## 3. Emissions in the end-of-life phase (effectiveness of incineration)

Incineration has proven to be an effective method of disposal via destruction and mineralization of polymeric PFAS (fluoropolymers). Publications can readily be found that describe how proper incineration parameters can reliably prevent emission of PFAS in flue gas or fly ash. Alexandrov et al. [1] studied municipal waste incineration and found no statistically significant difference in the PFAS content of flue gas and fly ash between model PFAS-free waste and waste doped with PTFE. Taylor et al. [2] have also published results demonstrating that incineration of fluoropolymers results in no detectable emissions of PFAS.

Operators of incinerator plants who have expertise in the disposal of hazardous waste are accustomed to maintaining suitable operating conditions that prevent emissions of organic carbon and fluorine. The combustion temperature is important to ensure mineralization of PFAS. Temperatures in excess of 850 °C with higher temperature after-burners are routine. Less widely discussed is the relevance of $H^+$ radicals in the combustion zone, since it is the presence of hydrogen radicals that results in the splitting of C-F bonds. Hence, incinerator conditions may be tuned to maximise the destruction of C-F bonds and result in complete mineralisation of PFAS in incinerators [3]

The Karlsruhe University of Technology (KIT) recently published a report [4] demonstrating that fluoropolymers are converted to inorganic fluorides and carbon dioxide when incinerated. The inorganic fluorides detected were hydrogen fluoride, which can be easily washed out of the emissions. A large majority of samples indicated that long-chain PFAS were below levels of 1 ng/$m^3$(>99% of samples associated with 860°C condition and >98% of samples associated with 1100°C condition). There were no short chain PFAS detected post incineration. TFA was non-detectable in all samples with a reporting limit of 14 µg/$m_3$. **The results confirm that fluoropolymers at their end of life when incinerated under representative European municipal incinerators conditions do not generate any measurable levels of PFAS emissions and therefore pose no risk to human health and the environment.** The main reason to include fluoropolymers in the EU PFAS restriction proposal was persistence (resistance to degradation in the environment) in the environment. The absence of organic fluorides and more specifically PFAS in tests representative of municipal waste incineration confirms complete mineralization of fluoropolymers and provides critical data in support for exempting Fluoropolymers from the EU REACH PFAS restriction proposal.

Reference [5] refers to recently developed technologies for PFAS degradation.

Submission from ATIEL (Attachment 9) describes the end of use phase for lubricants highlighting the industrial usage (non-consumer) and existence of emission control processes. Component composition and recycling documentation enabled by systems like the International Material Data System (IMDS) in automotive industry make it possible to track automotive parts that contain a variety of substances and the recycling of those parts at end of vehicle life.

[1] "Waste incineration of Polytetrafluoroethylene (PTFE) to evaluate potential formation of per- and Poly-Fluorinated Alkyl Substances (PFAS) in flue gas" by Krasimir Aleksandrov et al., Chemosphere 226 (2019) p898-906 DOI: 10.1016/j.chemosphere.2019.03.191

[2] “Investigation of waste incineration of fluorotelomer-based polymers as a potential source of PFOA in the environment” by P.H. Taylor et al. Chemosphere 110 (2014) p17-22 DOI: 10.1016/j.chemosphere.2014.02.037

[3]. Combustion of C1 and C2 PFAS: Kinetic modelling and experiments by Jonathan Krug et al Journal of the Air & Waste Management Association (2022) DOI: 10.1080/10962247.2021.2021317

[4]. Pilot-Scale Fluoropolymer Incineration Study: Thermal Treatment of a Mixture of Fluoropolymers under Representative European Municipal Waste Combustor Conditions
Dr. Gehrmann, Hans-Joachim1; Dr. habil. Bologa, Andrei1; Dr. Aleksandrov, Krasimir1; Bergdolt, Philipp1; Dr. Taylor, Philip2; Dr. Schlipf, Michael3; Dr. Ameduri, Bruno4; Gunasekar, Priyanga5; Kapoor, Deepak5
1 Institute for Technical Chemistry (ITC) at Karlsruhe Institute of Technology (KIT); 2 P Taylor & Associates, LLC, USA; 3 Pro-K, Germany; 4 ICGM, University of Montpellier, France; 5 Gujarat Fluorochemicals

[5].https://www.wral.com/story/durham-company-creates-unit-that-can-destroy-pfas-other-contaminants-from-water/20886770/

https://revive-environmental.com/press-releases-revive-environmental-pfas-annihilator-deployed-in-first-to-market-commercial-destruction-of-forever-chemicals/

