.

- *Graphene structures*
  This is certainly an area of interest for many things including barrier – which would be the obvious thing served here. However, the research takes time and actually the long term effects of having graphene in such materials may still not be known.
  It must also be noted that small particles of graphene can slice through cell walls for example. So how it would be used and its propensity to be released from materials would also have to be carefully considered.
- *Other?*
  It really depends what you are trying to emulate. As per above, difficult to capture all elements (chemical barrier and flame retardance) in a single material.
  Some examples as follows:
  - Broad chemical protection requiring multiple rubber layers and film laminate. If forced to give up fluoropolymer, there will be other options but simply limiting in some form
  - FR – similar.
  - Breathable monolithic films do exist which have excellent MVTR properties. Being monolithic, there would be advantages in terms of protectiveness as well, so use of PTFE in suits could be challenged with such materials.

- The biggest challenge is OIL REPELLENCE !!!
  alternatives do cause other issues:

  - influence of Flame retardancy
  - making materials more electro-statical (eg. through silicones)
  - negative influence of adhesion (& wash resistance) of heat sealed logo's, retro-reflectives, … or laminated membranes (protection against water, chemicals, blood born pathogens, …)
  - can cause a scratching 'writing effect' on the surface of dark colours
  - Etc…

6. *Have you evaluated other fluorochemicals / materials as substitutes for the currently used fluorochemistry? If so, please specify this chemistry.*

- Other things are used in other products – precisely because the use of fluoro-materials differentiates the products they are in by having better/more desirable properties, particularly the combination of chemical and FR protection with relative comfort (mainly thinking about RU-GT here but could extend to gloves). There would be no improvement to be made for fluoroplastics and rubbers since these are already significantly more environmentally friendly compared to shorter/smaller fluorinated molecules that will easily leech out and contaminate the environment, something that does not happen with polymers.

- For some alternatives to PFAS, we would like to raise the fact that many of it are inflammable and are a risk for PPE against flame and heat. Those alternatives (silicones, wax, paraffines) cannot be used in our laundries.

- We would need to carry out extensive testing/trials using these to see what works best and gives the same required results. Our main aim is ensure our products provide the same level of protection as they always have.

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Agenda point 4 – Quantities of PFAS in protective clothing

Questions

7. *What are the quantities of PFAS[17] used in protective clothing applications in the EEA?*

8. *Annex I of the PPE regulation[18] (EU 2016/425) divides PPEs into three risk categories. What share of the quantities of PFAS are used in the three risk categories, respectively?*

    - All the PPE mentioned in the table added are CAT III with one or two exemptions.

    - This is all Category III basically. This is the highest risk category and as such requires materials that perform and protect from dangerous chemicals and flames.

9. *Do you apply industrial re-impregnation of PFAS in your products? If so, what quantities of PFAS are used for industrial re-impregnation of your products?*

    - See also questions 3 and 5

    - As fabric producer and finisher, we apply 1x FC finish but with high concentration FC and proper fixation (left-overs are collected and disposed)
      In industrial laundry, reimpregnation is done every cleaning cycle. Problem is that the fixation is very low as FC reimpregation has low affinity with fabric (no crosslinking). FC reimpregation concentration is very low (about 10%). Disposal and collection is difficult.

Agenda point 5 – Emissions and waste management

Questions

10. *What are the quantities of emissions of PFAS from reimpregnation of your products?*

11. *What measures can be taken to minimize the emissions from reimpregnation? What are the costs associated with these measures?*

    - Re-use and collection of leftovers in production to separate waste-stream disposal.

12. *How are your PFAS containing protective clothing dealt with at end-of-life?*

    - Depending on the use and the contamination these would be discarded.

    - Incineration is probably the best way, if done properly. Landfill is obviously not as good an alternative but it should be noted that the polymers will not leach out into the environment the way shorter PFAS molecules will.

13. *What are the quantities of emissions of PFAS from protective clothing in the waste phase?*

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[17] PFAS here defined as having the following structural formula: X-(-CF2-)n-X’ with n equal to or larger than 1 and X, X’ not being H (thus including X-CF3), meaning fluorinated substances that contain at least one aliphatic carbon atom that is both, saturated and fully fluorinated, i.e. any chemical with at least one perfluorinated methyl group (-CF3) or at least one perfluorinated methylene group (-CF2-), –), including branched fluoroalkyl groups and substances containing ether linkages, fluoropolymers and side chain fluorinated polymers.

[18] EU 2016/425, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32016R0425

- Not known.

14. *What measures can be taken to minimize the emissions from the waste phase? What are the costs associated with these measures?*

    - If we had the answer to this question, that would really help – but there should be a lot of work to go into determining this. Could be slow to even get off the ground and very costly if we want to get proper data. Also worth noting that small scale investigations were written off for incineration waste data because only full scale incinerators recycle the gases to break everything down properly.

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