Application for derogation from PFAS REACH restriction for use in membranes that facilitate air and/or sound transmission whilst providing ingress protection for devices that may be used for communications

November 2022

Table of Contents

1. Acronyms

EoL	End of life
ePTFE	Expanded polytetrafluoroethylene
PFAS	Polyfluoroalkyl substances
REACH	Regulation (EC) No 1907/2006

2. Technical description

2.1 Application description

In today's society, the general public in Europe rely on their smartphones and headphones to continue to provide two-way communications in an emergency. In the future, society may come to rely on other devices for communications.

This derogation application is based on smartphones because these are the main devices on the market today that consumers currently rely on for communications. The European Chemicals Industry (CEFIC) case study[1] highlights that all types of communication devices need protection from dust and water ingress so that life-saving information can reach its recipient during an accident or emergency. Therefore, this derogation application is also applicable to headphones and other devices that consumers may come to rely on for communications in the future.

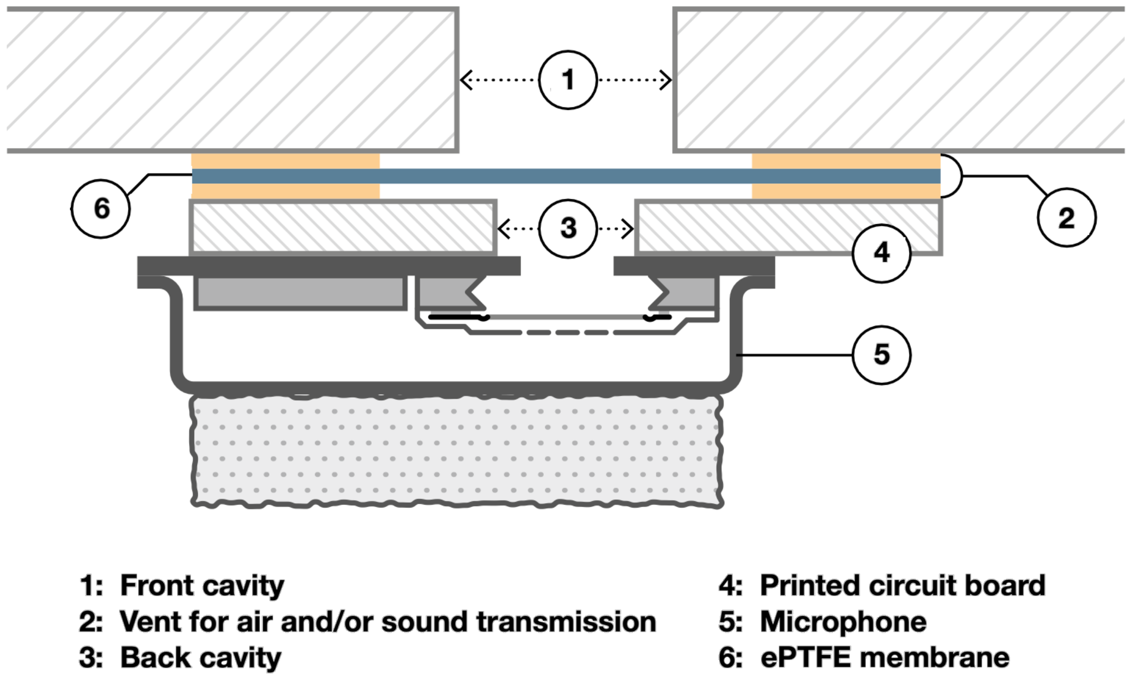
The acoustic paths of microphones and speakers in a smartphone are open to the external environment and this exposes the microphones and speakers to risk of contamination by dirt, debris, dust, water and other liquids. Smartphones use vents to equalise the air pressure and to protect the microphones and the speakers from damage by water and contaminants while enabling transmission of air and/or sound, Figure 1. Without effective protection against these elements, the smartphone will fail.

As electronic devices operate, they generate heat which can cause internal temperatures to increase and therefore pressure to build up inside the housing. Internal pressure can also change rapidly if the device is exposed to sudden changes in external temperatures or altitudes. The acoustic paths for microphones and speakers can be constructed to provide some protection against large debris, however all smartphones need vents to protect against dust, water and other liquids and to allow atmospheric pressure to equalize on both sides of the microphones and speakers. Without such pressure equalising vents, the difference in pressure across the microphone and speaker will create transducer bias[2], which degrades the microphone and speaker performance such that the sound becomes unintelligible.

