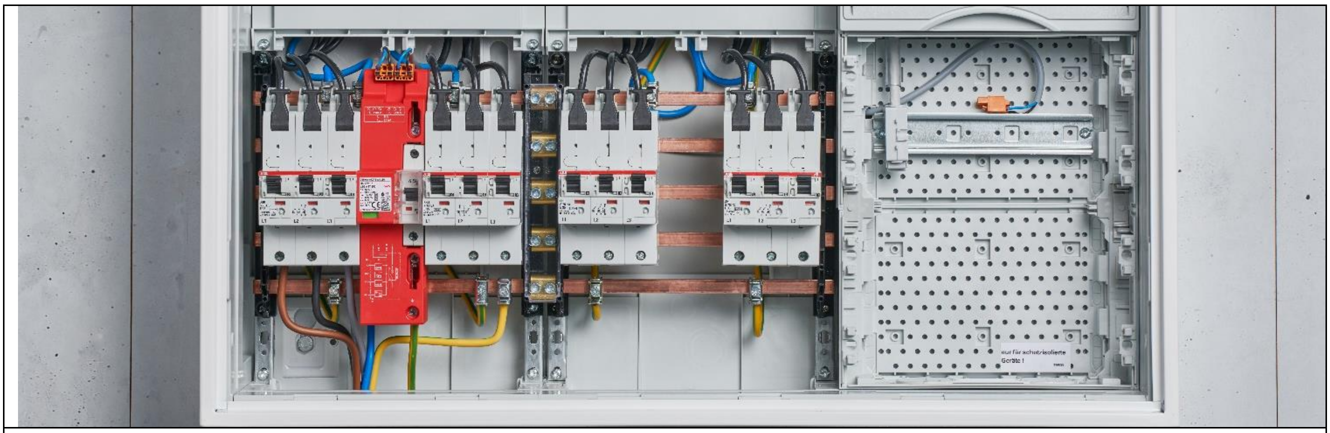
Surge protection devices with spark gaps for power supply systems



llustration 1: Electrical installation with protection devices [DEHN SE]

They are used in a vast variety of business sectors and applications

Surge/overvoltage protection of systems and equipment against surges caused by atmospheric discharge and switching operations for example in the market sectors:
Process industry, medical and healthcare, buildings (commercial and private households), mobile communication, renewable energy, public transportation and e-mobility

a) The annual tonnage and emissions and type of PFAS associated with the relevant use

Gruppe	Verbrauch / a	Gewicht [kg]	Umsatz
Flachdichtung/O-Ring/Dichtscheibe	777.805	239,00	
Membrane	3.244	0,81	
Mikroschalter mit PTFE-haltigem Drücker	1.412.466	241,41	
Ölbeständige Anschlussleitung PTFE-ummantelt	30	58,53	
PFTE-Schlauch	3.601	11,91	
PTFE-Gewindeband	1.512	2,33	
PTFE-Isolierplatten	1.148.284	327,06	
Schmieröl (PTFE-haltig)	186	55,80	
Gesamt			**ca. 130.000.000 €**

During the manufacturing phase, PFAS are handled with care and in accordance with applicable regulations regarding hazardous chemicals, occupational health and safety as well as emissions to the environment. Whenever critical substances are used in the manufacturing, technical, organizational or personal protective measures are established to protect both people and the environment from contamination. In the electronics industry, lead, diisocyanate and many other substances are already handled responsibly according to the state of the art.

There is no foreseeable emission of PFAS into the environment during use of electrical installation systems or protection devices under normal conditions.

The amount of PFAS, which can theoretically be emitted in the end-of-life treatment, is also very limited. PFAS containing articles in electrical and electronic equipment are collected and dealt with in accordance with applicable regulations, e.g. Waste Framework Directive (WFD) 2008/98/EC and WEEE Directive 2012/19/EU. If the components cannot be repaired or directly reused, they are sent to specialized waste electrical equipment recyclers for material or thermal recycling (a recent study by Conversio has shown that at its end-of-life approximately 85% of all fluoropolymers end up in waste-to-energy recovery incinerators). In these processes, the polymeric PFAS contained in our articles are either broken down into their original components or mineralized so that the PFAS properties are lost. Latest studies 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.

b) The key functionalities provided by PFAS for the relevant use

Application: Insulation layer for spark gaps of surge protection devices (PTFE)