## 5. Proposed derogations – Tonnage and emissions:

PTFE is used as a solid lubricant and/or thickener in lubricant formulations. Some suppliers recycle PTFE i.e., post-industrial PTFE is collected and reconditioned for new usage.

a. Tonnage:

In 2022, DuPont calculated it introduced less than 60 tonnes of PTFE and 8 tonnes of PFPE and fluorosilicones combined due to commercial industrial sales of PFAS containing lubricants. Some products contain multiple types of PFAS, and/or may be primarily composed of non-PFAS compounds. The calculated tonnage is consistent with the data presented in Table 3 of the Annex 15 report based on our known market share of PFAS containing lubricants in EMEA.

b. Key properties and Alternative Comparison

PFAS containing lubricants possess multiple properties that allow them to perform under harsh (extreme) conditions. Superior oxidative and thermal stability, non-flammability, and chemical resistance are only a few of the properties that PFAS containing lubricants possess when compared to alternative materials. Common lubricants such as petroleum oils or non-fluorinated silicones are more vulnerable to attack and degradation by aggressive or reactive chemicals such as chlorine, oxygen, and the decomposition products from plasma etching in the electronics industry. Non-fluorinated lubricants are not resistant to solvents and aviation fuel, nor do they lead to the longest possible life in sealed and lubricated for life applications such as automotive components or industrial tools and equipment.

Our attachments provide factual data and visual evidence pertaining to the superior performance of these materials. The following attachments have been provided:

1. Solvay's product brochure "Fomblin® PFPE". The Solvay information gives a general overview for, and outlines, the advantages of fluorinated lubricant base oils used to make fluorinated lubricants. Pages 8-13 highlight key superior properties of PFPE base oils compared to other currently existing synthetic lubricant base oils.
2. IHS Chemical Lubricants, Synthetic Specialty Chemicals Update report – A report on the global lubricants industry that, on page 23, draws attention to challenges of innovation due to mechanical components becoming smaller and doing more work at higher speeds and temperatures. Fluorinated lubricants are critical in helping society invent more effective devices and components. This point is critical to consider when weighing the benefits of fluorinated lubricants to society that are often overlooked. Page 52 presents a physical properties comparison chart. Pages 58-61 present facts about PFPE's and fluorosilicones and advantages including chemical resistance. Page 75 contains comments on inertness, low volatility, and non-flammability of PFPE's. Pages 102 and 103 discuss the benefit of PFPE-based and PTFE filled lubricants in applications including aerospace, automotive, electronics and chemical manufacturing.
3. Chapter 8 of "Synthetics, Mineral Oils and Bio-Based Lubricants Chemistry and Technology" edited by Leslie Rudnick and published by CRC Press provides several pages of content regarding the properties and advantages of PFPE lubricant base oils. Highlights include sections on lubrication performance, chemical and physical properties including materials compatibility, inertness, hydrolytic stability, and radiation resistance. Some key end-use applications are noted such as in protection of valves and o-rings in oxygen service, aircraft instruments, lubricated for life electric motor bearings and more.
4. SCE-EPRI-Doble Case Study - Circuit Breaker Mechanism Lubricant Performance Assessment - highlights how PFAS containing lubricants are used to maximize performance, extend the lifetime and maintenance intervals of high voltage electrical distribution circuit breakers in the modern electrical power distribution grid, and minimize the number of power outages experienced in society. The case study states the evidence that many circuit breaker failures can be traced to degraded lubricants and recommends on page 19 of the document that fluorosilicone lubricants with PTFE thickeners are an appropriate choice for circuit breaker lubrication given the challenges of environmental conditions and need for long-term maintenance intervals.
5. Anti-noise performance in passenger car interior components – dry film lubricants containing PTFE particles are more effective than dry film lubricants containing polyethylene wax in anti-noise performance; they are effective along the whole vehicle lifetime; annoying noises can be eliminated allowing the drivers to fully concentrate in driving activities. (see attachment 10 – Anti-noise durability performance of Molykote(R) D-96 Anti-Friction Coating).
6. Dry lubrication of automotive starter plungers – PTFE based dry film lubricants provide lifetime lubrication to engine starter plungers allowing a proper operation of start-stop systems in passenger cars; this contributes to fuel and CO2 reduction (see attachment 11 simulation of life time performance of engine starter plungers with Molykote(R) PTFE-based Anti-Friction Coatings PFPE Lubricants in general have superior resistance to different rubber types and outperform conventional lubricants such as standard silicone and ester based. Another aspect is related to fluorosilicone lubricants. Fluoropolymer rubbers are broadly used due to their thermal and chemical stability. Silicone based rubber can be considered as potential alternatives for some of the applications. However, standard silicone-based lubricants cannot be used in combination with silicone rubber due to their incompatibility. Attached test data (Attachment 1) illustrate superior

compatibility of PFPE lubricants with different rubber types as well as compatibility of fluorosilicone based lubricants in combination with silicone rubber.