[1] https://www.fpp4eu.eu/case-studies/pfas-protects-communication-devices-from-dust-and-water/

[2] Transducer bias is distortion of the pressure-sensitive diaphragm which is located inside the transducer of the microphone or speaker

Figure 1: Vent for air and/or sound transmission in a typical smartphone



The front cavity is a gap in the smartphone housing that leads to the microphone or speaker. Typically, the front cavity gap for a microphone is 1 mm diameter or less.

2.2 Properties and function of PFAS in the membrane

The membranes which are used in these vents for air and/or sound transmission are typically engineered from expanded polytetrafluoroethylene (ePTFE), a material with a unique structure that optimizes vent performance and device reliability. ePTFE is a PFAS. The ePTFE material is engineered to produce a very thin and low-mass membrane with mechanical properties and porous microstructure that enable optimal transmission of air and/or sound.

ePTFE membranes can enable sound transmission in two different ways. In some cases, the membrane vibrates easily and quickly in response to sound waves, converting their airborne energy to mechanical vibrations. These vibrations are reproduced on the other side of the membrane to create high-quality acoustics. In other cases, the microstructure is permeable enough to allow direct transmission of the sound waves through the membrane's porosity. The optimal transmission properties of ePTFE also enable the vent structure to rapidly equalize pressure changes, protecting sensitive electronics against condensation and minimizing stress on device seals.

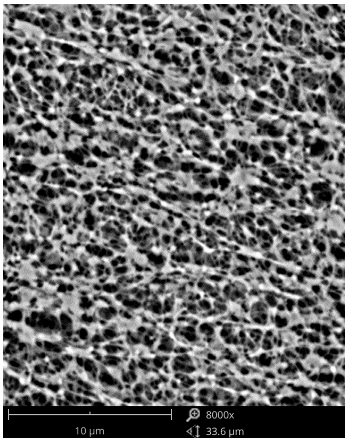
Vents for air and/or sound transmission for smartphones have a diameter of about 4 mm (with an inner diameter of 1.6mm) and the thickness of the ePTFE membrane is about 0.007 mm. The typical density of ePTFE in smartphone vents is about 0.4 gm / cm^3 and so the weight of ePTFE in a vent is about 0.035 mg.

Although the ePTFE membrane is very thin, the PFAS has two essential properties which enable it to repel water effectively and provide ingress protection. The microstructure of the membrane provides effective protection against dust particles and the oleophobic treated surface effectively repels oils, sweat, cleaning solutions and other common fluids that can threaten device reliability.

2.2.1 Tortuous microstructure traps dust and debris

PTFE, a polymerized tetrafluoroethylene known for its chemical inertness, high thermal stability, low coefficient of friction and other distinctive properties, can be stretched rapidly to create a strong microporous material known as expanded PTFE, or ePTFE. The ePTFE structure consists of nodes, fibrils and pores, Figure 2. This structure facilitates the transmission of air and sound, while effectively repelling water, other fluids and particulates.

Figure 2. Complex, three-dimensional microstructure in ePTFE membrane



ePTFE membranes for vents for air and/or sound transmission have a complex, three-dimensional microstructure which provides a tortuous path through the material. This complex, tortuous path traps very small particles with great efficiency.

2.2.2 Oleophobic surface repels water and fluids

ePTFE is naturally hydrophobic and has a surface energy of 21 dynes per centimeter (dyn/cm)[3]. This allows it to easily repel fluids with surface tensions above 40 dyn/ cm, such as water (72 dyn/cm) and coffee (40 dyn/cm), Table 2.

The ePTFE membrane may be further treated with additional fluoropolymer (which is also a PFAS) to make it even more hydrophobic, to create a material which is sometimes called ‘super hydrophobic’ or ‘oleophobic.’ Oleophobic treated ePTFE has a reduced surface energy and can effectively repel fluids with very low surface tensions. For example, the surface tension of household cleaners ranges from 27–32 dyn/cm, and the surface tension

---

[3] http://www.accudynetest.com/polymer_surface_data/ptfe.pdf

of isopropanol is 22 dyn/cm, Table 2. In addition to reducing the ingress of liquids, the oleophobic properties of treated ePTFE reduces the wettability of the acoustic vent membrane, so that liquids do not remain on the membrane and degrade acoustic performance.

Table 1. Surface tensions of some typical fluids

Fluid	Surface Tension (dynes/cm)
Water	73
10% Methyl Alcohol in Water	59
Castor Oil	36
Benzene	29
Ethyl Alcohol	24
Acetone	24
Methanol	24
Isopropanol	22

Source: https://acct.chemnetbase.com

2.2.3 Ingress protection whilst allowing transmission of air and/or sound

Table 1 illustrates the ingress protection rating system and format of the international standard IEC/EN 60529 which classifies the degree of protection provided by mechanical casings and electrical enclosures against intrusion of debris, dust and water. The first digit indicates the level of protection provided against ingress of solid foreign objects such as debris and dust particles. The second digit indicates the level of protection provided against harmful ingress of water.