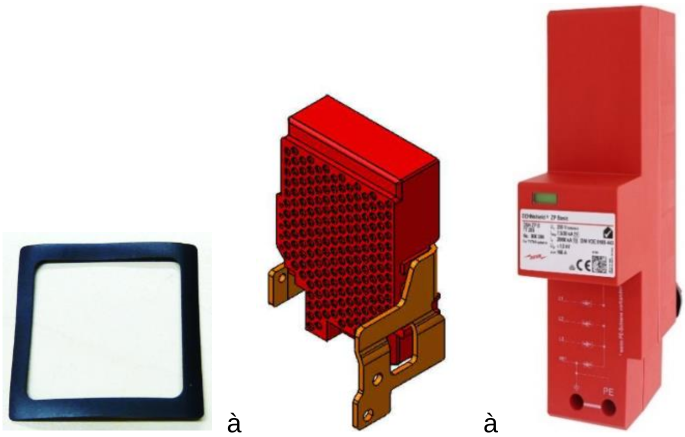
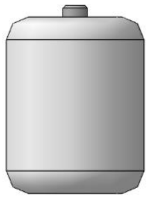
<table>
<tr>
<td>Insulation layer for spark gaps of surge protection devices</td>
<td>

Illustration 2: Insulation layer → spark gap → surge protection device [DEHN SE]</td>
</tr>
<tr>
<td>PFAS substance/ substance group:
• PTFE/fluoropolymer</td>
<td>PFAS-containing material/component:
• Insulation layer</td>
</tr>
<tr>
<td colspan="2">Reason for PFAS Use/Requirements Profile:
• Excellent electrical insulation/dielectric strength
• High temperature performance (up to 260 °C)
• Heat resistance at extreme temperatures and non-flammability (high LOI)
• Chemical resistance against aggressive media (e.g. ozone)
• No absorption of moisture / water
• Non adhesive surface
• Resistance against climatic influences (e.g. UV, moisture, dust)
• Long lasting lifetime</td>
</tr>
</table>

Application: Sealing of encapsulated non-exhausting spark gabs of surge protective devices (FKM)

Sealing of encapsulated non exhausting spark gaps of surge protection devices	 à  à  **Illustration 3:** Sealing → encapsulated non-exhausting spark gap → surge protection device [DEHN SE]
PFAS substance/ substance group: • FKM/fluoroelastomer	**PFAS-containing material/component:** • Sealing
Reason for PFAS Use/Requirements Profile: • Heat resistance at extreme temperatures and non-flammability • Mechanical properties (e.g. flexibility, impermeability for gases) • High temperature performance (up to 260 °C) • Chemical resistance against aggressive media (e.g. ozone) • Electrical insulation/dielectric strength • Resistance against climatic influences (e.g. moisture, wetness, dust) • Long lasting lifetime	

Application: Remote contact operating-plunger of surge protective devices

Requirements / Material properties:
- Very low dynamic friction
- Long lasting lifetime
- Resistance against climatic influences (e.g. moisture, wetness, dust)
- High temperature performance

c) The number of companies in the sector estimated to be affected by restriction

Market environment

The relevant applications for the affected products are process, transportation, railway, highways, data center, commercial buildings, residential buildings, renewable energy (especially wind, PV, battery storage systems,…), hospitals, airports, telecommunication.

Share of jobs and turnover accounted by products containing PFAS

The concerned turnover is about 40 %. 60% of the employees are in contact with PFAS during the manufacturing process.

Key requirements and key success factors

The most important requirement is that the relevant products do not have to handle a lightning event very often, but they have to work for a long time without any restrictions of the products requirements after a period of time. With the relevant products and the used components inside this products we have a experience of decades that they will work.

To qualify alternative materials for the products and to guarantee the working principle of years, a longer time for qualification is necessary.

d) The availability, technical und economic feasibility, hazards and risks of alternatives for the relevant use

While some chemistries/materials might offer a similar performance to PFAS for a particular parameter or property, it is the unique combination of properties that sets fluoropolymers apart and makes them vital for the electrical installation systems industry.

Alternative solutions are only partially available for some specific applications, for some no alternative is known at all.

- **PTFE**
  - Exemplary use cases: electrical insulation of spark gaps or electronic components (wire or cable sheaths, shrink tubes, tubes etc.)
  - Required characteristics: unique combination of electrical insulation/dielectric strength, heat resistance at extreme temperatures and non-flammability, long lasting lifetime, resistance to oil,…
  - Alternatives: PVC or PP are already in use as wire insulation for low temperature applications, but they cannot be used if high operating temperatures (>105 °C) are required. Polymers like PEEK or Polyimide are suitable for high operating temperature but have different mechanical and/or electrical properties compared with fluorinated polymers.