7. The independent test data (attachments 2 and 3) from DVGW in Karlsruhe were done with a standard silicone non-PFAS based compound as well as with silicone compound thickened with PTFE. Gas resistance has only been achieved with PTFE thickened product, and silicone based non-PFAS containing compound has failed the testing.
8. Fluorosilicone, PFPE and PTFE containing lubricants find broad application due to the superior chemical stability, thermal and oxidation resistance in various application (Reference to VSI letter). Examples include:

   - Automotive industry. The ACEA (European Automobile Manufacturers' Association) highlighted in their position paper (attachment 8), that PFPE lubricants are essential for multiple applications operating under harsh conditions or are related to safe functioning and safety of equipment. Furthermore, ACEA mentioned that PFPE lubricants are used as lifetime lubricants and that alternatives may lead to a lack of sustainability in vehicles, since existing vehicles won't be repairable after the proposed derogation period. Overall, more time is needed to analyze the full impact of the proposed PFAS containing lubricant restrictions on the automotive industry.
   - Food industry
   - Hydraulic and pneumatic equipment, valves and seals
   - Bearings of all kinds
   - Precision and electrical engineering/electronics (semiconductor industry)
   - Service companies incl. leisure services
   - Automotive engineering, passenger cars, commercial vehicles, motorbikes
   - Basic industry, basic materials for the construction industry, glass
   - Chemical industry, refineries, rubber, plastic and leather industry
   - Systems and equipment carrying liquid or gaseous oxygen (e.g., gas cylinders)
   - Energy transmission and connection systems
   - Power generation (wind and renewables, nuclear) and energy storage
   - Mechanical engineering
   - Robotics
   - Paper and printing industry
   - Film stretching industry
   - Railway and aircraft industry
   - Conveyor and transport equipment
   - Pharmaceutical and cosmetics
   - Medical technology
   - Compressors
   - Mining and coal-fired power plants
   - Shipping
   - Oil and gas
   - Cement, lime, gypsum
   - Weapons and military vehicles
   - Aerospace
   - Diving and underwater applications
   - Optical and analytical instruments

- Hydrogen industry

The attached case studies give some selected examples of PFAS containing lubricant uses in critical applications where conventional based lubricants fails:

a. Attachment 4: PFPE/PTFE based lubricants like MOLYKOTE® HP-300 Grease and MOLYKOTE® L-8030 Lubricant are widely used in HV connectors due to their superior dielectric properties, wide service temperature range and good compatibility with different elastomers.
b. Attachment 5: PFPE/PTFE based lubricants like MOLYKOTE® HP-300 Grease and MOLYKOTE® PD-930 Lubricant perfectly meets the requirements of Hydrogen-exposed applications. Hydrogen is viewed as significant contributor to achieve climate goals. The alternative chemistry does not withstand the compatibility requirements.
c. Attachment 6: PFPE/PTFE based lubricant MOLYKOTE® HP-300 Grease is successfully used for inverter electrical connectors due to its excellent compatibility with various elastomers and its superior thermal stability.
d. Attachment 7: Fluorosilicone grease MOLYKOTE® 3451 Chemical Resistant Bearing Grease ensures reliable and safe operation of circuit breakers. It can extend maintenance intervals and improve electrical grid reliability due to its chemical inertness and wide service temperature range.
e. High temperature silicone-based products thickened with PTFE are used in spark plug boot lubrication in the automotive industry and no alternative is available which meets the application requirements. The reference submission of the end-user can be taken here: 47d3c0eb-5f8d-4f05-b41c-fd98fd0400af.
f. PTFE based anti-friction coatings are well-known for their noise and friction reduction properties and superior durability. They are widely used in automotive applications like interior trim components, dashboard components, door panels and starter motors where they outperform products without PFAS (examples in attachment 10 and 11).
g. ATIEL (Technical Association of the European Lubricants Industry) has submitted evidence (submission number 4423) explaining the usage of PFAS in lubricant industry highlighting such facts as low environmental concern for fluoropolymers (PTFE and PFPE), control of environmental emissions during production and use phase, limitation availability of alternatives and information about the benefits and the challenges of any transition period. Please refer to attachment 9.