Table 2. Ingress Protection Rating format: IP X Y

Protection Against Foreign Solid Object (X)		Protection Against Liquid (Y)	
0	No protection	0	No protection
1	Solid foreign objects (≥ 50 mm in diameter)	1	Drops of water or condensation falling vertically on an enclosure
2	Solid foreign objects (≥ 12.5 mm in diameter)	2	Water sprayed at an angle up to 15° on either side of vertical
3	Solid foreign objects (≥ 2.5 mm in diameter)	3	Water sprayed at an angle up to 60° on either side of vertical
4	Solid foreign objects (≥ 1.0 mm in diameter)	4	Water splashed against the enclosure from any direction

5	Dust entry is limited so that operation of the apparatus or safety is not compromised	5	Water projected in low-pressure jets against the enclosure from any direction
6	No dust particulates enter the enclosure	6	Water projected in high-pressure jets against the enclosure from any direction
		7	Temporary immersion in up to 1 meter of water for 30 minutes
		8	Continuous immersion in more than 1 meter of water under manufacturer conditions
		9k	Steam directed at a high pressure against the enclosure from any direction

Source: International standard IEC 60529 "Degrees of protection provided by enclosures"

90% of smartphones placed on the market in the EU are equipped with ePTFE membrane vents and thus achieve an ingress protection rating according to IP 67 or IP 68. IP 68 means that the smartphone provides protection against foreign sold objects up to level 6 "No dust particulates enter the enclosure" and protection against liquid ingress up to level 8 "Continuous immersion in more than 1 meter of water under manufacturer conditions". The 10% of smartphones that do not use ePTFE membrane vents are lower specification models that have open apertures, where there is no protection between the speaker/microphone and the environment.

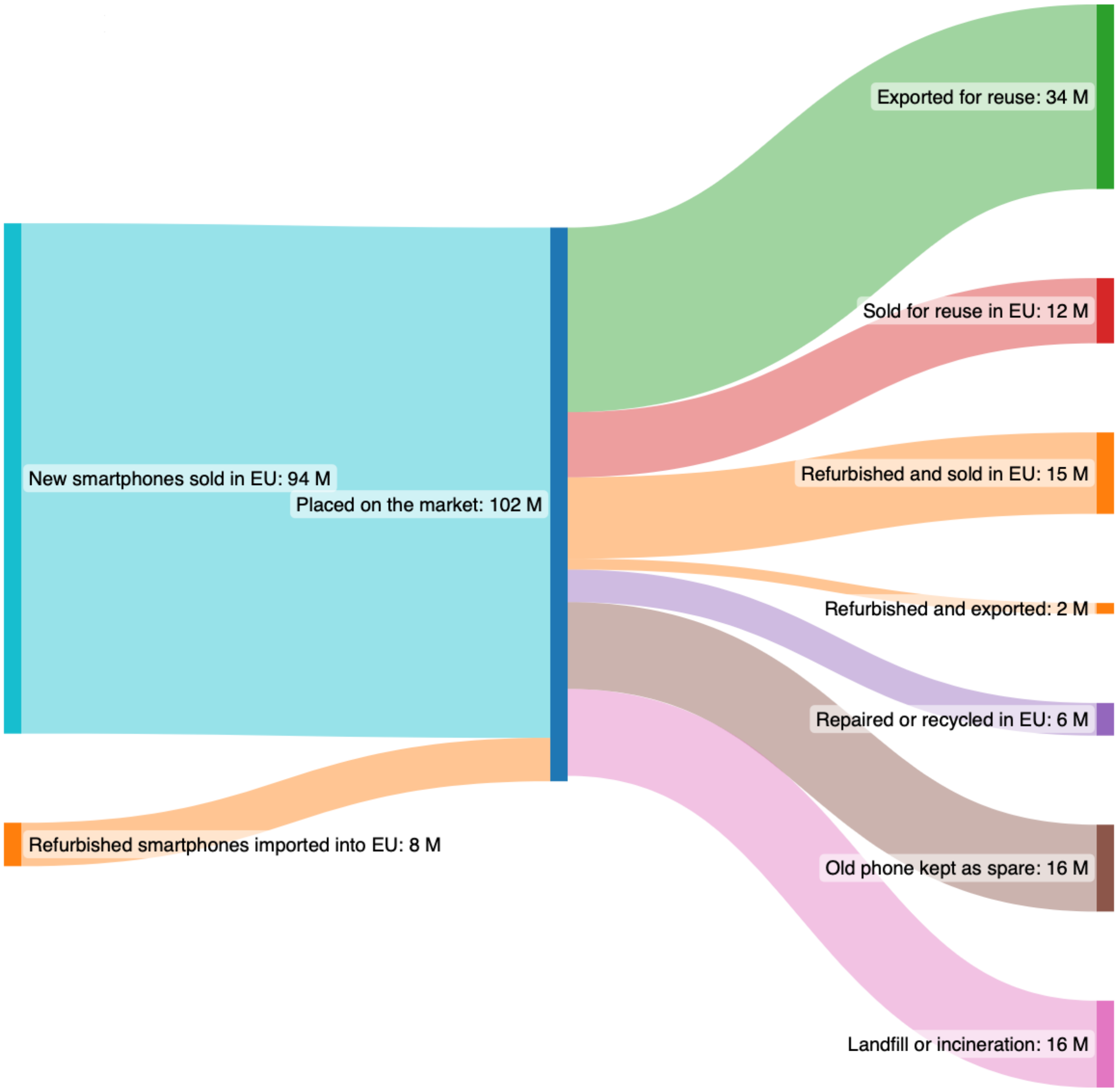
3. Consumption and emissions of PFAS in the EU