- **FKM**
  - Exemplary use cases: O-rings and sealings
  - Required characteristics: unique combination of heat resistance, resistance against climatic influences (e.g. UV, moisture, dust) and aggressive media (e.g. ozone) as well as mechanical properties (e.g. flexibility, impermeability for gases)
  - Alternatives: EPDM rubber, nitrile rubber (NBR) or hydrogenated NBR as sealings are not suitable in most applications

e) For cases in which alternatives are not yet available, information on the status of R&D processes for finding suitable alternatives

For certain applications, it is currently not possible to show that a PFAS-free alternative has the same specific properties. In such cases, it may even be necessary to invent and synthesize new chemicals/materials, and/or develop alternative approaches to realize the required safety performance of protection devices. Given that inventing new chemicals/materials is an open-ended process without a specified timeline or guarantee of success, it may take 5 to more than 25 years to find suitable alternatives which then can be implemented. Because of the long term timeline it is impossible to give a financial frame for the qualification. Also the process to find an alternative material is not safe.

f) For cases in which substitution is technically and economically feasible but more time is required to substitute

- The material manufacturers have to develop a new material fulfilling the technical requirements of application (combination of heat resistance, electrical strength, high temperature performance etc.). The duration of this process may take several years, rough approach 5 years.
- This material needs to be qualified and certified also by 3rd party labs. Required time up to 3 years.
- If the material is available and certified it needs to be designed in and qualified in the wide variety of products from DEHN, including mechanical and electrical testing. If necessary, also new production processes or process modifications need to be implemented. Required time up to 3 years.
- Finally, also the final product often needs to be qualified by 3rd certification (e.g. UL, KEMA...). Required time 1-2 years.

Therefore the estimated time for all this process needs to be considered up to 13 years.

g) For cases in which substitution is not technically or economically feasible, information on what the socio-economic impacts would be for companies

Consequences of the Proposed Restriction

- Shortage of raw materials and waste of materials
  Products containing PFAS can no longer be supplied after the compliance enforcement date. Existing stocks of PFAS-containing electrical installation systems and protection devices already placed on the market for the first time have to be disposed of as hazardous waste, incl. almost all electric and electronic equipment for second-hand use.
  Recycling industry is working with high volume processing, such as shredding, of different types of products with different compositions on a ton scale and not on a single piece scale. Given the extremely low threshold of 25 ppb, even a few components containing PFAS would degrade extremely large quantities of recycled materials into hazardous waste.
  High amounts of high-quality material as well as still fully functional devices must be treated as hazardous waste instead of being recycled, reused and conserving resources. Instead, high amounts of virgin materials are required to cover the needs with the related environmental impact and the dependance on the sources, which are often outside of the EEA.

- Spare parts for products
  For protection devices the lifetime period is usually 20 to 25 years. The availability of spare parts is essential to realize the lifetime potential.
  Especially where fluoropolymers are concerned, the design of PFAS-free spare parts is hampered by the fact that there is no suitable alternative material with the same properties available on the market, that does not contain PFAS.
  The consequence of the above is that the lack of a spare part exemption will lead to the inability to repair products and to the premature obsolescence of those products. This contradicts the new EU circular economy action plan.

- Interruption of supply chain
  Due to the lack of exemptions and derogations usable for electrical and electronic equipment sector, production and sales would abruptly be interrupted as soon as the ban comes into force. Under the assumption that substitution of PFAS in electronic products is only possible by 2035, the currently proposed restriction would result in several years of disrupted supply.

For the electric installation systems sector and protection devices, the proposed restriction imposes a blanket ban on a huge number of substances in an undifferentiated manner and without proof of a specific risk. It is threatening production, research and development sites and activities in Europe and their competitiveness worldwide.

PFAS are crucial as an enabling material not only to sustain our European production and business, but also for the ability to achieve the targets of strategic EU policies set in terms of the European Green Deal, the decarbonization of the European industry, the envisaged energy/heating and mobility turnaround as well as the European re-industrial policies.

Studien Waste Incineration PFAS/Fluoropolymers – Stand 30.06.2023

DANK an Hatice Söyler, Hans-Jürgen Völkl, Jakob Bierwagen

Fate of Per- and Polyfluoroalkyl Substances in Postconsumer Products during Waste Management Debra R. Reinhart, F.ASCE; and Jiannan Chen, .M.ASCE ; Stephanie C. Bolyard, M.ASCE, Chemosphere, Volume 226, July 2019, Pages 898-906	Fate of Per- and Polyfluoroalkyl Subs
The decomposition and emission factors of a wide range of PFAS in diverse, contaminated organic waste fractions undergoing dry pyrolysis, Journal of Hazardous Materials, 454 (2023) 131447	The decomposition and emission factor: https://doi.org/10.1016/j.jhazmat.2023.131447
The first quantitative investigation of compounds generated from PFAS, PFAS-containing aqueous film-forming foams and commercial fluorosurfactants in pyrolytic processes - ScienceDirect	The First Quantitative Investig
	Giraud, R., Taylor, P. Huang, P. (2021). Combustion operating conditions for municipal Waste-to-Energy facilities in the U.S.. Waste Management (132) 124-132. https://doi.org/10.1016/j.wasman.2021.07.015.
Neuwahl, F., Cusano, G., Gomex Benvanides, J., Holbrook, S., Roudier, S. (2019). Best Available Techniques (BAT) Reference Document for Waste Incineration: Industrial Emissions	. Best Available Techniques (BAT) reference document for waste incineration - Publications Office of the EU (europa.eu)