3.1 Consumption of PFAS in smartphones placed on EU market

In 2021, the total number of new smartphones sold in the EU was 94 million and the number of refurbished smartphones imported into the EU was 8 million, resulting in 102 million smartphones being placed on the market, Figure 3. 90% of these smartphones use ePTFE membranes to achieve IP67 or IP68 ingress protection ratings. The remaining 10% of smartphones are lower specification models that do not include ingress protection and therefore do not contain ePTFE membranes. This application for a derogation from the REACH restriction of PFAS for use in membranes is needed by all smartphone manufacturers that achieve IP67 or IP68 ingress protection ratings for their devices.

A typical smartphone has four microphones (two at the bottom of the phone, one at the top of the phone and one on the back of the phone to assist with video recording) and two speakers (one at the bottom of the phone and one at the top of the phone). Therefore, the total amount of ePTFE in a typical smartphone is about 0.2 mg which results in an estimated total annual weight of ePFTE in smartphones placed on the market in the EU of 19 kg per year.

Figure 3. Smart phones placed on the EU market and collected for reuse and recycling in 2021, all manufacturers



Source: Refurbished Smartphone Market Update, 2021, Counterpoint, March 2022, https://www.counterpointresearch.com/devices/smartphones/

3.2 Emissions of PFAS in waste smartphones disposed to landfill or incineration

In 2021, about 70 million smartphones were collected for recycling and reuse in the EU as follows, Figure 3:

- 34 million were exported for reuse as-is
- 12 million were sold for reuse as-is in the EU
- 15 million were refurbished in the EU and sold for reuse in the EU
- 2 million were refurbished in the EU and exported for reuse
- 7 million were repaired or recycled in the EU

The 70 million smartphones that were collected for recycling and reuse in 2021 in the EU represent over 69% of the 102 million smartphones that were placed on the market in the

EU in 2021. However, that does not mean that 32 million old smartphones were disposed of to landfill or incineration in 2021.

In 2019, the Royal Society of Chemistry commissioned an Ipsos MORI survey of 2,353 people in the UK which found that 23% of households have an unused mobile phone and 69% of households intend to store these unused phones as spare devices[4].

In view of this survey data, we conservatively estimate that less than 50% of these 32 million old smartphones (that were not collected for recycling and reuse in 2021) were disposed of to landfill or incineration, Figure 5. Therefore, we estimate that 3 kg of ePTFE is disposed to landfill or incineration in the EU in waste smartphones each year.

PTFE emissions from controlled landfills in the EU

Since 2016, most European countries have introduced restrictions on landfilling waste which have generally been implemented in Member States as bans on landfilling specific waste streams such as plastic, textiles and carpet wastes, and these wastes are increasingly incinerated. Furthermore, the revised Waste Framework Directive has set a target for reducing the amount of municipal waste sent to landfills of 10% of total waste by 2035. In landfill conditions mechanical breakdown can cause PFAS to detach and become mobile.

PTFE decomposition during controlled incineration in the EU

PTFE gradually starts decomposing at around 260 °C followed by a rapid decomposition above 400 °C[5]. The degradation products depend on the incineration conditions.

Recent research[6] has found that municipal incineration of PTFE does not generate significant amounts of other PFAS substances and instead mainly results in emissions of hydrofluoric acid and carbon dioxide. Hydrofluoric acid can be removed from municipal incinerator flue gas and neutralized[7].

Pyrometallurgical treatment in one of the EU's copper smelters, for example Aurubis (Germany), Boliden (Sweden), or Umicore (Belgium), operates at higher temperatures of between 900 and 1,500 °C. These smelters are equipped with state-of-the-art flue gas cleaning technologies which destroy any residual emissions.

---

[4] https://www.rsc.org/new-perspectives/sustainability/elements-in-danger/#surveyfindings

[5] *Conesa et al. (2001): "Polytetrafluoroethylene decomposition in air and nitrogen", Polymer Engineering and Science 41 (12), S. 2137–2147. DOI: 10.1002/pen.10908.*

[6] *Aleksandrov et al. (2019): "Waste incineration of Polytetrafluoroethylene (PTFE) to evaluate potential formation of per- and Poly-Fluorinated Alkyl Substances (PFAS) in flue gas".* https://www.sciencedirect.com/science/article/pii/S0045653519306435.

[7] *Chen et al. (2019): "Performance analysis of an online lime separation system in a refuse incineration plant."* https://www.sciencedirect.com/science/article/pii/S0032591019311556

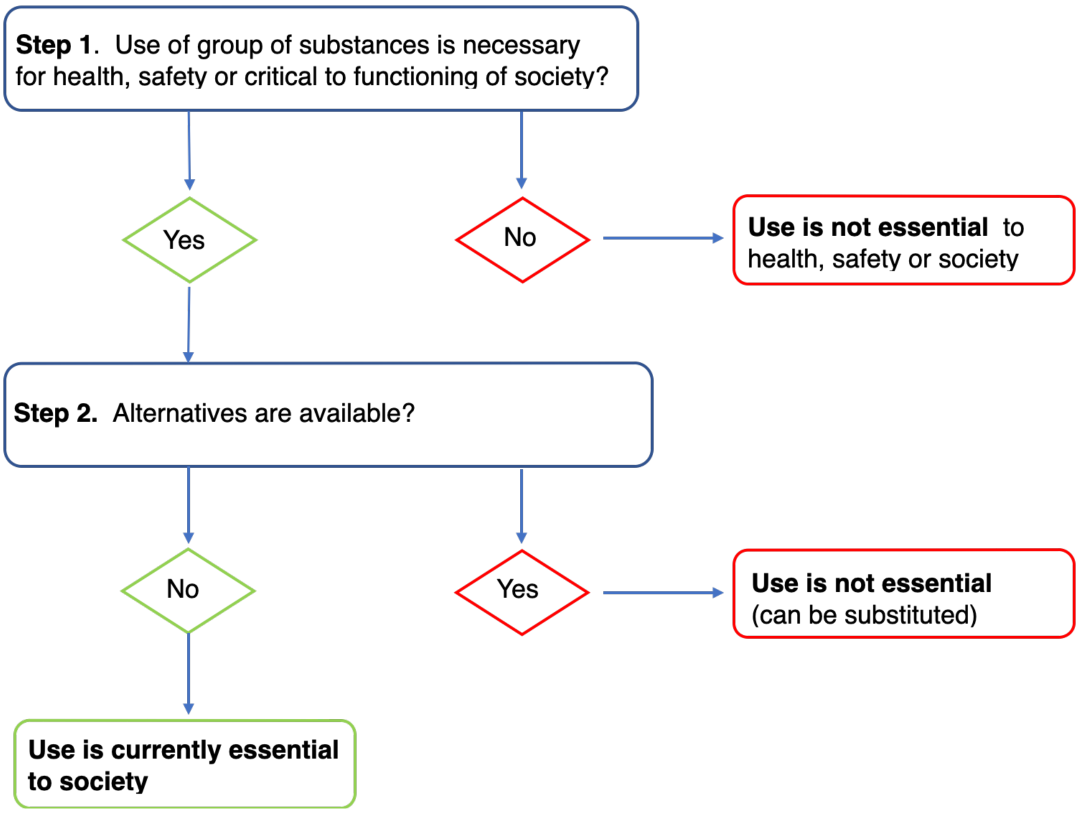
Emissions from PTFE in waste treatment outside the EU

As highlighted in Figure 3, some of the smartphones that are placed on the EU market are exported for reuse outside the EU. This includes exports to developing countries which may not operate controlled landfills or controlled incineration to the same performance levels that are required in the EU. When these devices reach their end of life, they may be treated in uncontrolled landfill or incineration processes which can give rise to higher emission levels of PFAS and other decomposition products than would be the case if these devices were disposed to landfill or incineration in the EU.