Directive 2010/75/EU (Integrated Pollution Prevention and Control), EUR 29971 EN. European IPPC Bureau, Joint Research Centre, Luxembourg	
auch unter Bedingungen der Hausmüllverbrennung nach dem Stand der Technik bei einer Mindestverbrennungstemperatur von 850°C zu anorganischem Fluorid umgewandelt (Aleksandrov K. et al. 2019):	(schon im ZVEi verteilt, kam über FEC) WasteIncineration Of_PTFE_Aleksandrc https://www.sciencedirect.com/science/article/pii/S0045653519306435
Ganz NEU Juni 2023 proK prelimanary	Preliminary report-Pilot-Scale Fl
Bislang wenige und widersprüchliche Daten zu den Bedingungen, unter denen PFAS bei der Verbrennung vollständig mineralisiert werden:	1) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9778349/ 2) https://www.glwater.org/wp-content/uploads/2021/07/Winchell-et-al-WER-2021.pdf
Die 17. Bundesimmissionsschutzverordnung (17. BImSchV) schreibt eine Mindestverbrennungstemperatur von 850 °C vor. (Paragraph 6, (1)): • 1.100 °C, wenn Halogenanteil im Abfall > 1% • Laut Bund sind bei vielen PFAS-haltigen Produkten und in Siedlungsabfällen der Fluorgehalt	https://www.gesetze-im-internet.de/bimschv_17_2013/BJNR104400013.html

deutlich geringer als 1 %.	
Verbrennungsanlagen arbeiten typischerweise zwischen 600-1600 °C:	https://www.sciencedirect.com/science/article/pii/S2095809917300796
Mind. 1.100°C über 2 Sekunden zur vollständigen Spaltung der meisten PFAS (Yamada T. et al. 2005):	https://www.sciencedirect.com/science/article/abs/pii/S004565350500425X
lässt vermuten, dass kürzere PFAS höhere Verbrennungstemperaturen benötigen: 1) Komplette Mineralisierung bei Temperaturen > 1000°C: 2) Mineralisierung von Tetrafluormethan (CF4) von mehr als 1.400°C (Tsang W. et al., 1998): und/oder 90 % an CF4 zerstört bei 1295 °C	1) https://www.tandfonline.com/doi/abs/10.1080/00102209808952095 2) Combustion of C1 and C2 PFAS: Kinetic modeling and experiments (tandfonline.com)
Verbrennung von PFOA, PFHxA, PFOS bei verschiedenen Temperaturen (800, 900, 1000). Fazit: bei höheren Temperaturen (1000 °C) keine Bildung von fluorierten Nebenprodukten	Residual organic fluorinated compounds from thermal treatment of PFOA, PFHxA and PFOS adsorbed onto granular activated carbon (GAC) | SpringerLink
In Schweden: mind. 850 °C (bis 1100°C):	FULLTEXT01.pdf (diva-portal.org) (Abschnitt 2.4.1)
99% an PFOS bei 600°C zerstört (Taylor & Yamada, 2003):	https://cswab.org/wp-content/uploads/2019/02/Taylor-PFAS-3M-Study-Incineration-PFAS-Degradation2000-Degrees-Fahrenheit-40-seconds-2003.pdf

99.9% of PFAS (PFOA, PFOS, and PFHxS) bei 350-400°C entfernt (in einer Woche:	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8375574/
90 % PFOA und PFOS entfernt durch Pyrolyse bei 500-600 °C	Removal of PFASs from biosolids using a semi-pilot scale pyrolysis reactor and the application of biosolids derived biochar for the removal of PFASs from contaminated water - Environmental Science: Water Research & Technology (RSC Publishing) aus Recent advances on PFAS degradation via thermal and nonthermal methods - ScienceDirect
Auch interessant, dass gleichzeitig an Methoden gearbeitet wird, die eine vollständige Mineralisierung von PFAS unter ziemlich milden Bedingungen erlauben (40-120 °C):	https://www.science.org/doi/10.1126/science.abm8868
Zusammenfassender Artikel zu „REMOVAL OF PFAS FROM WASTEWATER THROUGH ADSORPTION AND SORBENT INCINERATION“:	https://www.ghd.com/en/about-us/examining-thermal-destruction-for-pfas-waste.aspx#:~:text=The%20United%20States%20Environmental%20Protection,in%201%20second%20residence%20time

Weitere Studien

Raw Materials Foresight Study 202	Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study (europa.eu)