4. Essential Use Assessment

As part of the Chemicals Strategy for Sustainability published October 2020, the European Commission will *"define criteria for essential uses to ensure that the most harmful chemicals are only allowed if their use is necessary for health, safety or is critical for the functioning of society and if there are no alternatives that are acceptable from the standpoint of environment and health. These criteria will guide the application of essential uses in all relevant EU legislation for both generic and specific risk assessments."*

Figure 4. Essential Use Concept in Chemicals Strategy for Sustainability



Use of PFAS in membranes that facilitate air and/or sound transmission whilst providing ingress protection for devices that may be used for communications, meets these criteria for essential use.

4.1 Criticality to functioning of society

In 2020, 472 million people in Europe (86% of the population) subscribed to mobile services[8]. In today's society, the general public in Europe rely on their smartphones to provide effective two-way communication in an emergency. The European Chemicals Industry (CEFIC) case study[9] highlights that all types of communication devices need protection from dust and water ingress so that life-saving information can reach its recipient during an accident or emergency. Therefore, this use of PFAS is also critical to the functioning of society for headphones and other devices that consumers may come to rely on for communications in the future.

In September 2022, the European Commission published draft EcoDesign regulations under the Energy-related Products Directive (ErP) 2009/125/EC which will require mobile phones and slate tablets to achieve reliability requirements which include protection from dust and water ingress[10]. The new regulations are expected to be signed into law in early 2023 and the reliability requirements will come into force 12 months later in 2024[11]. Headphones and other devices for communications may also be required to meet similar reliability requirements in the future. These EcoDesign regulations further underline that ingress protection for devices that may be used for communications is critical to the functioning of society.

4.2 Availability of alternatives

The availability assessment of alternatives includes

- Potential substitute materials for use in membranes, which could provide similar properties and functions to ePTFE
- Alternative technologies which could potentially eliminate the need for membranes

4.2.1 Substitute materials

At present, there are no available substitute materials that could replace ePTFE in membranes and provide the unique air permeability, acoustic properties and chemical/water resistance that is required for vents that facilitate air and/or sound transmission whilst providing ingress protection.

4.2.2 Alternative technologies

Open apertures

About 10% of smartphones on the market today are lower specification models that have open apertures, where there is no protection between the speaker/microphone and the

---

8 https://www.gsma.com/mobileeconomy/europe/

9 https://www.fpp4eu.eu/case-studies/pfas-protects-communication-devices-from-dust-and-water/

10 https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12797-Designing-mobile-phones-and-tablets-to-be-sustainable-ecodesign_en

11 https://www.izm.fraunhofer.de/en/news_events/tech_news/eu-regulations-set-to-make-smartphones-and-tablets-more-sustainable.html

environment. Such open apertures provide unimpeded sound, but provide no protection from dust, liquids or immersion — hazards that nearly all smartphones will encounter. Designs with open apertures are highly susceptible to component failures, decreased device life and consumer perceptions of poor quality.

These phones could be protected from water and dust particles by placing them in plastic containers, however they are of limited use in many emergency situations. When the phone is taken out of the container for use during storm weather and heavy rains, the phone will become wet and will cease to function. In case of a construction site or other location with high levels of dust, the particulates will penetrate to the microphones and loudspeakers and the phone will also cease to function.

As mentioned in section 4.1, from 2024 all mobile phones and slate tablets placed on the market in the EU will be required to achieve reliability requirements which include protection from dust and water ingress. Smartphones with open apertures may not be able to meet these new regulatory requirements.

Sealed housings

Sealed housings can protect electronic devices by providing a barrier against water or dust, for example by using non-porous covers such as urethane, silicone or PEEK can be used to cover apertures. However, these materials do not breathe to allow pressure equalisation.

As electronic devices operate, they generate heat, which can cause internal temperatures to increase and therefore pressure to build up inside the housing. Internal pressure can also change rapidly if the device is exposed to sudden changes in external temperatures or altitudes. These internal pressure changes put significant stress on the housing seals. Over time this leads to failed seals, which then allow water and contaminants to enter the device.

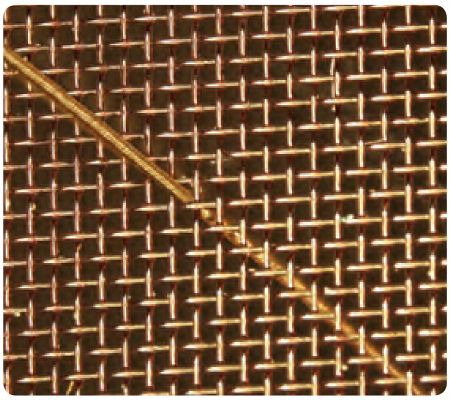
When external pressure in the front cavity builds (due to operation of the phone, the external temperature or altitude changes), the pressure on the compliant surfaces of the microphone transducer and speaker transducer increases. This pressure creates transducer bias that can significantly degrade microphone and speaker performance such that the sound becomes unintelligible. As a result, sealed housings are not a viable option.

Woven mesh covers

Woven mesh covers offer a partial solution, in that they can protect an aperture from liquid splash, spray or rain. Mesh covers are available in pore sizes ranging from 150 microns down to 7 microns.

The mesh covers consist of a single-layer grid and spacing pattern with a defined hole size. Any dust particles smaller than the defined hole size will pass through the screen and deposit on the transducer, or they will propagate through the device, potentially causing device failure. For example, a human hair has a surface area equal to or larger than the specified pore size of many woven materials, yet it can still pass through the material because of its shape, Figure 5.

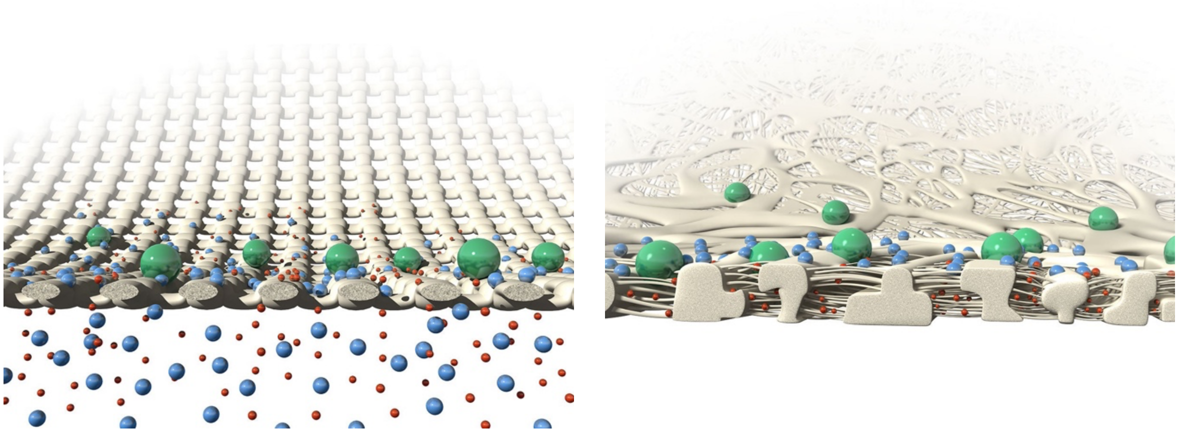
Figure 5. A human hair's shape enables it to pass through a woven material with an 80 microns pore size



Source: https://www.gore.com/resources/testing-for-ingress-protection-of-portable-electronic-devices

In contrast to woven mesh covers, ePTFE membranes provide a three-dimensional tortuous path structure which allows them to effectively capture particles of varied shapes and sizes, Figure 6.

Figure 6. Schematic of mesh cover with defined hole size, ePTFE membrane with three-dimensional tortuous path



Source: https://www.gore.com/products/gore-acoustic-vents

5. Development of possible substitutes

5.1 Actions taken to develop alternative technologies or substitute materials

At present, there are no available substitute materials or alternative technologies that could replace ePTFE membranes and provide the unique air permeability, acoustic properties and chemical/water resistance that are required for vents that facilitate air and/or sound transmission whilst providing ingress protection. A range of alternative non-PFAS materials are being investigated to identify possible substitutes that may have suitable properties that can be further developed. However, these possible substitute materials are many years away from being available as commercial solutions that are ready for use by industry.

5.2 Stages and timeframes needed to establish possible substitute materials

Smartphone manufacturers are working with their suppliers to investigate whether alternative non-PFAS polymer vents could be developed which have similar properties. We estimate it could take at least another three to five years to identify and develop possible substitute polymer materials. The below Table 3 outlines the individual stages and the timeframes.

Table 3. Stages and timeframes needed to establish possible substitutes

Stage	Timeframe
Identify and develop suitable alternative materials	3 - 5 years
Optimise material for specific application requirements (e.g. ingress protection and acoustic performance)	1 year
Reliability testing of manufactured components	1.5 years
Supply chain development (new production capabilities and capacity for mass production)	1.5 years
Total	**7 – 9 years**

The possible substitute materials will need further development to optimise them for specific application requirements (e.g. ingress protection and acoustic performance). We estimate that this stage could take about 1 year. The ingress protection and acoustic properties of these alternative materials will need to be evaluated to ensure that they provide adequate performance.

The final optimised material will then need to be manufactured into vent components so that reliability testing can be carried out in assembled smartphones, headphones and other devices that consumers may come to rely on for communications in the future.

The final stage is supply chain development. This stage focusses on developing and optimizing new supply chain production capabilities (equipment and process) and developing supply chain capacity to support development and mass production requirements.

6. Request for derogation for use of PFAS in membranes that facilitate air and/or sound transmission whilst providing ingress protection for devices that may be used for communications

This derogation application is based on smartphones because these are the main devices on the market today that consumers currently rely on for communications. The European

Chemicals Industry (CEFIC) case study[12] highlights that all types of communication devices need protection from dust and water ingress so that life-saving information can reach its recipient during an accident or emergency. Therefore, this derogation application is also applicable to headphones and other devices that consumers may come to rely on for communications in the future.

As highlighted in section 5.2, we estimate that it may take smartphone manufacturers about nine years to work with their suppliers to establish possible substitutes. These possible substitutes could potentially be used to provide ingress protection for headphones and other devices that consumers may come to rely on for communications in the future.

If the proposed REACH restriction of PFAS takes effect in 2025, we estimate that smartphone manufacturers would need a derogation from this restriction until December 2031 for use of PFAS in membranes that facilitate air and/or sound transmission whilst providing ingress protection for devices that may be used for communications.

Our proposed draft text for this derogation request is
"*use of PFAS in membranes that facilitate air and/or sound transmission whilst providing ingress protection for devices that may be used for communications, until December 2031*"

As highlighted in section 3.2, we estimate that 3 kg of ePTFE is disposed to landfill or incineration in the EU in waste smartphones each year. If the proposed REACH restriction of PFAS takes effect in 2025 and this derogation is permitted until December 2031, we estimate that this derogation would result in less than 21 kg of additional ePTFE disposed of to landfill or incineration from waste smartphones.

We believe that this time-limited derogation would be proportionate based on the essential use of PFAS in membranes in devices that may be used for communications compared to the very small additional emissions of PFAS from landfill or incineration whilst smartphone manufacturers establish possible substitutes.

[12] https://www.fpp4eu.eu/case-studies/pfas-protects-communication-devices-from-dust-and-water/

Annex: Verification statement from Fraunhofer IZM

Fraunhofer
IZM

Technical support for the preparation of the

"Application for derogation from PFAS REACh restriction for use in membranes that facilitate air and/or sound transmission whilst providing ingress protection for devices that may be used for communications"

Berlin, October 14, 2022

Dr. Otmar Deubzer

Senior Scientist
Fraunhofer IZM
Dept. Environmental & Reliability Engineering
Gustav-Meyer-Allee 25
13355 Berlin
Germany
Tel.: +49.30.46403-156
Fax: +49.30.46403-211
e-mail: otmar.deubzer@izm.fraunhofer.de

Statement

Fraunhofer IZM provided technical support for the preparation of below application for a derogation in the context of the REACh regulation:

"Application for derogation from PFAS REACh restriction for use in membranes that facilitate air and/or sound transmission whilst providing ingress protection for devices that may be used for communications"

The technical support included a critical review of the application focusing on the below aspects:

- Completeness and stringency of the information in the applications;
- Plausibility of technical information as to the use of the specific PFAS in the application;
- Technical plausibility of arguments as to the necessity of continued use of specific PFAS in the application;
- Technical plausibility of information concerning the availability and properties of alternatives for the PFAS, i.e. substitutes for the specific PFAS in the applications or alternative technologies providing comparable functionalities without the use of PFAS;
- Technical plausibility that the requested derogation for the use of PFAS in the application reflects the current scientific and technical state of the art concerning the substitutability of the PFAS in the electronics industry.

Fraunhofer IZM reviewed drafts of the application in the period between 1 September 2022 to 14 October 2022 to provide comments, clarifying questions and requests to add data or to complete data and information to fill gaps. Fraunhofer IZM performed further critical reviews to ensure that the feedbacks were processed adequately.

Fraunhofer IZM confirm that the final critical review did not reveal implausible technical information, data or assumptions and conclusions.

Dr. Otmar Deubzer -
Fraunhofer IZM
Dept. Environmental and
Reliability Engineering

Reviewer Credentials and Qualification

Dr. Otmar Deubzer: Experience and background relevant for the critical review task

- Since 2006 review of (renewal) requests for exemptions from the substance restrictions of Directive 2011/65/EU (RoHS Directive) for the European Commission;

- Since 2008 review of exemptions from the substance restrictions under Directive 2000/53/EC (ELV Directive) for the European Commission;

- PhD thesis on the sustainable use and substitution of soldering metals in electronics: Ecological and economic consequences of the ban of lead in electronics and lessons to be learned for the future (2007)

- Master in Environmental Engineering at TU Berlin including environmental chemistry and environmental microbiology (1997)